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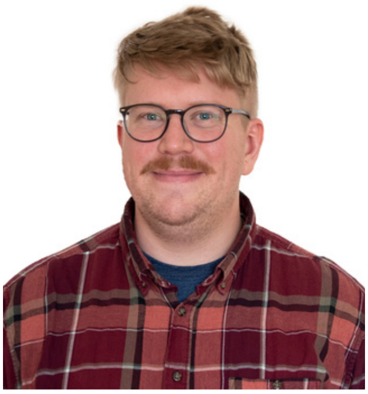

Data-Driven Remaining Useful Life Prediction of Energy-Intensive Industrial Assets

Wilhelm Söderkvist Vermelin

Licentiate Thesis Defence

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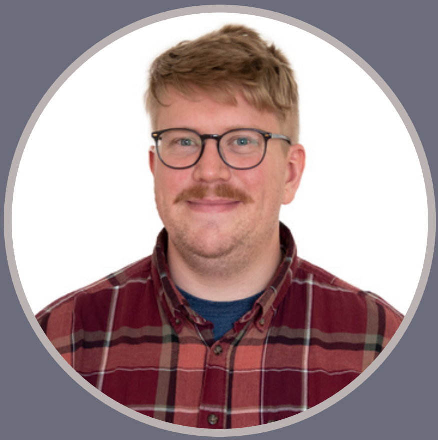

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Abstract

In response to increasing demands for reliability and uptime, organizations are progressively monitoring more of their mission-critical assets through various sensing and data collection devices. The accumulated data enables several emerging technologies, particularly data-driven approaches such as machine learning, which are becoming more viable in industrial contexts.

These technologies have the potential to enhance the effectiveness and efficiency of asset management and maintenance. A key framework for realizing this potential is prognostics and health management, an engineering approach that deals with the identification and prognostication of system degradation. A major aspect of prognostics and health management is remaining useful life prediction, which develops models to forecast the remaining operational time of systems. Accurate prediction of future system state provides useful insight that aids maintenance planning.

This thesis addresses challenges and aspects of data-driven remaining useful life prediction with a focus on deep learning-based approaches. The research proposes solutions to key challenges in remaining useful life prediction, including limited access to complete run-to-failure trajectories, data sharing constraints, and decentralized training requirements. Additionally, this thesis investigates remaining useful life predictions for discrete power electronics, components used in safety-critical high-power applications such as automotive systems -- an area that remains understudied within prognostics and health management.

The findings demonstrate that remaining useful life prediction is a viable technology in these domains, with models benefiting from self-supervised pretraining and decentralized training through federated learning. Furthermore, the research establishes that discrete power electronics can be effectively monitored using data-driven remaining useful life prediction methods.

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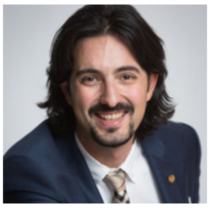

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List of publications in the thesis

Paper A
W.Söderkvist Vermelin, A. Lövberg, and K. Kyprianidis, "Self-supervised learning for efficient remaining useful life prediction" 2022 Annual Conference of the Prognostics and Health Management Society, PHM 2022, Nashville31 October 2022 through 4 November 2022.

Paper B
W.Söderkvist Vermelin, A. Lövberg, M. Misiorny, and M. P. Eng, "Data-Driven Remaining Useful Life Estimation of Discrete Power Electronic Devices" 33rd European Safety and Reliability Conference (ESREL 2023).

Paper C
W.Söderkvist Vermelin, M. Mishra, M.P. Eng and D. Andersson, "Collaborative Training of Data-Driven Remaining Useful Life Prediction Models Using Federated Learning". Prognostics and Health Management Society , 2024. Vol. 15, no 2.

Biography

Wilhelm Söderkvist Vermelin is a researcher at RISE Research Institutes of Sweden (Mölndal), an industrial PhD student at Mälardalen University (MDU), and a participant in the IndTech industrial research school. With a background in physics and applied mathematics, his research intersects prognostics and health management (PHM), machine learning, and the monitoring of industrial equipment. He focuses on developing machine learning systems to assess the health of critical assets like power electronics, specifically tackling data scarcity challenges such as limited degradation histories and decentralized datasets.

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IndTech graduate school is an industrial Ph.D. school at MDU offering advanced training in the field of industrial digitization, a new and emerging field of technology that revolutionizes all aspects of the manufacturing and process industry. A total of 25 doctoral students will, within the framework of the program, combine employment at companies with pursuing postgraduate studies at MDU from 2021-2027.

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