IEEE CONFERENCE ON CONTROL APPLICATIONS

IEEE SYMPOSIUM ON COMPUTER-AIDED CONTROL SYSTEMS DESIGN

IEEE INTERNATIONAL SYMPOSIUM ON INTELLIGENT CONTROL

FINAL PROGRAM

AND

BOOK OF ABSTRACTS

October 4-6, 2006

Technical University Munich

Germany

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Welcome

On behalf of the IEEE Control Systems Society, the Program and Operating Committees, and Technical Co-sponsors I would like to express my warmest welcome to all attendees of the Joint 2006 IEEE Conference on Control Applications (CCA), Computer-Aided Control Systems Design Symposium (CACSD) and International Symposium on Intelligent Control (ISIC). The joint 2006 CCA/CACSD/ISIC multi-conference is sponsored by the IEEE Control Systems Society (CSS), and is organized in cooperation with the Japanese Society for Instrument and Control Engineers (SICE), and the European Union Control Association (EUCA).

The 2006 CCA/CACSD/ISIC will be held Wednesday through Friday, October 4-6, 2006, at the Technical University of Munich, Germany. Munich, the state capital of Bavaria, is a well known economic hub and leisure center, focal point of art and culture, crossroads of history and modern times. The metropolis on the Isar River combines old Bavarian tradition and broad-minded openness toward the world, deep-rooted customs and dynamic innovation, sovereign composure and pulsating activity. The 2006 CCA/CACSD/ISIC is held just after the 2006 Oktoberfest, the most traditional and world famous Munich festival (September 16 – October 3).

The Technical Program integrates CCA, CACSD and ISIC submissions into a single cohesive package while maintaining their individual identities. Thanks to our program chairs Martin Buss (CCA), Christian Schmid (CACSD) and Derong Liu (ISIC) we were able to accomplish this very successfully. The Technical Program includes 11 parallel tracks of sessions (7 for CCA, 2 for CACSD, 2 for ISIC) with 594 papers selected from 760 submissions (433 regular papers and 161 invited papers). The paper presentation sessions are framed each day by highly exciting plenary events: a plenary talk preceding the morning sessions and a keynote talk following the afternoon presentations organized by some of our industrial sponsors. The conference itself is preceded on Tuesday, October 3, 2006, by three full-day tutorial workshops. Industrial and publisher exhibits will be available throughout the conference.

The joint 2006 CCA/CACSD/ISIC is being made possible because of the vital contributions of a great number of individuals. First, my sincere thanks go out to all authors, plenary and keynote speakers, and workshop organizers for enriching the technical content. I thank all the members of the Operating Committee: Program Chairs Martin Buss, Christian Schmid and Derong Liu, Invited Session Chairs Mitsuji Sampei, Pieter Mosterman, and Jagannathan Sarangapani, Workshops Chair Vasile Sima, Publicity Chairs Marco Lovera and Chun-Yi Su, Finance Chair Ferdinand Svaricek, Publications Chair Didier Henrion, Registration Chairs Sandra Hirche and Pradeep Misra, Exhibits Chair Johann Reger, Best Student Paper Award Chair Lalit K. Mestha, and Local Arrangements Chair Simon Hecker. Special thanks go to CSS Conference Editorial Board Chair Thomas Parisini and CSS Information Technology Chair Pradeep Misra for their sustained support in using PaperPlaza, a wonderful tool for conference organizers. I also want to thank the Control System Society for providing funds for travel support for students and participants from developing countries, and for sponsoring the CCA Best Student Paper Award. In the same vein, I thank The Mathworks, Inc. and the Automation & Robotics Research Institute, University of Texas at Arlington for sponsoring the CCA and ISIC Best Student Paper Awards.

I look forward to seeing you at the joint 2006 CCA/CACSD/ISIC and encourage you to consider spending a few extra days to enjoy the many opportunities for outdoor and cultural activities.

Andras Varga
General Chair

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Conference information

Venue

The technical sessions of the conference will be hosted in the downtown campus of one of the foremost universities in Germany, the Technische Universität München (Technical University of Munich, TUM). In 2006, the TUM comprises in its three campuses, twelve faculties with about 20,000 students (of whom about 20% come from abroad), 440 professors and roughly 8,500 staff members.

The TUM can trace back its origins to the Royal Polytechnic School founded by King Ludwig II in 1868. In 1970 it changed its name from Technische Hochschule München to Technische Universität München. TUM has since long time become a synonym for technological progress. Many outstanding TUM professors have secured their place in the history of technology, many important scientists, architects, engineers and entrepreneurs studied there. Such names as Karl Max von Bauernfeind, Rudolf Diesel, Claude Dornier, Walther von Dyck, Hans Fischer (Nobel prize for Chemistry, 1930), Ernst Otto Fischer (Nobel prize for Chemistry, 1973), August Föppl, Robert Huber (Nobel prize for Chemistry, 1988), Carl von Linde, Heinz Maier-Leibnitz, Walther Meissner, Rudolf Mössbauer (Nobel prize for Physics, 1961), Willy Messerschmitt, Wilhelm Nusselt, Hans Piloty, Friedrich von Thiersch, Franz von Soxhlet are closely connected with the TUM.

The six plenary sessions of the conference will take place in the centrally situated Auditorium Maximum (Audimax). Its Foyer will host the Registration Desk, the Exhibits area and the Sightseeing Tours booking desk. The Welcome and Farwell Receptions will also take place in the Foyer of the Audimax. The conference rooms hosting the technical sessions are conveniently located around Audimax at short distances (see inside of back cover).

Registration

All conference attendees must be registered. The provided personal badges must be worn to identify registered participants. All registration categories include access to technical sessions, coffee breaks, welcome and farewell receptions. All registered participants will receive a CD-ROM containing the conference proceedings and the book of abstracts. Full rate registration (IEEE/SICE member and non-member) also includes the Conference Banquet on Thursday, October 5th. The registration packages will be available at the registration desk during the following hours:

Monday	October 2	15:00 - 18:00
Tuesday	October 3	7:30 – 10:30, 15:00 - 17:00
Wednesday	October 4	7:30 - 18:30
Thursday	October 5	7:30 - 18:30
Friday	October 6	7:30 - 15:00

Proceedings

Additional conference proceedings on CD-ROM can be purchased for 50 USD (16% VAT not included) at the registration desk. Printed (harcopy) conference proceedings are not available, but may be purchased from IEEE after the conference.

Exhibits

A number of exhibitors participate including The Mathworks, Inc., National Instruments, Scilab, dSpace, Dynasim, Hasomed, Quanser, Springer.

Social program

Welcome Reception, October 3, 17:00 – 19:00, Foyer Audimax
All attendees and their accompanying guests are invited to attend. From 19:00 to 23:00 there remains still plenty of time to attend the last evening of the famous Oktoberfest!

Conference banquet, October 5, 19:30 - 23:30 - Löwenbräukeller (see back cover)
One banquet ticket will be provided in each registration (except for reduced registration fee attendee). Additional tickets may be purchased at the Registration Desk. The banquet is celebrated as a little Oktoberfest-Beer-Festival in the famous Löwenbräu brewery. Enjoy a traditional buffet with Bavarian market stalls and a whole ox roasted on the spit - a genuine Bavarian delicacy and a festival for nose, eyes and palate. Unique are the special "Oktoberfest Offers" with fairground attractions like shooting galleries, miniature merry go rounds, sugar cotton wool, sweet roasted almonds, candied fruits and a genuine Bavarian brass brand. This will be the "highlight" of an unforgettable stay in Munich!

Farwell Reception, October 6, 18:30 – 20:00, Foyer Audimax
All attendees and their accompanying guests are invited to attend.

Internet access

During conference hours, a free wireless Internet access is provided in most areas of the venue. Please configure your WLAN-Adapter to SSID „**con"**. This network name is not broadcasted everywhere and it may be necessary to enter it manually. Please disable WEP encryption. No Proxy server is necessary. The IP address is obtained automatically.

Lunch facilities

Lunch can be served from 11:00 to 13:45 in the University Mensa (for its location see back cover). Lunch tickets must be purchased at the Registration Desk. Alternatively, several neighboring restaurants will fulfil every taste for lunch.

Sightseeing tours

Several 2 hours city tours and full day trips are offered by **Munich Insider** travel agency before, during and after the conference. For complete information see the agency's homepage: `http://www.munich-insider.com/en/index.php?page_id=3000`. Tour booking at the conference will be possible **only** on Wednesday, October 4, between 9:00 – 12:00 hours. Look for **Munich Insider** desk (near to the conference registration desk).

City walks and tours
Munich, the capital of Bavaria, is regarded as one of the most beautiful and charming cities of Europe. It offers a great variety of unusual delights, fascinating events, and marvellous experiences. For companion orientation, the Munich Orientation Tour scheduled on Wednesday, October 4, 10:00 – 12:00, is highly recommended. Besides this, a Beer tour, a Highlight tour, a Shopping tour, and a Tasting tour offer unique insights into the typical Bavarian way of life and to the city´s extraordinary flair.

Day trips
Munich is situated in the centre of glorious Bavaria and is thus the ideal starting point for day trips to the surrounding provinces. Precious medieval cities and King Ludwig´s marvellous castles in the alpine upland are awaiting to be discovered. Professional tour guides will accompany each group to the chosen destination. The tour offer includes trips to Castle Neuschwanstein, Castle Herrenchiemsee, Salzburg (Austria), Andechs Monastery & Lake Starnberg.

Best student paper awards

To recognize excellence in a conference paper whose primary contributor is a Student Member of the IEEE, the Best Student Paper Award (BSPA) is granted separately for each of the three conferences. The prize consists of a certificate laminated on a plaque and travel expenses to the 2006 CCA/CACSD/ISIC. The unique eligibility criterion for the BSPA is that the primary contributor of a paper, was a student at the time of original submission. The basis for judging candidate papers is originality, clarity, and potential impact on practical applications of control. This year the BSPA for CCA is jointly funded by the IEEE Control Systems Society and The Mathworks, while the BSPA for ISIC is funded by the Automation and Robotics Institute of the University of Texas at Arlington. Due to lack of nominations of high quality papers, the BSPA for CACSD has been not granted this year.

The following finalists have been selected:
CCA: Alexander Kharitonov, Sikandar Samar, Wilfred Kwok, Thomas Conord, Vivek Yadav
ISIC: Atalla Sayda, Nishant Unnikrishnan, Alma Alanis

All finalists will receive certificates. The presentation of the BSPA will take place at the 2006 CCA/CACSD/ISIC Conference Banquet on Thursday, October 5.

The award winning papers for the 2006 CCA/CACSD/ISIC are:

1. **Alexander Kharitonov**, Oliver Sawodny
   Flatness-Based Disturbance Decoupling for Heat and Mass Transfer Processes with Distributed Control
   Schedule code: WeB09.5 (CCA)
2. **Sikandar Samar**, Dimitry Gorinevsky, Stephen P. Boyd
   Embedded Estimation of Fault Parameters in an Unmanned Aerial Vehicle
   Schedule code: FrC10.1 (CCA)
3. **Atalla Sayda**, James H. Taylor
   An Implementation Plan for Integrated Control and Asset Management of Petroleum Production Facilities
   Schedule code: ThA03.1 (ISIC)

Tutorial workshops

Workshop 1: Identification in Closed Loop - a Powerful Design and Tuning Tool (Theory, Algorithms and Applications)

Tuesday, October 3, 2006; 8:15 – 17:00, Room 0999

Organizer: **Ioan D. Landau**
Laboratoire d'Automatique de Grenoble (CNRS/INPG), France

System identification in closed loop operation has witnessed a very important development in the last ten years. Two main reasons motivated this development: the frequent requirement for system identification in closed loop (either because the system is unstable or has important drift in open loop operation or because a controller exists already), and the important discovery that models identified in closed loop are generally better, for control design, than those identified in open loop (provided that appropriate algorithms are used). Identification in closed loop is also a very useful tool for controller reduction.

Workshop Outline:

- Introduction
  - Why we need identification in closed loop?
  - An example: flexible transmission
  - Objectives of the identification in closed loop
  - Brief review of open loop identification algorithms
  - Brief review of robust digital control (structure, sensitivity function, robustness)

- Algorithms for Identification in Closed Loop
  - Basic schemes for identification in closed loop
  - The CLOE algorithms for identification in closed loop (closed loop output error)
  - Validation of models identified in closed loop

- Methodology for Identification in Closed Loop
  - Summary of the methodology for identification in closed loop
  - Iterative identification in closed loop and controller re-design
  - Experimental results: flexible transmission, active suspension, flexible arm

- Methodology for Controller Complexity Reduction
  - Direct controller reduction by identification in closed loop
  - Basic schemes and algorithms
  - Experimental results: active suspension system, flexible transmission

- Concluding Remarks

Workshop 2: Distributed Intelligent Networks and Systems

Tuesday, October 3, 2006; 8:15 – 17:00, Room 3999

Organizers:

Enrique H. Ruspini
Artificial Intelligence Center
SRI International, USA

J. Douglas Birdwell
Dept. of Electrical and Computer Engr.
University of Tennessee, Knoxville

The topic of this workshop is Distributed Intelligent Networks and Systems (DINS). The workshop aims to help develop a strategy to build a better "home" for the research areas and technologies within the scope of DINS. These research areas and technologies cut across the traditional boundaries of many IEEE technical societies, and a more coordinated approach is likely to bring greater visibility to both the areas and technologies and to the IEEE's roles in fostering continued developments in these fields. The workshop is targetted to students and researchers working — from different perspectives — on a variety of distributed sensing, control, and decision problems.

This workshop has a non-traditional structure since—beyond providing an opportunity to learn about a wide variety of approaches to deal with problems in distributed sensing, communication, and control—it also seeks participation from the audience to help identify future IEEE activities in this field. These activities include, but are not limited, to the development of conferences, publication, standards, technical organizations, and local interest groups (e.g., Chapters and Student Chapters). Furthermore, the workshop seeks to provide a forum where representatives from industry and government seeking solutions to important technological problems may interact with scientists and engineers that are actively working to develop such solutions.

Workshop Outline:

- Collaborative agents (Charles L. Ortiz)
- On distributed linear quadratic optimal control (Anders Rantzer)
- Controller adaptation to compensate deterioration effects - An evolutionary algorithms application (Piero P. Bonissone)
- Distributed control of teams of robots (Regis Vincent)
- Fault diagnosis and accommodation in distributed dynamical systems (Marios M. Polycarpou)
- Hybrid optimal control with applications to hybrid electric vehicles and load balancing in computer networks (Raymond DeCarlo jointly with Doug Birdwell, Milos Zefran, Kasemsak Utiechena, Brian Moerdyk, John Chiasson, and Steve Pekarek)
- Concluding discussion on exploring future directions

Workshop 3: Advanced Computational Intelligence Techniques for Identification, Control and Optimization of Nonlinear Systems

Tuesday, October 3, 2006; 8:15 – 17:00, Room 2607

Organizers:

Ganesh Kumar Venayagamoorthy
University of Missouri-Rolla

Radhakant Padhi
Indian Institute of Science, Bangalore

Neural networks and fuzzy systems are natural candidates as approximators of a nonlinear time series or dynamical system, due to their intrinsic nonlinearity and computational simplicity. Under the stationarity hypothesis for the system generating the data, the NARX (Nonlinear Auto-Regressive with an eXogenous (X) variable) neural networks are able to solve the nonlinear identification problem. The multilayer feedforward and recurrent neural networks types are employed.

Various nonlinear control approaches using intelligent systems, such as neural networks, fuzzy systems, reinforcement learning, artificial immune systems, and many others, have been proposed. There is a wide-gap between applications of these methods in real time and in simulation. The most comprehensive solution approach to nonlinear optimal control in a state feedback form is offered by the dynamic programming formulation. However, solving the associated Hamilton-Jacobi-Bellman equation demands a very large amount of computations and storage space. The innovative "Approximate Dynamic Programming" (ADP) formulation obtains the solution through a dual neural network approach called Adaptive Critic Designs. The optimization technique is based on a combination of reinforcement learning and ADP, by successively adapting two artificial neural networks, an action network (delivering the control signals) and a critic network (which 'learns' the desired performance index). A recent improvement, "Single Network Adaptive Critics (SNAC)", applicable to a wide class of nonlinear problems, results in a substantial reduction of computational load for training the networks, while retaining all the beneficial properties of the AC architecture.

Workshop Outline:

- Computational Intelligence: Approaches and Applications (Venayagamoorthy)
  - Neural networks
  - Fuzzy logic
  - Evolutionary computing
  - Artificial immune systems
  - Swarm intelligence
  - Application: Unmanned vehicle navigation
  - Application: Hardware evolution

- Nonlinear System Identification and Control with Applications (Venayagamoorthy)
  - Nonlinear system identification using neural networks
  - Adaptive neurocontrol
  - Application: Power systems control
  - Reinforcement learning

- Optimal Control Design and Applications (Padhi & Venayagamoorthy)
  - Classical optimal control theory: variational approach and dynamic programming; Examples and computational difficulties (Padhi)
  - Approximate dynamic programming, AC and SNAC architectures; Examples (Padhi)
  - Adaptive critic designs and applications to power systems control (Venayagamoorthy)
  - Optimal control of distributed parameter systems; Examples (Padhi)

Plenary sessions

Dr. J. M. Maciejowski , University of Cambridge

Plenary Lecture: The Changing Face and Role of CACSD

Wednesday, October 4, 8:15-9:15, Audimax

Computer Aided Control Engineering involves three parallel streams: Simulation and modelling, Control system design (off-line), and Controller implementation. In industry the bottleneck problem has always been modelling, and this remains the case – that is where control (and other) engineers put most of their technical effort. Although great advances in software tools have been made, the cost of modelling remains very high – too high for some sectors. Object-oriented modelling, enabling truly re-usable models, seems to be the key enabling technology here. Software tools to support control systems design have two aspects to them: aiding and managing the work-flow in particular projects (whether of a single engineer or of a team), and provision of numerical algorithms to support control-theoretic and systems-theoretic analysis and design. The numerical problems associated with linear systems have been largely overcome, so that most problems can be tackled routinely without difficulty – though problems remain with (some) systems of extremely large dimensions. Recent emphasis on control of hybrid and/or constrained systems is leading to the emerging importance of geometric algorithms (ellipsoidal approximation, polytope projection, etc). Constantly increasing computational power is leading to renewed interest in "design by optimisation", an example of which is MPC. Innovations in commercial tools, however, emphasise project-management rather than systems-theoretic support. The explosion of "embedded" control systems has highlighted the importance of autocode generation, directly from modelling/simulation products to target processors. This is the `new kid on the block', and again much of the focus of commercial tools is on this part of the control engineer's job. Here the control engineer can no longer ignore computer science (at least, for the time being).

Dr Jan Maciejowski is a Reader in Control Engineering in the Department of Engineering at the University of Cambridge, and currently Head of the Control Group. He is also a Fellow of Pembroke College, Cambridge. He graduated from Sussex University in 1971 with a B.Sc degree in Automatic Control, and from Cambridge University in 1978 with a Ph.D degree in Control Engineering. From 1971 to 1974 he was a Systems Engineer with Marconi Space and Defence Systems Ltd, working mostly on attitude control of spacecraft and high-altitude balloon platforms. He was President of the European Union Control Association from 2003 to 2005. In 2002 he was President of the Institute of Measurement and Control. He is a Fellow of the IEE and of the InstMC, and a Senior Member of the IEEE. He is also a "Distinguished Lecturer" of the IEEE Control Systems Society.

He has held Visiting Professorships at the University of California at Santa Barbara, at Delft Technological University, and at NTU Singapore. He has also consulted for several UK and US companies on various control and signal processing problems. His book "Multivariable Feedback Design", published by Addison-Wesley in 1989, received the IFAC Control Engineering Textbook Prize in 1996. In 2001 he published "Predictive Control with Constraints" (Prentice-Hall), which has recently (2005) been translated into Japanese. He has published about 100 journal and conference papers on control systems. His current research interests are in predictive control, its application to fault-tolerant control, in hybrid systems, and in system identification.

Dr. Pascal Gahinet , The MathWorks Inc.

Keynote Lecture: CACSD Tools - A MathWorks Perspective

Wednesday, October 4, 17:40:18:30, Audimax

Software tools are playing an increasingly central role in the adoption and dissemination of CACSD techniques throughout academia and industry. As a leading provider of such tools for the past 20 years, MathWorks has been actively involved in shaping and facilitating the software revolution in control systems engineering.

This talk looks at some trends and challenges in building the next generation of CACSD tools. We discuss ongoing efforts to make control technology less intimidating and more widely accessible. We showcase the merits of integrated tool chains for professionals and students alike. Finally, we highlight some technical challenges in building reliable general-purpose tools and discuss related work on numerical algorithms and time-delay modeling.

Pascal Gahinet graduated in 1984 from Ecole Polytechnique in Paris and got a Ph.D. in Electrical Engineering from the University of California, Santa Barbara in 1989. From 1990 to 1996 he was a research fellow at INRIA, France with interests in numerical sofware, robust control theory, and LMI-based design. He was one of the co-authors of the LMI Control Toolbox. He has been with The MathWorks since 1996, first as lead developer for the Control System Toolbox, and more recently as technical manager of the Control & Identification product family.

Professor Brian D.O. Anderson
Australian National University

Plenary Lecture: Control and Information Architectures for Formations

Thursday, October 5, 8:15-9:15, Audimax

Formations of robots, underwater vehicles and autonomous airborne vehicles are slowly being deployed to tackle problems in both civilian and military spheres—bush fire control, surveillance and the like. In many situations, it is desirable that the formation maintain its shape while executing an overall change of location, or change from one shape to another, perhaps to avoid an obstacle; again, on occasions a formation may need to split, or merge with a different formation. Living organisms, especially fish and birds, often exhibit this sort of behaviour.

The presentation will consider the types of control, communications and sensing architecture that allow scalability for formations with many individual agents, and allow preservation of the formation shape, merging, splitting, or closing ranks in the event of loss of one or more agents. The scalability requirement imposes a need for significant decentralization of information and control structures, and, just as in a formation of birds, no one bird can be expected to watch all other birds and compute its own trajectory using even partial knowledge of the trajectories of all other individual birds, so the amount of sensing, communication and control computation by any one agent has to be limited.

Professor Brian Anderson was born in Sydney, Australia. He took his undergraduate degrees in Mathematics and Electrical Engineering at Sydney University, and his doctoral degree in Electrical Engineering at Stanford University in 1966. His research interests have been principally in control systems, with significant work also in signal processing, telecommunications and circuit theory.

From 1990 to 1993 he was President of the International Federation of Automatic Control, and from 1994-2002 he was Director of the Research School of Information Sciences and Engineering at the Australian National University, and he served as President of the Australian Academy of Science from 1998-2002. He is currently Chief Scientist of National ICT Australia and Distinguished Professor in the Research School of Information Sciences and Engineering at ANU.

Professor Anderson is a Fellow of the Australian Academy of Science and Academy of Technology Sciences and Engineering, the Institute of Electrical and Electronic Engineers, the Royal Society, London; an Honorary Fellow of the Institution of Engineers, Australia and a Foreign Associate of the US National Academy of Engineering. He holds Honorary Doctorates from the Catholic University of Louvain, Belgium, the Swiss Federal Institute of Technology, and a number of Australian Universities.

Prof. Dr.-Ing. habil. Raymond Freymann, BMW Group Research & Technology

Keynote Lecture: The Role of Driver Assistance Systems in a Future Traffic Scenario

Thursday, October 5, 17:40-18:30, Audimax

It is shown in how far driver assistance systems can contribute to enhance the overall traffic safety. Thereby it must be considered as a goal to increase the performance of active safety systems in the scope of an integrated approach, allowing to realize a variety of interactions between the three elements involved in a traffic scenario: the driver, the vehicle and the driving environment. Focus is pointed on the related technology, the inherent system complexity and aspects of customer acceptance.

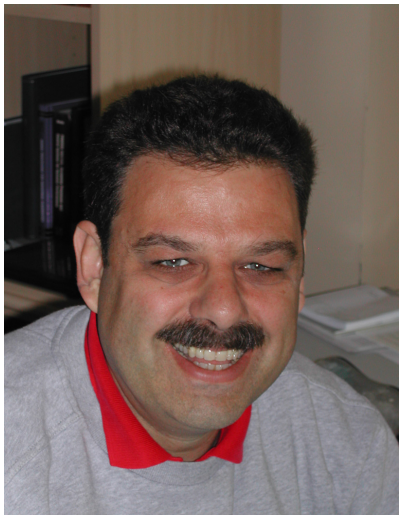
Raymond Freymann is Managing Director of BMW Group Research and Technology since 2003. He has an engineering degree in aerospace technology and a doctor of engineering degree from the Technical University of Braunschweig. He has performed a ten years research work in the aerospace sector at the Institute of Aeroelasticity of the DLR (German Aerospace Research Center) in Göttingen and at the Flight Dynamics Laboratory of Wright Patterson AFB in Dayton (Ohio). His career at BMW Group started in 1986 as Head of Structural Dynamics and Acoustics. Raymond Freymann got his habilitation from the Technical University of Munich (TUM) in 2000 and is acting as a honorary professor at the TUM.

Professor Thomas Parisini, University of Trieste

Plenary Lecture: Control of Distributed-Information Nonlinear Stochastic Systems

Friday, October 6, 8:15-9:15, Audimax

In engineering and economic systems, many situations may occur, in which a process is influenced by the presence of several decision makers (DM). Different degrees of cooperation and different degrees of distribution of available information among the DM are possible. In this lecture, we consider the case where various DM share different information patterns but they make decisions aimed at the accomplishment of a common goal, i.e., the minimization of the same cost functional. A general approach to the solution of a team optimal decision problem has not yet been presented in the literature. Therefore, in this lecture we give up looking for optimal solutions to a general team optimal control problem, and propose a technique to obtain suboptimal (but approximate to any degree of accuracy) solutions. This is accomplished by constraining the control functions to take on the structure of feedforward neural networks thanks to their powerful approximation capabilities and because these functional structures allow for a simple distributed computation of the local control strategies by stochastic approximation techniques. The neural control methodology is worked out on two important benchmark problems. A simple team within the LQG framework is first considered, where two decision makers with scalar information are present. When the problem admits a known optimal solution, our approach has demonstrated to be able to approximate it. Quite satisfactory results were obtained also in a case (the well-known Witsenhausen counterexample) where the optimal solution has not yet been found (it is however known that it exists). Then, dynamic routing in communication networks is considered. A nonlinear discrete-time dynamic model is given for a store-and-forward packet switching network in which the routing nodes play the role of cooperating DM of a team. The resulting problem does not verify either the LQG hypotheses or the partially nestedness assumption on the information structure.



Thomas Parisini received the ``Laurea'' degree (Cum Laude and printing honours) in Electronic Engineering in 1988 and the Ph.D. degree in Electronic Engineering and Computer Science in 1993 both from the University of Genoa. He was with Politecnico di Milano as associate professor and in 2001 he was appointed full professor and Danieli Endowed Chair of Automation Engineering at the University of Trieste.T. Parisini is the Chair of the IEEE Control Systems Society Conference Editorial Board. He was the Chair of the Technical Committee on Intelligent Control and he is a Distinguished Lecturer of the IEEE Control Systems Society. He is the co-recipient of the 2004 Outstanding Paper Award of the IEEE Trans. on Neural Networks. T. Parisini is currently serving as an Associate Editor of Automatica, of the Int. J. of Control, and as Subject Editor of the Int. J. of Robust and Nonlinear Control and served as Associate Editor of the IEEE Trans. on Automatic Control, of the IEEE Trans. on Neural Networks, and as Subject Editor of the Int. J. of Adaptive Control and Signal Processing. He was also the Guest Editor of two special issues in the IEEE Trans. on Neural Networks. He was involved in the organization and in the technical program committees of several IEEE CSS sponsored conferences including the IEEE CDCl and the IEEE CCA. In particular, he was Vice-Program Chair of the 2003 IEEE CDC and he was recently appointed as Program Chair of the 2008 IEEE CDC. His research interests include neural-network approximations for optimal control and filtering problems, fault diagnosis for nonlinear systems, hybrid control systems and control of distributed systems. He is also involved as Project Leader in several projects funded by the European Union, by the Italian Ministry for Research and by some major process control companies (ABB, Danieli, Duferco, Galileo Avionics among others).

Dr. Christian Philippe, ESA

Keynote Lecture: ESA Perspectives on Advanced Control Technology for Complex Space Systems

Friday, October 5, 17:40-18:30, Audimax

Prior to any space vehicle development it is crucial in the very early stage of the project to understand the dynamical behaviour and achievable system performance. The theory and tools offered by system theory allow us to model, simulate and manipulate complex system characteristics until satisfactory behaviour is obtained. Underlying to this is a control design process that in a multidisciplinary setting will iteratively dictate the architecture of system to be designed. In order to manage uncertainty and complexity, fundamental design tools based on recent advanced control techniques are used to support this process. These tools are generic and allow responding in a flexible way to various mission needs. This will be illustrated on a spectrum of ESA missions where Systems & Control are fundamental. For some challenging space missions the main control design drivers will be highlighted by means of illustrative design examples. The experience and results achieved with advanced modelling and control techniques will be reviewed. Based on this experience an integrated view on control technology will be given, seen from an experimental perspective and highlight potential directions for the improvement of the management of complex space systems.

Christian Philippe leads the Navigation, Guidance and Control Section at the European Space Research and Technology Centre (ESTEC), which is developing and implementing innovative cutting-edge guidance, navigation and control technologies for formation flying, autonomous rendezvous, reusable launcher and planetary entry, descent, landing and ascent vehicles. Mr. Philippe graduated from Ecole Nationale Supérieure de l'Aéronautique et de l'Espace (SUPAERO) with a PhD degree in Numerical Methods and Theoretical Mechanics from Pierre-et-Marie-Curie University.

International program committees

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Technical Program Wednesday October 4, 2006

Track 1: CACSD	Track 2: CACSD	Track 3: ISIC	Track 4: ISIC	Track 5: CCA	Track 6: CCA	Track 7: CCA	Track 8: CCA	Track 9: CCA	Track 10: CCA	Track 11: CCA
Room 2601	Room 1601	Room 0670	Room 2605	Room 0601	Room 0602	Room 0606	Room 2607	Room 0999	Room 3999	Audimax
08:15-09:15 Audimax WePPL Plenary Lecture: Jan Maciejowski, University of Cambridge										
09:45-11:45 WeA01 Robust Numerical Methods for Control	09:45-11:45 WeA02 Semantically Rich Control Systems Design Tools	09:45-11:45 WeA03 Neural and Fuzzy Control of Nonlinear Systems	09:45-11:45 WeA04 Wireless Sensor Networks for Intelligent Systems	09:45-11:45 WeA05 Automotive I	09:45-11:45 WeA06 Human-Centered Applications I	09:45-11:45 WeA07 Model Predictive Control I	09:45-11:45 WeA08 Mechatronics	09:45-11:45 WeA09 Emerging Control Applications I	09:45-11:45 WeA10 Robust Control I	09:45-11:45 WeA11 Hybrid & Switching Systems I
13:00-15:00 WeB01 Symbolic Methods	13:00-15:00 WeB02 Modeling and Simulation of Multidisciplinary Systems and Networked Embedded Control Systems Design	13:00-15:00 WeB03 New Trend in Approximate Dynamic Programming and Control Applications	13:00-15:00 WeB04 New Trends in Switched and Hybrid Systems	13:00-15:00 WeB05 Automotive Control - Powertrain Control	13:00-15:00 WeB06 Human Adaptive Mechatronics	13:00-15:00 WeB07 Computational Algorithms for Model Predictive Control	13:00-15:00 WeB08 Computer Vision	13:00-15:00 WeB09 Analysis and Control of Distributed-Parameter Systems with Applications	13:00-15:00 WeB10 Robust Control II	13:00-15:00 WeB11 Nonlinear and Robust Control Applications for Mechanical Systems
15:30-17:30 WeC01 Hybrid Evolutionary-Algebraic Techniques in Control	15:30-17:30 WeC02 Computer-Aided Design of the Control of Fluid Power Systems	15:30-17:30 WeC03 Reinforcement and Iterative Learning Control	15:30-17:30 WeC04 Hybrid and Switched Systems	15:30-17:30 WeC05 Automotive II	15:30-17:30 WeC06 Human-Centered Applications II	15:30-17:30 WeC07 Model Predictive Control II	15:30-17:30 WeC08 Sliding Mode Control	15:30-17:30 WeC09 Emerging Control Applications II	15:30-17:30 WeC10 Robust Control III	15:30-17:30 WeC11 Vibration Control
17:40-18:30 Audimax WeKPL Keynote Lecture: Pascal Gahinet, The Mathworks, Inc.										

Technical Program Thursday October 5, 2006

Track 1: CACSD	Track 2: CACSD	Track 3: ISIC	Track 4: ISIC	Track 5: CCA	Track 6: CCA	Track 7: CCA	Track 8: CCA	Track 9: CCA	Track 10: CCA	Track 11: CCA
Room 2601	Room 1601	Room 0670	Room 2605	Room 0601	Room 0602	Room 0606	Room 2607	Room 0999	Room 3999	Audimax
08:15-09:15 Audimax ThPPL Plenary Lecture: Brian D.O. Anderson, Australian National University										
09:45-11:45 ThA01 Linear Systems and LMI-Based Control System Analysis and Synthesis	09:45-11:45 ThA02 Tools for Co-Design of Control Systems and Their Real-Time Implementation	09:45-11:45 ThA03 Intelligent Systems and Intelligent Control	09:45-11:45 ThA04 Biologically-Inspired Methods and Biosystems	09:45-11:45 ThA05 Automotive III	09:45-11:45 ThA06 Networked Control Systems I	09:45-11:45 ThA07 Process Control I	09:45-11:45 ThA08 Modeling	09:45-11:45 ThA09 Robotics	09:45-11:45 ThA10 Robust Control IV	09:45-11:45 ThA11 Hybrid & Switching Systems II
13:00-15:00 ThB01 Computer-Aided Control Design and Optimization	13:00-15:00 ThB02 Computer-Aided Design of Hybrid Control Systems	13:00-15:00 ThB03 Neural Networks and Neurocontrol	13:00-15:00 ThB04 Estimation, Identification and Modeling	13:00-15:00 ThB05 Automotive Control: Next Generation Power Source	13:00-15:00 ThB06 Advances in Networked Control	13:00-15:00 ThB07 System Theoretical Analysis and Control in Systems Biology	13:00-15:00 ThB08 Observers	13:00-15:00 ThB09 Robotics - Navigation	13:00-15:00 ThB10 Adaptive Control II	13:00-15:00 ThB11 Discrete-Event Systems
15:30-17:30 ThC01 Object-Oriented Modelling and Simulation Environments	15:30-17:30 ThC02 Control Design and Computational Methods	15:30-17:30 ThC03 Intelligent Robust Control with Applications	15:30-17:30 ThC04 Adaptive Control I	15:30-17:30 ThC05 Automotive Control: Powertrain Modeling and Calibration	15:30-17:30 ThC06 Networked Control Systems II	15:30-17:30 ThC07 Process Control II	15:30-17:30 ThC08 Fuzzy Control I	15:30-17:30 ThC09 Robot Control	15:30-17:30 ThC10 Various Applications I	15:30-17:30 ThC11 Nonlinear Systems I
17:40-18:30 Audimax ThKPL Keynote Lecture: Raymond Freymann, BMW Group Research & Technology										

Technical Program Friday October 6, 2006

Track 1: CACSD	Track 2: CACSD	Track 3: ISIC	Track 4: ISIC	Track 5: CCA	Track 6: CCA	Track 7: CCA	Track 8: CCA	Track 9: CCA	Track 10: CCA	Track 11: CCA
Room 2601	Room 1601	Room 0670	Room 2605	Room 0601	Room 0602	Room 0606	Room 2607	Room 0999	Room 3999	Audimax
08:15-09:15 Audimax FrPPL Plenary Lecture: Thomas Parisini, University of Trieste										
09:45-11:45 FrA01 Computer Tools for Control Education and Computer-Based Learning Environments	09:45-11:45 FrA02 Computer-Aided Design and Calibration of Automotive Control Systems	09:45-11:45 FrA03 Neural Networks and Learning	09:45-11:45 FrA04 Fuzzy and Robust Control	09:45-11:45 FrA05 Combustion Engines	09:45-11:45 FrA06 Power Systems I	09:45-11:45 FrA07 Process Control III	09:45-11:45 FrA08 Robotics - Manipulation, Actuation	09:45-11:45 FrA09 Aerospace/ Flight Control	09:45-11:45 FrA10 Identification - Methods	09:45-11:45 FrA11 Nonlinear Systems II
13:00-15:00 FrB01 Process Control, Fault Detection and Tools	13:00-15:00 FrB02 Automotive Control Systems	13:00-15:00 FrB03 Fuzzy Control II	13:00-15:00 FrB04 Agent-Based Systems	13:00-15:00 FrB05 Predictive Control of Combustion Engines	13:00-15:00 FrB06 Advances in Vehicle Dynamics Control	13:00-15:00 FrB07 Learning Control	13:00-15:00 FrB08 Robotics - Redundant, Cooperative	13:00-15:00 FrB09 Advanced Control Techniques for Future Space Applications	13:00-15:00 FrB10 Identification - Applied	13:00-15:00 FrB11 Linear System Methods
15:30-17:30 FrC01 Model Reduction and Computer-Aided Control Design Problems	15:30-17:30 FrC02 Tools and Toolboxes	15:30-17:30 FrC03 Mechanical Systems and Robotics	15:30-17:30 FrC04 Intelligent Control Applications	15:30-17:30 FrC05 Engine Control	15:30-17:30 FrC06 Power Systems II	15:30-17:30 FrC07 Neural Network Control	15:30-17:30 FrC08 Time Delay Systems	15:30-17:30 FrC09 Various Applications II	15:30-17:30 FrC10 Fault Diagnosis	15:30-17:30 FrC11 Biosystems & Environmental Control
17:40-18:30 Audimax FrKPL Keynote Lecture: Christian Philippe, ESA/ESTEC										

Book of Abstracts

WePPL Audimax
Plenary Lecture: Jan Maciejowski (Plenary Session)
Chair: Schmid, Christian Ruhr Univ. Bochum

WePPL: 08:15-09:15
The Changing Face and Role of CACSD, pp. 1-7
Maciejowski, Jan M. Univ. of Cambridge

Computer Aided Control Engineering involves three parallel streams: Simulation and modelling, Control system design (off-line), and Controller implementation. In industry the bottleneck problem has always been modelling, and this remains the case - that is where control (and other) engineers put most of their technical effort. Although great advances in software tools have been made, the cost of modelling remains very high - too high for some sectors. Object-oriented modelling, enabling truly re-usable models, seems to be the key enabling technology here. Software tools to support control systems design have two aspects to them: aiding and managing the work-flow in particular projects (whether of a single engineer or of a team), and provision of numerical algorithms to support control-theoretic and systems-theoretic analysis and design. The numerical problems associated with linear systems have been largely overcome, so that most problems can be tackled routinely without difficulty - though problems remain with (some) systems of extremely large dimensions. Recent emphasis on control of hybrid and/or constrained systems is leading to the emerging importance of geometric algorithms (ellipsoidal approximation, polytope projection, etc). Constantly increasing computational power is leading to renewed interest in design by optimisation, an example of which is MPC. The explosion of embedded control systems has highlighted the importance of autocode generation, directly from modelling/simulation products to target processors. This is the `new kid on the block', and again much of the focus of commercial tools is on this part of the control engineer's job. Here the control engineer can no longer ignore computer science (at least, for the time being).

WeA01 Room 2601
Robust Numerical Methods for Control (Invited Session)
Chair: Kressner, Daniel Umea Univ.
Co-Chair: Sima, Vasile ICI Bucharest
Organizer: Kressner, Daniel Umea Univ.
Organizer: Sima, Vasile ICI Bucharest

WeA01.1: 09:45-10:05
Passivity Preserving Model Reduction Via a Structured Lanczos Method (I), pp. 8-13
Fassbender, Heike Tech. Univ. Braunschweig
Benner, Peter Tech. Univ. Chemnitz

Nowadays, modeling dynamical systems often yields state-space models of very high order (that is, 10,000 or more equations). In order to guarantee a numerical simulation in reasonable time, the dynamical system is reduced to one of the same form which allows simulation of and control-design for the reduced-order state-space model in much less computing time. Usually one would like to obtain a reduced-order system that has the same properties as the original system. In this paper, we will consider stable and passive systems. Antoulas suggests an approach based on positive real interpolation which is modified by Sorensen. The algorithm is based upon interpolation at selected spectral zeros of the original transfer function to produce a reduced-order transfer function that has the specified roots as its spectral zeros. These interpolation conditions are satisfied through the computation of a basis for a selected invariant subspace of a Hamiltonian matrix which has the spectral zeros as its spectrum. Here we propose to employ a structure-preserving Lanczos algorithm for this part of the computation in order to make use of the underlying structure and physical properties of the problem.

WeA01. 2: 10:05-10:25
Solving Projected Generalized Lyapunov Equations Using SLICOT (I), pp. 14-18
Stykel, Tatjana Tech. Univ. Berlin

We discuss the numerical solution of projected generalized Lyapunov equations. Such equations arise in many control problems for linear time-invariant descriptor systems including stability analysis, balancing and model order reduction. We present solvers for projected generalized Lyapunov equations based on matrix equations subroutines that are available in the Subroutine Library In COntrol Theory (SLICOT).

WeA01.3: 10:25-10:45
A MATLAB Repository for Model Reduction Based on Spectral Projection (I), pp. 19-24
Benner, Peter Tech. Univ. Chemnitz

We describe a collection of MATLAB functions for model reduction of linear, time-invariant systems. All MATLAB functions described here employ in one or the other way spectral projection methods such as the sign function. Included are implementations of modal and balanced truncation as well as selected balancing-related model reduction algorithms. Several of the balancing-related model reduction functions are not yet available in other software packages. The numerical performance of the provided MATLAB functions is tested for several model reduction benchmark examples.

WeA01.4: 10:45-11:05
Reordering the Eigenvalues of a Periodic Matrix Pair with Applications in Control (I), pp. 25-30
Granat, Robert Umea Univ.
Kagstrom, Bo Umea Univ.
Kressner, Daniel Umea Univ.

Reordering the eigenvalues of a periodic matrix pai is a computational task that arises from various applications related to discrete-time periodic descriptor systems, such as pole placement or linear-quadratic optimal control. However, it is also implicitly present in recently developed robust control methods for linear time-invariant systems. In this contribution, a direct algorithm for performing this task based on the solution of a periodic generalized Sylvester equation is proposed. The new approach is numerically backward stable and it is demonstrated that the resulting deflating subspaces can be much more accurate than those computed by collapsing methods.

WeA01.5: 11:05-11:25
Finding the Distance to Instability of a Large Sparse Matrix (I), pp. 31-35
Kressner, Daniel Umea Univ.

The distance to instability of a matrix A is a robust measure for the stability of the corresponding dynamical system, known to be far more reliable than checking the eigenvalues of A. In this paper, a new algorithm for computing such a distance is sketched. Built on existing approaches, its computationally most expensive part involves a usually modest number of shift-and-invert Arnoldi iterations. This makes it possible to address large sparse matrices, such as those arising from discretized partial differential equations.

WeA01.6: 11:25-11:45
Computational Experience with Robust Pole Assignment Algorithms (I), pp. 36-41
Sima, Vasile ICI Bucharest
Tits, Andre L. Univ. of Maryland
Yang, Yaguang Orbital Sciences Corp.

Two algorithms for robust pole assignment by state feedback, proposed by Kautsky, Nichols and Van Dooren (1985) and by Tits and Yang (1996) are briefly reviewed. MATLAB code implementations of these algorithms, place (from the MATLAB Control System Toolbox) and robpole (from SLICOT), are then numerically compared on randomly generated test data sets, as well as on examples from two benchmark collections, in terms of the robustness (insensitivity of poles to variations in plant parameters) of the

closed-loop systems they produce. The functions place and robpole are also compared with each other, as well as with the (non robust) pole assignment code pass (from SLICOT) in terms of CPU time and accuracy of the pole assignment.

WeA02 Room 1601
Semantically Rich Control Systems Design Tools
(Invited Session)

Chair: Karsai, Gabor	Vanderbilt Univ.
Co-Chair: Mosterman, Pieter	The MathWorks, Inc.
Organizer: Sprinkle, Jonathan	Univ. of California Berkeley
Organizer: Mosterman, Pieter	The MathWorks, Inc.

WeA02.1: 09:45-10:05
Deriving Simulators for Hybrid Chi Models (I), pp. 42-49

Van Beek, D.A.	Eindhoven Univ. of Tech.
Man, K.L.	Eindhoven Univ. of Tech.
Reniers, M.A.	Eindhoven Univ. of Tech.
Rooda, J.E.	Eindhoven Univ. of Tech.
Schiffelers, R.R.H.	Eindhoven Univ. of Tech.

The hybrid Chi language is a formalism for modeling, simulation and verification of hybrid systems. The formal semantics of hybrid Chi allows the definition of provably correct implementations for simulation, verification and real-time control. This paper discusses the principles of deriving an implementation for simulation and verification directly from the semantics, and presents an implementation based on a symbolic solver. The simulator is illustrated by means of a case study.

WeA02.2: 10:05-10:25
The Model-Integrated Computing Toolsuite: Metaprogrammable Tools for Embedded Control System Design (I), pp. 50-55

Karsai, Gabor	Vanderbilt Univ.
Ledeczi, Akos	Vanderbilt Univ.
Neema, Sandeep	Vanderbilt Univ.
Sztipanovits, Janos	Vanderbilt Univ.

Model-Integrated Computing is a development approach that advocates the use of Domain-Specific Modeling throughout the system development process and lifecycle. This paper describes and summarizes the generic and reusable software tools that support MIC and which can be tailored to solve a wide variety of modeling, analysis, and generation problems in an engineering process.

WeA02.3 : 10:25-10:45
Unit & Dynamic Typing in Hybrid Systems Modeling with CHARON (I), pp. 56-61

Anand, Madhukar	Univ. of Pennsylvania
Lee, Insup	Univ. of Pennsylvania
Pappas, George J.	Univ. of Pennsylvania
Sokolsky, Oleg	Univ. of Pennsylvania

In scientific applications, dimensional analysis forms a basis for catching errors as it introduces a type discipline into the equations and formulae. Dimensions in physical quantities are measured via their standard units. However, many programming and modeling tools provide limited support for incorporating these units into the variables. Thus, it is quite difficult for a programmer to ensure dimensional consistency in the code. Different existing standards for units further complicates this problem and an incautious use could cause inconsistencies, often with catastrophic results. In this paper, we propose an extension of the basic type system in CHARON, a language for modeling of hybrid systems, to include Unit and Dynamic data types. Through a combination of indirect user-guided annotations and type inference, we address the problem of ensuring both dimensional consistency, and consistency with respect to different unitsystems. Further, we also introduce dynamic data typing, that allows programmers to specify entities that bind at runtime. Such abstractions are particularly useful to program controllers for dynamic environments. We illustrate these benefits with an example on mobile robots.

WeA02.4: 10:45-11:05
A Computational Approach for Estimating Stability Regions (I), pp. 62-68

Koo, T. John	Vanderbilt Univ.
Su, Hang	Vanderbilt Univ.

In this paper, we propose a computational approach for estimating the stability region of an asymptotically stable equilibrium point. The stability region is estimated through an iterative process specified as an algorithm. Reachable sets are used in the estimation algorithm for checking the invariant property of the initial estimate of a stability region and for representing the enlarged stability regions. The convergence of the estimation algorithm can be shown by considering the sequence properties of the reachable sets. Level set methods are used for representing reachable sets and tracking the evolution of the boundary of a reachable set since they can be used to effectively represent complex continuous sets and, furthermore, there exist efficient computation methods for computing the evolution of reachable sets for nonlinear systems. The proposed approach allows natural extension to higher dimensional systems and enables the computation to be carried out in a parallel manner. ReachLab, a model-based tool, is developed to enable rapid prototyping of the algorithm, and to allow the use of various computation methods for implementing the algorithm on a cluster of parallel computing machines. The accuracy of the proposed approach is compared with another accurate approach. The computation results for three nonlinear systems are presented.

WeA02.5: 11:05-11:25
Multi-Domain Physical System Modeling and Control Based on Meta-Modeling and Graph Rewriting (I), pp. 69-75

Sen, Sagar	McGill Univ.
Vangheluwe, Hans	McGill Univ.

A methodology is presented which enables the specification and synthesis of software tools to aid in plant and controller modeling for multi-domain (electrical, mechanical, ...) physical systems. The methodology is based on meta-modeling and graph rewriting. The plant is modeled in a domain-specific formalism called the Real World Visual Model (RWVM). Such a model is successively transformed to an Idealized Physical Model (IPM), to an Acausal Bond Graph (ABG), and finally to a Causal Bond Graph (CBG). A Modelica (www.modelica.org) model, consisting of a Causal (algebraic and differential equation) Block Diagram} (CBD), is generated from the CBG. All transformations are explicitly modeled using Graph Grammars. A PID controller model, specified in Modelica as a CBD is subsequently integrated with the plant model. AToM^3 (atom3.cs.mcgill.ca), A Tool for Multi-formalism and Meta Modeling is used to meta-model and synthesize visual modeling environments for the RWVM, IPM, ABG, and CBG formalisms as well as for transformations between them. The entire process of modeling, transformation, and simulation is demonstrated by means of a hoisting device example. Our methodology drastically reduces development time (of the modeling tool an indirectly of the domain-specific models), integrates model checking via Bond Graph causal analysis, and facilitates management and reuse of meta-knowledge by explicitly modeling formalisms and transformations.

WeA02.6: 11:25-11:45
ConPAHS - a Software Package for Control of Piecewise-Affine Hybrid Systems (I), pp. 76-81

Collins, Pieter	CWI
Habets, Luc C.G.J.M.	CWI
Kuut, Anton	CWI
Nool, Margreet	CWI
Petreczky, Mihaly	CWI
van Schuppen, Jan H.	CWI

The software package ConPAHS facilitates control design of continuous-time piecewise-affine hybrid systems on polytopes. For the control objective of reaching a particular state from a specified initial state, the output of the package is a piecewise-affine control law. After a short review of the control theory for this problem, the paper presents the

functional specification of ConPAHS, the objected oriented software principles used, the program structure, and the design choices. Three examples including simulations are provided to illustrate the use of ConPAHS.

WeA03 Room 0670
Neural and Fuzzy Control of Nonlinear Systems
(Invited Session)

Chair: Feng, Gang	City Univ. of Hong Kong
Co-Chair: Tan, Yonghong	Guilin Univ. of Electronic Tech.
Organizer: Feng, Gang	City Univ. of Hong Kong
Organizer: Ge, Shuzhi	National Univ. of Singapore

WeA03.1: 09:45-10:05
Neural Adaptive Control of Dynamic Sandwich Systems with Hysteresis (I), pp. 82-87

Zhao, Xinlong	Shangai Jiaotong Univ.
Tan, Yonghong	Guilin Univ. of Electronic Tech.

An adaptive control strategy is presented for dynamic sandwich systems with hysteresis. The so-called sandwich system with hysteresis is the system that can be represented by a cascade of a dynamic smooth nonlinear (DSNL1), a hysteresis nonlinear (HNL) and another dynamic smooth nonlinear (DSNL2) subsystem. In this control strategy, a neural network based inverse model is constructed to compensate for the effect of the first dynamic block (i.e. DSNL1)of the sandwich system. Thus, the sandwich system can be transformed into a dynamic nonlinear subsystem preceded by hysteresis. Then a novel hysteretic operator is proposed to transform the multi-valued mapping of hysteresis into a one-to-one mapping. Base on the proposed hysteretic operator,a neural adaptive controller is developed for the modified system. One of the advantages of the controller is that it does not need to construct the inverse model of hysteresis to cancel the hysteretic effect.

WeA03.2: 10:05-10:25
Robust Adaptive Neural Control of SISO Nonlinear Systems with Unknown Nonlinear Dead-Zone and Gain Sign (I), pp. 88-93

Zhang, Tianping	Yangzhou Univ.
Ge, Shuzhi Sam	National Univ. of Singapore

In this paper, robust adaptive neural tracking control is developed for a class of uncertain SISO nonlinear systems in a Brunovsky form with unknown nonlinear dead-zone and unknown control gain and its sign. The design is based on the principle of sliding mode control and the use of Nussbaum-type function in solving the problem of the completely unknown function control gain. A novel description of general nonlinear dead-zone, which makes the control system design possible, is introduced by using the mean value theorem. The approach removes the condition of the equal slope with defined region for the dead-zone. By utilizing the integral-type Lyapunov function and introducing an adaptive compensation for the upper bound of the optimal approximation error and the dead-zone disturbance, the closed-loop control system is proved to be semi-globally uniformly ultimately bounded.

WeA03.3: 10:25-10:45
Piecewise Robust H-Infinity Filtering for Fuzzy Systems with Time-Varying Uncertainty (I), pp. 94-99

Chen, Meng	City Univ. of Hong Kong
Feng, Gang	City Univ. of Hong Kong
Yin, Yixin	Univ. of Science and Tech. Beijing

Based on a piecewise quadratic Lyapunov function, this paper investigates the piecewise robust H-infinity filtering design problem for fuzzy systems subject to time-varying uncertainties. It is shown that via suitable matrix linearization transformations and changes of variables, the design problem can be converted into a convex programming problem in term of linear matrix inequalities Finally, a simulation example is presented to illustrate the application and performance of the proposed approach.

WeA03.4: 10:45-11:05
Radial Basis Functions Based Iterative Learning Control for Stochastic Distribution Systems (I), pp. 100-105

Wang, Hong	Univ. of Manchester
Afshar, Puya	Univ. of Manchester

In this paper, an Iterative Learning Control (ILC) scheme is presented for the control of the shape of the output probability density functions (PDF) for a class of stochastic systems in which the relationship between approximation basis functions and the control input is linear, and the stochastic system is not necessarily Gaussian. A Radial Basis Function Neural Networks (RBFNN) has been employed for the output PDF approximation and the coefficients of the approximation are linearly related to the control input. A three-stages method for the ILC-based PDF control is proposed which incorporates a) identifying PDF model parameters; b) calculating the control input; and c) updating RFBN parameters. The latter is accomplished based on P-type ILC law and the difference of the desired and calculated output PDF within a batch. Conditions for the convergent ILC rules have been derived. Simulation results are included to demonstrate the effectiveness of proposed method.

WeA03.5: 11:05-11:25
Robust Adaptive Control for a Class of Perturbed Strict-Feedback Nonlinear Systems with Unknown Prandtl-Ishlinskii Hysteresis (I), pp. 106-111

Feng, Ying	South China Univ. of Tech.
Hu, Yue-ming	South China Univ. of Tech.
Su, Chun-Yi	Concordia Univ.

This paper deals with robust adaptive control of a class of perturbed strict-feedback nonlinear systems with unknown hysteresis. By using Prandtl-Ishlinskii model with play and stop operators and the properties of this model mathematicaly, a robust adaptive control scheme is proposed. The global stability of the adaptive system is achieved, and the effectiveness of the proposed control apporoach is demostrated through simulation example.

WeA03.6 : 11:25-11:45
*Global Robust Asymptotical Stability of Delayed Neural Networks with Parameter Uncertainty (I)**

Li, Chuandong	Chongqing Univ.
Liao, Xiaofeng	Chongqing Univ.

WeA04 Room 2605
Wireless Sensor Networks for Intelligent Systems
(Invited Session)

Chair: Commuri, Sesh	Univ. of Oklahoma
Co-Chair: Fonda, James W.	Univ. of Missouri-Rolla
Organizer: Commuri, Sesh	Univ. of Oklahoma

WeA04.1: 09:45-10:05
A LabVIEW Based Test-Bed with Off-The-Shelf Components for Research in Mobile Sensor Networks (I), pp. 112-118

Ballal, Prasanna	Univ. of Texas at Arlington
Giordano, Vincenzo	Pol. di Bari
Dang, Pritpal	Univ. of Texas at Arlington
Gorthi, Sankar	Univ. of Texas at Arlington
Mireles Jr., Jose	Univ. Autónoma de Ciudad Juárez
Lewis, Frank L.	Univ. of Texas at Arlington

This paper describes the development of a mobile sensor network test-bed at the Automation and Robotics Research Institute (University of Texas at Arlington). LabVIEW high-level programming language is used to program, control and monitor a variety of off-the-shelf hardware platforms (both sensor motes and mobile robots). The test-bed is composed of two independent mobile sensor networks connected to the same base station. The first network has controlled mobility and performs environmental monitoring tasks. The second network has random mobility and acts as an unpredictable source of events for the first network. After providing a detailed description of the hardware and software design of our test-bed, we describe two case studies in mobile sensor network research which we are currently implementing on our test-bed, namely potential field localization and discrete event coordination.

WeA04.2: 10:05-10:25
Development and Implementation of Optimized Energy-Delay Sub-Network Routing Protocol for Wireless Sensor Networks (I), pp. 119-124

Fonda, James W.	Univ. of Missouri-Rolla
Zawodniok, Maciej	Univ. of Missouri-Rolla
Jagannathan, Sarangapani	Univ. of Missouri-Rolla
Watkins, Steve. E.	Univ. of Missouri-Rolla

The development and implementation of the optimized energy-delay sub-network routing (OEDSR) protocol for wireless sensor networks (WSN) is presented. This on-demand routing protocol minimizes a novel link cost factor which is defined using available energy, end-to-end (E2E) delay and distance from a node to the base station (BS), along with clustering, to effectively route information to the BS. Initially, the nodes are either in idle or sleep mode, but once an event is detected, the nodes near the event become active and start forming sub-networks. Formation of the inactive network into a sub-network saves energy because only a portion of the network is active in response to an event. Subsequently, the sub-networks organize themselves into clusters and elect cluster heads (CHs). The data from the CHs are sent to the BS via relay nodes (RNs) that are located outside the sub-networks in a multi-hop manner. This routing protocol improves the lifetime of the network and the scalability. This routing protocol is implemented over the medium access control (MAC) layer using UMR nodes. Experimental results illustrate that the protocol performs satisfactorily as expected.

WeA04.3: 10:25-10:45
Mobility Controllable Relays for Conserving Power in a Network of Mobile Wireless Sensors: Usage and Issues (I), pp. 125-130

Venkateswaran, Aravindhan	Pennsylvania State Univ.
Chittimalla, Eashwar	Oklahoma State Univ.
Sarangan, Venkatesh	Oklahoma State Univ.
Radhakrishnan, Sridhar	Univ. of Oklahoma
Acharya, Raj	Pennsylvania State Univ.

We investigate the idea of using nodes with controllable mobility as intermediate relays for reducing the power consumption in a network of mobile wireless sensors. We present the relay deployment problem, which is to optimally position the relay nodes in the network so as to minimize the power consumed in communication. We discuss and evaluate a localized solution methodology that computes the optimal position and movement of the relay nodes based on the information pertaining to the active data flows and the mobility patterns of the sensors in the network. Results from a preliminary simulation study indicate that deployment of relay nodes can result in considerable energy savings. We also outline some of the issues that need to be addressed in deploying such mobility-controllable relay nodes in a real network.

WeA04.4: 10:45-11:05
Energy-Efficient Approaches to Coverage Holes Detection in Wireless Sensor Networks (I), pp. 131-136

Watfa, Mohamed	Univ. of Oklahoma
Commuri, Sesh	Univ. of Oklahoma

A Sensor network is a sensing, computing and communication infrastructure that allows us to instrument, observe, and respond to phenomena in the physical and cyber infrastructure. As sensors are typically battery operated, it is important to efficiently use the limited energy of the nodes to extend the lifetime of the sensor network. Several anomalies can occur in wireless sensor networks that impair their desired functionalities resulting in the formation of different kinds of holes such as coverage holes, routing holes, jamming hole, and worm holes. The coverage problem is one of the fundamental issues in wireless sensor networks. In this paper, the coverage hole problem in sensor networks is rigorously analyzed. We provide distributed as well as centralized algorithms that allow the selection of the set of sensors that are on the boundary of the coverage holes in the region. Holes boundary detection is crucial for optimizing sensor placement and identifying regions of interest for the end user. Mathematical as well as experimental proofs are provided to validate the correctness and efficiency of our algorithms.

WeA04.5: 11:05-11:25
Optimal Sensor Placement for Border Perambulation (I), pp. 137-142

Watfa, Mohamed	Univ. of Oklahoma
Commuri, Sesh	Univ. of Oklahoma

Recent advancement in wireless communications and electronics has enabled the development of low-cost sensor networks and these networks are finding increased application in the development of intelligent, distributed systems. Distributed deployment of sensor systems has to address issues in power management and efficiency. In this paper, these issues are addressed from the standpoint of optimal deployment of sensors nodes for boundary coverage. Lower bounds on the number of sensors needed for surveillance and target intrusion detection is presented and a “Border Perambulation” technique where each border node can swap between working and sleeping modes and the network only maintains a subset of working nodes is proposed. Mathematical as well as experimental proofs are provided to validate the correctness and efficiency of our algorithms.

WeA04.6 : 11:25-11:45
Applying Novel Supervised Fuzzy Adaptive Resonance Theory (SF-ART) Neural Network and Biorthogonal Wavelets for Ballistocardiogram Diagnosis, pp. 143-148

Akhbardeh, Alireza	Tampere Univ. of Tech.
Junnila, Sakari	Tampere Univ. of Tech.
Koivistoinen, Teemu	Tampere Univ. Hospital
Varri, Alpo	Tampere Univ. of Tech.

In this study, we applied Biorthogonal wavelets to extract essential features of the Ballistocardiogram (BCG) signal and to classify them using a novel neural network so-called Supervised Fuzzy Adaptive Resonance Theory (SF-ART). SF-ART has two stages. At first stage, pre-classification level, the input data is clustered roughly to arbitrary (M) classes using self-organized fuzzy ART tuned for fast learning. At the second stage, post-classification level, the SF-ART performs supervised clustering using a special array called Affine Look-up Table (ALT) with M elements, which are used to store the labels of corresponding input samples. In testing mode, first the self-organized fuzzy ART classifies the input data roughly. In the next step, the content of an ALT cell with address equal to the index of the first stage’s winning output line will be read. The read value declares the class that input data belongs to. Initial tests with BCG from six subjects (both healthy and unhealthy people) indicate that the method can classify the subjects into three classes with a high accuracy, high learning speed (elapsed time for learning around half second), and very low computational load compared with the well-known neural networks such as Multilayer Perceptrons (elapsed time for learning above five minutes). The method is insensitive to latency and non-linear disturbance. Moreover, the applied wavelet transform requires no prior knowledge of the statistical distribution of data samples.

WeA05 Room 0601
Automotive I (Regular Session)

Chair: Muller, Bernhard	Univ. Erlangen-Nurnberg
Co-Chair: Rantzer, Anders	Lund Univ.

WeA05.1: 09:45-10:05
Vehicle Dynamics Control and Controller Allocation for Rollover Prevention, pp. 149-154

Schofield, Brad	Lund Univ.
Hagglund, Tore	Lund Univ.
Rantzer, Anders	Lund Univ.

Vehicle rollover accidents are a particularly dangerous form of road accident. Commercial vehicles are especially prone to rollover accidents due to their high centres of gravity. A nonlinear control strategy is presented which guarantees asymptotic tracking of a yaw rate reference while bounding the roll angle, thus preventing rollover. A new

computationally–efficient control allocation strategy is used to map controller commands to braking forces, taking into account actuator constraints. The strategy is based on consideration of the tire forces generated during extreme manouvering. Simulations show that the strategy is capable of preventing rollover of a commercial van during various standard test manoeuvres.

WeA05.2: 10:05-10:25
Modeling and Control of a Four Wheel Drive Parallel Hybrid Electric Vehicle, pp. 155-162

Boyali, Ali	Istanbul Tech. Univ.
Demirci, Murat	Istanbul Tech. Univ.
Acarman, Tankut	Galatasaray Univ.
Guvenc, Levent	Istanbul Tech. Univ.
Tur, Okan	TUBITAK Marmara Res. Center
Ucarol, Hamdi	TUBITAK Marmara Res. Center
Kiray, Burak	Ford Otosan
Ozatay, Evren	Ford Otosan

Modeling and control of a hybrid electric vehicle is presented in this paper. A four wheel drive parallel hybrid electric vehicle is built by assembling an auxiliary electrical machine and battery group. Some preliminary instrumentation such as accelerator pedal, brake, clutch pedal position sensors and gear ratio estimation are realized to split torque demand into the two power sources. The first power source is the internal combustion engine and the second one is the permanent magnet electric motor. A rule-based control strategy is developed by setting transition rules between the two power sources. The control strategy is implemented on a proof-of-concept vehicle and road tested. In order to satisfy smooth transient switching between the two power sources, and in order not to disturb the driver by abrupt or retarded transitions, torque splitting is achieved by taking the power source dynamics and vehicle dynamics in the longitudinal direction into account. The internal combustion engine is not operated at its high emission and low fuel efficient regions. Regenerative braking is implemented to charge the electric motor battery pack during braking.

WeA05.3: 10:25-10:45
Trajectory Generation and Feedforward Control for Parking a Car, pp. 163-168

Muller, Bernhard	Univ. Erlangen-Nurnberg
Deutscher, Joachim	Univ. Erlangen-Nurnberg
Grodde, Stefan	Univ. Erlangen-Nurnberg

In this paper a two-step trajectory planning algorithm is applied to generate suitable trajectories for an autonomous parking maneuver of a car. It is shown how important requirements of the automotive industry can be met with the proposed approach. Furthermore, some details on the implementation of the algorithm are given, which are essential to obtain reasonable computation times.

WeA05.4: 10:45-11:05
A Computational Method to Vibration Reduction of Vehicle Engine-Body System Using Haar Wavelets, pp. 169-174

Karimi, Hamid Reza	Tech. Univ. Munich
Lohmann, Boris	Tech. Univ. Munich

This paper deals with the modelling of engine-body vibration structure to robust control of bounce and pitch vibrations using Haar wavelets. The authors' attention is focused on development of the Haar wavelet-based robust optimal control for vibration reduction of the engine-body system computationally that guarantee desired L2 gain performance. The Haar wavelet properties are introduced and utilized to find the approximate solutions of trajectories and robust optimal control by solving only algebraic equations instead of solving the Riccati differential equation. Numerical results are presented to illustrate the advantage of the approach.

WeA05.5: 11:05-11:25
*Advanced Model Based Methods and Tools for Electric Power Steering Feeling Improvement: From Simulations to Vehicle Testing**

Tenneriello, Luigi	Elasis
Martella, Paolo	Fiat Auto
Campo, Sebastiano	Fiat Auto
Fiorillo, Valerio	Elasis
Fioriniello, Angela	Elasis
Pugliese, Alessandro	Elasis
Riegel, Alessandro	Elasis
Scala, Stefano	Elasis

The automotive industry is showing a growing interest towards the usage of EPS (Electric Power Steering) systems. With the enhancements in mechatronic technologies they are spreading from the small size cars to medium and large size cars. Actually EPS systems provide a number of advantages with respect to hydraulic power steering, first of all fuel consumption and product standardization. However, there are still some areas of performance improvement. This note describes the methodological approach applied for a mid-size passenger car to improve the software of EPS, supplied to FIAT Auto SpA by TRW Electric Steering ltd., which resulted in a proposal of modification of both the control logics and the tuning parameters. Some results coming from tests on the track are also reported, demonstrating the consistency with the expectations deriving from analytical studies in the virtual environment.

WeA06 Room 0602
Human-Centered Applications I (Regular Session)

Chair: Azorin, Jose M.	Univ. Miguel Hernandez de Elche
Co-Chair: Papadopoulos, Evangelos	National Tech. Univ. of Athens

WeA06.1: 09:45-10:05
Transparency in the Bilateral Control Methodology by State Convergence, pp. 175-180

Azorin, Jose M.	Univ. Miguel Hernandez de Helche
Sabater, Jose M.	Univ. Miguel Hernandez de Helche
Garcia, Nicolas M.	Univ. Miguel Hernandez de Helche
Perez, Carlos	Univ. Miguel Hernandez de Helche
Aracil, Rafael	Univ. Pol. de Madrid

This paper shows that the bilateral control methodology based in the state convergence can be used to achieve transparency in teleoperation systems with communication time delay. The paper explains that through the correct selection of some design parameters, a bilateral control system that verify the transparency property can be obtained. In order to verify that the transparency is achieved, different simulation results are presented considering a teleoperation system of 1 dof.

WeA06.2: 10:05-10:25
Using Force Control for Fidelity in Low-Force Medical Haptic Simulators, pp. 181-186

Vlachos, Kostas	National Tech. Univ. of Athens
Papadopoulos, Evangelos	National Tech. Univ. of Athens

In this paper the effect of force control in the fidelity of a low-force five degree-of-freedom (dof) haptic mechanism is investigated. Strict conditions that guarantee stability are presented. Our effort focuses on haptic devices, able to reproduce accurate low forces in a soft virtual environment, rather than large forces in stiff virtual environments. Open and closed loop controllers are applied to a haptic mechanism, which is a part of a training medical simulator for urological operations, and consists of a two-dof, five bar linkage and a three-dof spherical joint. The force control algorithm is described and discussed. Open and closed loop schemes are compared. Simulation and experimental results of the force control law applied to the five-dof mechanism are presented. It is shown that the use of closed-loop force control law increases the haptic device fidelity and the realism of the simulation. It is also shown that in case of haptic devices used in soft virtual environments, issues like signal noise and device stiffness are more critical than maintaining system stability.

WeA06.3: 10:25-10:45
Transparent Collaborative Haptic Simulation, pp. 187-192

Tourbah, K.	Evry Val d'Essonne Univ.
Arioui, Hichem	Evry Val d'Essonne Univ.
Seguy, N.	Evry Val d'Essonne Univ.
Kheddar, A.	Evry Val d'Essonne Univ.

This paper deals with the problem of transparency (or fidelity) in force feedback systems or more particularly for haptics simulation under time delay transmission. The haptics rendering transparency is more difficult in distributed collaboration between distant users because it is necessary also to make feel faithfully the mutual interactions. The idea suggested in this article gives an original solution to overcome this lack of transparency in haptic shared collaborations on the network using a principle called the "Latency Envelope" (LE). One advantage of this implementation is the anticipation of the contact between users and virtual objects. The delay can then be partially or completely compensated from the operator perception point of view. Also it does not affect at all the stability of haptics simulation (carried out using well known control laws).

WeA06.4: 10:45-11:05
A Telerobotic Manipulator System with Impedance Control, pp. 193-198

Cheng, Chi-Cheng	National Sun Yat-Sen Univ.
Zhao, Ying-Jie	National Sun Yat-Sen Univ.

The master-slave manipulator is capable of extending human dexterous skills to the distant or dangerous environment. In order to enhance its operational efficiency, the impedance at both the master and the slave sides should be designed separately. This paper presents a preliminary study on implementing impedance control to a telerobotic manipulator system using a hybrid control strategy. The hybrid control architecture fully applies position and force signals at both the master and the slave ends, and can be used for versatile operation requirements. Basic design considerations for parameter selection using this control framework are also addressed.

WeA06.5: 11:05-11:25
A New Adaptive Inverse Control Scheme for Teleoperation System with Varying Time Delay, pp. 199-204

Sha Sadeghi, Mokhtar	Tarbiat Modares Univ.
Momeni, Hamidreza	Tarbiat Modares Univ.
Ganjefar, Soheil	Bou Ali Sina Univ.
Amirifar, Ramin	Tarbiat Modares Univ.

This paper presents a new force-reflecting teleoperation control system scheme with varying time delay. Time delay is an unavoidable factor in teleoperation. Transmission time delays are possibly destabilizing, and reduce significantly ability of teleoperation. Considering the time-varying non-deterministic characteristic of the control and delays, a novel adaptive inverse controller is proposed. Moreover, force feedback is provided to ascertain that the system is robust and transparent. An elaborate and special strategy is presented to design the reference model for adapting the slave-side controller, and accordingly, drift in position tracking has been compensated in free motion status and reduced in hard contact.

WeA06.6: 11:25-11:45
Predictive Adaptive Control of Unconsciousness - Exploiting Remifentanil As an Accessible Disturbance, pp. 205-210

Mendonca, Teresa	Univ. Porto
Nunes, Catarina S.	Univ. Porto
Magalhaes, Hugo	Univ. Porto
Lemos, Joao	INESC-ID/IST
Amorim, Pedro	Hospital Geral de Santo Antonio

The problem of controlling the level of unconsciousness measured by the BIS index of patients under anesthesia, is considered. It is assumed that the manipulated variable is the administration rate of propofol, while remifentanil is also administered for analgesia. Since these two drugs interact, the administration rate of remifentanil is considered as an accessible disturbance. A predictive adaptive controller structure that explores this fact is proposed and illustrated by means of simulation.

WeA07 Room 0606
Model Predictive Control I (Regular Session)

Chair: Allgower, Frank	Univ. of Stuttgart
Co-Chair: Heine, Thomas	Tech. Univ. Berlin

WeA07.1: 09:45-10:05
Nonlinear Predictive Control for Real Time Applications, pp. 211-216

Balbis, Luisella	Univ. of Strathclyde
Katebi, Reza	Univ. of Strathclyde
Ordys, Andrzej W.	Univ. of Strathclyde
Dunia, Ricardo	National Instruments
Grimble, Michael J.	Univ. of Strathclyde

The design of nonlinear predictive controllers based on linear time-varying prediction models is discussed. The linear time-varying models can be obtained by applying a local linearization along the nominal input and state trajectory or by describing the nonlinear state equations by state dependent state space equations. A graphical predictive control framework that provides practical methods for nonlinear control design is introduced using LabVIEW. The effectiveness of the algorithms and the easy applicability of the developed framework are illustrated in a simulation example.

WeA07.2: 10:05-10:25
Nonlinear Model Predictive and Flatness-Based Two-Degree-Of-Freedom Control Design: A Comparative Evaluation in View of Industrial Application, pp. 217-223

Utz, Tilman	Univ. Stuttgart
Hagenmeyer, Veit	BASF Aktiengesellschaft
Mahn, Bernd	BASF Aktiengesellschaft
Zeitz, Michael	Univ. Stuttgart

Two advanced nonlinear model-based controller design methods – nonlinear model predictive control (NMPC) and two-degree-of-freedom (2DOF) control with flatness-based feedforward control design and decentralized PI-controllers – are compared in view of industrial application. The comparison is carried out on a setpoint-transition of the Klatt- Engell benchmark reactor model. Based on an analysis of simulation scenarios, the controllers are compared with respect to controller performance and several robustness criteria. Furthermore, implementation issues of both controllers are discussed. The choice of the control task as well as the tuning of the controllers and the comparison methodology are strongly oriented on industrial practice.

WeA07.3: 10:25-10:45
Robust Model Predictive Control Using the Unscented Transformation, pp. 224-230

Heine, Thomas	Tech. Univ. Berlin
Kawohl, Michael	Tech. Univ. Berlin
King, Rudibert	Tech. Univ. Berlin

This paper presents a new approach for robust open-loop and closed-loop control of nonlinear processes with parameter uncertainties and a comparison with classical concepts. The approach leads to trajectories that show small variations if uncertain parameters and uncertain initial conditions are present. The algorithm utilizes the Unscented Transformation. It allows a 2nd order approximation of the first two statistical moments of the system's output as a function of the stochastic system's state and uncertain model parameters. Because the numerical burden is low, it can be used for optimization based online closed-loop process control as well.

WeA07.4: 10:45-11:05
A Hybrid MPC Approach to the Design of a Smart Adaptive Cruise Controller, pp. 231-236

Corona, Daniele	Delft Univ. of Tech.
Lazar, Mircea	Eindhoven Univ. of Tech.
De Schutter, Bart	Delft Univ. of Tech.
Heemels, Maurice	Embedded Systems Inst.

In this paper we investigate the possibility of applying the hybrid Model Predictive Control (MPC) framework to solve a control problem regarding tracking of a moving vehicle. The study originates from the design of an adaptive cruise

controller (ACC) of a Smart car, that aims to closely follow a reference trajectory transmitted by a leading vehicle. The physical behavior of the Smart and the constraints arising from the specifications related to safety and security issues make the hybrid MPC framework suitable for this task. An adaptation of the terminal cost and constraint set MPC approach, which is commonly used for fixed set-point regulation, is employed in order to achieve good tracking of a time-varying reference trajectory. The simulation results indicate the effectiveness of the developed hybrid MPC algorithm and the industrial feasibility with respect to on-line computation restrictions.

WeA07.5: 11:05-11:25
Nonlinear Model Predictive Control of a Four Tank System: An Experimental Stability Study, pp. 237-242

Raff, Tobias	Univ. of Stuttgart
Nagy, Zoltan K.	Loughborough Univ.
Allgower, Frank	Univ. of Stuttgart

There are well-known theoretical examples that show that stability constraints in nonlinear model predictive control (NMPC) are necessary in order to guarantee closed loop stability. In this paper it is shown that these stability constraints, derived from theory, are also essential in practice. In particular, an experimental study is carried out on a four tank system that illustrates the stability behavior of NMPC.

WeA07.6: 11:25-11:45
Industrial Application of a Model Predictive Control Solution for Power Plant Startups, pp. 243-248

D'Amato, Fernando Javier	GE Global Res.

This paper reports on the development and a successful MPC implementation for startups of combined-cycle plants. Minimizing startup times is important for energy utility companies to reduce operating costs due to lower fuel consumption and lower emissions. The new controller regulates the gas turbine loads while keeping the main operating constraints (steam turbine stresses) within their allowable ranges. The real-time implementation has been particularly challenging since the MPC required solving an optimization problem with more than 3000 variables and 4000 constraints at every control step. The critical enablers for this technology were the development of efficient algorithms to solve large scale quadratic programming problems with highly structured problem data, and the use of an advanced control platform and software application tools that provided the flexibility for a seamless prototyping. The MPC solution was implemented in the 480 MW 9H combined-cycle plant at Baglan Bay, South Wales. The first trial of the MPC startup controller showed time savings of 52 minutes, fuel savings of 62900 pounds-mass (lbm) and emission reductions of 117 pounds-mass, with respect to the previously existing startup controller.

WeA08 Room 2607
Mechatronics (Regular Session)

Chair: Sano, Akira	Keio Univ.
Co-Chair: Bruijnen, Dennis	Eindhoven Univ. of Tech.

WeA08.1: 09:45-10:05
Controller-Switching Strategy for HDD Servo Systems with Measurement Errors and Constraints on State and Control Variables, pp. 249-254

Okuyama, Atsushi	Hitachi
Kobayashi, Masahito	Hitachi

The head-positioning control system of a hard disk drive (HDD) must enable precise positioning and high-speed access. Mode-switching control (MSC) has widely been used to meet these control requirements. One of the issues with MSC is how to determine the controller-switching strategy, which needs decisions on the controller's switching conditions and its initialization. We propose a method that utilizes initial value compensation (IVC) to determine the initial state of the controller. Although mode switching is non-linear, transient responses can be improved if the control system takes the initial-state response after mode switching into consideration. IVC, which is based on this, can improve the transient response after mode switching. We also propose a method, which is based on the concept of a maximal output admissible set, of determining the switching conditions. It takes pointwise-in-time constraints and measurement errors in the plant's initial state into consideration. Experimental evaluations of the switching-control strategy we propose were undertaken with a 2.5-inch form-factor HDD.

WeA08.2: 10:05-10:25
Optimization Aided Loop Shaping for Motion Systems, pp. 255-260

Bruijnen, Dennis	Eindhoven Univ. of Tech.
Molengraft, Rene van de	Eindhoven Univ. of Tech.
Steinbuch, Maarten	Eindhoven Univ. of Tech.

An approach is proposed which improves the quality and speed of manual loop shaping. Loop shaping is an iterative and creative controller design procedure where the control engineer uses frequency response function (FRF) data of the plant to shape the open loop response such that it satisfies stability, performance and robustness specifications. The advantage compared to automated controller design methods is that the control engineer can exploit all available a priori knowledge and expertise about the plant during the design process. As an assisting tool in manual loop shaping, we add a global optimization method, i.e. a genetic algorithm, where the objective function resembles as good as possible what the control engineer wants. As a result, the tuning process is substantially accelerated. The approach has been implemented in a Matlab-based control tuning tool showing good results.

WeA08.3: 10:25-10:45
Integrated Approach to Electromechanical Design of a Digitally Controlled High Precision Actuator for Aerospace Applications, pp. 261-265

Sofka, Jozef	Binghamton Univ.
Skormin, Victor Arcady	Binghamton Univ.

The paper proposes an integrated approach to the design of robotic manipulators, addressing both the mechanical and control system aspects within the same mathematical framework in order to facilitate the design optimization. The integration of the mechanical, electrical, and controller design aspects, combined with parameter optimization, results in a significant reduction of the cost and duration of design efforts and facilitates flexible manufacturing of the device for a wide variety of applications. The methodology is demonstrated by its application to a known device, the Omni-Wrist III.

WeA08.4: 10:45-11:05
Stability Aspects in Case of Small Delayed Robot Manipulators System, pp. 266-270

Trusca, Mirela	Tech. Univ. of Cluj
Dobra, Petru	Tech. Univ. of Cluj

There are analyzed the effects of the small delays in the feedback loop that inevitably lead the systems into an unstable situation. How small must be the delay in real conditions such that to preserve the system stability, will be studied and analyzed for a robot manipulator. The case of an adaptive controller is also developed for the robot system actuated by brushed direct current motors in the presence of external disturbances and parametric uncertainties. The control scheme requires the measurements of link position and armature current for feedback. These measurements are delayed due to the actuators unfasten response. The elaborated adaptive controller results in a closed-loop system locally stable while the all states and signals are bounded and the tracking error can be obtained as small as possible. The advantage of the presented algorithm consists in the number of parameter estimates equal to the number of unknown parameters throughout the entire mechanical system. In consequence, it is eliminated the overparametrization induced by employing the integrator backstepping technique in control of electrically driven robots. Finally, the performance of the proposed approach is illustrated in simulation examples.

WeA08.5: 11:05-11:25
Nonlinear Analysis of an AMB System Using Harmonic Domain LTV Models, pp. 271-276

Jugo, Josu	Univ. del Pais Vasco
Lizarraga, Ibone	Univ. del Pais Vasco
Arredondo, Inigo	Univ. del Pais Vasco

Although the AMB technology has important advantages mainly due to the lack of mechanical friction, its nonlinear nature complicates the design and control of such systems. In this work, the nonlinear analysis of an AMB system, the MBC500 Rotor Dynamics from Launchpoint Technologies, is presented. This analysis is based on the harmonic domain linearization of the AMB system around a nonlinear stationary solution, leading to a LTV model for each rotating speed. The nonlinear nature of the response appears at high speeds, due to the large oscillations introduced by the shaft unbalance. Using the presented methodology, low frequency gain loss is detected when increasing the rotating speed. This phenomenon causes the instability of the system, leading to destructive crashes.

WeA08.6: 11:25-11:45
*Transformation of Mechanical Systems with Application to the Overhead Crane**

Mabrouk, Mohamed	INRIA Lorraine
Vivalda, J. Claude	INRIA Lorraine

Our study relates to systems whose dynamics are described by Euler-Lagrange equations, where the velocities are unmeasured. We give necessary and sufficient conditions under which a global change of coordinates which makes the dynamics linear in the velocities exists. Furthermore methods to compute this transformation is presented in Lemma one. To illustrate our approach we chose to apply it to the so called the overhead crane and an exponentially converging observer with an arbitrary rate of convergence is presented.

WeA09 Room 0999
Emerging Control Applications I (Regular Session)

Chair: Duncan, Stephen	Univ. of Oxford
Co-Chair: Eleftheriou, Evangelos	IBM Res.

WeA09.1: 09:45-10:05
Modeling and Control of Gas Flow in Anesthesia, pp. 277-282

van der Hoeven, Saartje	Univ. of Oxford
Duncan, Stephen	Univ. of Oxford
Farmery, Andrew	Univ. of Oxford
Hahn, Clive	Univ. of Oxford

This paper describes the development of a model of an anesthetic circle system. The different components of the model are validated by a series of experiments. The results of these experiments show that the simulated system closely follows the actual system. The mathematical model is used for controlling the gas concentrations during inspiration, both within the time frame of an individual inhaled breath, and between breaths. A PI controller is used to get an indication of the problems to be expected in predictive control. The dominant problems are the discontinuities in the control signal and the stiction in the mass-flow controller valves. The discontinuities in the control signal arise because control is only applied during inhalation, which results in an unsatisfactory transient response, but the rise time can be improved by including a feedforward component in the controller. Stiction occurs because the valves are closed during expiration which results in delayed opening on subsequent inspiration. A range of methods were considered for overcoming stiction, and the most effective approach was found to be adding a strong pulse to the control signal at the start of inhalation.

WeA09.2: 10:05-10:25
Towards Faster Data Access: Seek Operations in MEMS-Based Storage Devices, pp. 283-288

Sebastian, Abu	IBM Res.
Pantazi, Angeliki	IBM Res.
Cherubini, Giovanni	IBM Res.
Lantz, Mark	IBM Res.
Rothuizen, Hugo	IBM Res.
Pozidis, Haralampos	IBM Res.
Eleftheriou, Evangelos	IBM Res.

Even in the most advanced hard-disk drives (HDDs), data access is a slow process because of the relatively large mechanical structures, the one-dimensional actuation capability of the head, and the latency due to rotating disks. It is expected that MEMS-based storage devices with two-dimensional actuation capability could significantly improve the speed of data access. In this paper we demonstrate this experimentally with a MEMS-based probe-storage prototype using a micro-scanner that serves as the positioner for the storage medium. First the theoretically minimum achievable seek times are derived for the micro-scanner by approximating its dynamics with a damped harmonic oscillator model. Then the similarity of the time-optimal solution with that of the better studied double integral system is exploited to employ a proximate-time-optimal controller for the experimental studies. The experimental results demonstrate seek times of approximately 1.6 ms for seek operations of 50 micrometers.

WeA09.3: 10:25-10:45
Control of Neurotransmitters in Brain Neurons Using Soft-Switching Sliding Mode Control, pp. 289-294

Lyshevski, Sergey	Rochester Inst. of Tech.

In this paper we propose a mathematical model to describe the dynamics of neurotransmitter's active, available and reprocessed states. A set of nonlinear differential equations is obtained from neurophysiological and biochemical reasoning. To solve a tracking control problem, we study cellular feedback mechanisms that regulate the amount of neurotransmitters at distinct states. The neurotransmitters are the information carriers, and we control the amount of neurotransmitters at the active state. The cellular feedback mechanisms are examined and prototyped utilizing a sound analog control methodology. Though modeling and control problems are formulated and solved by using a number of hypotheses, the reported results have a direct impact on the envisioned bioinspired data/signal processing and cognitive information processing platforms. These processing platforms are expected to be designed using an information-theoretic paradigm and fluidic/solid molecular electronics hardware solutions.

WeA09.4: 10:45-11:05
Remarks on Hands-Free Manipulation System Using Simple Brain-Computer Interface, pp. 295-300

Takahashi, Kazuhiko	Doshisha Univ.
Nakauke, Takashi	Doshisha Univ.
Masafumi, Hashimoto	Doshisha Univ.

This paper proposes a nonverbal interface system using bio-potential signals, such as EOG and EMG, measured by a brain-computer interface and investigates its possibility of applying to control application. A simple gesture recognition algorithm is presented to estimate the user's intentions from the EOG and EMG signals, and the user's emotion is evaluated by using the EEG signal. To evaluate the feasibility and the characteristics of the nonverbal interface system, moving control experiments in 3D virtual space are carried out and the effectiveness of the proposed interface system is confirmed.

WeA09.5: 11:05-11:25
The Estimation of Complexity for the Electroencephalogram in Humans, pp. 301-306

Darkhovsky, Boris	Russian Acad. of Sciences
Kaplan, Alexander	Lomonosov Moscow State Univ.
Kosinov, Maxim	Lomonosov Moscow State Univ.

A new approach to an estimation of complexity of the

electroencephalogram (EEG) in humans is proposed. The basic idea of the approach consists in that complexity of continuous curve must be estimated by a relative part of information which one needs to recover the curve by given set of approximation methods with given accuracy based upon finite number of observations.

WeA10 Room 3999
Robust Control I (Regular Session)

Chair: Hanebeck, Uwe Univ. Karlsruhe
Co-Chair: Reger, Johann Univ. of Armed Forces Munich

WeA10.1: 09:45-10:05
Parameterized Joint Densities with Gaussian Mixture Marginals and Their Potential Use in Nonlinear Robust Estimation, pp. 307-312

Sawo, Felix Univ. Karlsruhe
Brunn, Dietrich Univ. Karlsruhe
Hanebeck, Uwe Univ. Karlsruhe

This paper addresses the challenges of the fusion of two random vectors with imprecisely known stochastic dependency. This problem mainly occurs in decentralized estimation, e.g. of a distributed phenomenon, where the stochastic dependencies between the individual states are not stored. To cope with such problems we propose to exploit parameterized joint densities with both Gaussian marginals and Gaussian mixture marginals. Under structural assumptions these parameterized joint densities contain all information about the stochastic dependencies between their marginal densities in terms of a generalized correlation parameter vector Xi. The parameterized joint densities are applied to the rediction step and the measurement step under imprecisely known correlation leading to a whole family of possible estimation results. The resulting density functions are characterized by the generalized correlation parameter vector Xi. Once this structure and the bounds of these parameters are known, it is possible to find bounding densities containing all possible density functions, i.e., conservative estimation results.

WeA10.2: 10:05-10:25
Robust Observer Design for Underwater Vehicles, pp. 313-319

Refsnes, Jon Erling Norwegian Univ. Sci. Tech.
Sorensen, Asgeir Johan Norwegian Univ. Sci. Tech.
Pettersen, Kristin Y. Norwegian Univ. Sci. Tech.

In this paper we propose a new observer system for underwater vehicles. The main design objective behind this strategy is to reduce the effect of the destabilizing Coriolis and centripetal forces and moments. For low cost vehicles with limited measurement equipment, these forces and moments represent a significant challenge for automatic control when the forward speed is high. However, by explicitly utilizing an estimation of the current velocity in the observer, this paper shows that a high degree of robustness relative to environmental disturbance and measurement noise is achievable. This is strongly related to the estimation of the destabilizing Coriolis and centripetal forces and moments. Furthermore, this observer scheme has shown to be tolerant to large error in the position measurements, which is a common occurrence in underwater navigation.

WeA10.3: 10:25-10:45
A Novel Robust Nonlinear Motion Controller with Disturbance Observer, pp. 320-325

Yang, Zi-jiang Kyushu Univ.
Tsubakihara, Hiroshi Kyushu Univ.
Kanae, Shunshoku Kyushu Univ.
Wada, Kiyoshi Kyushu Univ.
Su, Chun-Yi Concordia Univ.

In this paper, a novel robust nonlinear motion controller with disturbance observer (DOB) for positioning control of a nonlinear single-input-single-output (SISO) mechanical system is proposed. The controller is designed in a backstepping manner. At the first step, a PI controller is designed to stabilize the position error. Then at the second step, a novel robust nonlinear velocity controller with DOB is designed to stabilize the velocity error. By using some elegant nonlinear damping terms, the input-to-state stability (ISS) property of the overall nonlinear control system is proved, which leads to a major contribution of construction of a heoretically guaranteed robust nonlinear controller with DOB for the first time in the literature. The performance of the proposed controller is verified through application to a magnetic levitation system. Comparative studies with an adaptive robust nonlinear controller are also carried out. It is shown that the proposed novel controller while being simple is superior over the adaptive robust nonlinear controller for the experimental setup under study.

WeA10.4: 10:45-11:05
Robust Algebraic State Estimation of Chaotic Systems, pp. 326-331

Reger, Johann Univ. of Armed Forces Munich
Mai, Philipp Univ. of Armed Forces Munich
Sira-Ramirez, Hebertt J. CINVESTAV-IPN

In this article, we propose an improvement of a recently introduced algebraic approach for the non-asymptotic state and parameter estimation of nonlinear systems. In particular, we increase the robustness of the estimation method with respect to zero mean, high frequency, measurement noises by introducing a so-called *invariant filtering* technique. In order to reduce an already fast transient to the convergence, when subject to measurement noise, we devise an estimation policy consisting of two overlapping estimators with appropriate switchings between their results. These are two identical time-shifted estimators running in parallel with an overlapping estimation period. The benefits of our method are demonstrated on the state observation of a chaotic system of the Rössler type.

WeA10.5: 11:05-11:25
Robust Trajectory Tracking of Flat Nonlinear Systems, pp. 332-336

Mahout, Vincent LAAS-CNRS
Bernussou, Jacques LAAS-CNRS
Khansah, Hael LAAS-CNRS

In this paper we propose to use the important work made in the area of linear robust control to ameliorate the global robustness of a flatness based control. The main idea consists in adding a linear feedback on the nominal flat control. This feedback is calculated on the linearised system of the error tracking. From the linearised system (depending on the desired trajector) is defined a polytopic representation including the trajectory. A pole localization using a polytopic representation leads to the solve of a set of LMI and gives the feedback gain. At last, parameter uncertainties and integral term are included in the constructive approach to design the robust control law. A magnetic levitation of a ball is used as example and the different simulation results confirm the robustness of the proposed approach.

WeA10.6: 11:25-11:45
Application of Dynamic Safety Margin in Robust Fault Detection and Fault Tolerant Control, pp. 337-342

Abdel-geliel, Mostafa Univ. of Mannheim
Badreddin, Essam Univ. of Mannheim
Gambier, Adrian Univ. of Mannheim

The Dynamic Safety Margin (DSM) is defined as a performance index, whose independent variable is the distance from a predefined safety boundary, which is described in the state space by a set of inequality constraints, to the current system state. Robustness is an important issue for fault detection and isolation (FDI) system. In this work, design a robust FDI system based on DSM is applied. The fault is detected based on the analysis of DSM and isolated using a multi-model approach. The main properties of the suggested FDI system is discussed and the main limitation as well. The design of a controller based on DSM is useful to maintain a predefined margin of safety during the transient phase of the system or when disturbances are present. Therefore, the application of DSM in fault tolerant control (FTC) design using in particular model predictive control (MPC) is discussed. The fruitiness of the proposed FDI system and FTC is illustrated by real-time implementation.

WeA11 Audimax
Hybrid & Switching Systems I (Regular Session)

Chair: Gueguen, Herve — Supelec
Co-Chair: Aschemann, Harald — Univ. of Ulm

WeA11.1: 09:45-10:05
Algebraic and Geometrical Conditions for the Observability of the Discrete State for a Class of Dynamical Hybrid Systems, pp. 343-348

Chaib, Salim — ENSI Bourges
Boutat, Driss — ENSI Bourges
Benali, Abderraouf — ENSI Bourges
Barbot, Jean-Pierre — ENSEA

In this paper we deal with the observability of piecewise-affine hybrid systems. Our aim is to give the sufficient conditions to observe the discrete and continuous states, in terms of algebraic and geometrical conditions. First, we will give the algebraic conditions for discrete state observability based on the switch function reconstruction for linear hybrid systems. Secondly, we will give a geometrical condition based on a transversality concept for nonlinear hybrid systems.

WeA11.2: 10:05-10:25
A Polynomial Algorithm Solving a Special Class of Hybrid Optimal Control Problems, pp. 349-354

Bauso, Dario — Univ. di Palermo
Pesenti, Raffaele — Univ. of Palermo

Hybrid optimal control problems are, in general, difficult to solve. A current research goal is to isolate those problems that lead to tractable solutions [Branicky et al., 1998]. In this paper, we identify a special class of hybrid optimal control problems which are easy to solve. We do this by using a paradigm borrowed from the Operations Research field. As main result, we present a solution algorithm that converges to the exact solution in polynomial time. Our approach consists in approximating the hybrid optimal control problem via an integer-linear programming reformulation. The integer-linear programming problem is a Set-covering one with a totally unimodular constraint matrix and therefore solving the Set-covering problem is equivalent to solving its linear relaxation. It turns out that any solution of the linear relaxation is a feasible solution for the hybrid optimal control problem. Then, given the feasible solution, obtained solving the linear relaxation, we find the optimal solution via local search.

WeA11.3: 10:25-10:45
Interval Methods for Simulation of Dynamical Systems with State-Dependent Switching Characteristics, pp. 355-360

Rauh, Andreas — Univ. of Ulm
Kletting, Marco — Univ. of Ulm
Aschemann, Harald — Univ. of Ulm
Hofer, Eberhard — Univ. of Ulm

In this paper, an interval arithmetic simulation algorithm is introduced for simulation of continuous-time systems with state-dependent switchings between different dynamical models. For that purpose, the conditions for all possible transitions between these models have to be evaluated during simulation to determine the switching times and hence to obtain guaranteed enclosures for all state variables. In contrast to other simulation techniques, all system parameters are defined as interval variables to analyze the effect of uncertainties on the switching times and the dynamical behavior of the complete system.

WeA11.4: 10:45-11:05
Observer Design for Linear Switched Systems : A Common Lyapunov Function Approach, pp. 361-366

Chaib, Salim — ENSI Bourges
Boutat, Driss — ENSI Bourges
Benali, Abderraouf — ENSI Bourges
Guillot, Jean Claude — ENSI Bourges
Barbot, Jean Pierre — ENSEA

In this paper, we give sufficient conditions for the stability of a class of switched systems. Based on the symmetric part of the state space matrix and on LaSalle's invariance principle, to ensure the asymptotic stability of switched linear systems, under a special class of switching signals. The proposed stability results are used to design an observer of switched linear systems for which the discrete state is available. Examples are given to highlight our propositions.

WeA11.5: 11:05-11:25
The Open-Loop Control for the Start-Up of a Double Resonance Converter Using a Hybrid Systems Approach, pp. 367-372

Zainea, Marius — Supelec
Godoy, Emmanuel — Supelec
Buisson, Jean — Supelec
Cormerais, Herve — Supelec
Gueguen, Herve — Supelec

Radiological medical imaging generally requires the use of very high voltages associated with strong powers, for example for the power supply of the X-ray tubes. Associated to these needs it is necessary to add strong constraints in terms of the dynamic performances required by the power systems supply. One solution for this kind of application is to use a double resonant converters.

A problem arising from the control of this kind of generator is the launching phase starting from zero initial conditions in order to obtain a desired internal behavior. Formal methods are difficult to use when dealing with complex systems like the double resonance converter. Besides the dimensional complexity, the fact that autonomous transitions could occur, due to the presence of diodes, it makes the start-up sequence a priori unknown and it induces also a variation in the dimension of the dynamics equation, reasons for which the problem becomes even stiffer. More, formal translation of constraints that come from practical issues is not straightforward.

This paper proposes a solution that overcomes these difficulties using an off-line nonlinear constrained optimization to determine the commutation instants, where the evaluation of the cost function is obtained via simulation. The simulation model is obtained in the event tracking framework from the hybrid automata equivalent model for the system. The advantage is that, in order to take into consideration the set of constraints, only the control block has to be adapted to the start-up problem.

WeA11.6: 11:25-11:45
Hybrid Modelling and Control of a Free-Piston Energy Converter, pp. 373-378

Xia, Hao — Univ. of Strathclyde
Pang, Yan — Univ. of Strathclyde
Grimble, Mike — Univ. of Strathclyde

Free piston energy converters are a potential technology for future hybrid vehicles, as well as stationary power generation applications. In a free piston energy converter, the piston is not connected to a crank-shaft. Instead, the piston movement is "free" and controlled by a linear hydraulic or electric machine. The major advantages of such a design over the conventional ones are the simpler engine layout and much improved conversion efficiency. In this paper, the free piston converter is modeled as a hybrid automaton. Then a hierarchical hybrid controller is designed based on the model. The proposed controller performance is demonstrated by a simulation study.

WeB01 Room 2601
Symbolic Methods (Invited Session)

Chair: Karampetakis, Nikos — Aristotle Univ. of Thessaloniki
Co-Chair: Vardulakis, Antonis — Aristotle Univ. of Thessaloniki
Organizer: Karampetakis, Nikos — Aristotle Univ. of Thessaloniki
Organizer: Vardulakis, Antonis — Aristotle Univ. of Thessaloniki

WeB01.1: 13:00-13:20
Computational Algebra Techniques for Linear Dynamical Systems Over Rings: State Estimations Problems. (I), pp. 379-384

Perdon, Anna Maria — Univ. Pol. delle Marche
Anderlucci, Maria — Univ. Pol. delle Marche
Caboara, Massimo — Univ. di Genova

Linear delay differential systems can be modeled as systems with coefficients in a suitable ring, so that several design problems can be solved using a geometric approach. To practically compute the solutions obtained for systems over a ring, Computational Algebra techniques must be used. The freely available software CoCoA is an efficient tool and easy to effectively implement the needed algorithms. The paper describes in details how the algorithms contained in the package "control.cpkg" can be used to practically solve State Estimations Problems for delay differential systems.

WeB01.2: 13:20-13:40
An Equivalent Reduction of a 2-D Symmetric Polynomial Matrix (I), pp. 385-390

Karampetakis, Nikos — Aristotle Univ. of Thessaloniki

A new family of companion forms for polynomials and polynomial matrices has recently been developed in Fiedler (2003) and Antoniou & Vologiannidis (2004) respectively. The application of these new companion forms to polynomial matrices with symmetries has been examined in Antoniou et.al. (2005). In this work we extend the results presented in Antoniou et.al. (2005) to the case of 2-D polynomial matrices and thus provide a new linearization of a 2-D polynomial matrix that preserves both the symmetric structure and the structural invariants, of the original 2-D polynomial matrix.

WeB01.3: 13:40-14:00
First Order Representations of Time-Varying Linear Systems (I), pp. 391-396

Zerz, Eva — RWTH Aachen Univ.

We construct a special type of first order representation of a linear time-varying system given by linear ordinary differential equations with rational or meromorphic coefficients. Under certain conditions, such a representation yields a classical state space model. We show that every system admits a partition of its variables into inputs and outputs such that a state representation can be obtained. All the problems addressed in this paper can be solved algorithmically by calculating in a polynomial ring over a field, in which the coefficients and the indeterminate obey a commutator rule that reflects the product rule of differentiation. Some recent advances of non-commutative computer algebra make it possible to tackle such problems computationally.

WeB01.4: 14:00-14:20
Guaranteed Accuracy Algorithm in H2 Optimal Tracking Controller Synthesis, pp. 397-402

Kanno, Masaaki — Japan Science and Tech. Agency
Hara, Shinji — Univ. of Tokyo

This paper develops a guaranteed accuracy algorithm for the H2 optimal tracking problem. Given a SISO plant, the method computes, in a manner which guarantees accuracy, the best achievable cost and the optimal controller that achieves it. The algorithm is also able to carry out in two ways the robustness analysis of the performance level against parametric uncertainty in the plant. The algorithm is illustrated on a numerical example.

WeB01.5: 14:20-14:40
Computing Adaptive Backstepping Control Law Using Computer Algebra Systems, pp. 403-407

Pozo Montero, Francesc — Univ. Pol. de Catalunya
Ikhouane, Faycal — Univ. Pol. de Catalunya

The backstepping-based adaptive tuning functions design is a recursive control scheme for uncertain systems that ensures reasonably good stability and performance properties of the closed loop. However, the complexity of the control algorithm makes inevitable the use of digital computers to perform the calculation of the control law. To this end, we use the computer algebra system namely Maple. The symbolic manipulation of Maple provides an excellent platform to derive this recursive algorithm.

WeB02 Room 1601
Modeling and Simulation of Multidisciplinary Systems and Networked Embedded Control Systems Design (Invited Session)

Chair: Mann, Herman — Czech Tech. Univ.
Co-Chair: Broenink, Jan F. — Univ. of Twente
Organizer: Mann, Herman — Czech Tech. Univ.

WeB02.1: 13:00-13:20
Automated Symbolic Model Reduction for Mechatronical Systems (I), pp. 408-415

Broz, Jochen — Fraunhofer ITWM
Clauss, Christoph — Fraunhofer IIS
Halfmann, Thomas — Fraunhofer ITWM
Lang, Patrick — Fraunhofer ITWM
Martin, Roland — Fraunhofer IIS
Schwarz, Peter — Fraunhofer IIS

A new modelling approach for mechatronical systems using symbolic methods based on the EDA tool Analog Insydes is presented. The netlist-based modelling language has been extended for the handling of multi-domain and vector-type through and across variables. Additionally, a library of symbolic models for a basic set of mechanical components has been implemented. With this approach, an automated setup of symbolic model equations in terms of a differential-algebraic system of equations starting from a netlist description is possible. This allows the application of DAE solvers for numerical simulation as well as the application of symbolic model reduction methods of mechatronical systems.

WeB02.2: 13:20-13:40
Multi-View Methodology for the Design of Embedded Mechatronic Control Systems (I), pp. 416-421

Groothuis, Marcellinus Alexander — Univ. of Twente
Broenink, Jan F. — Univ. of Twente

The design of embedded control systems for monitoring and control of mechatronic systems has a multi-disciplinary development trajectory. These systems consist of heterogeneous components developed by different disciplines (control engineering, electrical engineering, software engineering and often many more). The design trajectory needs therefore a multi-disciplinary design methodology that enables concurrent design and interactions between all involved disciplines, reducing inconsistencies and conflicts that occur during the design phase. This paper proposes a multi-view methodology to address the above-mentioned issues. The main purpose is to shorten the design time and at the same time increasing the reliability and predictability of embedded (computer) control systems.

WeB02.3: 13:40-14:00
Modeling Multidisciplinary Systems with Hybrid Statecharts (I), pp. 422-427

Ferreira, Jorge Augusto Fernandes — Univ. of Aveiro
Estima de Oliveira, Joao — Univ. of Aveiro

Some of the problems when modelling and/or simulating multidisciplinary systems, in today's engineering systems, result from the different time scales of the involved components. Often, the behaviour of fast components may be modeled with instantaneous changes, thus reducing the stiffness of the equations to be solved numerically. This approach leads to a variable structure of a DAE system of

equations which is, basically, a hybrid DAE. This representation, being a low level formalism, is not intuitive when extracting the fundamentals of the system's behaviour. The Hybrid Statecharts, being a graphical formalism, is an interesting way to increase the legibility of hybrid DAEs. This paper explores the Hybrid Statecharts formalism in order to represent continuous and discrete behaviour in the engineering field. The Statecharts hierarchy mechanism, implemented by means of state decomposition, is important to address the modelling of complex hybrid behaviour, as is normally the case with multidisciplinary systems.

WeB02.4: 14:00-14:20
Modelling Electro-Mechanical Actuators (I), pp. 428-433

Wilde, Andreas	Fraunhofer IIS
Schneider, Peter	Fraunhofer IIS
Presoto, Wellinton	Fraunhofer IIS

An electro-magnetic relay model is setup using a generalized Kirchhoff-network approach. The model features several mechanical nonlinear elements (stops), a nonlinear model for magnetization based on the Jiles-Atherton model and a nonlinear model for the non homogeneous magnetization of the anchor at the air gap. The model is tested using different voltage signals applied to the coil of the magnet system with varying positions of the mechanical stops. The simulation results are compared to data measured on a specially prepared relay, which allows to adjust the positions of the mechanical stops as well. The simulated and measured data agree well, which enables indirect determination of mechanical parameters through electric measurements.

WeB02.5: 14:20-14:40
Co-Simulation of Networked Embedded Control Systems, a CSP-Like Process-Oriented Approach (I), pp. 434-439

ten Berge, Matthijs H.	Univ. of Twente
Orlic, Bojan	Univ. of Twente
Broenink, Jan F.	Univ. of Twente

Complex control software problems can be solved by using structured design methods that take advantage of hardware abstraction and concurrency. In our lab, a toolchain has been developed that facilitates such a design method. This paper presents two extensions to this toolchain. The first, a distributed simulation framework, enables one to simulate a complete distributed control system, prior to the actual implementation. Focus has been on the influence the network communication exerts on the overall behavior of the system. The second extension, a new communication framework, allows for a smooth transition from simulation to a real control system, by hiding all low-level communication details from the control software. This separates the concerns of the control software from distribution and inter-node communication issues, creating freedom in process allocation.

WeB02.6: 14:40-15:00
On the Design and Control of Wireless Networked Embedded Systems, pp. 440-445

Arzen, Karl-Erik	Lund Inst. of Tech.
Bicchi, Antonio	Univ. di Pisa
Hailes, Steven	Univ. Coll. London
Johansson, Karl Henrik	Royal Inst. of Tech.
Lygeros, John	Univ. of Patras

Wireless networked embedded systems are becoming increasingly important in a wide area of technical fields. In this tutorial paper we present recent results on the design of these systems and their use in control applications, that have been developed within the project Reconfigurable Ubiquitous Networked Embedded Systems (RUNES). RUNES is a European Integrated Project with the aim to control complexity in networked embedded systems by developing robust and scalable middleware systems. New components for control under varying network conditions are discussed for the RUNES architecture. The paper highlights how the complexity of the closed-loop system is increased, due to additional disturbances introduced by the communication system: additional delays, jitter, data rate limitations, packet losses etc. Experimental work on integration test beds that demonstrates these results is presented, together with motivating links to the RUNES disaster relief tunnel scenario.

WeB03 Room 0670
New Trend in Approximate Dynamic Programming and Control Applications (Invited Session)

Chair: Venayagamoorthy, Ganesh	Univ. of Missouri-Rolla
Co-Chair: Jagannathan, Sarangapani	Univ. of Missouri-Rolla
Organizer: Venayagamoorthy, Ganesh	Univ. of Missouri-Rolla
Organizer: Jagannathan, Sarangapani	Univ. of Missouri-Rolla

WeB03.1: 13:00-13:20
Finite Horizon Discrete-Time Approximate Dynamic Programming (I), pp. 446-451

Liu, Derong	Univ. of Illinois at Chicago
Jin, Ning	Univ. of Illinois at Chicago

Dynamic programming for discrete time system is difficult due to the "curse of dimensionality": one has to find a series of control actions that must be taken in sequence, hoping that this sequence will lead to the optimal performance cost, but the total cost of those actions will be unknown until the end of that sequence. In this paper, we present our work on adaptive optimal control of nonlinear discrete time system using neural networks. We study the relationships of optimal controls for different control steps and then develop a neural dynamic programming algorithm based on these relationships.

WeB03.2: 13:20-13:40
Dynamic Re-Optimization of a Spacecraft Attitude Controller in the Presence of Uncertainties (I), pp. 452-457

Unnikrishnan, Nishant	Univ. of Missouri-Rolla
Balakrishnan, S.N.	Univ. of Missouri-Rolla
Padhi, Radhakant	Indian Inst. of Science Bangalore

Online trained neural networks have become popular in recent years in the design of robust and adaptive controllers for dynamic systems with uncertainties due to their universal function approximation capabilities. This paper discusses a technique that dynamically reoptimizes a Single Network Adaptive Critic (SNAC) based optimal controller in the presence of unmodeled plant uncertainties. The SNAC based optimal controller designed for the nominal plant model no more retains optimality in the presence of uncertainties/unmodeled dynamics that may creep up in the system equations during operation. This calls for a strategy to re-optimize the existing SNAC controller with respect to the original cost function but corresponding to new constraint (state) equations. The controller re-optimization is carried out in two steps: (i) synthesis of a set of online neural networks that capture the uncertainties in the plant equations on-line (ii) re-optimization of the existing SNAC controller to drive the states of the plant to a desired reference by minimizing the original cost function. This approach has been applied in the online re-optimization of a spacecraft attitude controller and numerical results from simulation studies are presented here.

WeB03.3: 13:40-14:00
A Performance Gradient Perspective on Approximate Dynamic Programming and Markov Decision Processes (I), pp. 458-463

Dankert, James	Arizona State Univ.
Yang, Lei	Arizona State Univ.
Si, Jennie	Arizona State Univ.

This paper shows an approach to integrating common approximate dynamic programming (ADP) algorithms into a theoretical framework to address both analytical characteristics and algorithmic features. Several important insights are gained from this analysis, including new approaches to the creation of algorithms. Built on this paradigm, ADP learning algorithms are further developed to address a broader class of problems: optimization with partial observability. This framework is based on an average cost formulation which makes use of the concepts of differential costs and performance gradients to describe learning and optimization algorithms. Numerical simulations are conducted including a queueing problem and a maze problem to illustrate and verify features of the proposed algorithms. Pathways for applying this analysis to adaptive critics are also shown.

WeB03.4: 14:00-14:20
Adaptive Critic Neural Network Force Controller for Atomic Force Microscope-Based Nanomanipulation (I), pp. 464-469

Yang, Qinmin — Univ. of Missouri-Rolla
Jagannathan, Sarangapani — Univ. of Missouri-Rolla

Automating the task of nanomanipulation is extremely important since it is tedious for humans. This paper proposes an atomic force microscope (AFM) based force controller to push nano particles on the substrates. A block phase correlation-based algorithm is embedded into the controller for the compensation of the thermal drift which is considered as the main external uncertainty during nanomanipulation. Then, the interactive forces and dynamics between the tip and the particle, particle and the substrate are modeled and analyzed. Further, an adaptive critic NN controller based on adaptive dynamic programming algorithm is designed and the task of pushing nano particles is demonstrated. This adaptive critic NN position/force controller utilizes a single NN in order to approximate the cost functional and subsequently the optimal control input is calculated. Finally, the convergence of the states, NN weight estimates and force errors are shown.

WeB03.5: 14:20-14:40
Adaptive Critic Designs Based Coupled Neurocontrollers for a Static Compensator (I), pp. 470-475

Mohagheghi, Salman — Georgia Inst. of Tech.
Venayagamoorthy, Ganesh — Univ. of Missouri-Rolla
Harley, Ronald — Georgia Inst. of Tech.

A novel nonlinear optimal neurocontroller for a static compensator (STATCOM) connected to a power system, using artificial neural networks, is presented in this paper. The heuristic dynamic programming (HDP) method, a member of the adaptive critic designs (ACD) family, is used for the design of the STATCOM neurocontroller. The proposed controller is a nonlinear optimal controller that provides coupled control for the line voltage and the dc link voltage regulation loops of the STATCOM. An action dependent approach is used, in which the controller is independent of a model of the network. Moreover, a proportional-integrator approach allows the neurocontroller to deal with the actual signals rather than the deviations. Simulation results are provided to show that the proposed ACD based neurocontroller is more effective in controlling the STATCOM compared to finely tuned conventional PI controllers.

WeB04 Room 2605
New Trends in Switched and Hybrid Systems
(Invited Session)

Chair: Zhai, Guisheng — Osaka Prefecture Univ.
Co-Chair: Michel, Anthony N. — Univ. of Notre Dame
Organizer: Zhai, Guisheng — Osaka Prefecture Univ.
Organizer: Michel, Anthony N. — Univ. of Notre Dame

WeB04.1: 13:00-13:20
Design of Nonlinear Digital Servo Systems Using Switching of Control Gains and Reference Inputs (I), pp. 476-481

Fukuda, Dai — Kobe Univ.
Ohta, Yuzo — Kobe Univ.

In this paper, we consider digital control of nonlinear robust servo systems using reference governor. In this method, reference inputs and controllers are switched according to the location of the state of the system, that is, we need to consider nonlinear systems with constraints. Continuous-time controllers are designed using polytopic Lyapunov functions and piecewise linear Lyapunov function. To execute this control scheme, we need to implement controllers digitally. The main issue is to give a criterion of determining the sampling period which guarantees stability of the nonlinear digital servo system.

WeB04.2: 13:20-13:40
Stability Analysis and Design for Switched Descriptor Systems (I), pp. 482-487

Zhai, Guisheng — Osaka Prefecture Univ.
Kou, Ryuuen — Osaka Prefecture Univ.
Imae, Joe — Osaka Prefecture Univ.
Kobayashi, Tomoaki — Osaka Prefecture Univ.

In this paper, we consider stability analysis and design for switched systems consisting of linear descriptor systems that have the same descriptor matrix. When all descriptor systems are stable, we show that if the descriptor matrix and all the subsystem matrices are commutative pairwise, then the switched system is stable under arbitrary switching. This is an extension of the existing well known result in [1] for switched linear systems with state space models to switched descriptor systems. Under the same commutation condition, we also show that in the case where all the descriptor systems are not stable, if there is a stable convex combination of the unstable descriptor systems, then we can establish a class of switching laws which stabilize the switched system.

WeB04.3: 13:40-14:00
A Design of a Partial Sliding Mode Controller Using Duality to Linear Functional Observer (I), pp. 488-491

Inoue, Akira — Okayama Univ.
Deng, Mingcong — Okayama Univ.

This paper considers a control scheme to control outputs having a dimension less than the dimension of the state variable by using sliding mode controller. Sliding mode controller controlling n-dimensional state variable with r control inputs has a switching hyper plane with n-r dimension. If the control objective is to control outputs having less dimension than the state variable, then the characteristics of the hyper plane could be separated into two characteristics having less order than n-r, and outputs could be controlled faster than the case of order n-r. This paper proposes a design scheme for hyper plane with less order using the duality between the design of a switching hyper plane of a sliding mode controller and the design of a linear functional observer. Also, the controller having stability of closed-loop system is shown to exist.

WeB04.4: 14:00-14:20
Unifying Theory for Stability of Continuous, Discontinuous, and Discrete-Time Dynamical Systems (I), pp. 492-497

Michel, Anthony N. — Univ. of Notre Dame
Hou, Ling — St. Cloud State Univ.

We show that if the hypotheses for the classical Lyapunov stability results for continuous dynamical systems [1], [2] (continuous-time dynamical systems whose motions are continuous with respect to time) are satisfied, then the hypotheses of the corresponding stability results for discontinuous dynamical systems (continuous-time dynamical systems whose motions are not necessarily continuous with respect to time, abbreviated DDS), reported in [4], are also satisfied. We then embed discrete-time dynamical systems into a class of DDS with equivalent stability properties and we show that when the hypotheses of the classical Lyapunov stability results for discrete-time dynamical systems are satisfied, then the hypotheses of the corresponding stability results for DDS are also satisfied. This shows that the stability results for DDS given in [4] are less conservative than corresponding classical Lyapunov stability results for continuous dynamical systems and discrete-time dynamical systems. This is demonstrated further by means of two specific examples. The results summarized above, establish a unifying stability theory for continuous dynamical systems, discrete-time dynamical systems and discontinuous dynamical systems.

WeB04.5: 14:20-14:40
Stability of Digital Control Systems with Time Delays (I), pp. 498-503

Michel, Anthony N. — Univ. of Notre Dame
Sun, Ye — Univ. of Notre Dame
Zhai, Guisheng — Osaka Prefecture Univ.

We consider an important class of digital control systems

whose plants are endowed with delays, and we show that such systems may be described by discontinuous functional differential equations. Next, we establish Lyapunov stability results for this class of systems. To accomplish this, we make use of some of our earlier work concerning the stability of discontinuous dynamical systems determined by functional differential equations.

WeB04.6: 14:40-15:00
Robust Stability and Stabilization of a Class of Nonlinear Switched Systems, pp. 504-508

Ji, Zhijian — Qingdao Univ.
Zhao, Keyou — Qingdao Univ.
Guo, Xiaoxia — Ocean Univ. of China
Wang, Long — Beijing Univ.

This paper addresses the problem of robust stability and stabilization of a class of nonlinear switched systems when each subsystem is not stabilized by a designed single static output feedback. Both the condition on robust stability only via switching and the condition on switched static output feedback controllers are expressed in terms of matrix inequalities. These conditions are derived by multiple Lyapunov functions technique and the switching rules adopted are state-dependent. All these results can be regarded as an extension of some existing results for non-switched systems.

WeB05 Room 0601
Automotive Control - Powertrain Control (Invited Session)

Chair: Christen, Urs — Ford Forschungszentrum
Co-Chair: Ohata, Akira — Toyota Motor Corp.
Organizer: Christen, Urs — Ford Forschungszentrum
Organizer: Ohata, Akira — Toyota Motor Corp.

WeB05.1: 13:00-13:20
Model-Based Feedback Control of the Air-To-Fuel Ratio in Diesel Engines Based on an Empirical Model (I), pp. 509-514

Alfieri, Ezio — ETH Zurich
Amstutz, Alois — ETH Zurich
Onder, Christopher Harald — ETH Zurich
Guzzella, Lino — ETH Zurich

This paper discusses the application of a model-based feedback control loop for the air-to-fuel (AF) ratio instead of the standard exhaust gas recirculation (EGR) control loop that utilizes the hot-film air-mass meter (HFM) as control variable. A comparison between the model-based controller that contains information about the plant dynamics and the standard EGR controller is carried out. In terms of performance and driveability the results of the AF ratio controller match those of a standard EGR controller. Moreover, with this new configuration, production tolerances and drift of sensors and actuators, such as the HFM and the injectors, can be detected and compensated. The starting point for the controller design is an empirical linear engine model with the EGR valve control signal as input signal and the AF ratio as the output signal.

WeB05.2: 13:20-13:40
Engine Intake Manifold Modeling and High Speed Solving for Predictive Control (I), pp. 515-520

Xie, Long — Waseda Univ.
Ogai, Harutoshi — Waseda Univ.
Inoue, Yasuaki — Waseda Univ.

The intake manifold model of turbocharged engine is constructed and a high speed calculation algorithm is developed for model based predictive control in real time. The model is built according to the analysis of its thermodynamic and hydrodynamic characteristics and the sampled experiment data. The model equations are expressed by a set of differential equations with switching (bifurcation) on the right hand side. The switching surface is divided into two parts: sliding and crossing. We analyze the switching situations existing on the surface and develop the well-defined control semantics for managing the behavior discontinuities in the case of mode transition. The calculation algorithm can seamlessly integrate the continuous behavior and the discrete mode switching together. Using this method we can solve this model under entire region of input throttle angles. Furthermore the stability is greatly increased and the calculation time is greatly reduced for the real time control system.

WeB05.3: 13:40-14:00
Data-Driven Algorithms for Engine Friction Estimation (I), pp. 521-526

Stotsky, Alexander A. — Volvo Car Corp.

Errors in an estimate of friction torque in modern spark ignition automotive engines have a direct impact on a driveability performance of a vehicle and necessitate a development of real-time algorithms for adaptation of the friction torque. Friction torque in the engine control unit is presented as a look-up table with two input variables (engine speed and indicated engine torque). Algorithms proposed in this paper estimate the engine friction torque via the crankshaft speed fluctuations at the fuel cut off state and at idle. Computationally efficient filtering algorithm for reconstruction of the first harmonic of a periodic signal is used to recover an amplitude which corresponds to engine events from the noise contaminated engine speed measurements at the fuel cut off state. The values of the friction torque at the nodes of the look-up table are updated, when new measured data of the friction torque is available. New data-driven algorithms which are based on a step-wise regression method are developed for adaptation of look-up tables. Algorithms are verified by using a spark ignition six cylinder prototype engine.

WeB05.4: 14:00-14:20
MPC for a Simplified Transmission Model with Backlash Using UKF (I), pp. 527-532

Saito, Masahiro — Tokyo Inst. of Tech.
Yamakita, Masaki — Tokyo Inst. of Tech.

Backlash mechanisms can be seen in many mechanical systems and they may deteriorate the performance of the systems. So the control of the backlash is very important for practical applications. In this paper we propose a control method for a simplified transmission system with the backlash using a Model Predictive Control (MPC) and Unscented Kalman filter(UKF). The efficiency of the proposed method will be demonstrated using a simplified transmission model numerically.

WeB05.5: 14:20-14:40
A Wavelet-Based Combustion Noise Meter (I), pp. 533-538

Christen, Urs — Ford Forschungszentrum
Vantine, Katie — Ford Forschungszentrum
Chevalier, Alain — Ford Forschungszentrum
Moraal, Paul E. — Ford Motor Company
Scholl, David J. — Ford Motor Company

The combustion noise of diesel engines can be assessed by filtering in-cylinder pressure traces. In this paper, two wavelet-based methods are discussed. It is shown that the statistical properties of a noise meter based on shift-invariant wavelet transforms are improved compared to one that is based on traditional (shift-variant) wavelet transforms. The application of noise metering for pilot injection detection is also presented.

WeB05.6: 14:40-15:00
Key Considerations in the Translation of Legacy Embedded Control Software to Model Based Executable Specifications (I), pp. 539-544

Baloh, Michael — Emmeskay, Inc.
Raghav, Gopal — Emmeskay, Inc.
Sivashankar, Narayanan — Emmeskay, Inc.

Traditionally, control algorithms were explored using analytical approaches and limited computational methods while they were implemented as hand-written C-code by software engineers. This gap between algorithm exploration and implementation is being bridged by using graphical modeling tools such as Simulink. Models implemented in Simulink® serve as Executable Specifications. They can be simulated to verify against requirements and be used as the basis for embedded code generation. The benefits of this approach have prompted many organizations to undertake fairly large effort to migrate their existing Legacy Embedded Software to Model Based Executable Specifications in order to reuse and to leverage their existing control know-how. This paper discusses some key aspects of this Translation Process that are important to

ensure that the process is efficient and it results in a work product that is a “true representation” of the source code. The importance of a structured process, aids for model implementation, and, criteria to measure the resulting model quality are discussed in detail in this paper.

WeB06 Room 0602
Human Adaptive Mechatronics (Invited Session)

Chair: Furuta, Katsuhisa	Tokyo Denki Univ.
Co-Chair: Pan, Yaodong	Tokyo Denki Univ.
Organizer: Pan, Yaodong	Tokyo Denki Univ.
Organizer: Furuta, Katsuhisa	Tokyo Denki Univ.

WeB06.1: 13:00-13:20
Assisting Control in Human Adaptive Mechatronics - Single Ball Juggling - (I), pp. 545-550

Furuta, Katsuhisa	Tokyo Denki Univ.
Kado, Yuya	Tokyo Denki Univ.
Shiratori, Shinya	Tokyo Denki Univ.

Human Adaptive Mechatronics aims to develop Mechatronic systems adapting and assisting human operations. In this paper, an operator assisting system is studied from the control design viewpoint and an assisting system for a juggling operation is developed. It is found that such assisting system is useful for developing a skill for a complex operation.

WeB06.2: 13:20-13:40
Development of a Steward Robot for Human-Friendly Interaction (I), pp. 551-556

Lee, Hyong-Euk	Korean Adv. Inst. Sci. Tech.
Kim, Youngmin	Korean Adv. Inst. Sci. Tech.
Park, Kwang-Hyun	Korean Adv. Inst. Sci. Tech.
Bien, Z. Zenn	Korean Adv. Inst. Sci. Tech.

Independence of people in need in their living environment becomes an imperative notion for any society in the years to come. As an approach to achieve independence, this paper addresses the problem of controlling an assistive home environment emphasizing a human-friendly man-machine interaction. We introduce a new service robot, named Joy, which can be categorized as a steward robot. As an intermediate agent between inhabitants and a complex smart house environment, this robot can provide the users with easily accessible, convenient, and cost effective environment for independent living. The learning capability and emotional interaction of the robot can enhance human-friendliness in various tasks. A learning system can provide personalized services by accumulating knowledge of the behavior patterns of the user in daily activities. An emotional interaction system generates facial expressions to be more human-friendly. We have developed two types of steward robots: a software type and hardware type. The hardware-type robot has a mobile platform and two robotic arms to perform various tasks with mobility.

WeB06.3: 13:40-14:00
Relation between Skill Level and Input Output Time Delay (I), pp. 557-561

Hidaka, Koichi	Tokyo Denki Univ.
Saida, Kazumasa	Tokyo Denki Univ.
Suzuki, Satoshi	Tokyo Denki Univ.

In this paper, we try to obtain knowledge about human skill on machine operation, using data measured by simple test, and analyze up-skilling. In order to obtain experimental data for human manipulation, we utilize a tele operated robot system. For the tele operation, it is necessary that human operates machine by using image information from display monitor. We aim at the acquisition of evaluation quantity about state of skill, and pay attention to delay time during the machine operation. For the skill, we investigated correlation with response delay time of human operation and control characteristics of the operations. We confirmed a possibility of quantification of progress of the up-skilling.

WeB06.4: 14:00-14:20
Extraction of Visual Attention with Gaze Duration and Saliency Map (I), pp. 562-567

igarashi, Hiroshi	Tokyo Denki Univ.
Suzuki, Satoshi	Tokyo Denki Univ.
Sugita, Tetsuro	Tokyo Denki Univ.
Kurisu, Masamitsu	Tokyo Denki Univ.
Kakikura, Masayoshi	Tokyo Denki Univ.

Measurement of gaze is effective to evaluate human operator's attention, one's operation skills, perceptional capability and so on. Especially, gaze duration, called fixation time, is often utilized. Generally, it is said that long fixation time is detected when the operator pays attention to something intentionally. However, the duration also depends on saliency of displayed image, especially humans' perception characteristics are sensitive to intensities of an image. Although a lot of researchers have presented models of visual attention with the saliency map, the high saliency may attract a human gaze even if he/she do not have attention. Therefore, in order to estimate the human attention, we consider human vision characteristics with foveal vision. The foveal vision is used for scrutinizing highly detailed objects, and it also may relate to the attention. In this paper, we propose a new approach to estimate human visual attention by checking gaze duration and a saliency map considering human foveal vision characteristics. The estimation technique was experimented with five participants, and as the results, we found the technique makes aware of the attention more than conventional technique which considers only gaze duration.

WeB06.5: 14:20-14:40
Analysis of Safe Manual Control by Using Furuta Pendulum (I), pp. 568-572

Iwase, Masami	Tokyo Denki Univ.
Astrom, K. J.	Lund Inst. Tech.
Furuta, Katsuhisa	Tokyo Denki Univ.
Akesson, J.	Lund Inst. Tech.

This paper focuses on the interaction of manual and automatic control in a demanding task where the process is unstable and has actuator limitation. The problem is inspired by control of high performance aircrafts but which is similar to controlling the arm of a Furuta pendulum while maintaining the stability of the pendulum. The task is to control the position of the pendulum arm manually while maintaining the pendulum in the upright position. The analysis of regions for safe maneuvers is important to realize the desired control system.

WeB06.6: 14:40-15:00
Elucidation of Skilled Human Controller on Stabilization with Voluntary Motion (I), pp. 573-578

Kurihara, Keiichi	Mitsubishi Precision Co.,Ltd,
Suzuki, Satoshi	Tokyo Denki Univ.
Furuta, Katsuhisa	Tokyo Denki Univ.

This paper introduces an experimental analysis to elucidate catholic characteristic of human skill on machine manipulation for realization of a Human Adaptive Mechatronics(HAM). HAM is a novel concept of intelligent mechanical systems that adapt themselves to the user's skill and assist to improve the user's skill. Using a force-feedback haptic device and a real-time computer graphics of a virtual pendulum, we acquired data until human was skilled, and tried to extract human control axiom by data-analysis and simulation checking. It was confirmed that skilled person stabilized a virtual pendulum by forecasting it's motion by using the velocity information and switched one's controllers according to a positional limit of an input device.

WeB07 Room 0606
Computational Algorithms for Model Predictive Control
(Invited Session)

Chair: Imura, Jun-ichi	Tokyo Inst. of Tech.
Co-Chair: Ohtsuka, Toshiyuki	Osaka Univ.
Organizer: Imura, Jun-ichi	Tokyo Inst. of Tech.
Organizer: Ohtsuka, Toshiyuki	Osaka Univ.

WeB07.1: 13:00-13:20
A Networked Formation Control for Groups of Mobile Robots Using Mixed Integer Programming (I), pp. 579-584

Kopfstedt, Thomas	Diehl BGT Defence
Mukai, Masakazu	Kyushu Univ.
Fujita, Masayuki	Tokyo Inst. of Tech.
Sawodny, Oliver	Univ. of Stuttgart

In this paper we will demonstrate an effective way of description and control for network-controlled formations of mobile robots using minimized inter-robot communication. Therefore we use a global centralized planning algorithm and solve the optimal trajectory problem of the formation of mobile robots by mixed integer quadratic programming (MIQP). This description of formation can be used for non-static formations as well as for formation switching between different kinds of formations where inter-robot collisions will be avoided and the formations are organized as unit-center-referenced formations The environment itself can be formulated by convex polygons that are described as hybrid systems. The moving along the optimum trajectories is controlled by a controller structure in three levels, whereby the highest level is set on a master robot and controls the general formation using Bluetooth communication between the robots. The control of the position of each robot is realized by an individual controller on every robot and a motor controller for every wheel of each robot. The effectiveness of our formation control structure and the algorithm for the planning of the trajectory is demonstrated in simulations and experiments which also verify the dynamic models of the robots.

WeB07.2: 13:20-13:40
Nonlinear Model Predictive Control for Constrained Mechanical Systems with State Jump (I), pp. 585-590

Lee, Junmuk	Tokyo Inst. of Tech.
Yamakita, Masaki	Tokyo Inst. of Tech.

In this paper, a nonlinear model predictive control (MPC) scheme for constrained mechanical systems with state discontinuity, or state jump, is examined. The proposed control method extends a fast numerical algorithm based on continuation and GMRES methods, allowing online implementation for mechanical systems possible. The validity of the strategy is demonstrated through numerical simulations, applying the method to landing control of a simplified humanoid model. The system is constrained to restrict the position of the zero moment point (ZMP) of the robot and state discontinuity exists at the landing instant.

WeB07.3: 13:40-14:00
Fast NMPC of a Chain of Masses Connected by Springs (I), pp. 591-596

Wirsching, Leonard	Univ. of Heidelberg
Bock, Georg	Univ. of Heidelberg
Diehl, Moritz	Univ. of Heidelberg

Aim of this study is to compare two variants of the real-time iteration (RTI) scheme in nonlinear model predictive control (NMPC): the standard RTI scheme as described in [M. Diehl. Real-Time Optimization for Large Scale Nonlinear Processes. PhD Thesis, University of Heidelberg, 2001] and a new adjoint based RTI scheme as described in [H.G. Bock, M. Diehl, E. Kostina and J.P. Schloeder. Constrained optimal feedback control of systems governed by large differential algebraic equations. In Real-time and Online PDE-Constrained Optimization. SIAM, 2004] and [L. Wirsching. An adjoint based SQP algorithm using inexact derivatives and its application to direct multiple shooting. Master's thesis, University of Heidelberg, 2006. (thesis submitted)]. We compare their performance on returning a chain of spring connected masses to its steady state, after a strong perturbation has been exerted to the chain. The adjoint based RTI shows to be about one order of magnitude faster.

WeB07.4: 14:00-14:20
Non-Linear Prediction Horizon Time-Discretization for Model Predictive Control of Linear Sampled-Data Systems (I), pp. 597-602

Gondhalekar, Ravi	Tokyo Inst. of Tech.
Imura, Jun-ichi	Tokyo Inst. of Tech.

Model predictive sampled-data control of linear continuous-time plants is considered. The time-discretization of the prediction horizon may be non-linear, in order to reduce the number of optimization variables for a given prediction horizon length. This is done for the purpose of allowing faster implementation. While the method is aimed at constrained systems, this paper focuses on the achievable performance of such control strategies for unconstrained systems. A general solution to the finite-horizon optimal control problem is derived for a prediction horizon of arbitrary time-discretization. The model predictive control strategy is consequently derived, and the optimal control input shown to be given by a time-invariant state feedback expression. Three non-linear prediction horizon time-discretization schemes are proposed, and their relative merits discussed. The benefit of employing the presented control strategy is demonstrated by a satellite attitude control case study. The same case study is further used to highlight limitations of and performance differences between the three proposed prediction horizon time-discretization schemes.

WeB07.5: 14:20-14:40
Nonlinear Receding Horizon Control of an Underactuated Hovercraft with a Multiple-Shooting-Based Algorithm (I), pp. 603-607

Shimizu, Yuichi	Osaka Univ.
Ohtsuka, Toshiyuki	Osaka Univ.
Diehl, Moritz	Univ. of Heidelberg

In this paper, we propose a real-time algorithm for nonlinear receding horizon control using multiple shooting and the continuation/GMRES method. The multiple shooting is expected to improve numerical accuracy and stability in calculations for solving a boundary value problem. The continuation method is combined with a Krylov-subspace method, GMRES, to update unknown quantities by solving a linear equation. At the same time, we apply condensing, which reduces the size of the linear equation, to speed up numerical calculations. The proposed algorithm is applied to an underactuated hovercraft. Computational results show that the proposed algorithm is superior to a conventional one in the numerical accuracy and stability.

WeB07.6: 14:40-15:00
Model Predictive Control for Continuous-Time Piecewise Affine Systems Based on Mode Controllability (I), pp. 608-613

Tazaki, Yuichi	Tokyo Inst. of Tech.
Imura, Jun-ichi	Tokyo Inst. of Tech.

This paper presents an approximate semi-offline approach to model predictive control of continuous-time piecewise affine (CTPWA) systems. The proposed method computes in the offline phase a controllable set and a minimum transition cost associated with each discrete state sequence. Then at each sampling time in the online phase, the controller determines the optimal sequence of intermediate target states over a prediction horizon, taking advantage of the information precomputed off line. By effectively distributing the computation over the offline phase and the online phase, real-time control is achieved, striking a good balance between the amount of precomputed data and the online computation time. The proposed method has been applied to a simple CTPWA system, obtained by piecewise linear approximation of a pendulum.

WeB08 Room 2607
Computer Vision (Regular Session)

Chair: Savkin, Andrey V. Univ. of New South Wales
Co-Chair: Kovacic, Zdenko Univ. of Zagreb

WeB08.1: 13:00-13:20
A Method for Vision-Based Docking of Wheeled Mobile Robots, pp. 614-619
Low, May Peng Emily Univ. of New South Wales
Manchester, Ian Univ. of New South Wales
Savkin, Andrey V. Univ. of New South Wales

We present a new control law for the problem of docking a wheeled robot at a certain location with a desired heading. Recent research into insect navigation has inspired a solution which uses just one environment sensor: a video camera. The control law is of the ``behavioral'' or ``reactive'' type, in that no attempt is made to observe the relative pose of robot and target, all control actions are based on immediate visual information. Experiments were performed for verification of docking strategy and practical realization of some aspects of insect behavior such as locating and fixation on a target

WeB08.2: 13:20-13:40
A Model Validation Approach to Robot Motion Segmentation in Computer Vision, pp. 620-625
Al-Takrouri, Saleh Univ. of New South Wales
Savkin, Andrey V. Univ. of New South Wales

A new model validation approach to motion segmentation problem is proposed. In order to demonstrate the proposed method, we study the motion segmentation problem for a mobile wheeled robot. Experiments were carried out on a Pioneer 3 mobile robot and a stationary camera.

WeB08.3: 13:40-14:00
Vision System for Monitoring the Production of Corrugated Cardboard, pp. 626-631
Balestrino, Aldo Univ. of Pisa
Landi, Alberto Univ. of Pisa
Pacini, Luca Univ. of Pisa

In this paper a vision system for the control quality in a factory of corrugated cardboard is described. The problem under study is the automatic detection and monitoring of the sheets of cardboard constituting a unit of sale. A precise measurement of the number of sheets is a difficult task, since, during the process, some sheets must be discarded, because of their inferior quality, or because they have been damaged during the transport. Usually, the number of the sheets is estimated from the ratio between the weight of the unit and the nominal weight of a single sheet. Since the weight of a sheet is uncertain, an estimation based on the weight ratio is poor and its reliability is very low. A different solution is proposed in this paper: it estimates the number of the sheets via a suitable vision system. It offers a very high precision (the middle error is smaller of 2%) and it has the advantages to avoid invasive interactions with the process of production and to be a low cost solution.

WeB08.4: 14:00-14:20
Modeling and Control of a Robotic Power Line Inspection Vehicle, pp. 632-637
Jones, Dewi I. Univ. of Wales Bangor
Golightly, Ian Univ. of Wales Bangor
Roberts, Jonathan Queensland Centre for Adv. Tech.
Usher, Kane Queensland Centre for Adv. Tech.

Power line inspection is a vital function for electricity supply companies but it involves labor-intensive and expensive procedures which are tedious and error-prone for humans to perform. A possible solution is to use an unmanned aerial vehicle (UAV) equipped with video surveillance equipment to perform the inspection. This paper considers how a small, electrically driven rotorcraft conceived for this application could be controlled by visually tracking the overhead supply lines. A dynamic model for a ducted-fan rotorcraft is presented and used to control the action of an Air Vehicle Simulator (AVS), consisting of a cable-array robot. Results show how visual data can be used to determine, and hence regulate in closed loop, the simulated vehicle's position relative to the overhead lines.

WeB08.5: 14:20-14:40
A Mobile Mapping System for Road Data Capture Based on 3D Road Model, pp. 638-643
Ishikawa, Kiichiro Waseda Univ.
Takiguchi, Jun-ichi Mitsubishi Elec.
Amano, Yoshiharu Waseda Univ.
Hashizume, Takumi Waseda Univ.

The development of road telematics requires the management of continuously growing road database. A MMS (Mobile Mapping System) can acquire this road database, while offering an unbeatable productivity with the combination of navigation, and videogrammetry tools. The proposed MMS, featuring a GPS/DR(Dead Reckoning) combined navigation system, a GPS-Gyro/IMU(Inertial Measurement Unit) , laser scanners, nearly horizontal cameras and high sampling rate road data measurement logger, can measure centerline and side-line location precisely considering 3D road surface model based on a laser scanner. The carrier phased D-GPS/DR combined navigation system and GPS-Gyro/IMU performs highly accurate position and posture estimation at a few centimeter and 0.1 degree order. It can be said that the proposed MMS and its unique road signs positioning method is valid and effective as the road sign location error is within 100[mm] even in the slanted road by considering the 3D road surface model.

WeB08.6: 14:40-15:00
Integrated Vision System for Supervision and Guidance of a Steam Generator Tube Inspection Manipulator, pp. 644-649
Birgmajer, Bruno Univ. of Zagreb
Kovacic, Zdenko Univ. of Zagreb
Postruzin, Zeljko HRID-NDT Ltd.

In this paper we present a machine vision system for supervision and guidance of a tube inspection manipulator used for eddy-current inspections of steam generators in nuclear and thermal power plants. Operation of nuclear power plants is regulated by very strict safety standards. In one inspection cycle a few hundred out of a mesh of approximately 6,000 tubes need to be tested, so omissions and misidentifications can occur. A supervisory vision system is introduced into the inspection manipulator motion control loop to increase its reliability and enable full automation of the inspection procedure. The developed system supervises robot movements over the tube mesh and verifies that the eddy-current probe is positioned into the desired tube. On final approach of the manipulator arm to the tube opening, the vision system automatically guides the manipulator to achieve accurate positioning for probe insertion, thus eliminating the need for operator input and reducing probe wear.

WeB09 Room 0999
Analysis and Control of Distributed-Parameter Systems with Applications (Invited Session)

Chair: Meurer, Thomas Saarland Univ.
Co-Chair: Sawodny, Oliver Univ. of Stuttgart
Organizer: Meurer, Thomas Saarland Univ.
Organizer: Sawodny, Oliver Univ. of Stuttgart

WeB09.1: 13:00-13:20
Flatness-Based Feedforward Control Design for Flexible Structures (I), pp. 650-655
Becker, Jens Univ. of Stuttgart
Meurer, Thomas Saarland Univ.
Gaul, Lothar Univ. of Stuttgart

This contribution presents a solution to the feedforward tracking control problem for flexible beam structures. The design methodology is based on the modal analysis of the structural dynamics to determine an inverse system representation by parameterizing modal states and system input in terms of aparameterizing function and its time-derivatives. Convergence of the resulting parameterizations is thereby directly related to the problem of motion planning. In addition, the analytical feedforward control design approach is adapted to incorporate finite-element methods, which makes

this approach especially suitable for the control of structures with complex geometry, boundary conditions or spatially varying material properties. Simulation results for a clamped-free Timoshenko beam with piezoelectric actuation are presented, where it is desired to drive the beam tip from zero deflection to a given desired stationary deflection within a finite-time interval.

WeB09.2: 13:20-13:40
Application of a Combined Flatness and Passivity-Based Control Concept to a Crane with Heavy Chains and Payload (I), pp. 656-661

Thull, Daniel — Saarland Univ.
Wild, Daniel — Saarland Univ.
Kugi, Andreas — Saarland Univ.

This paper deals with the application of a flatness-based open-loop tracking controller in combination with a passivity-based closed-loop controller to the infinite-dimensional model of a crane with heavy chains and payload. It turns out that the position of the load serves as a flat output. This allows us to perform the trajectory planning task in a straightforward way. The objective of the stabilizing controller is on the one hand to provide a good damping of the vibrations of the chains and on the other hand to stabilize the desired position of the cart. Furthermore, the controller has to cope with stick-slip effects in the wheel bearings of the cart which are always present in an experimental setup. By means of a suitable passivity-based controller design combined with the classical integrator backstepping approach, the demands on the closed-loop system can be fulfilled in a systematic and physically motivated way. Simulation and measurement results of a laboratory experiment show an excellent performance of the proposed control concept.

WeB09.3: 13:40-14:00
Controllability and Stabilization of a Moving Water Tank System Considering Fluid-Structure Interaction (I), pp. 662-667

Mottelet, Stephane — Univ. of Tech. Compiegne

This paper deals with the modeling and the mathematical analysis of problems involving a rectangular container installed on a cart. The overall system is controlled via a longitudinal force in order to move the cart from one location to another, and the key problem is the suppression of sloshing during transportation. We firstly make a precise mathematical analysis of the model in order to obtain a system under an adequate form, in order to study some controllability and stabilization problems with standard techniques. Note that in this paper, we want to control and stabilize simultaneously the fluid and the cart. We show that the system is not approximately controllable in finite time, but only on [0,infty). We also study the stabilization of the system with two different static feedbacks. The first feedback uses the observation of the cart speed only. The second feedback uses the cart speed and a measurement of the elevation of the free surface of the fluid in the container. We show that strong stability holds in both cases, although the coupled system is not dissipative for the second type of feedback.

WeB09.4: 14:00-14:20
Dissipative Boundary Control Systems with Application to Distributed Parameters Reactors (I), pp. 668-673

Le Gorrec, Yann — Univ. of Lyon
Maschke, Bernhard — Univ. of Lyon
Villegas, Javier Andres — Univ. of Twente
Zwart, Hans — Univ. of Twente

In this paper we consider distributed parameter physical systems composed of a reversible part associated with a skew-symmetric operator J as Hamiltonian systems and a symmetric operator associated with some irreversible phenomena. We will show how to use results obtained on reversible systems to parametrize the boundary conditions such that the solution of the associated PDE is contractive. The theoretical results are applied to the example of a tubular reactor with first order chemical reaction. The obtained parametrization is compared with the classical Dankwert conditions.

WeB09.5: 14:20-14:40
Flatness-Based Disturbance Decoupling for Heat and Mass Transfer Processes with Distributed Control (I), pp. 674-679

Kharitonov, Alexander — Univ. of Stuttgart
Sawodny, Oliver — Univ. of Stuttgart

This paper deals with the control of heat and mass transfer processes. The mathematical model of a process is presented by a distributed parameter system described by inhomogeneous parabolic partial differential equations in one-dimensional space. The control input is represented by a source function, while the boundary inputs correspond to disturbances in the system of interest. The flatness of these systems is studied. In contrast to the systems with boundary control, the flat output for such systems does not coincide with the control output and cannot be uniquely defined. A part of the dynamic relations describes the influence of the boundary inputs, i.e. disturbances, on the control output. In the paper the approach for the decoupling of the control output from the disturbances on the bounds is proposed. The approach is based on the examination of the inverse dynamics of the system and the design of the observer for the state variables reproducing the influence of the disturbance. Some numerical simulations are included and demonstrate the efficiency of the proposed approach.

WeB09.6: 14:40-15:00
Design of a Combined Quasi-Linear Distributed State and Online Parameter Estimator for a Stratified Storage Tank (I), pp. 680-685

Kreuzinger, Tobias — Bosch Company
Bitzer, Matthias — Bosch Company
Marquardt, Wolfgang — RWTH Aachen Univ.

This contribution presents the late lumping design of a combined distributed state and online parameter estimator for a state of the art domestic hot water storage system, a so called stratified storage tank. The discrete- and continuous-time dynamics of the storage tank are described by a hybrid, quasi-linear distributed parameter system, namely a finite state automaton interacting with an underlying diffusion-convection system (DCS), characterized by heat exchange to the ambiance and change of the flow direction. For the development of an advanced process control, the reconstruction of the temperature profile in the storage tank is compulsory. Therefore, a quasi-linear distributed parameter observer with a simultaneously running online estimation algorithm for the determination of the flow velocity are derived. Hereby, the injected correction terms and their tuning parameters are designed based on physical and heuristical considerations. In view of observer convergence, a discussion on the choice of appropriate sensor locations as well as the approximation of the initial temperature profile for the state observer are given. The performance of the distributed state observer and parameter estimator is illustrated by simulation studies and compared to measurement data.

WeB10 Room 3999
Robust Control II (Regular Session)

Chair: van Essen, Gijs — Delft Univ. of Tech.
Co-Chair: Lohmann, Boris — Tech. Univ. Munich

WeB10.1: 13:00-13:20
Application of Robust L2 Control to Erbium Doped Fiber Amplifier: Input and State Uncertainty, pp. 686-692

Stefanovic, Nem — Univ. of Toronto
Pavel, Lacra — Univ. of Toronto

We extend the results of [9] to increase the robustness of an L2 nonlinear controller applied to an erbium doped fiber amplifier (EDFA). We consider the rejection of input and state uncertainties to a full information (FI) extended state space model of the EDFA. The generic robust stabilization problem is solved and the concept of state uncertainty is shown to be associated to parametric uncertainty in the EDFA model. We compare the improved robust L2 controller to the standard L2 controller of [9].

WeB10.2: 13:20-13:40
Low Order Robust Controllers for Active Vehicle Suspensions, pp. 693-698

Yousefi, Amirhossein — Tech. Univ. Munich
Akbari, A. — Tech. Univ. Munich
Lohmann, Boris — Tech. Univ. Munich

This paper considers an H infinity control scheme for active suspensions. A quarter car model, which captures many features of real structures, is used in this study and a pragmatic approach to select the uncertainty and performance weights is proposed. The controller improves ride comfort without sacrificing ride safety and is robust to parametric uncertainties of the model. To decrease the costs of implementation, various controller reduction tools, are applied to reach the same performance by a lower order controller. System performance using reduced controllers are assessed and compared with each other. Numerical data, time and frequency domain simulations demonstrate the effectiveness of the reduced order controller.

WeB10.3: 13:40-14:00
Robust Optimization of Oil Reservoir Flooding, pp. 699-704

van Essen, Gijs — Delft Univ. of Tech.
Zandvliet, Maarten — Delft Univ. of Tech.
Van den Hof, Paul M.J. — Delft Univ. of Tech.
Bosgra, Okko H. — Delft Univ. of Tech.
Jansen, Jan Dirk — Delft Univ. of Tech.

Over the recent years a variety of new developments have been introduced within the field of oil recovery, with the aim to maximize production of oil and gas from petroleum reservoirs. One of these new developments is the introduction of so-called "smart wells", which are equipped with control valves to actively control the oil production. The optimal operational strategy of these control valves can be found using a dynamic optimization procedure. However, due to geological uncertainty inherent to reservoir modelling, the mismatch between the reservoir model and the real reservoir may become considerable. As a result, a model-based optimal solution may seize to be the optimal, but will yield sub-optimal or even worse results. Within this work a robust optimization approach is presented that takes the possibly large impact of the mismatch between model and reservoir into account using a set of multiple reservoir realizations.

WeB10.4: 14:00-14:20
Robust H-Infinity, H2/H-Infinity Controller for Rotational/Translational Actuator (RTAC), pp. 705-710

Adlgostar, Rahman — K. N. Toosi Univ. of Tech.
Azimian, Hamid — K. N. Toosi Univ. of Tech.
Taghirad, Hamid D. — K. N. Toosi Univ. of Tech.

In this paper, robust controllers have been proposed for oscillation suppression in the RTAC benchmark problem. A nominal plant and an uncertainty model are extracted out of varieties of linear models, identified for the nonlinear system and the generalized plant for the unstructured uncertainty problem has been presented. Based on passivity, a cascade controller has been designed to reduce amount of uncertainty in lower frequencies. It is verified that through a nonlinear feedback controller in the inner loop, the uncertainty of linear estimates of the system reduces significantly, and becomes plausible to use linear robust techniques such as mixed sensitivity and H2/H-infinity to design controller for the system. Finally H-infinity and H2/H-infinity controllers have been designed for new generalized plant and results are compared with the previous reports in literature.

WeB10.5: 14:20-14:40
Control of a Distillation Column: A Decentralized Approach, pp. 711-714

Makaremi, Iman — K. N. Toosi Univ. of Tech.
Labibi, Batool — K. N. Toosi Univ. of Tech.

This paper presents a decentralized controller for a binary distillation column. The interactions between subsystems are considered as uncertainty. Then appropriate local H-infinity problems are defined such that by solving them and applying the designed controller to the system, closed-loop stability and diagonal dominance are guaranteed.

WeB10.6: 14:40-15:00
Nonparametric Identification and Robust H-Infinity Controller Synthesis for a Rotational/Translational Actuator, pp. 715-719

Bagheri, Farzaneh — K. N. Toosi Univ. of Tech.
Purazarm, Sepideh — K. N. Toosi Univ. of Tech.
Taghirad, Hamid D. — K. N. Toosi Univ. of Tech.

In this paper an H-infinity methodology based on nonparametric identification is developed for RTAC benchmark problem. In this nonlinear system, it is required to design a controller to satisfy stabilization and disturbance rejection objectives in spite of limited control effort. In order to design an H-infinity controller, first,the nonlinear system is estimated as a nominal linear system. Moreover, the deviation of the system from the model, which involves nonlinearities, uncertainties, and disturbances, is encapsulated by a multiplicative uncertainty. Then, a robust controller is designed by developing a mixed-sensitivity problem to satisfy all performance requirements. Simulation results illustrate the tracking performance achievements.

WeB11 Audimax
Nonlinear and Robust Control Applications for Mechanical Systems (Invited Session)

Chair: Suzuki, Ryoichi — Kanazawa Inst. of Tech.
Co-Chair: Tibken, Bernd — Univ. of Wuppertal
Organizer: Sawodny, Oliver — Univ. of Stuttgart
Organizer: Suzuki, Ryoichi — Kanazawa Inst. of Tech.

WeB11.1: 13:00-13:20
Semi-Active Switching Vibration Control for Dynamic Absorber Based on the Seismic Frequency (I), pp. 720-725

Abe, Naoto — Meiji Univ.

Dynamic absorber is a famous strategy to suppress a vibration with an additive mass without using any kind of energy. The performance is restrictive than active vibration control devices, however, it is practical use. The resonance curve of the dynamic absorber has two same level peaks which depends on damping coefficients. Hard-damper of the absorber decrease the both peaks. In anti-resonance frequency the gain of soft-damper is lower than hard-damper case. In this paper, an semi-active switching control for the dynamic absorber is considered on the basis of frequency responses by using band pass filter. The semi-active switching control designed adequately has good performance against all type of earthquake by using simulation and experimentation.

WeB11.2: 13:20-13:40
A New Optimization Problem for the Solution of Decision Problems with Applications to Passenger Occupation Detection in Cars (I), pp. 726-727

Tibken, Bernd — Univ. of Wuppertal
Albani, Mike — DELPHI
Fischer, Thomas — DELPHI

In this paper a new optimization problem for decision support is presented and motivated with statistical interpretations. This research was motivated by a real world example from automotive industry. Namely, the problem of passenger occupation detection in cars. It is of fundamental importance to detect the possible occupation of a front seat with a child in order to eventually disarm the corresponding airbag. The main goal of this contribution is to motivate the solution of this problem as an optimization problem and in the next step to reformulate the optimization problem as a convex problem. Some comments on the application to the above mentioned problem will conclude the paper. Due to legal restrictions the application is not outlined in detail but the authors hope that sufficient material is presented in order to show the relevance of this approach.

WeB11.3: 13:40-14:00
GIMC-Based Switching Control of Magnetically Suspended Steel Plates (I), pp. 728-733

Maruyama, Hideto — Nagaoka Univ. of Tech.
Namerikawa, Toru — Kanazawa Univ.

This paper deals with robust control of magnetically suspended steel plates by using a switching control based on Generalized

Internal Model Control (GIMC) structure. First, we derive a mathematical model for the magnetically suspended steel plate. The system is a multi-input and multi-output unstable mechatronic system. Then we design a robust controller which achieves both of high performance and high robustness for the magnetically suspended steel plates. GIMC structure is constructed with a general outer feedback loop and an inner loop. The outer-loop controller is a nominal high performance controller and it can be used for the nominal plant. On the other hand, the inner-loop controllers are designed via the parameterization of a set of stabilizable controllers. Finally, several experimental results show that the designed GIMC structure based switching controller has both of high performance for the nominal plant and the high robustness for the perturbed plants compared with a robust Mu controller.

WeB11.4: 14:00-14:20

Decoupling Property of Full Information H-Infinity Control and Its Application to Mechanical Systems (I), pp. 734-739

Suzuki, Ryoichi — Kanazawa Inst. of Tech.
Tani, Masashi — Kanazawa Inst. of Tech.
Ikemoto, Motoki — Kanazawa Inst. of Tech.
Fujiki, Nobuaki — Kanazawa Inst. of Tech.
Kobayashi, Nobuaki — Kanazawa Inst. of Tech.
Hofer, Eberhard — Univ. of Ulm

In this paper, a limiting property of full information H-infinity control is discussed. Existence of a stabilizing solution to the control problem is shown, and limiting behaviors, i.e., disturbance attenuation property and decoupling property, of the closed-loop system are proposed. Moreover, the relationship with limiting properties of LQ control is also mentioned. To confirm effectiveness of the proposed limiting property of full information H-infinity control, the paper gives experimental results on decoupling control of a 2-link robot manipulator.

WeB11.5: 14:20-14:40

Image-Based Dynamic Visual Feedback Control Via Passivity Approach (I), pp. 740-745

Kawai, Hiroyuki — Kanazawa Inst. of Tech.
Murao, Toshiyuki — Tokyo Inst. of Tech.
Fujita, Masayuki — Tokyo Inst. of Tech.

This paper deals with the image-based dynamic visual feedback control via the passivity approach which is investigated in the position-based one. We construct an energy function using the error in the image plane. The passivity of the visual feedback system is derived from the energy function. We show passivity of the image-based dynamic visual feedback system by combining the passivity of both the visual feedback system and the manipulator dynamics which allows us to prove stability in the sense of Lyapunov. The L2-gain performance analysis, which deals with the disturbance attenuation problem, is then considered via dissipative systems theory. This paper suggests that the two types of classical visual servoing, i.e. the image-based visual servoing and the position-based visual servoing, can be discussed with the same strategy.

WeB11.6: 14:40-15:00

Robust Acceleration and Displacement Control of Electrodynamic Shaker (I), pp. 746-751

Uchiyama, Yasuhiro — IMV Corp.
Fujita, Masayuki — Tokyo Inst. of Tech.

This paper presents an acceleration and a displacement control of an electrodynamic shaker that cannot employ iterative control method freely. In order to extend the controlled frequency band, two controlled variables are employed in each frequency band that a response signal is larger than noise. The acceleration controller is used at higher frequency, and the displacement controller is used at lower frequency. Both controllers are coupled in series. The controllers are designed by using mu-synthesis, and a two degrees of freedom controller is designed to improve the transient response. Finally, the experiment using an actual electrodynamic shaker is carried out. A comparison between the proposed controller and single loop controller is shown.

WeC01 Room 2601
Hybrid Evolutionary-Algebraic Techniques in Control
(Invited Session)

Chair: Werner, Herbert — Hamburg Univ. of Tech.
Co-Chair: Collins, Emmanuel — Florida State Univ.
Organizer: Werner, Herbert — Hamburg Univ. of Tech.

WeC01.1: 15:30-15:50

Application of Robust l_1 Fault Detection and Isolation to an Industrial Benchmark Problem Using a Genetic Algorithm (I), pp. 752-759

Curry, Tramone — Belcan Corp.
Collins, Emmanuel — Florida State Univ.

To aid in the transition of fault detection and isolation (FDI) theory to practice, a realistic, nonlinear industrial diesel engine benchmark was defined by Blanke et al. This paper applies a robust l_1 fault detection and isolation (FDI) technique to this benchmark. Using a linear model and assuming appropriate parametric uncertainty, a bank of robust linear estimators is developed using mixed structured singular value (MSSV) and l_1 theories. To obtain the estimator parameters a real-coded genetic algorithm is used to solve the optimization problem. These estimators are then used to perform FDI of the industrial diesel engine actuator. The results illustrate the power of hybrid evolutionary algebraic techniques for solving important problems in estimation and control.

WeC01.2: 15:50-16:10

Efficient Design of Low-Order H Infinity Optimal Controllers Using Evolutionary Algorithms and a Bisection Approach (I), pp. 760-765

Popov, Andrey — Hamburg Univ. of Tech.
Werner, Herbert — Hamburg Univ. of Tech.

This paper considers a hybrid evolutionary-algebraic approach to the non-convex problem of designing low-order H-infinity optimal controllers. It is shown that using the closed-loop H-infinity norm as fitness measure in a population-based, evolutionary search does not require the computation of the H-infinity norm for each controller of the population. Instead, the fact that evolutionary algorithms assign fitness measures to individuals based on a ranking is exploited and a bisection approach is proposed that allows to trade accuracy that is not needed against computational efficiency without loosing information. Three design examples are used to illustrate the improvement in computational speed achieved with the proposed method.

WeC01.3: 16:10-16:30

Lyapunov-Based Stability Analysis Automated by Genetic Programming (I), pp. 766-771

Grosman, Benyamin — Technion
Lewin, Daniel Roberto — Technion

This contribution describes an automatic technique for detecting maximal domains of attraction for nonlinear systems using genetic programming (GP). The theoretical basis for the work is Lyapunov's Direct Method, which provides sufficient conditions for the existence of a region of attraction of a stable focus. In work presented here, our GP approach for defining Lyapunov functions that accurately predict the maximum region of attraction has been extended by defining a target function accounting for level sets. We demonstrate the approach on the analysis of two dynamic systems: (a) van der Pol's equation, which features both a stable and unstable limit cycle; and (b) a model of an exothermic, continuous stirred tank reactor (CSTR), whose stable trajectories tend to move away from the origin before converging.

WeC01.4: 16:30-16:50

Design of LQG Controllers for VSC HVDC Transmission Links Using Genetic Algorithms (I), pp. 772-777

Durrant, Martyn — Hamburg Univ. of Tech.
Werner, Herbert — Hamburg Univ. of Tech.
Abbott, Keith — Areva T&D Power Electronic Activities

In this paper a genetic algorithm (GA) approach to designing controllers for a VSC HVDC terminal are described. The controller is required to have good time domain performance, actuator usage roll-off and robustness across a range of

operating points. Suitable controllers are found by direct search for LQG controllers that fulfill the series of performance and robustness objectives at characteristic points within the operating range, as built into an objective function suitable for use with genetic algorithms. The idea is extended to include as extra variables the elements of the constant Youla Parameter associated with the LQG controller. Different formulations of the objective function are discussed and compared and the results demonstrated on a non-linear model of the plant.

WeC01.5: 16:50-17:10
Robust Control of a Class of LPV Systems - a Combined Evolutionary - LMI Approach (I), pp. 778-783

Farag, Adel Omram	Hamburg Univ. of Tech.
Werner, Herbert	Hamburg Univ. of Tech.

In this paper, recent analysis results on robust stability of linear parameter-varying (LPV) systems are used to develop a synthesis procedure for robust controller design that takes known bounds on the rate of parameter variation into account. This is achieved by first replacing robust stability conditions which take the form of linear matrix inequalities with an algebraic Riccati equation that is parameterized by a quadratic separator. The synthesis problem is then solved with a DK-iteration type of approach, where alternatingly the controller and the quadratic separator are fixed. In the K-step a combination of Riccati solver and evolutionary search is used to find the controller, and in the D-step an LMI problem is solved for the separator. An advantage of the new method is that dynamic order and structure of the controller (e.g. decentralized) can be freely chosen. A numerical design example is provided to illustrate the practicality and numerical efficiency of the proposed method.

WeC01.6: 17:10-17:30
Adaptive PBIL Algorithm and Its Application to Solve Scheduling Problems, pp. 784-789

Pang, Hali	Northeastern Univ.
Hu, Kunyuan	Shenyang Inst. of Automation
Hong, Zongyou	Northeastern Univ.

An adaptive population-based incremental learning algorithm (APBIL) is presented basing on analyzing the characteristics of traditional PBIL algorithm in this paper. Overcoming disadvantages of traditional PBIL algorithm, the proposed APBIL algorithm can adjust learning rate and mutation probability automatically according to the evolution degree of the algorithm's searching performed. Extensive computational tests with Flow shop and Job shop scheduling problems are carried out. The results compared with standard PBIL algorithm's and genetic algorithm's show that the proposed algorithm exceed the traditional PBIL algorithm and GA in calculation efficiency and search capability. The proposed algorithm can acquire stable high quality solution.

WeC02 Room 1601
Computer-Aided Design of the Control of Fluid Power Systems (Invited Session)

Chair: Ferreira, Jorge Augusto Fernandes	Univ. of Aveiro
Co-Chair: Mann, Herman	Czech Tech. Univ.
Organizer: Ferreira, Jorge Augusto Fernandes	Univ. of Aveiro

WeC02.1: 15:30-15:50
Modeling Pneumatic Servovalves Using Neural Networks (I), pp. 790-795

Falcao Carneiro, Joao	Univ. of Porto
Gomes de Almeida, Fernando	Univ. of Porto

This paper presents a study where static models of the flow stage of a 3/2 pneumatic servovalve are obtained using artificial neural networks. For simulation purposes, a direct model is proposed in which the mass flow is determined for a given working pressure and command input. For control purposes, an inverse model is proposed in which the command input is determined given the working pressure and the desired mass flow. This approach enables the use of mass flow as the synthesised control action, thus rendering the overall pneumatic system affine. Therefore, control techniques requiring this condition on the system model can be directly used. Under normal working conditions, both servovalve models provide an excellent agreement with experimental results taken from an industrial pneumatic servovalve.

WeC02.2: 15:50-16:10
Joint Space Controller Design for Electrohydraulic Servos (I), pp. 796-801

Davliakos, Ioannis	National Tech. Univ. of Athens
Zafiris, Athanassios	National Tech. Univ. of Athens
Papadopoulos, Evangelos	National Tech. Univ. of Athens

This paper focuses on the joint space control of mechanical systems with electrohydraulic servos. Using mechanism inverse kinematics, desired Cartesian trajectories yield desired actuator trajectories, which are fed to a novel model-based controller. Rigid body equations of motion and hydraulics dynamics, including friction and servovalve models are employed. The developed feedback controller uses the system dynamic and hydraulic model to yield servovalve currents. As an example, the developed controller is applied to a single degree-of-freedom (dof) servomechanism. Identification procedures employed in estimating the physical parameters of the experimental single dof servomechanism are discussed. In contrast to other approaches, here, force, pressure or acceleration feedback is not required. Simulations with typical desired trajectory inputs are presented and a good performance of the controller is obtained.

WeC02.3: 16:10-16:30
Control of a Servo-Pneumatic Gripper with Individually Movable Jaws (I), pp. 802-806

Gauchel, W.	RWTH Aachen Univ.
Schell, Ralf	FLUIDON GmbH

The paper describes the control of a servo-pneumatic gripper with individually movable jaws. After the description of the developed gripper, the position controller, which uses an observer to generate a velocity signal, is introduced. The observer is created and parameterized with the Simulation Tool DSHplus so that an easy creation and usage also for people with a miner comprehension of non-linear-pneumatic systems is guaranteed. At least some measurement results are shown. By means of the good positioning accuracy with a deviation smaller of 0.1 mm the operability and the capability of the presented controller system can be demonstrated.

WeC02.4: 16:30-16:50
Robust Force Control in a Hydraulic Workbench for Flight Actuators (I), pp. 807-813

Di Rito, Gianpietro	Univ. of Pisa
Galatolo, Roberto	Univ. of Pisa
Denti, Eugenio	Univ. of Pisa

The work deals with the design of the force control in a hydraulic workbench for primary flight actuators, to be used for hardware-in-the-loop simulations of a modern Fly-By-Wire Flight Control System. For this application, a high-bandwidth force response is needed in order to simulate aerodynamic loads on the control surfaces, but plant uncertainties can imply significant limitations. The variation of structural stiffness, due to hinge play and hinge local deformation, the uncertainties related to the flight actuator stiffness and the ones related to the hydraulic plant parameters lead to the necessity of a robust approach to the design of the force control. In the paper, a nominal LTI model of the plant is developed and the closed-loop force control is designed by means of a loop-shaping approach for different values of the bandwidth. The stability of the closed-loop force-controlled system is then verified by a robustness analysis, assuming the structural stiffness, the flight actuator stiffness, and some of the hydraulic plant characteristics as uncertain parameters. The bandwidth of the force control is determined by finding an optimal compromise between dynamic performance and stability margin. Finally, in order to overcome the additional problems related to the flight actuator movements due to aircraft manoeuvres, a compensation feedback based on the flight actuator acceleration is proposed.

WeC02.5: 16:50-17:10
Design and Control of a Hydraulic Press (I), pp. 814-819

Ferreira, Jorge Augusto Fernandes	Univ. of Aveiro
Sun, Ping	Univ. of Aveiro
Gracio, Jose	Univ. of Aveiro

The present paper describes the development of a 100kN hydraulic actuated press to perform aluminum stamping operations as well as mechanical tests. The press has two hydraulic servomechanisms: a hydraulic cylinder, driven by a servo-solenoid flow control valve, to support the punch tool; a hydraulic cylinder, where the chamber pressure is controlled by a servo-solenoid pressure control valve, to support the operations of loading and unloading of the press blank holder. A real time DSP based control card form dSPACE, which is directly programmed by the Matlab/Simulink environment, is used to implement the control and monitoring tasks and to perform data acquisition. The cylinders piston positions and chambers pressures are acquired with two optical scales and with analogue pressure sensors, respectively. The software setup allows the implementation of a hybrid controller (force + position) for the punch in such a way that it will be easy to switch between position and/or force control. A computer vision system is also integrated with the press control system in order to measure experimental data based on video images. An experiment to automatically measure the springback angle on an aluminum stamping operation is used, as an example, to show the functionality of the overall control and instrumentation systems.

WeC02.6: 17:10-17:30
Construction and Control of Massive Hydraulic Miniature-Actuator-Sensor Array (I), pp. 820-825

Zhu, Haihong	Georgia Inst. of Tech.
Book, Wayne J.	Georgia Inst. of Tech.

Massive actuator arrays have found applications in robotics, pharmaceutics, aerospace, etc. Compared with either electrically or pneumatically powered actuator arrays, a hydraulic array has the advantages of higher force density (i.e. force / actuation volume), better controllability, and simpler remote control accessibility. This paper presents approaches to construct and control a massive hydraulic miniature actuator array. The massive hydraulic actuator array was originally constructed for project “Digital Clay” (a novel hydraulic actuated human machine interface device) as a tangible human and machine interaction media. A pin-rod planar actuator array is investigated in this work. In this paper, designs of the practical kinematical structure are discussed, proposed control methods for the actuator array are introduced and experiment results are presented.

WeC03 Room 0670
Reinforcement and Iterative Learning Control
(Regular Session)

Chair: Moore, Kevin L.	Colorado School of Mines
Co-Chair: Rogers, Eric	Univ. of Southampton

WeC03.1: 15:30-15:50
Model-Free Learning Control for Processes with Constrained Incremental Control, pp. 826-831

Syafiie, Syam	Univ. of Valladolid
Tadeo, Fernando	Univ. of Valladolid
Martinez, Ernesto	CINCT Santa Fe

This paper proposes a technique to design controllers for systems with constrained incremental control and input-output constraints called Model-Free Learning Control (MFLC). MFLC, which is based on Reinforcement Learning algorithms, is a simple approach without needing precise detailed information of the system. MFLC is proposed for process control, which in practical problems exhibit constraints. As a simple example, the controller is designed and tested for a two-tank system. Simulation results show that the MFLC controller learns to adequately control the process.

WeC03.2: 15:50-16:10
Intermittent Iterative Learning Control, pp. 832-837

Ahn, Hyo-Sung	Utah State Univ.
Chen, YangQuan	Utah State Univ.
Moore, Kevin L.	Colorado School of Mines

In this paper we present a mathematical formulation of the problem of robust iterative learning control (ILC) design when the system is subject to data dropout. It is assumed that an ILC scheme is implemented via a networked control system (NCS) and that during the data transfer from the remote plant to the ILC controller data dropout occurs, resulting in what we call intermittent measurement. Using the Kalman filtering approach, we show that it is possible to design a learning gain such that the system eventually converges to a desired trajectory as long as there is not complete data dropout.

WeC03.3: 16:10-16:30
Comparing the Performance of Two Iterative Learning Controllers with Optimal Feedback Control, pp. 838-843

Ratcliffe, James David	Univ. of Southampton
Lewin, Paul	Univ. of Southampton
Rogers, Eric	Univ. of Southampton

The tracking performance of two iterative learning control algorithms is compared to that, which can be achieved by an optimal feedback controller. P-type iterative Learning Control in parallel with a proportional feedback controller is compared with norm-optimal iterative learning control, then both ILC systems are compared with the performance achieved by an optimal feedback controller. Considering that the ILC plus proportional controller requires no prior modelling of the plant and minimal adjustment of gains, the tracking performance in terms of mean squared error (mse) per iteration can be reduced by two orders of magnitude further than can be achieved with the optimal feedback controller. However, the Norm-Optimal ILC improves upon this performance by reducing the mse by an extra order of magnitude. The experimental results are derived from tests performed on a gantry robot.

WeC03.4: 16:30-16:50
Iterative Learning Control of Perspective Dynamic Systems, pp. 844-849

Ma, Lili	Virginia Tech.
Moore, Kevin L.	Colorado School of Mines
Chen, YangQuan	Utah State Univ.

This paper introduces the problem of iterative learning control (ILC) for perspective dynamic systems (PDS), referred to as ILC-PDS, where the task is to track a 3-D desired trajectory from information observed on the image plane of an imaging system, such as a camera. Unlike many ILC implementations in motion control applications, which use feedback from encoders, we assume measurements from the image plane are used as feedback to the ILC system. We focus our analysis on 2-D motion with a 1-D perspective measurement. It is shown analytically and via simulation that under the standard ILC assumption of identical initial conditions from trial-to-trial, tracking in the 2-D space can be achieved using the 1-D PDS image feedback.

WeC03.5: 16:50-17:10
Development of Reinforcement Learning Methods in Control and Decision Making in the Large Scale Dynamic Game Environments, pp. 850-855

Orafa, S.	Tehran Univ.
Yazdanpanah, M. J.	Tehran Univ.
Lucas, Caro	Tehran Univ.
Rahimi-Kian, Ashkan	Tehran Univ.
Nili Ahmadabadi, Majid	Tehran Univ.

In this paper, an analytical comparison is done between dynamic programming and reinforcement learning methods in dynamic two-player games. The emphasis is on the large number of states and actions available for each player and different conflictive optimization objectives of these games that make them complicated in modeling and analysis. Optimization and decision making is done through quantifying a modified Q-Learning algorithm. By this method, it is shown that the information processing in large scale-long stage games will take shorter times and will result in lower decision costs whereas dynamic programming methods cannot handle them across long time-horizons.

WeC04 Room 2605
Hybrid and Switched Systems (Regular Session)

Chair: Sahajpal, Anurag Bergen Univ. Coll.
Co-Chair: Ji, Zhijian Qingdao Univ.

WeC04.1: 15:30-15:50
Preliminary Results on Null Controllable Region of Discrete-Time Switched Linear Systems with Input Saturation, pp. 856-861

Ji, Zhijian Qingdao Univ.
Guo, Xiaoxia Ocean Univ. of China
Xu, Shixu Qingdao Univ.
Wang, Long Beijing Univ.
Xie, Guangming Beijing Univ.

Geometric properties of null controllable region of discrete-time switched linear systems with input saturation are studied. We show that the null controllable region is not convex in general and is centrally symmetric. Under certain conditions, it can be well approximated by a nondecreasing region sequence. It is also shown that the null controllable region is contained in the Minkowski sum of null controllable regions of all its sub-switched systems.

WeC04.2: 15:50-16:10
Consensus Behavior of Agents in Networked Systems under General Communication Topologies, pp. 862-867

Xiao, Feng Beijing Univ.
Wang, Long Beijing Univ.

In this paper, we study consensus problems and some related topics in networked dynamic systems with single-integrator dynamics. First, by introducing two useful definitions: "leader" and "follower" with respect to consensus functions, the consensus property of systems will be well characterized. For systems with general weakly connected communication topologies, we partition the agents into two groups: boundary agents and internal agents, and prove that the states of internal agents will converge to a convex combination of boundary agents. Finally, we extend the same idea to the formation control of vehicles and obtain some useful results.

WeC04.3: 16:10-16:30
Disturbance Attenuation of Discrete-Time Switched Linear Systems, pp. 868-873

Ji, Zhijian Qingdao Univ.
Yu, Haisheng Qingdao Univ.
Guo, Xiaoxia Ocean Univ. of China
Wang, Long Beijing Univ.

Based on multiple Lyapunov functions methodology, we study disturbance attenuation of discrete-time switched linear systems. A bilinear matrix inequalities (BMIs) based condition is derived to stabilize the switched system with a prescribed disturbance attenuation level gamma when only switching can be utilized in the control of systems. This condition can be dealt with as linear matrix inequalities (LMIs) if the associated scalars are selected in advance. Then the synthesis problem via switched state feedback is studied. All the switching rules adopted are state dependent and are constructively designed.

WeC04.4: 16:30-16:50
Optimization of THD and Suppressing Certain Order Harmonics in PWM Inverters Using Genetic Algorithms, pp. 874-879

Sayyah, Arash Shahid Beheshti Univ.
Aflaki, Mitra Sharif Univ. of Tech.
Rezazade, Ali Reza Shahid Beheshti Univ.

In this paper the aim is to minimize the total harmonic distortion (THD) in PWM inverters while suppressing chosen harmonics concurrently and maintaining the fundamental component of the output voltage at a required level. This is reformed as an optimization task and the optimal pulse patterns are accomplished using genetic algorithm (GA) optimization technique to minimize a predefined fitness function. The complete solutions that suppress the 5th and 7th harmonics and optimize the THD are given. A practical limitation on the determination of sequential switching angles has been considered as a set of constraints in derivation of the results.

WeC04.5: 16:50-17:10
Transcription of Text by Incremental Support Vector Machine, pp. 880-884

Sahajpal, Anurag Bergen Univ. Coll.
Kristensen, Terje Bergen Univ. Coll.

This paper deals with an on-going work aimed at developing a Suport Vector Machine (SVM) based incremental learning algorithm in the domain of text-based phoneme transcription for Norwegian language. The motivation for this is to reduce the long computation time witnessed in the batch-learning scenario. A standard SVM algorithm is modified in such a way that it incorporates the new data as it becomes available in time. The transcription scheme used is SAMPA for Norwegian. We conclude the paper with a discussion on further research in this direction.

WeC05 Room 0601
Automotive II (Regular Session)

Chair: Bajcinca, Naim German Aerospace Center
Co-Chair: Nuthong, Chaiwat Univ. of Armed Forces Munich

WeC05.1: 15:30-15:50
Predictive Estimation of the Road-Tire Friction Coefficient, pp. 885-890

Holzmann, Frederic Siemens VDO Automotive
Bellino, Mario Ecole Pol. Fed. Lausanne
Siegwart, Roland Ecole Pol. Fed. Lausanne
Bubb, Heiner Tech. Univ. Munich

The road-tire friction coefficient μ is as fundamental information for the algorithms dealing with the vehicle dynamics with high accuracy like in emergency cases. This paper introduces a new predictive methodology for the estimation of μ by using a camera and a microphone. After a description of the limits of the current methodologies, the new concept will be described step-by-step by following the data flow. The algorithm extracts the patterns orresponding of the different μ depending on the general luminance. These patterns will be matched on the current specimens to deduce the friction coefficient along the road ahead and a confidence value. Finally the results will be auto-correlated over the time to improve their stability. Moreover the reliability will be improved over a correlation with local measures based on microphone.

WeC05.2: 15:50-16:10
Non-Local Extremum Seeking Control for Active Braking Control Systems, pp. 891-896

Tanelli, Mara Pol. di Milano
Astolfi, Alessandro Imperial Coll. London
Savaresi, Sergio M. Pol. di Milano

A non-local extremum seeking control approach for active braking control systems is proposed. The typical design objective in electronic Anti-lock Braking Systems is to regulate the wheel slip as close as possible to the peak of the friction curve in any road condition. Accordingly, this control problem naturally fits the extremum seeking framework, as the output–to–reference map exhibits a global maximum and the control purpose is to select the set-point value so as to keep the output as the extremum value. To fulfill the requirements for an extremum seeking control scheme a parametric stabilizing feedback control law is devised via Lyapunov-based methods. A discussion on parameters' tuning is provided, which highlights the trade-offs in designing an extremum seeking controller. The effectiveness of the proposed approach is assessed via simulations.

WeC05.3: 16:10-16:30
A New Strategy for Lane Departure Avoidance, pp. 897-902

Minoiu, Nicoleta INRETS
Netto, Mariana INRETS
Mammar, Said Univ. Evry Val d'Essonne
Glaser, Sébastien INRETS

In this paper we present a vehicle steering assistance to avoid lane departure during driver inattention. A switching control strategy and a linear state feedback control have been developed to this end. Lyapunov and LMI methods have been used to optimized the control, confining its transient response during the assistance activation.

WeC05.4: 16:30-16:50
Sideslip Angle, Lateral Tire Force and Road Friction Estimation in Simulations and Experiments, pp. 903-908
Baffet, Guillaume — Univ. of Tech. Compiegne
Charara, Ali — Univ. of Tech. Compiegne
Stephant, Joanny — Univ. Limoges

Transversal tire forces and sideslip angle are essential data for improving vehicle safety, handling, steerability, comfort and performance. This paper proposes and compares four observers designed to calculate vehicle sideslip angle and lateral tire forces. The different observers are derived from the Extended Kalman filter (EKF), the single-track model, and use different on tire-force models. The first three tire-force models are the linear model, the Burckhardt model and the Pacejka model. The remaining tire-force model, the "linear adaptive" model, is proposed in this paper in order to construct an adaptive observer. The "linear adaptive" model is based on the linear model, but with an additional variable used to correct wheel cornering stiffness errors. The paper describes models and observers, along with a road-friction identification method. Observers are first compared in a simulation context using a professional vehicle simulator. Subsequently, observers are applied to real experimental data acquired on the Heudiasyc Laboratory car.

WeC05.5: 16:50-17:10
Design of Active Steering and Intelligent Braking Systems for Road Vehicle Handling Improvement: A Robust Control Approach, pp. 909-914
Baslamisli, Caglar — Bogazici Univ.
Kose, Emre — Bogazici Univ.
Anlas, Gunay — Bogazici Univ.

Linear Matrix Inequality (LMI) based robust control tools are used for the design of active steering and intelligent braking controllers for handling improvement of road vehicles. Vehicle plane dynamics are expressed in the generic Linear Parameter Varying (LPV) form and static state feedback controllers ensuring robust performance against changing road conditions are designed. First, stable braking on split mu road is taken into consideration. Simulations reveal efficiency of active steering when compared to intelligent braking, ensuring both high vehicle deceleration and low yaw rate and body side slip angle build-up for relatively high mu gradient. Second, the performance of intelligent braking is tested during cornering maneuvers on low mu roads. In all cases, it is shown that static state feedback controllers obtained by the proposed design method can achieve acceptable road handling performance.

WeC05.6: 17:10-17:30
Adaptive Headlight System Design Using Hardware-In-The-Loop Simulation, pp. 915-920
Hacibekir, Tahsin — Istanbul Tech. Univ.
Karaman, Sertac — Istanbul Tech. Univ.
Kural, Emre — Istanbul Tech. Univ.
Ozturk, Eyup Serdar — Istanbul Tech. Univ.
Demirci, Murat — Istanbul Tech. Univ.
Aksun Guvenc, Bilin — Istanbul Tech. Univ.

According to traffic accident data, the majority of severe road accidents occur at night. It is, therefore, of great importance to use available technology to contribute to road safety by improving the visual conditions provided by vehicle headlights. This paper presents the hardware in the loop simulation of an Adaptive Headlight System for motor vehicles. The Adaptive Headlight System is an active safety system, where the headlamp orientation control system rotates the right and left low beam headlights independently and keeps the beam as parallel to the curved road as possible to provide better night time visibility. In the paper, the real time vehicle and road models used are presented first. The hardware-in-the-loop simulation setup proposed for testing the adaptive headlight concept is then given. Real time simulations using this simulator are used to illustrate the approach.

WeC06 Room 0602
Human-Centered Applications II (Regular Session)
Chair: Guelton, Kevin — Univ. de Champagne-Ardenne
Co-Chair: Buss, Martin — Tech. Univ. Munich

WeC06.1: 15:30-15:50
Disturbance Estimation by Generalized Internal Model Control and Its Application to Assistive Devices for Rehabilitation Technology, pp. 921-926
Suzuki, Ryoichi — Kanazawa Inst. of Tech.
Hofer, Eberhard — Univ. of Ulm
Tani, Masashi — Kanazawa Inst. of Tech.
Fujiki, Nobuaki — Kanazawa Inst. of Tech.
Furuya, Shigehiko — Kanazawa Tech. Coll.
Kobayashi, Nobuaki — Kanazawa Inst. of Tech.

Control applications to life science are significant for the development interacting with humans. Assistive devices for rehabilitation technology will be used by elderly or disabled people in order to support more life independence. For the interaction with humans, safety and reliability conditions have to be fulfilled, and control design methods for assistive devices have to be robust against parameter perturbations. To improve these situations, disturbance estimation property of the generalized internal model control (GIMC) design is applied. The effectiveness of the GIMC design is confirmed by experimental case studies for assistive devices.

WeC06.2: 15:50-16:10
H-Infinity Takagi-Sugeno Fuzzy Control of a Lower Limbs Rehabilitation Device, pp. 927-932
Seddiki, Lynda — Univ. of Reims
Guelton, Kevin — Univ. of Reims
Mansouri, Badr — Univ. of Reims
Zaytoon, Janan — Univ. of Reims

This paper deals with the nonlinear control of a lower limbs isokinetic rehabilitation device based on a Takagi-Sugeno modeling. A Parallel Distributed Compensation control law is used to stabilize the closed-loop system in the whole operational space. The human force applied to he device's arm is considered as an external disturbance to the system dynamics. To attenuate this disturbance, an H-infinity criterion is considered and classical stability conditions were adapted for a class of external perturbed TS model. The voluntary control of the movement by the patient is finally proposed with the use of a discrete state machine.

WeC06.3: 16:10-16:30
Complementary Limb Motion Estimation Based on Interjoint Coordination Using Principal Components Analysis, pp. 933-938
Vallery, Heike — Tech. Univ. Munich
Buss, Martin — Tech. Univ. Munich

For the restitution of walking of a hemiplegic patient by means of a motorized orthosis, as well as in intelligent prosthetics, a major challenge is the coordination of healthy and robotically assisted limbs. The approach suggested here employs the method of Principal Components Analysis to first analyze the coupling of human Degrees of Freedom (DoFs) in healthy subjects. Based on this knowledge, adequate motion for inoperable DoFs in impaired patients is estimated on-line from sound limb motion. Thus, the intention of a partially paralyzed person or an amputee can be deduced from residual body motion, in order to coordinately actuate or supervise the impaired limbs. To evaluate the approach, simulations with recorded gait trajectories of healthy subjects are performed. The results of these theoretical investigations show a promising potential.

WeC06.4: 16:30-16:50
Neuro-Fuzzy Control of a Power Assist Omni-Directional Wheelchair to Enhance Maneuverability, pp. 939-946
Urbano, Juan — Toyohashi Univ. of Tech.
Terashima, Kazuhiko — Toyohashi Univ. of Tech.
Kitagawa, Hideo — Gifu National Coll. of Tech.

For helping attendants of handicapped people and elderly people, a power assist system has been added to an Omni-directional Wheelchair (OMW). With this addition it is possible

for the attendants to deal with heavy loads, but there is a problem of operability when the attendants want to move the OMW laterally or rotate around OMW's Gravity Center. In this paper, for solving this problem, a fuzzy reasoning method has been proposed for estimating the navigation direction according to the force added by the attendants to the handgrips of the handle of the OMW. A neuro-fuzzy system (ANFIS) is used for the tuning of the membership functions of the fuzzy system according to each attendant's characteristics, by using the input data of the attendants.

WeC06.5: 16:50-17:10
H-Infinity Controller Synthesis for a Physiological Motor Control System Modeled with Bond Graphs, pp. 947-952
Mughal, Asif — Univ. of Arkansas at Little Rock
Iqbal, Kamran — Univ. of Arkansas at Little Rock

Physiological structures exhibit complex characteristics for postural stability and movements. These structures consist of muscles, muscle spindles, Gologi tendon organs and neural activation mechanism etc. In this paper physiological models are studied with bond graph modeling technique, which provides new prospective to study physiological components and combined musculoskeletal system via flow of power. The central nervous controller for muscle activation is designed and analyzed with H-infinity optimal controller. This controller design optimizes the output of the musculoskeletal structures in the presence of neural activity and disturbance toques to the joints. Simulation results are provided for the different physiological variables for postural stability of a single link biomechanical model with proprioceptive feedback and H-infinity controller design.

WeC06.6: 17:10-17:30
Nearly Time-Optimal Point to Point Navigation Control Design for Power Wheelchair Dynamics, pp. 953-959
Atesoglu, Ozgur — Aselsan Inc.

This study focuses on a specific type of power wheelchair driven by rear wheels using direct drive BLDC electrical motors. The speed and direction of the wheelchair is mainly controlled by means of a joystick for man in the loop steering. For autonomous steering, the linear and angular velocity commands are generated by means of a velocity command generator rather than a joystick.

Throughout this study both speed and maneuvering capabilities are investigated for the designed wheelchair model. The rear wheels are actuated differentially in order to gain both speed and maneuvering motions. The desired motion in “velocity” sense is ready to be given by means of joystick commands and distributed to left and right rear wheels. The dynamics of the wheelchair is divided into linear and nonlinear parts and the controller is designed on the linear part of the dynamics. The nonlinear part of the dynamics is left as the disturbance torque.

Linear part of the dynamics is treated as a simple second order mass and damper system. A discrete time proportional with integral (PI) type controller is designed for the velocity control loop. The position loop is closed with a simple gain which is regulating the error of the incremental angle motion of the wheels. The incline, rolling friction and cg offset from wheel shaft are left in the nonlinear dynamics part and treated as the disturbance torque on the actuator motors. This is decoupled from the motors by using the inverse of the torque constant of the motor as the disturbance input decoupler (DID) term.

The velocity command generator, originating from nearly time-optimal point to point navigation, is designed. The problem is formed as a mixed type two point boundary value problem (TPBVP). By using the kinematics of the wheelchair the optimal trajectories are found. The co-state numerical time evolution is integrated with the nonlinear dynamics and the designed velocity controllers. Simulations are done for analyzing the fidelity of the modeling, performance of the controller and guidance by means of optimal trajectory generated autonomous movement for point to point navigation. The results are presented graphically and conclusion is made.

WeC07 Room 0606
Model Predictive Control II (Regular Session)
Chair: Heine, Thomas — Tech. Univ. Berlin
Co-Chair: Bernard, Thomas — Fraunhofer IITB

WeC07.1: 15:30-15:50
Nonlinear Model Predictive Control of a Glass Forming Process Based on a Finite Element Model, pp. 960-965
Bernard, Thomas — Fraunhofer IITB
Ebrahimi Moghaddam, Ehsan — Fraunhofer IITB

A complex glass forming process as an example of a complex, nonlinear distributed parameter system is investigated. The system is modeled by four coupled and strongly nonlinear partial differential equations (Trouton model) which are numerically solved by Finite Element method (FEM). As large steps in the setpoint can hardly be controlled with linear controllers and the the controlled variables can only be measured with dead time we investigate nonlinear model predictive control (NMPC) as control methodology for the forming process. The use of FEM models in NMPC has not attracted much attention so far although it has a huge potential for process optimization. One reason for the absence of FEM models in control engineering is that the calculation of FEM models in many cases are very time consuming. Hence the NMPC scheme is designed in a way that a trade-off between computational effort and control performance is met. A large step in the setpoint of the two controlled variables (diameter and cross section area of the tube) is investigated as a realistic scenario. The impact of important design parameters of the NMPC is worked out. The good performance of the control and its potential for industrial application is shown.

WeC07.2: 15:50-16:10
Analysis of Nonlinear Predictive Control with Extended Dynamic Matrix Control, pp. 966-971
Fischer, Matthias — Univ. of Applied Sciences Jena

In this paper a procedure for nonlinear predictive control is analyzed. To demonstrate the performance of the procedure a process described by a nonlinear differential equation (NDE) is used. The predictive algorithm operates with an empirical model of the process. Due to the nonlinear behavior of the system, a Multilayer Percepton (MLP) is used for identification. In this paper a brief characterization of the identification with the MLP is given. After this the predictive algorithm is analyzed and explored with simulations. The predictive controller is compared with a PID- controller. Further, the behavior of the controller in presence of disturbances and various parameter adjustments is examined.

WeC07.3: 16:10-16:30
Predictive Control As an Intelligent Tool to Manage Water Distribution Networks, pp. 972-977
Figueiredo, Joao Manuel — Univ. Evora
Sa da Costa, Jose — Tech. Univ. Lisbon

Fresh water is becoming a major concern in actual societies as it represents only 2.5% of the total Earth water reserves. Some recent studies point the year 2025 when 2 of every 3 persons will be affected by the lack of fresh water. This paper presents a Predictive Controller strategy that is implemented on a modern automated water canal where sensors and actuators are controlled via a PLC (Programmable Local Controller) network supervised by a SCADA system (Supervisory Control And Data Acquisition). This canal prototype is composed by a set of distributed sub-systems that manage local control to assure the water level in each canal pool, defined by discharge gates (control variable) and water off-takes (disturbances). All local controllers are connected through an industrial network to be assessed by a SCADA system where the global overview and the centralized Predictive Control algorithm is running. Extreme severe situations have been simulated and the obtained results proved the very good robustness of the developed controller.

WeC07.4: 16:30-16:50
GPC Control Design for a Temperature and Humidity Prototype Using ICD Analysis, pp. 978-983
Liceaga-Castro, Jesus Ulises ITESM-CEM
Ramírez España, Carlos Isaac ITESM-CEM
Liceaga-Castro, Eduardo SEPI ESIMI Ticomán IPN

In this paper the design of a multivariale control system for an air conditioning process is presented. The controller design is based on the classical Generalized Predictive Control (GPC) scheme, while the resulting stability, robustness and performance properties are analysed in the context of Individual Channel Design (ICD). The design specifications in this work are those established by the Mexican Goverment Metrology Office (Centro Nacional de Metrología, México); it indicates that the temperature and humidity values must be kept within certain ranges. The designed control system has been tested using the Gunt Hamburg ET605 Recirculating Air Conditioning Trainer. Real time results are included in order to show the excellent performance of the control design.

WeC07.5: 16:50-17:10
Stability Analysis for Generalized Predictive Control (GPC) with Different Classes of Uncertain Systems, pp. 984-989
Gomma, H. W. Univ. of Helwan

This paper presents stability analysis for the well known generalised predictive control (GPC) when dealing with different classes of uncertain systems namely systems with unmodelled poles, uncertain gains and uncertain poles. The proposed analysis is based on the explicit relation between the system transfer function and the step response coefficients. It reveals part of the mystery behind the stability strength of the GPC.

WeC08 Room 2607
Sliding Mode Control (Regular Session)
Chair: Brandtstaedter, Heide Tech. Univ. Munich
Co-Chair: Acarman, Tankut Galatasaray Univ.

WeC08.1: 15:30-15:50
Cost Functional Minimizing Sliding Mode Control Design, pp. 990-995
Fischer, Christian Tech. Univ. Munich
Brandtstaedter, Heide Tech. Univ. Munich
Utkin, Vadim I. Ohio State Univ.
Buss, Martin Tech. Univ. Munich

In this paper, a three-step method is proposed to design a sliding mode control strategy, that provides optimal system dynamics with respect to a given cost functional. The method is based on methods of constrained continuous dynamic optimization. It allows a systematic control unit design and therefore reduces the time to find an appropriate sliding mode control law. The proposed technique is successfully applied to the position control of a three-phase permanent magnet synchronous motor. During operation, the dissipative power loss of the machine is minimized.

WeC08.2: 15:50-16:10
Sliding Mode Control Design with Time Varying Sliding Surfaces for a Class of Nonlinear Systems, pp. 996-1001
Salamci, Metin U. Gazi Univ.
Tombul, G. Serdar Middle East Tech. Univ.

This paper presents sliding mode control (SMC) design for a class of nonlinear systems in which the sliding surface is designed to be linear with time varying slope(s). The sliding surface design is based on the frozen-time approach. The nonlinear system is frozen at each operation step resulting in linear time invariant (LTI) model and the sliding surface is designed for the LTI model. The surface slope is updated at each frozen step which gives, in general, a moving sliding surface. The control term, on the other hand, is designed so that the moving sliding surface is reached in a finite time. Therefore sliding mode is achieved and the nonlinear system is restricted to stay on the moving sliding surface. We demonstrate the design methodology developed in this study on an inverted pendulum model. The simulation results show the success of the method.

WeC08.3: 16:10-16:30
Sliding Mode Servomechanism Design, pp. 1002-1007
Acarman, Tankut Galatasaray Univ.
Ozguner, Umit Ohio State Univ.

In this paper, a frequency-shaped optimal sliding mode approach combined with Lyapunov based backstepping design is presented to solve the robust servomechanism problem. The parametric uncertainties, unmodeled dynamics and uncertain exogenous disturbance belonging to a specified class are attenuated by using compensator dynamics introduced in sliding mode through an augmented dynamic sliding surface.

WeC08.4: 16:30-16:50
An Adaptive Sliding Mode Control Law for Induction Motors Using Field Oriented Control Theory, pp. 1008-1013
Barambones, Oscar Univ. of the Basque Country
Garrido, Aitor J. Univ. of the Basque Country
Maseda, Francisco J. Univ. of the Basque Country
Alkorta, Patxi Univ. of the Basque Country

In this paper, an indirect field-oriented induction motor drive with a sliding-mode controller is presented. The proposed sliding-mode control law incorporates an adaptive switching gain that avoids calculating an upper limit of the system uncertainties. The design also includes rotor speed computation from measured stator terminal voltages and currents. The calculated speed is used as feedback in an indirect vector control system achieving the speed control without the use of shaft mounted transducers. Stability analysis based on Lyapunov theory is also presented, to guarantee the closed loop stability. Finally simulated results show on the one hand that the proposed controller with the proposed estimator provides high-performance dynamic characteristics, and on the other hand that this scheme is robust with respect to plant parameter variations and external load disturbances.

WeC08.5: 16:50-17:10
Optimal Sliding-Mode Guidance Law for Fixed-Interval Propulsive Maneuvers, pp. 1014-1018
Bahrami, Mohsen Amirkabir Univ. of Tech.
Ebrahimi, Behrouz Amirkabir Univ. of Tech.
Roshanian, Jafar K. N. Toosi Univ. of Tech.

An optimal strategy based on minimum control effort with terminal position constraint is developed for an exoatmospheric interceptor with a fixed-interval guidance time. It is then integrated with sliding-mode control theory to drive an optimal sliding-mode guidance law for fixed-interval guidance time. In addition, this guidance law is generalized for intercepting an arbitrarily time-varying target maneuver. Robustness of the new guidance method against disturbances and good miss distance performance are proved by second method of Lyapunov and simulation results. The presented guidance law is simple to implement in practical applications.

WeC08.6: 17:10-17:30
Regulated Sliding Mode Control of Space Free-Flying Robots, pp. 1019-1024
Moosavian, S. Ali A. K. N. Toosi Univ. of Tech.
Homaeinejad, M. Reza K. N. Toosi Univ. of Tech.

Energy consumption of control actuators is an important issue in space systems, due to considerable cost of transferring supplies to orbit. In this paper, a chattering avoidance sliding mode controller is developed for Space Free-Flyer Robots (SFFR) as highly nonlinear coupled systems. Chattering phenomenon results in significant energy dissipation and causes practical difficulties for actuators. In order to fulfill stability requirements, robustness properties and chattering elimination, a regulating routine is proposed to determine proper positive values for the coefficient of sliding condition. To this end, first a multi input sliding mode control law is applied to the given SFFR in order to control its orientation and position to catch a moving target. Next, focusing on the chattering phenomenon, the new approach is employed to alleviate the chattering trend. Then, the explicit dynamics of a 14-DOF SFFR is derived via SPACEMAPLE. To consider practical aspects, the system dynamics is modeled in the presence of parametric uncertainties, also deviations (noises) in measurements are considered. Besides, to evaluate the new

proposed algorithm in a more complicated condition, it is assumed that for controlling the base of SFFR only on-off actuators, which can just generate a constant positive or negative force/moment, are available as it is the case in real systems. Therefore, the exact demanded force/moment can not be supplied on the base, which will affect control of the whole system. The obtained results show that the proposed regulated sliding mode controller can significantly alleviate the chattering trend, and consequently energy consumption will be substantially decreased.

WeC09 Room 0999
Emerging Control Applications II (Regular Session)

Chair: Gaspar, Peter Hungarian Acad. of Sciences
Co-Chair: Runolfsson, Thordur Univ. of Oklahoma

WeC09.1: 15:30-15:50
Servo Tracking Optimisation with the Base Functions Approach, pp. 1025-1030
Leva, Alberto Pol. di Milano
Bascetta, Luca Pol. di Milano

The Base Functions (BF) approach, recently proposed in the literature, is an effective method for set point tracking optimisation with two-degree-of-freedom (2-d.o.f.) regulators, but requires an a priori choice of the feedforward path structure. This manuscript proposes a way to overcome that limitation, and discusses some significant experimental results to illustrate the usefulness of the proposal.

WeC09.2: 15:50-16:10
Adaptive H-Infinity Control Method with Frictions Compensation and Disturbance Rejection for Robotic Manipulators, pp. 1031-1036
Sato, Kazuya Saga Univ.
Tsuruta, Kazuhiro Kyushu Sangyo Univ.

This paper considers an adaptive H-infinity control method with link frictions compensation and external disturbances rejection for robotic systems. It is assumed that all the system parameters for friction model and robot are unknown. The proposed method ensures that the unknown parameters are estimated and approximation errors of friction model and external disturbances are attenuated by means of H-infinity H-infinity control problems, the compensator can design without solving the Hamilton-Jacobi-Isaacs equation. Simulation and experimental results are given to illustrate the effectiveness of our proposed method. It is also shown that we can easily design to determine the relative importance of the error and the expenditure of the input energy.

WeC09.3: 16:10-16:30
New Method for Modeling Plastic Deformation in Incremental Sheet Forming, pp. 1037-1042
Raithatha, Ankor Mahendra Univ. of Oxford
Jackson, Kathryn Univ. of Cambridge
Duncan, Stephen Univ. of Oxford
Allwood, Julian Univ. of Cambridge

This paper proposes a new fast method for determining plastic deformation of sheet metal. The method is applied to a flexible metal shaping process, Incremental Sheet Forming (ISF), which is applicable to low volume manufacturing and rapid prototyping. Being able to predict the deformation of the sheet is a key requirement of a model predictive based control system to regulate the geometric accuracy of parts formed by the process. Existing models for ISF, which are predominantly based on finite element modeling, are slow since the model must be updated at every time step of the process. Other modeling approaches have combined plane-strain or shear deformation equations with approximate empirical relationships, but their accuracy is limited by the conditions under which these experimental relationships were obtained. Here, a fast executing model for the incremental forming process is proposed that is based on the numerical minimization of the plastic energy within the plate. The optimization can be formulated as a second order cone program (SOCP), which can be solved using efficient numerical methods.

WeC09.4: 16:30-16:50
Observer Based Estimation of the Wheel-Rail Friction Coefficient, pp. 1043-1048
Gaspar, Peter Hungarian Acad. of Sciences
Szabo, Zoltan Hungarian Acad. of Sciences
Bokor, Jozsef Hungarian Acad. of Sciences

Since a minimum possible brake distance is required at all times an efficient and robust slip prevention control must be developed. The aim of this paper is to present an estimation method for the actual wheel-rail friction coefficient whose knowledge is indispensable in the design and implementation of an antislip braking control algorithm. The proposed method is based on an adaptive observer scheme. The estimation algorithm is tested through simulation examples.

WeC09.5: 16:50-17:10
Model Reduction of Uncertain Complex Dynamical Systems, pp. 1049-1054
Runolfsson, Thordur Univ. of Oklahoma

In this paper we consider the problem of finding a low dimensional approximate model for a discrete time Markov process. This problem is of particular interest in systems that exhibit a so-called metastable behavior, i.e. systems whose behavior is principally concentrated on a finite number of disjoint components of the state space. The developed approach is based on a proper orthogonal decomposition and, unlike most existing approaches, does not require the Markov chain to be reversible. An example is presented to illustrate the effectiveness of the proposed method.

WeC09.6: 17:10-17:30
Design of Nano and Microsystems with Novel Control Laws, pp. 1055-1060
Lyshevski, Sergey Rochester Inst. of Tech.

This paper solves nonlinear control problems to optimize dynamic nano- and microscale systems. We use the Hamilton-Jacobi theory to analytically design optimal controllers. The system dynamics is optimized by minimizing designed novel functionals with a new class of nonquadratic performance integrands. Necessary conditions for optimality are utilized and examined synthesizing innovative optimal control laws. The proposed performance functionals results in nonlinear controllers which guarantee superior performance, e.g., stability, robustness, minimum-time dynamics, etc. We synthesize and examine optimal controllers for practical nano- and microsystems.

WeC10 Room 3999
Robust Control III (Regular Session)

Chair: Ohse, Nagato Kyoto Inst. of Tech.
Co-Chair: Biannic, Jean-Marc ONERA

WeC10.1: 15:30-15:50
Synthesis of Dynamic Controllers for a Class of Nonlinear Systems: An Application to a Ball-On-Wheel System, pp. 1061-1066
Matsuda, Yoshitaka Kyoto Inst. of Tech.
Ohse, Nagato Kyoto Inst. of Tech.

This paper deals with a synthesis of dynamic controllers for a class of nonlinear systems. First, mathematical model of nonlinear plant with sector-bounded nonlinearity is given. Secondly, the analysis condition for systems with sector-bounded nonlinearity is introduced, and based on this condition, the synthesis problem is formulated as a bilinear matrix inequality one. Since it is difficult to solve the problem directly, this paper proposes an iterative linear matrix inequality algorithm to synthesize a controller so as to expand the region of sector and minimize L2-gain. Finally, the proposed synthesis method is utilized for designing a dynamic controller for a ball-on-wheel system to illustrate the effectiveness.

WeC10.2: 15:50-16:10
Robust Stability Analysis Method for Vibration Systems by Using Virtual Perturbations, pp. 1067-1072
Chida, Yuichi — Shinshu Univ.
Kimura, Takeo — Shinshu Univ.
Furukawa, Ryo — Toshiba

In this paper, a robust stability analysis problem for mechanical vibration systems is considered. As well known, mu-analysis is a useful tool in order to guarantee stability robustness, but obtained results by conventional procedures are sometimes conservative. It is caused by weakness of valuation tools of perturbations. For example, a specified weighting function whose gain covers all of the gains of unstructured perturbations requires tolerating wider perturbations than realistic ones. On the other hand, to guarantee stability robustness of active control system is extremely important and tight evaluation methods are required. In this paper, a new robust stability analysis method for mechanical vibration systems by using virtual parametric perturbations is proposed. The effectiveness of the proposed method is verified by a mechanical vibration system example and the proposed method can guarantee the stability robustness with reducing conservativeness in comparison with conventional methods.

WeC10.3: 16:10-16:30
Simultaneously Stabilizing Controller Structure Design for Control Over Network with Plant Uncertainties, pp. 1073-1078
Witheephanich, Kritchai — Srinakharinwirot Univ.
Tipsuwanporn, Vittaya — King Mongkut's Inst. of Tech. Ladkrabang

In recent years, there has been increasing interest in controlling systems over communication networks because communication networks are among the fastest-growing areas in engineering. Networked control system (NCS) is a feedback control system wherein the control loops are closed through a computer network. Such systems offer advantages such as lower installation costs, increased flexibility and rapid installation. However, communication delay is a general problem in NCS, and it could destabilize the closed-loop system. In this paper, controller structure is provided for NCS with constant delay and plant uncertainties. Our formulation and solution method utilize robust control design. We apply the proposed control strategy on a specific example testing with hardware-in-the-loop simulation using dSPACE DS1104 controller board for controlling a modular servo system.

WeC10.4: 16:30-16:50
Hinf Control of a Three-Phase Shunt Active Filter: An LMI Approach, pp. 1079-1084
Al Chaer, Toufic — Univ. of Poitiers
Rambault, Laurent — Univ. of Poitiers
Gaubert, Jean-Paul — Univ. of Poitiers
Najjar, Maged — Univ. of Balamand

The main objective of this work is to synthesize a robust static state feedback controller capable of controlling an active power filter connected in parallel to a three-phase voltage distribution system. A shunt active filter is used to improve power quality by eliminating harmonic distortion generated by non-linear loads. The open-loop system is described, in a complex frame, by a linear state space representation with complex-valued parameters. The synthesis of such controller is performed using Hinf robust control based on a Linear Matrix Inequality (LMI) approach.

WeC10.5: 16:50-17:10
Adaptive Friction Compensation Using the GMS Model with Polynomial Stribeck Function, pp. 1085-1090
Nilkhamhang, Itthisek — Keio Univ.
Sano, Akira — Keio Univ.

An adaptive friction compensator is proposed using the generalized Maxwell-slip (GMS) friction model, with a new, linearly-parameterized Stribeck function. It employs a polynomial equation that is linear-in-the-parameter to describe the nonlinear Stribeck effect in the GMS model, and simplifies the design of an adaptive friction compensator. The proposed compensator has a switching structure to accomodate for the hybrid nature of the GMS model, and the parameter projection method is used to guarantee a boundedness on parameter estimates and stability of the switching adaptive controller. The validity and effectiveness of the proposed, linearly-parameterized friction compensator is verified by simulations for the velocity control of an inertia system under the influence of dynamic friction.

WeC10.6: 17:10-17:30
*Robust Fuzzy Fault Detection for Continuous-Time State-Delayed Nonlinear Dynamic Systems**
El-Ghatwary, Magdy — Univ. of Duisburg-Essen

A new fault detection scheme for continuous-time state delayed nonlinear dynamic system is studied. The nonlinear system is modelled by Takagi-Sugeno fuzzy model. A fuzzy observer-based approach is presented to detect the fault accured in the dynamic sysem. Finally an example is given to illustrate the efficiency of the present design techniques.

WeC11 Audimax
Vibration Control (Regular Session)
Chair: Leva, Alberto — Pol. di Milano
Co-Chair: Gutman, Per-Olof — Technion

WeC11.1: 15:30-15:50
Semiactive Backstepping Control for Vibration Attenuation in Structures Equipped with Magnetorheological Actuators, pp. 1091-1096
Luo, Ningsu — Univ. de Girona
Villamizar, Rodolfo — Univ. Industrial de Santander
Vehi, Josep — Univ. de Girona
Dyke, Shirley J. — Washington Univ.

This paper deals with the problem of semiactive vibration control of civil engineering structures subject to unknown external disturbances (for example, earthquakes, winds, etc.). Two kinds of semiactive controllers are proposed based on the backstepping control technique. The experimental setup used is a 6-story test structure equipped with shear-mode semiactive magnetorheological dampers being installed in the Washington University Structural Control and Earthquake Engineering Laboratory (WUSCEEL). The experimental results obtained have verified the effectiveness of the proposed control algorithms.

WeC11.2: 15:50-16:10
Active Damping of Longitudinal Oscillations in a Wheel Loader, pp. 1097-1102
Hallander, Elin — Royal Inst. of Tech.
Gutman, Per-Olof — Technion

A simplified model of the longitudinal motion around a constant velocity trajectory of a wheel loader is developed, for the purpose of finding a control that actively damps oscillations in the acceleration, following an up shifting gear change. Measurements from different drivers and different gear changes indicate similar oscillation frequencies for the investigated vehicle. The model parameters and the gear change induced disturbance are adjusted so that the model output closely fits the true measurements of the vehicle acceleration after a gear change, in the investigated frequency band. With the engine as a torque actuator, active damping of the oscillations in the acceleration is investigated through simulations. The possible improvements using feedback from measured engine speed seem to be limited, while a predefined feed-forward programme shows promising results.

WeC11.3: 16:10-16:30
Modelling and Active Vibration Control of a Turbomolecular Vacuum Pump, pp. 1103-1108
Leva, Alberto — Pol. di Milano
Piroddi, Luigi — Pol. di Milano
Casaro, Fausto — Varian Vacuum Tech.

This manuscript presents an experimental activity aimed at modeling a turbo-molecular vacuum pump, and designing an active vibration control system. After describing the experimental setup, a data-based frequency domain model of the pump is illustrated. Some possible control design strategies for broadband and/or narrowband vibration reduction are then discussed. Simulations and (preliminary) experimental results

are reported, to evaluate and compare the proposed control design solutions.

WeC11.4: 16:30-16:50
Vibration Suppression Beyond Nyquist Frequency in Hard Disk Drives, pp. 1109-1114

Atsumi, Takenori Hitachi
Okuyama, Atsushi Hitachi
Kobayashi, Masahito Hitachi

In conventional hard disk drives, a control system compensates for the vibration in which frequency is higher than the Nyquist frequency by using a multi-rate filter that can decrease the gain above the Nyquist frequency. However, such a control system can only avoid instability that results from mechanical vibrations and cannot suppress the vibrations. In response to these problems, we proposed a design method for a sampled-data control system that decreases vibrations in which frequencies are higher than the Nyquist frequency. Our method can easily design a control system and can calculate the norm of the sensitivity function in a sampled-data system by using frequency responses of a controlled object. When the method was applied to the head-positioning system of a hard disk drive, we found that the control system can suppress the disturbance in which the frequency was higher than the Nyquist frequency.

WeC11.5: 16:50-17:10
Vibration and Motion Control Design and Trade-Off for High-Performance Mechatronic Systems, pp. 1115-1120

Verscheure, Diederik Katholieke Univ. Leuven
Paijmans, Bart Katholieke Univ. Leuven
Van Brussel, Hendrik Katholieke Univ. Leuven
Swevers, Jan Katholieke Univ. Leuven

This paper discusses the H-infinity-based design of a vibration controller for an industrial pick-and-place machine. A vibration controller is added to the classical motion control scheme with the purpose of improving positioning behavior by reducing the vibration level and settling time. It is shown that a trade-off is required between vibration reduction and motion control. The approach is validated experimentally and the results clearly illustrate the benefit of the proposed method.

WeC11.6: 17:10-17:30
Experiments on the Vibration Suppression of a Piezoelectric Beam Using a Self-Sensing Mechanism, pp. 1121-1126

Nam, Yoonsu Kangwon National Univ.
Park, Jongsoo Kangwon National Univ.
Jang, Huyeong Kangwon National Univ.
Kim, Jaewoo Kangwon National Univ.
Park, Haegyoon Kangwon National Univ.

This paper deals with a problem of vibration suppression of a piezoelectric beam using a self-sensing algorithm. Two methods, which are PPF(positive position feedback) and SRF(strain rate feedback), are considered to suppress a residual vibration of a piezoelectric beam developed during the step positioning of a beam end point. It turns out that the vibration suppression based on using PPF algorithm is better than using SRF. Two self-sensing algorithms are treated here, which are a strain and its rate estimator of a beam movement, in order to provide feedback information for the closed loop vibration suppression control. The efficacy of the proposed idea is evaluated through experiments.

WeKPL Audimax
Keynote Lecture: Pascal Gahinet (Plenary Session)

Chair: Birdwell, J. Douglas Univ. of Tennessee/IEEE

WeKPL : 17:40-18:30
*CACSD Tools - a MathWorks Perspective**

Gahinet, Pascal M. The MathWorks, Inc.

Software tools are playing an increasingly central role in the adoption and dissemination of CACSD techniques throughout academia and industry. As a leading provider of such tools for the past 20 years, MathWorks has been actively involved in shaping and facilitating the software revolution in control systems engineering. This talk looks at some trends and challenges in building the next generation of CACSD tools. We discuss ongoing efforts to make control technology less intimidating and more widely accessible. We showcase the merits of integrated tool chains for professionals and students alike. Finally, we highlight some technical challenges in building reliable general-purpose tools and discuss related work on numerical algorithms and time-delay modeling.

ThPPL Audimax
Plenary Lecture: Brian D.O. Anderson (Plenary Session)
Chair: Buss, Martin Tech. Univ. Munich

ThPPL: 08:15-09:15
Control and Information Architectures for Formations, pp. 1127-1138
Anderson, Brian D.O. Australian National Univ.
Yu, Changbin Australian National Univ.
Fidan, Baris Australian National Univ.
Hendrickx, Julien M. Univ. Catholique de Louvain

This paper reviews a number of concepts and results relevant to the design of architectures to maintain the shape of a formation of autonomous agents. The paper begins with motivating examples from nature and the manmade world, and emphasises the task of providing satisfactory sensing, communication and control architectures within a formation of autonomous agents. Then some technical tools for characterising and designing architectures are described, largely resting on graph theoretic considerations.

ThA01 Room 2601
Linear Systems and LMI-Based Control System Analysis and Synthesis (Regular Session)
Chair: Werner, Herbert Hamburg Univ. of Tech.
Co-Chair: Henrion, Didier LAAS-CNRS

ThA01.1: 09:45-10:05
An LMI Condition for Asymptotic Stability of Discrete-Time System Based on Quadratic Difference Forms, pp. 1139-1143
Kojima, Chiaki Kyoto Univ.
Takaba, Kiyotsugu Kyoto Univ.

This paper is concerned with the stability analysis of a linear discrete-time system described by a high-order difference-algebraic equation. It is well known that, in the behavioral approach, a Lyapunov for a linear system is characterized in terms of a so-called quadratic difference form (QDF). For a discrete-time case, Kojima and Takaba (2005) derived a necessary and sufficient condition for the asymptotic stability in terms of the QDFs. On the basis of this QDF condition, we derive a numerically more tractable stability condition in terms of LMIs.

ThA01.2: 10:05-10:25
Design of Multirate Digital Control Systems with Semidefinite Programming, pp. 1144-1151
Hofer, Anton Graz Univ. of Tech.
Horn, Martin Graz Univ. of Tech.

A computer aided design method for linear multirate digital control systems is presented in this paper. The design problem is formulated on the infinity norm of signals and the induced l1-system norm. An upper bound for the l1-system norm leading to matrix inequalities is the basis of the design procedure. It is a characteristic feature of the method that the controller is attained by repeatedly solving small size convex optimization problems. Considering an example it turns out, that multirate digital controllers can help to overcome the well known problem of inflating controller order in l1-control.

ThA01.3: 10:25-10:45
Robust Multi-Objective Control Toolbox, pp. 1152-1157
Peaucelle, Dimitri LAAS-CNRS
Arzelier, Denis LAAS-CNRS

A new "Robust Multi-Objective Control" toolbox is presented. It is freely distributed (www.laas.fr/OLOCEP/romuloc) and works in Matlab environment along with the parser YALMIP. The current version tackles stability, pole location, H-infinity, H-2 and impulse-to-peak analysis problems. The uncertain models are all in state-space and range from interval matrices to structured rational representations. For each considered problem, the user has the opportunity to choose between parameter dependent or independent Lyapunov functions. This gives more or less conservative conditions associated with different numerical burden. The paper exposes the underlying theoretical results and illustrates the use of the tool on some examples.

ThA01.4: 10:45-11:05
Robust Stabilization of a Class of Linear Discrete-Time Time-Varying Systems: A LMI Approach, pp. 1158-1162
Jetto, Leopoldo Univ. Pol. delle Marche
Orsini, Valentina Univ. Pol. delle Marche

The stabilization problem of a linear, discrete-time, time-varying, uncertain system is considered and a numerically efficient method for its solution is proposed. The elements of the dynamical matrix of the system are modelled as unknown time functions taking values inside known compact intervals. The measure and the control matrices are assumed to be known and time-invariant. It is required to find a linear, time-invariant, dynamic output controller yielding an uniformly, asymptotically stable closed-loop system. The problem solvability conditions are stated in terms of feasibility of a set of LMI's, which is independent of the number of uncertain parameters.

ThA01.5: 11:05-11:25
Analysis of Stability Nonlinear Systems with Varying Parameters Using Popov Criterion, pp. 1163-1166
Dobra, Petru Tech. Univ. of Cluj
Trusca, Mirela Tech. Univ. of Cluj

This paper establishes sufficient conditions for absolute stability of time-varying control systems. The proposed conditions extend in a simple way the classical Popov criterion to time-varying memoryless nonlinearities, using previous results of Kharitonov. They are expressed in terms of Linear Matrix Inequalities LMIs. A weaker frequency domain criterion is deduced, leading to a simple graphical interpretation. The results ensure in general local stability, however, the stability is global for linear time-varying systems. Examples are presented to show the efficacy of these extensions within the MATLAB environment.

ThA01.6: 11:25-11:45
Comparative Study of Methods for Computing the Maximal Output for the Design of Critical Systems, pp. 1167-1172
Satoh, Toshiyuki Akita Prefectural Univ.
Saito, Naoki Akita Prefectural Univ.

Computing the maximal output of a linear time-invariant (LTI) system is an important part of the design of critical systems. We compare three numerical methods for computing the maximal output of an LTI system subject to inputs with limited magnitude and rate of change. The three methods are: (1) quadratic programming method, (2)convex optimisation method, and (3) upper bound method. Two numerical examples are given to examine the three methods in terms of accuracy, efficiency, and conservativeness. We show that the quadratic programming method is superior to the other two methods from the viewpoint of accuracy and efficiency of computing the theoretically maximal output, while only the convex optimisation method has the capability to allow for the input's frequency range, which leads to good estimation of the practically maximal output and less conservative control system design. We also issue a guideline for selecting the order of Fourier series expansion required in the convex optimisation method.

ThA02 Room 1601
Tools for Co-Design of Control Systems and Their Real-Time Implementation (Invited Session)

Chair: Hanzalek, Zdenek	Czech Tech. Univ. Prague
Co-Chair: Arzen, Karl-Erik	Lund Inst. of Tech.
Organizer: Hanzalek, Zdenek	Czech Tech. Univ. Prague

ThA02.1: 09:45-10:05
Tool Supporting the Co-Design of Control Systems and Their Real-Time Implementation; Current Status and Future Directions (I), pp. 1173-1180

Torngren, Martin	Royal Inst. of Tech.
Arzen, Karl-Erik	Lund Inst. of Tech.
Henriksson, Dan	Lund Univ.
Cervin, Anton	Lund Univ.
Hanzalek, Zdenek	Czech Tech. Univ. Prague

Control systems design has traditionally been treated separately from the design of its software and hardware implementation. The increasing use of embedded control in for example distributed, safety critical and mass-produced systems has caused an increasing need for the simultaneous consideration of the control system and its implementation platform during development. To this end, there is a need for both theoretical contributions and supporting tools that assist designers in understanding and analyzing the intricate relationships between the qualities, such as control performance, robustness and cost, and design parameters related to control system and platform design. This paper explores issues in co-design. A number of representative tools are compared with the purposes of illustrating different approaches concerning the levels of abstraction, analysis vs. synthesis features, constraints addressed and usability features. A perspective to the co-design tools is also provided, where opportunities and challenges for future design environments are discussed.

ThA02.2: 10:05-10:25
TORSCHE Scheduling Toolbox for Matlab (I), pp. 1181-1186

Sucha, Premysl	Czech Tech. Univ. Prague
Kutil, Michal	Czech Tech. Univ. Prague
Sojka, Michal	Czech Tech. Univ. Prague
Hanzalek, Zdenek	Czech Tech. Univ. Prague

This paper presents a Matlab based Scheduling toolbox TORSCHE (Time Optimization of Resources, SCHEduling). The toolbox offers a collection of data structures that allow the user to formalize various off-line and on-line scheduling problems. Algorithms are simply implemented as Matlab functions with fixed structure allowing users to implement new algorithms. A more complex problem can be formulated as an Integer Linear Programming problem or satisfiability of boolean expression problem. The toolbox is intended mainly as a research tool to handle control and scheduling co-design problems. Therefore, we provide an interfaces to a real-time Matlab/Simulik based simulator TrueTime and a code generator allowing to generate parallel code for FPGA.

ThA02.3: 10:25-10:45
Model Based Integration in the Development of Embedded Control Systems – a Characterization of Current Research Efforts (I), pp. 1187-1193

Chen, DeJiu	Royal Inst. of Tech.
Torngren, Martin	Royal Inst. of Tech.
Shi, Jianlin	Royal Inst. of Tech.
Arzen, Karl-Erik	Lund Inst. of Tech.
Lonn, Henrik	Volvo Tech. Corp.
Gerard, Sebastien	CEA-List
Stromberg, Mikael	Systemite AB
Servat, David	CEA-List

The design of advanced embedded control systems requires a systematic approach in handling their increasing complexity and in particular integration of the different aspects and parts of a product worked on by different experts. Several variants of model-based approaches are today advocated to facilitate systems integration. This paper describes a number of representative efforts that address multiple concerns or views including modeling languages such as AADL and EAST-ADL as well as model integration environments such as GeneralStore, ToolNet, and Fujaba. We present a characterization of the approaches and thereby highlight their commonalities and differences regarding basic integration mechanisms and engineering support. We conclude with a prospect for future work.

ThA02.4: 10:45-11:05
Control Loop Timing Analysis Using TrueTime and Jitterbug (I), pp. 1194-1199

Cervin, Anton	Lund Univ.
Arzen, Karl-Erik	Lund Univ.
Henriksson, Dan	Lund Univ.
Lluesma, Manuel	Univ. Pol. de Valencia
Balbastre, Patricia	Univ. Pol. de Valencia
Ripoll, Ismael	Univ. Pol. de Valencia
Crespo, Alfons	Univ. Pol. de Valencia

A modern control system is typically implemented as a multitasking software application executing in a real-time operating system. If the computer load is high, the controller will experience delays and jitter, which in turn degrade the control performance. Arguing for an integrated design approach, the paper describes two computer tools for implementation-aware control analysis: TrueTime and Jitterbug. An example is given where the tools are used together to evaluate the performance of various control task implementations.

ThA02.5: 11:05-11:25
Schedulability Issues in Complex Embedded Control Systems (I), pp. 1200-1205

Crespo, A.	Univ. Pol. de Valencia
Albertos, Pedro	Univ. Pol. de Valencia
Balbastre, Patricia	Univ. Pol. de Valencia
Valles, Marina	Univ. Pol. de Valencia
Lluesma Camps, Manuel	Univ. Pol. de Valencia
Simo, Jose	Univ. Pol. de Valencia

The design of embedded control systems should be addressed in both the controller definition and its implementation. While the design of the controller is based on control theory, the implementation is designed by assuming the principle that control loops can be modeled and implemented as periodic activities. Periodic activities that can be organise attending to different implementation criteria. Recently, the authors have introduced the concept of control kernel dealing with the essential control activities to guarantee the safe behaviour of the complete system. For this purpose, we proposea control arrangement in different layers. At the level of the OS, activities to closing the loop and driving the system to a safe position should be included. At the top level, the control system may include several on-line controller options as well as supervising and optimising activities. This part should be independent of both the particular implementation and the resources availability. In this paper we propose an implementation and a scheduling scheme to implement complex control applications.

ThA02.6: 11:25-11:45
The SAE Architecture Analysis & Design Language (AADL) a Standard for Engineering Performance Critical Systems (I), pp. 1206-1211

Feiler, Peter	Carnegie Mellon Univ.
Lewis, Bruce	US Army
Vestal, Steve	Honeywell

The Society of Automotive Engineers (SAE) Architecture Analysis & Design Language, AS5506, provides a means for the formal specification of the hardware and software architecture of embedded computer systems and system of systems. It was designed to support a full Model Based Development lifecycle including system specification, analysis, system tuning, integration, and upgrade over the lifecycle. It was designed to support the integration of multiple forms of analyses and to be extensible in a standard way for additional analysis approaches. A system can be automatically integrated from AADL models when fully specified and when source code is provided for the software components. Analysis of large complex systems has been demonstrated in the avionics domain.

ThA03 Room 0670
Intelligent Systems and Intelligent Control
(Regular Session)

Chair: Commuri, Sesh — Univ. of Oklahoma
Co-Chair: Taylor, James H. — Univ. of New Brunswick

ThA03.1: 09:45-10:05
An Implementation Plan for Integrated Control and Asset Management of Petroleum Production Facilities, pp. 1212-1219

Sayda, Atalla — Univ. of New Brunswick
Taylor, James H. — Univ. of New Brunswick

This paper addresses innovative issues of asset management for the petroleum industry, which is very crucial for profitable oil and gas facilities operations and maintenance. A research project was initiated to study the feasibility of an intelligent asset management system. Having proposed a conceptual model for such a system in previous work, we describe its behavior in terms of data and control flow, and pave the way for an implementation and rapid prototyping plan for such system. Furthermore we discuss the required off-the-shelf development tools. A simplified system prototype is introduced as a colored petri net model, which will be used to analyze the prototype logical structure and dynamic performance. We finally discuss the project progress status and future work.

ThA03.2: 10:05-10:25
FPGA Implementation of Dynamic Run-Time Behavior Reconfiguration in Robots, pp. 1220-1225

Tadigotla, Viswanath — Univ. of Oklahoma
Sliger, Lee — Univ. of Oklahoma
Commuri, Sesh — Univ. of Oklahoma

Using a single robot for multiple operations has been a significant problem for researchers in Robotics since available space, cost, and power consumption are constraints to the increasing number of behaviors on a robot. An efficient technique to implement multiple behaviors in robots using FPGA based partial reconfigurable hardware is presented in this paper. Robots built using reconfigurable FPGAs can have their functionalities modified at run-time without completely taking the robot off-line. Resource efficiency increases because only the modules corresponding to the current behavior are implemented in the FPGA while inactive modules are stored in an external memory. The approach is validated through a case study where teams of robots are configured to meet application specific requirements and the run-time behaviors of these robots are modified dynamically using Xilinx Virtex-II Pro FPGAs.

ThA03.3: 10:25-10:45
Intelligent Coin Identification System, pp. 1226-1230

Khashman, Adnan — Near East Univ.
Sekeroglu, Boran — Near East Univ.
Dimililer, Kamil — Near East Univ.

The use of neural networks to simulate our perception of patterns is important in developing intelligent recognition systems. Currently, coin identification by machines relies on the assessment of the coin's physical parameters. An intelligent coin identification system that uses coin patterns for identification helps prevent confusion between different coins of similar physical dimensions. In this paper, an intelligent coin identification system (ICIS) is proposed. ICIS uses a neural network and pattern averaging to recognize rotated coins at various degrees. Slot machines in Europe accept the new Turkish 1 Lira coin as a 2 Euro coin due to physical similarities. A 2 Euro coin is roughly worth 4 times the new Turkish 1 Lira. ICIS was implemented to identify the 2-EURO and 1-TL coins and the results were found to be encouraging.

ThA03.4: 10:45-11:05
Natural Computation Architecture of Immune Control Based on Normal Model, pp. 1231-1236

Cai, Zixing — Central South Univ.
Gong, Tao — Central South Univ.

Information security, fault diagnosis and system failover are three of crucial hard problems in intelligent control systems. To solve the bottlenecks, a normal model was proposed to detect 100% selfs and 100% non-selfs. The normal model was built on the space-time properties of each component in the control system, and some theorems were proved on its effectiveness. Based on the normal model, an immune control system was proposed and the natural computation architecture of the immune control was proposed and analyzed. Moreover, some theorems were proved on the complexity of the natural computation. Therefore, through the normal model and natural computation, the immune control will improve the science and technology on intelligent control, artificial intelligence, artificial immune system and computer science etc.

ThA03.5: 11:05-11:25
A Heuristic-Based Route Planning Approach for a Homogeneous Multi-Robot Team, pp. 1237-1242

Yazici, Ahmet — Eskisehir Osmangazi Univ.
Sipahioglu, Aydin — Eskisehir Osmangazi Univ.
Parlaktuna, Osman — Eskisehir Osmangazi Univ.
Gurel, Ugur — Eskisehir Osmangazi Univ.

One of the main concerns in multi-robot applications is the effects of interactions among the robots on the total performance of the team. If the robots are assigned to spatially separate tasks, the negative impact of these interactions may be decreased. In this paper a VRP-based method is proposed to create non-intersecting routes for a team of robots. In the method, a heuristic approach composed of sweep, savings, and Dijkstra's shortest path algorithm is used to find routes for each robot. Simulations are performed on some VRP test problems for different number of robots, and experiments are performed for a 13-node, 2-robot problem in a real environment. Results show that the method is very effective to determine non-intersecting routes for the individual robots of a team of robots.

ThA03.6: 11:25-11:45
A Calculating Method of Evaluating the Intelligence Quality of Intelligent Control Systems, pp. 1243-1246

Liu, Dong — Univ. of Science and Tech. Beijing
Yin, Yixin — Univ. of Science and Tech. Beijing
Dong, Jie — Univ. of Science and Tech. Beijing
Tu, Xuyan — Univ. of Science and Tech. Beijing
Fan, Chengli — Univ. of Chemical Tech. Beijing

In this paper, we emphasize the importance of evaluating the intelligence level of intelligent control systems. We bring forward the idea that the evaluating system is composed of a three tier construction: organizing level, coordinating level and executive level, and we put the intelligence calculation in the organizing level. We also put forward the index system of the intelligence evaluating system of the ICS, which comprises 5 first grade indexes (I1), 17 second grade indexes (I2) and 52 third grade indexes (I3). And then, we give the formula to calculate the intelligent quality of the ICS. Finally we cite two examples to show the calculation of the ICS's intelligent quality.

ThA04 Room 2605
Biologically - Inspired Methods and Biosystems
(Regular Session)

Chair: Bauer, Peter H. — Notre Dame Univ.
Co-Chair: Wang, Hong — Univ. of Manchester

ThA04.1: 09:45-10:05
Synchronization Analysis for Networked Oscillators, pp. 1247-1251

Chen, Xinkai — Shibaura Inst. of Tech.
Zhai, Guisheng — Osaka Prefecture Univ.

Networks of coupled large scale oscillators have been studied in biology for a number of years. It has been recognized that transient in the nearest neighbor connected networks may take far too long to die out. In the model of mammalian rhythm, it is considered that a few long distance interconnections exist. Typically, these long distance interconnections are considered to occur in a random way. In this study, we discuss the synchronization problem for coupled oscillator networks which can model the mammalian rhythm. Then, the distribution model for the random long distance connections is proposed and is demonstrated by simulation. Furthermore, simulation

also shows that synchronization still holds even a large part of the network is destroyed.

ThA04.2: 10:05-10:25
Design and Real-Time Implementation of a TS Fuzzy Observer for Anaerobic Wastewater Treatment Plants, pp. 1252-1257

Carlos-Hernandez, Salvador	CINVESTAV
Beteau, Jean-Francois	Inst. Nat. Pol. Grenoble
Sanchez, Edgar N.	CINVESTAV

A new methodology to design fuzzy observers for anaerobic wastewater treatment plants is introduced in this article. First, a general explanation of the anaerobic digestion in a completely stirred tank reactor is presented. A model of the system is explained and studied using the principal components analysis in view to choose variables and local models which characterize the bioprocess. These variables and local models will be used to design the fuzzy observer. The observer performances are validated via realistic simulations and experimentally.

ThA04.3: 10:25-10:45
A Scalable, Robust, Ultra-Low Complexity Agent Swarm for Area Coverage and Interception Tasks, pp. 1258-1263

Scheutz, Matthias	Univ. of Notre Dame
Bauer, Peter H.	Univ. of Notre Dame

Simulations of biologically inspired swarms where agents jointly achieve tasks using local rules rather than global centralized or distributed control have demonstrated the high performance of agent swarms on a variety of tasks (such as surveillance, plume tracking, or target interception). However, most swarm systems rely on the information exchange of agents with their neighbors, which in practical instantiations would involve digital communication. Moreover, many systems would require global positioning methods (e.g., GPS) to determine the exact location of agents in their environment.

We propose a beacon-based principle for target-oriented navigation of large numbers of autonomous agents, which is radically different from previous methods in that it neither requires digital communication nor any kind of global position information for coordination of movements and interactions and, moreover, has only minimal "computing" requirements. Results from extensive simulations of the system in an area coverage and agent interception task show that (1) the system achieves perfect task performance (i.e., all hostile agents are intercepted), (2) scales (works with an arbitrary number of agents), and (3) is robust (adapts to changes in agent position and configuration).

ThA04.4: 10:45-11:05
Co-Evolutionary Self-Adaptive Differential Evolution with a Uniform-Distribution Update Rule, pp. 1264-1269

Nobakhti, Amin	Univ. of Manchester
Wang, Hong	Univ. of Manchester

Differential Evolution (DE) is a simple evolutionary algorithm which is inherently adaptive. This is due to the fact that the mutation amount is derived from the difference of randomly chosen members of the population, which is automatically reduced as the population diversity drops. The process is however governed by an important weighing parameter F, to which the global properties of the DE are very sensitive. Large F can lead to significant reductions in convergence speed, whilst small F can cause the algorithm to get stuck. In this paper, a simple co-evolutionary process is proposed to automatically update the F parameter during the optimization process based on a uniformly distributed update rule. The behavior of the adaptive DE is studied and investigated with some benchmark functions.

ThA04.5: 11:05-11:25
Dynamic Modeling for Modulation of ATP Concentration at the Endothelial Surface by Viscous Shear Flow, pp. 1270-1275

Qin, Kai-Rong	Shanghai Jiao Tong Univ.
Xu, Zhe	Fudan Univ.
Zhang, Hui	Fudan Univ.
Xiang, Cheng	National Univ. of Singapore
Ge, Shuzhi Sam	National Univ. of Singapore
Jiang, Zong-Lai	Shanghai Jiao Tong Univ.

In this paper, dynamic modeling is investigated for shear stress induced adenosine triphosphate (ATP) release from endothelial cells (ECs). The modulation of ATP concentration at the endothelial surface by viscous shear flow is extensively investigated through numerical analysis based on the release model. The simulation results demonstrate that shear stress induced ATP release, convection and diffusion of ATP, and ATP hydrolysis by ecto-ATPase synergistically determine the ATP concentration against time at endothelium-fluid interface.

ThA04.6: 11:25-11:45
Improved Bacterial Foraging Strategy for Controller Optimization Applied to Robotic Manipulator System, pp. 1276-1281

Coelho, Leandro Dos Santos	Pontifical Catholic Univ. of Parana
da Costa Silveira, Camila	Pontifical Catholic Univ. of Parana

During the course of evolution, colonies of ants, bees, wasps, bacteria and termites have developed sophisticated behavior, intricate communication capabilities, decentralized colony control, group foraging strategies and a high degree of worker cooperation when tackling tasks. Utilizing these capabilities, any bio-inspired optimization techniques using analogy of swarming principles and social behavior in nature - swarm intelligence - have been adopted to solve a variety of engineering and robotics problems. In this paper, new approaches of bacterial colony optimization method with variable speed based on uniform, Gaussian, and Cauchy probability distribution were tested. Bacterial colony, a swarm intelligence methodology, is evaluated for a problem of optimization of a PID (proportional-integral-derivative) multivariable controller. The simulation results are compared with classical bacterial colony approach with constant velocity for a case study of control of a robotic manipulator system with two degree of freedom.

ThA05 Room 0601
Automotive III (Regular Session)

Chair: Akar, Mehmet	NUI, Maynooth
Co-Chair: Svaricek, Ferdinand	Univ. of Armed Forces Munich

ThA05.1: 09:45-10:05
Autonomous All-Wheel Car Steering, pp. 1282-1287

Bajcinca, Naim	German Aerospace Center

The autonomous car steering problem is defined as a regulation task of yaw and relative lateral position dynamics along a given path trajectory. Therefore a control structure based on vehicle dynamics inversion is proposed to decouple the two regulation tasks. The inversion structure assumes all-wheel (joint front- and rear-axle) steering actuation. The resulting algorithm exhibits additionally integrated robust yaw stabilization and is validated by simulation of different maneuvers for different vehicle speeds and road conditions with linear and detailed nonlinear vehicle model.

ThA05.2: 10:05-10:25
Road Feedback Estimation for Steer-By-Wire Control, pp. 1288-1293

Bajcinca, Naim	German Aerospace Center
Nuthong, Chaiwat	Univ. of Armed Forces Munich
Svaricek, Ferdinand	Univ. of Armed Forces Munich

Sensing represents a critical issue in the design of steer-by-wire systems. Specifically, the road feedback information resulting from the interaction between the tire, vehicle dynamics and road is important for the quality of force feedback. Its sensing is however related to disadvantages

with respect to cost, robustness and failure issues. In this paper instead, the estimation strategies are proposed as favorable approach. The friction forces are modelled as stochastic Gauss-Markov process and an extended Kalman filter is designed for its estimation. This signal is further coupled to a steer-by-wire control setup. Simulation data with a non-linear vehicle dynamics model validate the applicability and efficiency of the approach.

ThA05.3: 10:25-10:45
Robust H-Infinity Based Vehicle Steering Control Design, pp. 1294-1299
Hecker, Simon — German Aerospace Center

Two vehicle steering controllers to improve the yaw dynamics of a mid-size passenger car are designed based on robust H-infinity synthesis techniques. The controllers fulfill the desired mixed-sensitivity performance specifications robustly with respect to large uncertainties in the vehicle model parameters for longitudinal speed, road adhesion, mass and moment of inertia. The parametric uncertainties are non-conservatively considered using a minimal-order linear fractional representation (LFR) for the uncertain vehicle model during control design. One approach is based on mu-synthesis, which guarantees robust performance assuming that parameters are uncertain but constant. The second design is based on linear parameter varying (LPV) control design techniques, guaranteeing robust performance also in case of bounded variation rates of the longitudinal speed, which is an important property in real-life situations like mu-split braking. To allow real-time implementation, frequency weighted controller reduction techniques are applied to reduce the order and to eliminate high frequency dynamics of the controllers.

ThA05.4: 10:45-11:05
Yaw Rate and Sideslip Tracking for 4-Wheel Steering Cars Using Sliding Mode Control, pp. 1300-1305
Akar, Mehmet — Hamilton Inst.

In this paper, a robust sliding mode controller is proposed for automotive vehicles with 4-wheel steering capability in order to emulate some desired sideslip and yaw rate dynamics. Analytically, it is shown that the proposed controller is robust to plant parameter variations by %10, and is invariant to unmeasurable wind disturbance. The performance of the sliding mode controller is evaluated via computer simulations to verify its robustness to vehicle parameter variations and delay in the loop, and its insensitivity to wind disturbance.

ThA05.5: 11:05-11:25
Control of Linear Full Vehicle Active Suspension System Using Sliding Mode Techniques, pp. 1306-1311
Chamseddine, Abbas — Univ. Aix - Marseille
Noura, Hassan — Univ. Aix - Marseille
Raharijaona, Thibaut — Univ. Aix - Marseille

For the purpose of fault diagnosis and accommodation, a Sliding Mode Controller (SMC) is designed for a linear full vehicle active suspension system. An investigation about the available sensors for the controller implementation is also presented. Two levels are studied: the level of vehicle prototypes and the level of industrial vehicles. Difficulties of vehicle instrumentation and possible solutions are discussed. Simulation is made to illustrate the proposed controller where the active suspension system performances are compared with those of passive suspension.

ThA05.6: 11:25-11:45
Robust QFT Tracking Controller Design for a Car Equipped with 4-Wheel Steer-By-Wire, pp. 1312-1317
Barreras, Marta — Public Univ. of Navarra
Villegas, Carlos — Univ. of Ireland
Garcia-Sanz, Mario — Public Univ. of Navarra
Kalkkuhl, Jens Christian — DaimlerChrysler AG

In the present paper, a non-diagonal multi-input multi-output (MIMO) Quantitative Feedback Theory (QFT) controller design methodology is applied to control the lateral and yaw motions of a car equipped with four-wheel steering. The overall objective is to track the sideslip angle and yaw-rate with the aim of achieving satisfactory performance specifications for the vehicle lateral dynamics, regarding the rejection of external disturbances on yaw rate and sideslip angle, minimizing the interaction as much as possible and taking into account the model uncertainty.

ThA06 Room 0602
Networked Control Systems I (Regular Session)
Chair: Hirche, Sandra — Tokyo Inst. of Tech.
Co-Chair: Miyoshi, Takanori — Toyohashi Univ. of Tech.

ThA06.1: 09:45-10:05
A Design Method of Wave Filter for Stabilizing Non-Passive Operating System, pp. 1318-1324
Miyoshi, Takanori — Toyohashi Univ. of Tech.
Terashima, Kazuhiko — Toyohashi Univ. of Tech.
Buss, Martin — Tech. Univ. Munich

In this paper, the force-position haptic teleoperating system is proposed. Although a force-position system is generally non-passive, stability is ensured by the wave filters to suppress the H infinity norm of theloop gain to less than 1. In this system, accurate positioning and transparency are achieved in the static state. It was also proven that the viscosity of the system increases in accordance with time-day and the step response of the wave filters.The advantage of our proposed method is demonstrated by an experiment of teleoperation between Munich and Toyohashi via the Internet with significant packet losses. Furthermore, the validity of our model is also shown by the simulation.

ThA06.2: 10:05-10:25
Towards Quality-Of-Service Control of Networked Control Systems: A Switched Time Delay Systems Approach, pp. 1325-1330
Chih-Chung, Chen — Tech. Univ. Munich
Hirche, Sandra — Tokyo Inst. of Tech.
Buss, Martin — Tech. Univ. Munich

The stability and performance of a networked control system (NCS) strongly depends on the communication quality in terms of time delay for example. According to the Quality-of-Service (QoS) concept in modern communication technology, the communication quality can be adapted to the requirements of the network application. This paper presents a first approach to conjointly control the NCS as well as the communication quality on basis of the QoS concept. We assume that the controller together with the time delay is switched to meet control and network performance objectives. Sufficient stability conditions are presented for the resulting switched time delay system based on the concept of piecewise continuous Lyapunov functions and the Razumikhin approach. Simulations and experiments validate the proposed approach.

ThA06.3: 10:25-10:45
Teleoperation with Haptic Feedback by Means of Electromagnetic Brake and Deadband Control for Rehabilitation, pp. 1331-1336
Duong, Minh Duc — Toyohashi Univ. of Tech.
Terashima, Kazuhiko — Toyohashi Univ. of Tech.
Imamura, Takashi — Toyohashi Univ. of Tech.

In this paper, teleoperation of a master-slave robot system with haptic feedback and network traffic reduction for rehabilitation are presented. At first, the stability of the teleoperation system with haptic feedback via time delay communication environment is mathematically shown for multi-joint robot arm system. Experiments show that the system is stable, despite of time delay. In order to reduce packet transfer rate for transmission of data, deadband control approach is used. A new data reconstruction algorithm is proposed to improve system's performance for telerehabilitation while keeping the stability of the system. The validity of the approach is shown in simulations.

ThA06.4: 10:45-11:05
Networked Control Systems Over Profibus-DP: Simulation Model, pp. 1337-1342

Casanova, Vicente	Univ. Pol. de Valencia
Salt, Julian	Univ. Pol. de Valencia
Cuenca, Angel	Univ. Pol. de Valencia
Mascarós, Vicente	Univ. Pol. de Valencia

This paper deals with the problem of simulating the sequence of events in the communication through one of the most commonly used fieldbuses: Profibus-DP. Control systems using a fieldbus or any other kind of shared communication medium, are known as Networked Control Systems. A detailed description of the operation of Profibus, when transmitting a signal in a round trip between slave and master devices, is included. This operation is characterized with a collection of parameters whose values are determined by the practical implementation of the network. A simulation model, using Matlab/Simulink is built to emulate the behavior of the real system. This model has been validated, processing the transmitted signal and using histograms to compare the results obtained from real and simulated transmission.

ThA06.5: 11:05-11:25
A PID Dual Rate Controller Implementation Over a Networked Control System, pp. 1343-1349

Salt, Julian	Univ. Pol. de Valencia
Cuenca, Angel	Univ. Pol. de Valencia
Casanova, Vicente	Univ. Pol. de Valencia
Mascarós, Vicente	Univ. Pol. de Valencia

In networked control systems (NCS) environments is usual to find restrictions with data-acquisition frequency. If the control action updating can be faster than the output measurement, the use of a dual rate controller is a natural solution. Due to PIDs are useful controllers in industrial applications, in this paper a dual rate PID controller is designed splitting a conventional PID into two parts acting at different sampling rates. Its implementation over a specific NCS scenario (Profibus DP) is assumed. The study includes a description of a NCS, the introduction of a dual rate design methodology for PID controllers and also an analysis that validates the real implementation using this approach. Finally, theoretical and practical results are shown too.

ThA06.6: 11:25-11:45
A Guaranteed Forwarding Service for Differentiated Service Architecture, pp. 1350-1355

Norouzi, Ali	Amirkabir Univ. of Tech.
Talebi, H.A.	Amirkabir Univ. of Tech.
Shafiee, Masoud	Amirkabir Univ. of Tech.

This paper presents an assured forwarding service for Differentiated Service architecture computer networks. In DiffServ, traffic flows are grouped into different classes such that the higher priority traffics have lower loss rate and delay as compared to lower priority traffics. We introduce two feedback controllers that guarantee the quality of service (QoS) for different classes of service. In each class, QoS is defined as the queuing delay and the amounts of loss rates in the queue. The first controller is employed to control internal loop controls the delay associated to each class. By controlling the output bit rate of each link, we can adjust the delay while maximizing the link utilization. The proposed controller can be called a Nonlinear Deadbeat Controller since the error dynamics are all canceled out. The second controller external loop is also added to control the loss rate associated to each class. The controller uses the amount of overflow in the buffer to determine the amount of packets each class has to drop such that the loss specifications are also met. The stability of the closed-loop system is also shown. Simulation results are given to demonstrate the enhanced performance of the system utilizing the proposed controller.

ThA07 Room 0606
Process Control I (Regular Session)

Chair: Engell, Sebastian	Univ. of Dortmund
Co-Chair: Wellenreuther, Andrea	Univ. of Mannheim

ThA07.1: 09:45-10:05
Online Optimizing Control of Emulsion Polymerization Processes with Evaporative Cooling, pp. 1356-1361

Arora, Sachin	Univ. Dortmund
Engell, Sebastian	Univ. Dortmund

This work aims at optimizing the productivity of emulsion homopolymerization processes with evaporative cooling. A dynamic model of emulsion polymerization processes is extended by the inclusion of vaporization from the liquid phase in the reactor to the gaseous phase. The multi-component gas-liquid mass transfer phenomenon is described by the Maxwell-Stefan diffusion equations. An online optimization problem for maximizing the productivity with the minimum usage of nitrogen is formulated in the MPC framework. Simulation results are presented for the homopolymerization of vinyl acetate for an industrial scale reactor operated in semi-batch mode. The results show that a significantly higher productivity can be achieved by the proposed approach.

ThA07.2: 10:05-10:25
Sensor Fault Detection and Isolation for Chemical Batch Reactors, pp. 1362-1367

Paviglianiti, Gaetano	Univ. di Reggio Calabria
Pierri, Francesco	Univ. degli Studi della Basilicata

In this paper a scheme for detection and isolation of sensor faults in chemical batch reactors is proposed. The scheme is based on a bank of two observers for residual generation which guarantees sensor fault detection and isolation in presence of external disturbances and model uncertainties. In the observers a hinf approach is adopted for the design of the gains, while the unknown dynamics of the reactor (i.e., the heat released by the reaction) are estimated by an on-line interpolator based on a Radial Basis Functions (RBF) neural network. Finally, the estimates provided by the observers and the sensor measures are processed by a Decision Making System (DMS) that provides information about the faulty sensor and an healthy measure. In order to test the effectiveness of the proposed approach, a simulation case study is developed.

ThA07.3: 10:25-10:45
Optimal Control of a Reverse Osmosis Desalination Plant Using Multi-Objective Optimization, pp. 1368-1373

Gambier, Adrian	Univ. of Mannheim
Wellenreuther, Andrea	Univ. of Mannheim
Badreddin, Essameddin	Univ. of Mannheim

In this contribution, the control of a reverse osmosis desalination plant by using an optimal multi-loop approach is presented. Controllers are assumed to be players of a cooperative game, whose solution is obtained by multi-objective optimization (MOO). The MOO problem is solved by applying a genetic algorithm and the final solution is found from this Pareto set. For the reverse osmosis plant a control scheme consisting of two PI control loops are proposed. Simulation results show that in some cases, as for example this desalination plant, multi-loop control with several controllers, which have been obtained by join multi-objective optimization, perform as good as more complex controllers but with less implementation effort.

ThA07.4: 10:45-11:05
Adaptive Fuzzy Output Feedback Control of an Unstable Reactor, pp. 1374-1379

Salehi, Shahin	Tehran Petroleum Univ. of Tech.
Shahrokhi, Mohammad	Sharif Univ.
Karim, Salahshoor	Tehran Petroleum Univ. of Tech.

In this paper, design of non-adaptive and adaptive nonlinear controller for a class of continuous stirred tank reactor (CSTR) is considered. First the well-known global input-output linearization controller (GLC) is used to control the reactor temperature. Since for implementation of GLC concentration

is needed, a nonlinear observer is used to estimate concentration. Second an adaptive fuzzy output feedback controller is proposed and applied to the reactor. The linguistic rules of this adaptive version are constructed based on temperature measurements. The simulation results imply that both controllers are capable of controlling the reactor temperature. Moreover the performance of the adaptive fuzzy controller for load rejection and bearing the model mismatch is superior.

ThA07.5: 11:05-11:25
QFT Design for Load Frequency Control of Non-Minimum Phase Hydro Power Plant, pp. 1380-1385

Khodabakhshian, Amin — Isfahan Univ.
Rahimi, Habib — Isfahan Univ.
Golbon, Navid — Behineh Niru

Design of a robust PID controller for load frequency control of non-minimum phase hydro power plants using the Quantitative Feedback Theory (QFT) is addressed in this paper. Motivated by the large uncertainty in dynamic models of power system components this paper proposes a simple and systematic procedure to tune the parameters of the controller. The resulting controller in simulation results is shown to minimize the effect of disturbances and to maintain the robust performance.

ThA08 Room 2607
Modeling (Regular Session)

Chair: Bokor, Jozsef — Hungarian Acad. of Sciences
Co-Chair: Rantzer, Anders — Lund Univ.

ThA08.1: 09:45-10:05
Tracking Design for Wiener Systems Based on Dynamic Inversion, pp. 1386-1391

Szabo, Zoltan — Hungarian Acad. of Sciences
Gaspar, Peter — Hungarian Acad. of Sciences
Bokor, Jozsef — Hungarian Acad. of Sciences

This paper investigates the problem of reference tracking for systems defined by a Wiener model. The proposed algorithm is based on a dynamic inversion method in which it is assumed that the full state vector is unavailable. However it is assumed that the inverse of the nonlinear part is a known static function. The performance of the closed-loop system is tuned by an error feedback. As an example a tracking control of an industrial pressurizer is also presented.

ThA08.2: 10:05-10:25
Dynamic Modelling of Cam Indexers Driven by DC Servomotors, pp. 1392-1397

Incerti, Giovanni — Univ. of Brescia

Dynamic equations of the intermittent motion of an indexing mechanism are derived in this paper. The vibrations due to the compliance of the mechanical components and the backlash effect of the gear speed reducer coupled to the mechanism are studied by means of a lumped parameters model of the system. Besides the non-rigid behaviour of the device, the computer simulations consider also the effects related to the electromagnetic behaviour of the motor and to the velocity controller. The numerical results, presented and discussed in the paper, indicate that the proposed model is feasible to foresee the dynamic behaviour of an actual system.

ThA08.3: 10:25-10:45
A Model Reduction Case Study: Automotive Engine Air Path, pp. 1398-1403

Nilsson, Oskar — Lund Univ.
Chauvin, Jonathan — Ecole Nat. Sup. Mines de Paris
Rantzer, Anders — Lund Univ.

Low complexity plant models are essential for model based control design. Often a detailed high order model is available and simplification to a low order approximative model is needed. This paper presents a case study of two model reduction methodologies applied on the automotive engine air path. The first methodology is based on balanced truncation of models obtained by linearization around equilibria and trajectories. Under appropriate assumptions, this technique yields strict bounds on the approximation error. The second is a heuristic methodology, based on intuition commonly used when modeling engine dynamics. Although it is successfully used in practice, the approximation error is seldom known. The two methodologies are used to derive simple models for the required fuel charge in an SI engine, given engine speed and throttle positions. Performance, complexity and similarities of the two resulting low order models are compared.

ThA08.4: 10:45-11:05
Order Reduction of Nonlinear Hydropneumatic Vehicle Suspension, pp. 1404-1408

Yousefi, Amirhossein — Tech. Univ. Munich
Lohmann, Boris — Tech. Univ. Munich

This paper considers the problem of passing from a nonlinear time-invariant high-order model of a nonlinear hydropneumatic vehicle suspension to a low-order approximation. The method presented in this paper requires the simulation of original system with its typical inputs. In the next step, it designates one part of the state space which contains the major information the so-called dominant subspace (xdo). Performance is achieved by minimizing the norm of error between state variables and their approximation and also the norm of error between the state variable derivatives. The main idea can be generalized in form of an approach for similar nonlinear systems.

ThA08.5: 11:05-11:25
Supervisory Control by Using Active Virtual 3D Models In-The-Loop, pp. 1409-1413

Reichenbach, Tomislav — Univ. of Zagreb
Damjan, Miklic — Univ. of Zagreb
Kovacic, Zdenko — Univ. of Zagreb

Virtual 3D models play important role in a today factory layout design, physical modeling, control synthesis, performance analysis, dynamic simulation and visualization of real systems. In this paper, we go one step further and besides visualization, we monitor all measurable states in the real system and use active 3D models in-the-loop for real-time supervisory control. Such concept enables an event detection not possible with conventional sensors, including the ability to predict possible outcomes in the system operation. A virtual environment simulator and the way it can be connected to other simulators (e.g. Matlab/Simulink), is presented. The examples of virtual sensors, and collision free-based trajectory planning for robotic manipulators are demonstrated.

ThA09 Room 0999
Robotics (Regular Session)

Chair: Papadopoulos, Evangelos — National Tech. Univ. of Athens
Co-Chair: Yaz, Edwin — Marquette Univ.

ThA09.1: 09:45-10:05
Control of the Multi Agent Micro-Robotic Platform MiCRoN, pp. 1414-1419

Vartholomeos, Panagiotis — National Tech. Univ. of Athens
Loizou, Savvas — Univ. of Pennsylvania
Thiel, Michael — Univ. of Karlsruhe
Kyriakopoulos, Kostas J. — National Tech. Univ. of Athens
Papadopoulos, Evangelos — National Tech. Univ. of Athens

This paper presents the theoretical framework for the centralized control architecture of the multi agent micro-robotic platform MiCRoN. The entire control system architecture integrates sensory modules, modeling modules, and control modules. The latter are composed by (i) a high level simulation and autonomous execution unit that is capable for on-line multi-robot navigation with collision avoidance, (ii) a trajectory tracking unit for manipulation purposes, and (iii) a low level position controller that performs position control exploiting machine learning algorithms. The high level controllers take into account behaviors specific to the micro-scale. The performance of the layered control system is evaluated through simulations and preliminary hardware experiments on a micro-robotic platform. The application domain of the MiCRoN platform is cell manipulation, and 3-D assembly for micro-fabrication.

ThA09.2: 10:05-10:25
The Software Architecture of the Berkeley UAV Platform, pp. 1420-1425

Tisdale, John	Univ. of California at Berkeley
Ryan, Allison	Univ. of California at Berkeley
Zennaro, Marco	Univ. of California at Berkeley
Xiao, Xiao	Univ. of California at Berkeley
Caveney, Derek	Toyota Tech. Center
Rathinam, Sivakumar	Univ. of California at Berkeley
Sengupta, Raja	Univ. of California at Berkeley
Hedrick, Karl	Univ. of California at Berkeley

This paper details the software architecture of the Berkeley Unmanned Aerial Vehicle (UAV) Platform. Developed over the course of three years, this platform has successfully demonstrated autonomous vision-based navigation and obstacle avoidance. A software architecture has been developed to allow for collaborative control concepts to be examined. This modular architecture has been shown to be effective for use in allowing a team of UAVs to collaboratively perform a set of missions. The performance of the architecture was demonstrated using 3 UAVs to perform autonomous collaborative patrolling and vision-based navigation.

ThA09.3: 10:25-10:45
An Improved Nonlinear-Estimation Based Chaotic Communication Scheme, pp. 1426-1431

Hounkpevi, Franck	Marquette Univ.
Yaz, Edwin	Marquette Univ.

In this work, an improved nonlinear estimator based scheme is introduced to enhance the performance of a previously proposed chaotic digital communication scheme. The earlier scheme was improved in two ways. First the speed of the scheme is improved by a factor greater than ten, therefore is more suitable for real time communication where all delays (including processing time) must be kept extremely small in applications such as radar communication, telephony, and videoconferencing. Second, the new scheme's bit error rate performance is superior to that of the previous one. The key factor for the fast decoding of this new algorithm is that it is designed based on faster divergence of the estimator in case of chaotic system mismatch. Simulation results are provided and show the feasibility and superiority of our scheme over the earlier proposed one.

ThA09.4: 10:45-11:05
Linear Optimal Estimation Algorithms Based on the Monte Carlo Method and Neural Networks for Nonlinear Navigational Problems, pp. 1432-1437

Stepanov, Oleg A.	Central Scientific Res. Inst. Elektropribor
Amosov, Oleg S.	Komsomolsk-on-Amur State Tech. Univ.

Problems of navigation data processing intended to estimate the time invariant vector by nonlinear measurements are considered. The Bayesian approach, which provides the basis for determining optimal (minimum variance) estimates, is used. Suboptimal algorithms based on linear optimal estimates are proposed. Two methods for calculation of these estimates are considered. One of them is based on the Monte Carlo method, the other uses neural networks. The algorithms proposed are compared with nonlinear optimal and linearized algorithms. An example and the results of application of linear optimal estimates to the problem of navigation with the use of reference beacons are given.

ThA09.5: 11:05-11:25
A Generic Reconfigurable Agent Model for Distributed Manufacturing System, pp. 1438-1443

Wang, Qing	Northeastern Univ.
Yung, Kai Leung	The Hong Kong Pol. Univ.
Ip, W.H.	The Hong Kong Pol. Univ.

Agent-Based System have been considered to be a powerful methodology in developing competent manufacturing management systems controlling the whole manufacturing cycle in a distributed manner. This paper reviews the technologies about ABS and proposes a Generic Reconfigurable Agent Model (GRAM): an XML-based framework implemented by Java. This model excels in its flexibility and adaptability to reconfigure distributed manufacturing. It can be applied either to develop an intelligent ABS or to integrate with legacy systems. Experiments show that it is easy to embed intelligence or knowledge in the GRAM application. The GRAM employs the dominant paradigm with client-server mechanism, providing agent clients with more ability to utilize agent resources through controllable XML-based communication.

ThA09.6: 11:25-11:45
Observability Conditions for Target States with Bearing-Only Measurements in Three-Dimensional Case, pp. 1444-1449

Ferdowsi, Mohammad Hossien	Malek Ashtar Univ. of Tech.

In target tracking with a passive sensor such as infrared seekers, angle-only information is determined. In this case no information about the range of the target is provided and unobservable system is resulted. This paper studies the observability of discrete time three-dimensional bearing–only target tracking. The target is assumed to be moving in a straight line while a single moving observer (own-ship) measures its relative (elevation and azimuth) bearing angles. By transforming the inherently nonlinear bearing measurements into a pseudo-linear form, a linear Least Squares (LS) estimator is formulated. Observability is then analyzed by studying the solvability of the associated LS problem. This approach has the advantage of providing simple unobservability conditions as opposed to other approaches in the continuous time setup. In this paper, most of motivation and problem formulation is taken from [9]. It is shown that for no maneuvering target, at least three independent measured bearings for system observability is required.

ThA10 Room 3999
Robust Control IV (Regular Session)

Chair: Maizi, Nadia	Ecole des Mines de Paris
Co-Chair: Singh, Tarunraj	State Univ. of New York at Buffalo

ThA10.1: 09:45-10:05
Multiobjective Robust Control Via Youla Parametrization, pp. 1450-1456

Neering, Jan	Ecole des Mines de Paris
Drai, Rémi	European Space Agency
Bordier, Marc	Ecole des Mines de Paris
Maizi, Nadia	Ecole des Mines de Paris

Using Youla parametrization and linear matrix inequalities a multi-objective robust control system design for continuous linear time invariant systems with bounded uncertainties is described. The design objectives can be a combination of H-infinity and H2 performances, constraints on the control signal, etc. Based on an inital stabilizing controller all stabilizing controllers for the uncertain system can be described by the Youla parametrization. Given this representation, all objectives can be formulated by independent Lyapunov functions, increasing the degree of freedom for the control design.

ThA10.2: 10:05-10:25
Robust Delay-Dependent H-Infinity Filtering for a Class of LPV State-Delayed Systems, pp. 1457-1462

Karimi, H. R.	Tech. Univ. Munich
Lohmann, B.	Tech. Univ. Munich
Buskens, C.	Univ. of Bremen

This paper deals with the robust delay-dependent H-infinity filtering problem for a class of LPV systems with multiple constant time-delays in the state vector. It is shown that, by using the Hamiltonian-Jacoby-Isaac (HJI) function and the polynomially parameter-dependent quadratic functions and a suitable change of variables, the required sufficient conditions with high precision are established in terms of parameter-independent linear matrix inequalities (LMIs) for the existence of the desired filters. However, the explicit expression of the robust delay-dependent H-infinity filters is derived to satisfy both asymptotic stability and H-infinity performance. A numerical example is provided to demonstrate the validity of the proposed design approach.

ThA10.3: 10:25-10:45
Analysis and Design of Control System with Equivalent-Input-Disturbance Estimation, pp. 1463-1469
She, Jin-Hua — Tokyo Univ. of Tech.
Xin, Xin — Okayama Prefectural Univ.
Yamaura, Tomio — Tokyo Univ. of Tech.

This paper examines the mechanism of disturbance rejection in control systems employing a technique called equivalent-input-disturbance estimation. Analysis of the mechanism shows that the filter in the control system strongly affects the disturbance rejection performance. A new method of designing such control systems that employs H-infinity control theory and linear matrix inequalities is presented; and simulations of a magnetic levitation system demonstrate its validity.

ThA10.4: 10:45-11:05
Robust Input Shaper Design Using Linear Matrix Inequalities, pp. 1470-1475
Thomas, Conord — State Univ. of New York at Buffalo
Singh, Tarunraj — State Univ. of New York at Buffalo

This paper proposes an Linear Matrix Inequality based problem formulation to determine input shaped profiles. The cost function is the residual energy, a quadratic function of the amplitude of the shaped profile, for each sampling interval. The Schur complement permits representing the quadratic function as a Linear Matrix Inequality. Augmenting the state space model with the sensitivity of the states to uncertain parameters, input shaped profiles which are robust to model uncertainties can be derived. Finally, a minimax input shaped profile which minimizes the maximum magnitude of the residual energy over the domain of uncertainties is determined using the LMI problem. The proposed technique is illustrated on the single spring-mass-dashpot example. The solutions derived are shown to coincide with the solutions presented in the literature, without the requirement of solving a nonlinear programming problem.

ThA10.5: 11:05-11:25
Adaptive Nonlinear H-Infinity Controllers Applied to a Free-Floating Space Manipulator, pp. 1476-1481
Taveira, Tatiana de F. P. A. — Univ. of Sao Paulo at Sao Carlos
Siqueira, Adriano A. G. — Univ. of Sao Paulo at Sao Carlos
Terra, Marco Henrique — Univ. of Sao Paulo at Sao Carlos

This paper deals with the problem of tracking control with a guaranteed H-infinity performance for free-floating manipulator systems with plant uncertainties and external disturbances. Adaptive nonlinear H-infinity control techniques based on linear parametrization and neural network are applied to this kind of robot. The Dynamically Equivalent Manipulator approach is used in order to obtain experimental results in a planar fixed base manipulator. The main contribution of this paper is that the neural network is used as a complement to the nonlinear H-infinity control based on nominal model, it is used to compensate only the uncertainties of the free-floating manipulator.

ThA10.6: 11:25-11:45
Robust D-Stability Analysis Based on Pendulum Systems, pp. 1482-1486
Wang, Jialian — Hangzhou Dianzi Univ.
Xue, Anke — Hangzhou Dianzi Univ.
Zhao, Xiaodong — Hangzhou Dianzi Univ.

This note deals with the problem of robust D-stability analysis on pendulum systems, with respect to structured uncertainties. Sufficient conditions, which are computationally simple, and need not calculate the eigenvalues of the system, is proposed to ensure that the inverted pendulum system is D-stable, that is, all its finite poles are located within a specified disk.

ThA11 Audimax
Hybrid & Switching Systems II (Regular Session)
Chair: Bonhomme, patrice — Univ. of Tours
Co-Chair: Dourado, Antonio — Univ. of Coimbra

ThA11.1: 09:45-10:05
Hysteresis Switched Observer Design for General Manipulation Systems, pp. 1487-1492
Chaib, Salim — ENSI Bourges
Boutat, Driss — ENSI Bourges
Benali, Abderraouf — ENSI Bourges

In this paper, we focus on the problem of a observer design for a manipulation system. The mechanical compliance introduced by the cooperation between the manipulators and their interactions with load is complex and nonlinear which makes the observer design very difficult. The last motivates us to develop a new approach to design a multi models-based observer that we will call hysteresis switched observer. The proposed hysteresis switched observer is based on a piecewise linear approximation of the dynamic model. The robust design of the observers composing the hysteresis switched one and the hysteresis behavior of the switching logic ensure the asymptotic stability of the error of the observation with a smooth dynamics.

ThA11.2: 10:05-10:25
Piecewise Affine Identification of MIMO Processes, pp. 1493-1498
Vasak, Mario — Univ. of Zagreb
Klanjcic, Damir — Univ. of Zagreb
Peric, Nedjeljko — Univ. of Zagreb

In this paper PieceWise ARX (PWARX) model identification of a nonlinear MIMO process is discussed. PWARX models comprise several ARX models where each of them is valid over a polytope in the regressor space. The identification procedure simultaneously estimates both the polytopic regions and the ARX model coefficients in each region. Here we use the clustering-based identification procedure, that is designed for MISO processes, and proceed in a natural way to extend this approach to identification of nonlinear MIMO processes. A very important role in identification of process nonlinearities for each MISO process plays a suitable linear transformation in the regressor space. A new way for choosing that linear transformation is suggested, automatically from the identification data position in the regressor space. Using the proposed procedure, a PWARX MIMO model of a magnetic levitation laboratory setup is identified and validated.

ThA11.3: 10:25-10:45
A Control Strategy for Control of Discrete-Time Piecewise Affine Systems on Polytopes Using System Inherent Bounds, pp. 1499-1504
Hodrus, Thomas Erhard — Univ. Karlsruhe
Wolff, Florian — Univ. Karlsruhe
Krebs, Volker G. — Univ. Karlsruhe

In this paper we propose a local control strategy for the control of discrete-time piecewise affine systems on full-dimensional polytopes using system inherent bounds. The overall control strategy is divided into this local control and a supervisory control. The local control problem is to reach and cross one selected facet of a polytope ensuring that the next sample of the discrete-time trajectory is picked up in the adjacent polytope. The procedure is based on system inherent bounds assisted by conditions for the discrete-time gradient of the system. The controller design can be performed intuitively or with both the inherent bounds and the conditions an optimization problem can be formulated minimizing a performance index. A control law is obtained that is valid on the entire polytope for one specific facet. The supervisory control problem is to find a suitable combination of polytopes and local control strategies that transfer the trajectory to the polytope that contains the operating point.

ThA11.4: 10:45-11:05
Control and Performances Evaluation of Time Dependent Systems Using an Enumerative Approach, pp. 1505-1510
Bonhomme, Patrice — Univ. of Tours

Petri nets are a powerful formalism for the specification and verification of concurrent systems, such as sequential systems and manufacturing systems. To deal with systems whose time issues become essential, different extensions of Petri nets with time have been proposed in the literature, each one being dependent on the application considered. In this paper, a new enumerative analysis technique for P-time Petri nets is proposed. It consists of simple operations on time intervals and does not require complex computations contrary to the other methods, dealing with time critical systems, which can be found in the literature. Moreover a control approach is also derived.

ThA11.5: 11:05-11:25
Supervision and Fault-Tolerant Control: A Robust Model-Based Approach, pp. 1511-1516
Cardoso, Alberto — Univ. of Coimbra
Dourado, Antonio — Univ. of Coimbra

A fault-tolerant control strategy based on a robust model-based approach is addressed in order to design and implement a supervisory system. The approach considers the application of a robust control technique to integrate the control design and the fault diagnosis in the same framework. A model-based approach is used to estimate the system's state variables and to synthesize the robust controller. The design objectives are formulated in terms of H-infinity specifications and the problem is solved with the structured singular value (mu) technique. The supervisor is designed to accommodate the sensor faults when they occur, generating actions based on the analysis of the residual signals. Whenever a fault is detected and isolated, the supervisor should switch off the faulty sensor and replace its output by a reconstructed signal. The main purpose is to obtain a robust fault-tolerant controller and a fault detection filter to generate residual signals for fault diagnosis and supervision purposes. This approach was applied to an unstable and nonlinear process, the inverted pendulum laboratory plant.

ThA11.6: 11:25-11:45
An Approach of PI Gain Scheduling with Hysteresis Switching for the Control of Boiler Drum Level in the Coal-Fired Power Generation Units, pp. 1517-1521
Bi, Zhenfu — Shandong Electric Power Res. Inst.
Pan, Yuezhi — Shandong Zouxian Power Company
Zhang, Qiangfu — Shandong Zouxian Power Company
Wang, Fusheng — Shandong Electric Power Res. Inst.

An approach, where hysteresis switching logic is used in gain scheduling of PI controller, is proposed and applied practically in the control of boiler drum level of 4×300MW coal-fired power generation units. The parameterized candidate PI controllers are designed at a number of operating points based on on-site engineering tuning/tests, and, hysteresis switching logic, which is shown theoretically can be used with the aim that switching stops in finite time, is applied to make controller decision over those candidate PI controllers. The unit generation output is used as scheduling variable by the hysteresis switching logic. The proposed controller structure is used to control drum level of 4×300MW coal-fired power generation units at Zouxian Power Generation Inc, P.R.China.

ThB01 Room 2601
Computer-Aided Control Design and Optimization
(Regular Session)
Chair: Lampe, Bernhard P. — Univ. of Rostock
Co-Chair: Henrion, Didier — LAAS-CNRS

ThB01.1: 13:00-13:20
Linear Controller Retuning Approach Based on Nonconvex Nonsmooth Optimization, pp. 1522-1527
Lassami, Bilal — Supelec
Font, Stephane — Supelec

The purpose of this paper is to describe how the fundamental problem of linear controller design can be solved, for general specifications, by combining a theoretical result with a recent numerical nonconvex nonsmooth optimization technique. Various temporal and/or frequency design criteria and constraints can be considered. The formulated optimization problem is complex; it involves implicit and explicit design parameters and nonsmooth criteria as well. A new algorithm based only on the gradient notion is fully described. This algorithm, mixing with an exact computation of gradients based on parametric sensitivity functions, appears to be well suited for controller design and retuning. As illustration, this method is used to design an optimal PI controller for a benchmark oscillatory model and to tune a PID controller for a motor position control. Computer simulations and experimental bench results are given to demonstrate the effectiveness of the proposed algorithm.

ThB01.2: 13:20-13:40
Haar Wavelet-Based Optimal Control of Time-Varying State-Delayed Systems: A Computational Method, pp. 1528-1533
Karimi, H. R. — Tech. Univ. Munich
Jabehdar Maralani, P. — Univ. of Tehran
Lohmann, B. — Tech. Univ. Munich
Moshiri, B. — Univ. of Tehran

Using Haar wavelets, a computational method is presented to determine the piecewise constant feedback controls for a finite-time linear optimal control problem of a time-varying state-delayed system. The method is simple and computationally advantageous. The approximated optimal trajectory and optimal control are calculated using Haar wavelet integral operational matrix, Haar wavelet product operational matrix and Haar wavelet delay operational matrix. An illustrative example is included to demonstrate the validity and applicability of the technique.

ThB01.3: 13:40-14:00
Solving Static Output Feedback Problems by Direct Search Optimization (I), pp. 1534-1537
Henrion, Didier — LAAS-CNRS

Direct search methods are local optimization algorithms maximizing a possibly nonsmooth and nonconvex function using its values only (no first-order gradient or second-order Hessian information). More than one decade ago, N. J. Higham implemented some simple Matlab routines for direct search optimization, investigating questions on stability and accuracy of numerical algorithms in matrix computations. The purpose of this note is to report numerical experiments showing that with these routines a non-expert user can solve at moderate cost most of the static output feedback design problems available in the problem library COMPLIB.

ThB01.4: 14:00-14:20
Minimum-Time Feedforward Control with Input and Output Constraints, pp. 1538-1543
Consolini, Luca — Univ. of Parma
Piazzi, Aurelio — Univ. of Parma

For linear continuous-time scalar systems, the paper proposes the problem of synthesizing a minimum-time rest-to-rest feedforward control with input and output constraints. In a behavioral framework, simple sufficient conditions for the problem to have a solution are provided. Then using discretization, an arbitrarily good approximation to the global minimum-time solution is found by solving a sequence of linear programming problems. Computational examples to show the effectiveness of the proposed approach are included.

ThB01.5: 14:20-14:40
Detecting Design Flaws in Control Systems Using Optimisation Methods, pp. 1544-1549
Bostrom, Pontus — Abo Akademi Univ.
Jerker, Bjorkqvist — Abo Akademi Univ.

Complicated control systems are used in many safety-critical applications, such as in cars and airplanes. Due to the nature of these systems, verification can be very difficult to do analytically or algorithmically. The only feasible analysis and verification method is often simulation. The generation of good test cases that can expose flaws in the controller design is therefore of great importance. In this paper we investigate the use of optimisation methods for finding such test cases automatically. For this purpose we give a language to express assertions in control systems, as well as a translation of the assertions to a form suitable for optimisation. We also discuss different ways to generate the input signals for the systems to maximise performance of the optimisation. To evaluate if optimisation is a feasible approach, we provide a case study demonstrating that optimisation methods are beneficial for investigating properties of control system designs.

ThB01.6: 14:40-15:00
Semismooth Hybrid Automata (I), pp. 1550-1555
Yunt, Mehmet — Massachusetts Inst. of Tech.
Barton, Paul — Massachusetts Inst. of Tech.

The determination of the optimal mode sequence for hybrid systems with autonomous transitions is examined. A class of hybrid systems that exhibit a locally Lipschitz mapping between their parameters and their continuous states is introduced. Lipschitzian optimization methods such as bundle methods are explored for the solution of parametric optimization problems that have this class of hybrid systems embedded.

ThB02 Room 1601
Computer-Aided Design of Hybrid Control Systems
(Invited Session)

Chair: Levine, William S. — Univ. of Maryland
Co-Chair: Barros, Fernando J. — Univ. de Coimbra
Organizer: Hristu-Varsakelis, Dimitris — Univ. of Macedonia
Organizer: Levine, William S. — Univ. of Maryland

ThB02.1: 13:00-13:20
Discrete Dynamic Feedback for a Class of Hybrid Systems on a Lattice (I), pp. 1556-1561
Del Vecchio, Domitilla — Univ. of Michigan

We address the problem of designing a dynamic output feedback control for a hybrid system in order to satisfy system specifications, once the continuous variables are measured. In absence of a structure on the discrete variable space, the design of such a controller requires a number of computations at least proportional to the size of the discrete variable set and to the size of the control set. In this paper, we propose to exploit a partial order structure on the set of discrete variables and inputs. The control input is thus computed as a function of two discrete variable values that are updated at each step. This algorithm is applied to a multi-robot game involving two teams competing against each other in a “capture the flag”-like game.

ThB02.2: 13:20-13:40
Optimization of Signal Processing Software for Control System Implementation (I), pp. 1562-1567
Bhattacharyya, Shuvra S. — Univ. of Maryland
Levine, William S. — Univ. of Maryland

Signal processing plays a fundamental role in the design of control systems - the portion of a digitally-implemented control system between the sensor outputs and the actuator inputs is precisely a digital signal processor. Consequently, effective techniques for design and optimization of signal processing software are important in achieving efficient controller implementations.

Motivated by these relationships, this paper reviews techniques for modeling signal processing functionality in a manner that exposes aspects of application structure that are useful for mapping the functionality into efficient implementations. The paper then introduces some representative techniques that operate on such models to systematically derive optimized implementations from them.

ThB02.3: 13:40-14:00
A Hybrid System Formalism for Modeling and Simulation (I), pp. 1568-1573
Nikoukhah, Ramine — INRIA

A formalism for modeling hybrid dynamical systems is presented. Unlike most work on hybrid dynamical systems where the objective of model construction is system analysis and controller synthesis, the objective here is to construct a formalism suited for modular model construction and simulation. This formalism is used in the open-source modeling and simulation software Scicos.

ThB02.4: 14:00-14:20
On the Implementation of Control Loops by Software (I), pp. 1574-1581
Caspi, Paul — CNRS-VERIMAG
Maler, Oded — CNRS-VERIMAG

This article is intended to present a survey of what we consider as one of the central aspects of embedded systems, namely the realization of control systems by software. Although computers are today the most popular medium for implementing controllers, we feel that the state of understanding of this topic is not satisfactory, mostly due to the fact that it is situated in the frontier between two different cultures and world views (Control and Informatics), which are not easy to reconcile. The purpose of this article is to clarify these issues and present them in a uniform and, hopefully, coherent manner.

ThB02.5: 14:20-14:40
Recent Progress in Continuous and Hybrid Reachability Analysis (I), pp. 1582-1587
Asarin, Eugene — Univ. Paris 7
Dang, Thao — VERIMAG
Frehse, Goran — VERIMAG
Girard, Antoine — VERIMAG
Le Guernic, Colas — VERIMAG
Maler, Oded — VERIMAG

Set-based reachability analysis computes all possible states a system may attain, and in this sense provides knowledge about the system with a completeness, or coverage, that a finite number of simulation runs can not deliver. Due to its inherent complexity, the application of reachability analysis has been limited so far to simple systems, both in the continuous and the hybrid domain. In this paper we present recent advances that, in combination, significantly improve this applicability, and allow us to find better balance between computational cost and accuracy. The presentation covers, in a unified manner, a variety of methods handling increasingly complex types of continuous dynamics (constant derivative, linear, nonlinear). The improvements include new geometrical objects for representing sets, new approximation schemes, and more flexible combinations of graph-search algorithm and partition refinement. We report briefly some preliminary experiments that have enabled the analysis of systems previously beyond reach.

ThB02.6: 14:40-15:00
OpenModelica – a Free Open-Source Environment for System Modeling, Simulation, and Teaching (I), pp. 1588-1595
Fritzson, Peter — Linkoping Univ.
Aronsson, Peter — Linkoping Univ.
Pop, Adrian — Linkoping Univ.
Lundvall, Hakan — Linkoping Univ.
Nystrom, Kay — Linkoping Univ.
Saldamli, Levon — Linkoping Univ.
Broman, David — Linkoping Univ.
Sandholm, Anders — Linkoping Univ.

Modelica is a modern, strongly typed, declarative, and object-oriented language for modeling and simulation of complex systems. This paper gives a quick overview of some aspects of the OpenModelica environment – an open-source

environment for modeling, simulation, and development of Modelica applications. An introduction of the objectives of the environment is given, an overview of the architecture is outlined and a number of examples are illustrated.

ThB03 Room 0670
Neural Networks and Neurocontrol (Regular Session)

Chair: Sanchez, Edgar N. CINVESTAV
Co-Chair: Rovithakis, George A. Aristotle Univ. of Thessaloniki

ThB03.1: 13:00-13:20
Robustness of Complete Stability for a Class of Nearly-Symmetric Cellular Neural Networks, pp. 1596-1601
Di Marco, Mauro Univ. of Siena
Forti, Mauro Univ. of Siena
Tesi, Alberto Univ. of Firenze

Cellular neural networks (CNNs) are one of the most popular paradigms for real-time information processing. Recently, CNNs have found interesting applications in the solution of on-line optimization problems, and the implementation of intelligent sensors. In these applications the CNNs are required to be completely stable, i.e. each trajectory should converge toward a stationary state. Such an important dynamical property is typically guaranteed by requiring that the neuron interconnection matrix is symmetric. The present paper investigates the issue of robustness of complete stability, with respect to perturbations of the nominal symmetric interconnections, deriving from the hardware implementation of the CNNs. In particular, a class of circular one-dimensional CNNs with nearest-neighbor interconnections only, is considered. The class has sparse interconnections and is subject to perturbations which preserve the interconnecting structure. It is shown that in the general case complete stability is not robust for this class of CNNs, i.e., there are small perturbations leading to the loss of all nominal asymptotically stable equilibrium points. This paper extends previous work on robustness of complete stability of CNNs, and confirms the importance to develop design methods that guarantee not only complete stability on the nominal symmetric case, but also its robustness with respect to tolerances in the implementation.

ThB03.2: 13:20-13:40
An Adaptive Neuro-Fuzzy Control Approach for Nonlinear Systems Via Lyapunov Function Derivative Estimation, pp. 1602-1607
Moustakidis, Serafim Aristotle Univ. of Thessaloniki
Rovithakis, George A. Aristotle Univ. of Thessaloniki
Theocharis, John Aristotle Univ. of Thessaloniki

An adaptive neuro-fuzzy controller is proposed in this paper to deal with the problem of tracking nonlinear affine in the control dynamical systems with unknown nonlinearities. The plant is described by means of a Takagi-Sugeno fuzzy model, including dynamic fuzzy rules of generalized form, where the local submodels are realized through nonlinear input-output mappings. Instead of modelling the plant dynamics directly, our approach relies upon the effective approximation of certain terms that involve the derivative of the Lyapunov function and the unknown system nonlinearities on a local basis using linear in the weights neural networks. A resetting scheme is proposed to assure validity of the control input. The uniform ultimate boundedness of the tracking error with respect to an arbitrarily small set of the origin is achieved, along with the boundedness of all other signals in the closed loop. Illustrative simulations highlight the approach.

ThB03.3: 13:40-14:00
Force/Position Tracking for a Robotic Finger in Compliant Contact with a Surface Using Neuro-Adaptive Control, pp. 1608-1613
Karayiannidis, Yiannis Aristotle Univ. of Thessaloniki
Rovithakis, George A. Aristotle Univ. of Thessaloniki
Doulgeri, Zoe Aristotle Univ. of Thessaloniki

In this work, the problem of force/position tracking for a robotic finger in compliant contact with a surface under non-parametric uncertainties is considered. In particular, structural uncertainties are assumed to characterize the compliance model as well as the robot dynamic model. A novel neuro-adaptive controller is proposed that exploits the approximation capabilities of the linear in the weights neural networks and the uniform ultimate boundedness of force and position error is proved. Simulation results illustrate the performance of the proposed controller.

ThB03.4: 14:00-14:20
Decentralized Neural Identification and Control for Robotics Manipulators, pp. 1614-1619
Sanchez, Edgar N. CINVESTAV
Gaytan, Armando CINVESTAV
Saad, Maarouf Ecole de Tech. Superieure, Montreal

This paper presents a decentralized control scheme, based on a recurrent neural identifier with a block control structure, and its application to robotics manipulators. A local joint controller is proposed for each joint, using only local angular position and velocity measurements. These very simple local joint controllers allow trajectory tracking, with reduced computations. The applicability of the proposed scheme is illustrated, via simulations, first by the applications to a two degree of freedom robotic manipulator and then to a seven degree of freedom one.

ThB03.5: 14:20-14:40
Discrete-Time Nonlinear Recurrent High Order Neural Observer, pp. 1620-1624
Alanis, Alma Y. CINVESTAV
Sanchez, Edgar N. CINVESTAV
Loukianov, Alexander G. CINVESTAV

This paper presents the design of an adaptive recurrent neural observer for nonlinear systems, whose mathematical model is assumed to be unknown. The observer is based on a recurrent high order neural network (RHONN), which estimates the state vector of the unknown plant dynamics. The learning algorithm for the RHONN is based on an extended Kalman filter. This paper also includes the respective stability analysis, on the basis of the Lyapunov approach, for the neural observer trained with the extended Kalman filter. Some simulation results are included to illustrate the applicability of the proposed scheme.

ThB03.6: 14:40-15:00
The Learning and Dynamics of VSF-Network, pp. 1625-1630
Kakemoto, Yoshitsugu Japan Res. Inst.
Nakasuka, Shinichi Univ. of Tokyo

In this paper, we show an overview of VSF-network, the presumption of parameters for the additive learning, results of the learning applied to obstacle avoidance task using the presumed parameters, and we examined the state of the hidden-layer in VSF-network that the additive learning is applied. The recognition of patterns that are the learned the existing pattern, the incrementally learned pattern, and the pattern that is combined those both patterns, are improved, by setting the state of GCM-module where is a weak chaotic state in the incremental learning phase. The feature which can be recognized using the pattern that combines both the freshly learned pattern and the existing pattern that have never learned, is the key feature of VSF-network. A T-junction, a simple obstacle, and a compound obstacle were provided to a hierarchical network and VSF network that are incrementally learned, and the outputs from the hidden-layer were compared. Through the comparison, we confirmed that the output pattern of units that is incrementally learned pattern, and the combination of both patterns respectively on VSF-network.

ThB04 Room 2605
Estimation, Identification and Modeling (Regular Session)
Chair: Tan, Yonghong Guilin Univ. of Electronic Tech.
Co-Chair: Yau, Stephen S.-T. Univ. of Illinois at Chicago

ThB04.1: 13:00-13:20
Neural Nets Based Modeling of Inverse Model for Hysteresis Using Continuous Transformation, pp. 1631-1635
Ma, Lianwei Shangai Jiaotong Univ.
Tan, Yonghong Guilin Univ. of Electronic Tech.

This paper proposes a novel and simple approach for modeling of the inverse hysteresis. In this method, the continuous transformation technique is utilized to construct an elementary inverse hysteresis model (EIHM), which sets up a one-to-one mapping between the input space and the output space of the inverse hysteresis nonlinearity. Then the output of the EIHM is used as one of the input signals of the neural network (NN) to approximate the inverse behavior of hysteresis. Finally, the proposed method is applied to the modeling of the inverse model of hysteresis inherent in piezoelectric actuator.

ThB04.2: 13:20-13:40
General Model of Neuronal Population Activity, pp. 1636-1638
Jiao, Xianfa Donghua Univ.
Wang, Rubin East China Univ. Sci. Tech.

We propose a general model of neuronal population activity, where the variation of the amplitude of the neuronal oscillator is introduced to describe the resting state of neuronal oscillator. We introduce a firing density to describe the collective behavior of neuronal population. By numerical simulations we found that a stronger stimulation brings the collective firing of a neuronal population into synchronous oscillation, desynchronization, and resynchronization. This suggests that a stronger stimulation could enhance information coding that is mediated by the firing density of a neuronal population. Numerical simulation shows that external stimulation can improve the learning effect of nervous system.

ThB04.3: 13:40-14:00
Mixture Weighted Gating and Its Application to Target Tracking, pp. 1639-1644
Hashemzadeh, Farzad Univ. of Tehran
Nadjar Araabi, Babak Univ. of Tehran
Lucas, Caro Univ. of Tehran

This paper presents a new approach to gating in target tracking. Here, the gate is defined as the region in which the tracked target is expected to exist. The observation vector in the gate is used for tracking. In tracking in a two-dimensional plane, various shapes can be conceived as a gate, including a rectangle, circle, and ellipse. Elliptical gate is optimal for linear Gaussian modeled systems and suboptimal for non-Gaussian systems. This paper introduces mixture weighted gating by generalizing Kalman filter to non-Gaussian linear systems. This non-elliptical gate is applied in target tracking and its advantage respect to elliptical gate is shown.

ThB04.4: 14:00-14:20
On Convergence of the Linear Extended State Observer, pp. 1645-1650
Yoo, Dongchul Univ. of Illinois at Chicago
Yau, Stephen S.-T. Univ. of Illinois at Chicago
Gao, Zhiqiang Cleveland State Univ.

Motivated by the gap between theory and practice in control problems, Linear Active Disturbance Rejection Control(LADRC) addresses a set of control problems in the absence of precise mathematical models. LADRC depends on the quick convergence of a unique state observer, known as the extended state observer, proposed by Han. This paper shows numerically the tracking condition and the absolute error estimation of this observer for a class of nonlinear and uncertain motion control problems.

ThB04.5: 14:20-14:40
*A Fast JPDA-IMM-UKF Algorithm Based DFS Approach for Highly Maneuvering Targets**
Djouadi, Mohand Said Ecole Militaire Pol.

ThB04.6: 14:40-15:00
*Simulated Model for Hydro Turbine Speed Identification at Water and Load Disturbances**
Kishor, Nand Indian Inst. of Tech. Roorkee
Singh, S. P. Indian Inst. of Tech. Roorkee

ThB05 Room 0601
Advances in Engine and Fuel Cell Controls (Invited Session)
Chair: Koch, Charles Robert Univ. of Alberta
Co-Chair: Johansson, Rolf Lund Univ.
Organizer: Koch, Charles Robert Univ. of Alberta
Organizer: Guzzella, Lino ETH Zurich

ThB05.1: 13:00-13:20
Modeling and Predictive Control of a New Injection System for Compressed Natural Gas Engines (I), pp. 1651-1656
Lino, Paolo Pol. di Bari
Maione, Bruno Pol. di Bari
Amorese, Claudio Centro Ricerche Fiat S.C.p.A.
De Matthaeis, Sisto Centro Ricerche Fiat S.C.p.A.

The accurate metering of the air/fuel mixture in internal combustion engines equipped with Common Rail injection systems strictly depends on the injection pressure regulation. This is a critical objective to be accomplished in Compressed Natural Gas injection systems, as the gas compressibility makes the fuel delivery process more complex. Since the design of a controller requires a model of the injection system, in this paper a physics-based state space model of an innovative Compressed Natural Gas injection system is presented. The model parameters only depend on well defined geometrical data and fuel properties. Comparison of simulation and experimental results for different operating conditions validates the model. Further, the proposed model is used for designing a Generalized Predictive Controller (GPC) for the injection pressure regulation. The implementation of the control law consists of simple steps. Experimental results show the effectiveness of the proposed approach.

ThB05.2: 13:20-13:40
Design and Control of an Electromagnetic Valve Actuator (I), pp. 1657-1662
Braune, Steffen Univ. of Applied Sciences Wernigerode
Liu, Steven Tech. Univ. Kaiserslautern
Mercorelli, Paolo Univ. of Applied Scieces Wolfsburg

In this paper we present theoretical and experimental results for designing and operating a special linear electromagnetic motor as a variable engine valve actuator. Detailed description is given to the design procedure to meet the requirements of high dynamic and low power consumption, including the determination of actuator topology and parameters, the force, dynamic and power loss calculations. Based on a non-linear model a control strategy is presented and discussed as well. Both computer simulation and laboratory experimental results which demonstrate the excellent behavior of the developed system are presented.

ThB05.3: 13:40-14:00
Flatness-Based Tracking of an Electromechanical VVT Actuator with Magnetic Flux Sensor (I), pp. 1663-1668
Chladny, Ryan Univ. of Alberta
Koch, Charles Robert Univ. of Alberta

A flatness-based end controller of an automotive solenoid valve has been demonstrated in both simulation and on an actuator test-bench. The simulation model provides an accurate representation of the real system and allows for the development of control strategies. The simulation results are contrasted with those of an actuator test-bench equipped with 42 volt automotive solenoid valves and a pressure chamber to simulate valve opening with exhaust gas pressures. A flux-based sensor which is suitable for real engine operation is used for position estimation in the soft-landing control.

ThB05.4: 14:00-14:20
On Control of HCCI Combustion-Neural Network Approach (I), pp. 1669-1674

Mirhassani, Mitra	Univ. of Windsor
Chen, Xiang	Univ. of Windsor
Tahmasebi, Ali	Univ. of Windsor
Ahmadi, Majid	Univ. of Windsor

Due to environmental consideration and recent regulations on the car emission, new technologies are explored. HCCI engine, thanks to its low NOx emission and high efficiency may be one of the candidate solutions. Therefore, exploration of enhanced HCCI combustion control is of strong interest to both the auto industry and the academic community and of a challenge due to complexities in ignition timing prediction. In this paper, application of a neural network assisted controller for a control-based model of an HCCI combustion engines is explore. The model is updated on-line and is used to predict the ignition timing. Simulation results show that the controller is able to predict the proper inputs to the model and to track the desired peak pressure accurately. Hence a neural-network-based control strategy could be potentially established for HCCI combustion control.

ThB05.5: 14:20-14:40
Model Predictive Control of Homogeneous Charge Compression Ignition (HCCI) Engine Dynamics (I), pp. 1675-1680

Bengtsson, Johan	Volvo Powertrain Corp.
Strandh, Petter	Volvo Powertrain Corp.
Johansson, Rolf	Lund Univ.
TunestÍl, Per	Lund Univ.
Johansson, Bengt	Lund Univ.

The Homogeneous Charge Compression Ignition (HCCI) combustion principle lacks direct ignition timing control, instead the auto-ignition depends on the operating condition and fast combustion phasing control is necessary for reliable operation. A six-cylinder heavy-duty HCCI engine was controlled on a cycle-to-cycle basis in real time using a variety of sensors, actuators and control structures for control of the HCCI combustion in comparison. Combustion phasing control based on ion current was compared to feedback control based on cylinder pressure. Two actuators were compared, dual fuel and Variable Valve Actuation (VVA). Model-based control synthesis requiring dynamic models of low complexity and HCCI combustion models were estimated by system identification and by physical modeling. The models identified by system identification were used to design model-predictive control (MPC) with several desirable features and today applicable to relatively fast systems. Both control of the combustion phasing and control of load-torque with simultaneous minimization of the fuel consumption and emissions were included.

ThB05.6: 14:40-15:00
Optimal Power Split in Fuel Cell Hybrid Electric Vehicle with Different Battery Sizes, Drive Cycles, and Objectives (I), pp. 1681-1688

Sundstrom, Olle	Univ. of Michigan
Stefanopoulou, Anna G.	Univ. of Michigan

This paper explores different hybridization levels of a vehicle powered by a polymer electrolyte membrane fuel cell stack. The energy buffer considered is a lead-acid type battery. The effects of the battery size on hydrogen consumption and stack dynamic loading for different drive cycles are determined when dynamic programming determines the optimal current drawn from the fuel cell stack system. The optimal power split policies are analyzed to quantify all the energy losses and their paths in an effort to clarify the hybridization needs for a fuel cell vehicle.

ThB06 Room 0602
Advances in Networked Control (Invited Session)

Chair: Hirche, Sandra	Tokyo Inst. of Tech.
Co-Chair: Spong, Mark W.	Univ. of Illinois at Urbana-Champaign
Organizer: Hirche, Sandra	Tokyo Inst. of Tech.

ThB06.1: 13:00-13:20
Remote Control of Sampled-Data Systems under Constrained Communication (I), pp. 1689-1694

Ishii, Hideaki	Univ. of Tokyo

In implementing control systems using shared networks, it is important to consider the quality and the efficient usage of communication. In this paper, we consider a sampled-data remote control problem under two communication constraints: Multiple components of the system share the channels using a periodic transmission scheme while messages are randomly lost due to errors and delays in the channels. We develop a design method employing an H-infinity norm type criterion. This allows us to take account of the intersample behavior of the system. The approach is illustrated through a numerical example of a magnetic ball levitation system.

ThB06.2: 13:20-13:40
Networked PID Control (I), pp. 1695-1700

Quevedo, Daniel E.	Univ. of Newcastle
Welsh, James S.	Univ. of Newcastle
Goodwin, Graham C.	Univ. of Newcastle
McLeod, Malcolm	Univ. of Newcastle

PID controllers are the most widely used control scheme in industry. Traditionally these controllers have been implemented in analog or digital form on specifically dedicated communication links. However, there has been significant recent interest into deploying control over general purpose communication channels, which allow one to transmit data, voice and control signals. Naturally the successful design of such a Networked Control System necessitates a blend of techniques which reflect both Control and Communication aspects. The present work examines the effect of channel noise (or, equivalently, of channel capacity) on closed loop system behaviour. It is shown, and experimentally verified, how performance can be optimized via signal coding.

ThB06.3: 13:40-14:00
An Experimental Comparison of Bilateral Internet-Based Teleoperation (I), pp. 1701-1706

Rodriguez-Seda, Erick Joel	Univ. of Illinois at Urbana-Champaign
Lee, Dongjun	Univ. of Illinois at Urbana-Champaign
Spong, Mark W.	Univ. of Illinois at Urbana-Champaign

This paper presents a detailed experimental comparison of several published algorithms for motion and force control of bilateral internet teleoperators. Different control techniques based on wave variables, smith predictors, and recent algorithms on synchronization are compared under variable time delays, packet losses and environmental disturbances. The experiments are performed using a pair of two-link direct drive arms equipped with force/torque sensors and connected in a master-slave configuration. Comparing different control schemes on the same physical hardware allows a detailed comparison of their respective performance.

ThB06.4: 14:00-14:20
Memoryless Input-Output Encoding for Networked Systems with Unknown Constant Time Delay (I), pp. 1707-1712

Matiakis, Tilemachos	Tech. Univ. Munich
Hirche, Sandra	Tokyo Inst. of Tech.

Communication time delay in a networked control system (NCS) degrades the performance and may lead to instability. The time delay value depends on the network configuration, e.g. number of nodes and is not exactly known during the controller design stage. Based on a novel delay-independent input-output approach the problem of unknown constant time delay is addressed in this paper. The plant and the controller input and output are encoded by a memoryless transformation into new variables which are transmitted over the communication channel. Thereby finite gain L2 stability is achieved. The performance of the memoryless encoding

approach, validated in simulations and experiments, is superior over two other approaches, the standard small gain and a lead-lag control approach.

ThB06.5: 14:20-14:40
Hybrid Optimal Control for Load Balancing in a Cluster of Computer Nodes (I), pp. 1713-1718

Moerdyk, Brian	Purdue Univ.
DeCarlo, Raymond A.	Purdue Univ.
Birdwell, J. Douglas	Univ. of Tennessee
Zefran, Milos	Univ. of Illinois at Chicago
Chiasson, John	Univ. of Tennessee

This paper develops a hybrid optimal control technique and resulting experimental data using a previously reported deterministic dynamic nonlinear system model for load balancing in a cluster of computer nodes used for parallel computations in the presence of time delays and resource constraints. The model accounts for the trade-off between using processor resources to process tasks and transferring tasks to distribute the load evenly between the nodes to reduce overall processing time. The desired performance is achieved using hybrid optimal control techniques in a model predictive control context. Results demonstrate superior performance.

ThB06.6: 14:40-15:00
Internal Flow Management in a Multi-Zone Climate Control Unit (I), pp. 1719-1724

De Persis, Claudio	Univ. of Rome La Sapienza
Jessen, Jan Jakob	Aalborg Univ.
Izadi-Zamanabadi, Roozbeh	Aalborg Univ.
Schioler, Henrik	Aalborg Univ.

We investigate the control of a dynamic model describing the evolution of internal climate conditions in a closed environment partitioned into zones for which different climate conditions must be guaranteed. The zones are not separated, large air masses are exchanged among them, and the behavior of each zone is strongly affected by those in the neighbor zones. We discuss a control strategy which, by acting on the heating and ventilation devices of the overall system, is able to achieve the control task while efficiently managing the internal flow. It is pointed out that the controller is hybrid and decentralized. An additional feature of the controller is that it takes on values in a finite set. The possible implementation in a networked environment is briefly discussed.

ThB07 Room 0606
System Theoretical Analysis and Control in Systems Biology (Invited Session)

Chair: Sauter, Thomas	Univ. of Stuttgart
Co-Chair: Sawodny, Oliver	Univ. of Stuttgart
Organizer: Sauter, Thomas	Univ. of Stuttgart
Organizer: Sawodny, Oliver	Univ. of Stuttgart

ThB07.1: 13:00-13:20
A Reduced Stoichiometric Model to Describe Metabolism in Hepatocytes (I), pp. 1725-1729

Kremling, Andreas	Max Planck Inst.
Zeilinger, Katrin	Univ. Berlin
Gerlach, Joerg C.	Univ. Berlin
Gilles, Ernst Dieter	Max Planck Inst.

Stoichiometric models are widely used in Metabolic Engineering and Systems Biology to estimate the flux distribution in cellular systems during steady-state operation. For a number of applications it is desirable to have a model with a small number of state variables. This is of particular interest, if static metabolic models are combined with dynamical models of gene expression. Such integrated models can be used to analyze, monitor and control cell culture bioreactors working as extracorporeal liver support systems. Such systems provide the option for bridging the liver function in case of acute hepatic failure until liver transplantation or until regeneration of the patient's own organ. In this contribution a reduced stoichiometric model of the central metabolism of hepatocytes, i.e. the most important cell type in the liver, is presented.

ThB07.2: 13:20-13:40
Design Principles of Signal Transduction Pathways to Compensate Intracellular Perturbations (I), pp. 1730-1733

Bartholome, Kilian	Univ. of Freiburg
Timmer, Jens	Univ. of Freiburg
Kollmann, Markus	Humboldt Univ.

One of the great paradoxes in studying signal transduction pathways is their seemingly oversized topology. Even in rather small signalling cascades like MAP kinase it is unclear why so many kinase reactions are involved. Similarly one can show in bacterial chemotaxis that the topology can be simplified to arrive at almost perfect adaptation. These facts give the impression that signalling pathways are rather 'tinkered' than 'properly engineered'. But the underlying assumption within this view on signalling pathways is the concept of 'modularisation' on one hand and moderate component tolerances on the other hand. Only these assumptions allow us to investigate signalling networks ignoring intra-cellular perturbations. In this work we show that the chemosensory pathway of E. coli is not only designed to transmit changes in ligand concentration to the flagella motor proteins under the condition of almost perfect adaptation, but also to resist intracellular perturbations.

ThB07.3: 13:40-14:00
A Robustness Analysis of Eukaryotic Cell Cycle Concerning Cdc25 and Wee1 Proteins (I), pp. 1734-1739

Azuma, Takehito	Kanazawa Univ.
Moriya, Hisao	Systems Biology Inst.
Matsumuro, Hayato	Kanazawa Univ.
Kitano, Hiroaki	Sony Computer Science Lab.

This paper discusses a robustness analysis of eukaryotic cell cycle and focuses on understanding functions of Cdc25 and Wee1 proteins. The robustness of the eukaryotic cell cycle is analyzed based on the sensitivity analysis for a mathematical model. From the first analysis result, it was shown that Cdc2 and Cyclin proteins have main roles for eukaryotic cell cycle in this model but the robustness is not high against perturbation on its parameters. By introducing Cdc25 and Wee1 proteins to the mathematical model, it was verified by the sensitivity analysis that the modified has higher level of robustnesses than the original model does. Numerical examples are shown to demonstrate the original model and the modified model have almost identical cell cycle behaviors leaving robustness as a salient difference.

ThB07.4: 14:00-14:20
Control Theoretic Views on Circadian Rhythms (I), pp. 1740-1745

Takeuchi, Tsutomu	Waseda Univ.
Hinohara, Takamichi	Waseda Univ.
Uchida, Kenko	Waseda Univ.
Shibata, Shigenobu	Waseda Univ.

Circadian rhythms, which are observed in most of living things, e.g. bacteria, fungi, plants, and animals, are self-sustained oscillations with about 24 hours period, and have the following properties: The first property is that the oscillation is entrained by light/dark cycles; the second one is that the oscillation, especially the period of the oscillation, is robust against changes of environment. In this paper, we investigate these two properties from control theoretic viewpoints. First, considering light/dark cycle as periodic control input, we try to explain how periodic control inputs can entrain one self-sustained circadian oscillator described by a core molecular model for Drosophila by Goldbeter (1995). Second, for structural understanding of robustness of circadian rhythms, we propose an evaluation method of the robustness based on period sensitivity, and try to design some rate parameters, which are regarded as control parameters, based on some optimizations using a robustness measure, when a rate parameter is moved to outside of normal area by environmental changes.

ThB07.5: 14:20-14:40
Sensitivity Analysis of Programmed Cell Death and Implications for Crosstalk Phenomena During Tumor Necrosis Factor Stimulation (I), pp. 1746-1752

Eissing, Thomas	Univ. of Stuttgart
Waldherr, Steffen	Univ. of Stuttgart
Gondro, Cedric	Univ. of New England
Bullinger, Eric	National Univ. of Ireland
Sawodny, Oliver	Univ. of Stuttgart
Allgower, Frank	Univ. of Stuttgart
Scheurich, Peter	Univ. of Stuttgart
Sauter, Thomas	Univ. of Stuttgart

Different methods for analyzing the sensitivity of the direct signal transduction pathway of receptor-induced apoptosis to parameter changes are presented. Apoptosis is a form of programmed cell death, removing unwanted cells within multicellular organisms to maintain a proper balance between cell reproduction and death. The results indicate the importance of controlling activated caspases by direct inhibition to prevent apoptosis. A misregulation of IAP molecules, one of the main inhibitors, appears to be especially critical. The results indicate how an increased production of this molecule promotes survival and might promote cancer progression, while a reduced degradation might not, thereby providing insight of potential pharmaceutical relevance and also stimulating experimental verification. The different engineering methods applied, nicely complement each other to provide valuable insight into this important process. Because IAPs, among others, are also an important connection to other signaling pathways, the results will enable a more efficient extension of the current model. This is outlined at the example of Tumor Necrosis Factor induced signaling pathways.

ThB07.6: 14:40-15:00
*Modeling Interactions between Growth Factor and Apoptotic Signaling Pathways (I)**

Zak, Daniel	Univ. of Delaware
Kholodenko, Boris	Thomas Jefferson Univ.
Schwaber, J.S.	E.I. DuPont de Nemours & Co.
Ogunnaike, Babatunde A.	Univ. of Delaware

ThB08 Room 2607
Observers (Regular Session)

Chair: Furtmueller, Christian — Johannes Kepler Univ. Linz
Co-Chair: Fernando, Tyrone Lucius — Univ. of Western Australia

ThB08.1: 13:00-13:20
Output Estimator Based Fault Detection, Isolation and Estimation for Systems with Unmatched Unknown Inputs, pp. 1753-1758

Chen, Wei-tian	Simon Fraser Univ.
Saif, Mehrdad	Simon Fraser Univ.

This paper considers fault detection, isolation and estimation problems for a class of systems with unknown inputs which may not satisfy certain matching conditions. Such conditions are often required for existence of sliding mode observers (SMO). In cases when the unmatched unknown inputs are present, no SMO could be designed such that the state estimation error is invariant to all the unknown inputs, and therefore, existing SMO based fault diagnosis schemes can not be employed. In this article we propose a novel approach to design of output estimators using sliding mode technique. The estimators are then used for fault detection, isolation, and estimation. First, a canonical representation of the system which decouples the matched and unmatched unknown inputs is derived. Second, based on this canonical form, output estimators using sliding mode technique are proposed, and their properties are investigated. Third, a fault diagnosis scheme is developed to carry out the fault detection, isolation, and estimation tasks. Finally, an example is given to show the effectiveness of the output estimator based fault diagnosis scheme in terms of fault detection, isolation and estimation.

ThB08.2: 13:20-13:40
Design of Reduced-Order State/Unknown Input Observers: A Descriptor System Approach, pp. 1759-1763

Fernando, Tyrone Lucius	Univ. of Western Australia
Trinh, Hieu Minh	Deakin Univ.

This paper addresses the problem of estimating simultaneously a linear function of both the state and unknown input of linear system with unknown inputs. By adopting the descriptor system approach, the problem can be conveniently solved. Observers proposed in this paper are of low-order and do not include the derivatives of the outputs. New conditions for the existence of reduced-order observers are derived. A design procedure for the determination of the observer parameters can also be easily derived based on the derived existence conditions.

ThB08.3: 13:40-14:00
Suppression of Periodic Disturbances in Continuous Casting Using an Internal Model Predictor, pp. 1764-1769

Furtmueller, Christian	Johannes Kepler Univ. Linz
Gruenbacher, Engelbert	Linz Center of Mechatronics

Fluctuations of the mold level of continuous caster greatly influence the surface quality of the final product. In many plants however periodic disturbances called dynamic bulging occur, which are difficult to suppress because of a substantial input delay. In this work a new measurement is used as disturbance estimate. This signal is then predicted with an internal model observer and applied as disturbance feed forward to the control input. Simulation results with experimental data are presented to show the effectiveness of the approach for mold level control.

ThB08.4: 14:00-14:20
Proportional Assist Ventilation Using a Disturbance Observer and Predictive Control, pp. 1770-1776

Ozaki, Kenji	Kawasaki Safety Service Industries
Soga, Kazutoshi	Kawasaki Safety Service Industries
Ishikawa, Yutaka	Kawasaki Safety Service Industries
Shin, Seiichi	Univ. of Tokyo
Marukawa, Seishiro	Hyogo Coll. of Medicine
Yamauchi, Junko	Minamiosaka Hospital
Younes, Magdy	Toronto Univ.

This paper presents a general control representation for medically-proposed methods of mechanical ventilation, and then proposes an improved configuration with a disturbance observer and with a predictive control block against an existing Proportional Assist Ventilation (PAV) method. The trade-off relation between robust stability margin and responsibility has been shown using infinity norm of sensitivity functions in Nyquist diagrams and time-response results with our mechanical ventilator SSV-200 connected to our lung simulator (LUNGOO). Also, a clinical issue of expiratory asynchrony is compared between two methods with the same test construction. The actual clinical tests for these performances will be expected with a next new version of our SSV. We also present on-line identification methods for patient's airway resistance and respiratory compliance which are necessary for implementation of PAV. Animal test results and a few clinical test results of our techniques are also reported for these identification methods.

ThB08.5: 14:20-14:40
Evaluating Nonlinear Kalman Filters for Parameter Estimation in Reservoirs During Petroleum Well Drilling, pp. 1777-1782

Nygaard, Gerhard	Intl. Res. Inst. of Stavanger
Naevdal, Geir	Intl. Res. Inst. of Stavanger
Mylvaganam, Saba	Telemark Univ. Coll.

When drilling into a petroleum reservoir, the geological properties of the reservoir might require that the well pressure is kept slightly below the reservoir pore pressure. This leads to a migration of reservoir fluids from the reservoir into the oil well. The amount of reservoir fluids flowing into the well is dependent of the reservoir parameter named production index. This paper evaluates the performance of the extended Kalman filter, the ensemble Kalman filter and the unscented Kalman filter to estimate the production index.

The comparison is based on a nonlinear two-phase fluid flow model. The results show that all three filters are capable of identifying the reservoir production index parameter, but that the unscented Kalman filter gives the best performance both when evaluating the least squares deviation from the true value and calculation resource requirements.

ThB08.6: 14:40-15:00
A Novel Adaptive Nonlinear Dynamic Data Reconciliation and Gross Error Detection Method, pp. 1783-1788

Taylor, James H. Univ. of New Brunswick
Laylabadi, Mazyar Univ. of New Brunswick

Data reconciliation is a well-known method in on-line process control engineering aimed at estimating the true values of corrupted measurements under constraints. Most nonlinear dynamic data reconciliation methods have studied cases where the input variables are constant over relatively long periods of time separated by simple step changes (e.g., set-point changes). While this scenario is not uncommon in process control, it imposes strong limitations on a method's applicability. In this paper a novel adaptive nonlinear dynamic data reconciliation algorithm is presented that extends the method presented by Laylabadi and Taylor [1] to the cases where the input variables are ramps or slow sinusoidal functions or, for that matter, any slow, smooth variation.

ThB09 Room 0999
Robotics - Navigation (Regular Session)

Chair: Reger, Johann Univ. of Armed Forces Munich
Co-Chair: Wollherr, Dirk Tech. Univ. Munich

ThB09.1: 13:00-13:20
An Algebraic Perspective to Single-Transponder Underwater Navigation, pp. 1789-1794

Jouffroy, Jerome Norwegian Univ. Sci. Tech.
Reger, Johann Univ. of Armed Forces Munich

This paper studies the position estimation of an underwater vehicle using a single acoustic transponder. The chosen estimation approach is based on nonlinear differential algebraic methods which allow to express very simply conditions for observability. These are then used in combination with an integrator-based time-derivative estimation technique to design an algebraic estimator, which, contrary to asymptotic observers, does not require sometimes tedious convergence verification. Simple simulation results are presented to illustrate the approach.

ThB09.2: 13:20-13:40
Monitoring and Preventing Collisions for a Triple Axes Spectrometer, pp. 1795-1800

Mühlbauer, Quirin Tech. Univ. Munich
Hradil, Klaudia Univ. of Gottingen

Neutron spectroscopy is a powerful tool to examine the fundamental properties of condensed matter, mostly using a so called triple axis spectrometer. A critical problem of this measurement procedure is the collision free and time optimized physical positioning of the instruments axes to the desired coordinates in momentum and energy space. This work shows the concept and the implementation of the library 'paprika', which is a control tool for neutron spectrometers, avoiding collisions and calculating a time optimized path. The tool was created for the PUMA, a triple axis spectrometer located at the new research reactor FRM-II in Garching near Munich. Furthermore it can easily adopted to other applications.

ThB09.3: 13:40-14:00
Navigation of an Autonomous Underwater Vehicle (AUV) Using Robust SLAM, pp. 1801-1806

West, Michael Univ. of Hawaii at Manoa
Syrmos, Vassilis L. Univ. of Hawaii at Manoa

This paper will present a robust extended Kalman filter (REKF) applied to the navigation of an autonomous underwater vehicle (AUV) using robust Simultaneous Localization and Mapping (SLAM) techniques. Conventional Kalman Filter methods suffer from the assumption of Gaussian noise statistics, which often lead to failures when these assumptions do not hold. Additionally, the linearization errors associated with the implementation of the standard EKF can also severely degrade the performance of the localization estimate. Currently, Stochastic Mapping provides a framework for the concurrent mapping of landmarks and localization of the vehicle with respect to the landmarks. However, the Stochastic Map is essentially an augmented EKF with the limitations thereof. This research addresses the linearization and Guassian assumption errors as they relate to the SLAM problem by proposing a new method, Robust Stochastic Mapping. The Robust Stochastic Map uses a Robust EKF (REKF) in order to address these limitations through the implementation of the bounded H-infinity norm. Simulated data are presented to illustrate the advantage of the localization using the proposed estimation procedure.

ThB09.4: 14:00-14:20
3D Reconstruction by a Mobile Robot Using Multi-Baseline Omni-Directional Motion Stereo Based on GPS/DR Compound Navigation System, pp. 1807-1812

Meguro, Jun-ichi Waseda Univ.
Takiguchi, Jun-ichi Mitsubishi Elec.
Amano, Yoshiharu Waseda Univ.
Hashizume, Takumi Waseda Univ.

In this paper, a unique dense 3D shape reconstruction method featuring GPS/DR coupled omni-direction multi-baseline motion stereo system is presented. The epipolar plane equation between two Omni Directional Vision images is computed from the GPS/DR's position and posture information. Then, the precise epipolar lines can be obtained robustly by projecting the intersection line between the epipolar plane and the ODV's image plane. The robust matching method featuring hybrid use of the future based matching and the area based matching, as well as the bi-directional matching which chose common mutual matching points to improve robustness is also presented. Voting process using multi-baseline is used to reduce distance error of motion stereo. Hundreds of dense range images are unified based on the precise position/posture information to generate the successive dense 3D outdoor model. The range estimation accuracy within 10 [m] area is 140 [mm], which is equal to a laser radar. It can be said that the proposed omni-directional stereo vision has robustness toward environmental complication and accurate distance estimation performance for rich textured object.

ThB09.5: 14:20-14:40
Improved Global Localization and Pose Tracking of an Autonomous Mobile Robot Via Fuzzy Adaptive Extended Information Filtering, pp. 1813-1818

Tsai, Ching-Chih National Chung-Hsing Univ.
Lin, Hung-Hsing National Chung-Hsing Univ.

This paper presents an improved global localization method and an improved pose tracking approach for an indoor autonomous mobile robot (AMR) with ultrasonic and laser scanning measurements using a fuzzy extended information filtering scheme. An ultrasonic self-localization system, consisting of two ultrasonic transmitters and three receivers, is presented to estimate both the unknown global position and orientation of the AMR in a world frame, and a fuzzy adaptive extended information filter (FAEIF) is proposed to improve estimation accuracy for the ultrasonic localization system. With the odometric data from the driving wheels and the laser scanning measurements from the robot's surrounding, a FAEIF-based pose tracking algorithm is proposed to continuously keep track of the robot's poses at slow speeds less than 100 cm/sec. The proposed algorithms were implemented using an industrial personal computer with a computation speed of 800MHz, and standard C++ programming techniques. The system prototype together with experimental results has been used to confirm the merit of the proposed methods in comparison with the well-known EIF.

ThB10 Room 3999
Adaptive Control II (Regular Session)
Chair: Schröder, Dierk Tech. Univ. Munich
Co-Chair: Leva, Alberto Pol. di Milano

ThB10.1: 13:00-13:20
Non-Identifier-Based Adaptive Control for a Mechatronic System Achieving Stability and Steady State Accuracy, pp. 1819-1824
Schuster, Hans Tech. Univ. Munich
Westermaier, Christian Tech. Univ. Munich
Schröder, Dierk Tech. Univ. Munich

Non-identifier-based concepts, as High-gain-control, can be applied to systems with uncertain parameters and reveal the advantage of simplicity compared to most other adaptive control concepts. To overcome the drawback of a nondecreasing gain function, Funnel-control was introduced. Because Funnel-control is a time-varying proportional control law only, a steady state error remains in general. Theoretically, if no measurement noise occurs, this error can be made arbitrarily small. But in practical applications a large control error remains however. In this paper, two appropriate extensions are presented, which obtain an improved performance of the controller, even in the presence of load disturbances and sensor noise. An integral control action together with a dynamic feedback are introduced, which yield a vanishing control error and provide active damping of mechanical oscillations in the shaft of an electrical drive system, even if the measurement signal is disturbed by noise.

ThB10.2: 13:20-13:40
A Stable Robust Adaptive Controller for a Class of Nonlinear Systems, pp. 1825-1830
Abdollahi, Farzaneh Concordia Univ.
Khorasani, Khashayar Concordia Univ.

In this paper, a robust adaptive control is proposed for a class of nonlinear systems subject to unmodeled dynamics and bounded disturbances. The nonlinear systems are represented by their input-output maps. The e_1-modification scheme is proposed to achieve robustness and enhance the convergence properties of the tracking error in the absence of disturbances. The stability of the closed-loop system is shown by Lyapunov's direct method. Simulation results demonstrate the improved performance of the proposed controller as compared with the previously reported adaptive controllers in the literature.

ThB10.3: 13:40-14:00
Adaptive Control for the Head-End Strip Gauge Using Recursive Least Squares at Hot Strip Mill, pp. 1831-1836
Ohta, Takeshi Sumitomo Metal Industries, Ltd.
Washikita, Yoshiro Sumitomo Metal Industries, Ltd.

Gauge control using an interstand thickness gauge is an important strip gauge control in a hot strip mill. This method measures the interstand thickness deviation by interstand gauge when the head-end strip passes the interstand thickness gauge, predicts thickness deviations that will be occur in following stands, and adjusts the roll gaps according to predicted gauge deviation. Although the effect depends on that prediction accuracy, the current method does not have the adaptive control and thus is unable to compensate for gauge deviation caused by circumstance change. This paper proposes the adaptive control using recursive least squares for prediction of thickness deviation. The effects of the proposed algorithm are verified using computer simulations.

ThB10.4: 14:00-14:20
Extremum Seeking Adaptive Control of Beam Envelope in Particle Accelerators, pp. 1837-1842
Schuster, Eugenio Lehigh Univ.
Torres, Nicholas Lehigh Univ.
Xu, Chao Lehigh Univ.

The matching problem for a low energy transport system in a charged particle accelerator is approached using the extremum seeking feedback method for non-model-based adaptive control. The beam dynamics, used only for simulation purposes, is modeled using the KV (Kapchinsky-Vladimirsky) envelope equations. Extremum seeking is employed for the lens adaptive tuning in both the matching and periodic channels. Numerical simulations illustrate the effectiveness of this approach.

ThB10.5: 14:20-14:40
Adaptive Control of Hydrodynamic Loads in Splash Zone, pp. 1843-1848
How, Bernard Voon Ee National Univ. of Singapore
Ge, Shuzhi Sam National Univ. of Singapore
Choo, Yoo Sang National Univ. of Singapore

In this paper, adaptive control for hydrodynamic forces acting on payloads going through the splash zone are investigated using model-based and non-model-based (neural network) parametrization techniques. After the presentation of a detailed mathematical model for hydrodynamic loads during water entry, model-based and non-model-based robust adaptive controllers are developed with closed-loop stability. Intensive computer simulations are carried out to show the effectiveness of the proposed control techniques. It is observed that as the parametrization techniques can capture the dominant dynamic behaviours, higher feedback gains for model-based control can be used and the speed of adaptation can also be increased for better control performance. It is also found that neural networks are suitable candidates for the modelling and adaptive controller design of hydrodynamic loads.

ThB10.6: 14:40-15:00
Improving the Antiwindup Properties of Autotuning PID Regulators, pp. 1849-1854
Leva, Alberto Pol. di Milano
Bascetta, Luca Pol. di Milano

This manuscript presents an antiwindup technique for industrial regulators, aiming at gaining some control on the characteristics of `large' transients (i.e., of transients involving significant control saturation). This is achieved by investigating the interplay between linear, in-the-small tuning rules, and the effects of the antiwindup itself. The proposed scheme is presented in connection with the PID structure, but it can easily be extended to other regulator types.

ThB11 Audimax
Discrete-Event Systems (Regular Session)
Chair: Afzalian, Ali Akbar Sh. Abbaspour Univ. of Tech.
Co-Chair: Stursberg, Olaf Univ. of Dortmund

ThB11.1: 13:00-13:20
Design of Verified Logic Control Programs, pp. 1855-1860
Lohmann, Sven Univ. of Dortmund
Dinh Thi, Lan Anh Univ. of Dortmund
Stursberg, Olaf Tech. Univ. Munich

To complement the largely manual design of logic control programs in industrial practice, this contribution proposes a method for systematically (and partly algorithmically) deriving logic controllers for given specifications. The main idea is to structure the information available for the design in form of specific intermediate formats which are iteratively refined and straightforwardly lead to controllers formulated as Sequential Function Charts. To analyze whether the design complies with all given specifications, model-based verification is applied subsequently, i.e. the controller is converted into timed automata, the latter are composed with a plant model, and model-checking algorithmically verifies (or falsifies) logic properties for the composed system. The procedure is described here for the example of a multi-product batch plant.

ThB11.2: 13:20-13:40
Diagnosis of Discrete Event System by Stochastic Timed Automata, pp. 1861-1866
Zemouri, Ryad ENS Cachan
Faure, Jean Marc ENS Cachan

The paper describes a diagnosis method for detecting and identifying faults that occur in a discrete-event system

described by a stochastic timed automaton. The proposed diagnosis algorithm is based whether the measured event time sequences are consistent with a stochastic timed discrete event model. The degree of this consistence is given by a continuous diagnosis function. The diagnosis which consists of two parts (fault detection and identification) is then obtained.

ThB11.3: 13:40-14:00
Discrete-Event System Modeling and Supervisory Control for Under-Load Tap-Changing Transformers, pp. 1867-1872

Afzalian, Ali Akbar	Sh. Abbaspour Univ. of Tech.
Saadatpoor, Ali	Univ. of Toronto
Wonham, W. M.	Univ. of Toronto

Discrete-event systems (DES) can be found as essential integrated subsystems in electrical power systems. The continuous trajectory of the system state can be interrupted by discrete control actions and uncontrolled disturbances. Under-load tap-changing transformers (ULTC) which obviously have discrete-event behavior are widely used in transmission systems to take care of instantaneous variations in the load conditions in substations. ULTC may be controlled either automatically or manually. The paper discusses synthesis of supervisory controller of ULTC as a discrete-event system. Different parts of the ULTC as well as its control logic (specification) have been modeled as DES. Supervisory controllers are designed for the tap-changer in Automatic and Auto/Manual modes of operation. It is shown that the specifications are controllable and the closed loop control system is non-blocking. Protective system designers in electrical powers systems can use the proposed approach to verify their control logic for ULTC.

ThB11.4: 14:00-14:20
String Algebra-Based Approach to Dynamic Routing in Multi-LGV Automated Warehouse Systems, pp. 1873-1878

Smolic-Rocak, Nenad	Univ. of Zagreb
Bogdan, Stjepan	Univ. of Zagreb
Kovacic, Zdenko	Univ. of Zagreb
Petrinec, Kresimir	Univ. of Zagreb

This paper presents a dynamic routing method for supervisory control of multiple Laser Guided Vehicles (LGVs) that are traveling within a layout of a given warehouse. In dynamic routing a calculated path particularly depends on the number of currently active LGVs' missions and their priorities. In order to solve the shortest path problem dynamically, the proposed routing method uses the string matrix composition and time windows in a vector form. For each mission requested by the supervisor, the string composition algorithm first finds the candidate paths and then checks if they are feasible. The feasibility of a particular path is evaluated by insertion of appropriate time windows and by performing the windows overlapping tests. The algorithm resolves the time windows conflicts iteratively by inserting new time windows until the conflicts disappear or remain present only on the path's origin arc, which means that the found candidate paths are not feasible. The use of time windows makes the algorithm apt for other scheduling and routing problems. The proposed method has been successfully tested in the industrial environment and the results are presented.

ThB11.5: 14:20-14:40
Analysis and Experimental Validation of Processor Load for Event-Driven Controllers, pp. 1879-1884

Sandee, Heico	Eindhoven Univ. of Tech.
Visser, Peter Martin	Univ. of Twente
Heemels, Maurice	Embedded Systems Inst.

Event-driven controllers differ from the standard digital controllers as their sample times are generally not periodic (time equidistant). In literature several proposals for event-driven controllers are made in order to reduce the number of control updates and consequently the processor load needed for its implementation. This is possible without deteriorating the control performance significantly. However, experimental validation has not been presented in literature. This paper aims at filling this gap. Simulations, as well as experiments on a copier paper path test setup, show that a reduction in the number of control updates indeed results in a considerable reduction of the processor load, with only a small decrease of control performance. Furthermore, we present a method to predict the processor load very accurately, without having to implement the controller on a test setup.

ThB11.6: 14:40-15:00
Control Synthesis and Implementation for an Integrated Manufacturing System Based on Supervisory Control Theory, pp. 1885-1890

Santos, Eduardo Alves Portela	Pontifical Catholic Univ. of Parana
Busetti, Marco Antonio	Pontifical Catholic Univ. of Parana
Vieira, Agnelo Denis	Pontifical Catholic Univ. of Parana

This paper presents the implementation of a controller to an integrated manufacturing system, made through the application of the Supervisory Control Theory (SCT). The work explores the modeling of subsystems and the specifications of a real manufacturing system. A supervisor, which fulfills the specifications, is synthesized. Based on these SCT implementation aspects presented on the text, the synthesized supervisor is accomplished in the manufacturing execution system. A physical implementation topology, which accomplishes the control proposal, is also discussed.

ThC01 Room 2601
Object - Oriented Modelling and Simulation Environments (Regular Session)

Chair: Lovera, Marco	Pol. di Milano
Co-Chair: Broenink, Jan F.	Univ. of Twente

ThC01.1: 15:30-15:50
Representing Dynamic Structure Hybrid Models in CAOSTALK (I), pp. 1891-1897

Barros, Fernando J.	Univ. de Coimbra

The ability to change model structure during simulation runtime is a key aspect to capture the dynamic nature of many complex systems. We present the Heterogeneous Flow System Specification (HFSS) a modeling formalism designed to describe hierarchical dynamic structure hybrid systems. HFSS is a unification formalism that can model sampled-based and discrete event systems. We show that adaptive step-size numerical explicit solvers for differential equations can be described as sampled systems, making possible to represent hybrid systems in the formalism. HFSS network models can change their composition and interconnection in runtime providing the structural similarity required for representing self-adaptive systems. The CAOSTALK Modeling and Simulation (M&S) environment, an implementation of the formalism in the Smalltalk language is described. We illustrate the use of HFSS by representing a pursuer-target system in CAOSTALK.

ThC01.2: 15:50-16:10
Object-Oriented Modelling for Spacecraft Dynamics: A Case Study, pp. 1898-1903

Lovera, Marco	Pol. di Milano
Pulecchi, Tiziano	Pol. di Milano

The development process for spacecraft control systems relies heavily on modelling and simulation tools for spacecraft dynamics. For this reason, there is an increasing need for adequate design tools in order to cope efficiently with tightening budgets for space missions. The aim of this paper is to discuss the main issues related to the modelling and simulation of satellite dynamics for control purposes, to present the results obtained so far in developing a Modelica library for spacecraft modelling and simulation and to illustrate them with a case study, currently being carried out for the SWARM ESA mission.

ThC01.3: 16:10-16:30
Data-Based Symbolic Simplification of Kinetic Mechanisms for Surface Reaction Networks, pp. 1904-1909
Nauta, Maarten Eindhoven Univ. of Tech.

Detailed kinetic surface reaction mechanisms are used in kinetic models for automotive catalysis applications. Therefore, these models are complex and often numerically stiff. For simulation, optimization and control purposes it is desirable to employ models of lower complexity that are accurate in specific operating regimes. In this contribution, a number of data-based kinetic mechanism reduction methods are combined in order to obtain an automated method for mechanism simplification. The principle of this method is to use time-scale analysis to generate nonlinear lumpings from partial equilibrium and quasi steady-state assumptions These lumpings have to remain as decoupled as possible, so that they can be solved explicitly.

ThC01.4: 16:30-16:50
Controller System Design Trajectory, pp. 1910-1915
Visser, Peter Martin Univ. of Twente
Broenink, Jan F. Univ. of Twente

This paper structures existing modelling techniques and theories into a systematic stepwise design trajectory with the goal to facilitate a less error-prone path from model to realization. It is a model-driven approach, whereby simulation is used to check whether refinement updates leave the model compliant with the requirements. Via various “in-the-loop simulations”, the design trajectory runs from complete simulation to full realization. Tests on a basic experimental set up showed that the design trajectory is feasible, although it is expected that all stages are really necessary when complex controller behavior is to be implemented on distributed embedded computers.

ThC01.5: 16:50-17:10
A Multidisciplinary Model-Based Test and Integration Infrastructure (I), pp. 1916-1921
Denissen, Will J.A TNO

Current market trends like shorter time to market, faster return on investment, flexible product families, first time right etc., will put strong requirements on the development process of manufacturing companies. Add to this the large groups of experts from multiple disciplines, which have to work closely together, all focussing on the same moving target, and you can grasp the challenges manufacturers of complex machines face. In the past the solution to this problem was just to add more people to the project, but this is not an option anymore. In this article we will present another approach, a multi-disciplinary modelbased test and integration infrastructure that supports the development process in these changing markets.

ThC01.6: 17:10-17:30
Simulink-Based Tools for Creating and Simulating Interconnected LFR Objects, pp. 1922-1927
Biannic, Jean-Marc ONERA
Magni, Jean-Francois ONERA
Doll, Carsten ONERA

This paper is a short tutorial on new tools for the LFR Toolbox which have been designed in order to simplify the computation of highly interconnected LFR objects and their simulation. A specific approach, based on a fixed-point algorithm has been implemented to handle high order LFR objects. Simple examples illustrate the efficiency of these new tools.

ThC02 Room 1601
Control Design and Computational Methods
(Regular Session)

Chair: Sima, Vasile ICI Bucharest
Co-Chair: Lampe, Bernhard P. Univ. of Rostock

ThC02.1: 15:30-15:50
A New Preconditioning Method for the Matrix Riccati Equation, pp. 1928-1933
Tsachouridis, Vassilios A. City Univ. London

A novel scaling method for preconditioning the classical matrix algebraic Riccati equation (ARE) is presented. The method is based on the assignment of predetermined values to the coefficients and the unknown matrices of the ARE. The proposed framework is independent of any numerical method and therefore its use is general. An Implementation of the method through the Newton algorithm is shown with a benchmark numerical example from the literature and comparisons with other existing methods are presented.

ThC02.2: 15:50-16:10
A Numerical Approach to Approximate Feedback Linearization, pp. 1934-1939
Deutscher, Joachim Univ. Erlangen-Nurnberg
Schmid, Christian Univ. Erlangen-Nurnberg

This contribution presents a numerical approach to approximate feedback linearization which transforms a single input nonlinear system into an approximately linear system. Linear matrix equations are explictly derived for determining the nonlinear change of coordinates and the nonlinear feedback that approximately linearize the nonlinear system. If these linear matrix equations are not solvable a least square solution by applying the Moore-Penrose inverse is proposed. The results of the paper are illustrated by the approximate feedback linearization of an inverted pendulum on a cart.

ThC02.3: 16:10-16:30
IQC Analysis for Sampled-Data Systems: A Cutting Plane Algorithm and Its Implementation, pp. 1940-1945
Fujioka, Hisaya Kyoto Univ.

A cutting plane algorithm is developed for the IQC (integral quadratic constraints) analysis of sampled-data systems based on the fact that the frequency response of sampled-data system has an STPBC (systems with two point boundary conditions) representation. The algorithm is implemented based on MATLAB, and demonstrated by a numerical example.

ThC02.4: 16:30-16:50
DSD 3.0 Toolbox for Matlab: Further Progress in Polynomial Design of Sampled-Data Systems, pp. 1946-1951
Polyakov, Konstantin Marine Tech. Univ. St. Petersburg
Rosenwasser, Efim N. Marine Tech. Univ. St. Petersburg
Lampe, Bernhard P. Univ. of Rostock

The paper presents a new version of the DirectSD toolbox for optimal design of sampled-data systems in MATLAB. This software realizes recently developed polynomial methods for optimal sampled-data systems design on the basis of parametric transfer function theory. As distinct from previous versions, the macros are applicable to the standard structure of sampled-data system with SISO controller.

ThC02.5: 16:50-17:10
Computer-Aided Design of Nonlinear H-Infinity Controllers Using Describing Functions, pp. 1952-1957
Nassirharand, Amir Islamic Azad Univ. Damavand
Mousavi Firdeh, S. R. Binary Micro Inst. Co.

A computer-aided procedure for design of nonlinear H-infinity controllers for nonlinear plants, whose dynamic and static behavior are highly sensitive to the amplitude level of excitation, is presented. The procedure is based on describing function concepts involving sinusoidal input describing function models of the nonlinear plant, and it includes an application of a newly developed inverse describing function technique to arrive at nonlinear gains of the controller. The procedure is applied to a servomechanism problem to demonstrate the typical results that may be achieved.

ThC02.6: 17:10-17:30
Computer-Aided Analysis and Design of Linear and Nonlinear Multivariable Control Systems: A Classical Approach, pp. 1958-1963
Gasparyan, Oleg State Engr. Univ. Armenia

This paper describes a new graphical user interface (GUI) working in the MATLAB environment and destined for the computer-aided analysis and design of linear and nonlinear

multi-input multi-output (MIMO) control systems. The investigation of MIMO systems is performed by the main frequency-domain and root methods known from the classical control theory. A special emphasis in the paper is laid on the underlying theoretical methods and approaches, as well as on the functional features and capabilities of the GUI. The design of a MIMO system with any number of channels is rigorously, that is without any approximation or model order reduction, accomplished in the GUI as the design of a certain fictitious single-input single-output system with generally complex parameters. In the multidimensional case, the GUI lends itself to all principal structural classes of MIMO systems described in the technical literature.

ThC03 Room 0670
Intelligent Robust Control with Applications
(Invited Session)

Chair: Kim, Youngbok	Pukyong National Univ.
Co-Chair: Zhai, Guisheng	Osaka Prefecture Univ.
Organizer: Zhai, Guisheng	Osaka Prefecture Univ.
Organizer: Kim, Youngbok	Pukyong National Univ.

ThC03.1: 15:30-15:50
Robust H-Infinity Fixed Order Control Strategies for Large Scale Web Winding Systems (I), pp. 1964-1970

Knittel, Dominique	Univ. Strasbourg
Vedrines, Marc	INSA Strasbourg
Henrion, Didier	LAAS-CNRS
Pagilla, Prabhakar	Oklahoma State Univ.

Demand for improved performance under a wide variety of dynamic conditions and web materials is placing additional emphasis on developing new advanced control strategies. This paper presents centralized and decentralized fixed order H-infinity controller results with model based feedforward for web winding systems which provide improved web tension and velocity regulation. First, mathematical models of fundamental elements in a web process line are presented. A state space model is developed which enables calculation of the phenomenological model feedforward signals and helps in the synthesis of H-infinity controllers around the set points given by the reference signals. Different H-infinity control strategies with additive feedforward have been validated on a nonlinear simulator identified on a 3-motor winding test bench.

ThC03.2: 15:50-16:10
Attitude Control of a Helicopter Model by Robust PID Controllers (I), pp. 1971-1976

Sakamoto, Tatsuya	Shinko Electric Company
Katayama, Hitoshi	Shizuoka Univ.
Ichikawa, Akira	Kyoto Univ.

In this paper the attitude control, by PID controllers, of a helicopter model with two degrees of freedom is considered. Cross-coupling in the system being neglected, dynamics of elevation and azimuth are independently considered and PID controllers are designed separately. It is then shown that pairs of PID controllers can stabilize the whole system and fulfill the step tracking. Starting a PID controller thus obtained, robust PID controllers are designed iteratively based on the method of Miyamoto. Experimental results show that the final controller stabilizes the whole helicopter model and gives satisfactory performances in step tracking.

ThC03.3: 16:10-16:30
A New Algorithm for Real-Time Optimization of Constrained Nonlinear Control Systems (I), pp. 1977-1982

Imae, Joe	Osaka Prefecture Univ.
Ogino, Jun	Osaka Prefecture Univ.
Kobayashi, Tomoaki	Osaka Prefecture Univ.
Zhai, Guisheng	Osaka Prefecture Univ.

When it comes to the real-time optimization of nonlinear control systems, model predictive control (MPC) and state-dependent Riccati equation (SDRE) methods are known to be effective and reliable. In this paper, we propose a new type of real-time control method for constrained nonlinear systems and demonstrate by some numerical simulations that the proposed method is also effective and reliable. In addition, by using our method, we show that there is a certain kind of relationship between the MPC and SDRE methods.

ThC03.4: 16:30-16:50
An Approach to Improving the Boarding Comfort of a Ship with the Flaps (I), pp. 1983-1987

Kim, Youngbok	Pukyong National Univ.
Zhai, Guisheng	Osaka Prefecture Univ.
Kim, Dongkyu	Pukyong National Univ.

We have investigated the usefulness of active stabilizing system to reduce ship rolling under disturbances, using reaction of the flaps. In the proposed anti-rolling system for a ship, the flaps as the actuator are installed on the stern side in order to reject rolling motion induced by disturbances like wave. The action induced by the flaps depends on power of disturbances which produces the undesirable ship motions and can take the ship balance. In this study, we define the controlled system using the frequency responses obtained from the experiments. The model identified from experiment and spectral analysis is used to design the controller. Hence, the usefulness of the proposed anti-rolling system is evaluated.

ThC03.5: 16:50-17:10
Adaptive Control for the Systems with Prandtl-Ishlinskii Hysteresis (I), pp. 1988-1993

Chen, Xinkai	Shibaura Inst. of Tech.
Su, Chun-Yi	Concordia Univ.
Kano, Hiroyuki	Tokyo Denki Univ.

Hysteresis hinders the effectiveness of smart materials in sensors and actuators. It is a challenging task to control the systems with hysteresis. This paper discusses the robust control for the discrete time linear systems preceded with hysteresis described by Prandtl-Ishlinskii model. The unknown parameters of the system together with the density function of the hysteresis are adaptively estimated simultaneously. The robust sliding mode tracking controller is synthesized by using the estimated parameters of the system and the density function of the hysteresis. The output tracking error can be controlled to be as small as required by using the proposed controller. Simulation results show the effectiveness of the proposed algorithm.

ThC03.6: 17:10-17:30
Development of an Anti-Seasickness Bed for Improving Boarding Sensitivity (I), pp. 1994-1998

Kim, Youngbok	Pukyong National Univ.
Lee, Kwon Soon	Donga Univ.
Suh, Jin Ho	Donga Univ.

In ship operation the consequence of roll and pitching motion can seriously degrade the performance of mechanical and personnel effectiveness. So many studies for the roll stabilization and trimming control system design have been performed and good results have been achieved where the stabilizing fins, tanks, rudders and flaps are used. However the ultimate objective of such approach must be focused on improving the boarding sensitivity. But there exist many weak points, for examples, increasing of navigation resistance, ship control performance degradation and increasing of system complexity. And, the achieved control performance could not give us enough comfortable boarding sense. The residual rolling and pitching motion are main drawbacks. To get rid of these disadvantages, the main hull control systems design approach [8] has been considered using semiactive absorber. In this system, dampers, spring, dynamic dampers and control system with sensors are incorporated. In our system considered in this study, just two motors and control system with sensors are used for the bed. In other word, the control system can be installed on each bed. So, we can control every bed on the specified control objective respectively. Above all, the good advantages of this system are the facts followed from simple idea and usefulness. Of course the structural modifications are needed. Considering actual sea states, we design control system and verify the usefulness of developed system from the experimental study.

ThC04 Room 2605
Adaptive Control I (Regular Session)

Chair: Stubberud, Stephen C. ANZUS, Inc.
Co-Chair: Ishihara, Abraham Stanford Univ.

ThC04.1: 15:30-15:50
System Identification Using the Neural-Extended Kalman Filter for State-Estimation Modification, pp. 1999-2004
Stubberud, Stephen C. ANZUS, Inc.
Kramer, Kathleen A. Univ. of San Diego

The neural extended Kalman filter has been shown to be able to work and train on-line in a control loop and as a state estimator for maneuver target tracking. Often, however, an adaptive component in the feedback loop is not considered desirable by the designer of a control system. Instead, the tuning of parameters is considered to be more acceptable. The ability of the NEKF to learn dynamics in an open-loop implementation, such as with target tracking and intercept prediction, can be used to identify mismodeled dynamics. The improved system model can then be used to adapt the state estimator of the control law to provide better performance based on the actual system dynamics. This new approach to neural extended Kalman filter control operations is introduced in this work using applications to the nonlinear version of the standard cart-pendulum system.

ThC04.2: 15:50-16:10
Feedback Error Learning with Basis Function Networks, pp. 2005-2011
Ishihara, Abraham Stanford Univ.
van Doornik, Johan Stanford Univ.
Sanger, Terence Stanford Univ.

In this paper, we examine the stability properties of Feedback Error Learning, a model for biological control systems. We consider a specific model for cerebellar learning during fast voluntary movements. We assume that the feedforward approximation is represented by a basis function network. We establish local stability regions and compute explicit bounds on the feedback gain matrices.

ThC04.3: 16:10-16:30
Model Reference Adaptive Control of Polytopic LPV Systems - an Alternative Approach to Adaptive Control, pp. 2012-2017
Miyasato, Yoshihiko Inst. of Statistical Mathematics

This paper provides an alternative approach to solve model reference adaptive control problems of uncertain processes. Plants in this manuscript are described as polytopic LPV systems in fixed polytopes defined by convex hulls of extreme systems, and uncertainties of system parameters correspond to those extreme systems. It is shown that control inputs are composed of weighted sums of control signals for each extreme systems, and that those weights are tuned adaptively. The stabilizing signals are also added to stabilize plants and to regulate the effect of time-varying components in uncertain processes. Those additional signals are derived as solutions of nonlinear H-infinity control problems for certain virtual systems.

ThC04.4: 16:30-16:50
Model-Free Learning Adaptive Controller with Neural Network Compensator and Differential Evolution Optimization, pp. 2018-2023
Coelho, Leandro Dos Santos Pontifical Catholic Univ. of Parana
Coelho, Antonio Augusto Rodrigues Fed. Univ. of Santa Catarina
Rodrigues Sumar, Rodrigo Fed. Univ. of Santa Catarina

A new design for a model-free learning adaptive control (MFLAC), based on pseudo-gradient concepts with compensation using neural network, is presented in this paper. A radial basis function neural network using differential evolution optimization technique is applied to the control design. Motivation for developing a new approach is to overcome the limitation of the conventional MFLAC design, which cannot guarantee satisfactory control performance when the plant has different gains for the operational range. Robustness of the MFLAC with neural compensation scheme is compared to the MFLAC without compensation. Simulation results for a nonlinear chemical reactor are given to show the advantages of the proposed compensation approach.

ThC04.5: 16:50-17:10
Chaos Control in Lorenz Systems Based on Adaptive Inverse Control of Support Vector Machines, pp. 2024-2029
Liu, Ding Xian Univ. of Tech.
Liu, Han Xian Univ. of Tech.

A newly developed chaos control method based on adaptive inverse control of support vector machines (SVM) is proposed which has the excellent nonlinearity approximation ability and better generalization performance. In this control strategy, an identifier is established based on support vector regression and under the invertible condition of control process a controller also designed. It is guaranteed that under the proposed control strategy, uncertain Lorenz system can drive the system state exactly to some specific points. Illustrative examples are used to demonstrate the effectiveness of the proposed design method.

ThC04.6: 17:10-17:30
Neural Network Based Direct Adaptive Control for a Class of Affine Nonlinear Systems, pp. 2030-2035
Kar, Indrani Indian Inst. of Tech. Kanpur
Behera, Laxmidhar Indian Inst. of Tech. Kanpur

This paper presents a neural network based direct adaptive control scheme for a class of affine nonlinear systems which are exactly input-output linearizable by nonlinear state feedback. When the system dynamics are completely unknown, the control input comprises two terms. One is an adaptive feedback linearization term and the other one is a sliding mode term. The neural networks weight update laws have been derived to make the closed loop system Lyapunov stable. It is shown that the proposed control action can also be applied to multi-input-multi-output systems with minor modifications. Simulation results are presented to validate the theoretical formulations.

ThC05 Room 0601
Automotive Control: Powertrain Modeling and Calibration (Invited Session)

Chair: Ohata, Akira Toyota Motor Corp.
Co-Chair: Roepke, Karsten IAV GmbH
Organizer: Ohata, Akira Toyota Motor Corp.
Organizer: Roepke, Karsten IAV GmbH

ThC05.1: 15:30-15:50
Integration of Physical and Statistical Models for Automotive Engine Control (I), pp. 2036-2041
Ohata, Akira Toyota Motor Corp.
Furuta, Katsuhisa Tokyo Denki Univ.

To encounter the complexity and the time consuming problem of engine control system developments, almost all automotive manufacturers want to realize Model Based Development (MBD) process. Rapid plant modeling is one of the most essential issues to establish MBD. In this paper, two types of physical and statistical model integration have been proposed as the model simplification methodologies based on the error function between physical model and experimental data and nonlinear ARX identification with balanced realization by using the generated data from physical model.

ThC05.2: 15:50-16:10
A Real-Time Model for the Prediction of the NOx Emissions in DI Diesel Engines (I), pp. 2042-2047
Schilling, Alexander ETH Zurich
Amstutz, Alois ETH Zurich
Onder, Christopher Harald ETH Zurich
Guzzella, Lino ETH Zurich

This paper describes the development of a real-time model for the prediction of the NOx emissions in DI diesel engines. First, on the basis of previous work described in the literature, a detailed crank-angle discrete physical model of the combustion process is presented from which, in a second step, the real-time model is derived. The detailed combustion

model is used off-line to extrapolate the sensitivities of the NOx emissions to the various engine inputs and store the results in maps as a function of the operating conditions. Then the real-time model uses these maps on-line for the real-time computation of the NOx emissions. The extrapolated sensitivities thus become the parameters of the real-time model. Results from experiments are presented, which demonstrate the prediction capabilities of the proposed real-time NOx model.

ThC05.3: 16:10-16:30
Modeling and Analysis of a Thermal Management System for Engine Calibration (I), pp. 2048-2053

Vermillion, Christopher	Univ. of Michigan
Sun, Jing	Univ. of Michigan
Butts, Kenneth R.	Toyota Tech. Center
Hall, Andrew	A and D Tech.

Controlling engine coolant and oil temperatures to desired values is critical to effective engine calibration on a dynamometer. Because of the large time constants associated with thermodynamic systems, the slow response of coolant and oil temperature often represents a bottleneck in improving engine mapping and calibration efficiency. Nonlinearities in component characteristics, together with varying operating conditions, render the simple PID controller ineffective, thereby motivating a model-based strategy. In this paper, we present a dynamic model of a thermal management system that involves both heat exchangers and heaters. The model is developed using thermodynamic principles and parameter identification techniques, and has been validated using experimental data. Based on the validated model, we present the system analysis results that have significant implications to system performance and subsequent control strategy development. It is worth noting that the dynamometer based model presented here may also be applied to the modeling of an in-vehicle cooling system.

ThC05.4: 16:30-16:50
Fast Measurement by Integrating Model-Based Methods and Advanced Test-Cell Automation (I), pp. 2054-2059

Knaak, Mirko	IAV GmbH
Schaum, Steffen	IAV GmbH
Roepke, Karsten	IAV GmbH

Modern calibration engine control unit requires a huge number of measurements to fill their maps. Steady state measurements at the engine test bed are still very important to find the optimal settings of all control parameters for an engine operating point. Model-based methods – like Design of Experiments – are more and more used to reduce the needed numbers of experiments for an engine calibration. Nevertheless, since the number of controllable engine parameters arises, new methods for accelerating each measurement are needed. This paper presents methods to shorten the measurement time by using transitions between measurement points and avoidance of stabilization.

ThC05.5: 16:50-17:10
Workflow for Data Evaluation During Basic Calibration of Combustion Engines (I), pp. 2060-2065

Niedernolte, Hermann	BMW Group
Kloepper, Florian	BMW Group
Mitterer, Alexander	BMW Group
Schwarzer, Fabian	ITK Engineering

Calibration of modern combustion engines is a complex and costly procedure. Qualitative criteria and temporal constraints can be met only by the development and use of most effective methods. This paper presents an advanced workflow for data evaluation and its application to basic engine calibration. Especially the data evaluation phase is highlighted, starting with the results of a model-based optimization.

ThC05.6: 17:10-17:30
Determining Adjustment Ranges for Model-Based Approaches Using Support Vector Machines (I), pp. 2066-2071

Bazarsuren, Uzmee	Tech. Univ. Berlin
Knaak, Mirko	IAV GmbH
Schaum, Steffen	IAV GmbH
Guehmann, Clemens	Tech. Univ. Berlin

Model-based methods, such as Design of Experiments (DoE), have become more and more established in recent years in optimizing control maps in engine ECUs from the aspects of ride comfort, fuel economy and emissions. As a result of the rising number of control parameters and ever shorter development times, the aim in this context is to develop automated intelligent setting strategies for test design. In doing so, it is imperative to find a range of settings at which the engine works safely (adjustment range).

This paper presents a method for determining adjustment range limits in engine measurement for high dimensional parameter spaces using the support vector machines (SVM). SVMs are a relatively new method in machine learning and are applied to learn a hull that models the unknown, actual test space on the basis of measurement points. In comparison with the conventional method of describing the feasible domain as a convex polyhedron, the SVM approach allows complex shaped spaces to be modelled due to its ability to handle non-linear dependencies between parameters.

With the proposed method it is possible to generate an approximation of real adjustment ranges even for high-dimensional problems in a relatively short time. With ongoing rapid determination of the distance between the planned operating point and the predicted range limits, the adjustment step width can be adapted flexibly. This provides the potential to reduce the number of adjustments, and therefore the on-line motor measurement time.

ThC06 Room 0602
Networked Control Systems II (Regular Session)

Chair: Birdwell, J. Douglas	Univ. of Tennessee
Co-Chair: Savkin, Andrey V.	Univ. of New South Wales

ThC06.1: 15:30-15:50
On a Problem Related to Application of Digital Networked Communication Technology to Stabilization of Noisy Plants Over Noisy Channels, pp. 2072-2077

Matveev, Alexey S.	St. Petersburg Univ.
Savkin, Andrey V.	Univ. of New South Wales

This paper addresses the stabilization problem involving communication errors and capacity constraints. Discrete-time partially observed unstable linear systems perturbed by exogenous uniformly bounded disturbances are studied. Unlike the classic theory, the sensor signals are transmitted to the controller over a noisy digital link. How much the capacity of this link should be in order that the stabilization be possible? We show that the capability of the noisy channel to serve almost sure stability is identical to exactly its capability to communicate information with no error. In other words, the answer to the above question is given by the standard characteristics of the latter capability, i.e., the zero-error capacity of the channel. The zero-error capacity in the presence of a perfect feedback communication link is concerned here. This is true even if there is no such a link in fact. Since the zero-error capacity may be greater with feedback than without, the class of systems almost surely stabilizable via a given channel appears to be wider than expected. To justify this, we show that perfect transmission of as much information as desired can be arranged from the controller to the sensor by means of control actions upon the plant without violating the main objective of keeping the stabilization error a.s. bounded. A particular scheme for such a transmission is offered.

ThC06.2: 15:50-16:10
Distributed Power Control in Cellular Mobile Radio Systems with Time-Varying Link Gains, pp. 2078-2080

Savkin, Andrey V.	Univ. of New South Wales
Pathirana, Pubudu N.	Deakin Univ.

A simple distributed power control algorithm for communication systems with mobile users and unknown time-varying link gains is proposed. We prove that the proposed algorithm is exponentially converging. Furthermore, we show that the algorithm significantly outperforms the well-known Foschini and Miljanic algorithm in the case of quickly moving mobile users.

ThC06.3: 16:10-16:30
Remote TCP/IP-Based Process Control with Time-Varying Sampling Period, pp. 2081-2086

Sala, Antonio	Univ. Pol. de Valencia
Valles, Marina	Univ. Pol. de Valencia
Díez, José Luis	Univ. Pol. de Valencia

This paper presents a remote process control application trough the Internet, considering the negative effects of TCP/IP-based networks over computer control due to time-varying sampling period. A controller design approach that uses time-varying observers and state feedback controllers designed by means of linear matrix inequalities (LMI) and quadratic Lyapunov functions helps in overcoming the outlined problem. An experimental setup for remote DC motor control shows the applicability of the approach in a real implementation.

ThC06.4: 16:30-16:50
An Approximate Dynamic Programming Approach to Admission Control in WCDMA Networks, pp. 2087-2092

Pietrabissa, Antonio	Univ. of Rome La Sapienza
Anticoli Borza, Daniele	Univ. of Rome La Sapienza

This paper presents a Connection Admission Control (CAC) algorithm for Wide-CDMA (WCDMA) networks based on an Approximate Dynamic Programming (ADP) approach: the network is modeled as a Markov Decision Process (MDP), and ADP algorithms are used to compute the optimal admission policy. Two innovative concept are introduced: i) by formulating the problem as a linear programming problem, the blocking probabilities of the different classes of service supported by the network are controlled by appropriately modifying the reward function; ii) on the ground of practical considerations on the CAC problem, a restricted structure policy is determined, based on the reduction of the action space for low load conditions. Numerical simulation results show the effectiveness of the approach.

ThC06.5: 16:50-17:10
A Robust Adaptive Congestion Control for Communication Networks with Time-Varying Delays, pp. 2093-2098

Pietrabissa, Antonio	Univ. of Rome La Sapienza
Delli Priscoli, Francesco	Univ. of Rome La Sapienza
Fiaschetti, Andrea	Univ. of Rome La Sapienza
Di Paolo, Federico	Univ. of Rome La Sapienza

This work presents a congestion control for high-speed networks in the single bottle-neck case with time-varying multiple delays, aimed at avoiding congestion by setting the rates of the traffic flows. The novelty of this paper is that the controller explicitly deals with saturated (i.e., non persistent) sources. The controller consists in a main controller based on classical control theory coupled with a controller based on fuzzy logic: the former works properly when the sources are not saturated; the latter provides a saturation compensation by setting an adaptive multiplicative gain which acts on the rate command. The scheme provides also robust stability to time-delay uncertainties. Simulations prove its effectiveness.

ThC07 Room 0606
Process Control II (Regular Session)

Chair: Mikles, Jan	Slovak Tech. Univ. Bratislava
Co-Chair: Gambier, Adrian	Univ. of Mannheim

ThC07.1: 15:30-15:50
Multi-Loop Controller Design for a Heat Exchanger, pp. 2099-2104

Wellenreuther, Andrea	Univ. of Mannheim
Gambier, Adrian	Univ. of Mannheim
Badreddin, Essameddin	Univ. of Mannheim

A new method to tune the parameters of two discrete controllers in a cascaded control structure is proposed and applied to the linear controller design of a heat exchanger system. Normally, this problem is solved either by decoupling the multiple loops and tuning the controllers independently or by keeping the structure but tuning the controllers consecutively from inwards to outwards. However, these methods are not always an appropriate solution. Therefore, this approach that is derivated from the game theory is applied in this paper for a heat exchanger system where discrete controllers of two cascaded loops act as players in a cooperative game. The players operate simultaneously and influence themselves. Each player has its own objective function, which also depends on parameters of the other players. Target of the game is to get values for the parameters, satisfying the objective functions of the players, which is done via multi-objective optimization.

ThC07.2: 15:50-16:10
Control of Stochastic Systems and Molecular Fluidic Electronic Devices, pp. 2105-2110

Lyshevski, Marina	Microsystems and Nanotechnologies
Sinha, A.S.C.	Univ. of Southern California
Lyshevski, Sergey	Rochester Inst. of Tech.

We formulate and solve the control problem for stochastic nonlinear systems. The Lyapunov stability theory is applied to study the stability of closed-loop systems. The stabilizing controllers are designed using the information-theoretic approach. The results reported are applied to design control laws for an envisioned fluidic molecular electronic devices. By mimicking the brain neuron, we study the controlled propagation of Brownian particles (molecules) under the thermal, hydrodynamic, electrostatic and electromagnetic forces. The molecules are the information carriers in the fluidic gap junctions (cavity) of the considered molecular electronic devices. The molecule motion (evolution) and dynamics, which is described by the nonlinear stochastic differential equations, are controlled. The fundamental, analytical and numerical results are reported.

ThC07.3: 16:10-16:30
Practical Use of HILS and an Approach to MBCSD for AT and CVT Development, pp. 2111-2114

Katsu, Fuyuku	JATCO Ltd
Matsumura, Toshio	JATCO Ltd

A practical example of ATCU(Automatic Transmission Control Unit) software automatic verification by use of HILS (Hardware In the Loop Simulation) for automatic transmission development, and also a trial to some new application domains such as control system development, are described. Additionally, our approach to MBCSD (Model Based Control System Development) in which MATLAB is used as a core element, is explained.

ThC07.4: 16:30-16:50
Support Vector Networks for Prediction of Floor Pressures in Shallow Cavity Flows, pp. 2115-2120

Efe, M. Onder	Econ. and Tech. Univ. Ankara
Debiasi, Marco	Ohio State Univ.
Yan, Peng	Ohio State Univ.
Ozbay, Hitay	Bilkent Univ. and Ohio State Univ.
Samimy, Mohammad	Ohio State Univ.

During the last decade, Support Vector Machines (SVM) have proved to be very successful tools for classification and regression problems. The representational performance of this type of networks is studied on a cavity flow facility developed to investigate the characteristics of aerodynamic flows at various Mach numbers. Several test conditions have been experimented to collect a set of data, which is in the form of pressure readings from particular points in the test section. The goal is to develop a SVM based model that emulates the one step ahead behavior of the flow measurement at the cavity floor. The SVM based model is built for a very limited amount of training data and the model is tested for an extended set of test conditions. A relative error is defined to measure the reconstruction performance, and the peak value of the FFT magnitude of the error is measured. The results indicate that the SVM based model is capable of matching the experimental data satisfactorily over the conditions that are close to the training data collection conditions, and the performance degrades as the Mach number gets away from the conditions considered during training.

ThC07.5: 16:50-17:10
A Run-To-Run Control Strategy for Polymorphic Transformation in Pharmaceutical Crystallization, pp. 2121-2126

Hermanto, Martin Wijaya — National Univ. of Singapore
Braatz, Richard D. — Univ. of Illinois at Urbana-Champaign
Chiu, Min-Sen — National Univ. of Singapore

Polymorphism is a phenomenon that a substance can have more than one crystal form, each with distinct characteristics. Consequently, controlling polymorphism in drug manufacturing industries are crucial in order to ensure consistent production of the desired polymorph. In this paper, a run-to-run concentration control (C-control) based on iterative learning control is developed. As a case study, a model of polymorphic transformation of L-Glutamic acid from metastable alpha-form to stable beta-form, where the yield of beta-form is to be maximized, is used to illustrate the proposed run-to-run C-control and its advantage over the conventional C-control.

ThC07.6: 17:10-17:30
H2 Optimal Controller with Integral Action for a Chemical Reactor, pp. 2127-2131

Mikles, Jan — Slovak Tech. Univ. Bratislava
Cirka, Lubos — Slovak Tech. Univ. Bratislava
Fikar, Miroslav — Slovak Tech. Univ. Bratislava

This paper deals with H2 control of a continuous stirred tank reactor (CSTR). The coolant temperature and the temperature in the reactor are respectively considered as control and controlled variables. A connection between H2 polynomial approach and the mixed sensitivity optimization for feedback control of CSTR is presented. The control algorithm has been implemented with the help of the Polynomial Toolbox for MATLAB. The resulting controller has integral action. Simulation results demonstrate the robustness properties of H2 control of CSTR.

ThC08 Room 2607
Fuzzy Control I (Regular Session)

Chair: Arnold, Jean-François — Le Moteur Moderne
Co-Chair: Sreenatha, Anavatti G. — Australian Defence Force Acad.

ThC08.1: 15:30-15:50
Control of the Air System of a Diesel Engine : A Fuzzy Multivariable Approach, pp. 2132-2137

Arnold, Jean-Francois — Le Moteur Moderne
Langlois, Nicolas — ESIGELEC
Chafouk, Houcine — ESIGELEC
Tremouliere, Gerard — Le Moteur Moderne

A new strategy based on a fuzzy multi-variable controller is proposed to regulate both the fresh airflow and the intake manifold pressure. This strategy has been designed to be implemented in a standard ECU (Electonic Control Unit) without any change of the engine instrumentation. The air system controller requires neither internal model nor certain feed-forward maps. It is intrinsically robust and very easy to tune with respect to strategies proposed in literature. The results obtained with this controller are compared to these of current embedded controllers.

ThC08.2: 15:50-16:10
Real-Time Validation and Comparison of Fuzzy Identification and State-Space Identification for a UAV Platform, pp. 2138-2143

Salman, Shaaban Ali — Australian Defence Force Acad.
Puttige, Vishwas R — Australian Defence Force Acad.
Sreenatha, Anavatti G. — Australian Defence Force Acad.

Unmanned aerial vehicles (UAVs) have been playing an increasingly important role in military and civilian applications. Identification of UAV model is an important process in the controller design. In this paper, identification of the attitude dynamics of UAV is investigated. Two different identification techniques for attitude dynamics of UAV are applied, verified and compared together. The first method is based on an error mapping approach, while the second one is based on fuzzy system approach. The main features of the two identification methods are discussed and compared. The identification algorithms are programmed onto the microcontroller and a real time validation was performed using the in-house developed Hardware in loop simulation (HIL) tool. The performance of both identification approaches is evaluated based on the flight data. Real time simulation results show that the fuzzy identification approach is better than error mapping approach.

ThC08.3: 16:10-16:30
Copper Sintering in a Solar Furnace through Fuzzy Control, pp. 2144-2149

Lacasa, David — Univ. of Almería
Berenguel, Manuel — Univ. of Almería
Yebra, Luis — Plataforma Solar de Almeria
Martínez Plaza, Diego — Plataforma Solar de Almeria

In this paper, the automatic control of the process of copper sintering is addressed. The approach presented includes additional difficulties because the process is conditioned by the power source being solar energy and the intrinsic non-linearities of a solar furnace housing.

Intelligent control capabilities come useful when a great degree of variability in tests and temperature patterns are in scope, so that a fuzzy control strategy is applied. A study of different plausible membership function partitions of the input universes of discourse has been undertaken, leading to distinct fuzzy rule bases constructed out of the expert operators knowledge through both direct enquiring and analysis of manual-controlled test performed in recent copper sintering test campaigns. The controller follows a Mamdani type with a Triangular Partition rule based inference system, which yields very promising results on the plant.

ThC08.4: 16:30-16:50
Temperature and Humidity Control in Greenhouses Using the Takagi-Sugeno Fuzzy Model, pp. 2150-2154

Nachidi, Meriem — Univ. of Valladolid
Benzaouia, Abdellah — Univ. Cadi Ayyad
Tadeo, Fernando — Univ. of Valladolid

The control of air temperature and humidity concentration in greenhouses is described by means of simultaneous ventilation and heating systems. To solve the problem of bi-linearity of greenhouse models, this paper proposes the construction of a Takagi-Sugeno (T-S) fuzzy model from a simplified nonlinear dynamic model of the greenhouse climate. Using this T-S fuzzy model, the stability analysis and control design problems can be reduced to sufficient conditions expressed as linear matrix inequalities (LMIs). This paper shows that it is possible to successfully control the greenhouse climate by using T-S fuzzy models and the parallel distributed compensation (PDC) concept. Simulation results for several tests showing the good performance and stability obtained with the proposed design methodology are presented.

ThC08.5: 16:50-17:10
Piecewise Linear Model Tree: A Modified Combination of Two Learning Algorithms for Neuro-Fuzzy Models, pp. 2155-2159

Sarabi Jamab, Atiye — Malek Ashtar Univ.
Nadjar Araabi, Babak — Univ. of Tehran

Locally Linear Model Tree (LOLIMOT) and Piecewise Linear Network (PLN) learning algorithms are two approaches in local linear modeling use different algorithm in each part of training phase. PLN learning is more depended on training data than LOIMOT and needs rich training data set. In PLN learning no division test is needed and it causes this algorithm to be much faster than LOLIMOT, but it may create adjacent neurons that would lead to singularity in regression matrix. In LOLIMOT, because of regular splitting of input space, this problem does not occur and always it leads to acceptable output error, but needs large number of neuron. Therefore, PILIMOT learning algorithm is introduced as modified combination of these two main Locally Linear approaches. This new method takes suitable error and neuron number from both of algorithms and leads to efficient network which is applicable to identify all functions. Simulation results show the advantage and behavior of new method.

ThC09 Room 0999
Robot Control (Regular Session)

Chair: Sampei, Mitsuji — Tokyo Inst. of Tech.
Co-Chair: Papadopoulos, Evangelos — National Tech. Univ. of Athens

ThC09.1: 15:30-15:50
Speed Control of Quadrupedal Bounding Using a Reaction Wheel, pp. 2160-2165

Cherouvim, Nicholas — National Tech. Univ. of Athens
Papadopoulos, Evangelos — National Tech. Univ. of Athens

To date, quadruped speed control has either been achieved with two actuators per leg, or with single actuators and time consuming trial and error experimentation for controller tuning. In this paper, a novel control method is developed that uses only one actuator per leg and yet requires no controller tuning from the user, since the control parameters are computed through analytical expressions derived from the robot dynamics. One further actuator is used to drive a reaction wheel situated on the body. The control method leads to stable bounding gaits with controllable forward speed, and as the control is based on analytical results from the robot dynamics, it is applicable to a range of design parameters, rather than a specific robot. Light, off-the-shelf DC motors are shown to be adequate for successful controller operation. Results are shown of the control applied to a detailed robot model, including leg and toe mass, foot collision, DC motor model, joint friction and a foot-ground friction model allowing foot slipping.

ThC09.2: 15:50-16:10
A Synthesis of Bipedal Runner by Output Zeroing, pp. 2166-2171

Ohata, Ryusuke — Mitsubishi Electric Corp.
Nakaura, Shigeki — Tokyo Inst. of Tech.
Sampei, Mitsuji — Tokyo Inst. of Tech.

Most controllers of bipedal runner are intended the joints of the biped to follow the optimal trajectory computed off-line. This method is not easy to redesign the trajectory on-line to adapt an uneven terrain, as has been demonstrated in early studies.

In this paper, to realize the running motion, an algorithm which is designed by output zeroing feedback control with an output function obtained by observing the human running is proposed. The output function indicates implicitly a human running motion such as moving the center of gravity and swinging legs. This output function is designed intuitively referred human running forms.

The benefit of this method is that the parameters of the output function are easily redesigned on-line (that is equivalent to redesigning the optimal trajectory), as a result higher adaptability to an uneven terrain is achieved. The main result is illustrated via the numerical simulation.

ThC09.3: 16:10-16:30
A SISO Linear System with an Unstable Inner Loop and Its Application to Zero Moment Point (ZMP) Control, pp. 2172-2177

Nazir, Napoleon — Tokyo Inst. of Tech.
Sampei, Mitsuji — Tokyo Inst. of Tech.
Nakaura, Shigeki — Tokyo Inst. of Tech.

An analysis of a cascade control system constructed by an inner and an outer feedback loop is presented. It differs from other researches, because the inner feedback loop is unstable. The control method is motivated by balance stabilization of a humanoid robot based on the Zero Moment Point (ZMP) principle where the effectiveness is well-known experimentally. This paper generalizes the control method, and analyzes the stability and the robustness w.r.t. parameter variations of the plant and external disturbances. Some examples to the ZMP control and a simple linear system are described and the simulation results are shown.

ThC09.4: 16:30-16:50
Design and Control of YAIP - an Inverted Pendulum on Two Wheels Robot, pp. 2178-2183

Akesson, Johan — Lund Univ.
Blomdell, Anders — Lund Univ.
Braun, Rolf — Lund Univ.

In this paper we describe the design and control of an inverted pendulum type robot on two wheels. The objective of the design is to provide a flexible platform intended for teaching and research, which provides rich opportunities for application of signal processing, control design, distributed control systems and consideration of implementational issues. In addition, a design constraint has been to use low-cost components. Issues such as selection of hardware and sensors, signal processing, modeling and control are treated. Special attention is given to the problem of obtaining high accuracy velocity estimates using analog encoder signals.

ThC09.5: 16:50-17:10
Model Predictive Control of an Autonomous Blimp with Input and Output Constraints, pp. 2184-2189

Fukushima, Hiroaki — Univ. of Electro-Communications
Saito, Ryosuke — Univ. of Electro-Communications
Matsuno, Fumitoshi — Univ. of Electro-Communications
Hada, Yasushi — RIKEN
Kawabata, Kuniaki — RIKEN
Asama, Hajime — Univ. of Tokyo

This paper focuses on how to design autonomous flight control systems taking into account input constraints due to actuator saturations and output limitations from the viewpoint of security. Model predictive control (MPC) is one of the most systematic ways to handle such constraints. To implement MPC, we first construct a simple linear model connected to a deadzone nonlinearity based on experimental data. Then, MPC controllers are derived offline as piecewise affine state feedback laws based on a robust MPC approach to take into account additive uncertainties. Indoor experiments are performed to investigate the effectiveness of the MPC controllers obtained based on the simple model.

ThC09.6: 17:10-17:30
Nonlinear H-Infinity Control Applied to Biped Robots, pp. 2190-2195

Siqueira, Adriano A G — Univ. of Sao Paulo at Sao Carlos
Terra, Marco Henrique — Univ. of Sao Paulo at Sao Carlos

In this paper, a control strategy based on nonlinear H-infinity approach is applied in a biped robot with torso, knees, and feet, that presents a passive dynamic walking. To obtain an anthropomorphic gait, the Foot Rotation Indicator was used as control variable. The H-infinity control adopted is based on the Linear Parameter Varying (LPV) approach with a quasi-LPV representation of the biped robot. Results obtained from simulation show that the proposed controller increases the basin of attraction of the system limit cycle against external disturbances.

ThC10 Room 3999
Various Applications I (Regular Session)

Chair: Lozano, Rogelio — Univ. of Tech. Compiegne
Co-Chair: Marcos, Andres — Deimos Space S.L.

ThC10.1: 15:30-15:50
Target-Based Prototyping System Applied to Fuel Control, pp. 2196-2201

He, Pingan — MotoTron Corp.
Suhre, Blake R. — MotoTron Corp.
Doyle, Chris — MotoTron Corp.
Lemancik, Michael J. — MotoTron Corp.

A target-based rapid prototyping system, MotoHawk, is described for controls development, vehicle or engine calibration, fleet testing and production. MotoHawk features the capability of controlling varied types of engines (gasoline and diesel engines from single-cylinder to multi-cylinder), auto-code generation of Simulink/Stateflow models to a family of production Electronic Control Units (ECUs), and a calibration interface incorporated into the models. Finally, an illustrative example of a MotoHawk application, the design and

implementation of a fuel control strategy for gasoline engines, is discussed in detail.

ThC10.2: 15:50-16:10
Attitude Stabilization of a Convertible Mini Birotor, pp. 2202-2206

Escareno-Castro, Juan	Univ. of Tech. Compiegne
Salazar-Cruz, Sergio	Univ. of Tech. Compiegne
Lozano, Rogelio	Univ. of Tech. Compiegne

This paper describes the vertical-flight mode of a novel unmanned air vehicle configuration designed to perform either vertical or forward flight. We present the mathematical model of the aircraft's attitude in vertical mode which is derived via the Euler-Lagrange formulation, followed by the control strategy, based on saturations. The control strategy is simple for embedded applications and it showed a good performance as is demonstrated in simulations and in real-time experiments.

ThC10.3: 16:10-16:30
Aircraft-On-Ground Lateral Control by an Adaptive LFT-Based Anti-Windup Approach, pp. 2207-2212

Roos, Clément	ONERA
Biannic, Jean-Marc	ONERA

Using a simplified LFT model of an aircraft-on-ground, a robust anti-windup control technique is efficiently applied to improve lateral control laws. The original idea of this work consists in taking advantage of a simplified representation of the nonlinear lateral ground forces which are reduced to saturation-type nonlinearities.

ThC10.4: 16:30-16:50
Nonlinear Simplified LFT Modelling of an Aircraft on Ground, pp. 2213-2218

Biannic, Jean-Marc	ONERA
Marcos, Andres	Deimos Space
Jeanneau, Matthieu	AIRBUS
Roos, Clément	ONERA

In this paper, a simplified nonlinear LFT model of an aircraft-on-ground is developed and compared to a full nonlinear model. The proposed simplifications are shown to be not so restrictive. The main contribution of the paper consists of an original approximation of the ground forces. Based on this approximation, which yet remains quite close to reality, some strong nonlinearities of the initial model are conveniently replaced by saturations and time-varying uncertainties. Thus, the proposed simplified model boils down to a reduced order LFT where the Delta-block only contains time-varying or constant (but uncertain) parameters on the one hand, and saturationtype non-linearities on the other hand. Such a model is then very useful for applying modern analysis and synthesis techniques.

ThC10.5: 16:50-17:10
Slow Time-Varying Delay Effects - Robust Stability Characterization of Deterministic Car Following Models, pp. 2219-2224

Sipahi, Rifat	Univ. of Tech. Compiegne
Niculescu, Silviu-Iulian	Univ. of Tech. Compiegne

It is very well known that traffic dynamics are inherently time delayed because of the limited sensing and acting capabilities of drivers against velocity and position sensing. Furthermore, as experimentally validated time delay is not a constant physical entity, but slowly time-varying. However, due to further complications, this has been ignored in the literature up until today, as to our best knowledge. We respond to the question of robust stability with respect to time varying time delays and present sufficient conditions on this time varying component guaranteeing the robust stability of a conceptual traffic flow scenario.

ThC10.6: 17:10-17:30
Predictive Control of Earth Station Antenna with Backlash Compensation, pp. 2225-2230

Mohammadzaman, Iman	Malek Ashtar Univ. of Tech.
Khaki Sedigh, Ali	K. N. Toosi Univ. of Tech.
Nasirian, Mehrzad	K. N. Toosi Univ. of Tech.
Ferdowsi, Mohammad Hossien	Malek Ashtar Univ. of Tech.

In this paper, Generalized Predictive Control (GPC) algorithm is implemented to control an earth station antenna. Nonlinear term in motors caused by gearbox or other parts is modeled by a backlash block. Simulation results show the effectiveness of GPC method for robust control in the presence of backlash nonlinearity without a priori knowledge about upper and lower bounds of backlash. Also, adaptation mechanism as a self tuning predictive control is used to conquer environment changing.

ThC11 Audimax
Nonlinear Systems I (Regular Session)

Chair: Wolff, Jan	Tech. Univ. Munich
Co-Chair: Wilson, David G.	Sandia National Lab.

ThC11.1: 15:30-15:50
Extension of High-Gain Controllable Systems for Improved Accuracy, pp. 2231-2236

Hackl, Christoph M.	Tech. Univ. Munich
Schröder, Dierk	Tech. Univ. Munich

A PI–Controller like extension structure for High- Gain controllable nonlinear systems with known relative degree is investigated. The extension ensures accurate asymptotic tracking for plants with proportional steady state characteristic. It can be guaranteed that the control error converges to zero. The introduced structure extends the original plant to an auxiliary system, which is still controllable with High- Gain based concepts. Funnel-Control, a sophisticated High- Gain based time-varying control strategy, is re-examined to illustrate the advantages of the extension. The extension neither affects the controllability of the orignial plant nor requires a supplementary (adaptive) controller design, but improves the achievable control performance by absolute accuracy.

ThC11.2: 15:50-16:10
Decoupling of Non Linear Bond Graph Models, pp. 2237-2242

Lichiardopol, Stefan	Ecole Centrale de Lille
Sueur, Christophe	Ecole Centrale de Lille

The aim of this paper is to study the structure of nonlinear bond-graph models for solving the input-output decoupling problem. First a graphical procedure is proposed for the analysis of the LTV models and then a technique for determining the decoupling matrices using the bond-graph representation of the system is introduced. In the second part the decoupling problem for nonlinear models is solved by using the variational bond-graph model.

ThC11.3: 16:10-16:30
Flatness-Based Control of a Simplified Wastewater Treatment Plant, pp. 2243-2248

Aschemann, Harald	Univ. of Ulm
Rauh, Andreas	Univ. of Ulm
Kletting, Marco	Univ. of Ulm
Hofer, Eberhard	Univ. of Ulm

This paper presents a nonlinear control approach for a simplified activated sludge model that covers the reduction of biodegradable substrate in biological wastewater treatment. In the proposed control scheme, the volume flow of oxygen into the aeration tank and the volume flow of excess sludge out of the settler tank are utilized as manipulated variables. As the oxygen concentration as well as the substrate concentration represent flat outputs, the proposed control strategy takes advantage of differential flatness. The inverse dynamics is evaluated in a feedforward manner using only desired values from a trajectory planning module in combination with stabilizing proportional-integral feedback of the substrate concentration as well as the oxygen concentration, respectively. Consequently, accurate tracking of desired

trajectories for the flat outputs becomes possible without cost-intensive and often unreliable measurements of the bacteria concentration. As shown by simulation results, steady-state accuracy concerning the substrate concentration is guaranteed due to the integral control part despite dominant parameter uncertainties concerning the maximum growth rate of bacteria and variations of substrate concentration in the influent volume flow as disturbance. Hence, regulations on the admissible substrate concentration at the plant output can be easily met and plant operating costs can be significantly reduced resulting in superior plant efficiency.

ThC11.4: 16:30-16:50
Exergy and Irreversible Entropy Production Thermodynamic Concepts for Control System Design: Regulators, pp. 2249-2256

Robinett, III, Rush D. Sandia National Lab.
Wilson, David G. Sandia National Lab.

This paper develops a novel control system design methodology that uniquely combines: concepts from thermodynamic exergy and entropy; Hamiltonian systems; Lyapunov's direct method and Lyapunov optimal analysis; electric AC power concepts; and power flow analysis. Relationships are derived between exergy/entropy and Lyapunov optimal functions for Hamiltonian systems. The methodology is demonstrated with a couple of fundamental numerical simulation examples: 1) a PID regulator control for a linear mass-spring-damper system and 2) a Duffing oscillator/Coulomb friction nonlinear model that employs PID regulator control. The control system performances are partitioned and evaluated based on exergy generation and exergy dissipation terms. This novel nonlinear control methodology results in both necessary and sufficient conditions for stability of nonlinear systems.

ThC11.5: 16:50-17:10
Semi-Global Enlargement of Domain of Attraction for a Class of Affine Nonlinear Systems, pp. 2257-2262

Hashemzadeh, Farzad Tehran Univ.
Yazdanpanah, M. J. Tehran Univ.

In this paper, a new approach to enlarge the domain of attraction of a nonlinear affine system based on Zubov Theorem is suggested. The affine systems which are studied in this paper some times have some constraints that coping with them are difficult. The proposed approach may alleviate these difficulties by introducing an extended controller design methodology. The controller can extend the domain of attraction as an n-dimensional ellipsoid in a way that the diameters of ellipsoid, may be used as the tuning factors for shaping and enlarging it as much as possible. In this approach, the ratios of diameters are not crucial. In other words, it is possible to stretch the domain of attraction along some directions and compress it along the others. The simulation results on the Van der Pole system and two case studies, namely, a vehicle dynamics and an inverted pendulum show the efficiency of the method.

ThC11.6: 17:10-17:30
Time-Dependent Invariant Sets in System Dynamics, pp. 2263-2268

Pastravanu, Octavian C. Tech. Univ. Gh. Asachi of Iasi
Matcovschi, Mihaela-Hanako Tech. Univ. Gh. Asachi of Iasi
Voicu, Mihail Tech. Univ. Gh. Asachi of Iasi

The paper provides new results on the flow (positive) invariance of the families of 0-symmetrical sets, which are defined by arbitrary Hölder norms and time-dependent diagonal matrices. Thus, we introduce the concept of “diagonal invariance” as a system property with local or global character. For this property, we formulate sufficient conditions in the case of time-variant or –invariant, nonlinear systems and necessary and sufficient conditions in the case of time-variant or –invariant, linear systems. We also derive a comparison method that allows exploring the diagonal invariance of time-variant or -invariant, nonlinear or linear systems, by using time-invariant, linear comparison systems. We illustrate the applicability of the diagonal invariance criteria to the important class of nonlinear systems described by Hopfield neural networks. These new results represent a meaningful generalization of some previous researches developed by the same authors.

ThKPL Audimax
Keynote Lecture: Raymond Freymann (Plenary Session)
Chair: Sampei, Mitsuji Tokyo Inst. of Tech./SICE

ThKPL: 17:40-18:30
The Role of Driver Assistance Systems in a Future Traffic Scenario, pp. 2269-2274

Freymann, Raymond BMW Group Res. and Tech.

It is shown in how far driver assistance systems can contribute to enhance the overall traffic safety. Thereby it must be considered as a goal to increase the performance of active safety systems in the scope of an integrated approach, allowing to real¬ize a variety of interactions between the three ele¬ments involved in a traffic scenario, say the driver, the vehicle and the driving environment. Focus is pointed on the related technology, the inherent system complexity and aspects of customer acceptance.

FrPPL Audimax
Plenary Lecture: Thomas Parisini (Plenary Session)
Chair: Liu, Derong Univ. of Illinois at Chicago

FrPPL: 08:15-09:15
Control of Distributed-Information Nonlinear Stochastic Systems
Parisini, Thomas Univ. of Trieste

In engineering and economic systems, many situations may occur, in which a process is influenced by the presence of several decision makers (DM). Different degrees of cooperation and different degrees of distribution of available information among the DMs are possible. In this lecture, we consider the case where various DMs share different information patterns but they make decisions aimed at the accomplishment of a common goal, i.e., the minimization of the same cost functional. A general approach to the solution of a team optimal decision problem has not yet been presented in the literature. Therefore, in this lecture we give up looking for optimal solutions to a general team optimal control problem, and propose a technique to obtain suboptimal (but approximate to any degree of accuracy) solutions. This is accomplished by constraining the control functions to take on the structure of feedforward neural networks thanks to their powerful approximation capabilities and because these functional structures allow for a simple distributed computation of the local control strategies by stochastic approximation techniques. The neural control methodology is worked out on two important benchmark problems. A simple team within the LQG framework is first considered, where two decision makers with scalar information are present. When the problem admits a known optimal solution, our approach has demonstrated to be able to approximate it. Quite satisfactory results were obtained also in a case (the well-known Witsenhausen counterexample) where the optimal solution has not yet been found (it is however known that it exists). Then, dynamic routing in communication networks is considered. A nonlinear discrete-time dynamic model is given for a store-and-forward packet switching network in which the routing nodes play the role of cooperating DMs of a team. The resulting problem does not verify either the LQG hypotheses or the partially nestedness assumption on the information structure.

FrA01 Room 2601
Computer Tools for Control Education and Computer-Based Learning Environments (Regular Session)
Chair: Levine, William S. Univ. of Maryland
Co-Chair: Schmid, Christian Ruhr Univ. Bochum

FrA01.1: 09:45-10:05
FRtool: A Frequency Response Tool for CACSD in Matlab, pp. 2275-2280
De Keyser, Robin M.C. Ghent Univ.
Ionescu, Clara Ghent Univ.

A control system can be designed either by applying a mathematical design method (the system theory approach) or by using a controller design tool (the CAD-approach). Graphical visually-interactive Computer Aided Design methods are nowadays quite attractive, especially for non-experts in control engineering. Matlab offers currently a controller design tool based on the root locus technique; time-delay systems have to be handled in a somewhat artificial way by approximating the dead-time with a rational transfer function. However time-delay systems can be tackled easily in the frequency-domain since the only influence of the dead-time is a shift in the phase. This paper thus presents a CAD-software based on the use of frequency charts as a controller design tool.

FrA01.2: 10:05-10:25
Some Uses for Computer-Aided Control System Design Software in Control Education, pp. 2281-2285
Levine, William S. Univ. of Maryland
Hristu-Varsakelis, Dimitrios Univ. of Macedonia

Several ways in which Computer-Aided Control System Design software and rapid prototyping tools have been used to enhance the controls educational program at our university are described. A key to the use in a lecture course has been to provide the students with a computer running the software during every exam. This motivates the students to learn to use the software and facilitates giving exam problems that focus on control design and analysis rather than on mechanical calculations. The use of computer-aided design software and rapid prototyping tools in the lab saves money and allows us to do more complicated experiments and simple projects. It also allows us to emphasize aspects of networked and embedded control systems that are not covered anywhere else within our curriculum.

FrA01.3: 10:25-10:45
GRID Technologies for Virtual Control Laboratories, pp. 2286-2291
Szczytowski, Piotr Ruhr Univ. Bochum
Schmid, Christian Ruhr Univ. Bochum

In this paper, Grid technologies are introduced to build e-Learning environments for control education. Service-oriented Grids open new fields of applications, the Learning Grids. The learning services concept and their deployment through Grid technologies are excellent means to integrate virtual control laboratories into e-Learning environments for control education. An example application from a virtual laboratory demonstrates the advantages of a Grid over classical solutions.

FrA01.4: 10:45-11:05
DSP Based Rapid Control Prototyping Systems for Engineering Education and Research, pp. 2292-2297
Hercog, Darko Univ. of Maribor
Curkovic, Milan Univ. of Maribor
Jezernik, Karel Univ. of Maribor

This paper presents custom made, DSP-based rapid control prototyping (RCP) systems that are suitable for control engineering education and research. Presented RCP systems provide an easy transition from the model-based control system design in MATLAB/Simulink to embedded DSP-based target implementation. In addition to rapid binary code generation, LabVIEW data visualization and parameter tuning solution is presented. The paper also includes an example of cascade DC motor control.

FrA01.5: 11:05-11:25
Petri Net Toolbox in Control Engineering Education, pp. 2298-2303
Matcovschi, Mihaela-Hanako Tech. Univ. Gh. Asachi of Iasi
Mahulea, Cristian Florentin Tech. Univ. Gh. Asachi of Iasi
Lefter, Claudiu Gabriel Tech. Univ. Gh. Asachi of Iasi
Pastravanu, Octavian C. Tech. Univ. Gh. Asachi of Iasi

The Petri Net Toolbox (PN Toolbox) for MATLAB is a software package that offers instruments for the simulation, analysis and design of untimed, deterministic and stochastic P-/T-timed and stochastic Petri nets (PNs). The facilities available in this toolbox are appropriate for studying the dynamics of many classes of discrete-event systems. The Petri Net Simulink Block (PNSB) allows the modeling and analysis of hybrid systems whose event-driven part(s) is (are) modeled based on the PN formalism. The current paper focuses on the exploitation of the PN Toolbox for illustrating the usage of the PN theory in Control Engineering from the pedagogic point of view, the discussion being supported by example problems and comments on the teaching goals. The PN Toolbox is included in the Connections Program of The MathWorks Inc., as a third party product.

FrA01.6: 11:25-11:45
Java Simulation Platform for Control System Based on Block Diagram, pp. 2304-2308

Koga, Masanobu	Kyushu Inst. of Tech.
Tsutsui, Yusuke	Kyushu Inst. of Tech.
Yabuuchi, Jun	Kyushu Inst. of Tech.

This paper proposes a new efficient method for modeling and simulation of control systems using an adjacency matrix in graph theory. A Java simulation platform, which has been developed based on the proposed method, is introduced. It provides an interactive graphical environment for modeling and simulation of control systems.

FrA02 Room 1601
Computer-Aided Design and Calibration of Automotive Control Systems (Invited Session)

Chair: Bohn, Christian	IAV GmbH
Co-Chair: Svaricek, Ferdinand	Univ. of Armed Forces Munich
Organizer: Bohn, Christian	IAV GmbH

FrA02.1: 09:45-10:05
Simulation Based Development within Global Chassis Control (I), pp. 2309-2314

Lauer, Peter	Continental AG & Co.
Semmler, Sascha Jens	Continental AG & Co.
Rieth, Peter Erich	Continental AG & Co.

Global Chassis Control (GCC) from Continental Teves is a logical enlargement of the current Electronic Stability Control (ESC). GCC aims to ensure the best possible levels of active safety, ride quality and driving pleasure under the given driving conditions, using the available configuration of electronically controlled chassis subsystems. Due to the complexity of interaction between these chassis components, vehicle simulation was used for development and evaluation of the advanced control algorithms. Simulation also allows analysis of the potential of each chassis actuator in stability critical driving situations, e.g. front or rear wheel steering intervention by braking on split-μ or during double lane change maneuvers.

FrA02.2: 10:05-10:25
An Optimization-Based Approach for the Calibration of Lookup Tables in Electronic Engine Control (I), pp. 2315-2320

Bohn, Christian	IAV GmbH
Stoeber, Pascal	IAV GmbH
Magnor, Olaf	IAV GmbH

This paper discusses the use of a parameter estimation approach for the calibration of electronic engine control software from an industrial perspective. Many functions in the software of automotive electronic engine control units are based on lookup tables. Calibrating, that is, tuning the entries of these lookup tables, is a crucial step in the process of automotive software engineering. At first sight, this corresponds to a standard parameter estimation problem. In the practical application, however, the calibrated parameters have to fulfill additional requirements. These additional requirements are discussed in this paper and it is illustrated how they can be included in an optimization-based calibration process. A software tool is described that has been developed to allow the calibration engineer, without having to be familiar with the mathematical background, to easily formulate these requirements, carry out the optimization, and analyze the results. The steps that are carried out in the optimization-based calibration process are outlined, and the advantages of this approach are discussed.

FrA02.3: 10:25-10:45
Robust Identification of Nonlinear Dynamic Systems Using Design of Experiment (I), pp. 2321-2326

Ayeb, Mohamed	Univ. of Kassel
Theuerkauf, Heinz	Univ. of Kassel
Wilhelm, Christian	Univ. of Kassel
Winsel, Thomas	Univ. of Kassel

Modern combustion engines are becoming increasingly complex, with more control variables, to meet the newest emissions regulations and improve the dynamic torque characteristics. However, the large number of control variables presents a challenge for the calibration process. The effects of all control variables and their interactions on the engine characteristics should be quantified in an accurate way to be able to derive the best control strategies aiming to minimise fuel consumption and emissions while generating the desired torque within acceptable time delays. Design of Experiment DoE methods have been used successfully to cope with the difficulties related to the characterisation of the underlying process in the presence of a large number of control variables. DoE provides experiment design methods aiming to reduce the number of measurements needed while ensuring the best quality of information related to a given optimisation criterion. In this paper a procedure is proposed to derive global dynamic models based on dynamic neural networks. The selection of the training data is derived by a D-optimality criterion to enhance the model quality. This ensures a reduction of the amount of measurement data needed for the training and hence an acceleration of the training process. It also improves the model quality by reducing the uncertainty on the model parameters.

FrA02.4: 10:45-11:05
Application of LPV Gain Scheduling to Charge Control of a SI Engine (I), pp. 2327-2331

Kwiatkowski, Andreas	Hamburg Univ. of Tech.
Blath, Jan P.	IAV GmbH
Werner, Herbert	Hamburg Univ. of Tech.
Schultalbers, Matthias	IAV GmbH

This paper presents an application of LPV control to an LFT model of the intake manifold of an SI engine. The gain scheduled LPV controller approach is motivated by the highly nonlinear nature of the system. A nonlinear model of the plant is derived and slightly simplified to construct an LPV model as LFT representation. Using a controller synthesis technique based on K-S iteration a controller is obtained and tested in nonlinear simulations.

FrA02.5: 11:05-11:25
Prototyping of Automotive Control Systems in a Time-Triggered Environment Using FlexRay (I), pp. 2332-2337

Stroop, Joachim	dSPACE GmbH
Stolpe, Ralf	dSPACE GmbH

Highly sophisticated control systems are a driving force for innovation in automotive electronics. However, the integration of these systems within current and future vehicle projects is facing a complexity problem. Established methods of realizing such control systems need to be revised. A promising approach to address these problems is to use deterministic time-triggered technologies within automotive electronic systems. In this paper we will describe how rapid prototyping of automotive control systems can be realized within a real-time and time-triggered environment.

FrA02.6: 11:25-11:45
A Rapid Calibration Tool for Engine Control Software and Its Application to Misfire Diagnosis Functions (I), pp. 2338-2342

Boker, Georg	IAV GmbH
Magnor, Olaf	IAV GmbH
Schultalbers, Matthias	IAV GmbH

Rigid legislation requirements on vehicle emissions and customer demands on comfort and efficiency have lead to a continuously increasing complexity of modern engine management systems, accompanied by a growing number of functions for engine control and component diagnosis, which all have to be calibrated. Nevertheless, for competitive reasons, time efficient methods for calibration are needed, where the accuracy of calibration is verified and well documented. For this purpose, the division of Powertrain Mechatronics Development Gasoline Engines (MD-G) of the IAV GmbH developed the idea of Rapid Calibration. In the RC tool environment in-vehicle measurements are automatically configured and executed, whereas the evaluation of the measurements, i.e. the calibration process, is mostly done on the basis of off-line optimization algorithms and simulation tools. Finally, documentation files, like for

example slide presentation files, are automatically generated and statistical analyzing methods, which prove the quality of the calibration, are applied. This contribution describes, from an engineer's point of view, the use of the Rapid Calibration tool environment for calibrating the misfire diagnosis function.

FrA03 Room 0670
Neural Networks and Learning (Invited Session)

Chair: Wang, Cong — South China Univ. of Tech.
Co-Chair: Liu, Derong — Univ. of Illinois at Chicago
Organizer: Wang, Cong — South China Univ. of Tech.

FrA03.1: 09:45-10:05
Motion/Force Control of Uncertain Constrained Nonholonomic Mobile Manipulator Using Neural Network Approximation (I), pp. 2343-2348
Wang, Zhuping — National Univ. of Singapore
Ge, Shuzhi Sam — National Univ. of Singapore
Lee, Tong Heng — National Univ. of Singapore

In this paper, an adaptive neural network control strategy is presented for motion/force control of a class of constrained mobile manipulators with unknown dynamics. The system is subject to both holonomic and nonholonomic constraints. The control law is developed based on a simplified dynamic model. The adaptive neural network controller is proposed to deal with the unmodelled dynamics in the system and eliminate the need for the error prone process in obtaining the LIP form of the system dynamics. In addition, the time-consuming offline training process for the neural network is avoided. Proportional plus integral feedback control is used for force control for the benefit of real-time implementation. The proposed control strategy guarantees that the system motion asymptotically converges to the desired manifold while the constraint force remains bounded.

FrA03.2: 10:05-10:25
Adaptive Nonlinear H-Infinity Control Systems Via Neural Network Approximators, pp. 2349-2354
Miyasato, Yoshihiko — Inst. of Statistical Mathematics

A new class of adaptive nonlinear H-infinity control systems for nonlinear and time-varying processes which include nonlinear parametric models approximated by neural networks (NN), is proposed in this manuscript. Those control schemes are derived as solutions of particular nonlinear H-infinity control problems, where unknown system parameters, approximation and algorithmic errors in NN, and estimation errors of layer weights in NN, are regarded as exogenous disturbances to processes, and thus, in the resulting control systems, L2 gains from those uncertain elements to generalized outputs are made less than prescribed positive constants. The resulting control systems are bounded for arbitrarily large but bounded variations of time-varying parameters and layer weights, and modeling and algorithmic errors in NN approximators.

FrA03.3: 10:25-10:45
Robust Iterative Learning Control Based on Neural Network for a Class of Uncertain Robotic Systems (I), pp. 2355-2359
Liu, Yanchen — BeiHang Univ.
Jia, Yingmin — BeiHang Univ.
Wang, Zhuo — BeiHang Univ.

This paper studies the problem of adaptive robust iterative learning control for trajectory-tracked task of a class of robotic systems with both structured and unstructured uncertainties. A composite control scheme is proposed in which the periodic uncertainties are approached by the learning controller, while the effect of non-periodic uncertainties on system performances is attenuated by the robust controller. In particular, by employing neural network the cone-bounded assumption on uncertain dynamics is removed. The simulation results are included.

FrA03.4: 10:45-11:05
An RBFN-Based Observer for Nonlinear Systems Via Deterministic Learning (I), pp. 2360-2365
Wang, Cong — South China Univ. of Tech.
Wang, Chenghong — National Nature Science Foundation of China
Song, Su — National Natural Science Foundation of China

Recently, it was shown that for a class of nonlinear systems with only output measurements, by using a high-gain observer and a dynamical radial basis function network (RBFN), locally-accurate identification of the underlying system dynamics can be achieved along the estimated state trajectory. In this paper, it will be shown that the learned knowledge on system dynamics can be reused in an RBFN-based nonlinear observer, so that correct state estimation can be achieved not by using high gain domination, but by the internal matching of the underlying system dynamics. The significance of the paper is that it shows that non-high-gain state estimation can be achieved by incorporating the knowledge reuse mechanism of the deterministic learning theory. Simulation studies are included to demonstrate the effectiveness of the approach.

FrA03.5: 11:05-11:25
Learning from Neural Control of General Brunovsky Systems (I), pp. 2366-2371
Liu, Tengfei — South China Univ. of Tech.
Wang, Cong — South China Univ. of Tech.

In this paper, we investigate deterministic learning from adaptive neural control of general Brunovsky systems, in which the affine terms are unknown functions of system states. We firstly present an extension of a recent result on stability analysis of linear time varying (LTV) systems. We then analyze the difficulties caused by the unknown affine term in deterministic learning for general Brunovsky systems. By taking a state transformation, the closed-loop control system is transformed into a LTV form for which exponential stability can be guaranteed when the PE condition is satisfied. Consequently, locally-accurate approximation of the closed-loop control system dynamics can be achieved along a periodic orbit of closedloop signals. Simulation studies are included to demonstrate the effectiveness of the approach.

FrA03.6: 11:25-11:45
*Neural Network Control for Nonlinear Time Delay Systems (I)**
Hua, Changchun — Yanshan Univ.
Xinping, Guan — Yanshan Univ.

FrA04 Room 2605
Fuzzy and Robust Control (Regular Session)

Chair: Nelles, Oliver — Univ. of Siegen
Co-Chair: Yoneyama, Jun — Aoyama Gakuin Univ.

FrA04.1: 09:45-10:05
Robust Stability and Stabilization of Fuzzy Systems with Discrete and Distributed Time-Delays, pp. 2372-2377
Yoneyama, Jun — Aoyama Gakuin Univ.

In this paper, we consider generalized delay-dependent stability conditions of Takagi-Sugeno fuzzy systems with discrete and distributed time-delays. For fuzzy systems with discrete time-delays, both delay-independent stability conditions and delay-dependent stability conditions have already been obtained. However, no stability condition for fuzzy systems with distributed time-delays has appeared in the literature. This is also true in case of the robust stability for uncertain fuzzy systems with distributed time-delays. With the aid of the stability theorems of linear systems with distributed time-delays, we employ a similar Lyapunov functional for the stability of fuzzy time-delay systems. Then we introduce many free matrices to such a Lyapunov functional, in order to obtain delay-dependent stability conditions. These techniques lead to generalized and less conservative stability conditions. In fact, delay-dependent stability conditions thus obtained are given in linear matrix inequalities(LMIs) and guarantee a wide stability region. We

also consider the robust stability of fuzzy time-delay systems with uncertain parameters. Applying the same techniques made on the stability conditions, we obtain delay-dependent sufficient conditions for the robust stability of uncertain fuzzy systems with discrete and distributed time-delays. Moreover, we consider the state feedback stabilization. Based on stability and robust stability conditions, we obtain conditions for the state feedback controller to stabilize the fuzzy time-delay systems. Finally, we take some examples to illustrate our results.

FrA04.2: 10:05-10:25
Axes-Oblique Partitioning Strategies for Local Model Networks, pp. 2378-2383
Nelles, Oliver — Univ. of Siegen

Local model networks, also known as Takagi-Sugeno neuro-fuzzy systems, have become an increasingly popular nonlinear model architecture. Usually the local models are linearly parameterized and those parameters are typically estimated by some least squares approach. However, widely different strategies have been pursued for the partitioning of the input space which determines the validity regions of the local models. The model properties crucially depend on the chosen strategy. This paper proposes an axes-oblique partitioning strategy and an efficient construction algorithm for its realization. Many advantages over the existing approaches are demonstrated.

FrA04.3: 10:25-10:45
Local Stability of Open and Closed-Loop Fuzzy Systems, pp. 2384-2389
Sala, Antonio — Univ. Pol. de Valencia
Arino, Carlos — Univ. Pol. de Valencia

In many current fuzzy control papers, LMI stability conditions are devised in order to prove stability of Takagi-Sugeno fuzzy systems. Such laws are usually independent of the values of membership functions, and fulfill for multiple shapes of them. Knowledge of the shape of the membership functions may allow to lift some conservativeness. In particular, in this paper local quadratic stability results are obtained, even in the case global quadratic-stability related LMIs are infeasible.

FrA04.4: 10:45-11:05
Multi-Agent Coordination for Target Tracking Using Fuzzy Inference System in Game Theoretic Framework, pp. 2390-2395
Harmati, Istvan — Budapest Univ. of Tech. and Econ..

This paper presents a multiple robot coordination method for target tracking problem. The coordination is to achieve a desired formation during the team operation. The individual decision of robots on the moving direction induces conflict situation within the team, a typical feature in a noncooperative game theory that makes the global coordination nontrivial. The contribution of the paper is a game theoretic approach that improves the convergence of target tracking independently of the initial weight of cost components. The method uses semi-cooperative Stackelberg equilibrium instead of Nash equilibrium, a new formation component in the individual cost functions and a fuzzy inference system for high level cost weight tuning. The results are simulated on a target tracking example where the target is followed by a team of three simple mobile robots.

FrA04.5: 11:05-11:25
An Improved Result on Overshoot Estimation, pp. 2396-2398
Ji, Zhijian — Qingdao Univ.
Xu, Shixu — Qingdao Univ.
Guo, Xiaoxia — Ocean Univ. of China

In [1][2], it is proved that for a given controllable pair (A,B) with A real n-by-n, B real n-by-m, and any lambda>0, a gain matrix K can be designed so that |e^(A+BK)t| <= M lambda^L e^{-lambda t}, where M and L are constants independent of lambda. Here we show that M and L can be chosen much smaller than that proposed in previous publications. As a consequence, the estimation on overshoot of a transition matrix can be bounded more precisely. This can be regarded as a complement to the result presented in works of D. Cheng in JCTA2004 and AC2005.

FrA05 — Room 0601
Combustion Engines (Regular Session)
Chair: Schwarzmann, Dieter — Robert Bosch GmbH
Co-Chair: Vysoky, Ondrej — Czech Tech. Univ. Prague

FrA05.1: 09:45-10:05
Pressure Control of a Two-Stage Turbocharged Diesel Engine Using a Novel Nonlinear IMC Approach, pp. 2399-2404
Schwarzmann, Dieter — Robert Bosch GmbH
Lunze, Jan — Ruhr Univ. Bochum
Schanz, Andreas — Univ. Stuttgart
Nitsche, Rainer — Robert Bosch GmbH

This paper deals with nonlinear multivariable output feedback control of a two-stage turbocharged diesel engine. The feedback structure of Internal Model Control (IMC) is used in combination with a nonlinear feedforward controller based on geometric nonlinear control design methods. Input saturations as well as measured disturbances are taken into account and a severe rank deficiency is handled. This novel control approach is the first model-based solution to this problem and results in impressive control performance.

FrA05.2: 10:05-10:25
Application of Modern Techniques to SI-Engine Torque Control, pp. 2405-2410
Ali, Abid — IAV GmbH
Blath, Jan P. — IAV GmbH

This contribution investigates the application of three modern design techniques to the torque control problem of a spark-ignited direct injection engine. The system to be controlled is a highly nonlinear system characterized mainly by the intake manifold dynamics. The first scheme applies feedack linearization in order to achieve a linear and uniform system behaviour over the whole range of operation. The second approach, nonlinear model predictive control, optimizes the control law over a finite time horizon taking the input and state constraints into account during optimization. The third approach is a gain-scheduled LQ-optimal control scheme based on the state-space description of the system. A comparative study of these schemes with the help of computer simulations is presented. The schemes are compared for achieved performance, computational cost, and implemetability on an electronic control unit.

FrA05.3: 10:25-10:45
An Engine Control Systems Design for Low Emission Vehicles by Generalized Predictive Control Based on Identified Model, pp. 2411-2416
Hashimoto, Seiji — Gunma Univ.
Okuda, Hiroyuki — Utsunomiya Univ.
Okada, Yasushi — Utsunomiya Univ.
Adachi, Shuichi — Keio Univ.
Niwa, Shinji — Daihatsu Motor Co.
Kajitani, Mitsunobu — Daihatsu Motor Co.

Conservation of the environment has become critical to the automotive industry. Recently, requirements for on-board diagnostic and engine control systems have been strictly enforced. In the present paper, in order to meet the requirements for a low-emissions vehicle, a novel construction method of the air-fuel ratio (A/F) control system is proposed. The construction method of the system is divided into two steps. The first step is to design the A/F control system for the engine based on an open loop design. The second step is to design the A/F control system for the catalyst system. The design method is based on the generalized predictive control in order to satisfy the robustness to open loop control as well as model uncertainty. The effectiveness of the proposed A/F control system is verified through the experiments using full-scale products.

FrA05.4: 10:45-11:05
Diesel Engine Identification and Predictive Control Using Wiener and Hammerstein Models, pp. 2417-2423

Perez Soler, Emilio — Pol. Univ. of Valencia
Blasco, Xavier — Pol. Univ. of Valencia
García-Nieto, Sergio — Pol. Univ. of Valencia
Sanchis, Javier — Pol. Univ. of Valencia

Air management process in a turbocharged Diesel engine is a multivariable, highly coupled nonlinear system with fast dynamics. Because of this, control algorithms with reasonably low computation times (enabling real time application) must be used. Furthermore, testing of new algorithms on a real engine is expensive. Therefore, a detailed non-linear engine simulator based on a first principles model is developed. A brief description of this model is shown. Next, identification and control schemes based on model predictive control and Wiener and Hammerstein models are proposed. Finally, some results of these algorithms implemented on the engine simulator are offered, and compared with those obtained by applying standard Generalized Predictive control (GPC).

FrA05.5: 11:05-11:25
A Simple HCCI Engine Model for Control, pp. 2424-2429

Killingsworth, Nick — Univ. of California at San Diego
Aceves, Salvador — Lawrence Livermore National Lab.
Flowers, Dan — Lawrence Livermore National Lab.
Krstic, Miroslav — Univ. of California at San Diego

The homogenous charge compression ignition (HCCI) engine is an attractive technology because of its high efficiency and low emissions. However, HCCI lacks a direct combustion trigger making control of combustion timing challenging, especially during transients. To aid in HCCI engine control we present a simple model of the HCCI combustion process valid over a range of intake pressures, intake temperatures, equivalence ratios, and engine speeds. The model provides an estimate of the combustion timing on a cycle-by-cycle basis. An ignition threshold, which is a function of the in-cylinder motored temperature and pressure is used to predict start of combustion. This model allows the synthesis of nonlinear control laws, which can be utilized for control of an HCCI engine during transients.

FrA05.6: 11:25-11:45
In-Cycle Thermodynamic Model of Linear Combustion Engine, pp. 2430-2435

Deutsch, Pavel — Ricardo Prague s.r.o.
Vysoky, Ondrej — Czech Tech. Univ. Prague

This paper presents a nonlinear time-based in-cycle thermodynamic model of a linear combustion engine (LCE) to utilize as a tool to develop precise control of a real prototype of an LCE. The model is posed as an open thermodynamic system and describes the thermodynamic, fluid-flow, heat-transfer and combustion phenomena that govern performance aspects of the combustion engine. The important equations, on which the model is based, are mass and energy conservation, with time as the independent variable. The overall LCE model consists of five sub-blocks: Intake, two Cylinders, Exhaust and Mechanics. The main benefit of the in-cycle thermodynamic model, which is introduced in this paper, is its ability to be an appropriate tool for development of modern optimal in-cycle control of the LCE, as well as for developing conventional controllers.

FrA06 Room 0602
Power Systems I (Regular Session)

Chair: Gordon, Mark — The Univ. of Sydney
Co-Chair: Sayda, Atalla — Univ. of New Brunswick

FrA06.1: 09:45-10:05
On Structure Preserving Control of Power Systems, pp. 2436-2441

Gordon, Mark — Univ. of Sydney
Hill, David J. — Australian National Univ.

Control designs based on Geometric Feedback Linearization (GFL) and the so-called Direct Feedback Linearization (DFL) technique for power system stability control are presented and compared. The physical integrity of the state space description of a classical single machine infinite bus (SMIB) power system model is preserved with the application of DFL in designing a robust excitation-voltage regulating control system. Firstly, the conflict of simultaneous angle stabilization and voltage regulation is studied. Then linear techniques on the linearized system are applied to design stabilizing feedback gain coefficients for the nonlinear excitation loop. It is shown that GFL results in a coordinate mapping for which the feedback loop stabilizes the angle while the DFL is seen to offer considerable flexibility in designing controllers for all relevant variables. The results emphasize the difference between geometric and direct feedback approaches and provide insights towards nonlinear control theory applications in power systems.

FrA06.2: 10:05-10:25
Model Identification and Robust H-Infinity Controller Design of a Motor-Synchronous Generator Group, pp. 2442-2449

Sayda, Atalla — Univ. of New Brunswick

This paper proposes a case study in which we address the challenging task of controlling a real-world synchronous generator. An experiment is designed to identify the generator model using the subspace state space identification method. Two controllers are designed using two different approaches, the first is based on the characteristic loci method, and the other is based on the H-infinity loop shaping technique. Each controller design procedure is discussed in details. The performance of each controller is evaluated by simulation and implementation on the real-world plant. A comparison between the two approaches is discussed.

FrA06.3: 10:25-10:45
DC Motor Speed Control through AC/DC Converter, pp. 2450-2455

Lachkar, Ibtissam — EMI Rabat
Giri, Fouad — Univ. Caen
Haloua, Mohamed — EMI Rabat
Abouloifa, Abdelmajid — EMI Rabat

We are considering the problem of DC motors through AC/DC power converters of the Buck-Boost type. The dynamics of the latter are explicitly accounted for in the controller design, unlike in most previous works. The control objectives are twofold: (i) speed regulation, (ii) unitary power factor operation. The control problem is dealt using the backstepping design technique. The regulator thus obtained involves two loops: (i) an inner loop enforcing the electric network voltage and current to be in phase (unitary power factor), (ii) an outer loop regulating the motor speed. This shown to achieve its objectives.

FrA06.4: 10:45-11:05
Compensation of Dynamic Torques and Flywheel Start in a CVT Based Hybrid Powertrain, pp. 2456-2461

Schlurmann, Jens — Tech. Univ. Munich
Schröder, Dierk — Tech. Univ. Munich

At the Technical University Munich a new powertrain for cars, that enables a maximum of energy saving and drivability at low complexity is under development in cooperation with the companies Epcos AG, GM Powertrain Europe, ZF Friedrichshafen AG and ZF Sachs AG. It mainly consists of a mild-hybrid structure and a wide spread CVT gearbox. To improve driveability the start of the internal combustion engine is performed using the flywheel effect of decelerated moment of inertia of the electric motor. Starting from the engery saving potentials this paper describes the structure and control of the powertrain. Furthermore the limits of dynamics of the CVT due to hydraulic operation are discussed and resulting operating method to apply the desired torque on the output, is described. In doing so the focus is on balancing torques and providing angular momentum for the start of the internal combustion engine.

FrA06.5: 11:05-11:25
Short-Term Memory-Based Control of Wind Energy Conversion Systems, pp. 2462-2467

Mei, Xiao-Yan	Chongqing Univ.
Sun, Zhao	National Inst. of Aerospace
Li, Bin	Chongqing Univ.
Yang, Zhi	Chongqing Univ.
Song, Yong D.	North Carolina A&T State Univ.

Variable speed wind turbine control is essential in extracting maximum electric power out of available wind power. The paper presents a memory-based method for variable speed control of wind energy conversion systems. The fundamental idea behind the method is to use certain memorized information (i.e., current rotor speed tracking error, most recent speed tracking error, and previous control experience) to directly modify the control command. The salient feature of the proposed approach lies in its simplicity in design and implementation. Furthermore, the total required memory space does not grow with time and is much smaller than most existing learning control methods. It is shown that this method, when applied to firing angle control of wind turbines, is able to ensure rotor speed tracking in the presence of varying operation conditions, as verified via computer simulation.

FrA07 Room 0606
Process Control III (Regular Session)

Chair: Medvedev, Alexander V.	Uppsala Univ.
Co-Chair: Uchida, Kenko	Waseda Univ.

FrA07.1: 09:45-10:05
Blast Furnace Operation Support System Integrated with Partial Unsteady Simulator and LOM, pp. 2468-2473

Ogawa, Masatoshi	Waseda Univ.
Tajima, Junichi	Waseda Univ.
Ogai, Harutoshi	Waseda Univ.
Ito, Masahiro	Nippon Steel Corp.
Matsuzaki, Shinroku	Nippon Steel Corp.
Uchida, Kenko	Waseda Univ.

In the field of pig ironmaking process, operation malfunction is caused by both enlarging a blast furnace and increasing use of low quality ore. Thus, operation support systems predicting a blast furnace performance are demanded. This paper reports a Java-based operation support system integrated with a "Large-scale database-based Online Modeling (LOM)" and a blast furnace simulator. The system predicts blast furnace performance by combining the partial unsteady simulator of the physical modeling method and the LOM of the local modeling method and supports the operation. To construct the system, the Java-based partial unsteady simulator is developed and the existing LOM is rebuilt by using versatile database and Java to realize the generalized LOM with general versatility. These systems are integrated by using Java.

FrA07.2: 10:05-10:25
Fuel Cell Carbon Monoxide Poisoning Estimation and Control with Air Bleed Injection, pp. 2474-2479

Di Penta, Damiano	Renault
Bencherif, Karim	Renault
Zhang, Qinghua	INRIA
Sorine, Michel	INRIA

This paper proposes a model-based control of CO poisoning for a reformate supplied fuel cell system. Carbon monoxide from the reformer is adsorbed on the catalyst layer and affects cell voltages through the anode overpotential. In order to mitigate this effect, an air bleed is injected into the anode to oxidize CO, but the excess of air is suspected to degrade the fuel cell life span. Thus, the CO coverage rate of the anode catalyst sites was found to be the key amount to control. A reduced model of CO poisoning based on anode electrochemical phenomena is first built and validated with experimental data. Then, we propose a control of CO coverage rate via a robust filter to ensure a low level of catalyst contamination while introducing a suitable amount of air into the anode feed.

FrA07.3: 10:25-10:45
Active Control of Thermoacoustic Oscillation, pp. 2480-2485

Kjaer, Martin Ansbjerg	Lund Univ.
Johansson, Rolf	Lund Univ.
Robertsson, Anders	Lund Univ.

Combustion processes serve as important sources of energy for both power generation and for transport, ranging from large scale power stations to micro turbines and aeroplane engines. Even though these different applications are quite different in operating conditions and design, their environmental impact has been subject to stringent restrictions. Lean premixed combustion offers a potential to reduce the emission levels, but suffers from instability problems which can be overcome by redesign of the combustion chamber or by the use of active control. This paper addresses the problem of active control of thermoacoustic instabilities in a laboratory test combustion chamber. A fuel actuating strategy is developed and implemented, and the dynamics of the combustion chamber are modeled using system identification methods. Successful damping of the combustion oscillations is shown with different control design methods.

FrA07.4: 10:45-11:05
Issues in the Modeling and Boundary Control of 2D Heat Flow: POD Based Modeling, pp. 2486-2491

Efe, Mehmet Onder	Econ. and Tech. Univ. Ankara

Low Dimensional (LD) modeling of systems governed by Partial Differential Equations (PDE) has been studied several times in the past. Various types of boundary excitations have been considered. This paper demonstrates how the external stimuli is made explicit in an autonomous set of ODEs and how the excitations along nonpoint subdomains of the boundaries are handled. Dirichlet type boundary excitations are considered and 2D heat equation has been chosen as the test bed. Linearity of the system makes it a good hoice for investigating the stability and performance issues. Proper Orthogonal Decomposition (POD) is used in the modeling stage and it is shown that the developed model reconstructs the essential dynamics of the solution of the PDE successfully. The contributions of the paper are on the effects of the number of modes on the model performance, spectral dependence of LD models to the initial and boundary conditions and the prime importance of a fundamental assumption.

FrA07.5: 11:05-11:25
Model-Based Slopping Monitoring by Change Detection, pp. 2492-2497

Evestedt, Magnus	Uppsala Univ.
Medvedev, Alexander V.	Uppsala Univ.

The most common steel-making process in the world is the Lintz-Donawitz converter. During operation, a slag foam is created to improve the converter performance. Problems arise when the foam level exceeds the height of the vessel and overflows, causing metal loss, process disruption and environmental pollution. The goal of this study is to design a model-based algorithm exploiting real-time process data to give an early warning to the operator, before the slopping is visible, so that appropriate actions can be taken. The algorithm was tested on data from the LD process at SSAB Oxelösund and found to work well.

FrA08 Room 2607
Robotics - Manipulation, Actuation (Regular Session)

Chair: Lin, Jonqlan	Ching Yun Univ.
Co-Chair: Abdellatif, Houssem	Univ. of Hannover

FrA08.1: 09:45-10:05
Modeling and Control of Fluidic Robotic Joints with Natural Compliance, pp. 2498-2503

Mihajlov, Miroslav	Univ. of Bremen
Hubner, Matthias	Univ. of Bremen
Ivlev, Oleg	Friedrich Wilhelm Bessel Inst. Bremen
Graser, Axel	Univ. of Bremen

This paper reports on basic properties, dynamic modeling,

pressure and position control of a newly developed fluidic actuator with rotary elastic chambers (REC-actuator), intended for robots working in human environment. This actuator with natural compliance can be operated by gas or oil. Pressure control of the actuator in pneumatic realization is designed using fast on-off valves, suitable for lightweight robotic joints. A phenomenological model of the actuator is considered, in which spring, damper and torque generating element are connected in parallel. The joint stiffness and damping as functions of pressures in the actuator chambers are identified in free oscillations experiments at constant pressures. The torque-generating element is further identified in a separate series of step responses experiments, using thereby previously obtained stiffness and damping. A sliding mode control law is applied for the position control of the naturally compliant actuator.

FrA08.2: 10:05-10:25
Interconnection and Damping Assignment Passivity-Based Experimental Control of a Single-Link Flexible Robot Arm, pp. 2504-2509

Sanz, Arantza — Univ. del Pais Vasco
Etxebarria, Victor — Univ. del Pais Vasco

Energy-based control design methodology (the so-called IDA-PBC, interconnection and damping assignment passivity-based control) is a well established technique that has shown to be very powerful to design robust controllers for physical systems described by Euler-Lagrange equations of motion. Their application potential is particularly important for under-actuated systems. This paper presents the application of this control design methodology to a single-link flexible robotic arm. It is shown that the method is well suited to handle this kind of under-actuated devices not only from a theoretical viewpoint but also in practice. A Lyapunov analysis of the closed-loop system stability is given and the design performance is illustrated by means of a set of simulations and laboratory control experiments, comparing the results with those obtained using conventional control schemes for mechanical manipulators.

FrA08.3: 10:25-10:45
On Compensation of Passive Joint Friction in Robotic Manipulators: Modeling, Detection and Identification, pp. 2510-2515

Abdellatif, Houssem — Univ. of Hannover
Heimann, Bodo — Univ. of Hannover

The progress made in friction compensation in robotics was concentrated on friction losses in the actuated joints. Today new mechanisms with a considerable number of passive joints, such parallel manipulators are emerging. This paper opens the discussion on the influence of passive joint friction (PJF) in robot's dynamics and its impact on control performance. It gives a basic framework on the modeling, detection and identification of such phenomena. All proposed methods pass on additional sensors and use only the actuators for detection and compensation. Due to its dependency on the robot's configuration, even small magnitudes of PJF can affect the system behavior, especially at unfavorable poses. To the best knowledge of the authors, the problem of PJF-compensation was not addressed systematically in literature yet.

FrA08.4: 10:45-11:05
Control of Multi-Degree-Of-Freedom Planar Actuators, pp. 2516-2521

van Lierop, Cornelis M. Maria — Eindhoven Univ. of Tech.
Jansen, Jacob Willem — Eindhoven Univ. of Tech.
Damen, Ad A. H. — Eindhoven Univ. of Tech.
van den Bosch, P. P. J. — Eindhoven Univ. of Tech.

This paper concerns a control-oriented analysis of a new commutation strategy which overcomes the limitations of dq0-decomposition for ironless multi-DOF planar actuators with integrated magnetic bearings. The new strategy minimizes the losses and allows for smooth switching of active coils while maintaining the decoupling of all degrees of freedom. Moreover, the method can also include the edge effects of the magnet-array which is not possible with dq0-transformation. The proposed controller has been implemented on a 3-DOF actuator which elucidates the good performance. When adding constraints to the new algorithm, multi-phase behavior can be achieved which is suitable for multi-phase amplifiers.

FrA08.5: 11:05-11:25
Tuning the PID Parameters for Robot Manipulators with Compliant Bases by Using Grey Theory, pp. 2522-2527

Lin, Jonqlan — Ching Yun Univ.
Huang, Zi-Zhan — Ching Yun Univ.

This research focuses on the issue of dynamic modeling and controlling a robotic manipulator attached to a compliant base. Such a system is known under the name macro-micro system, characterized by the number of control actuators being less than the number of state variables. The motion of equations for a two-link planar elbow arm mounted on an oscillatory base has presented in this investigation. In order to study the sensitivity of tuning the PID parameters to achieve the desired performance, the grey relational analysis has been proposed. Therefore, the optimization parameters of the output feedback PID controller by using grey theory have first investigated for such structure in this research. The experimental results of the proposed methodology also show that it is technically and economically feasible to develop a low-cost, reliable automatic, less time consuming controller for robots mounted on oscillatory bases.

FrA08.6: 11:25-11:45
Application Study on Iterative Learning Control of High Speed Motions for Parallel Robotic Manipulator, pp. 2528-2533

Abdellatif, Houssem — Univ. of Hannover
Feldt, Matthias — Univ. of Hannover
Heimann, Bodo — Univ. of Hannover

This paper presents a novel application of Iterative Learning Control (ILC). It is about bettering control performance of Parallel Kinematic Manipulators (PKM) in the range of high dynamics. Such mechanisms suffer very often from lack of accuracy at high speed, since uncertainties, nonlinearities and disturbances have an important impact. The case seems to be predestinated for applying ILC. This will be demonstrated in this paper, where additional to a feedforward decoupling control structure, ILC techniques are used to decrease remaining tracking errors. Three algorithms are chosen to be validated, adjusted and compared. It is shown, that with an appropriate strategy, linear ILC approaches can be implemented on highly nonlinear and coupled MIMO-Systems, such as parallel manipulators.

FrA09 Room 0999

Aerospace/ Flight Control (Regular Session)

Chair: Lozano, Rogelio — Univ. of Tech. Compiegne
Co-Chair: Sato, Masayuki — Japan Aerospace Exploration Agency

FrA09.1: 09:45-10:05
Flight Test of Flight Controller for Arbitrary Maneuverability and Wind Gust Rejection, pp. 2534-2540

Sato, Masayuki — Japan Aerospace Exploration Agency

This paper addresses flight controller design for the following two requirements: the realization of arbitrary maneuverability and the reduction of the motions driven by wind gust. For the lateral-directional motions of a research aircraft, we design a flight controller that satisfies the aforementioned two requirements; the latter is achieved by designing a feedback controller which minimizes H-infinity norm from wind gust to controlled outputs and the former is achieved by designing a right inverse system as the feedforward controller for the closed-loop system composed of the plant and the feedback controller. After confirming that the designed controller has good performance in hardware-in-the-loop simulations, i.e. the controller achieves good wind gust rejection and realizes arbitrary maneuverability, we conduct flight tests to verify these performance under real conditions. Flight tests also demonstrate that the controller has good performance for the simultaneous realization of wind gust rejection and arbitrary maneuverability.

FrA09.2: 10:05-10:25
Anti-Windup Design for Aircraft Flight Control, pp. 2541-2546
Queinnec, Isabelle LAAS-CNRS
Tarbouriech, Sophie LAAS-CNRS
Garcia, Germain LAAS-CNRS

This paper addresses the problem of static anti-windup strategy for linear unstable control systems with saturated dynamics describing some aircraft flight control. The approach is based on the use of quadratic Lyapunov functions, S-procedure and a sector nonlinearity description for modelling the behavior of the closed-loop nonlinear system. Anti-windup design is investigated to increase both a domain of admissible references to track and a safety region over which the stability of the resulting closed-loop saturated system is ensured.

FrA09.3: 10:25-10:45
Nonlinear State-Dependent Riccati Equation Control of a Quadrotor UAV, pp. 2547-2552
Voos, Holger Univ. Appl. Sci. Ravensburg-Weingarten

Small quadrotor UAVs represent a very interesting class of small flying robots because of their ability to fly in- and outdoor. Therefore, these vehicles have enormous potential for near-area surveillance and exploration. However, especially indoor flight poses a hard task to vehicle control which has to stabilize the velocity and the attitude of the quadrotor. This paper mainly describes the development of a nonlinear vehicle control system for velocity and attitude control based on state-dependent Riccati equations (SDRE). The controller is embedded in an overall mission system concept for UAVs.

FrA09.4: 10:45-11:05
Real-Time Embedded Control System for VTOL Aircrafts: Application to Stabilize a Quad-Rotor Helicopter, pp. 2553-2558
Lara, David Univ. of Tech. Compiegne
Sanchez, Anand Univ. of Tech. Compiegne
Lozano, Rogelio Univ. of Tech. Compiegne
Castillo, Pedro Univ. of Tech. Compiegne

In this paper, we present the design of an autopilot embedded control system for VTOL aircrafts using low cost sensors. The embedded control system uses parallel processing architecture. In addition, multitasking software is used to implement the data acquisition, control law computation, and correction output to get the desired set point. The control law can be easily tuning toimprove the performance of the vehicle. We evaluate the performance of this platform in a quad-rotor helicopter. The main goal is to achieve the stationary flight using two control strategies, a linear PD control and nonlinear nested saturations control. Real time experiments show that the autopilot is a platform relievable with low cost components.

FrA09.5: 11:05-11:25
Nonsmooth Optimization for Nonlinear Missile Autopilot: Improvement under Time Domain Constraints, pp. 2559-2564
Lassami, Bilal Supelec
Font, Stephane Supelec
Siguerdidjane, Houria Supelec

In this paper, a new parametric optimization approach to retune nonlinear controllers is proposed. It discusses the design of these controllers under temporal constraints. The formulated optimization problem is often complex; it involves nonsmooth design parameters and criteria. An efficient optimization algorithm based on the approximation of the epsilon subdifferential notion is presented. It only requires gradients which are computed using parametric sensitivity functions. The proposed approach is applied to tune a nonlinear missile autopilot. The purpose especially concerns how to appropriately apply our procedure in order to improve performance of a controlled nonlinear dynamic system. We show that the choice of the controller structure and parameters has a great effect on the validation of the temporal specifications. Simulation results are given to demonstrate the effectiveness of the proposed approach.

FrA10 Room 3999
Identification - Methods (Regular Session)
Chair: Furuta, Katsuhisa Tokyo Denki Univ.
Co-Chair: Joly-Blanchard, Ghislaine Univ. of Tech. Compiegne

FrA10.1: 09:45-10:05
Identification of Quadratic System by Local Gradient Search, pp. 2565-2570
Suleiman, Wael LAAS-CNRS
Monin, André LAAS-CNRS

In this paper, identifying Quadratic System (QS) is considered. In fact, it appears that many important nonlinear multivariable processes in engineering can be modeled by this structure. To solve this identification problem, we propose a method based on a local parameterization and a gradient search. The local parameterization is orthonormal to the tangent space of the manifold representing equivalent models, therefore the directions that do not change the output error cost function are projected out of the search direction in the update rule. Consequently, the amount of the gradient calculations is reduced to the minimal value. Furthermore, we present a numerically efficient implementation of the identification method.

FrA10.2: 10:05-10:25
Identifiability of Ordinary or Delayed Nonlinear Models: A Distribution Approach, pp. 2571-2576
Denis-Vidal, Lilianne Univ. of Lille
Joly-Blanchard, Ghislaine Univ. of Tech. Compiegne
Verdiere, Nathalie Univ. of Tech. Compiegne

An original method, combining algebraic and distribution theory approaches, is presented in this paper for analyzing the identifiability of some ordinary or delayed nonlinear models. Then, it is shown how this analysis can be used for parameter estimation. Our purpose is supported by examples and an application in aerospace domain.

FrA10.3: 10:25-10:45
Identification of Nonlinear ARX Model with Input and Output Dependent Coefficients, pp. 2577-2582
Ohata, Akira Toyota Motor Corp.
Furuta, Katsuhisa Tokyo Denki Univ.
Nita, Hiroaki Tokyo Denki Univ.

This paper proposes to identify a nonlinear system in the nonlinear ARX model from input-output data. A local linear ARX model identification is done by selecting the input and output data around the selected level. By integrating the local linear ARX models, a nonlinear ARX model with parameters nonlinearly depending on the input and output is identified. The dependence of parameters on the input and output is identified numerically and can be expressed approximately by the polynomials. The proposed method gives an approach to identify and to represent a nonlinear system which may be used to design a controller.

FrA10.4: 10:45-11:05
Nonparametric MIMO FRF Matrix Estimation Using a Single Periodic Broadband Excitation, pp. 2583-2588
Smolders, Kris Katholieke Univ. Leuven
Swevers, Jan Katholieke Univ. Leuven

This paper presents a new method to estimate the FRF matrix of a MIMO linear time-invariant system using periodic broadband excitation. The main advantage of this method lies in the fact that a full MIMO FRF matrix can be estimated using only one experiment in contrast to other approaches that require at least as many experiments as there are inputs. This yields a reduction of the experiment duration if the excitation signals are properly designed. Experimental validation of this new method on a multivariable test setup is presented.

FrA10.5: 11:05-11:25
Thruster and Vibration Control of Marine Powertrain Using a Class of Feedforward Approximators, pp. 2589-2594

Tao, Pey Yuen	National Univ. of Singapore
Ge, Shuzhi Sam	National Univ. of Singapore
Lee, Tong Heng	National Univ. of Singapore
Chen, Xiaoqi	Singapore Inst. of Manufacturing Tech.

In this paper, we consider the tracking problem of propeller shaft speed and simultaneously minimizing torsional vibrations in marine shafting system, in the presence of parametric/functional uncertainties and unmodelled dynamics. Torsional vibrations within the shafting system can be induced by the hydrodynamic forces acting on the propeller and the inertia forces of the crank mechanism. Excessive vibrations will lead to severe consequences such as fractured drive shaft and compromised structural integrity. Due to the difficulty in measuring or modelling the hydrodynamic forces as well as the frictional forces, neural networks are used to compensate for the uncertainties. Simulation results illustrate the effectiveness of the proposed controller.

FrA10.6: 11:25-11:45
Statistical Process Monitoring Via Independent Component Analysis and Learning Vector Quantization Method, pp. 2595-2600

Salahshoor, K.	Petroleum Univ. of Tech. Tehran
Keshtgar, Azadeh	Petroleum Univ. of Tech. Tehran

In this paper, a new method, ICA-LVQ, which integrates two data driven techniques, independent component analysis (ICA) and learning vector quantization (LVQ), for process monitoring is presented. ICA is a recently developed method in which the goal is to decompose observed data into linear combinations of statistically independent components. This method is used as a preprocessing for LVQ neural network to reduce dimension of observations. LVQ is a supervised learning technique that can be used for classification. The Tennessee Eastman process benchmark is then utilized to evaluate the developed method.

FrA11 Audimax
Nonlinear Systems II (Regular Session)

Chair: Tibken, Bernd	Univ. of Wuppertal
Co-Chair: Wolff, Jan	Tech. Univ. Munich

FrA11.1: 09:45-10:05
Semidefinite Programming Relaxations Applied to Determing Upper Bounds of C-Numerical Ranges, pp. 2601-2606

Tibken, Bernd	Univ. of Wuppertal
Fan, Youping	Univ. of Wuppertal
Glaser, Steffen J.	Tech. Univ. Munich
Schulte-Herbrueggen, Thomas	Tech. Univ. Munich

In this contribution the global optimal upper bounds of the C-numerical range of an arbitrary square matrix A is investigated. In general the geometry of the C-numerical range is quite complicated and can be yet only partially understood. However, quadratically constrained quadratic programs (QQPs), as an important modelling tool, are used to describe this optimization problem, where the quadratic constraints are in this case the unitary matrix condition $U^{+}U = I$ und its seemingly redundant unitary matrix condition $UU^{+} = I$.

Generally the QQPs are NP-hard and numerically intractable. However the Semidefinite Programming (SDP) Relaxations to the QQPs, based upon the Positivstellensatz, can be solved in a numerically stable way and then offer sharp approximate solutions to these optimization problems. Numerical results for some physical benchmark examples are presented which indicate that the proposed method yields at least competitive upper bounds of the C-numerical ranges in comparison with other methods.

FrA11.2: 10:05-10:25
Testing the Algorithms of Inverse Simulation, pp. 2607-2612

Ordys, Andrzej W.	Univ. of Strathclyde
Giovanini, Leonardo	Univ. of Strathclyde
Czechowski, Piotr	Univ. of Strathclyde

Inverse simulation is becoming more and more popular and widely used technique in flight mechanics studies. The ability to calculate control and response time histories for a predefined trajectory or manoeuvre is very useful in certain applications (i.e. autonomous vehicles). However, where it comes to numerical algorithms there has always been a major concern about numerical problems, usually encountered when solving the equations of motion in the inverse manner. In this paper some problems are presented as well as the simple inverse simulation algorithm applied to a sample system.

FrA11.3: 10:25-10:45
Anti-Windup Control for MIMO System Using Timescale Transform, pp. 2613-2618

Sampei, Mitsuji	Tokyo Inst. of Tech.
Nakaura, Shigeki	Tokyo Inst. of Tech.
Hoshi, Yoshikatsu	Musashi Inst. of Tech.
Hojo, Tatsuya	Yamatake Corp.
Kurosaki, Atsushi	Yamatake Corp.

Most of the inputs of actual plants have the limitations of variation range. These limitations may be due to physical restrictions on the actuators. It is well known that the effects of actuator saturation cause the deterioration of control performance called windup phenomena. In this paper, a novel anti-windup strategy for multi-input multi-output (MIMO) systems subject to actuator saturation is proposed. The method is based on the notion of timescale transform. Some simulation and experimental results are presented to show the effectiveness of the proposed method.

FrA11.4: 10:45-11:05
Phase Design of an IIR Filter and Its Application to an Inverse System, pp. 2619-2622

Kisaka, Masashi	Hitachi Global Storage Tech.

To suppress external vibration from affecting a position error for a hard disk drive, shock sensor feed forward techniques are proposed. To implement effective feed forward, it is important to apply the force that has opposite phase to the external vibration. In other word we have to design a filter whose phase is within a specified target range. In this paper a method to calculate an infinite response (IIR) filter whose order is specified is proposed. It is suggested that the phase specification is equivalent to solving linear inequalities, so that LMI (linear matrix inequalities) can be used to solve the inequalities. A stable IIR filter can be obtained if the target phase locus goes around the origin properly in the complex plain when a frequency increases from 0 to the Nyquist frequency. The order of the IIR filter can be estimated by counting how many times the phase trajectory crosses the real or imaginary axis.

FrA11.5: 11:05-11:25
Structural Controllability and Observability in Closed Loop for LTI Stable Systems, pp. 2623-2628

Galindo Orozco, Rene	Univ. of Nuevo Leon
Gonzqlez Avalos, Gilberto	Univ. of Michoacan
Juarez Guerrero, Rosa Isela	Univ. of Nuevo Leon

Linear Time Invariant (LTI) Multi-Input Multi-Output (MIMO) stable systems modeled in bond graph and described by their junction structures, are considered. Junction structures for the sensitivity and complementary sensitivity functions, are proposed. These structures are function of the free parameter of the family of stabilizing compensators, and allow to get necessary and sufficient conditions for structural controllability and observability in closed loop. Also, these structural properties are design criterions for the free parameter of the stabilizing compensator, which is implemented on the Internal Model Control (IMC) feedback configuration. Also, the free parameter is gotten from its state space realization, for Single-Input Single-Output (SISO) systems. Moreover, a junction structure for the stabilizing compensator, function of the free parameter, is presented. Based on this structure, a necessary condition for the structural stability of the compensator, is given. The results are illustrated on a damping mechanical system.

FrB01 Room 2601
Process Control, Fault Detection and Tools
(Regular Session)

Chair: Campbell, Stephen L North Carolina State Univ.
Co-Chair: Schmid, Christian Ruhr Univ. Bochum

FrB01.1: 13:00-13:20
Robust Autotuning of Industrial Regulators Based on Complex Process Models: The DIMC Approach, pp. 2629-2634

Leva, Alberto Pol. di Milano
Schiavo, Francesco Pol. di Milano

This manuscript presents an innovative approach to the (auto)tuning of industrial feedback regulators based on arbitrarily complex linear time invariant (LTI) process models. The presented technique allows to assess the robustness properties of the obtained control system, and greatly reduces the influence of the particular model identification method used on the tuning results. A single design parameter, bounds for which can be derived objectively, allows to trade performance versus stability degree in an easily interpreted way; in addition, the tuning results can be reliably forecast. After treating the matter from a theoretical standpoint, simulations are reported to illustrate the potentialities of the proposed approach.

FrB01.2: 13:20-13:40
Signal Based Functionality Testing of Control Systems, pp. 2635-2640

Lindegaard, Karl-Petter ABB Corp. Res. Norway
Kristiansen, Dag ABB Corp. Res. Norway

In many industries there is a trend towards more specialized and sophisticated applications for control and supervision of the plant. Control systems in general differ from enterprise and office applications, but the demand for efficient tools and practices is very much the same. However, it seems that at least the process industry is lagging somewhat behind in adopting new tools that could facilitate development. In this paper we will advocate automated functionality testing, one of the cornerstone practices in agile methods. There are indeed other areas that need attention during testing too, but functionality is perhaps the one area where automated test execution and reporting have the biggest potential. A test framework inspired by the simple yet very effective xUnit family is outlined. The underlying idea is to separate the test specification from the code by defining test case scenarios on a signal level. This approach is most advantageous for control systems, because it enables us to support a variety of platforms and languages.

FrB01.3: 13:40-14:00
Fault Detection and Isolation System Design for Omnidirectional Soccer-Playing Robots, pp. 2641-2646

Valdivieso, Cristobal Pontificia Univ. Catolica de Chile
Cipriano, Aldo Pontificia Univ. Catolica de Chile

A mobile robot has been constructed for entry in the Latinamerican RoboCup robot soccer contests. To improve the robot's robustness and availability, fault detection and isolation functions are required for major faults causing battery voltage drops or motor encoder decoupling. This article presents the design for such an FDI system. The omnidirectional robot and its models are described, and four FDI systems are developed, based on extended Kalman and particle filters. A comparison of the systems using simulation found that the FDI incorporating a modified version of the Rao-Blackwellised particle filter exhibits a better performance for battery faults.

FrB01.4: 14:00-14:20
Detection of System Changes for a Pneumatic Cylinder Using Self-Organizing Maps, pp. 2647-2652

Zachrison, Anders Linkoping Univ.
Sethson, Magnus Linkoping Univ.

Automated monitoring of system is growing in importance as systems become increasingly autonomous and intelligent control is being used. At the same time, component manufacturers' desire to offer components with embedded condition monitoring systems is also increasing.

The problem with classical model based monitoring for the component manufacturer is the lack of information about the actual application in which the component is to be used. A general, adaptive method is therefore needed. One such algorithm is the self-organizing (feature) map, which has the desired property of reducing the dimensions of the information space.

In this paper, two different measures of divergence from the normal state of operation are discussed: the quantization error and a measure of the neurons' individual training level. The combination of these measures is also briefly discussed.

FrB01.5: 14:20-14:40
Computer-Aided Design and Implementation of Interlock Control Code, pp. 2653-2658

Drath, Rainer ABB Corp. Res.
Fay, Alexander Helmut Schmidt Univ.
Schmidberger, Till Helmut Schmidt Univ.

The design of the basic control of a chemical plant is mainly based on the P&IDs (pipe & instrumentation diagrams) of the plant. These diagrams, which are complemented by further documents, contain the information which is needed to specify the sensors, actuators, and the binary and continuous control functions in between to run the plant at steady state and to ensure its safe operation. In the past, P&IDs have been available for control engineers only in the form of paper drawings, which required tedious manual analysis before the control specification and implementation could start. Today's Computer-Aided Engineering tools, as used by the process and plant design engineers, provide P&IDs in electronic format, but the control engineering workflow has not changed. However, the CAE tools' underlying database provides the basis for a computer-aided and more efficient control engineering process: the contents of the database can be parsed by computer algorithms which search for well-known patterns, e.g. certain combinations of plant objects (tanks, pipes, sensors, and actuators), and which assign well-known control solutions to each pattern found in the particular plant. Thus, repetitive, tedious, and error-prone engineering tasks can be automated. This paper describes an approach how this can be achieved, based on a standardized plant description model called CAEX and on rule-based algorithms. The authors have designed and developed a knowledge-based system which implements this approach and served to prove its feasibility and usefulness.

FrB01.6: 14:40-15:00
Model Based Failure Detection Using Test Signals from Linearizations: A Case Study (I), pp. 2659-2664

Campbell, Stephen L North Carolina State Univ.
Drake, Kimberly US Navy
Andjelkovic, Ivan North Carolina State Univ.
Sweetingham, Kelly North Carolina State Univ.
Choe, Dongkyoung North Carolina State Univ.

An active approach for failure detection based on the use of minimal auxiliary signals has recently been introduced for linear systems with both additive and model uncertainty. This paper discusses the extension of this approach to nonlinear systems. A nonlinear case study is performed to carefully examine this approach. Evaluation of the performance of the new test signal on the nonlinear system is discussed and an evaluation algorithm presented. The extension and its evaluation requires integration of a variety of control, simulation, and optimization software. Both the application to failure detection and the software and numerical issues involved are discussed.

FrB02 Room 1601
Automotive Control Systems (Regular Session)

Chair: Svaricek, Ferdinand Univ. of Bundeswehr Munich
Co-Chair: Bohn, Christian IAV GmbH

FrB02.1: 13:00-13:20
Tuning of an PID Based Idle Speed Controller for Heavy Load Rejection Using a Model-Based Optimization Methodology (I), pp. 2665-2670
Boehme, Thomas IAV GmbH
Kurdi, Oubida Tech. Univ. Braunschweig

An optimization method to tune the PID based idle speed controller gains using an nonlinear engine model is presented. The introduced optimization method is especially valuable for tuning the idle speed controller gains for heavy load scenarios which can occur in the take-off situation, when the driver releases the clutch rapidly. The model-based tuning methodology is evaluated on a PID based idle speed controller embedded in a production type ECU. The experiments has been carried out on a prototype car with a 1.6l, direct injection engine to optimize the take-off procedure. In order to get reproducible results a clutch robot has been used.

FrB02.2: 13:20-13:40
Active Vibration Control Systems As Prototyping Tools for Passive Vibration Absorbers (I), pp. 2671-2676
Knake-Langhorst, Sascha German Aerospace Center
Bohn, Christian IAV GmbH
Karkosch, Hans-Jürgen ContiTech Vibration Control GmbH
Marienfeld, Peter Michael ContiTech Vibration Control GmbH

Vibration absorbers are a well established method to reduce structural vibrations. Designing a vibration absorber consists of selecting its mechanical properties. In the automotive industry, the final design phase usually comprises extensive tests with different absorbers in the vehicle and subjective and objective evaluation of the results. This requires hardware modifications between different tests. In this paper, an approach is suggested that can assist in the development of vibration absorbers. It is based on tuning an active vibration control system such that it reproduces the behavior of a specified vibration absorber. This behavior can then be changed electronically without modifying the hardware. Two different control approaches are compared. In the first approach, the apparent physical properties of a vibration absorber are directly modified through well-known acceleration, velocity or displacement feedback structures. In the second approach, a desired dynamic mass transfer function for the vibration absorber is prescribed and an H2-norm optimal model matching problem is solved. Both approaches are straightforward from a theoretical point of view, however, some problems occurred during the practical implementation. Along with the results, these problems and related ad-hoc modifications are discussed.

FrB02.3: 13:40-14:00
Rapid Control Prototyping of Active Vibration Control Systems in Automotive Applications (I), pp. 2677-2682
Kowalczyk, Konrad Univ. of Armed Forces Munich
Karkosch, Hans-Jürgen ContiTech Vibration Control GmbH
Marienfeld, Peter Michael ContiTech Vibration Control GmbH
Svaricek, Ferdinand Univ. of Armed Forces Munich

This paper discusses the rapid controller prototyping approach used at Continental and the University of the German Armed Forces for the design and implementation of active vibration control systems. Continental has developed and implemented prototypes of active engine mounting systems on various test vehicles and demonstrated that significant reductions in noise and vibration levels are achievable.

FrB02.4: 14:00-14:20
Global Evaluation of the Drivability of Calibrated Diesel Engine Maps (I), pp. 2683-2688
Nessler, Adrian IAV GmbH
Haukap, Carsten IAV GmbH
Roepke, Karsten IAV GmbH

This paper presents the method Design of Experiments (DoE) in the engine calibration process shortly. Modern Diesel engines are controlled via maps that have to be calibrated using measurements from an engine test bench. The maps have to fulfill various soft and hard constraints like smoothness and drivability. Therefore two criteria for smooth and drivable calibrated Diesel engine maps are defined and evaluated. The criteria are used to create optimal and drivable engine maps. Optimization and smoothing are combined in one step of the engine calibration process.

FrB02.5: 14:20-14:40
Multidisciplinary Design Optimization of a Pressure Controller for CNG Injection Systems, pp. 2689-2694
Dellino, Gabriella Univ. di Bari
Lino, Paolo Pol. di Bari
Meloni, Carlo Pol. di Bari
Rizzo, Alessandro Pol. di Bari

In this work, the multidisciplinary design optimization (MDO) methodology is applied to a case arising in the automotive engineering in which the design optimization of mechanical and control features of a system are simultaneously carried out with an evolutionary algorithm based method. The system under study is the regulator of the injection pressure of an innovative Common Rail system for Compressed Natural Gas (CNG) automotive engines, whose engineering design includes several practical and numerical difficulties. To tackle such a situation, this paper proposes a constrained multi-objective optimization method, that pursues the Pareto-optimality on the basis of fitness functions that capture domain specific design aspects as well as static and dynamic objectives. The proposed scheme provides ways to incorporate the designers specific knowledge, from interactive actions to simulation based analysis or surrogate-assisted evolution. The computational experiments show the ability of the method for finding a relevant and satisfactory set of efficient solutions.

FrB02.6: 14:40-15:00
Object–Oriented Multibody Motorcycle Modelling for Control Systems Prototyping, pp. 2695-2700
Tanelli, Mara Pol. di Milano
Schiavo, Francesco Pol. di Milano
Savaresi, Sergio M. Pol. di Milano
Ferretti, Gianni Pol. di Milano

This paper presents a simulation model for the dynamic behavior of a motorcycle developed in Modelica, within the Dymola environment, tailored to be employed for test and validation of active control systems for motorcycle dynamics. Specifically, we illustrate the modular approach to motorcycle modeling and discuss the tire-road interaction model, which is the crucial part of the simulator. Moreover, we propose a virtual driver model which allows to track a predefined trajectory and keep a target speed during different maneuvers. Finally, we investigate the problem of active braking control system design for motorcycles, proposing a braking control logic which can handle panic brakes on a curve. This analysis assesses the effectiveness of the proposed model for control systems prototyping.

FrB03 Room 0670
Fuzzy Control II (Regular Session)

Chair: Feng, Gang City Univ. of Hong Kong
Co-Chair: Krishen, Jyoti Univ. of Reading

FrB03.1: 13:00-13:20
Efficient Fuzzy Control of a Rotary Inverted Pendulum Based on LQR Mapping, pp. 2701-2706
Krishen, Jyoti Univ. of Reading
Becerra, Victor M. Univ. of Reading

This paper develops fuzzy methods for control of the rotary inverted pendulum, an underactuated mechanical system. Two control laws are presented, one for swing up and another for the stabilization. The pendulum is swung up from the vertical down stable position to the upward unstable position in a controlled trajectory. The rules for the swing up are heuristically written such that each swing results in greater energy build up. The stabilization is achieved by mapping a stabilizing LQR control law to two fuzzy inference engines, which reduces the computational load compared with using a single fuzzy inference engine. The robustness of the balancing control is tested by attaching a bottle of water at the tip of the pendulum.

FrB03.2: 13:20-13:40
Development Method for Low Cost Fuzzy Controlled Servosystems, pp. 2707-2712
Precup, Radu-Emil Pol. Univ. of Timisoara
Preitl, Stefan Pol. Univ. of Timisoara

This paper proposes an original development method for low cost fuzzy control systems dedicated to a class of servosystems. The controlled plants in these systems can be characterized by second-order dynamics with integral type. The controller part in these systems is represented by attractive two-degree-of-freedom PI-fuzzy controllers. The method is based on using the linear case results expressed in terms of the Extended Symmetrical Optimum method and of Iterative Feedback Tuning algorithms, and by the transfer of these results to the fuzzy case. Real-time experimental results corresponding to a nonlinear servosystem validate the proposed development method.

FrB03.3: 13:40-14:00
Initial Setting of Takagi-Sugeno Zero-Order Fuzzy Controllers by State Space-Based Emulation of "Black-Box" SISO Controllers, pp. 2713-2718
Kovacic, Zdenko Univ. of Zagreb
Dobrina, Damir Univ. of Zagreb
Bogdan, Stjepan Univ. of Zagreb

In a large number of applications fuzzy controllers have replaced existing linear controllers and brought new quality of control. The design of fuzzy controllers has a heuristic character and therefore, the setting of fuzzy controller parameters may become a tedious, time consuming job. The paper presents a method for initial setting of fuzzy controllers based on the use of state space trajectories associated with controller inputs. The described state spacebased design approach does not depend on a type of emulated controller, so both linear and nonlinear controllers, including a human operator, can be transformed into an adequate fuzzy control function. The initial setting algorithm has been successfully tested by simulations in Matlab.

FrB03.4: 14:00-14:20
*Nonlinear Systems Stabilization Using Fuzzy Models and Switching Control**
Boumehraz, Mohamed Univ. of Biskra
Benmahammed, Khier Univ. Farhet Abass de Setif

A design approach is proposed for the stabilization of non linear systems using Takagi-Sugeno fuzzy models. The fuzzy model is reformulated as a collection of uncertain linear models corresponding to some region in the state space and the local model uncertainty depends on the fulfillment degree of the corresponding rule. An optimization procedure is used to design the local controller such as to maximize the stability region of each closed loop local system. The local controller design is based on the resolution of a set of independent LMIs. The global control law is obtained by switching between local controllers. A simulation example is given to illustrate the efficiency of the proposed method.

FrB03.5: 14:20-14:40
*Comparing Robustness and Performance of Hybrid and Non-Hybrid Fuzzy Controllers Aimed to Guide a Simulated Robot**
Moratori, Patrick Barbosa Fed.I Univ. of Rio de Janeiro
Cruz, Adriano Joaquim de Oliveira Fed. Univ. of Rio de Janeiro
Lima, Cabral Fed. Univ. of Rio de Janeiro

FrB03.6: 14:40-15:00
Three Link Robot Control with Fuzzy Sliding Mode Controller Based on RBF Neural Network, pp. 2719-2724
Gokhan Ak, Ayca Marmara Univ.
Cansever, Galip Yildiz Tech. Univ.

The purpose of this paper is to propose adaptive fuzzy Sliding Mode Control (SMC) based on Radial Basis Function Neural Network (RBFNN) for trajectory tracking problem of three link robot manipulator. A RBFNN is used to compute the equivalent control of sliding mode control. A Lyapunov function is selected for the design of the SMC and an adaptive algorithm is used for weight adaptation of the RBFNN. Simulation results of three link Scara robot manipulator verify the validity of the proposed controller in the presence of uncertainties.

FrB04 Room 2605
Agent-Based Systems (Regular Session)

Chair: Polycarpou, Marios M. Univ. of Cyprus
Co-Chair: Parisini, Thomas Univ. of Trieste

FrB04.1: 13:00-13:20
Global Real-Time Path Planning for UAVs in Uncertain Environment, pp. 2725-2730
Weiss, Bernhard Johannes Kepler Univ. Linz
Michael, Naderhirn AeroSpy GmbH
Del Re, Luigi Johannes Kepler Univ. Linz

In this work we introduce a real-time path planning method for Unmanned Aerial Vehicles (UAVs) in uncertain environment. The kinematic system of the vehicle is therefore heuristically reduced to a set of feasible trim trajectories. The local operating Iterative Step Method (ISM) sequentially determines the next best trim trajectory, which minimizes a local cost-function. By varying the respective weighting factors, it's possible to get a trade off between path length and risk of the path. The local ISM is then integrated in a graph-based search of the best global by using the algorithm of Dijkstra. Finally a procedure for the real time use of the global path planner is presented.

FrB04.2: 13:20-13:40
A Hierarchical Control System Based on Agent Technology, pp. 2731-2736
Dong, Jie Univ. of Science and Tech. Beijing
Yin, Yixin Univ. of Science and Tech. Beijing
Peng, Kaixiang Univ. of Science and Tech. Beijing

In this paper, we propose a multi-agent architecture for industrial control process and its software realization. We discuss the concepts and necessity of Distributed Intelligent Control (DIC) based on Distributed Artificial Intelligence (DAI) and Multi-agent System (MAS) respectively. A Multi-agent architecture for industrial control process is proposed. Moreover, function, components and their processing of every module in the architecture are discussed in detail. The object-oriented software structure is presented as well.

FrB04.3: 13:40-14:00
Control of Hot-Rolling Strip for Wavelet-Based System Identification Approach, pp. 2737-2741
Peng, Kaixiang Univ. of Science and Tech. Beijing
Tong, Chaonan Univ. of Science and Tech. Beijing
Dong, Jie Univ. of Science and Tech. Beijing

In this paper, a new scheme for Wavelet-based Force Feed-Forward Automatic Gauge Control (WFFF-AGC) based on multi-resolution decomposition using wavelets is proposed to

improve the conventional Automatic Gauge Control (AGC). Multi-resolution provides a variable resolution time-frequency distribution for the roll force of F1-F6 stand, then signals containing hardness information are converted into control decisions used for feed-forward control in latter stands. By doing so, the thickness error especially at the head-end part of the strip is considerably reduced.

FrB04.4: 14:00-14:20
A Fault Detection Scheme for Distributed Nonlinear Uncertain Systems, pp. 2742-2747

Ferrari, Riccardo M.G.	Univ. of Trieste
Parisini, Thomas	Univ. of Trieste
Polycarpou, Marios M.	Univ. of Cyprus

This paper considers the problem of designing a fault detection scheme for a distributed nonlinear dynamic system. A network of distributed estimators is constructed where an adaptive estimator based on an on-line neural approximation model is embedded into each estimation agent. The local detection decision is made on the basis of the knowledge of the local dynamic model and on an on-line-learned approximation of the dynamic influence of the neighboring sub-systems. The stability of the adaptive estimation scheme is rigorously investigated and sufficient fault detectability conditions are also proposed. Simulation results are finally provided to demonstrate the effectiveness of the proposed architecture and methodology.

FrB05 Room 0601
Predictive Control of Combustion Engines
(Invited Session)

Chair: Allgower, Frank	Univ. of Stuttgart
Co-Chair: Scattolini, Riccardo	Pol. di Milano
Organizer: Allgower, Frank	Univ. of Stuttgart
Organizer: Del Re, Luigi	Johannes Kepler Univ. Linz
Organizer: Scattolini, Riccardo	Pol. di Milano

FrB05.1: 13:00-13:20
Modeling, Simulation and Control of an Automotive Gasoline Engine (I), pp. 2748-2753

Scattolini, Riccardo	Pol. di Milano
Miotti, Alessandro	Pol. di Milano
Lorini, Gabriele	Pol. di Milano
Bolzern, Paolo	Pol. di Milano
Colaneri, Patrizio	Pol. di Milano
Schiavoni, Nicola L.M.	Pol. di Milano

Innovative automotive gasoline engines are equipped with new actuators, such as the Variable Valve Timing (VVT), besides the traditional electronic throttle (ETC)and Exhaust Gas Recirculation (EGR). All these actuators can be used to optimize the engine performance in terms of reduced fuel consumption and pollutant emissions. In turn, their presence makes the control of the engine a difficult task due to the intrinsic multi-variable nature of the problem. In the first part of this paper, a control-oriented model of a gasoline engine equipped with these devices is presented and validated with real data. This model, and the corresponding dynamic simulator, are then used in the synthesis of the control strategy including both static maps, as in most of the nowadays industrial applications, and a dynamic compensator designed with Model Predictive Control. Simulation results illustrate the benefits of this approach.

FrB05.2: 13:20-13:40
Fast Nonlinear Model Predictive Control of Gasoline Engines (I), pp. 2754-2759

Ferreau, Hans Joachim	Univ. of Heidelberg
Lorini, Gabriele	Pol. di Milano
Diehl, Moritz	Univ. of Heidelberg

Nonlinear Model Predictive Control (NMPC) has proven successful in many applications, especially in chemical and process engineering where sampling times are usually in the order of seconds or minutes. Combustion engines show highly nonlinear behaviour and require sampling times of few milliseconds which poses a challenging control problem. We aim at tracking a desired torque profile of a gasoline engine without increasing the emissions, using the throttle and the exhaust gas recirculation valve as manipulated variables. In our simulations, it was possible to reduce the torque error considerably compared to controls taken from an optimal static map. Employing Bock's direct multiple shooting method and the so-called real-time iteration scheme the average runtime needed for one re-optimisation was reduced to below 10 ms. These preliminary results show that NMPC might soon become a viable technique for demanding control problems within the automotive area.

FrB05.3: 13:40-14:00
MPC for a Diesel Engine Airpath Using an Explicit Approach for Constraint Systems (I), pp. 2760-2765

Ortner, Peter	Johannes Kepler Univ. Linz
Langthaler, Peter	Johannes Kepler Univ. Linz
Garcia-Ortiz, Jose Vte.	Univ. Jaume
del Re, Luigi	Johannes Kepler Univ. Linz

The air path of an internal combustion engine is a classical example of MIMO system with actuator constraints and high dynamic requirements. While the classical approach consists in using simple, decoupled heuristic controllers and empirical limitations, this paper proposes to state the problem in terms of an optimal control problem with input constraints and to solve it in a model based environment. To this end, a recently developed controller design - explicit MPC - is used to calculate the explicit solution of the state feedback control law offline and to store it in tables for online controller selection. The combination of plant and switched controller leads to a piecewise linear and discrete system – a special form of hybrid system. The approach has been tested on a production diesel engine yielding impressive improvements in terms of soot while compared with the basic application.

FrB05.4: 14:00-14:20
Nonlinear Model Predictive Control of a Turbocharged Diesel Engine (I), pp. 2766-2771

Herceg, Martin	Slovak Tech. Univ. Bratislava
Raff, Tobias	Univ. of Stuttgart
Findeisen, Rolf	Univ. of Stuttgart
Allgower, Frank	Univ. of Stuttgart

Control of turbocharged diesel engines is a challenging task due to system nonlinearities and constraints on the inputs and process variables. In this paper nonlinear model predictive control is applied to control a diesel engine with a variable geometry turbocharger and an exhaust gas recirculation valve. The overall control objective is to regulate the setpoints of the air-fuel ratio and the amount of recirculated exhaust gas in order to obtain low exhaust emission values and low fuel consumption without smoke generation. Simulation results are presented to study the advantages and disadvantages of nonlinear model predictive control. The achieved performance is compared in simulations with a linear state feedback controller and an input-output linearization based control method. As shown, nonlinear model predictive control achieves good overall control performance and constraint satisfaction.

FrB05.5: 14:20-14:40
GPC Control of the Airpath of High Speed Diesel Engines (I), pp. 2772-2777

Garcia-Ortiz, Jose Vte.	Univ. Jaume
Langthaler, Peter	Johannes Kepler Univ. Linz
Del Re, Luigi	Johannes Kepler Univ. Linz

This paper presents a predictive design approach for the airpath control of diesel engines (EGR/VGT). The approach arises naturally from a model based sight of engine control and is discussed both in the “double SISO” version as well as in a modified MIMO version designed to cope with artificial setpoints typically used to enforce exact closing of valves in engines subject to production variance. The approach has been tested on an AVL dynamic test bench with a production BMW four cylinder diesel engine and compared to the results obtained by the original control configuration. The results confirm that the model based predictive approach has a large potentiality to improve the system behavior in terms of pollutants during transients, and that in some cases even significant improvements of specific consumption are

achieved.

FrB05.6: 14:40-15:00
Predictive Thermal Management of Combustion Engines (I), pp. 2778-2783

Bruckner, Martin	Johannes Kepler Univ. Linz
Gruenbacher, Engelbert	Linz Center of Mechatronics
Alberer, Daniel	Johannes Kepler Univ. Linz
Del Re, Luigi	Johannes Kepler Univ. Linz
Atschreiter, Friedrich	TCG Unitech Systemtechnik GmbH

Temperature control is very important for combustion engines as temperature is a critical factor both for chemical reactions and mechanical stresses. Traditionally, temperature control is performed by feedback of a global quantity, the coolant temperature, which however is a poor indicator of specific temperatures. The use of electrical pumps opens new possibilities for thermal control, in particular in terms of efficiency, but also of pollution, especially in the cold start phase. This paper, instead, shows that predictive control and the use of electrical coolant pumps allows to regulate specific temperatures – here as an example the cylinder head temperature. The experiment based results shown in impressive reduction of the thermal swing for the use of an electrical pump speed control using a model predictive approach. The work related has been performed in the framework of a Regins Interreg project in cooperation with a leading producer of coolant pumps.

FrB06 Room 0602
Advances in Vehicle Dynamics Control (Invited Session)

Chair: Kolmanovsky, Ilya V.	Ford Motor Co.
Co-Chair: Koch, Charles Robert	Univ. of Alberta
Organizer: Fischbach, P.E., Kevin	Ford Motor Company
Organizer: Koch, Charles Robert	Univ. of Alberta

FrB06.1: 13:00-13:20
Estimation of Tire-Road Contact for Integrated Control Applications in Current Vehicles (I), pp. 2784-2789

Arndt, Christoph	Ford Motor Company
Karidas, Johannes	ITK Engineering

Current vehicle control strategies aim at the integration of several actuator algorithms of the vehicle. This means a combination of the available actuators according to multiple optimization criteria due to several targets. One goal is the comfort of the driver for cruising, another objective of the optimization is the agility and stability of the vehicle during cornering. Both targets require different setups of the vehicle and different tunings of the actuators that can be achieved by an integrated control system. Such an integrated control system requires a complete knowledge of the vehicle state. This includes the estimation of the longitudinal and lateral motion of the vehicle as well as the estimation of rotation (yaw, roll, pitch) and vertical movements of body and wheels. All this information is included in a vehicle state estimator (VSE) and it builds one basis of the integrated control approach. An important parameter of the VSE is the estimation of the tire-road contact, because the contact from tires to the road provides the stabilizing forces for traction and lateral movements of the vehicle. The friction coefficient varies from 1 to 0.1 and this means drastic changes in the forces that the vehicle is able to build up in the tire-road contact patch. This paper aims at the estimation of this important friction coefficient that is included in the estimation and in the control algorithms of the vehicle.

FrB06.2: 13:20-13:40
Longitudinal Vehicle Speed Estimation for Traction and Braking Control Systems (I), pp. 2790-2795

Tanelli, Mara	Pol. di Milano
Savaresi, Sergio M.	Pol. di Milano
Cantoni, Carlo	Brembo s.p.a.

Accurate estimation of longitudinal vehicle speed is crucial for effective design and implementation of Anti-lock Braking Systems (ABS) and Traction Control Systems (TCS). The knowledge of the current value of the vehicle speed, in fact, is the key for computing the longitudinal wheel slip, i.e., the main control variable in most advanced braking and traction control logics. This work presents a new algorithm for the estimation of longitudinal vehicle speed, based on the measurements of the four wheel rotational speeds and of the longitudinal vehicle acceleration. The main advantages of this approach are the low computational burden - which makes implementation on a commercial vehicle Electronic Control Unit (ECU) effective, and the accuracy of the final estimation results - which makes the tire slip current value available with small uncertainty. The algorithm has been extensively tested on an instrumented test car in different driving and road conditions.

FrB06.3: 13:40-14:00
A Receding Horizon Optimal Control Approach to Active State and Parameter Estimation in Automotive Systems (I), pp. 2796-2801

Kolmanovsky, Ilya V.	Ford Motor Company
Winstead, Vincent	Ford Motor Company

A receding horizon optimal control approach is proposed to control a system in such a way as to best estimate on-line its states and parameters, without significantly degrading tracking performance or violating pointwise-in-time constraints. Several automotive examples are considered to illustrate the potential of the approach. They include: vehicle mass and road grade estimation, engine wall-wetting parameter estimation, engine mapping, and estimation of the position and velocity of a moving vehicle from angle-only (passive) measurements by another vehicle.

FrB06.4: 14:00-14:20
Analysis of the Potential Performance of a Combined Hybrid Vehicle with Optimal Supervisory Control (I), pp. 2802-2807

Sciarretta, Antonio	ETH Zurich
Cipollone, Roberto	Univ. L'Aquila

The paper presents an optimization analysis of the supervision control strategies of a combined hybrid propulsion system, realized via a direct (i.e., without a planetary gear set) mechanical link between the shaft of the internal combustion engine and the shaft of the traction electric motor. The analysis is based on a quasistatic mathematical model of the overall system that is derived in a pure analytical fashion, using the Willans approach, in order to help the synthesis of the control laws. The latter are calculated using Pontryagin's Minimum Principle and the Euler-Lagrange equations of the optimal control theory. Simulation tests performed over a hybridized mass-production van show the potential of the combined-hybrid architecture, in terms of fuel economy, in comparison to the conventional (engine-only), the series-hybrid, and the parallel-hybrid architectures.

FrB06.5: 14:20-14:40
Cruise Control with Collision Avoidance for Cars Via Sliding Modes (I), pp. 2808-2813

Ferrara, Antonella	Univ. of Pavia
Vecchio, Claudio	Univ. of Pavia

Longitudinal control of platoons of vehicles is appropiate to improve the traffic capacity of road networks while maintaining safety distances between vehicles. This paper investigate the possibility of reducing the number of accidents involving pedestrians or other vulnerable road users, like cyclists and motorcyclists, by providing the control systems of the vehicles of the platoon with some collision detection and avoidance capability. The driver assistance system is realized by means of vehicle supervisors, which, on the basis of the data acquired by the sensors, make the decision on which is the appropriate current control mode for each controlled vehicle, and manage the switches among low–level controllers.

FrB06.6: 14:40-15:00
Development of 2 Degree of Freedom Steer-By-Wire Hand-Wheel Actuator Control (I), pp. 2814-2819

Sun, Xiao-Dong	TRW Conekt
Scotson, Peter G.	TRW Conekt
Luengen, Arno	TRW Automotive GmbH
Heitzer, Heinz-Dieter	TRW Automotive GmbH

The paper describes the application of model reduction and robust 2-degree-of-freedom loop-shaping control to the torque-feel control of the hand-wheel actuator of a fail-safe steer-by-wire system. These techniques are shown to produce a low-order controller with good hands-on feel and robust stability. The results of the robust controller are evaluated by stability & control quality measurements in Matlab, by component-in-the-loop simulation and by vehicle tests. The results show promising and superior control performance in both tracking performance and stability robustness.

FrB07 Room 0606
Learning Control (Regular Session)

Chair: Terashima, Kazuhiko	Toyohashi Univ. of Tech.
Co-Chair: Fujisaki, Yasumasa	Kobe Univ.

FrB07.1: 13:00-13:20
Adaptive Feedforward Control of Automatic Pouring Robot Considering Influence of the Accumulating Disturbance, pp. 2820-2825

Yano, Ken'ichi	Gifu Univ.
Kaneko, Motoki	Toyohashi Univ. of Tech.
Noda, Yoshiyuki	Toyohashi Univ. of Tech.
Terashima, Kazuhiko	Toyohashi Univ. of Tech.

The purpose of this study is to control the series of actions in the pouring process to improve the productivity of the factory, the safety of workers, and the quality of the product. A mathematical model of the pouring processes was built; based on the model, a forward tilting control input was designed to hold the liquid in the sprue cup at a constant level. A pouring flow rate model for the change in the pour rate due to the accumulating slag was constructed, and an adaptive feedforward control system for the automatic pouring robot was developed. The effectiveness of the proposed system is shown through control simulations and experiments.

FrB07.2: 13:20-13:40
A Frequency Domain Condition for Boundedness of Learning Control Using a Forgetting Factor, pp. 2826-2829

Fujisaki, Yasumasa	Kobe Univ.
Kato, Fuminori	Kobe Univ.

If there exist errors of initial setting, measurement noises, or system fluctuations, it is common to introduce a forgetting factor into iterative learning control for the case of not using the derivative of the tracking error. This paper deals with the learning control with the forgetting factor for general linear systems and presents a rigorous frequency domain condition under which the tracking error is bounded. An explicit bound of the tracking error is also provided, which suggests a suitable selection of the forgetting factor.

FrB07.3: 13:40-14:00
Improving the Drop-Consistency of an Inkjet Printhead Using Meniscus-Based Iterative Learning Control, pp. 2830-2835

Groot Wassink, M.B.	Delft Univ. of Tech.
Zollner, F.	Delft Univ. of Tech.
Bosgra, O.H.	Delft Univ. of Tech.
Koekebakker, S.H.	OceTech. B.V.

The performance of inkjet printheads is limited by residual vibrations and cross-talk, influencing the drop-consistency negatively. Given a certain printhead design, lifted ILC can be applied to design input wave forms that leave droplet formation undisturbed while minimizing these operational issues. The quality of the resulting pulses is largely dependent on the model's representativeness of the jetting process. In particular, the choice of proper sensor functionality is a key issue. In this paper, a model based on the meniscus (ink-air interface in the nozzle) velocity as sensor signal is identified and taken as starting point for the implementation of so-called meniscus-based ILC. The suitability of this choice is shown by the implementation of the designed input pulses resulting in a considerable improvement of the drop-consistency.

FrB07.4: 14:00-14:20
Neuro Control of Nonlinear Discrete Time Systems with Deadzone and Input Constraints, pp. 2836-2841

He, Pingan	MotoTron Corp.
Jagannathan, Sarangapani	Univ. of Missouri-Rolla
Gao, Wenzhi	Louisiana State Univ.

A neural network (NN) controller in discrete time is designed to deliver a desired tracking performance for a class of uncertain nonlinear systems with unknown deadzones and magnitude constraints on the input. The NN controller consists of two NNs: the first NN for compensating the unknown deadzones; and the second NN for compensating the uncertain nonlinear system dynamics. The magnitude constraints on the input are modeled as saturation nonlinearities and they are dealt with in the Lyapunov-based controller design. The uniformly ultimate boundedness (UUB) of the closed-loop tracking errors and the neural network weights estimation errors is demonstrated via Lyapunov stability analysis.

FrB07.5: 14:20-14:40
A New Method of Controlling Active Magnetic Bearing through Neural Network, pp. 2842-2847

Achkar, Roger	Univ. of Tech. Compiegne
Chaiban, Nasr	Lebanese Univ.
De Miras, Jerome	Univ. of Tech. Compiegne
Charara, Ali	Univ. of Tech. Compiegne

The active magnetic bearing AMB presents a solution for all the technical problems since it ensures the total levitation of a body in space eliminating any mechanical contact between the rotor and the stator. The goal of our work is to show that the control of the AMB by Multilayer perceptrons MLP involves an improvement of the response compared to the ordering of the AMB by classical controllers. Our team has developed several diagrams with MLP to control the AMB. A final diagram was used and in which we optimized all the parameters influencing the training in order to obtain better results concerning the temporal answers of the positions of the axes.

FrB07.6: 14:40-15:00
*A Predictive Ship Control Strategy Based on Self-Adaptation Radial Basis Function Network**

Yin, Jianchuan	Dalian Maritime Univ.
Dong, Fang	Dalian Maritime Univ.
Wang, Nini	Dalian Maritime Univ.

FrB08 Room 2607
Robotics - Redundant, Cooperative (Regular Session)

Chair: Bittencourt, Guilherme	Fed. Univ. of Santa Catarina
Co-Chair: Tektas, Umit Ali	Gebze Inst. of Tech.

FrB08.1: 13:00-13:20
Redundancy Resolution for Underwater Vehicle-Manipulator Systems Using a Fuzzy Expert System, pp. 2848-2853

Santos, Carlos Henrique	Fed. Univ. of Santa Catarina
Bittencourt, Guilherme	Fed. Univ. of Santa Catarina
Guenther, Raul	Fed. Univ. of Santa Catarina
Pieri, Edson Roberto De	Fed. Univ. of Santa Catarina

In this paper, the problem concerning how to coordinate the movement of an autonomous underwater vehicle-manipulator system (UVMS) is investigated. It is proposed an algorithm based in fuzzy logic that generates a desired trajectory for the vehicle taking into account three control objectives: the energy savings, the increase of system manipulability and utilization of all degrees of freedom (dof) when necessary. In this last, a particular rule disposition to distribute all dof's involved in task space is used. The simulation results demonstrate the efficiency of this approach.

FrB08.2: 13:20-13:40
Singularity Avoidance in Redundant Robots Using Hybrid Automaton, pp. 2854-2859

Santos, Carlos Henrique	Fed. Univ. of Santa Catarina
Bittencourt, Guilherme	Fed. Univ. of Santa Catarina
Guenther, Raul	Fed. Univ. of Santa Catarina
Pieri, Edson Roberto De	Fed. Univ. of Santa Catarina

We investigate in this work the possibility to solve the problem of singularity in redundant robotic systems using a hybrid automaton model. In this way, an index of kinematic performance as method of singularity verification is introduced. Simulation results of a planar redundant manipulator shows that the method is promising.

FrB08.3: 13:40-14:00
Robust Tracking Control of Kinematically Redundant Robot Manipulators Subject to Multiple Self-Motion Criteria, pp. 2860-2865

Zergeroglu, Erkan	Gebze Inst. of Tech.
Sahin, Husnu Turker	Gebze Inst. of Tech.
Ozbay, Ufuk	Gebze Inst. of Tech.
Tektas, Umit Ali	Gebze Inst. of Tech.

In this study, we consider a model based robust control scheme for kinematically redundant robot manipulators that also enables the use of self motion of the manipulator to perform multiple sub-tasks (like, maintaining manipulability, avoidance of mechanical joint limits and obstacle avoidance). The controller proposed ensures uniformly ultimately bounded end-effector and sub-task tracking despite the parametric uncertainty associated with the dynamic model. The controller design has been based on a Lyapunov type approach. Simulation results performed on a 3 link planar robot arm are presented to demonstrate the capabilities and the performance of the controller.

FrB08.4: 14:00-14:20
Sensors Optimization-Based Control of Two Planar Robots in Lifting, pp. 2866-2871

Chaib, Salim	ENSI Bourges
Boutat, Driss	ENSI Bourges
Benali, Abderraouf	ENSI Bourges

In this paper, we focus on one of the central problem of observers design and control of general manipulation systems. The mechanical compliance introduced by the cooperation between the manipulators and their load interactions complex. First, the control must be designed in this case in order to realize the object trajectory and/or external forces tracking. But, the controller action must respect and not violate at each moment the kinematic constraint of the manipulation system. Seconde and more importantly, the augmented manipulation system (the closed chain : manipulators-object) is nonlinear and complex system, then the observer design is very difficult, which motivate us to develop a new approach to design a multi models-based observer which we call hysteresis hybrid observer.

FrB08.5: 14:20-14:40
Multiple Impedance Control of Cooperative Manipulators Using Virtual Object Grasp, pp. 2872-2877

Moosavian, S. Ali A.	K. N. Toosi Univ. of Tech.
Rastegari, Rambod	K. N. Toosi Univ. of Tech.

Multiple Impedance control (MIC) is a Model-Based algorithm that enforces a designated impedance on all cooperating manipulators, the manipulated object, and the moving base if applied on a mobile robotic system. For tuning the inner object forces, it is needed to model the inner forces/torques. For this purpose, the virtual linkage model is introduced to determine the inner forces using the MIC law. Also, the load distribution between end-effectors is modeled. In the following, the MIC law is used to control both path tracking and inner forces tuning when manipulating an object. The moving object is grasped with three cooperating end-effectors either solidly, or flexible. The developed controller is compared to the Augmented Object Control (AOC) where impedance control was applied. Finally, the effects of gain tuning on inner forces are discussed. The obtained results reveal good tracking performance of the proposed MIC controller, besides tuning the object internal forces even in the presence of contact, and system flexibility.

FrB08.6: 14:40-15:00
Cooperative Object Manipulation Using Non-Model-Based Multiple Impedance Control, pp. 2878-2883

Moosavian, S. Ali A.	K. N. Toosi Univ. of Tech.
Ashtiani, Hadi R.	K. N. Toosi Univ. of Tech.

The Multiple Impedance Control (MIC) is a Model-Based algorithm that enforces a designated impedance on all cooperating manipulators, and the manipulated object itself. Although the MIC has been appeared as an efficient algorithm, but to apply model-based control laws the system dynamics has to be modeled. Furthermore, computation of the system dynamics even if perfectly known, may require considerable process time at each step for implementing the control law. In this paper, based on an approximated feedback linearization control approach, the MIC law is modified to be implemented without using system dynamics. Therefore, this modified MIC law, which is called Non-Model-Based Multiple Impedance Control (NMIC), is a quick and more realistic algorithm for implementation in cooperating robotic systems. Developing the NMIC law, error analysis shows that under the NMIC law all participating manipulators and the manipulated object exhibit the same designated impedance behavior. The proposed NMIC law is applied on an object manipulation task with two cooperating manipulators while one of them is equipped with a Remote Compliant Centre. The obtained results show good tracking performance even in the presence of impacts due to contact with an obstacle, and also system flexibility. These results reveal the merits of NMIC as a non-model-based algorithm for object manipulation tasks, while it can be implemented with reasonably limited on-line computations.

FrB09 Room 0999
Advanced Control Techniques for Future Space Applications (Invited Session)

Chair: Bennani, Samir	European Space Agency
Co-Chair: Lovera, Marco	Pol. di Milano
Organizer: Bennani, Samir	European Space Agency
Organizer: Lovera, Marco	Pol. di Milano

FrB09.1: 13:00-13:20
Six-Axis Decentralized Control Design for Spacecraft Formation Flying (I), pp. 2884-2889

Gaulocher, Sebastian	ONERA
Chretien, Jean-Pierre	ONERA
Pittet, Christelle	CNES
Alazard, Daniel	SUPAERO

This contribution addresses the control design for the three-spacecraft formation flying interferometry mission Pegase. The operational mode considered is the high-precision nulling phase. The control design has as major objective the minimization of the standard deviation of the controlled outputs, e.g. the optical path difference. The payload performance demands are shown to be fulfilled in spite of sensor and actuator noise. Furthermore, a novel iterative algorithm is proposed, capable of designing decentralized H2-suboptimal controllers. These controllers consist of a set of individual closed loops on board the different spacecraft which only use locally available measurements, forces and torques. This approach reduces communication bandwidth and enhances robustness concerning faulty communication links. Finally, the performance loss due to decentralization is investigated.

FrB09.2: 13:20-13:40
Station Keeping of Geostationary Satellites with On-Off Electric Thrusters (I), pp. 2890-2895

Losa, Damiana	Ecole des Mines de Paris
Lovera, Marco	Pol. di Milano
Marmorat, Jean-Paul	Ecole des Mines de Paris
Dargent, Thierry	Alcatel Space
Amalric, Joel	Alcatel Space

The aim of this paper is to consider the modelling and control

issues arising in the design of a station keeping system for geostationary satellites based on on-off electric thrusters. In particular, a model for the dynamics of a geostationary satellite affected by perturbations is derived and the electric station keeping problem is then formulated as an optimisation problem with mixed (continuous and discrete) constraints. Simulation results showing the feasibility of the control task on a spacecraft equipped with electric thrusters are also presented and discussed.

FrB09.3: 13:40-14:00
Modern Analysis Techniques for Gain Scheduled Thrust Vector Controllers of Launchers (I), pp. 2896-2901

Rotunno, Max Unmanned Tech. Res. Inst.
Fiorenzani, Tiziano Unmanned Tech. Res. Inst.
Petritoli, Paolo Unmanned Tech. Res. Inst.
Bennani, Samir European Space Agency

Current procedures used in the clearance/analysis of gain scheduled flight control laws for Launch Vehicles (LV) tend to be very time consuming and complicated. Furthermore, the clearance procedure is in many cases limited to only certain vertices (determined on prior experience) of the uncertain parameter space, in the hope that the worst case scenario is not somewhere in the middle.

The main objective of this study is to apply the modern control concepts of Linear Fractional Transformations (LFT), mu-analysis and Linear Parameter Varying (LPV) techniques, to the clearance/analysis of gain scheduled flight control laws for a single axis attitude Thrust Vector Control (TVC) Launch Vehicle.

FrB09.4: 14:00-14:20
Attitude Control of the Landing Demonstrator PHOENIX (I), pp. 2902-2907

Strauch, Hans EADS Space Transportation

Phoenix is a national German un-powered landing demonstrator, which was designed as a precursor project within the frame of the Next Generation Launcher Program. A first in-flight demonstration has been successfully performed in May 2004 with three fully automated landings on a concrete landing strip at the NEAT test range in Sweden. The emphasis of this paper is on the attitude control of PHOENIX. After a brief summary of the overall control structure, the paper describes in detail the design steps leading to the attitude control algorithm and presents flight data from the test.

FrB09.5: 14:20-14:40
Model Predictive Control of Low Earth Orbiting Spacecraft with Magneto-Torquers (I), pp. 2908-2913

Wood, Mark Loughborough Univ.
Chen, Wen-hua Loughborough Univ.
Fertin, Denis European Space Agency

The problem of attitude control using magnetic torque rods is addressed, in order to demonstrate predictive control as a suitable and effective technique of magnetic attitude control. The study addresses the key issues of magnetic field modeling, controller stability and implementation. Two controller designs are implemented, the first adopting an MPC approach with a constant magnetic field assumption, while the second method includes the true variation of the magnetic field within the control law. Both methods demonstrate significantly improved performance over PD control with the inclusion of the true magnetic field variation leading to the best results. Controller stability is considered with and without terminal penalty within the cost function. Floquet analysis demonstrates both methods to be stable, however the terminal penalty based method leads to a more stable controller.

FrB09.6: 14:40-15:00
A New Gain Scheduling Controller Synthesis and Its Application to Attitude Control Systems of a Large Flexible Satellite, pp. 2914-2920

Hamada, Yoshiro Japan Aerospace Exploration Agency
Ohtani, Takashi Japan Aerospace Exploration Agency
Kida, Takashi Univ. of Electro-Communications
Nagashio, Tomoyuki Univ. of Electro-Communications

This paper proposes a new synthesis of a gain scheduling controller based on approximation of Lyapunov solutions with spline functions. Using the proposed synthesis, scheduled controllers, which do not require large programs when implemented in an actual control system, can be derived by setting the number of ``knots" (i.e. grid points) of the controller as small as possible. Scheduled controllers which are piecewise-linear on a parameter can also be obtained by adding some constraints to the derived condition. The synthesis is applied to design an attitude controller of a large flexible satellite and simulation results are provided to show the effectiveness of our synthesis.

FrB10 Room 3999
Identification - Applied (Regular Session)

Chair: Werner, Herbert Hamburg Univ. of Tech.
Co-Chair: Ding, Limei Lulea Univ. of Tech.

FrB10.1: 13:00-13:20
Modelling and Identification of a Free Electron Laser RF System, pp. 2921-2926

Lichtenberg, Gerwald Hamburg Univ. of Tech.
Koch, Guido Hamburg Univ. of Tech.
Brandt, Alexander DESY
Werner, Herbert Hamburg Univ. of Tech.
Simrock, Stefan DESY

The operation of a Free Electron Laser in the X-ray wavelength range is the goal of the international XFEL project. The project critically depends on the linear accelerator component, where radio frequency fields have to be controlled with a very high amplitude and phase precision and under various sources of disturbances. This paper is about finding appropriate dynamical models for this RF system which will be essential for controller design. A physically motivated white box model is compared with a grey box and a black box model that are identified using measurements of an existing Ultraviolet Free Electron Laser VUV-FEL.

FrB10.2: 13:20-13:40
A Joint Structured Complex Uncertainty Identification and Mu-Synthesis Algorithm, pp. 2927-2932

Rodonyi, Gabor Hungarian Acad. of Sciences
Bokor, Jozsef Hungarian Acad. of Sciences

A joint uncertainty model identification and mu-synthesis algorithm is presented for linear time-invariant (LTI) systems. The goal is 1) to construct an uncertainty model set characterized by parameterized weighting functions of dynamic perturbations in the general linear fractional transformation (LFT) form and additive disturbances - customary representation in modern robust control and 2) to select from this set according to closed-loop control objectives. The motivation is to avoid conservatism of physics-based uncertainty modelling yet giving confidence in the model. The algorithm works on sampled, bounded-energy experimental data on the frequency-domain and integrates model invalidation/construction and control synthesis in order to achieve robust performance. Standard D-K iteration steps are combined with an optimization step on a group of selected data. The efficiency and applicability of the method is demonstrated on a vehicle control problem with real experimental data.

FrB10.3: 13:40-14:00
Physical Model Parameter Estimation of a Nonlinear Process, pp. 2933-2938

Ding, Limei	Lulea Univ. of Tech.
Gustafsson, Thomas	Lulea Univ. of Tech.
Johansson, Andreas	Lulea Univ. of Tech.

A physical model of a nonlinear subprocess in a continuous paper pulp digester is discussed and simplified. Model approximation is carried out in order to produce a simple linear model to be used for unknown parameter estimation of the physical model. The Taylor series expansion and the orthogonal collocation method are applied for the model linearization and model lumping, respectively. The reduced model is expressed as a standard state space form. The model parameters are estimated in the least squares sense, and the parameters retain their own physical meanings. The results of the parameter estimation are discussed and the model is verified using validation data.

FrB10.4: 14:00-14:20
Accounting for Nonlinearity and Periodicity in Ozone Model Identification, pp. 2939-2944

Elayan, Elamari	Univ. de Caen
Giri, Fouad	Univ. de Caen
Pigeon, Eric	Univ. de Caen
Massieu, Jean-Francois	Univ. de Caen

This paper deals with the multi-model description of the ozone generation process in the Basse-Normandie region. The nonlinearity and periodicity have been taken into consideration. The nonlinear feature is accounted for resorting to the Takagi-Sugeno approach. This structure involves a set of local linear models (each one is valid for a certain range of operating conditions) and an interpolative mechanism that combines the outputs of the local models into a continuous global output. The periodicity feature consists in using the variable time to design three membership functions, where the day is devised into three equal intervals to construct three periodical models (each one represents an interval of the day). The parameters of the global periodical model are estimated using the parametric identification approach and membership functions of the variable time to interpolate the three output of the periodical models to get the global output. The model thus obtained turned out to be satisfactory and currently used to build-up a predictor for this region.

FrB10.5: 14:20-14:40
Robust Identification of a Lightly Damped Flexible Beam Using Set-Membership and Model Error Modeling Techniques, pp. 2945-2949

Esmaeilsabzali, Hadi	Iran Univ. of Science and Tech.
Montazeri, Allahyar	Iran Univ. of Science and Tech.
Poshtan, Javad	Iran Univ. of Science and Tech.
Jahed-Motlagh, Mohammad Reza	Iran Univ. of Science and Tech.

The aim of this paper is robust identification of a lightly damped flexible beam model with parametric and non-parametric uncertainties. Our approach is based on worst case estimation theory where uncertainties are assumed to be unknown but bounded. We examine different outbounding algorithms (parallelotopic and ellipsoidal) for estimation of the feasible parameter set that has been delivered by the set membership identification algorithm. In order to proper handling with the high magnitude non-parametric uncertainties the proposed methods are compared and it is shown that the combination of set membership approach with model error modeling techniques will result in superior results.

FrB10.6: 14:40-15:00
*NNARX Model Identification and Predictive Control of Hydro Plant**

Kishor, Nand	Indian Inst. of Tech. Roorkee
Singh, S. P.	Indian Inst. of Tech. Roorkee

FrB11 Audimax
Linear System Methods (Regular Session)

Chair: Grimble, Michael John	Univ. of Strathclyde
Co-Chair: Piazzi, Aurelio	Univ. of Parma

FrB11.1: 13:00-13:20
Automated Tuning of LQG Cost Function Weightings: Scalar Case, pp. 2950-2955

Grimble, Michael John	Univ. of Strathclyde
Majecki, Pawel	Univ. of Strathclyde

A simple method of selecting the LQG dynamic weighting functions is proposed. This involves minimizing the traditional variance-based cost function but with a controller structure that is determined by a dynamic weighting LQG problem. This effectively forces a controller structure that has traditional integral action and controller roll-off terms. The methodology is similar to the so-called restricted-structure controller design used for optimal tuning of low-order controllers. The proposed algorithm is applied to a simulated model of a continuous-time process plant with transport delay.

FrB11.2: 13:20-13:40
ISA-PID Controller Tuning: A Combined Min-Max / ISE Approach, pp. 2956-2961

Vilanova, Ramon	Univ. Autonoma de Barcelona
Balaguer, Pedro	Univ. Autonoma de Barcelona

This communication addresses the problem of tuning a PID controller on the basis of a Model Reference Specification and posterior inclusion of Robustness considerations. The tuning is based upon a First Order Plus Time Delay (FOPTD) model and aims to achieve a step response specification. The industrial ISA-PID formulation is chosen. First of all the expression for the structure of optimal controllers as providers of an approximation of such a reference model is got. A tuning rule is derived where the four parameters of the ISA-PID are determined by means of two new parameters: one parameter, T_M, is related to the desired closed-loop time constant and the other one, z, that characterizes the approximation problem by means of the corresponding weighting function. As it is usual designs where a weighting function is used to set up the synthesis problem there should be some guide on how to select such weight. In this communication it is shown how this can be done by taking into account an ISE criterion. The introduction of ISE-like criterions for both parameters generates the optimal controller as a PI controller and the PID controller arises when detuning is introduced in order to increase the robustness.

FrB11.3: 13:40-14:00
Infinite Zero of Linear Time Varying Bond-Graph Models: Graphical Rules, pp. 2962-2967

Andaloussi, Chafik	Ecole Centrale de Lille
Chalh, Zakaria	Ecole Centrale de Lille
Sueur, Christophe	Ecole Centrale de Lille

The study of the infinite structure of linear time varying systems modeled by bond-graph is proposed in the paper. Firstly, a new bond-graph ring model is presented and the correspondence between the bond graph ring model and the module theory is proposed. Secondly, the Riegle rule is used in order to obtain the input-output representation. Graphical rules are proposed to study the infinite structure of the model. Finally, one application on a thyristor circuit model TCSC used in the power electronics is achieved, showing the efficiency and the simplicity of the approach.

FrB11.4: 14:00-14:20
An Automatic Tuning Method for Cascade Control Systems, pp. 2968-2973

Visioli, Antonio	Univ. of Brescia
Piazzi, Aurelio	Univ. of Parma

In this paper we present a new design method for cascade control systems. The proposed (open-loop) identification procedure allows to perform a one stage tuning of the PID controllers, whose parameters are selected in order to ensure a good load disturbance rejection performance. Then, the

model of the overall control system is reduced in order to apply the closed-form solution of an analytical stable inversion procedure as a command function. Thus, a high (predefined) performance is achieved also in the set-point following task. Simulation results show the effectiveness of the methodology.

FrB11.5: 14:20-14:40
Controllability of Bimodal LTI Systems, pp. 2974-2979

Bokor, Jozsef Hungarian Acad. of Sciences
Szabo, Zoltan Hungarian Acad. of Sciences
Balas, Gary J. Univ. of Minnesota

This paper gives a self contained treatment of the bimodal LTI problems pointing to the relevant structures of the problem. It is shown that for a certain class of bimodal systems controllability in case of closed–loop switching systems is equivalent with controllability of an open–loop switching system using nonnegative controls, i.e., to the controllability of a constrained open–loop switching system. To illustrate the main ideas, illustrative examples are also provided.

FrB11.6: 14:40-15:00
Special Approach to the Stability Criteria for Linear Systems, pp. 2980-2984

Medenica, Miroslav Univ. of Belgrade
Debeljkovic, Dragutin Pol. Acad.

This study introduces two new criteria for the stability of linear systems, based on the researches carried out in the field of stability criteria in the frequency domain. They are based on the implementation of the Pontarayn's criterion in systems with delay, as well as on the Cauchy's theorem of arguments in the domain of positive change in the arguments of the function $f^*(jw, e^{jt})$, regarding stable systems and the zeroes of characteristic equation located in the left semi-plane of the s-plane. On the given example of a linear system through the characteristic equation of the forth order, the analysis of stability features is clearly depicted, for all possible cases of the system, along with the obvious correspondence with the results of Hurwic and Mihailov, that is, their criteria.

FrC01 Room 2601
Model Reduction and Computer-Aided Control Design Problems (Regular Session)

Chair: Mosterman, Pieter The MathWorks, Inc.
Co-Chair: Lohmann, Boris Tech. Univ. Munich

FrC01.1: 15:30-15:50
Numerical Design of Nonlinear Observers with Approximately Linear Error Dynamics, pp. 2985-2990

Deutscher, Joachim Univ. Erlangen-Nurnberg

This paper presents a numerical approach for the approximate observer error linearization technique of Kazantzis and Krener. The proposed design procedure is based on the solution of a linear matrix equation that is obtained in explicit form. In addition, an alternative method for computing the change of coordinates and the output injection is developed that can be used to design regionally exponentially stable observers with approximately linear error dynamics. Simple examples demonstrate the results of the paper.

FrC01.2: 15:50-16:10
Modeling Internal Combustion Engines Using a Hyper-Class of Hybrid Automata: A Case Study, pp. 2991-2996

Deligiannis, Vasileios Univ. of Patras
Manesis, Stamatis Univ. of Patras

The reciprocating internal combustion engine is by far the most common form of engine or prime mover. As with most engines, the usual aim is to achieve a high work output with a high efficiency, and hence, control design is imperative. Subsequently, essential is the existence of a simulation model in order to give designer the ability to explore the merits of alternative designs without physically building the systems. This paper presents a new approach for modeling internal combustion engines. The modeling method is a recently proposed hyper-class of hybrid automata that provides greater modeling power compared with conventional methods, being suitable for modeling analysis of a wider variety of systems. The constructed model was implemented in an industrial software environment and simulation results were taken and presented.

FrC01.3: 16:10-16:30
Model Reduction by Second Order Krylov Subspaces: Extensions, Stability and Proportional Damping, pp. 2997-3002

Salimbahrami, Behnam Tech. Univ. Munich
Eid, Rudy Tech. Univ. Munich
Lohmann, Boris Tech. Univ. Munich

A discussion on second order Krylov subspace methods for the reduction of second order systems by applying a direct projection to the original model is presented with the following new results: (i) matching the moments about different expansion points, simultaneously, (ii) matching the Markov parameters, (iii) conditions to preserve stability of the original system, (iv) reducing second order systems with proportional damping, where the projection matrix can be derived independently of the damping matrix, (v) generalizing the method to reduce models with higher order structures.

FrC01.4: 16:30-16:50
Frequency Domain Stochastic Balanced Truncation: An Accuracy Enhanced Large Scale Model Reduction Technique, pp. 3003-3006

Shaker, Hamid Reza Shahid Bahonar Univ. of Kerman
Samavat, Mahmoud Shahid Bahonar Univ. of Kerman
Gharaveisi, Ali Akbar Shahid Bahonar Univ. of Kerman

A new method for relative error model order reduction is proposed. The reduction technique is based on two recently developed methods, namely frequency domain balanced truncation within a frequency bound and inner-outer factorization techniques. The proposed method is of interest for practical model order reduction because in this context it is important to keep the accuracy of the approximation as high as possible without sacrificing the computational efficiency. Numerical results show the accuracy and efficiency enhancement of the method.

FrC01.5: 16:50-17:10
Accuracy and Efficiency Enhanced Nonlinear Model Order Reduction, pp. 3007-3012

Gheisari, Yousof Islamic Azad Univ. Branch of Boushehr
Shaker, Hamid reza Shahid Bahonar Univ. of Kerman
Torabi, Mohammad Ali Ecole Pol. de Montreal
Samavat, Mahmoud Shahid Bahonar Univ. of Kerman

A new method for model order reduction for an important class of nonlinear dynamical systems is proposed. The reduction technique is based on the frequency balance reduction method within a desired frequency band and a developed trajectory piecewise-linear (TPWL) model order reduction approach. Both of the methods are recently developed techniques and they can increase the accuracy and efficiency of the reduction method. The computational load and memory is significantly reduced when the method is used in the hybrid reduction method. The accuracy enhanced hybrid method is applicable to very large scale nonlinear models efficiently and accurately. The numerical results show the accuracy and efficiency enhancement of the proposed method.

FrC02 Room 1601
Tools and Toolboxes (Regular Session)

Chair: Schmid, Christian Ruhr-Univ. Bochum
Co-Chair: Hofer, Anton Graz Univ. of Tech.

FrC02.1: 15:30-15:50
A Fault Detection Toolbox for MATLAB, pp. 3013-3018

Varga, Andras German Aerospace Center

The recently developed Fault Detection Toolbox for MATLAB is described. The new toolbox provides a comprehensive set of high level m-functions to support the design of residual generation filters using reliable numerical

algorithms recently developed by the author. The basic computational layer is formed by the Descriptor Systems Toolbox which contains all necessary tools to solve the underlying numerical problems. The m-functions based user interfaces ensure user-friendliness in operating with the functions of this toolbox via an object oriented approach.

FrC02.2: 15:50-16:10
Transforming a Control Design Model into an Efficient Production Application, pp. 3019-3023

Eisemann, Ulrich dSPACE GmbH
Beine, Michael dSPACE GmbH
Otterbach, Rainer dSPACE GmbH

Model-based design methods are well-established for the development of embedded control systems. Rapid control prototyping and automatic production code generation are widely applied to decisively speed up the software development process of electronic control units (ECUs). This paper describes the necessary transformation steps of the controller model from early controller design to final implementation on production hardware.

FrC02.3: 16:10-16:30
SCILAB Compatible Software for Analysis and Control of Repetitive Processes (I), pp. 3024-3029

Hladowski, Lukasz Univ. of Zielona Gora
Cichy, Blazej Univ. of Zielona Gora
Galkowski, Krzysztof Univ. of Zielona Gora
Sulikowski, Bartlomiej Univ. of Zielona Gora
Rogers, Eric Univ. of Southampton

In this paper the development of a SCILAB compatible software package for the analysis and control of repetitive processes is described. The core of the package consists of a simulation tool which enables the user to inspect the process dynamics with or without control laws applied. Reliable and numerically efficient algorithms for stability analysis and the control law design have been included. Illustrative examples are also given and areas of ongoing development is discussed.

FrC02.4: 16:30-16:50
Industrial CACSD for the Plant Design Process, pp. 3030-3035

Schumann, Reimar Univ. Applied Sci. Arts Hannover
Hoyer, Markus Univ. Applied Sci. Arts Hannover
Premier, Giuliano C. Univ. of Glamorgan

CACSD has become a standard design tool for control experts in industry and university. Nevertheless, a broad application by field engineers in industry is still missing. The paper describes the components of the ICACSD (Industrial CACSD) scheme developed since 1996 to provide industrial engineers with CACSD tools adapted to their knowledge background and industrial control design tasks. Today the ICACSD system comprises Matlab toolboxes for industrial process identification (ICAI) and control design (ICAC), the expert system based module Modeling for the qualitative modeling of process dynamics and the ModelCAT module which automatically generates process models from P&I diagrams in process CAE systems making use of simulation models from component catalogues. An application example demonstrates the interaction of ModelCAT, ICAI and ICAC for the computer aided control design at an industrial production process.

FrC02.5: 16:50-17:10
CACSD Tools for Tuning Multi-Rate PID Controllers in Time and Frequency Domains, pp. 3036-3041

Cuesta, Alfredo Univ. Complutense de Madrid
Grau, Luis Univ. Nac. Educ. Distancia
López, Ignacio Univ. Nac. Educ. Distancia

Usually constrains on the sensors are such that the control action could be updated N times faster than the output measurement. In order to generate the control signal, a digital PID controller with different internal rates (MRPID) is considered in this paper. Then, a CACSD tool implemented both for Matlab and Sysquake is presented. The tool calculates the gains of the controller for a generalisation to MR systems of Ziegler-Nichols frequency response method. Besides, using Sysquake, a tuning rule in the time domain is also found empirically thank to the huge number of experiments that can be done fast and easily.

FrC02.6: 17:10-17:30
Toolbox for Analysis and Synthesis of Petri Nets, pp. 3042-3046

Zhang, Wenle Ohio Univ.

In this paper, we present a classroom tool set for graphical editing, simulation, analysis and synthesis of deadlock free Petri net for automated manufacturing systems. Because of the discrete event nature of modern manufacturing systems, Petri nets have been widely applied in the modeling, control and performance analysis of such systems. The tool set consists of a graphical Petri net editor and simulator implemented in Java (JPNE) and a Petri net analysis and synthesis tool implemented in Matlab. The JPNE generates Petri net description data file, which can be read and parsed by the Matlab tool, and then analysis and synthesis can be performed on the parsed Petri net. The analysis includes reachability and deadlock detection, place-invariants and siphons calculation. The synthesis includes control place augmentation of the Petri nets based on selected minimal uncontrolled siphons. The synthesis process can be recursively applied to a Petri net and the result can be outputted to a data file which in turn can be read and parsed by JPNE and simulation can be run on newly synthesized Petri net. The major contributions are the implemented siphons calculation and the control place synthesis, which are rarely seen in existing software tools. Example applications are provided.

FrC03 Room 0670
Mechanical Systems and Robotics (Regular Session)

Chair: Behera, Laxmidhar Indian Inst. of Tech. Kanpur
Co-Chair: Kyriakopoulos, Kostas J. National Tech. Univ. of Athens

FrC03.1: 15:30-15:50
Motion Tasks for Robot Manipulators on Embedded 2-D Manifolds, pp. 3047-3052

Papageorgiou, Xanthi National Tech. Univ. of Athens
Loizou, Savvas Univ. of Pennsylvania
Kyriakopoulos, Kostas J. National Tech. Univ. of Athens

In this paper we present a methodology to drive the end effector of a robotic manipulator across the surface of an object in the workspace. Three typical tasks are considered, namely stabilization of the end effector over the object's surface, motion planning and eventually trajectory tracking of the end effector across the object's surface. The proposed controllers utilize navigation functions and are based on the belt zone vector fields concept. The derived dynamic controllers are realized using an integrator backstepping methodology. The derived feedback based controllers guarantee global convergence and collision avoidance. The closed form solution provides fast feedback rendering the methodology particularly suitable for implementation on real time systems. The properties of the proposed methodology are verified through non-trivial computer simulations.

FrC03.2: 15:50-16:10
Towards Recognition of Control Variables for an Exoskeleton, pp. 3053-3058

Papageorgiou, Xanthi National Tech. Univ. of Athens
McIntyre, Joe Coll. de France
Kyriakopoulos, Kostas J. National Tech. Univ. of Athens

In this paper we present a methodology to drive the end effector of a robotic manipulator, to which is attached a human hand, in order to follow the human's intention of movement. This set-up is inspired from a Neuro-Robotics scenario in order to develop systems for restoring motor functionalities in injured and disabled people. Three typical tasks are considered, namely the robot not to interfere with the human's motion, to assist a person with limited motion capabilities, and finally to be used from the subjects for rehabilitation reasons. The proposed controllers utilize a force

control in two different ways, with inner position loop and with inner velocity loop. The derived controllers attempt to incorporate neuroscientific models results. Also, stability and robust analysis is presented. The properties of the proposed methodology are verified through non-trivial computer simulations.

FrC03.3: 16:10-16:30

A Flexible Blind Source Recovery in Complex Nonlinear Environment, pp. 3059-3063

Vigliano, Daniele	Univ. of Rome La Sapienza
Scarpiniti, Michele	Univ. of Rome La Sapienza
Parisi, Raffaele	Univ. of Rome La Sapienza
Uncini, Aurelio	Univ. of Rome La Sapienza

In this paper the source recovery of nonlinear mixtures in the complex domain is addressed by an Independent Component Analysis (ICA) approach. Extending the well-known real PNL mixtures, source recovery is performed by a complex INFOMAX approach. Nonlinear complex functions involved in the learning process are realized by pairs of spline neurons called “splitting functions”, working on the real and the imaginary part of the signal respectively. A simple adaptation algorithm is derived and some experimental results that demonstrate the effectiveness of the proposed method are shown.

FrC03.4: 16:30-16:50

Laplacian Cooperative Attitude Control of Multiple Rigid Bodies, pp. 3064-3069

Dimarogonas, Dimos	National Tech. Univ. of Athens
Tsiotras, Panagiotis	Georgia Inst. of Tech.
Kyriakopoulos, Kostas J.	National Tech. Univ. of Athens

Motivated by the fact that linear controllers can stabilize the rotational motion of a rigid body, we propose in this paper a control strategy that exploits graph theoretic tools for cooperative control of multiple rigid bodies. The control objective is to stabilize the system to a configuration where the rigid bodies will have a common orientation and common angular velocity. The control law respects the limited information each rigid body has with respect to the rest of the team. Specifically, each rigid body is equipped with a control law that is based on the Laplacian matrix of the communication graph, which encodes the limited communication capabilities between the team members. Similarly to the linear case, the convergence of the multi-agent system relies on the connectivity of the communication graph.

FrC03.5: 16:50-17:10

Design of Robust Decentralized H-Infinity Control for Interconnected Descriptor Systems with Norm-Bounded Parametric Uncertainties, pp. 3070-3075

Chen, Ning	Central South Univ.
Gui, Weihua	Central South Univ.
Zhai, Guisheng	Osaka Prefecture Univ.

We consider a robust decentralized H-infinity control problem for interconnected descriptor systems. The uncertainties are assumed to be time-invariant, norm-bounded, and exist in both the system and control input matrices. Our interest is focused on dynamic output feedback. A sufficient condition for an uncertain interconnected descriptor system to be robustly stabilizable with a specified disturbance attenuation level, is derived in terms of a nonlinear matrix inequality (NMI). A two-stage homotopy method is employed to solve the NMI iteratively. First, a decentralized controller for the nominal descriptor system is computed by imposing block-diagonal constraints on the coefficient matrices of the controller gradually. Then, the decentralized controller is modified, again gradually, to cope with the uncertainties. On each stage, groups of variables are fixed alternately at the iterations to reduce the NMI to linear matrix inequalities. An example is given to show the use of this method.

FrC03.6: 17:10-17:30

Kinematic Control of Robot Manipulators Using Visual Feedback, pp. 3076-3081

Ray, Anjan Kumar	Indian Inst. of Tech. Kanpur
Agarwal, Mayank	Indian Inst. of Tech. Kanpur
Behera, Laxmidhar	Indian Inst. of Tech. Kanpur

This paper presents a hybrid visual motor control scheme for robot manipulators using visual feedback. The proposed scheme uses an extended Kohonen's Self Organizing Map (EKSOM) to find out the mapping from the task space to the joint space of the manipulator. Given the camera coordinates, the EKSOM has been trained to compute the joint space using visual feedback and system model. This scheme can be used to track the position of a moving object. The position-tracking of moving object is achieved using a prediction rule based on visual feedback from the camera. In the non-redundant case, this scheme is successfully implemented on a three-link manipulator for a known and unknown trajectory. In the redundant case, configuration control is used for the tracking of object position.

FrC04 Room 2605

Intelligent Control Applications (Regular Session)

Chair: Prokhorov, Danil	Toyota Motor Corp.
Co-Chair: Pedersen, Gerulf	Aalborg Univ. Esbjerg

FrC04.1: 15:30-15:50

Approximating Optimal Controls with Recurrent Neural Networks for Automotive Systems, pp. 3082-3087

Prokhorov, Danil	Toyota Tech. Center

We discuss ways of approximating optimal control sequences by neural networks in complex automotive systems. Our systems include engines and exhaust aftertreatment modules. Our goal is to minimize both emissions and fuel consumption. As our baseline, we use open-loop solutions based on dynamic programming (DP). First, we consider the case of a recurrent neural network trained directly on a DP solution, whether discrete- or continuous-valued. We show that close approximations of DP solutions are possible with neural networks, acting as feedback controller. Second, we discuss an iterative procedure which allows neurocontrollers to approximate DP solutions indirectly. Discussion is supported by high-fidelity simulation results.

FrC04.2: 15:50-16:10

Autonomous Cruise Control with a Quasi-Linear Minimal Order Feedback Controller, pp. 3088-3093

Junaid, Khan M.	Tsinghua Univ.
Shuning, Wang	Tsinghua Univ.
Pervaiz, Akhter	Pakistan Navy
Iqbal, Rao Naveed	Tsinghua Univ.

Continuous growth of population all over the world creates a great challenge to the transport management systems. The future intelligent transportation systems incorporates one important aspect of automation components which is the design of intelligent control systems that enables the system to behave autonomously, hence ensuring safety, comfort and best usage of available infrastructure. In this paper, a novel control strategy based on Quasi-linear feedback control is adopted for a longitudinal vehicle model. A third-order nonlinear system models the vehicle and power train dynamics. The system is feedback linearized and the resulted dynamics corresponds to a certain class of linear systems, which makes it attractive for the application of a simpler order feedback control designed on the basis of quasi-linear feedback theory. The designed controller not only guarantees asymptotic tracking of the desired trajectories, but also ensures safety and ride comfort under the constraints of physical limitations inherent in the system. The results are compared with the well established LQR optimal control theory, where a priori choice of the weights in the local quadratic criteria allows obtaining diverse desired overall system characteristics. The performance analysis reveals that the new quasi-linear strategy yields valid results.

FrC04.3: 16:10-16:30

Neural-Network-Based Inverse Control Method for Active Power Filter System, pp. 3094-3097

Wu, Jianhua Northeastern Univ.
Pang, Hali Northeastern Univ.
Xu, Xinhe Northeastern Univ.

A new type of active power filter (APF) is described. A multi-layered neural network based inverse control method for this APF system is proposed. The functioning of the APF system is based on a switching network whose characteristics are nonlinear. The characteristic of the switching on-off time of the switching network and the output current of the APF was demonstrated. The switching on-off time can be instantaneously calculated by using the Neural-Network-Based Inverse Control algorithm proposed. The neural network was designed. An all digital control way may be realized by using the algorithm. The validation of the results of Inverse Control for APF is proposed as well.

FrC04.4: 16:30-16:50

Automatic Tuning of PID Controller for a 1-D Levitation System Using a Genetic Algorithm - a Real Case Study, pp. 3098-3103

Yang, Zhenyu Aalborg Univ. Esbjerg
Pedersen, Gerulf Aalborg Univ. Esbjerg

The automatic PID control design for a one-dimensional magnetic levitation system is investigated. The PID controller is automatically tuned using the non-dominated sorting genetic algorithm (NSGA-II) based on a nonlinear system model. The developed controller is digitally implemented and tested. The preliminary simulation and test results show a potential to use artificial intelligence methods for supporting the control design for complicated nonlinear and open-loop unstable systems.

FrC05 Room 0601
Engine Control (Regular Session)

Chair: Gruenbacher, Engelbert Linz Center of Mechatronics
Co-Chair: Sampei, Mitsuji Tokyo Inst. of Tech.

FrC05.1: 15:30-15:50

Online Trajectory Shaping Strategy for Dynamical Engine Test Benches, pp. 3104-3109

Gruenbacher, Engelbert Linz Center of Mechatronics
Del Re, Luigi Johannes Kepler Univ. Linz
Kokal, Helmut AVL
Schmidt, Martin AVL
Paulweber, Michael AVL

Virtual vehicle testing on combustion engine test benches is becoming increasingly important to enhance testing speed in the automobile industry. To be able to achieve this target, dynamical test benches must be used which allow reproducing the load conditions on the engine crankshaft as occurring in the real vehicle. Dynamical testing usually consists in tracking speed versus torque profiles, which represent the expected vehicle operation. This also allows testing conditions which can not be measured in a real vehicle, and can lead to the situation in which the dynamics limit of the test bench and of the combustion engines are trespassed. This often leads to a chaotic performance of the test bench and to unreliable results. To cope with this problem we present an online capable algorithm which ensures that the test cycle is inside the performance limits. The algorithms are based on prefiltered design, the computation of feasible sets and of the use of augmented Kalman Filters to enforce feasibility. To prove the efficiency of the approach the algorithms are presented and simulation results are shown.

FrC05.2: 15:50-16:10

Nonlinear Control of Wound-Rotor Synchronous-Motor, pp. 3110-3115

El Magri, Abdelmounime EMI Rabat
Giri, Fouad Univ. Caen
Abouloifa, Abdelmajid EMI Rabat
Haloua, Mohamed EMI Rabat

The problem of controlling wound rotor synchronous motors is considered. First, a nonlinear model of the controlled motor is developed in the Park (d, q)-coordinates. Then, a nonlinear regulator is designed using the backstepping technique. The resulting closed-loop is proved to be asymptotically stable and the motor speed is shown to achieve its reference trajectory. These theoretical results are confirmed by simulations which, in addition, show that the proposed regulator has an important rejection capability with respect to load torque changes.

FrC05.3: 16:10-16:30

Modelling and LPV Control of an Electro-Hydraulic Servo System, pp. 3116-3121

Wijnheijmer, Frans Eindhoven Univ. of Tech.
Naus, Gerrit Eindhoven Univ. of Tech.
Post, Wil Eindhoven Univ. of Tech.
Steinbuch, Maarten Eindhoven Univ. of Tech.
Teerhuis, Pieter Delft Univ. of Tech.

This paper aims to show the modelling and control of an hydraulic servo system, targeting at frequency domain based controller design and the implementation of a Linear Parameter Varying (LPV) controller. The actual set-up consists of a mass, moved by a hydraulic cylinder and an electro-hydraulic servo valve. A nonlinear parametric model of the system, a number of fitted black box models as well as a LPV model combining these fits have been determined. In discretization of the control strategies for implemention on a digital control system, a new discretization algorithm is derived for LPV structures. Simulations and experimental results indicate the potential benefits of a position dependent controller over a classical controller, but show the limitations as well.

FrC05.4: 16:30-16:50

Stabilization Methods for Adaptive Engine Controls, pp. 3122-3127

Yasui, Yuji Honda R&D Co., Ltd.

The current engine systems to achieve extremely low emission has a wide range lambda sensor positioned upstream and a switching lambda sensor downstream a catalyst. The system is required to maintain the output of the switching lambda sensor to optimal target value under all engine load and catalyst aging conditions in order to optimize the conversion rate of catalyst. A standard STC (Self-Tuning Controller) and the robust adaptive controller composed of an identifier, a predictor and a sliding-mode controller were applied to the system at the beginning of this research. However, the standard STC caused the drift phenomena of adaptive parameters and could not provide sufficient control performance. The robust adaptive controller also caused the oscillation behavior of the output of the switching lambda sensor. Consequently, the identification algorithms of two adaptive controllers are modified to avoid these issues. As a result, the control performance of the output of the switching lambda was dramatically improved and the emission from the engine controlled by the system was reduced to the level meeting LEV-II emission standard in California.

FrC05.5: 16:50-17:10

High Gain and Sliding Mode Observers for the Control of an Electropneumatic Actuator, pp. 3128-3133

Girin, Alexis Ecole Centrale de Nantes
Plestan, Franck Ecole Centrale de Nantes
Brun, Xavier INSA de Lyon
Glumineau, Alain Ecole Centrale de Nantes
Smaoui, Mohamed INSA de Lyon

Electropneumatic actuators are more and more used in industrial applications. Due to nonlinear phenomena, for many applications, high accuracy can only be obtained when using nonlinear control laws. These strategies allow to get high performances but often need the knowledge of all state variables. Then, there is a real interest to design observers in order to estimate state from the measurements of only one of the chamber pressures in the actuator and carriage position. This paper focuses on a comparison between two nonlinear observers for a half-meter stroke electropneumatic unsymmetrical cylinder controlled by two three-way

servodistributors: a high gain observer and a sliding mode one.

FrC06 Room 0602
Power Systems II (Regular Session)

Chair: Schlurmann, Jens — Tech. Univ. Munich
Co-Chair: Higuchi, Kohji — The Univ. of Electro-Communications

FrC06.1: 15:30-15:50
Sliding Mode Control with Integral of Boost Converter by Microcontroller, pp. 3134-3138

Maker, Hattab — Univ. Tech. Belfort-Montbeliard
Gualous, Hamid — Univ. Tech. Belfort-Montbeliard
Outbib, Rachid — Univ. Tech. Belfort-Montbeliard

The aim of the paper is to present a new result on the control of Boost converter. More precisely, it deals in with the case where the converter is placed between a traction Battery and a 42V DC link. The behavior of the boost converter is modeled using state variable and the control strategy is based on sliding mode with integral. The experimental test is realized by using a microcontroller. A good agreement is found between simulation results and experimental ones.

FrC06.2: 15:50-16:10
DC-DC Converter Averaged Current Regulation and Non-Linear Phenomena Suppressing by Fuzzy Logic Controller, pp. 3139-3144

Guesmi, Kamel — Reims Univ.
Essounbouli, Najib — Reims Univ.
Hamzaoui, Abdelaziz — Reims Univ.
Zaytoon, Janan — Reims Univ.

DC-DC Power converters are characterized by cyclic switching of circuit topologies, which gives rise to a variety of nonlinear behaviors. This makes the system analysis and its behavior prediction difficult. So, a fuzzy logic approach is used in this paper to suppress theses nonlinear phenomena and to uphold the regulation performance in a wide range of the system parameters variation.

FrC06.3: 16:10-16:30
A Method to Improve a Resolution of Digital PWM Generator for DC-DC Converter Control, pp. 3145-3150

Takegami, Eiji — DENSEI-LAMBDA K.K.
Higuchi, Kohji — Univ. of Electro-Communications
Nakano, Kazushi — Univ. of Electro-Communications
Tomioka, Satoshi — DENSEI-LAMBDA K.K.
Watanabe, Kazushi — DENSEI-LAMBDA K.K.

In recent years, digitization of all control parts in switching power supplies including PWM generators is progressing for demands such as intelligent performances and common use of hardware, etc. Then, a problem is in the resolution of digital PWM generators for improving control performances. Since the digital PWM generator is constituted using a counter, a carrier wave turns into a stairs wave, and step amplitudes is decided with a clock cycle. When the clock cycle is fixed, the resolution becomes low as the switching frequency becomes high. Consequently, the accuracy of output voltage becomes bad. In this paper, a method for remarkably improving the resolution of the digital PWM generator using the pulse composite technique is proposed. The method is realizable by some parts and easy computation, and is applied to the digital PWM generator built-in DSP. The usefulness and practicality are verified by experiments.

FrC06.4: 16:30-16:50
Adaptive Sliding Mode Control of PWM Boost DC-DC Converters, pp. 3151-3156

El Fadil, Hassan — EMI Rabat
Giri, Fouad — Univ. Caen
Ouadii, Hamid — EMI Rabat

The problem of controlling switched boost power converters, in presence of load uncertainties, is considered. The converter is controlled according to pulse-width-modulation (PWM) and is modeled by an average nonlinear state-space representation. The control purpose is to enforce the output voltage to track any desired reference signal. First, supposing the converter model to be fully known, a nonlinear regulator is designed using the sliding mode technique. Accordingly, the control objective is reformulated in term of a sliding surface. The obtained regulator is shown to meet its objective and proves to be robust with respect to small load uncertainties. To deal with large uncertainties, an adaptive regulator is designed using the same technique. The adaptive regulator also meets its objective. Furthermore, its performances turn out to be less sensitive to the values of the associated design parameters.

FrC06.5: 16:50-17:10
Accounting of DC-DC Power Converter Dynamics in DC Motor Velocity Adaptive Control, pp. 3157-3162

El Fadil, Hassan — EMI Rabat
Giri, Fouad — Univ. Caen

This paper deals with the problem of velocity control of a DC motor taking account the dynamics of the DC-DC power converter, supposed here of Buck type. We will develop for the global system, constituted by combined DC-motor and Buck-converter, a model of fourth order. On the basis of this model a regulator is designed using the backstepping technique. The control purpose is, on one hand, asymptotic stability of the closed-loop system and, on the other hand, perfect tracking of the reference signal (the machine speed). Both non adaptive and adaptive versions are designed and shown to yield quite interesting performances. A theoretical analysis shows that both controllers meet their objectives. These results are confirmed by simulations which , besides, show that the adaptive version deals better with load torque changes.

FrC06.6: 17:10-17:30
Accounting for Coils Magnetic Saturation in Controlling DC-DC Power Converters, pp. 3163-3168

El Fadil, Hassan — EMI Rabat
Giri, Fouad — Univ. Caen
Ouadii, Hamid — EMI Rabat

Power converters regulators are generally designed based on standard models assuming linear the magnetic characteristics of the involved passive components. Since these characteristics are nonlinear, especially in presence of large currents or high temperatures, the proposed regulators are likely not to guarantee the performances they have been designed for. In the present paper, the effect of nonlinear magnetic characteristics on control performances is investigated for certain converters. It is shown that the control performances actually deteriorate if the nonlinear feature of relevant components is not accounted for in the converter model. A solution of such an issue is explicitly developed for two converters.

FrC07 Room 0606
Neural Network Control (Regular Session)

Chair: Balakrishnan, S.N. — Univ. of Missouri-Rolla
Co-Chair: Hanebeck, Uwe — Univ. Karlsruhe

FrC07.1: 15:30-15:50
Robust/Optimal Temperature Profile Control Using Neural Networks, pp. 3169-3174

Yadav, Vivek — Univ. of Missouri-Rolla
Padhi, Radhakant — Indian Inst. of Science Bangalore
Balakrishnan, S.N. — Univ. of Missouri-Rolla

An approximate dynamic programming (ADP) based neurocontroller is developed for a heat transfer application. Heat transfer problem for a fin in a car's electronic module is modeled as a nonlinear distributed parameter (infinite-dimensional) system by taking into account heat loss and generation due to conduction, convection and radiation. A low-order, finite-dimensional lumped parameter model for this problem is obtained by using Galerkin projection and basis functions designed through the 'Proper Orthogonal Decomposition' technique (POD) and the 'snap-shot' solutions. A suboptimal neurocontroller is obtained with a single-network-adaptive-critic (SNAC). Further contribution of this paper is to develop an online robust controller to account

for unmodeled dynamics and parametric uncertainties. A weight update rule is presented that guarantees boundedness of the weights and eliminates the need for persistence of excitation (PE) condition to be satisfied. Since, the ADP and neural network based controllers are of fairly general structure, they appear to have the potential to be controller synthesis tools for nonlinear distributed parameter systems especially

FrC07.2: 15:50-16:10
Modeling of Reheating-Furnace Dynamics Using Neural Network Based on Improved Sequential-Learning Algorithm, pp. 3175-3181

Liao, Yingxin — Tokyo Univ. of Tech.
Wu, Min — Central South Univ.
She, Jin-Hua — Tokyo Univ. of Tech.

In order to model the dynamics of a billet reheating furnace, a multi-input multi-output radial-basis-function neural network is constructed based on an improved sequential-learning algorithm. The algorithm employs an improved growing-and-pruning algorithm based on the concept of the significance of hidden neurons, and an extended Kalman filter improves the learning accuracy. Verification results show that the model thus obtained accurately predicts the temperatures of the various zones of the furnace.

FrC07.3: 16:10-16:30
A Robust Neural Network Controller for a TITO Interactive Nonlinear System, pp. 3182-3187

Li, Ji-Hong — Maritime Ocean Engr. Res. Inst.
Jun, Bong-Huan — Maritime Ocean Engr. Res. Inst.
Lee, Pan-Mook — Maritime Ocean Engr. Res. Inst.

This paper presents a robust NN control scheme for diving behavior of an autonomous underwater vehicle (AUV) whose dynamics can be simplified as a second-order TITO (two-input-two-output) nonlinear function. Because of singularity problem, above dynamics can't be properly solved using general backstepping method although it is in a well known strict-feedback form. Furthermore, the dynamics is in an interactive form so the traditional noninteracting control methods also can not be directly applied. In this paper, the value of one of two virtual inputs is derived from predefined vehicle's desired trajectory instead of stability point of view so the singularity problem can be avoided. Proposed scheme can guarantee all of the signals in the closed-loop system are semi-global uniformly ultimately bounded (SGUUB).

FrC07.4: 16:30-16:50
Adaptive Integral Position Control Using RBF Neural Networks for Brushless DC Linear Motor Drive, pp. 3188-3193

Tsai, Ching-Chih — National Chung-Hsing Univ.
Lin, Shui-Chun — National Chung-Hsing Univ.
Cheng, Tai-Shen — Victor Taichung Company

The paper presents an adaptive integral position controller using RBF (Radial Basis Function) neural networks (NNs) for a brushless DC linear motor. By assuming that the upper bounds of the nonlinear friction and force ripple, an RBF NN is used for approximating the friction, the force ripple and the load; an adaptive backstepping control with integral action is then proposed to achieve position tracking of the linear motor. The parameter adjustment rules for the overall controller are derived via the Lyapunov stability theory. Based on the LaSalle-Yoshizawa lemma, the proposed controller is proven asymptotically stable. Experimental results are conducted to show the efficacy and usefulness of the proposed control method.

FrC07.5: 16:50-17:10
*A New Sequential Learning Algorithm for RBF Networks and Application to Real-Time System Identification**

Yin, Jianchuan — Dalian Maritime Univ.
Dong, Fang — Dalian Maritime Univ.
Wang, Nini — Dalian Maritime Univ.

FrC07.6: 17:10-17:30
*Adaptive Radial Basis Function (RBF) Neural Networks for On-Line Identification**

Kasiri, Sepideh — Petroleum Univ. of Tech.

FrC08 Room 2607
Time Delay Systems (Regular Session)

Chair: Furtmueller, Christian — Johannes Kepler Univ.
Co-Chair: Niculescu, Silviu-Iulian — Univ. of Tech. Compiegne

FrC08.1: 15:30-15:50
A Separation Principle Associated with Sensor Time Delay Compensation in Feedback Control, pp. 3194-3199

Kwok, Wilfred Wai-Fung — Univ. of Waterloo
Davison, Daniel E. — Univ. of Waterloo

Motivated by recent research into the automation of radiotherapy for the treatment of cancer, this paper looks at feedback control problems where the feedback sensor introduces a time delay. As in previous work, the use of an asymptotic estimator (for example, an observer-based estimator) is considered as a method of compensating for the sensor time delay. The main result in this paper is that, if such a delay compensation strategy is used, a separation principle holds which allows the designer to independently design the feedback controller and the time-delay compensator. The radiotherapy problem is used as a case study to show how the separation principle can be exploited in design.

FrC08.2: 15:50-16:10
Further Remarks on Stability Crossing Curves for SISO Systems Controlled by Delayed Output Feedback, pp. 3200-3205

Morarescu, Irinel Constantin — Univ. of Tech. Compiegne
Niculescu, Silviu-Iulian — Univ. of Tech. Compiegne

This work focusses on the characterization of the stability crossing curves in the parameter space defined by the pair (gain, delay) for a class of SISO systems subject to delayed output feedback. The frequency-domain approach considered in this paper makes use of some geometric arguments, which simplifies the understanding of the stabilizing delay mechanism. Various examples complete the presentation.

FrC08.3: 16:10-16:30
Disturbance Suppression for an Industrial Level Control System with Uncertain Input Delay and Uncertain Gain, pp. 3206-3211

Furtmueller, Christian — Johannes Kepler Univ. Linz
del Re, Luigi — Johannes Kepler Univ. Linz

A controller to suppress periodic disturbances on an industrial level control system has been designed. The plant is located in a heavily disturbed environment and has parameter uncertainties and an unknown input delay. The controller has been designed for an integral plant with unknown input delay and unknown gain to adaptively suppress disturbances at the input of the integrator. It is assumed that an estimate of the disturbance can be measured, as it was the case in our industrial plant, and that the disturbance can be predicted ahead in time for at least the input delay time of the system. The resulting controller consists of a standard feedback controller and an 'adaptive plug-in controller' to explicitly compensate for the disturbance. The algorithm is appropriate to use the conventional controller already implemented on the plant and simply add the 'adaptive plug-in'. Simulation results fed by experimental data of the disturbed level control system demonstrate the success of the method in practice.

FrC08.4: 16:30-16:50
Disturbance Attenuation of 2-D Control Systems with Delays Via Observers, pp. 3212-3217

Izuta, Guido — Yonezawa Women's Coll.

The aim of this work is to investigate how to establish a 2-d observer based control system under the disturbance attenuation constraint. The model of the system to be controlled is endowed with components carrying past

information, which in the ordinary 1-d control systems correspond to the delays. This fact makes the work unique in the sense that reports on this issue are still not available in the literature, to the best of author's knowledge. In this paper, we adopt the Lyapunov method approach and furthermore make use of the linear matrix inequality (LMI) formalism to put the results in the computational context. Thus, the energy function introduced will play the key role in this study.

FrC08.5: 16:50-17:10
Design of Reduced-Order Observers for Neutral Time-Delay Systems, pp. 3218-3222
Fernando, Tyrone Lucius — Univ. of Western Australia
Trinh, Hieu Minh — Deakin Univ.

This paper presents a method for the design of reduced-order observers for a class of linear time-delay systems of the neutral-type. Conditions for the existence of reduced order observers that are capable of asymptotically estimating any given function of the state vector are derived. A step-by step design procedure is given for the determination of the observer parameters. A numerical example is given to illustrate the design procedure.

FrC08.6: 17:10-17:30
Robust Stability and Stabilization for a Class of Uncertain Lur'e Singular Delay Systems Based on Non-Direction Robot, pp. 3223-3228
Meng, Qingsheng — Hangzhou Dianzi Univ.
Xue, Anke — Hangzhou Dianzi Univ.
Li, Deyi — Hangzhou Dianzi Univ.
Lu, Renquan — Hangzhou Dianzi Univ.

This paper deals with the problem of delay dependant robust stability and stabilization for a class of Lur'e singular system based on the models of kinematic and dynamics of non-direction robot system. The conception 'non-direction' is firstly proposed and then the principle of the non-direction robot motion is analyzed. The synthesis problem addressed is to design a memoryless state feedback control law such that the resulting closed-loop system is regular, impulse free and asymptotically stable for all admissible uncertainties. An example is given to demonstrate the effectiveness of the presented method.

FrC09 Room 0999
Various Applications II (Regular Session)
Chair: Singh, Tarunraj — State Univ. of New York at Buffalo
Co-Chair: Novakovic, Branko — Univ. of Zagreb

FrC09.1: 15:30-15:50
Micropositioning Control Using Shape Memory Alloys, pp. 3229-3234
Asua, Estibalitz — Univ. del Pais Vasco
Etxebarria, Victor — Univ. del Pais Vasco
García-Arribas, Alfredo — Univ. del Pais Vasco

Shape memory alloys (SMA) are materials whose dimensions can be modified due to a temperature-dependent structural phase transition. This property can be used to generate motion or force in electromechanical devices and micro-machines. However, the accuracy of SMA actuators is severely limited by their highly nonlinear stimulus-response characteristics. In this work an experimental micropositioning device, based on a Ni-Ti alloy wire, is controlled. Several control strategies are experimented and position accuracies around one micron are achieved.

FrC09.2: 15:50-16:10
High Precision Point-To-Point Maneuvering of an Experimental Structure Subject to Friction Via Adaptive Impulsive Control., pp. 3235-3240
Kased, Rajaey — State Univ. of New York at Buffalo
Singh, Tarunraj — State Univ. of New York at Buffalo

Two adaptive pulse control schemes, PWC and PAPWC, are implemented on the rigid body subject to friction. Results show that the PAPWC control yields more accurate results than the PWC. It is further shown that the convergence of the experimental setup depends on the encoder resolution and both techniques will eventually converge. If the convergence tolerance is set smaller than the encoder resolution, the PWC will result in an infinite limit cycle, whereas the PAPWC will cause the system to get stuck outside the tolerance level.

FrC09.3: 16:10-16:30
Control for Induction Motor Fed by Five Level Inverter with Sliding Mode Observer, pp. 3241-3246
Boukhnifer, Moussa — ENSI Bourges
Chaib, Salim — ENSI Bourges

In This paper, a technique of robust control for an induction motor is presented. This motor is fed by five-level inverter controlled by the triangulo-sinusoidal strategy with four bipolar carriers. The control algorithm uses robust regulators calculated by the H infinity loop shaping approach associated with indirect field oriented control. The sliding mode observer is used to observe the rotor flux in the induction motor. The simulation results show that the controllers stabilize the system and reject the disturbances when the system is subjected to uncertainties, which theirs norms are lower than the maximum stability margin.

FrC09.4: 16:30-16:50
A Multimodel Regulation Scheme for a Tunnel-Diode Trigger Circuit - Extension to the Use of Butterworth and Chebyshev Filters, pp. 3247-3252
Bilbao-Guillerna, Aitor — Univ. del Pais Vasco
de la Sen, Manuel — Univ. del Pais Vasco
Alonso Quesada, Santiago — Univ. del Pais Vasco
Ibeas-Hernandez, Asier — Univ. del Pais Vasco

A multimodel scheme is designed for a tunnel-diode circuit. It improves the transient response in a transition or switching from a system equilibrium point to another one. Each model is obtained by a linearization of the circuit near an equilibrium point. Each of these models can be described as a combination of two other transfer functions describing the plant behavior near two different nominal equilibrium points. The scheme selects online the linear model of the circuit with the best tracking performance in order to generate the control law. Some simulations show the usefulness of this regulation strategy.

FrC09.5: 16:50-17:10
Passive Internal Model Based Repetitive Control of Robot Manipulators, pp. 3253-3258
Kasac, Josip — Univ. of Zagreb
Novakovic, Branko — Univ. of Zagreb
Majetic, Dubravko — Univ. of Zagreb
Brezak, Danko — Univ. of Zagreb

In this paper a new class of globally stable finite dimensional repetitive controller for robot manipulator is proposed. The passivity based design of the proposed repetitive controller avoid the problem of tight stability conditions and slow convergence of the conventional, internal model based, repetitive controllers. The passive interconnection of the controller with nonlinear mechanical systems provide stability margin which is the same as stability margin of the controller with exact feed-forward compensation of robot dynamics. The simulation results illustrate the convergence properties of the proposed controller.

FrC09.6: 17:10-17:30
Methods for Salient Frescoes Selection Based Mobile Robots Navigation, pp. 3259-3264
Pradel, Gilbert — Univ. d'Evry Val d'Essonne
Bogdanov, Ivan — Univ. Pol. Timisoara
Caleanu, Catalin — Univ. Pol. Timisoara

In this paper we consider the problem of non-metric/qualitative environment representation for frescoes based autonomous robot navigation. Within this framework, the problem of selecting meaningful set of frescoes and some possible solutions are analysed and compared. Experimental results using six different approaches (resemblance, barycentre, Hamming and Levenshtein distances, cross-correlation and selforganizing feature map neural network) are also provided.

FrC10 Room 3999

Fault Diagnosis (Regular Session)

Chair: Talebi, H.A. Amirkabir Univ. of Tech.
Co-Chair: Bennani, Samir European Space Agency

FrC10.1: 15:30-15:50
Embedded Estimation of Fault Parameters in an Unmanned Aerial Vehicle, pp. 3265-3270
Samar, Sikandar Stanford Univ.
Gorinevsky, Dimitry Stanford Univ.
Boyd, Stephen P. Stanford Univ.

In this paper, we present a model-based approach for estimating fault conditions in an aircraft. We formulate fault estimation as a convex optimization problem, where estimates are obtained by solving a constrained quadratic program (QP). A moving horizon framework is used to enable recursive implementation of the constrained QP of fixed size. The estimation scheme takes into account a priori known monotonicity constraints on the faults. Monotonicity implies that the fault conditions can only deteriorate with time. We validate the proposed estimation scheme on a detailed nonlinear simulation model of the Aerosonde unmanned aerial vehicle (UAV) in the presence of winds and turbulence. An excellent performance of the developed approach is demonstrated.

FrC10.2: 15:50-16:10
Fault Diagnosis Method Using a Signed Digraph for Multiple Origins of Failures, pp. 3271-3276
Tateno, Shigeyuki Waseda Univ.
Matsuyama, Hisasyoshi Waseda Univ.
Tsuge, Yoshifumi Kyushu Univ.

A fault diagnosis algorithm using a signed digraph as a model of a system is useful to real-time diagnosis of failures that occur in a chemical plant. It has been improved so much that it can find multiple origins of failures that occur in the plant at the same time. It is imperative that the diagnosis system be evaluated in the design phase of the system in advance for its practical use. In this paper, an accuracy of diagnostic results using the algorithm for multiple origins has been examined by its application to data obtained by the simulation of tank pipeline systems. The accuracy of diagnosis has been evaluated properly by the size of the greatest set of candidates.

FrC10.3: 16:10-16:30
Air Data Failure Management in a Full-Authority Fly-By-Wire Control System, pp. 3277-3281
Schettini, Francesco Univ. of Pisa
Calia, Alberto Univ. of Pisa
Poggi, Veronica Univ. of Pisa

The aim of the air data system, in a Full-Authority Fly-by-Wire Control System, is the determination of flight parameters, such as pressure altitude, Mach number, angles of attack and sideslip, from measurements of local pressures and of local flow angles on wings or fuselage, provided by a proper set of sensors. The architecture of the air data system is redundant in order to achieve the adequate level of reliability and safety. In this paper a possible methodology for the management of the redundancies of the air data system is described, which has been developed with reference to the air data system of the new jet trainer Aermacchi M-346. The developed algorithms identify the possible failures and provide an adequate system reconfiguration by comparing different estimates of the flight parameters. In addition, such algorithms are able to manage temporary situations where one or more sensors do not provide reliable measurements since they are in the wake of the fuselage.

FrC10.4: 16:30-16:50
An Intelligent Fault Detection and Recovery Scheme for Reaction Wheel Actuator of Satellite Attitude Control Systems, pp. 3282-3287
Talebi, H.A. Amirkabir Univ. of Tech.
Patel, Rajni Univ. of Western Ontario

In this paper, a Fault Detection and Recovery scheme is proposed for a reaction wheel type actuator of satellite attitude control systems. A state-space approach is used and a nonlinear-in-parameters neural network (NLPNN) is employed to identify the general unknown fault. The estimated fault is then used to reconfigure the controller. The recurrent network configuration is obtained by a combination of feedforward network architectures and dynamical elements in the form of stable filters. The neural network weights are updated based on a modified backpropagation scheme. The stability of the overall fault detection scheme is shown using Lyapunov's direct method. The effectiveness of the proposed fault diagnosis strategy is demonstrated via simulations carried out on a highly accurate dynamical model of a reaction wheel actuator.

FrC10.5: 16:50-17:10
Fault Tolerant Control of the B747 Short-Period Mode Using Progressive Accommodation, pp. 3288-3294
Ciubotaru, Bogdan Pol. Univ. of Bucharest
Staroswiecki, Marcel Univ. de Lille

Linear Quadratic design for the fault tolerant control of the short-period mode of the longitudinalmodel of the Boeing 747 aircraft is investigated. Under actuator faults, both fault accommodation and system reconfiguration procedures need the controller to be re-designed, which means solving the Algebraic Riccati Equation (ARE) associated with the post-fault system model. To overcome the risks of system instability and/or control inadmissibility, which result from fault detection and isolation delay, and computation time of the accommodated control, a progressive accommodation strategy, based on the Newton-Raphson algorithm for solving AREs, is used. The application shows the benefits associated with this approach.

FrC10.6: 17:10-17:30
Integrated vs Decoupled Fault Detection Filter & Flight Control Law Designs for a Re-Entry Vehicle, pp. 3295-3300
Castro, Helena European Space Agency
Bennani, Samir European Space Agency
Marcos, Andres Deimos Space S.L.

An integrated design of a robust fault detection filter and control system for a re-entry vehicle is presented. The integrated architecture is based on the four-block Youla parametrization which allows to better and directly tradeoff filter and control design objectives in the face of disturbances and uncertainties. H-infinity optimization techniques are used to design the integrated controller/filter system for a re-entry vehicle with actuator faults in the transonic flight regime where the aerodynamics are highly uncertain. Finally the resulting integrated controller/filter properties are compared with a decoupled fault detection filter and flight control designs. The integrated design obtained successfully identifies the desired faults for the nominal and uncertain cases. Moreover, the integrated design minimizes the faults effects on the system response better than the decoupled design. Lastly, it is clearly shown that the actuator activity is directly related with the faults introduced.

FrC11 Audimax

Biosystems & Environmental Control (Regular Session)

Chair: Pietrabissa, Antonio Univ. of Rome La Sapienza
Co-Chair: Duncan, Stephen Univ. of Oxford

FrC11.1: 15:30-15:50
Modeling the Cell Cycle of Fission Yeast by Means of Piecewise Linear System, pp. 3301-3305
Amato, Francesco Univ. degli Studi Magna Graecia di Catanzaro
Bansal, Mukesh Telethon Inst. of Genetics and Medicine
Cosentino, Carlo Univ. degli Studi Magna Graecia di Catanzaro
Curatola, Walter Univ. degli Studi Magna Graecia di Catanzaro
di Bernardo, Diego Telethon Inst. of Genetics and Medicine

Biological process modeling requires the use of a non-linear description. On the other hand, experimental data suggest that the behavior of many biological systems can be

described with good approximation by means of piecewise Linear Time-Invariant (LTI) models. On the basis of these considerations, the present work focuses on the problem of analyzing a set of experimental data and identifying the points where discontinuous phenomena occur. A validation of the technique is provided exploiting the well established cell cycle model of fission yeast by Novak and Tyson.

FrC11.2: 15:50-16:10

Black-Box Modelling Approaches for the Prediction of Microbiological Bacterial Growth, pp. 3306-3311

Poli, Cecilia Univ. of Rome La Sapienza
Pietrabissa, Antonio Univ. of Rome La Sapienza

This paper presents two black-box modelling approaches for predicting bacterial growth curves; the two approaches are developed and compared by using Support Vector Machines (SVM): the first approach is aimed at predicting the parameters of an already existing model from the available measures, whereas, in the second approach, the resulting SVM itself plays the role of the model. The simulations are based on real experimental data, show that the two approaches have similar prediction capabilities but have different characteristics, which suggest the use of the most appropriate approach depending on the availability of a reliable parametric model.

FrC11.3: 16:10-16:30

Using the EM Algorithm to Estimate the Disease Parameters for Smallpox in 17th Century London, pp. 3312-3317

Duncan, Stephen Univ. of Oxford
Gyongy, Miklos Univ. of Oxford

In predicting the spread of a disease such as smallpox, knowledge of R0, the transmission parameter in a population of susceptibles is important. Previous studies have estimated R0 from outbreaks of the disease, but these estimates are prone to uncertainties due to the small population sizes and the short data runs. This study uses data from smallpox deaths in London over the period 1708 to 1748. Although smallpox was endemic in the population at this time, by using the EM algorithm to estimate the parameters of an age-structured nonlinear model of the disease dynamics, an estimate of R0 is obtained. The algorithm exploits the structure of the model in which the parameter vector is affine, once estimates of the states have been obtained from an extended Kalman smoother. The model also reveals the importance of temperature and rainfall on the transmissibility of the disease.

FrC11.4: 16:30-16:50

Identifiability of a Pollution Source: The Distributed Model and the Semi-Discretized Differential Model, pp. 3318-3323

Verdiere, Nathalie Univ. of Tech. Compiegne
Joly-Blanchard, Ghislaine Univ. of Tech. Compiegne
Denis-Vidal, Lilianne Univ. of Lille

This paper is devoted to the identification of a pollution source in a river. A simple mathematical model of such a problem is given by a one-dimensional linear advection-dispersion-reaction equation with a right hand side spatially supported in a point (the source) and a time variant intensity, both unknown. The identifiability of the distributed system was established for two points of observations one upstream, the other downstream from the source provided the pollutant flow rate is zero on an interval [T,T+delta T] (T>0). But the distributed system has to be discretized in order to do a numerical estimation of the unknown parameters. It is why this paper is devoted to the identifiability of the differential system obtained by using a semi-discretization scheme in space. The proof of the identifiability does not require the restrictive assumption about the pollutant flow rate but the knowledge of the initial condition and one observation located upstream from the source. Moreover, from this study, a numerical procedure is deduced for estimating the unknown parameters. It does not necessitate a priori knowledge about the parameters and the unknown function is not expanded on a basis of special functions. Both aspects play an important role in the real applications.

FrC11.5: 16:50-17:10

Effective Treatment of Infectious Diseases: A Nonlinear Adaptive Control Theoretic Approach, pp. 3324-3329

Padhi, Radhakant Indian Inst. of Science Bangalore
Bhardhwaj, Jayender Indian Inst. of Tech. Madras

A nonlinear adaptive system theoretic approach is presented in this paper for effective treatment of infectious diseases that affect various organs of the human body. The generic model used does not represent any specific disease. However, it mimics the generic immunological dynamics of the human body under pathological attack, including the response to external drugs. From a system theoretic point of view, drugs can be interpreted as control inputs. Assuming a set of nominal parameters in the mathematical model, first a nonlinear controller is designed based on the principle of dynamic inversion. This treatment strategy was found to be effective in completely curing “nominal patients”. However, in some cases it is ineffective in curing “realistic patients”. This leads to serious (sometimes fatal) damage to the affected organ. To make the drug dosage design more effective, a model-following neuro-adaptive control design is carried out using neural networks, which are trained (adapted) online. From simulation studies, this adaptive controller is found to be effective in killing the invading microbes and healing the damaged organ even in the presence of parameter uncertainties and continuing pathogen attack.

FrC11.6: 17:10-17:30

Waste Disposal System and Its Modeling of Disposable Diapers, pp. 3330-3335

Yeh, Yichun Waseds Univ.
Ogai, Harutoshi Waseda Univ.
Yui, Ryouta Waseda Univ.
Morita, Hiroshi Kitakyushu Univ.
Takabayashi, Yukinori One Dream Co., Ltd

As an aging society is a tendency in the future, the production of disposable diaper has been increased year by year. It is believed that the problem of the disposal of diapers will be becoming a great problem in the future. For waste reduction, a new disposal technique for the used disposable diapers by the pair conditions of microorganisms, cryptomeria chips and ALGA is purposed. In this paper, we showed that microorganisms living with the cryptomeria chips have effect on the decomposition of the disposable diapers. A disposal process model of disposable diapers is built according to the results of experiments.

FrKPL Audimax

Keynote Lecture: Christian Philippe (Plenary Session)

Chair: Maciejowski, Jan M. Univ. of Cambridge/EUCA

FrKPL: 17:40-18:30

*ESA Perspectives on Advanced Control Technology for Complex Space Systems**

Philippe, Christian European Space Agency

Prior to any space vehicle development it is crucial in the very early stage of the project to understand the dynamical behaviour and achievable system performance. The theory and tools offered by system theory allow us to model, simulate and manipulate complex system characteristics until satisfactory behaviour is obtained. Underlying to this is a control design process that in a multidisciplinary setting will iteratively dictate the architecture of system to be designed. In order to manage uncertainty and complexity, fundamental design tools based on recent advanced control techniques are used to support this process. These tools are generic and allow responding in a flexible way to various mission needs. This will be illustrated on a spectrum of ESA missions where Systems & Control are fundamental. For some challenging space missions the main control design drivers will be highlighted by means of illustrated design examples. The experience and results achieved with advanced modelling and control techniques will be reviewed. Based on this experience an integrated view on control technology will be given, seen from an experimental perspective and highlight potential directions for the improvement of the management of complex space systems.

Index of authors, chairs and organizers

Keys: C = Chair, CC = Co-Chair, O = Organizer, PL = Plenary Speaker, KL = Keynote Speaker

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Sponsors

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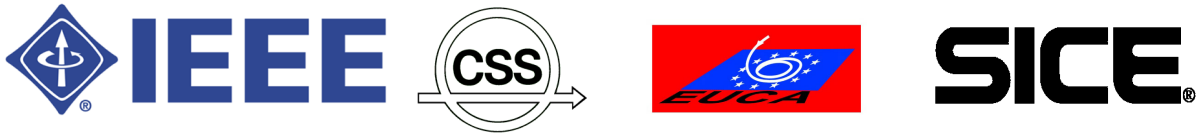

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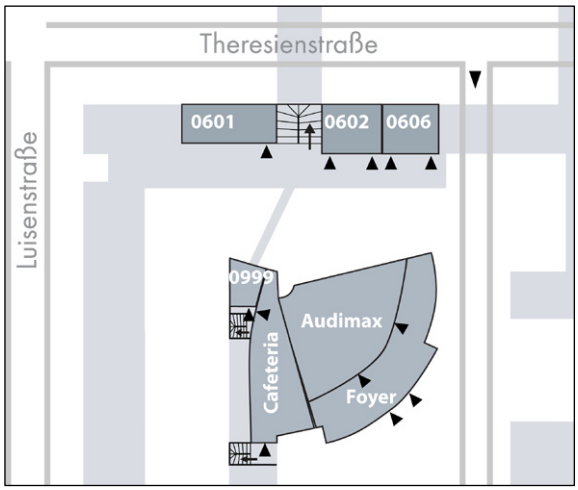
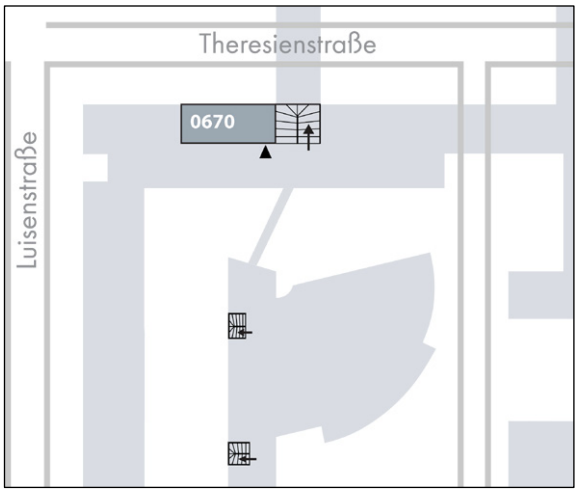
2006 CCA/CACSD/ISIC Conference Venue

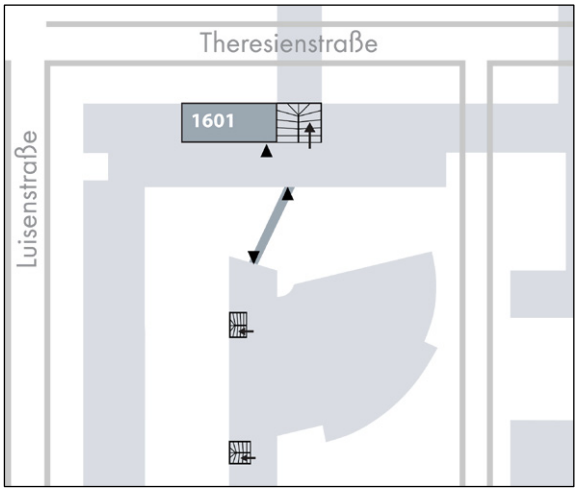
Ground Floor



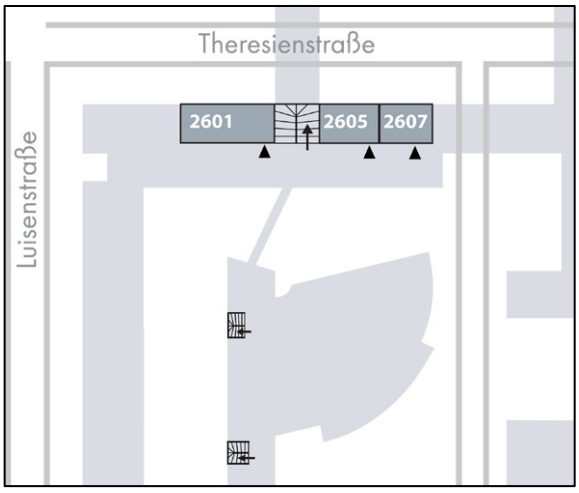
Intermediate Level



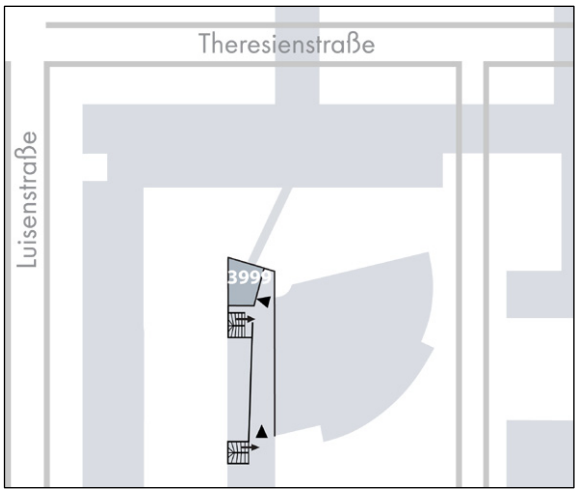
First Floor

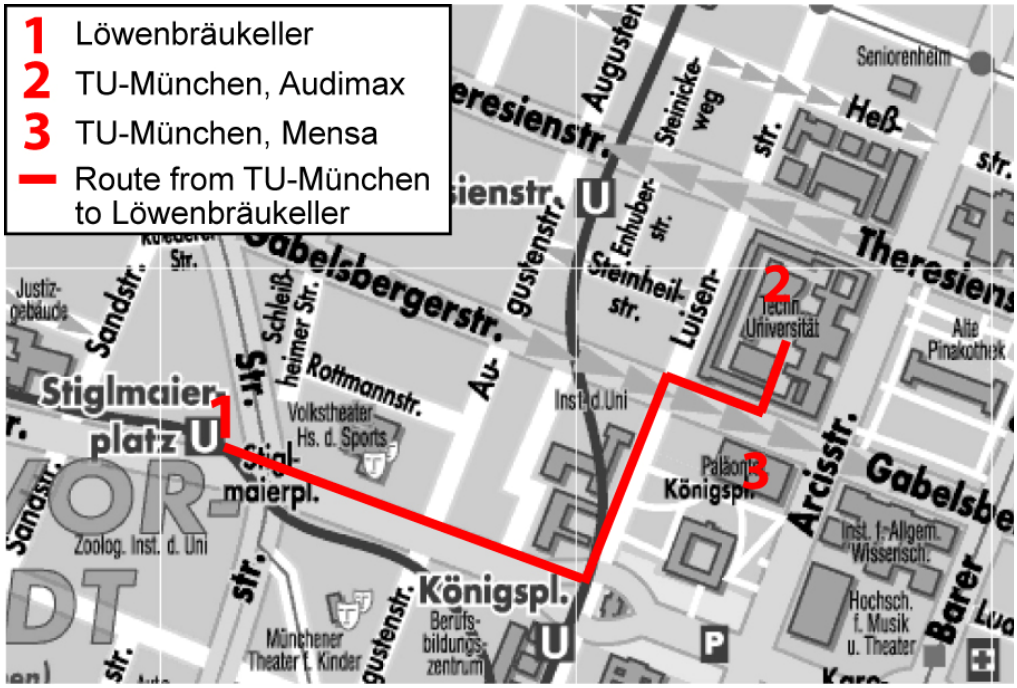


Second Floor



Third Floor





Tutorial Workshops: Tuesday, October 3, 2006
8:15 – 17:00, TU - München

Opening Reception: Tuesday, October 3, 2006
17:00 – 19:00, Foyer Audimax

Conference Banquet: Thursday, October 5, 2006
19:30 – 23:00, Löwenbräukeller
(follow route above)

Farewell Reception: Friday, October 6, 2006
18:30 – 20:00, Foyer Audimax

Lunch opportunity: October 4-6, 2006
11:00 – 13:45, University Mensa
(tickets available at Registration Desk)