2EL2230 – Maintenance and Industry 4.0

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Department: DÉPARTEMENT GÉNIE INDUSTRIEL ET OPÉRATIONS
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Business Sciences
Advanced level : Yes

Description

This course provides a solid culture on the concepts, methods and tools involved in the implementation of a predictive maintenance approach.

Predictive maintenance is one of the pillars of Industry 4.0. It is based on the use of data collected online, their processing and their integration into dynamic decision-making processes. It also relies on the provision of connected agents capable of performing tasks in real time and optimizing their management. Concretely, it is about anticipating failures, shutdowns, accidents in production processes or service systems and planning at best replacement, renewal, return to service operations, etc.

The objective of this course is to give future decision-makers the necessary culture to design, model and recommend predictive maintenance strategies. Emphasis is placed on data-driven approaches and probabilistic or statistical models that apply to any industrial system. This background should allow effective interaction with engineers "business" very close to applications and "data scientist" in charge of data processing

Quarter number
SG8

Prerequisites (in terms of CS courses)
Basic knowledge in probability and statistics, data analytics, modeling and optimisation

Syllabus

- Course introduction; Project introduction;
- Basics of data analytics (I): Feature extraction and data visualization
- Fault detection and diagnosis (I): Unsupervised learning
- Fault detection and diagnosis (II): Bayesian network

- Fault detection and diagnosis (III): Causal inference (or neural network)
- Fault detection and diagnosis (IV): Semi-supervised learning
- Renewal process theory and correntive maintenance planning
- Scheduled maintenance
- Predictive maintenance based on discrete state models (I)
- Predictive maintenance based on discrete state models (II)
- Predictive maintenance based on continuous state models
- Project Defense

Class components (lecture, labs, etc.)

- 15h of lectures and 15h of tutorials with practical implementations of the models.
- Possibility to have a proportion of the lecture in inverse class.

Grading

Examination with use case (3h)

Course support, bibliography

- System Reliability Theory, Models, Statistical Methods and Applications, Marvin Rausand, Anne Barros, Arnljolt Hoyland, 2020, Third Edition, Wiley
- Degradation Processes in Reliability, Waltraud Kahle, Sophie Mercier, Christian Paroissin, John Wiley & Sons, 2016
- Maintenance, Replacement, and Reliability: Theory and Applications, Second Edition (Mechanical Engineering) 2nd edition by Jardine, Andrew K.S., Tsang, Albert H.C. (2013) Hardcover
- Case Studies in Reliability and Maintenanc, Wiley Series in Probability and Statistics, Wallace R. Blischke, D. N. Prabhakar Murthy, John Wiley & Sons, 2003
- Reliability and Optimal Maintenance, Hongzhou Wang Hoang Pham, 2006, Springer Science & Business Media
- Reliability and Maintenance Engineering, R C Mishra, New Age International, 2006
- Models of Preventive Maintenance (Study in Mathematics & Managerial Economics), Ilya B. Gertsbakh, North Holland, 1977

Material

Slides, Website, Jupyter Notebook

Resources

- Teaching Team (lectures en tutorials): Anne Barros, Yiping Fang, Zhiguo Zeng

- Outils informatiques: Python, Matlab

Learning outcomes covered on the course

- Design a maintenance strategy in a given application context
    - Make the appropriate modeling choice to assess the performance of a maintenance strategy
    - Know how to define and formalize relevant state variables
    - Know how to define and formalize a performance criterion
    - Know how to develop a model with the right level of abstraction from the description of scenarios or a set of transition/states
- Quantify performance from probabilistic or data-driven models
    - Know how to identify the right modeling framework based on stochastic processes
    - Know how to identify the right learning or machine learning algorithm according to a given data set
    - Know how to calculate probability laws or average quantities from an analytical formalism or Monte Carlo simulation
- Optimizing the performance of a maintenance strategy
    - Know how to implement parametric optimization techniques for a given performance criterion
    - Know how to formalize an optimization problem when the maintenance strategy is not fixed a priori

Description of the skills acquired at the end of the course
Validated skills:

- Design, model and recommend predictive maintenance strategies (C1.1 and C1.2)
- Being able to interact with business engineers and data scientists on this subject (C1.5 - milestone 2)
- Supervise the implementation of a predictive maintenance strategy from data collection to the practical implementation of maintenance activities (C1.5, milestone 2)
- The final case study is part of C1.3 (milestones 1B, 2B, 3B), C6.5 and C7.1

Validation mode

- Skills C1.1 (milestones 1 and 2) and C1.2 are validated during the TD sessions. Competency C1.1 is validated during the final case study for milestone 3.
- Competency C1.5 is validated during the final case study.