Centre for Applied Intelligent Systems Research

eXplainable Predictive Maintenance
XPM

Halmstad University & Inesc Tec &
Jagiellonian University & IMT Lille-Douai

CAISR
Centre for Applied Intelligent Systems Research

Scientific Background

XPM

- Integrate explanations into AI solutions in Predictive Maintenance
  - real-world applications of PM are increasingly complex
  - AI models (often deep learning) are showing high predictive accuracy
  - capturing intricate interactions of many components but as black-box

- PM effectiveness depends less on the accuracy of alarms from AI…
  - than on the relevancy of actions operators perform based on these alarms
  - today, AI does not really support experts in making “smart” maintenance decisions based on the deviations that the black-box model detects

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Project Impact

XPM

- AI decisions are often difficult for human experts to understand
  - and, therefore, to act upon… detecting the symptoms is just the first step
- Repair plan requires complex reasoning and planning processes
  - involving many actors and balancing different priorities
  - not realistic to be automated, with too much context to consider
- Operators require insights to understand what is happening
  - why it is happening, and how to react
  - today’s mostly black-box AI does not provide these insights
- Project started 01.03.2021 – therefore, not many results yet ;)

but join us for Special Session & Summer School @ DSAA’2021!

HALMSTAD UNIVERSITY

Key Challenges

- Develop several different types of explanations, e.g.,
    - visual analytics, prototypical examples, deductive argumentative systems
    - in four domains: electric vehicles, metro trains, steel plants, wind farms
- Demonstrate benefits of explanations for AI decisions
    - identify component/part of the process where the problem has occurred
    - understand the severity and future consequences of detected deviations
    - choose optimal repair from several alternatives based on different priorities
    - understand the reasons why the problem has occurred in the first place, as a way to improve system design for the future

Halmstad University

(coordinator)

- Center for Applied Intelligent Systems Research (CAISR)
  - the scientific focus of (CAISR) is “aware” intelligent systems
  - “human” aware, “situation” aware and “self” aware
- These systems combine different sources of information
  - to automatically, or semi-automatically, extract new knowledge
  - getting an overall picture of the situation and monitoring themselves
  - machine learning and data mining are the main research areas
- Particular focus of CAISR is on weakly-supervised machine learning

Inesc Tec - LIAAD

- Laboratory of Artificial Intelligence and Decision Support
  - Data Mining and Machine Learning
  - Data Mining from Structured Data
  - Data Analysis and Statistical Methods
  - Modeling & Optimization

- We focus on modelling data that evolve in time and have clear non-stationary properties, demanding for the ability of handling regime shifts in the process generating data
  - due to dynamic nature, these continuous streams of data require models able to adapt to this recent information as time goes by

Jagiellonian University

- GEIST research group in Institute of Applied Computer Science
  - interest in heterogenous intelligent systems combining ML with KBS
  - semantics in data mining and ML, explainability (XAI) in intelligent systems
- Jagiellonian Human-Centred AI Laboratory
  - researchers from engineering, law, psychology, games, physics
  - integration of human expert-based decision making with the AI operation
- AI & Law
  - legal analysis of liability norms related to AI systems,
  - guidelines, standards and criteria for evaluation of the AI systems

IMT Lille-Douai

- We focus on building data-driven degradation models
  - characterize the degradation dynamic progress over time
  - estimate in reliable and precise way the Remaining Useful Time

- Define a strategy for the design of predictive maintenance actions
  - optimize maintenance costs, logistic inventory and environmental conditions
  - link degradations (location, severity) to components design and operation

- Related projects
  - Design of decision support tool for fault prognosis of large-scale wind farms, Design of cost-effective integral condition health monitoring tool in order to enhance the reliability and availability of wind turbines, 2012-2015

Use Case: Metro do Porto

Early Failure Detection in Public Transport Vehicles in Operational Context

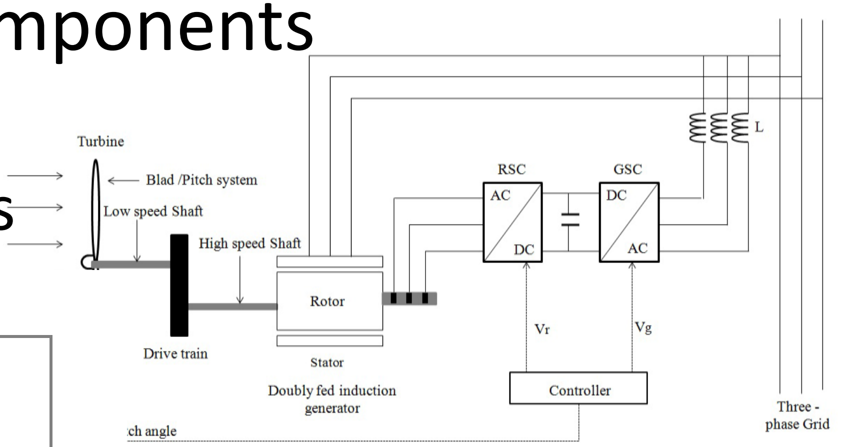
Our Goals:

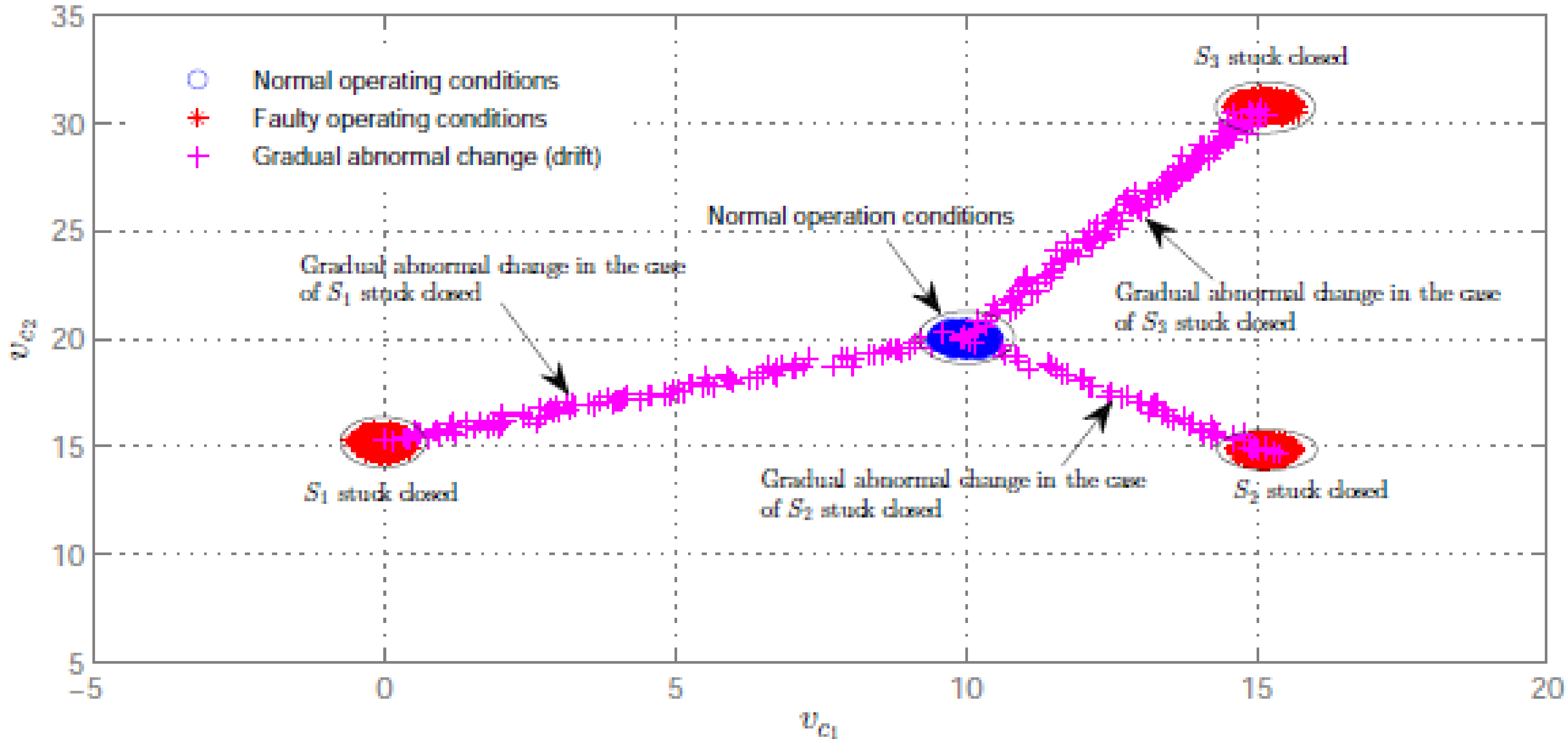
- Install a set of sensors in the APU system of a vehicle to collect data regularly.

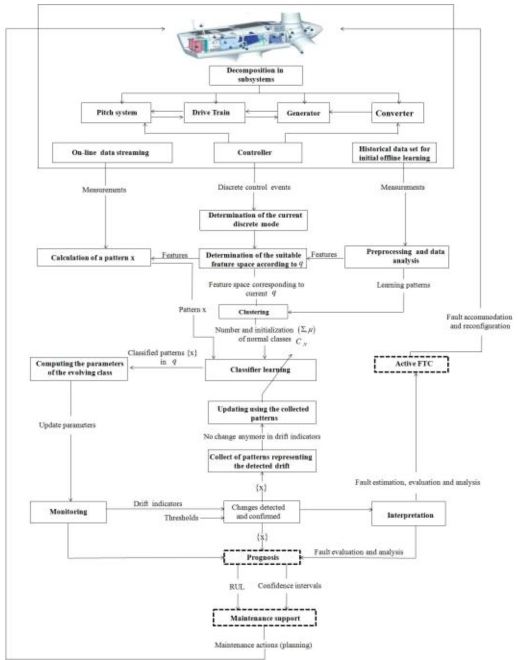
- Develop a system based on real-time data to timely notify the maintenance team of the existence of a failure in development.
- Decrease in the number of vehicles withdrawn from service
- Study and infer the most probable causes for the fault.

Use Case: Wind Turbines

- Characterise degradation modes for critical components
  - converter, pitch system, generator, …
  - fault tolerant control to mitigate the consequences





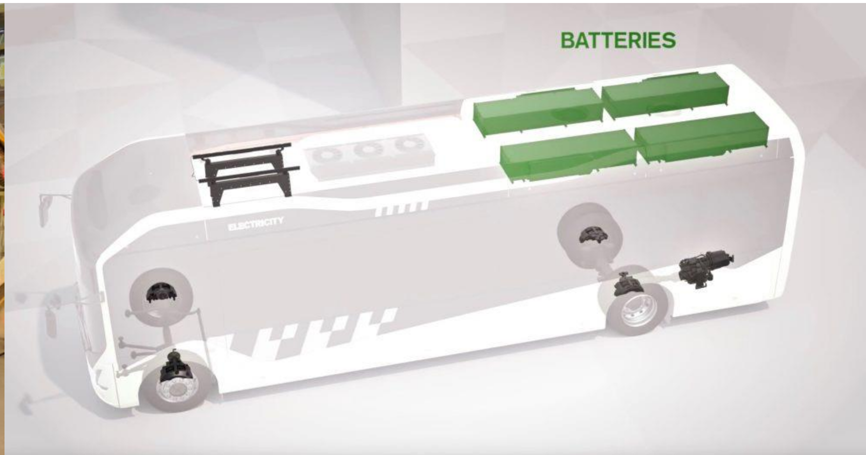


Use Case: Electromobility

- General lifetime models for key components in the electrical driveline
  - hybrid and fully electric buses, streaming data from an internal CAN network

- Our goal is to find the right balance between:
  - estimating remaining useful life of critical components
  - predicting imminent failures of for increased uptime
  - communicating new insights to domain experts





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