1SC4191 – Algorithms for monitoring and decision of the state of health of aircraft engines. Application to the diagnosis of the oil circuit of a turbojet.

Instructors: Sorin Olaru
Department: DOMINANTE - GRANDS SYSTÈMES EN INTERACTION
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 27,00

Description

The availability and safety of aircraft have been at the heart of air transport since their creation. Failures, particularly in flight, may result in the aircraft being diverted to an airport other than the destination or delayed on arrival. They can also significantly degrade the engine. The extra costs generated can be significant for the company or the manufacturer. In collaboration with Safran, this integration course focuses on the monitoring of the state of health of aircraft engines by limiting the study, because of the complexity of the general problem, in the case of the oil circuit of a turbojet. The oil circuit plays a vital role in the lubrication of the engine bearings of an aircraft. Several failure modes can lead to a degradation of the lubrication efficiency inducing the damage of the bearing and then the engine and subsequently a stopping of the engine in flight. This has important consequences in economic terms: availability of the engine or repair if the engine is repairable.
Failures can occur for example due to leaks or coking (deposits on pipes or sprinklers). One of the paths explored for detecting a failure of this system is to monitor a number of circuit parameters such as pressure or temperature.
In this case study, the goal is to be able to detect a drift. The direct use of the pressure is insufficient due to the dispersions of the flight scenarios.
The question of finding the influencing parameters on the oil pressure become primordial by means for example of a statistical modeling. Subsequently, algorithms need to be design to follow-up and help the decision process.

Quarter number
ST4

Prerequisites (in terms of CS courses)
Statistics and probability

Syllabus

- Economic context: importance of availability and resilience in the rail sector.
- Meaning of these concepts in this context. Implications for design and maintenance.
- The principles and tools of classification, decision maing and PHM ("Predictions & Health Management") and their application in the context.
- The contributions of digital transformation.
- Link to operational safety.
- Normative standards.
- Performance indicators.
- Concrete applications.
- Perspectives and challenges.
- Obstacles to adoption and support for change.
- Implications for the business and the actors in maintenance, design and operation.

Part 1: Introduction to concepts and issues (a participant from Safran).
Part 2: Implementation on a practical example (rolling stock, signaling or infrastructure).
Part 3 (group - one week): work of one or two groups of students on data provided by our industrial partner, Safran.

Class components (lecture, labs, etc.)

Project-based learning

- Modalities of participation of the partner involved

o Participation of Saran speakers in the introductory session.
o Presence of an Safran expert in coaching mode during group work.
During this work, industrial data (possibly anonymized) will be provided to students. Some will be labelled, others not. Some will include historical information from the maintainers: types of defects or degradations identified, maintenance actions carried out), others will not.
Students will be asked to combine knowledge of physical systems and data processing algorithms to extract useful information from the raw data and make recommendations for use by maintainers.
Two modalities are envisaged:
- Either divide the tasks into small groups of students;
- Either give the same tasks to two or three groups that will work in parallel, in challenge mode.

Grading

Oral presentation and evaluation of the project along the week

Resources

1 room for 30 élèves, overhead projectr, partition by groups
Software : Matlab/Simulink (network licence – wifi preferably) on individual PCs for each student; Python, …
2 academic supervisiors + 1 expert from Safran
Involvement of Safran over the entire week

Learning outcomes covered on the course

At the end of this course the students will be able to:
- to understand the issue of resilience and predictive maintenance as well as the potential benefits of such an approach
- to analyse a complex system and develop the elements of reflection leading to a representation model (physical, statistical, etc.) of the phenomena whose identification is the subject of the study
- to conduct the modelling process with an appropriate choice of modelling assumptions and to understand the limits of the models
- apprehend and use machine learning algorithms to extract information useful for predictive maintenance from raw data
- conclude and decide on the relevance of the approach and on the performance of the algorithms evaluated

Description of the skills acquired at the end of the course

C1: Analyze, design and build complex systems with scientific, technological, human and economic components
C.1.1: The aim is to understand and analyse a complex system and study the problem as a whole for decision-making where the economic and human dimensions are important.
The cost and human impact aspects are important for decision-makers, who will have to convince them of the economic benefits of such a solution while maintaining a high level of security or even improving it depending on the project, and to convince users of the viability and reliability of the solutions envisaged.
C1.2: Use and develop appropriate models, choose the right modeling scale and relevant simplifying assumptions to address the problem
In all projects it will be necessary to recover a large volume of data from an industrial company and from different sources. This will raise the problem of data aggregation, assumptions for eliminating outliers and model(s) for selecting the appropriate scale and level of accuracy required.
C4: Ability to create value for your company and its customers
In this context, it will be a question of creating value for the customer by increasing availability time by assessing the risk of failure and optimizing maintenance phases (periodicity, critical equipment, etc.).
C6: Being comfortable and innovative in the digital world

C6.5 Use any type of data, structured or unstructured, including massive data.
This will involve processing massive data provided by the manufacturer. This data, exploited using algorithms to be developed, will provide information on the risks of failure. The use of data for diagnosis will require prior treatment to eliminate outliers.
C7: Collect relevant and reliable information to support an argument (e. g. to retrieve relevant data).
–C8 Lead a project, a team