

# Mioara Maria Joldes

<http://homepages.laas.fr/mmjoldes/>  
LAAS-CNRS  
7, avenue du Colonel Roche  
BP 54200  
31031 Toulouse cedex 4

Phone: (+33) (0)5 61 33 69 26  
E-mail: [joldes@laas.fr](mailto:joldes@laas.fr)

## Personal Details:

Born August 1984; Romanian nationality.

## Work:

Jan 2013 - CNRS Researcher (CR2, Section 06) in MAC Team, LAAS-CNRS, Toulouse, France.  
2011 - 2013 Postdoctorant, Computer-aided proofs in analysis (CAPA) Team, Mathematics Department, Uppsala Univ., Sweden.

## Education

2008 -2011 **PhD in Computer Science** at École Normale Supérieure de Lyon.  
Mention: Très Honorable. Thesis subject: *Rigorous polynomial approximations and applications*.  
Phd advisors: Nicolas Brisebarre and Jean-Michel Muller.  
2007 - 2008 **Master Diploma in Computer Science** at École Normale Supérieure de Lyon.  
Mention: Good. Master report subject: *Computation of various infinite norms, in one or several variables, for the development of mathematical libraries*. Supervisors: Nicolas Brisebarre and Jean-Michel Muller.  
2003 - 2008 **Engineer Diploma** obtained in June 2008 from Technical University of Cluj-Napoca, Computer Science Department, English Section, grade 10/10.

## Research Themes, Results and Objectives

*Rigorous computing (validated computing)*: use numerical computations, but provide mathematical statements about the obtained result, such as sure, yet reasonably tight, error bounds. Build efficient symbolic-numeric objects, algorithms and software tools with direct applications in control of dynamical systems (direct and indirect optimal control, hybrid control) and in particular in the aerospace domain. Use and develop expertise and ideas from *Computer Arithmetic, Computer Algebra, Dynamical Systems*.

A. *Towards Fast and Certified Multiple Precision Arithmetic Libraries*: develop a multiple precision arithmetic library tuned for Graphics Processing Units (GPUs). Targets high-performance computing problems which require multiple precision e.g., the study of strange attractors such as the Hénon attractor [2]. Use *floating-point expansions* that is, extended precision is represented as the unevaluated sum of standard machine floating-point numbers.

Recent results: new efficient and accurate (with proven error bounds) algorithms for normalization, division and sqrt [6], [3]. Used our library in a computer assisted proof for massive parallel search of sinks for the Hénon map [2].

Objectives: formally proven algorithms, elementary functions implementation.

B. *Rigorous Polynomial Approximation (RPA)*: a polynomial approximation together with rigorous error bounds. Use *Taylor Models* [1, 12, 13, 7] and *Chebyshev polynomial interpolation/series Models* [9], [17, Chap. 4]. Adapt to rigorous computations many numerical algorithms based on Chebyshev/Taylor Series for solving ordinary differential equations, quadrature, etc.

Recent results: compute rigorous uniform approximations based on Chebyshev Series for *D-finite functions*, i.e. solutions of ordinary differential equations with polynomial coefficients [18] e.g., erf, exp, sin, Bessel, Airy functions; efficient computations of supremum norms of approximation errors [1]; formally proven Taylor Models [7].

Objectives: efficient implementation of operations with Chebyshev Models, extensions to multivariate functions; efficient finite precision evaluation of power series.

C. *Applications to Optimal Control and Aerospace*.

Recent results: we proposed a new accurate, reliable and efficient method to compute a *certified orbital collision probability* between two spherical space objects involved in a short-term encounter under Gaussian-distributed uncertainty. In this model of conjunction, the probability of collision is reduced to the integral of a 2D Gaussian probability density function over a disk. Our computational method is based on an analytic expression for the integral, derived by use of *Laplace transform* and *D-finite functions* [4, 5, 19].

On going works: Validated methods for high dimensional Gaussian-like integrals; Validated impulsive spacecraft rendezvous; Certifying stability of linear differential equations with polynomial coefficients.

**Thematic Mobility:** (1) During my post-doctorate in a Dynamical Systems Team (pure Mathematics), I applied Computer Arithmetic and High Performance Computing related concepts for improving the speed and reliability of computational methods used in computer assisted proofs (see Sec. A above). (2) Since January 2013, I joined MAC –Methods and Algorithms in Control– Team, which does research in the field of systems and control theory. This is an emergent natural outlet for reliable computations: I aim to develop symbolic-numeric objects and algorithms for improving the numerical reliability of control laws analysis and synthesis for systems including uncertainties, disturbances and nonlinearities. I focus mainly on validated optimal control methods applied in aerospace (see Sec. C above).

## Research Projects

**ANR FASTRELAX:** *Fast and Reliable Approximation*, 60 months, 600kEuros, starting October 2014. I am the scientific responsible of the LAAS-CNRS research partner, with a participation ratio of 28.6 person.month. Other partners: INRIA Centre Grenoble Rhône-Alpes, INRIA Saclay-Idf, INRIA - Centre Sophia Antipolis - Méditerranée, Université Pierre et Marie Curie (UPMC) - Paris 6. Head of the project: Bruno Salvy (Inria, AriC, Lip).

**ANR VORACE:** *Verification of fast optimization algorithms applied in critical embedded control*, ANR Astrid Project, 300kEuros, 36 months. I am a participant since September 2013. Other partners: INPT, ONERA, Rockwell Collins France. The goal is assess the possibility of porting complex optimization algorithms in critical embedded systems. For this we use formal verification techniques. Head of project: Marc Pantel (ENSEEIH, IRIT, ACADIE Team).

**Research collaboration contract with Airbus Defence and Space (formerly known as Astrium):** *Méthodes d'optimisation probabiliste pour l'évitement de collision spatiale*, head of project: Denis Arzelier (MAC Team); I am a member since September 2014.

## Collaboration with Academic Partners

**CAPA Team, Uppsala, Sweden** Since 2011 I collaborate with Computer Aided Proofs in Analysis (CAPA) team, Mathematics Department, Uppsala, Sweden. I work with Prof. Warwick Tucker for solving problems in Discrete Dynamical Systems in with the help of high performance computing. For that, we do mutual visits and research seminars.

**AriC Team, LIP, Lyon** I tightly collaborate with AriC Team in various projects (thesis of V. Popescu, ANR FastRelax) related to Computer Arithmetic and Computer Algebra (N. Brisebarre, J.-M. Muller, V. Popescu, B. Salvy). We hope that this collaboration will result in a broader visibility, understanding and application of arithmetic and computer algebra techniques for the automatic control community.

**Pequan Team, LIP6, Paris** I collaborated with my co-authors M. Mezzarobba and Ch. Lauter in the field of validated methods using truncated power or Chebyshev series.

## Publications

### International peer-reviewed journals

- [1] Sylvain Chevillard, John Harrison, Mioara Joldes, and Christoph Lauter. Efficient and accurate computation of upper bounds of approximation errors. *Theoretical Computer Science*, 16(412):1523–1543, 2011.
- [2] Mioara Joldes, Valentina Popescu, and Warwick Tucker. Searching for sinks for the Hénon map using a multipleprecision GPU arithmetic library. *SIGARCH Comput. Archit. News*, 42(4):63–68, December 2014.
- [3] Mioara Joldes, Olivier Marty, Jean-Michel Muller, and Valentina Popescu. Arithmetic algorithms for extended precision using floating-point expansions. *IEEE Transactions on Computers*, 2015. In print, doi: 10.1109/TC.2015.2441714, <https://hal.archives-ouvertes.fr/hal-01111551>.

### Publications in the peer-reviewed proceedings of international conferences

- [4] Romain Serra, Denis Arzelier, Mioara Joldes, Jean-Bernard Lasserre, Aude Rondepierre, and Bruno Salvy. A new method to compute the probability of collision for short-term space encounters. In *Astrodynamics Specialist Conference*, pages 1–7, Aug 2014.
- [5] Romain Serra, Denis Arzelier, Mioara Joldes, and Aude Rondepierre. Probabilistic collision avoidance for long-term space encounters via risk selection. In *3rd CEAS European Aerospace Guidance, Navigation and Control (EuroGNC) Conference*, pages –21, Dec 2014.
- [6] Mioara Joldes, Jean-Michel Muller, and Valentina Popescu. On the computation of the reciprocal of floating point expansions using an adapted Newton-Raphson iteration. In *IEEE 25th International Conference on Application-Specific Systems, Architectures and Processors, ASAP 2014, Zurich, Switzerland, June 18-20, 2014*, pages 63–67. IEEE, 2014.
- [7] Nicolas Brisebarre, Mioara Joldes, Érik Martin-Dorel, Micaela Mayero, Jean-Michel Muller, Ioana Pasca, Laurence Rideau, and Laurent Théry. Rigorous polynomial approximation using Taylor Models in Coq. In Alwyn Goodloe and Suzette Person, editors, *NASA Formal Methods - 4th International Symposium, NFM 2012, Norfolk, VA, USA, April 3-5, 2012. Proceedings*, volume 7226 of *Lecture Notes in Computer Science*, pages 85–99. Springer, 2012.
- [8] Nicolas Brisebarre, Mioara Joldes, Peter Kornerup, Érik Martin-Dorel, and Jean-Michel Muller. Augmented precision square roots and 2-d norms, and discussion on correctly rounding  $\sqrt{x^2+y^2}$ . In Elisardo Antelo, David Hough, and Paolo Ienne, editors, *20th IEEE Symposium on Computer Arithmetic, ARITH 2011, Tübingen, Germany, 25-27 July 2011*, pages 23–30. IEEE Computer Society, 2011.
- [9] Nicolas Brisebarre and Mioara Joldes. Chebyshev interpolation polynomial-based tools for rigorous computing. In Wolfram Koepf, editor, *Symbolic and Algebraic Computation, International Symposium, ISSAC 2010, Munich, Germany, July 25-28, 2010, Proceedings*, pages 147–154. ACM, 2010.
- [10] Florent de Dinechin, Mioara Joldes, and Bogdan Pasca. Automatic generation of polynomial-based hardware architectures for function evaluation. In François Charot, Frank Hannig, Jürgen Teich, and Christophe Wolinski, editors, *21st IEEE International Conference on Application-specific Systems Architectures and Processors, ASAP 2010, Rennes, France, 7-9 July 2010*, pages 216–222. IEEE, 2010.
- [11] Florent de Dinechin, Mioara Joldes, Bogdan Pasca, and Guillaume Revy. Multiplicative square root algorithms for FPGAs. In *International Conference on Field Programmable Logic and Applications, FPL 2010, August 31 2010 - September 2, 2010, Milano, Italy*, pages 574–577. IEEE, 2010.
- [12] Sylvain Chevillard, Mioara Joldes, and Christoph Quirin Lauter. Sollya: An environment for the development of numerical codes. In Komei Fukuda, Joris van der Hoeven, Michael Joswig, and Nobuki Takayama, editors, *Mathematical Software - ICMS 2010, Third International Congress on Mathematical Software, Kobe, Japan, September 13-17, 2010. Proceedings*, volume 6327 of *Lecture Notes in Computer Science*, pages 28–31. Springer, 2010.
- [13] Sylvain Chevillard, Mioara Joldes, and Christoph Quirin Lauter. Certified and fast computation of supremum norms of approximation errors. In Javier D. Bruguera, Marius Cornea, Debjit Das Sarma, and John Harrison, editors, *19th IEEE Symposium on Computer Arithmetic, ARITH 2009, Portland, Oregon, USA, 9-10 June 2009*, pages 169–176. IEEE Computer Society, 2009.

### Publications in the peer-reviewed proceedings of national conferences

- [14] Mioara Joldes, Valentina Popescu, and Warwick Tucker. Searching for sinks of Hénon map using a multiple-precision GPU arithmetic library. In *Forum des Jeunes Mathématicien-ne-s*, pages –6, Nov 2013.
- [15] Mioara Joldes. When a logarithm is a misspelled algorithm. In *Proceedings of the Association Femmes et mathématiques*, September 2010.
- [16] Florent de Dinechin, Mioara Joldes, Bogdan Pasca, and Guillaume Revy. Racines carrées multiplicatives sur FPGA. In *SYMPosium en Architectures nouvelles de machines (SYMPA)*, Toulouse, September 2009.

### Articles under submission, research reports

- [17] Mioara Joldes. *Rigorous Polynomial Approximations and Applications*. Thesis, École Normale Supérieure de Lyon - ENS LYON, September 2011. <https://tel.archives-ouvertes.fr/tel-00657843>.
- [18] Alexandre Benoit, Mioara Joldes, and Marc Mezzarobba. Rigorous uniform approximation of D-finite functions using Chebyshev expansions. *Submitted for publication to Mathematics of Computation*, July 2014. <https://hal.archives-ouvertes.fr/hal-01022420>.

- [19] Romain Serra, Denis Arzelier, Mioara Joldes, Jean-Bernard Lasserre, Aude Rondepierre, and Bruno Salvy. A power series expansion based method to compute the probability of collision for short-term space encounters. *Under revision at Journal of Guidance, Control, and Dynamics*, 2015. <https://hal.archives-ouvertes.fr/hal-01131384>.
- [20] Romain Serra, Denis Arzelier, Mioara Joldes, and Aude Rondepierre. Probability of collision between spherical space objects for short-term space encounters. Technical report, LAAS-CNRS No. 14154, Mars 2014. Astrium Funding for PhD.
- [21] Nicolas Brisebarre and Mioara Joldes. Rigorous polynomial approximations based on Chebyshev series expansions. *In preparation*, 2015.

## Software

- **CAMPARY** –Cuda Multiple Precision ARithmetic librarY–. Multiple precision arithmetic routines based on Floating-Point Expansions for CPUs/GPUs, written in CUDA C. See <http://homepages.laas.fr/mmjoldes/campary/>. Developed with O. Marty, J.-M. Muller, V. Popescu and W. Tucker. Related articles: [2, 6, 3].
- **Unifapprox** Experimental Maple code for Rigorous Uniform Approximation of D-Finite Functions using Chebyshev Expansions. See <http://homepages.laas.fr/mmjoldes/Unifapprox/>. Developed with A. Benoit and M. Mezzarobba. Related articles: [18].
- **ChebModels**, developed with N. Brisebarre. Collects Maple packages developed for rigorous polynomial approximations to univariate functions. See <http://www.ens-lyon.fr/LIP/Arenaire/Ware/ChebModels/>. Related articles: [9].
- **FloPoCo**. FloPoCo is a generator of arithmetic cores (Floating-Point Cores, but not only) for FPGAs. See <http://www.ens-lyon.fr/LIP/Arenaire/Ware/FloPoCo/>. I developed a small specific part related to computing piecewise polynomial approximations for function evaluation specifically targeted for FPGAs. Related articles: [10, 11].
- **Sollya**. Sollya is a tool environment for safe floating-point code development. It is particularly targeted to the automatized implementation of mathematical floating-point libraries (libm). See <http://sollya.gforge.inria.fr/>. Since 2008 I joined S. Chevillard and Ch. Lauter for developing Sollya’s functionalities mainly related to Taylor models and certified computation of supremum norms of approximation errors. Related articles: [1, 7, 12, 13].

## Invited stays

- **March 2011 and December 2014**: CAPA Group, Uppsala University, Sweden.
- **October 2014 and May 2013**: AriC Team, LIP, Lyon, France.
- **April 2012**: one week at National Institute of Aerospace, Hampton, Virginia, USA.

## Supervision

- Phd Student: Valentina Popescu (started September 2014), collaboration to the thesis supervision with Jean-Michel Muller, AriC, Lyon. Title: *Towards Fast and Certified Multiple Precision Arithmetic Libraries*.
- Master Student: Valentina Popescu, Master 2 Internship, July 2014, *Towards fast and certified multiple-precision libraries*.
- L3 Student: Olivier Marty, L3 Internship, September 2014, *On the computation of the square root of floating-point expansions using an adapted Newton-Raphson iteration*.
- L3 Student: Valentina Popescu, L3 Internship, September 2013, *Efficient arithmetic routines for scientific computing on Graphics Processing Units*.

## PhD Defense Juries

I took part in one PhD Jury: principal opponent (reviewer) of Ferenc M. Bartha thesis, entitled *Computer-aided proofs and algorithms in analysis*, for the PhD-degree of the University of Bergen, Mathematics Department, Norway, June 14, 2013.

## Teaching

2012 *Qualification "Maître de conférences"*, Section CNU 26 (Applied Mathematics); 27 (Informatics).  
 2014 Plenary lectures in the Automatic Control Course of Denis Arzelier at ENSICA, Toulouse: Automatique des systèmes linéaires (L2 level), 5h.

2014 *Travaux Pratiques*, M1 level, Université Toulouse 3, Paul Sabatier: Méthodes et outils de Conception Assisté par Ordinateur. This involves teaching C Language and implementation of some usual numeric methods, 24h.

2015 Plenary lectures in the Automatic Control Course of Denis Arzelier at ENSICA, Toulouse: Automatique des systèmes linéaires (L2 level), 8h.

## Conference Organization

- Organized the Symbolic-Numeric Session of SEAMAC Days: 2 days of seminars, talks and animation with MAC Team and invited speakers.
- Part of the Organization Committee of IFAC –International Federation of Automatic Control– 2017 World Congress which will take place in Toulouse.

## Vulgarization:

Gave talks at Forum des Jeunes Mathématicien-ne-s in 2010 and 2013, see also [15, 14]: broad audience, intended for promoting, encouraging, emphasizing the participation of women in Mathematics.

## Selected Talks

- **June 2015:** Talk at Canadian Mathematical Society Summer Meeting, June 5-8, Charlottetown, P.E.I, Canada.
- **June 2015:** Talk at SIAM 13th International Symposium on Orthogonal Polynomials, Special Functions and Applications, June 1-5, NIST, Gaithersburg MD, USA.
- **December 2014:** Talk at CAPA Project's Seminar, Uppsala University, Sweden.
- **June 2014:** Talk at ASAP Conference, Zurich, Switzerland.
- **February 2014:** Talk at "Mathematical Structures of Computation - Formal Proof, Symbolic Computation and Computer Arithmetic" (SMC2014), Lyon.
- **November 2013:** Talk at "6ème Rencontres Arithmétiques de l'Informatique Mathématique" (RAIM), Paris.
- **November 2013:** Talk at "13ème forum des jeunes mathématicien-ne-s", Lyon.
- **June 2013:** Talk at AriC seminar, LIP, ENS Lyon (France).
- **April 2012:** Talk at National Institute of Aerospace, Hampton, Virginia, USA.
- **November 2011:** Talk at a seminary of MAC Team, LAAS, Toulouse (France).
- **November 2011:** Talk at a seminary of Pequan Team, LIP6, Paris (France).
- **November 2011:** Talk at Journées Nationales de Calcul Formel (JNCF), CIRM, Luminy (France).
- **June 2011:** Talk: *Rigorous uniform approximation of D-finite functions*, at Small Workshop on Interval Methods (SWIM 2011), Bourges, France.
- **April 2011:** Talk: *Automatic generation of polynomial-based hardware architectures for function evaluation*, at Technical University of Cluj-Napoca, Romania.
- **April 2011:** Talk: *Tools for Rigorous Computing using Chebyshev Series Approximations*, at CAPA Project's Seminar, Uppsala University, Sweden.
- **February 2011:** Talk at RAIM'11 : 4èmes Rencontres Arithmétique de l'Informatique Mathématique, Perpignan, France.

## Reviewer

Reviewed articles for the following journals/conferences: Numerical Algorithms Journal, Mathematics in Computer Science Journal, ASAP 2013-2014, Arith20, CIFA2012, ISAAC 2012.

## Awards

- **August 2007.** International master scholarship at ENS Lyon
- **May 2007.** 1st prize at "Diligent Design Contest" for the project "Hexapod Robot with Imaging System" (VHDL design).
- **2000 - 2002** Prises at the National Mathematics Olympiad.