Neuro-Symbolic techniques for Predictive Maintenance (Discussion Paper)

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Abstract

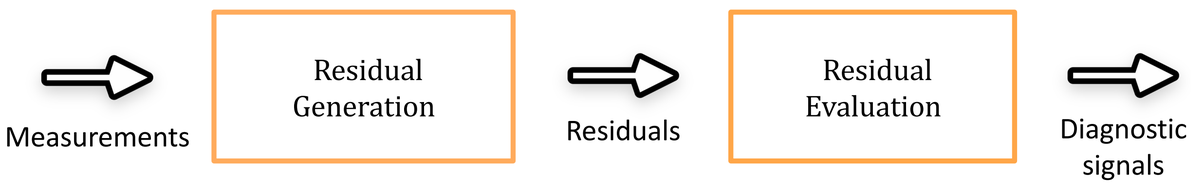
Predictive maintenance plays a key role in the core business of the industry due to its potential in reducing unexpected machine downtime and related cost. To avoid such issues, it is crucial to devise artificial intelligence models that can effectively predict failures. Predictive maintenance current approaches have several limitations that can be overcome by exploiting hybrid approaches such as **Neuro-Symbolic techniques**. Neuro-symbolic models combine neural methods with symbolic ones leading to improvements in **efficiency**, **robustness**, and **explainability**. In this work, we propose to exploit hybrid approaches by investigating their advantage over classic predictive maintenance approaches.

Motivations

- Overcoming current predictive maintenance approach issues
- Combining model-based and data-driven models
- Leveraging new architectures prioritizing **interpretability**, **robustness** as well as maintaining **high-performance levels**

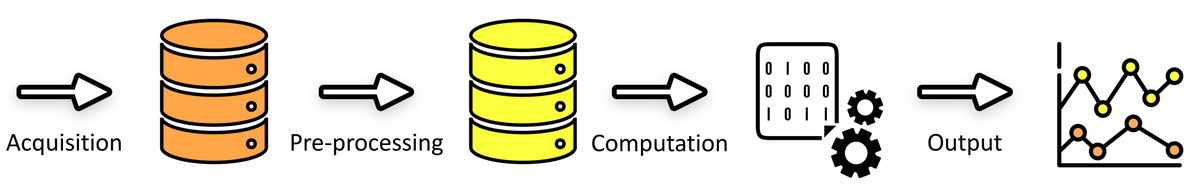
Traditional Predictive Maintenance Approaches and Limitations

Model-based



- Experts can make **assumptions** that may **not** always **reflect** the **complexity** of the **real-world problems** they are trying to solve
- Specific and deep knowledge can lead to **high costs** for industries
- **Poor results**

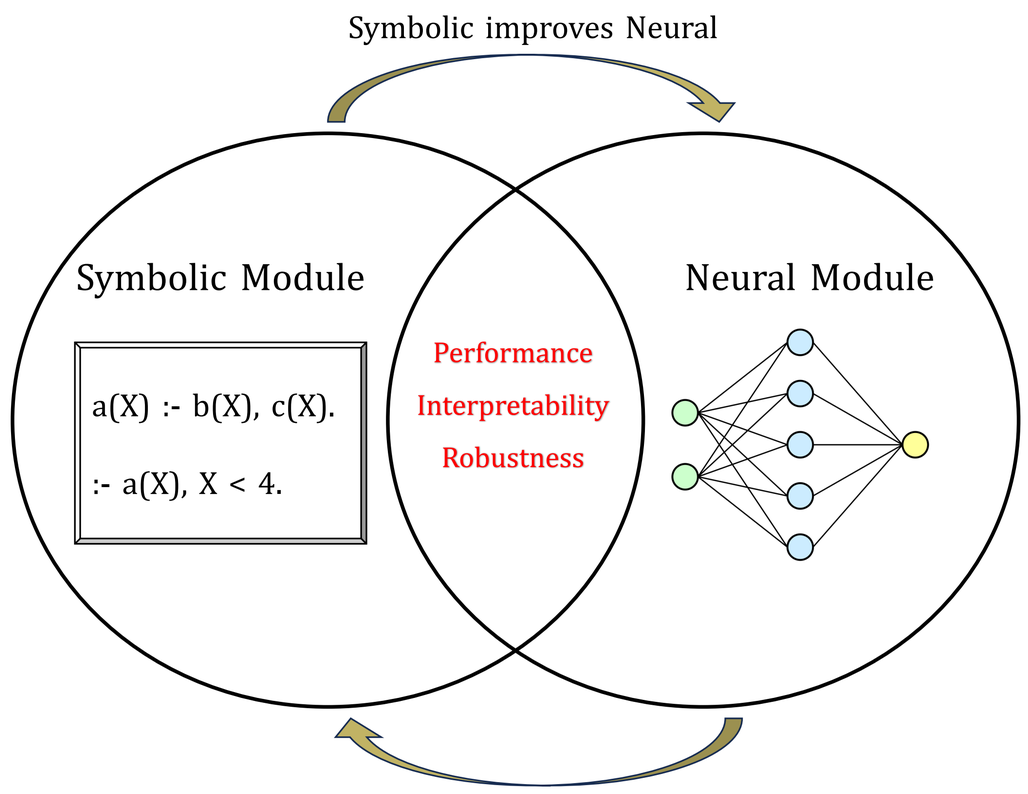
Data-driven



- Real **data** can be **noisy**, **inconsistent**, and **sparse**, this can lead models to overfit or to develop biases
- Black-box data-driven models are **not explainable**
- Historical data could **not** be fully **representative** of real-world scenarios.

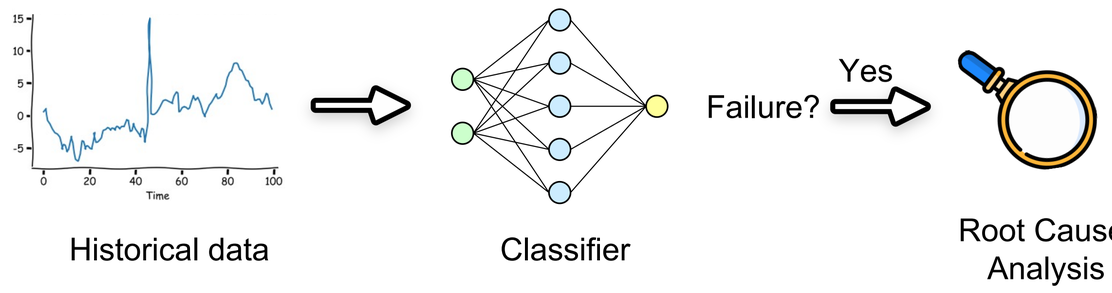
Neuro-Symbolic

- Hybrid models exploiting both deductive (**symbolic**) and inductive (**deep learning**) approaches



Use - Case

- Monitoring operational status of a train
- Defining relationships among train components through logical formalism
- Using machine/deep learning models for failure detection in each component
- Identifying which causes have determined the failure exploiting root cause analysis



Acknowledgements

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