A Data-Driven Approach to Remote Fault Diagnosis of Heavy-duty Machines

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Abstract

Heavy-duty machines are equipment constructed for working under rough conditions and their design is meant to withstand heavy workloads. However, the last decades technical development in cheap electronically components have lead to an increase of electrical systems in traditionally mainly mechanical systems of heavy-duty machines. As the complexity of these machines increases, so does the complexity of detecting and diagnosing machine faults. However, the addition of new electrical systems, such as on-board computational power and telematics, makes it possible to add new sensors that measure signals relevant for fault detection and diagnosis, and to process signals on-board or off-board the machines.

In this thesis, we address the diagnostic problem by investigating data-driven methods for remote diagnosis of heavy-duty machines, where a part of the analysis is performed on-board the machine (fault detection), while another part is performed off-board the machine (fault classification). We propose a diagnostic framework where we use a novel combination of methods for each step in the diagnosis. On-board the machine, we have used logistic regression as an anomaly detector to detect faults that will lead to a stream of individual cases classified as anomalous or not. Then, either on-board or off-board, we can use a probabilistic anomaly detector to identify whether the stream of cases is truly anomalous when we look at the stream of cases as a group. The anomalous group of cases is called a composite case. Thereafter, off-board the machine, each anomalous individual case is classified into a fault type using a case-based reasoning approach to fault diagnosis. In the final step, we fuse the individual classifications into a single aggregated classification for the composite case. In order to be able to assess the reliability of a diagnosis, we also propose a novel case-based approach to estimating the reliability of probabilistic predictions. It can, for instance, be used for assessing the confidence of the classification of a composite case given historical data of the predictive reliability.

Biography

Tomas Olsson has been working as a researcher and software developer at SICS Swedish ICT since 1998 and he has been a PhD student at Mälardalen University since 2011.

He has a long experience in both software development and in data analysis, and his research interests are in statistical machine learning and big data analytics.

Tomas has a MSc in Computer Science from KTH (1998) and a licentiate degree from Uppsala University (2006).

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Intelligent systems

The research group Intelligent Systems, led by Peter Funk, focuses on foundational and applied research in intelligent systems for industrial and medical applications. The research focuses on methods and techniques for intelligent systems and artificial intelligence enabling adaptation, learning, experience reuse, and experience sharing.
List of Publications

Publications Included in the Doctoral Thesis


**Case-Based Reasoning for Explaining Probabilistic Machine Learning.** Tomas Olsson, Daniel Gillblad, Peter Funk, Ning Xiong. In International journal of computer science & information technology (IJCSIT), 6(2), April 2014.

**Explaining Probabilistic Fault Diagnosis and Classification using Case-based Reasoning.** Tomas Olsson, Daniel Gillblad, Peter Funk, and Ning Xiong. In Case-Based Reasoning Research and Development. Proceeding of the 22d International Conference on Case-Based Reasoning (ICCBR-2014), Cork, Ireland, September 2014.


**Fault Diagnosis via Fusion of Information from a Case Stream.** Tomas Olsson and Ning Xiong and Elisabeth Källström and Anders Holst. In Case-Based Reasoning Research and Development. Proceeding of the 23h International Conference on Case-Based Reasoning (ICCBR-2015), Frankfurt, Germany, September 2015.
The ITS-EASY post graduate school for Embedded Software and Systems

ITS-EASY is an industrial research school in Embedded Software and Systems, affiliated with the School of Innovation, Design and Engineering (IDT) at Mälardalen University (MDH) as an integrated part of the MDH strategic research area Embedded Systems (ES).

ITS-EASY is funded by the Knowledge Foundation (KKS), and the eleven participating companies. ITS-EASY started October 1st 2011, and will continue until September 30th 2020. During that period the PhD students will complete their studies and obtain the doctoral degree in Computer Science.

ITS-EASY is a large organization: it counts 22 PhD students, 14 main advisors from IDT, 18 co-advisors from IDT and the partner companies, and more than 25 associated members; senior researchers and industrial specialists. The board, led by Helena Malmqvist, ABB, has six members, and the industrial committee where all participating companies are represented, has 11 members. The management team of the research school consists of four members. All in all, about 85 persons are directly engaged in ITS-EASY.

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