CIVIL-426

Machine learning for predictive maintenance applications

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Cursus	Sem.	Type
Civil Engineering	MA1, MA3	Opt.
Civil engineering minor	H	Opt.
Data and Internet of Things minor	H	Opt.
Managmt, tech et entr.	MA1, MA3	Opt.
Mechanical engineering	MA1, MA3	Opt.
Robotics	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Withdrawal	Unauthorized
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	2 weekly
Exercises	2 weekly
Project	2 weekly
Number of positions	

It is not allowed to withdraw from this subject after the registration deadline.

Summary

The course aims to develop machine learning algorithms capable of efficiently detecting faults in complex industrial and infrastructure assets, isolating their root causes, and ultimately predicting their remaining useful lifetime.

Content

Early and reliable detection, isolation and prediction of faulty system conditions enable operators to take corrective actions to prevent critical system failures, ensuring high levels of availability and safety. This is particularly crucial for complex systems such as infrastructures, power plants, and aircraft engines. Consequently, these systems are increasingly monitored by a large number of diverse condition monitoring sensors.
With the increased availability of system condition data and the growing complexity of explicit physics-based system models, the application of data-driven approaches for predictive maintenance has been rising recently.
This course provides insights and hands-on experience in selecting, designing, optimizing and evaluating machine learning algorithms to address the challenges faced by predictive maintenance systems in complex engineered systems.
Specific topics include:
-Introduction to condition monitoring and predictive maintenance systems
-Feature extraction and selection methodology
-Machine learning algorithms for fault detection and fault diagnostics
-End-to-end learning architectures for fault detection and fault diagnostics
-Unsupervised and semi-supervised learning algorithms for predictive maintenance
-Deep learning algorithms for predicting the remaining useful lifetime
-Performance evaluation of the algorithms
-Predictive maintenance systems at fleet level
-Domain adaptation for fault diagnostics
-Explainable machine learning algorithms for predictive maintenance
-Federated learning in predictive maintenance applications
-Graph Neural Networks for predictive maintenance applications
-Phyics-guided machine learning for predictive maintenance applications
-Introduction to decision support systems for maintenance applications
-Benefits and costs of predictive maintenance

Keywords

machine learning; predictive maintenance, fault detection, fault diagnostics, prognostics, remaining useful lifetime

Learning Prerequisites

Required courses

Mandatory pre-requisite course: Introduction to machine learning for engineers or other introductory machine learning courses

Learning Outcomes

By the end of the course, the student must be able to:

- Define the learning problem in way that allows its solution based on existing constraints such as lack of fault samples.
- Design data-driven predictive maintenance applications for complex engineered systems from raw condition monitoring data.
- Assess / Evaluate the performance of the applied algorithms.
- Choose machine learning algorithms for fault detection, diagnostics and prognostics.
- Interpret the results of the algorithms.

Teaching methods

Lectures, excercises, final project

Assessment methods

Performance will be assessed during the semester based on
-exercises that require students to work on various case studies to design a predictive maintenance system (accounting for 70% of the final grade)
-A final project involving a real case study (and real data) in designing a predictive maintenance system based on raw condition monitoring signals of a complex engineered system. This project requires students to submit a detailed report (including the implementation) and give a presentation, accounting for 30% of the final grade.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Moodle Link

- https://go.epfl.ch/CIVIL-426