

# Application Prospect of Data Mining Technology in Intelligent Manufacturing

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**Abstract:** In recent years, with the application of sensors, data acquisition equipment and other modules with sensing ability in the service of complex products, the operation and maintenance system of complex products has become increasingly digital and intelligent. New-generation information technologies such as big data, cloud computing, Internet of Things, mobile Internet, augmented reality (AR) and virtual reality (VR) have also been rapidly applied in the operation and maintenance of complex products. Real-time, multi-source, and massive data has become the basis for decision-making. Data-driven intelligent services have become the development direction of modern manufacturing services. This paper introduces the connotation of intelligent manufacturing and the characteristics of industrial big data, analyzes the application status of data mining technology in intelligent manufacturing, and envisages the future application trend.

**Keywords:** Data Mining Technology, Intelligent Manufacturing, Application.

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## 1. Introduction

Manufacturing big data refers to the big data generated in the manufacturing field. With the development of industrial automation and informatization, information technology has penetrated into all links of the manufacturing industry chain. Technologies such as barcodes, QR codes, RFID, industrial sensors, automatic control systems, ERP, and CAX have been widely applied in the manufacturing industry. The integration of new-generation information technologies (such as the Internet, mobile Internet, and the Internet of Things) with the manufacturing industry enables data generated in all links of the manufacturing industry to be quickly collected and stored in the information system.[1] With the expansion of enterprises and the accumulation of time, such data has increased at an unprecedented rate, driving the manufacturing industry into the “big data era”. There is plenty of valuable potential information in the continuously generated and accumulated big data. With big data analysis methods such as statistics, machine learning, and data mining, the data generated in the manufacturing industry can be analyzed, and knowledge and rules in the data can be explored, on the basis of which processes of the manufacturing industry can be guided, including research and development (R&D), production and manufacturing, sales and after-sales, as well as business management. Eventually, production methods are improved, management processes are optimized, customer needs are perceived, and brand value is enhanced, contributing to the goals of saving costs, improving efficiency, and reducing energy consumption, and gradually making the manufacturing industry intelligent.

## 2. The Connotation of Intelligent Manufacturing

In the face of a new round of technological revolution and industrial reform, “German Industry 4.0”, “American Industrial Internet”, and the “Made in China 2025” strategy have been put forward one after another, leading the traditional manufacturing industry to develop towards intelligent manufacturing, which is a generalized

manufacturing concept and a new manufacturing mode based on intelligent technology. Its purpose is to make full use of advanced information technology, manufacturing technology and intelligent technology to optimize and improve the links in the entire life cycle of products, such as R&D, manufacturing, transaction and management. With the interconnection of information islands realized by Internet information technology, and the life cycle of products simplified by intelligent equipment and data analysis, production efficiency, product quality and service level are improved. Intelligent manufacturing has become an objective trend in the development of manufacturing industry. The development of intelligent manufacturing is not only an inherent requirement for China to realize the transformation and upgrading of traditional manufacturing industry, but also a significant goal for China to achieve the high-quality development of manufacturing industry.

The intelligent plant is the carrier and embodiment of intelligent manufacturing, where users can customize products directly on its user-interactive customized platform and participate in the personalized customization of products. Users anywhere in the world can freely choose the style, color and performance of products according to their personal preferences, and then submit the order directly to the plant. Through the network system, intelligent plant can realize the real-time interconnection in the whole process of customized production, control the supply chain and the manufacturing progress, and track the delivery of goods.

Under the production mode of intelligent manufacturing, the main steps of the product design process are “demand, design, sales, and production”. Users hope to design or select the required products through the customized platform, unwilling to accept the design without much choice. This process can be realized based on three points. First, the user puts forward the design requirement of the product, which is completed by the designer. Second, the user chooses from the design schemes provided by the designer, so as to meet his design needs. Third, choose from the formed design products to obtain the design scheme. Users participate in the whole process of product design, production and delivery through the enterprise’s customized platform. By selecting and

combining different product modules, they can build characteristic products that conform to their own personality,

significantly simplifying the product design process[2].

**Table 1.** Traditional manufacturing services and Data-driven intelligent service

Service Mode	Response Mode	Service Scheduling	Fault Diagnosis and Maintenance Mode	Process Management	Analysis and Decision Mechanism	System Operation Control Mode
Traditional manufacturing services (product services)	Customer requests	Passively waiting for services and resources	Breakdown maintenance	Independent service management	Putting the engineer's subjective experience and judgment first	Artificial regulation
Data-driven intelligent service	Active identification and personalized recommendation of service providers	Active and dynamic scheduling	Attaching importance to fault prediction and pre-breakdown maintenance	Realizing data integration and sharing with product design	Joint decision-making of multidisciplinary engineers to serve big data and manufacturers	Attaching importance to system autonomous regulation

### 3. Characteristics and Architecture of Big Data in Manufacturing

Big data in manufacturing is the sum of industrial data and related technologies and applications. Its core is production business, equipment IoT and external cross-border data, while it extends to related technologies and applications. In addition to the “5V” (Volume, Velocity, Variety, Value and Veracity) characteristics shared by big data, big data in manufacturing also has many characteristics related to those of manufacturing industry.

#### 3.1. Characteristics of Big Data in Manufacturing

##### 3.1.1. Diverse Data Sources

Due to the large number of categories in manufacturing, the big data of enterprises comes from various data sources, such as product design software, production equipment operation process, product quality monitoring equipment, enterprise management information system, supply chain and sales network. What's more, due to the inconsistent automation of manufacturing enterprises, plenty of small and medium-sized enterprises have not reached the level of full automation, and human-machine collaboration remains. Therefore, big data in manufacturing includes both machine-generated data (such as real-time perception data) and human-generated data (such as enterprise management data and supply chain data). Data inconsistencies and conflicts in many autonomous data sources, coupled with complex manufacturing process, massive data, and fast update speed, result in the greater probability of data errors in manufacturing.[3]

##### 3.1.2. Low Data Quality

Due to the complex environment in the manufacturing process, the sensors collecting data or the wireless network transmitting information may have errors, resulting in more noise or missing in the collected data than in general big data.

##### 3.1.3. Complex Information Contained in Data

Due to uneven level of informatization in manufacturing enterprises and different characteristics of production process in different industries, there may be different degrees of coupling between the steps of production links. Therefore, the correlation and mutual influence between data are relatively common in manufacturing industry.

#### 3.1.4. High Real-time Performance in Data

Production line monitoring data (such as operating status monitoring data of equipment and production status monitoring data of each process) is continuously sampled time series data with time labels and sequences. Since the industrial system is a typical real-time control and real-time information processing system, many links in the production line have strict real-time constraints, which determines that a large proportion of the data in manufacturing is real-time data.

### 3.2. Architecture of Big Data in Manufacturing

The architecture of industrial big data includes four levels:

#### 3.2.1. Data Perception and Collection

Based on sensor, RFID, embedded technology, and digital integrated technology, data is obtained from multiple data sources. Data transmission through the Internet, radio frequency, infrared, etc., coupled with data fusion, can ensure real-time and accurate source data.

#### 3.2.2. Data Storage and Modeling

Combined with traditional database technology and cutting-edge distributed storage technology, a multi-level hybrid storage structure is established for various storage systems and can be uniformly accessed. Data is stored in the form of global ontology models such as equipment, process, production line, and user.

#### 3.2.3. Data Analysis and Decision-making

Data is input from the storage system, an appropriate computing framework is selected, data mining algorithms such as classification and regression are integrated to build an industry analysis model, and the results are visually displayed.

#### 3.2.4. Data Application

The industrial big data application scenarios are determined based on business needs. And the application scenarios for production management and control include production scheduling, fault diagnosis and prediction, quality management, supply chain analysis and optimization, etc.

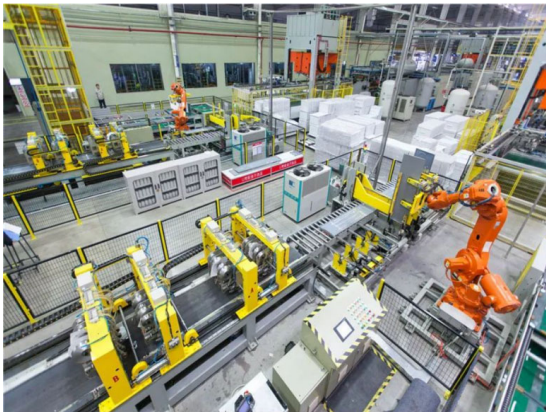
## 4. Application Prospect of Data Mining Technology in Intelligent Manufacturing

### 4.1. Production Scheduling

The deviation between actual production and plan can be

detected by dynamically monitoring abnormal events (such as material shortage, equipment failure, and emergency order insertion) on the basis of intelligent sensing technology, and by predicting process parameters (such as completion date and remaining tool life) with big data analysis. With the consideration of the constraints on processes, processing capability, material handlers, and production cost, scheduling rules are mined or filtered from production process data, intelligent optimization algorithms (such as genetic algorithm) are adopted, and production planning and scheduling are actively adjusted, so as to ensure on-time delivery of tasks.[4]

Haier Group's COSMO Plat, an industrial big data platform, uses IoT sensing, cloud platform, intelligent decision-making and other technologies to monitor equipment status, process variables, as well as resource usage and efficiency online. Meanwhile, through the analysis and prediction of production capacity and inventory, the optimum production schedule and resource adjustment plan can be achieved, effectively optimizing resource allocation and improving production efficiency. Based on big data and the Internet of Things, Haier has set up COSMO Plat, a global user-centered intelligent manufacturing cloud platform, to realize the transformation from manufacturing products to creating user value through mass customization.



**Figure 1.** Intelligent factory supported by Haier Group's COSMO Plat

## 4.2. Fault Diagnosis and Prediction

Traditional equipment fault diagnosis and prediction judge the fault type and locate the fault location mainly by real-time alarm and expert experience, resulting in the poor performance of timeliness. In terms of diagnosis and prediction based on big data, the load, vibration, speed and other parameters of the equipment can be obtained through sensors. Then real-time and accurate diagnosis and early warning can be established for the target system through data mining methods (such as anomaly detection algorithm, decision tree, sliding window frequency pattern tree, machine learning algorithm, etc.), or combined with the knowledge base.[5]

General Electric Corporation of the United States collects, models and analyzes the machine data, alarm data and maintenance history data of its aircraft engine production line, so as to help factory personnel understand machine operating status in real time. Meanwhile, fault locations are identified according to parameters such as pressure, temperature, and current, and possible equipment failures are predicted, enabling automatic maintenance suggestions.

## 4.3. Supply Chain Analysis and Optimization

RFID electronic identification, Internet of Things and other technologies have built a complete supply chain big data lake. With these data, people can: predict the supply and demand of materials to avoid shortages on the premise of controlling inventory; optimize the supply chain network, including the location of transportation vehicles, transportation routes, and the optimization of logistics center location, etc.; conduct cluster analysis on the transportation behavior of certain products to tap potential transportation risks and prevent them in advance. The application of big data in the supply chain field will greatly improve the efficiency of warehousing and distribution, and reduce costs.

SAP develops a big data platform, HANA, and launches supply chain solutions with its advantages in enterprise informatization, so as to quickly predict and disseminate the changes in supply and demand in the upstream and downstream of the supply chain, discover supply and demand imbalances in time, and simulate alternatives. Meanwhile, real-time analysis is conducted on inventory, orders and other data, so as to determine optimum inventory targets for raw materials, work in progress, and finished products, and to reduce supply chain operating costs.

## 5. Conclusion

Complex prediction and optimization problems can be found in many business scenarios of manufacturing. Data mining and intelligent analysis have provided new ideas for solving such problems, and achieved satisfactory results. Looking forward to the future, the in-depth application of big data in manufacturing is inseparable from artificial intelligence which is based on data, such as deep learning and computer vision. With the further deepening of artificial intelligence, intelligent workshops and plants will realize the leap to their wise counterparts.

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