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Statistical process control versus deep learning for predictive maintenance of power plant process data

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Abstract

This work is motivated by the non-documented, practical learnings gained by a predictive maintenance (PdM) development team in the Danish energy company Ørsted. The team implements PdM solutions for power plant machinery to monitor for faults in the making. Their learnings support the hypothesis that there are not significant enough benefits to be gained from using overly complicated condition monitoring models on selected machinery.

To explore this hypothesis, we set out to compare two different methodologies for detecting faults in process data. We compare a classical latent structure-based method from the field of statistical process control (SPC) with a standard autoencoder deep neural network. Furthermore, we compare the fault detection performance of these methods with two more experimental deep learning models recently proposed in literature [1]. The reason for these specific models is that they a priori seem very well suited for the modelling task the PdM team had undertaken due to the models'alleged ability to automate domain knowledge in a data-driven way.

We benchmark all methods against each other using first the well-known Tennessee Eastman Process (TEP) data, and subsequently data collected from two feedwater pumps (FWP) at a large Danish combined heat and power plant.

The TEP data stems from a simulation tool for generating data from the process, and thus a large number of datasets are generated for each of 20 process disturbances. For the FWP data, six historical faults in the form of leaks are used to test the methods against each other in their ability to detect faults as they develop over time. Each methods'ability to detect faults is measured using a weighted combination of performance metrics such as mean absolute error, ROC AUC and average precision AP.

Preliminary results of the experiments suggest that detection performance is comparable between the different models on both datasets, but that each model seems to come with its own set of advantages in terms of fault detection performance, as in the case of reaction time to certain types of faults.

Based on the mentioned datasets and models, we discuss the quantitative results of these experiments, as well as other pros and cons, such as number of modelling decisions, hyperparameters etc. of each paradigm that may influence the choice of detection model in an industrial setting.

References

1. Schulze, J.-P, Sperl, P, Böttinger, K. 2022, "Anomaly Detection by Recombining Gated Unsupervised Experts", arXiv preprint: https://doi.org/10.48550/arXiv.2008.13763

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