PhD : CRAN, University of Lorraine, CNRS, France

Data-driven nonlinear system identification and health state prognostics using deep learning. Application to predictive maintenance of business jet aircraft

The Research Centre for Automatic Control of Nancy, France, announces a vacancy for a three year PhD position to be started in October 2020.

Project description

The successful candidate will carry out research in the field of data-driven model-based predictive maintenance. The proposed PhD project is part of a collaboration with Dassault Aviation whose final objective is to develop a function for monitoring the condition of business jet aircraft systems by analyzing data recorded in flight.

The aim of the PhD is to design novel methods that lie at the crossovers of data-driven nonlinear dynamical model identification approach and deep learning for robust predictive maintenance of business jet aircraft. The research will have both theoretical and applied components.

The data-driven modeling and predictive maintenance of complex systems is undergoing a revolution, driven by the rise of big data, advanced algorithms in machine learning and optimization, and modern computational hardware. Increasingly, these model-based predictive maintenance strategies are aided by data-driven techniques that characterize the input-output dynamics of a system of interest from measurements alone, without relying on first principles modeling. This is known as system identification, which has a long and rich history in control theory. However, with increasingly powerful data-driven techniques, such as those coming from the machine learning community, nonlinear system identification has encountered renewed interest.

Amongst the different models and associated techniques, deep learning methods will be considered and investigated. Deep learning has indeed emerged in the domain of Artificial Intelligence as an efficient data-driven method for data/event classification and prediction for dynamical nonlinear systems under variable operating conditions. The PhD will therefore explore the links between the classical system identification approach [1, 2] and deep learning methods [3] for such systems.

Predictive maintenance is closely based on prognostics of failure [4] and prediction of the remaining useful life (RUL) of critical components [5]. Prediction of RUL becomes a difficult problem in absence of exact deterioration knowledge. The availability of degradation data base must be leveraged for efficient RUL predictions.

Recently, several works have highlighted the utility of Recurrent Neural Networks (RNNs) and Long Short Term Memory (LSTM) neural networks for identification of dynamic systems and prediction of futuristic events such as faults, failures and remaining useful life of industrial systems [6, 7]. These recent works would be referred to study, explore and be the basis for developing novel Deep LSTM-based solutions for identification/prediction using the observed data.

Among other aspects, the research will focus on improving the generalization capability of the method in the sense that the developed methodology/algorithms should demonstrate excellent generalizable capacity in face of unknown/unseen asset properties or anomalies. The developed algorithms should be verifiable and should propose efficient means of quantifying the accuracy of output results. Suitable procedures should be developed to analyze the prediction accuracy of novel algorithms. Another major focus area would be unsupervised type of learning wherein it is expected that developed algorithms are able to learn relevant representations of anomalies/health symptoms in self-supervised or unsupervised manner leading to better generalizations and accuracy.

The aim is the PhD is therefore to propose solutions for the different research challenges formulated above. The proposed solutions will be implemented and tested by exploiting routine operation data.
coming from several business jet aircraft.

References


Skills and profile

Prospective candidates should have a solid background in mathematics, systems, control and computer science; a strong Master’s and Engineering School degree and experience in Matlab or in Python. The candidate should have the French citizenship and have excellent oral and written communication skills in English.

Salary and benefits

Duration : 36 months - starting date of the contract : October 1st, 2020
You will receive about EUR 2500 gross salary per month (around 2000 EUR monthly salary after taxes).
During your PhD, you will have the opportunity to attend and present your contributions to the annual workshop of the European Research Network in System Identification (ERNSI) and to the Prognostics and Health Management (PHM) conferences. This will give you the opportunity to develop some collaborations with leading research groups in Europe.
You will be mainly working in Nancy joining a research group with PhD students coming from all over the world and could visit the Dassault Aviation research centre for short periods of research.

Application

If you are interested, please contact
— Prof. Hugues GARNIER at hugues.garnier@univ-lorraine.fr
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— Dr Farid CERBAH at farid.cerbah@dassault-aviation.com

Your application should include :
1. Your curriculum vitae
2. A motivation letter
3. Undergraduate and MS course programs and certified results
4. One or two contact referees (including name, e-mail, and phone number) for recommendation request