DATA SCIENCE SERVICE

OMRON

Monitor stability of machines using Data Science Machine Monitoring Service.

CONTENT

WHITEPAPER

OMRON Data Science Services Overview

Data Quick Scan

If you are collecting production and machine data, but not using it, we can perform a data quick scan. The usability and quality of the data is judged, and suggestions are made on how you can start using the value inside the data. Thus, helping you to define the first or next step towards a data enabled organization.

Machine Sanity Check

Signals from sensors and (where possible) actuators will be logged on a high frequency (1 ms interval), analysed and linked to the machine process and control program. By doing this together with the machine operators and/or engineers, you get a detailed insight in the machine and spot deviations and inconsistencies, like sensor misalignment, misconfiguration and worn out parts. This service is especially helpful when you want to reduce the micro stoppages of your machine or need to know the root cause of an intermittent and indistinct problem.

Machine Monitoring

Where your machine and/or production process is constantly monitored to detect process and quality anomalies, to discover trend drifts and to give advises on best maintenance (predictive maintenance). This is a full service: from implementation to regular (model) updates. Your machine changeover time and more input data for model training becomes available. Thus, regular update of the models is necessary to keep and/or enhance the predicting accuracy.

OMRON Sysmac AI-Controller

We can also help you with getting you up and running with OMRON Sysmac AI-Controller in various ways: Serve you with a Proof of Concept, assist during the implementation of the AI-Controller on your line or even offer you AI-as-a-service where we will take care of the complete implementation, updates, upgrades, and maintenance. Even AI systems need regular attention to improve and adapt to the detected changes in machine behaviour and/or production process.

Machine Monitoring Service – Industrial Anomaly Detection

Every signal generated inside a machine can nowadays be continuously logged and monitored, giving detailed insight in the machine. Continuous monitoring helps manufacturers to achieve machine stability, detect anomalies, and predict a failure to increase Overall Equipment Efficiency (OEE).

Anomaly detection aims to discover situations that are unusual within data. Anomaly detection is used in many different domains such as network intrusion detection, fault detection, system health monitoring, and event detection in sensor networks and machines. In all these domains anomaly detection is very important and a critical technique to identify the rare events that may have high influence on the process but are hard to find.

OMRON Machine Monitoring Service can contribute to machine stability and provides basis for anomaly detection and predictive maintenance modelling. Through this service, the factories can be sure that machines work healthy at their best condition. Moreover, abnormal situations are detected before the faults become costly and have impacts on the whole production line. System alerts maintenance and engineering teams and provides detailed information to find root cause as fast as possible.

Supporting Technologies

OMRON introduced Sysmac Artificial Intelligence Controller (AI-Controller) to continuously monitor the condition of the machines and ensure equipment availability. The AI-Controller is designed to provide tools that are used in different phases such as data collection, data analysis, and data utilization:

- Data Collection: Collect raw high-fidelity data from machines in real time.
- Data Analysis: Store data locally on the machine and create a model.
- Data Utilization: Monitor machine features in real-time based on that model and act immediately.

The Data Analysis function of AI-Controller enables machine learning modelling and data analysis. OMRON embedded a machine learning solution based on Isolation Forest algorithm to identify the abnormal cases. The solution executes completely on the Edge to put all the power of AI closest to the machine.

The Data Collection function of AI-Controller provides capabilities for data acquisition in real-time (1/ms) in a fast and reliable manner. Other platforms can be connected to AI-Controller and stream data to a desired analytics tool, like Python, for further data analysis, machine learning modelling, and building operational and analytical dashboards.

In section 4, an example of Anomaly Detection Service for a Pin Stitcher Machine in an assembly line at Omron factory in The Netherlands is provided. The Sysmac AI-Controller is used in the Pin Stitcher not only to capture machine signals in real-time and alarm operators and engineering team in case of anomalies, but also control machine directly as a machine controller.

Case Study

A Data Science project performed at the OMRON Manufacturing of The Netherlands (OMN) factory at the NX assembly line, which consists of several stages such as Board Programming, Pin Stitcher, Automatic Soldering, and Lasering. The focus of this project was on the Pin Stitcher machine that stitches pins into plastic cases.

The Pin Stitcher machine contains several motors and sensors that generate more than 50 signals in parallel. The goal of this project was to monitor all the signals at the same time and discover abnormal situations. The AI-Controller captured signals every 2 milliseconds as event data and stored them for data analytics and anomaly detection. There are several situations that anomaly detection can useful in Pin Stitcher Machine.

One of the common problems in the Pin Stitcher machine called "reel jammed" that is caused by Bending and Reel Feeding motors when machine does not move the reel in a good manner. This problem needs a maintenance activity which stops the whole production line for almost one hour. The Anomaly detection model detects the faults early and sends alarm to the engineers and maintenance. For Pin Stitcher machine the alarm represents the prediction of major problem few hours before its occurrence. This early alarm prevents the standstill of machine because it avoids timely maintenance action and suggest simple correction without significant machine stoppage.

Another problem in Pin Stitcher is that there are some changes in the machine that are not feasible to be detected by humans. The anomaly detection model discovered a very small change in duration of one production cycle. The weekly change made the Pin Stitcher machine for each production cycle few milliseconds slower. This change was not captured by operators and engineers. Although this change is small, but continuation of this process will make the machine 10% slower than its speed right now and will produce 15% less products in one day. The root cause of this issue found through monitoring behavior of all signals by anomaly detection models and adjustments took place to keep the machine performance at its high level.

Two approaches in modelling for anomaly detection are applied in this project and presented in sections 4.1 and 4.2.

4.1- AI-Controller and Isolation Forest

The Data Analysis function in AI-Controller brings the opportunity to use the Isolation Forest Algorithm for anomaly detection easily. For that, after discussion with the engineer experts, some events have been defined and programmed in the AI-Controller for collection and analysis. Then, the Isolation Forest model is applied on history data and the monitoring scores calculated to identify abnormal cases out of normal cases via setting the threshold for the monitoring score.

The trained Isolation Forest model and threshold for scores are imported to the AI-Controller. Then, it collects stream event data from the machine and check the event with the threshold of scores to discover whether the event is an anomaly or not. Data Collection and Data Analysis, including model inference and judgment calculations, are executed in real-time withing a few milliseconds. These aspects provide ability of immediate detection and feedback on the machine when things tend to go wrong. Figure 1 shows the Isolation Forest scores calculated for every event and presented in a live dashboard for engineers and operators to track the production. The last event is an abnormal event since its score is higher than threshold.

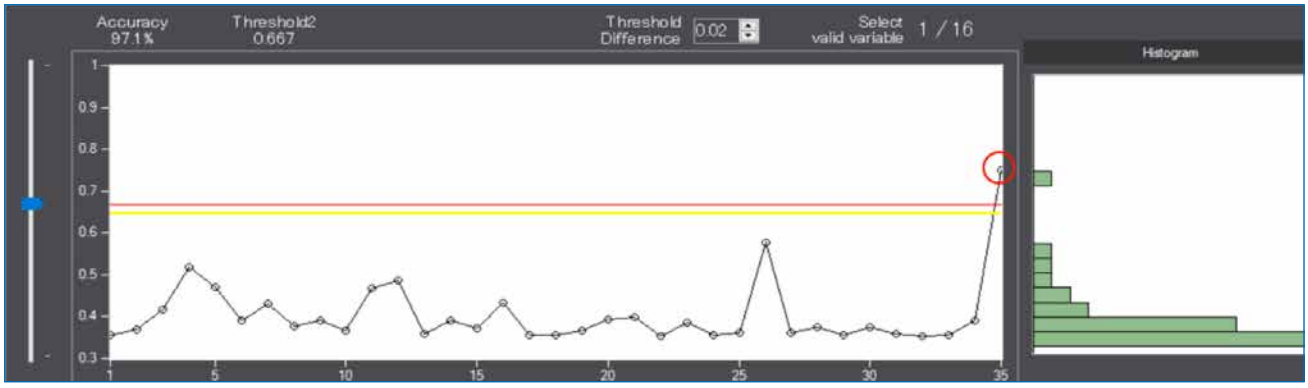

Figure 1: AI-Controller Isolation Forest anomaly detection model results

4.2- AI-Controller and Median Absolute Deviation (MAD)

The fast and precise Data Collection and Data Utilization functions of the AI-Controller provides a good opportunity to apply and implement desired data analysis and machine learning modelling. As an example, the Median Absolute Deviation (MAD) model has been implemented on the Pin Stitcher machine to identify abnormal signals. The analytics cycle is defined for the AI-Controller to collect data. The collected data is used to calculate the limitation control of a production cycle for every signal. This limitation control is used as the boundary to check whether the machine's signals are behaving normal or not. Whenever the signals are outside the boundary, an abnormal situation occurred in the machine. Figure 2 shows the normal behaviour and in control signal on the left and abnormal behaviour of the same signal on the right.

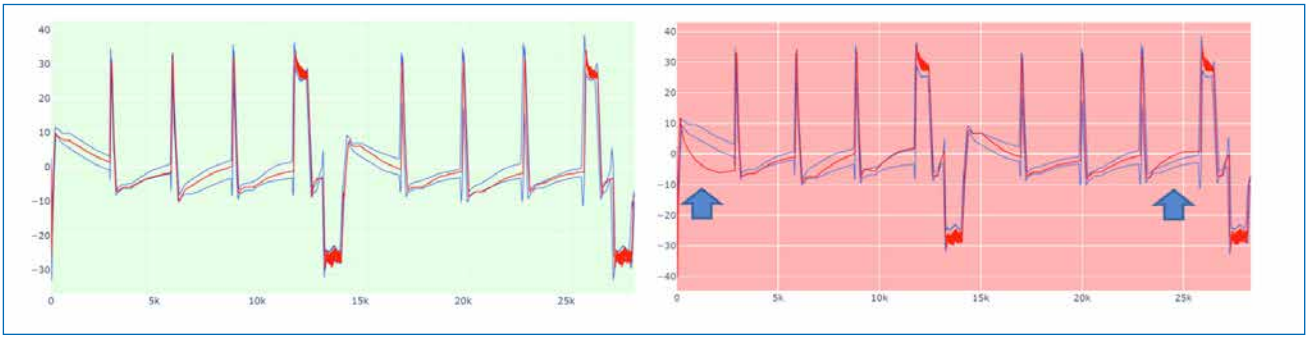

Figure 2: Normal (left) and abnormal (right) behaviour of a signal captured by MAD model.

After setting up the in-control boundaries for all signals, the AI-Controller is ready to collect the live stream data and find the anomalies. Kafka as stream-processing software platform is used to pull live data from AI-Controller and push it to MAD models. In this way all signals from the machine are monitored and checked with the MAD models and limitation control boundaries. The results are generated in the analytical dashboard, shown in figure 3, to continuously monitor the machine status and signal's stability alongside the anomalies. Furthermore, anomaly alert system is designed to send alert via email to the process engineer in case that the number of anomalies in one production cycle gets higher than the defined threshold.

Figure 3: Anomaly detection dashboard using MAD models

Conclusions

OMRON Data Science Services are designed to ensure AI solutions that can be beneficially used in industrial automation domain. We recommend the Machine Monitoring service to detect problems before they influence production and become costly. This white paper showed how Machine Monitoring service could help OMN in increasing OEE of the Pin Stitcher machine.

We developed a system that monitors stability of the machine through applying an anomaly detection model on all machine's signals. Also, we created a system that sends alarms to engineering members about machine abnormal behaviour. The alarm contains machine status information and the source of problems. This information brings smarter maintenance plans, faster and to-the-point actions, and less maintenance disturbance for the machine.

OMRON Machine Monitoring service, and Sysmac AI-Controller in particular, empower data science and AI systems to provide real-time detection of unforeseen failures and act immediately. In addition, this approach is an edge solution that one can easily integrate in an existing infrastructure to monitor machine health and performance in factories long-term.

Would you like to exploit the full value of your industrial data or do you have a problem for which you believe the solution is hidden in your data? Contact Tim Foreman (tim.foreman@omron.com), Mahdi Fayazbakhsh (mahdi.fayazbakhsh@omron.com), Dingeman Knaap (dingeman.knaap@omron.com), or Mariya Yurchenko (Mariya.Yurchenko@omron.com)