Pasi Ojala*

Machine Learning for Intelligent Maintenance

Abstract: In this publication, we introduce how Efora is applying predictive analytics and machine learning in intelligent maintenance. We apply non-supervised methods to train models for anomaly detection and failure prediction. The approach has proven to work as evolving issues have been found and fixed before problems in production appeared.

Keywords: Predictive maintenance, machine learning, anomaly detection

***Pasi Ojala:** Efora Oy, E-mail: pasi.ojala@efora.fi

1 Introduction

Our requirements for asset availability are set high to ensure efficient operations without production loss. Development work on maintenance processes has driven the number of systematic problems low. Known issues on process lines have been already been identified and handled with scheduled preventive maintenance process. Root cause analysis and continuous improvement methods are applied to tackle them. The problem is with wearing components, unexpected technical failures and events that occur rarely or that have never been seen before. To reach availability targets, even these cases need to be handled.

2 Predictive maintenance

Maintenance process is driven by decisions that are based facts found in data. And when going beyond signal trending and thresholding, we need machine learning based solutions.

Typical supervised machine learning requires vast amounts of training data and labelling information from past process failures. However, when facing unexpected issues and rare events, the problem becomes far more complex. Unsupervised learning is needed. And instead of failure prediction, the analytics should inform maintenance personnel about upcoming risks. Human factor is needed to make decisions based on findings. Therefore, the solution combines our process knowledge with advanced analytics.

3 Machine learning solution

We have built machine learning based solutions that compare actual process measurements to model output, detect evolving anomalies, find causal relationships to the change, and reveal the possible root cause of the problem. Due to the dynamic nature of the process, we apply Recursive Neural Networks (RNN) for modelling and prediction. Well trained autoencoder is able to detect even minor anomalies and evolving issues. Maintenance experts use the analytics tools to get prewarning on possible problems, pinpoint the issue and schedule required preventive actions.

4 Anomaly detection

We have managed to find unexpected issues in the production line with anomaly detection tool. Even with limited coverage, the system has successfully detected sensor failures, process malfunctions, and eventually, prevented production losses. Figure 1 presents an example of an evolving issue in web profile control in Steambox. In this case, the trained autoencoder model detected a process anomaly soon after a production break. The process appears to work normally, but based on earlier learnings, the unsupervised process model is expecting nearly constant steam consumption in web profile control while the measurement indicates a slight increase. Since the measurement is well within typical operation point and in acceptable range, the process control did not issue any alarms. Hence, it is not possible to see process deviation simply by following measurement trends. However, trained process model disagrees with the measurement. In this case, operational problems were already present further in the production line.

The process anomaly of Figure 1 was detected with autoencoder, and the true root cause was found by analyzing related measurement trends. The evolving problem was fixed immediately and production loss was avoided.

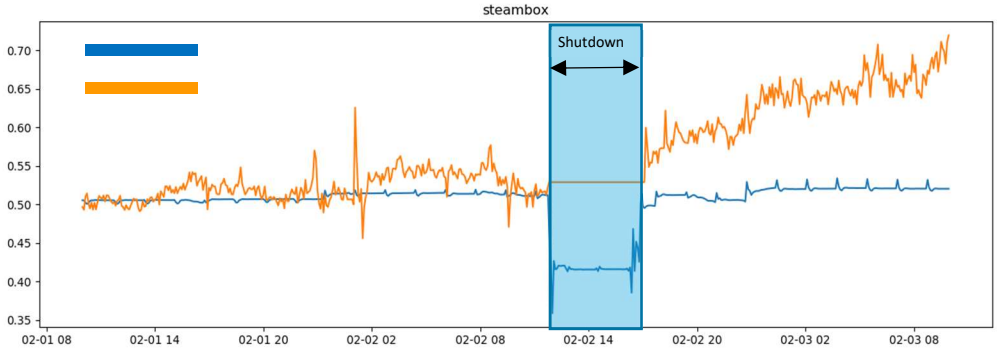

Figure 1. Evolving anomaly in Steambox.

5 Next steps

The system is being developed further based on user experiences on the new way of working and bases on how the analytics tools are being applied. The system is constantly learning when domain expert input and model findings are combined. Results from the analytics can be directly mapped to failure notifications and preventive maintenance work orders in ERP as well as diagnosis done by the maintenance experts. As a result, our solution reduces laborious routine work when large data mass can be analyzed automatically and findings can be fed directly to preventive maintenance process.