JFE TECHNICAL REPORT
No. 26 (Mar. 2021)

Provision of Services by Applying Data Science

1. Introduction

Against the background of improved computing power and digital data use techniques, application of big data has progressed rapidly in recent years, and accompanying this development, diffusion of IoT (Internet of Things), which links all types of data, has also accelerated.

JFE Techno-Research Corporation (JFE-TEC) actively utilizes rapidly-developing data science technologies such as AI (artificial intelligence) and machine learning to solve technical problems in manufacturing.

However, due to shortages of human resources who possess an adequate knowledge of data science, which affect not Japan but also other countries, the supply of capable people cannot keep up with demand. To cope with this shortage of human resources who are able to utilize big data, JFE-TEC provides data analysis methods and optimization methods necessary for problem solving in steel manufacturing, engineering and other fields by making full use of advanced data analysis technologies.

This paper introduces examples of anomaly detection and diagnosis and optimization and simulation applying data science technologies.

2. Application of Data Science

2.1 Anomaly Detection and Diagnosis

Because abnormalities in equipment or operation have a large impact on the quality of production, products and services, minimizing trouble is a critical issue for all companies.

Conventional anomaly detection and diagnosis were performed by using an abnormality judgment logic, and specialized knowledge in connection with the quality of the logic and detection accuracy was necessary.

At the same time, it is also difficult to collect large amounts of data on abnormalities and malfunctions which have a low frequency of occurrence. Therefore, in the conventional method of judgment based on abnormality data, the boundary between the normal region and the abnormal region inevitably overlapped due to lack of data, and false positives were common (**Fig. 1**).

In contrast, abnormalities and trouble can be discovered easily by applying data science technology.

Since it is possible to obtain a large volume of time-series data for normal operating conditions and running conditions, the features of the normal data can be extracted automatically by applying machine learning to normal data, as shown in **Fig. 2**, and as a result, the machine learning discrimination device, which learns the features of normal operation, can judge that various normal data indicate the normal operational state.

However, if operational data containing anomalies are input to the learning discrimination device, the device can judge that this anomalous data represents "abnormal operation" because it "cannot be judged as normal."

Although this is an example of judgment from time-series data, the same principle can also be applied to

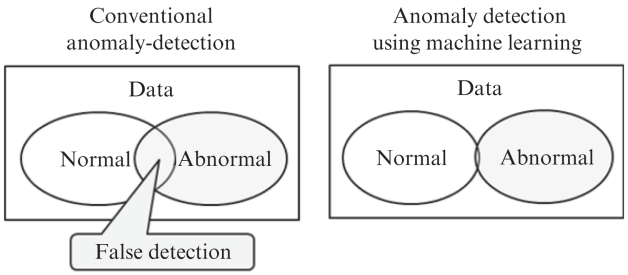

Fig. 1 Overview of anomaly detection

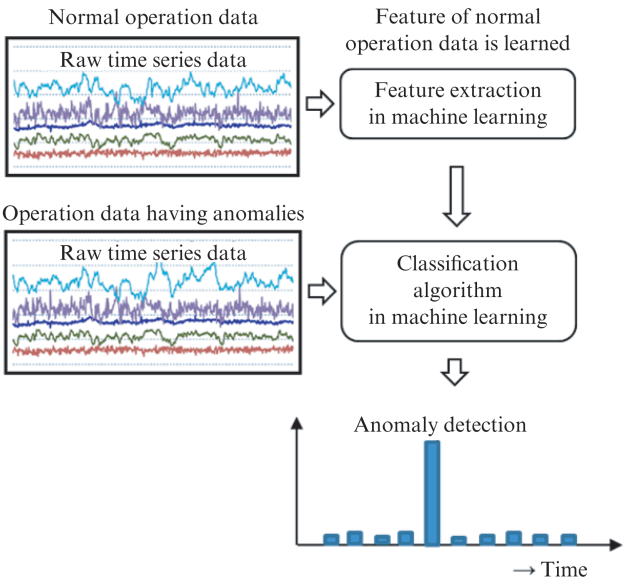

Fig. 2 Data anomaly detection using machine learning

† Originally published in *JFE GIHO* No. 45 (Feb. 2020), p. 75−76

data in image form. In this case, judgment of a non-conforming product due to an abnormal part, contamination or a defect is possible by applying machine learning to image data of products and parts in a normal condition, for which a large volume of data is available.

2.2 Optimization/Simulation Technologies

Although companies and factories possess large amounts of useful information, there are cases where equipment and time cannot be managed efficiently because that data cannot be used. Waste-free use of information and use in new businesses and productivity improvement can be expected by utilizing data science.

Figure 3 shows the verification flow of operations and production using data science.

The current operation and production condition of various equipment or treatment processes is visualized as changes on the time axis based on the numerical and character data collected in a company or factory. An analytical approach is decided by extracting issues from the visualized data, and a data analysis is carried out. For example, in order to identify points where bottlenecks occur or conditions that reduce efficiency, a statistical data analysis method (distribution analysis, histogram, correlation scatter plot, cluster analysis, *etc.*) is selected according to the purpose of analysis in order to discover knowledge and concepts that are useful for improvement. For quantitative verification of the effectiveness of the obtained knowledge and concepts, an effectiveness verification is carried out using a simulation model and optimization technology.

In cases where it is not possible to obtain the effects assumed from those results, and cases where further room for new improvement is discovered, the statistical data analysis method is reviewed once more, a revised simulation model or optimization method based on the results of the review is applied, and the effects are verified again. Methods and measures for clarifying and solving problems are proposed through this PDCA cycle of effectiveness verification, contributing to improvement of the company's capital investments strategy, production scheduling, *etc.*

As an example, **Fig. 4** shows the result of a proper inventory management simulation.

Changes in production lead time accompanying operational fluctuations such as production volume or the composition of manufacturing items and the effect of those changes on the storage capacity of the warehouse and delivery center were analyzed. Based on the results, a simulator and tools capable of verifying the intermediate inventory management and production schedule of products were developed so as to keep the predicted inventory trend (stock forecast) from falling

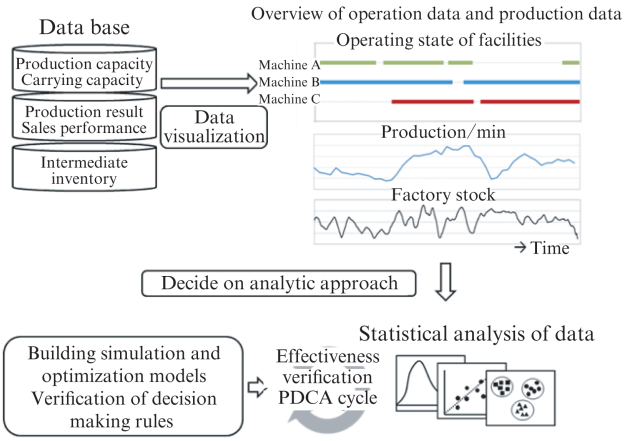

Fig. 3 Verification flow of operations and production using data science

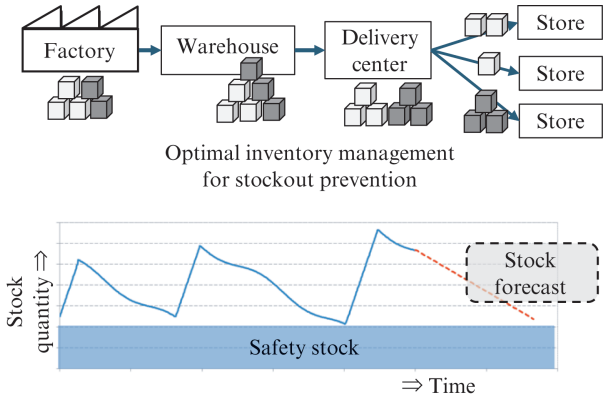

Fig. 4 Example of proper stock simulation result

below the safety stock level.

In order to realize the optimum operational condition, it is important to propose the optimum operation method considering trade-off relationships, capacity constraint conditions, bottleneck processes, *etc.*, and to verify the proposed method by simulation.

Concretely, this approach has made it possible to visualize inventory fluctuations quantitatively, increase the shared recognition of those concerned and prevent lost opportunities by maintaining a proper inventory level.

3. Conclusion

With improvement of computing power and digital data use techniques, application of data science has become an effective means for stable operation of equipment and problem-solving in factory operation and production, distribution and other processes.

As further evolution of AI technologies is expected, JFE Techno-Research will continue to work diligently in the future in order to provide more advanced data analysis services utilizing AI.

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