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Airbus Group Innovations
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Research Internship (MSc degree) at Airbus Group Innovations with LAAS co-supervision

Title
Hybrid data/model-driven decision support tooling for assisted health management

Keywords
Deep Learning, Model-Based Reasoning, Prognosis and Diagnosis, Artificial Intelligence, Assisted Maintenance Operations

Subject
Finding failures root causes or predicting the evolution of a system are central topics of health management. Nowadays, there exist mainly algorithmic tools able to automatically analyze previous observations of a system in order to infer the most probable causes of observed failures (diagnosis process) or predict the most probable future states of the system (prognosis process). Among these tools, some academic ones are based on general models of the system's dynamics which can represent and reason about both diagnosis and prognosis problems in a single same formalism. For instance, the LAAS laboratory in Toulouse recently worked on such a tool named "hymu", built upon Hybrid Particle Petri Nets and advanced adaptive sampling algorithms which produce accurate diagnosis and prognosis analysis from a unique dynamic model of the system. This tool has been successfully deployed on a NASA rover upon a fruitful collaboration with LAAS.

Dealing with explicit models enables to design efficient reasoning algorithms that can exploit the specific known structure of the models. It also provides the capability to reuse the same model for various related but different tasks, typically diagnosis and prognosis, as is the case of LAAS' "hymu" tool. On the other hand, it is often tricky and cumbersome to design correct and helpful models of the system, which pushed many practitioners to go rather for full data-driven health management tools. In addition to their preconceived lesser efficiency, models learned with pure machine learning techniques in place of formalized ones are also less readable and understandable by systems' experts.

In this AIRBUS/LAAS internship we would like to look at less extreme approaches and move the cursor in-between by reconciling learning and model approaches for best representation of real industrial health management systems. Our aim is to start with a first expert model of the system which will be continuously enriched and modified from observations by means of deep learning techniques. Using deep learning methods to learn accurate structures of formal models radically differs from the standard approach consisting in building black box models, in the sense that the structured learned model can be exploited by efficient algorithms designed for reasoning about the specific learned structure. Specifically, data feeding the deep learning algorithms could be collected during maintenance phase and used to enrich the learned diagnosis/prognosis model.

The candidate will implement the target hybrid data/model-driven health management tool on the basis of a small but sufficiently complex system, e.g. landing gears for aircraft or imagery processing units for satellites. A typical use case would predict the most probable health evolutions of the system in operation before its scheduled maintenance, then use the result of this prognosis to help diagnose its state in maintenance, and finally reason about the diagnosis and maintenance actions to update the prognostic before the service reentrance. The formal diagnostic/prognostic model will be ideally continuously reinforced by both operational and maintenance data.

The objective of this internship can be naturally extended in a potential PhD towards the integration of planning capabilities in order to proactively generate optimal troubleshooting procedures, or help insert maintenance actions in existing schedules, or design condition-based and proactive planning algorithms whose reasoning models intrinsically rely upon the hybrid data/model-driven health management technology developed during this internship. Under this perspective, this PhD subject will provide an integrated versatile decision-making tool based on diagnosis, prognosis and planning capabilities within an approach mixing model-based reasoning and deep reinforcement learning techniques.

<u>Connaissances requises</u> : optimisation mathématique sous contraintes, algorithmique et programmation