PhD within the framework of the European project (ETN) “MOIRA”:

Probabilistic fleet monitoring based on model manifold

Context

This PhD position is part of the “MOIRA” (MOnItoRing of large scale complex technologicAl systems) project, funded by the European Commission through the H2020 “Marie Skłodowska-Curie Innovative Training Networks” program (grant number 955681).

Modern technological systems increase in scale and are becoming more and more complex and sophisticated. Parallel, the revolution in electronics, digital technology and communications have drastically modified and expanded the physical diversity, scope, processing capabilities and complexity of the monitoring equipment and infrastructure used. Millions of networked sensors are being embedded in the physical world sensing, creating and communicating data. The amount of data available for capturing has been exploding and the era of Big Data is already here, as the Internet of Things (IoT) is becoming a reality. The main question which arises is how, following which steps and with which tools the data can be transformed to information and knowledge.

The objectives of MOIRA are

i) the development of novel signal processing tools for the monitoring of industrial processes based on machine learning methods applied on heterogeneous time series,
ii) the application of data mining technologies for the estimation of Key Performance Indicators which determine the operational profit,
iii) the conception, development and validation of methodologies for automated monitoring of cyber physical system fleets, iv) the multi sensor machine condition monitoring under variable operating conditions.

The proposed MOIRA project brings together early stage researchers and experienced specialists from key players in academia and industry across Europe covering different scientific disciplines and industrial stakeholders from a broad range of backgrounds to optimally tackle the challenges ahead. The MOIRA Fellows will be trained in innovative PhD topics as well as receiving specific theoretical and practical education in the fields of mechanical engineering and computer science, focusing towards the online early accurate identification of abnormal incidents with minimum false alarms and missed detections.

Program of the PhD

Within the context of the MOIRA project, the PhD student will develop model-based techniques for monitoring individual units in a fleet from a probabilistic approach. The principles is based on the comparison of a parametric model identified from measured data to a generic model provided by dynamic modelling by taking in account acceptable differences between the generic model of the fleet and individual units. This will be solved as an inverse problem in the presence of “modelling errors” that reflect the departure of individual units from the nominal model representing the fleet. After identification of the model parameters from experimental data – a non-trivial issue due to the fact that modelling errors are highly structured and do not comply with the simplifying assumption commonly advocated in system identification theory -- each unit will be assigned a different realization of the

same model seen as a random object. This will be formalized in the probabilistic space spanned by the parameter values, thus leading to the concept of a population of models embedded in a probabilistic manifold endowed with a topological information geometry. This formalism will be useful to view and manipulate models as probabilistic objects. The objective for monitoring will then be to assess whether the dispersion attached to a specific unit is due to normal variability or to the presence of an abnormality. In addition, the dynamic evolution in time of models will be accounted for (presence of confounding environmental variables, dependence on operational conditions) as trajectories in the probabilistic manifold. Therefore, a Bayesian probabilistic approach will be developed in order to 1) account for all elements of information that are a priori available on modelling errors, 2) propagate them in the inverse problem, and 3) set up credible intervals used in the ultimate diagnostic step. Monte Carlo Markov Chains will be used as the machinery to solve these objectives, as they make possible to jointly infer the model parameters and the modelling errors characteristics. The methodology will be applied on fleets of vehicles and wind turbines.

Recruitment on the project is 36 months.

Candidates must have completed an M2 level with excellent academic results in applied mathematics OR in mechanical engineering; they must meet the eligibility conditions of ETN projects:

- no residence in France longer than 12 months in the past 3 years immediately before the date of recruitment
- not been involved in research for more than 4 years (full time equivalent) starting to count the date this person graduates his/her first MSc degree.

Supervision

Professors Jérôme Antoni (LVA), University of Lyon, will supervise the PhD.

The PhD will take place in France (Lyon), with 3 months with SIEMENS Industry Software (Belgium), 3 months with Katholieke Universiteit Leuven (Belgium), including a substantial salary and living allowance (supported by the EC grant allowed to the project).

PhD candidates will be employed by INSA, including a substantial salary and living allowance (supported by the EC grant).

Application is open from March to December, 2021; send a message to
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