**How to Optimize Production Processes Systematically based on methods of Artificial Intelligence and Machine Learning**

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There is a great hype about the renaissance of Artificial Neural Networks (ANN) and Deep Learning (DL). Several favourable factors were coinciding during the last decade that enabled such a successful comeback of ANN. The four most important factors are: growth of computational power (e.g. GPU), availability of huge amounts of data, architectural progresses (e.g. Convolutional Neural Networks (CNN), Long Short-Term Memories (LSTM)) and algorithmic innovations w.r.t. learning of such networks.

In industrial application one essential requirement for using DL is frequently not fulfilled. There is usually not enough data to train successfully deep networks with their millions of parameters. Instead, typically there is a lot of expert knowledge about processes and perhaps more or less elaborated process models are available. Such additional information and knowledge are valuable and should be used to substitute a considerable part of the actually necessary data volume. This requires mechanisms to integrate prior knowledge of any kind into machine learning (ML) in order to reduce the required amount of data.

In contrast to universal black boxes like ANN this direction of thought leads inevitably to models with less parameters, where structural knowledge about processes is incorporated before learning takes place. Ideally, a white box model of a real world process should be available, which precisely describes the true physical interrelations. However, such a model is regularly very expensive to establish. Between the extremes of black box and white box models there is a broad range of the so-called grey box models. Depending on the prior knowledge that is to be incorporated, there exist different mathematical approaches for grey box models, which allow to learn process behaviour reliably based on the actually available data.

But, what is it good for?

For example, AI and ML can help to accelerate the maturation of new production processes towards fully capable processes in order to reduce the time to market of new products significantly. A process is called “immature” if it cannot be operated with the required productivity and product quality. This is especially the case when new materials and production technologies are employed, when the manufacturing process has a vast number of parameters and high-dimensional state-spaces, and when only poor dynamical process models are available at the outset. The basic idea for fast process maturation is to learn dynamic models of the process and its sub-processes automatically and to use these models to design optimal controllers. Closing the pertaining control loops forces the process to better fulfil dynamic requirements and additionally enables to steer the process into yet unexplored regions of the state space in order to improve the process model in turn. The improved models can then be exploited to design better controllers and so on. Moreover, the acquired models can be used in simulations to optimize the adjustable parameters of process.

Several practical examples will be presented that show, how such models can be deployed in industrial applications to control processes, to predict process behaviour, to detect anomalies, to optimize processes etc.