Title of Master Thesis:

Machine Learning for a plug-and-play Digital Twin of the production resource

Abstract:
The progress of the Industrial Internet of Things enables virtual representations of production resources in the form of Digital Twins. Digital Twins accurately map resource properties to support effective Production Planning and Control, and thereby e.g. increase resource utilisation. For predictive modelling, supervised Machine Learning can be applied based on connected continuous shop floor data, but the effort and difficulty are high. A uniform, generally applicable Machine Learning algorithm can enable a plug-and-play Digital Twin, but is not yet described in scientific literature.

Objective:

This Thesis conceptualises a Machine Learning algorithm that enables a plug-and-play Digital Twin of the production resource based on two case studies. The case studies will be used to examine a Digital Twin of the production resource for Production Planning and Control in multi-variant batch production and one-off production. This will allow us to reduce the effort of applying Machine Learning for predictive modelling, while achieving sufficient accuracy.

Methodology:

- Literature review on the state of scientific knowledge regarding the application of Machine Learning for Digital Twins, plug-and-play concepts for Machine Learning, and Continuous Learning. The literature review is conducted through key-word based scientific database search, selection and full-text assessment of 30 articles.
- Analysis of requirements regarding the Machine Learning algorithm through literature research and the analysis of 2 empirical case studies. 5 measurable requirements - including accuracy and implementation effort - are identified along with metrics, and validated through 2 expert interviews.
- Identification of suitable Machine Learning techniques based on literature research and theoretical analysis. 5 techniques are assessed with regards to the requirements.
- Literature research and conceptualising of a continuous Machine Learning algorithm. 3 Continuous Learning techniques are identified and assessed.
- Implementation and comparative analysis of knowledge-based, analytical, specific Machine Learning, and plug-and-play Machine Learning approaches for predictive modelling. The evaluation is based on 2 datasets from batch production and one-off production, as well as the identified requirements and metrics.
- Analysis of model interpretability, as well as application prerequisites regarding data quality and modelling confidence. Identification of a suitable metric for both data quality and modelling confidence, and specification of a required score.

Provision:

The thesis must contain a detailed description of all developed and used algorithms as well as profound result evaluation and discussion. The implemented code must be documented and provided. An extended research on literature, existing patents and related work in the corresponding areas has to be performed.

Advisors: Mario Luber M.Sc. (Fraunhofer IGCV), Tatiana Merzhevich M.A., Prof. Dr. Bjoern Eskofier

Student: Amlan Jyoti Buragohain (Information and Communication Technology)

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