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A Study on Big Data Analytics Services and Standardization for Smart Manufacturing Innovation

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Abstract

Major developed countries are seriously considering smart factories to increase their manufacturing competitiveness. Smart factory is a customized factory that incorporates ICT in the entire process from product planning to design, distribution and sales. This can reduce production costs and respond flexibly to the consumer market. The smart factory converts physical signals into digital signals, connects machines, parts, factories, manufacturing processes, people, and supply chain partners in the factory to each other, and uses the collected data to enable the smart factory platform to operate intelligently. Enhancing personalized value is the key. Therefore, it can be said that the success or failure of a smart factory depends on whether big data is secured and utilized. Standardized communication and collaboration are required to smoothly acquire big data inside and outside the factory in the smart factory, and the use of big data can be maximized through big data analysis. This study examines big data analysis and standardization in smart factory. Manufacturing innovation by country, smart factory construction framework, smart factory implementation key elements, big data analysis and visualization, etc. will be reviewed first. Through this, we propose services such as big data infrastructure construction process, big data platform components, big data modeling, big data quality management components, big data standardization, and big data implementation consulting that can be suggested when building big data infrastructure in smart factories. It is expected that this proposal can be a guide for building big data infrastructure for companies that want to introduce a smart factory.

Keywords: *Smart Factory, Smart Factory Framework, Big Data, Data Modeling, Data Quality Management, Smart Factory Standardization*

1. Introduction

Recognizing the importance of manufacturing, the world's interest in building smart factories to strengthen manufacturing competitiveness is growing. However, compared to the recognition of the need for the introduction of big data, the infrastructure construction strategy for securing and analyzing high-quality big data, which is an essential element of building a smart factory, is lacking. Smart Factory connects all objects,

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facilities, people, and cooperative partners on the changing production site in real time, collects, stores, and analyzes data that is a manufacturing plant to predict machine operation, inspection items, and pre-maintenance to improve machine efficiency and improve efficiency. Increase productivity. We have the ability to produce high-quality products, operate our factories optimally, and operate our own [1].

To prepare for the 4th Industrial Revolution, major advanced countries are pushing ahead with plans such as implementing intelligent innovation projects, securing growth engine technology, creating industrial infrastructure and ecosystems, and responding to changes in the future society. Innovative projects that maximize intelligence by applying artificial intelligence (AI) and Internet of Things (IoT) not only to smart factories, robots, and drones, but also to water and sewage systems and traffic lights will be promoted. The manufacturing industry is a key industry that contributes to economic development with workers and products produced in factories. It is a key industry that leads various industries such as service and distribution in the value chain. Therefore, hardening of manufacturing competitiveness through smart factory establishment is a very important task in advanced manufacturing industries [2].

In this study, we first examine manufacturing innovation by major countries such as Germany, the United States, China, Japan, and Korea, the framework for building a smart factory, factors influencing the implementation of the smart factory, and big data analysis and visualization. Next, learn about services such as big data infrastructure construction process, big data platform, big data modeling, big data quality management components, big data standardization, big data implementation consulting that can be suggested when building big data infrastructure in smart factories. see.

2. Manufacturing innovation and Smart Factory

2.1 Manufacturing innovation

Major industrialized countries are recognizing the importance of manufacturing industry and making various efforts and investments to strengthen manufacturing competitiveness. The following are the manufacturing policies and strategies of major countries[3].

2.1.1 Germany

Germany, which started Industry 4.0, is collaborating with companies, academia and the government to find ways to innovate to increase manufacturing competitiveness, led by the government. The Platform Industry 4.0 Secretariat, formed by the German Information and Telecommunications Association (BITKOM), the German Machinery Industry Association (VDMA) and the German Electrical and Electronics Industry Association (ZVEI), is working on a field-oriented industry 4.0 project[4].

2.1.2 USA

The United States promulgated the 2012 policy to revitalize manufacturing. Two organizations, the Smart Manufacturing Leading Association (SMLC) and the Industrial Internet Consortium (IIC), are leading the creation of the Manufacturing Innovation Infrastructure (NNMI). SMLC is focusing on manufacturing companies in 2012 to develop open smart manufacturing platform for smart manufacturing and strengthen industry-academia cooperation. IIC was formed in 2014 and is leading the promotion of the Internet of Things through collaborative standardization around private companies.

2.1.3 China

China is pursuing a new industrial revolution by combining 'China Manufacturing 2025', 'Internet Plus' and 'Public Entrepreneurship & Man-in-War' based on the 'one-to-one' strategy aimed at reviving the industry and emerging economies. 'China Manufacturing2025' is a strategy to develop China's manufacturing capability into creativity, speed, and quality as Chinese brands rather than promoting Chinese products, and 'Internet Plus' integrates and converges the Internet in all industries to innovate. We are creating an environment where anyone can easily start a business by creating a new business model.

2.1.4 Japan

In 2013, Japan introduced the "Industrial Rehabilitation Plan" and is investing heavily in technology development to enhance the competitiveness of the manufacturing industry. In response to the Fourth Industrial Revolution, Japan established the Industrial Value Chain Association (IVI) and the Robot Revolution Realization Association(RRI) to develop technology standards that enable data transfer between facilities operating at each plant. Industry-academic institutions are actively collaborating to promote the Second Industrial Revolution.

2.1.5 Korea

Korea announced the 'Manufacturing Innovation 3.0' policy to realize the creative economy in 2014,and the government is focusing on creating an environment to secure manufacturing competitiveness through the convergence of IT and software. The Korean government announced the 'Smart Manufacturing Innovation Vision 2025' to form a Smart Manufacturing Innovation Promotion Group, centered on companies and economic groups, aiming to build 10,000 smart factories by 2020 and 30,000 by 2025[5].

2.2 Framework for building a Smart Factory

4M2E (Man, Machine, Material, Method, Energy, Environment), which are the elements of physical factory, should actively respond to technological development and environmental change.

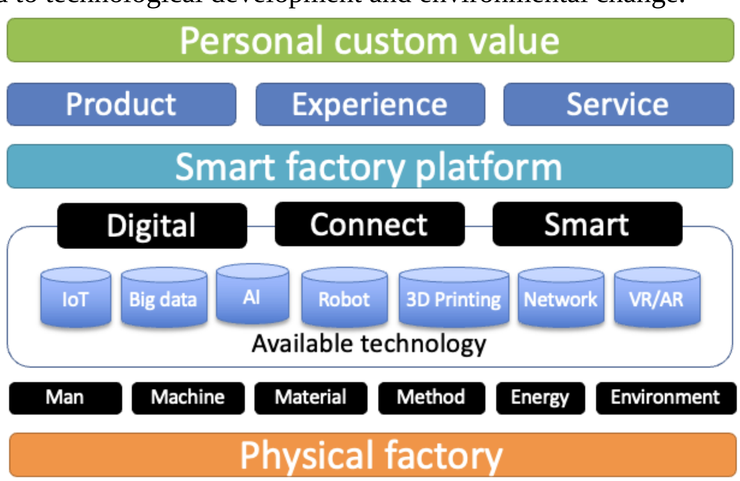

Figure 1. Smart Factory Platform

Figure 1 shows Smart Factory Platform. To produce a product in a physical factory, components such as man, machine, material, method, energy, and environment are needed. These production factors are connected, digitized, and smartized through ICT technologies such as IoT, big data, AI, robot, 3D printing, network, and VR/AR and provided to customers in the form of products, experiences, and services.

Smart manufacturing refers to technology that fuses human, technology, and information for strategic innovation in the manufacturing industry and applies various information communication technology to the manufacturing industry. Smart Factory is connected, integrated, and operated autonomously based on operation technology, information technology, and data technology in facilities, factory management, manpower, and supply chain network[6].

2.3 Factors Affecting Smart Factory Implementation

Cyber Physical System(CPS), Industrial Internet of Things (IIoT), Industrial Internet of Services(IIoS), Industrial Data Analytics, Smart Sensor, Intelligent Robot, Automation Facilities, Interoperability Platform, Cloud Computing Research and development of various key elements such as manufacturing and manufacturing intelligence. Smart manufacturing is basically a strategy of optimizing all production processes by combining and applying new ICT such as IoT to traditional manufacturing industry. Through this, the goal is 'manufacturing optimization', and smart factory CPS manages, refines, and analyzes big data collected at the manufacturing site. Achieving optimization is a key execution strategy for Smart Factory. Korea is establishing mid- and long-term road maps for eight smart manufacturing technologies, smart sensors, cyber physics systems, 3D printing, energy savings, the Internet of Things, cloud, big data, and holograms. In addition, Smart Factory is developing manufacturing intelligence technology by applying machine learning and AI technology based on big data of production sites[7].

2.4 Big data analysis and visualization

The characteristics of big data are generally described by 3V - Volume of data, Velocity of data, Variety of form - and recently emphasizes the importance of data reliability. Big Data Analysis is a core asset that extracts value from data with big data characteristics at low cost and determines the superiority of future competitiveness by collecting, storing, processing and analyzing data to suit the characteristics and purpose of industrial field. Big data visualization refers to the process of visualizing and delivering big data analysis results to understand way. It is becoming more important to apply analysis results and values to services and how to show them to users. Data visualization, information visualization, and infographic as shown in table 1 are the effective ways to communicate the analysis results[8].

Table 1. Visualization Technology

division	application
Data Visualization	Use the meaning of graphs to communicate and communicate information clearly and effectively. It mainly conveys the idea of raw data effectively.
Information Visualization	Mainly express large quantity or non-quantity information visually using statistics (charts, graphs, etc.), images, and colors. Information visualization methods are divided into time, distribution, comparison, and spatial visualization.
Infographic	Rather than conveying information, it is often used to convey persuasive messages. Rather than using raw data, it is a persuasive message that visually expresses information, data, and knowledge using various charts, diagrams, and illustrations.

3. Infrastructure construction for big data utilization

3.1 Big Data Infrastructure Building Process

Building a Big Data Infrastructure for Smart Factories is not just collecting data. It is important to share real-time data with cooperating partners scattered all over the world. Securing continuous and high quality data is also important. To do this, we need to collaborate with a variety of stake holders, including data scientists, field manufacturing specialists, business specialists, value chain network partners, customers, service users, and external consulting personnel. Figure 2 shows Big Data Infrastructure Building Process. Big data infrastructure building process is divided into big data project plan, big data infrastructure building, project execution and enterprise expansion of analysis ability. Big data project planning stage includes problem definition, problem business effect analysis, problem solving success standard, success value definition, data requirements, and difference analysis of AS-IS and TO-BE. Big data infrastructure building includes bid data platform, big database, analysis system, visualization system, data modeling, and data quality management. Project execution and enterprise expansion of analysis ability includes project execution, evaluation of analysis results, derive improvement plan, new method proposal, and enterprise expansion of analysis ability.

This will enhance data analytics and make manufacturing more competitive. Big Data Project Planning examines the definition of the purpose of using data accumulated at the production site, what data is collected to achieve the goal, and which analysis techniques are used[9].

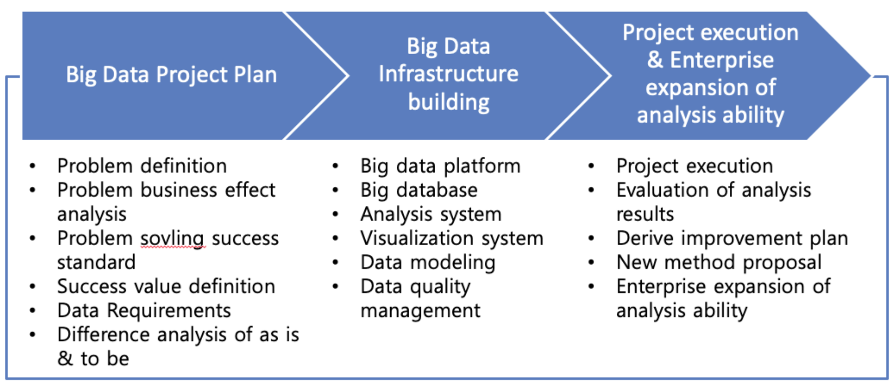

Figure 2. Big Data Infrastructure Building Process

3.2 Big Data Platform

The big data platform is a collection of big data technologies and an environment ready to use data technologies well. Big data platforms are needed to gather enterprise data in one place, rather than collecting big data from industrial sites for the purpose of a unit factory or a specific organization. The introduction of big data platforms is very important in building intelligent factories where processes such as these are connected by data. Figure 3 shows the big data platform components. Big data is generated from components such as man, equipment, parts, process, environment, and energy. Such big data is collected, stored, processed, and managed in a big database and utilized for analysis software, visualization software, and platform operation.

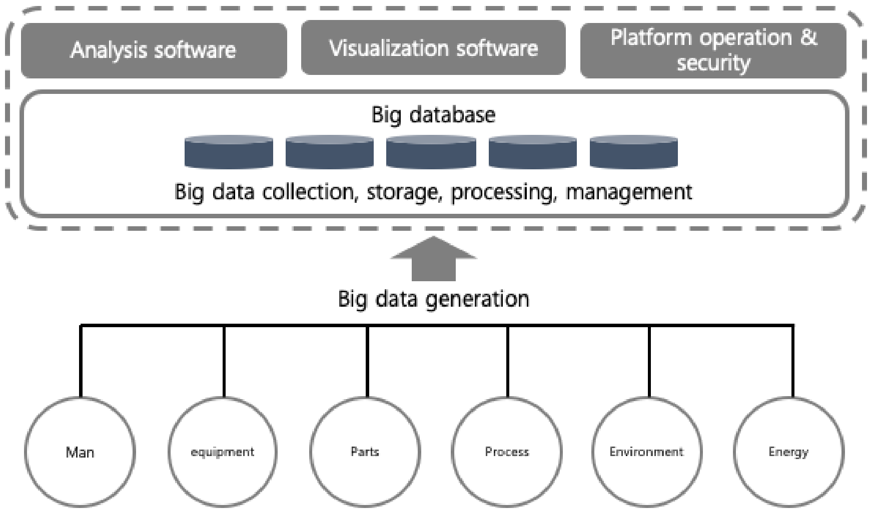

Figure 3. Big Data Platform Components

3.3. Big Data Modeling

To build a Smart Factory, create a data list of what data to collect. You need to construct an architecture for how to collect data and create a data model for storing them in a big database. Data modeling is an abstraction technique that clearly expresses facts that can discriminate true or false against data or business rules, based on a comprehensive understanding of business operations. The logical data model defines a logical data set, management items, and relationships by defining a conceptual data model, and a physical data model refers to a logical model that implements a data structure in consideration of a big database characteristic and performance. Figure 4 shows the big data modeling process. In the beginning stage of big data modeling, data scientist, field engineer, business professional IT professional, etc. do data standardization, domestic and international industry standard. Next, logical data modeling and physical data modeling are performed sequentially.

Data modeling is based on a comprehensive understanding of corporate business. It is an abstraction technique that clearly expresses the fact that it exists in the data or that it can be determined whether it is true or false about a business rule, in terms of access, data, and computerization[11].

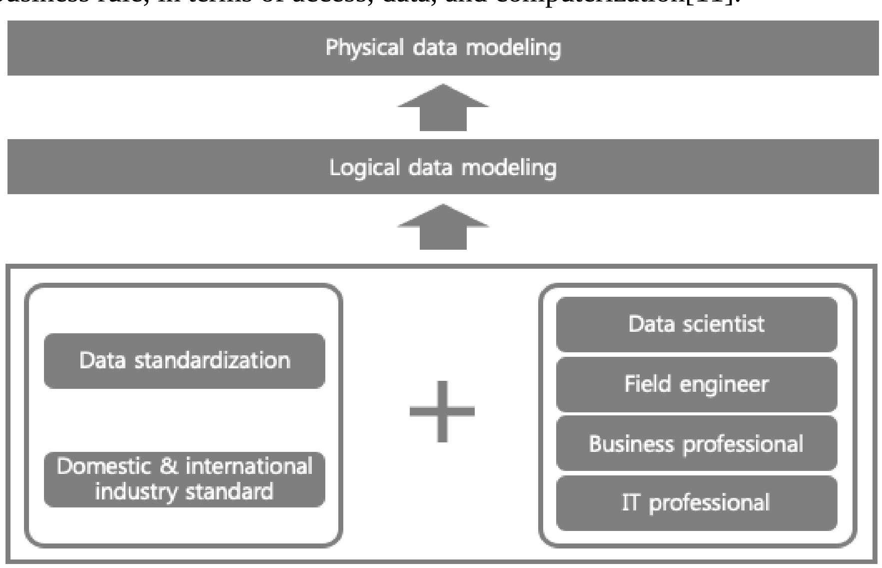

Figure 4. Big Data Modeling Process

3.4. Big Data Quality Management

Data Quality Management refers to a series of activities, such as quality goal setting, quality diagnosis and improvement, and related tools to support the quality of data to provide useful value to users. Data quality management is divided into planning, construction, operation, and utilization phases, and data quality management activities are conducted. Data quality elements define data quality management items that take into account data values, business rules, data standards, data structures, production sites, facilities, and process data characteristics.

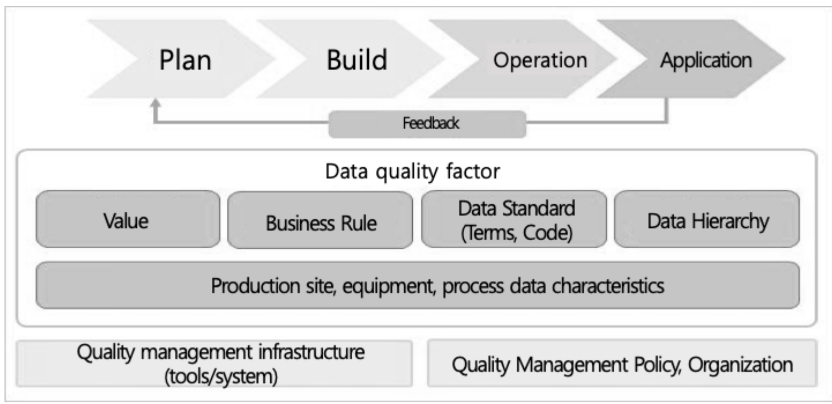

Figure 5. Components for Big Data Quality Management

Figure 5 shows the components for big data quality management. Value, business rule, data standard, data hierarchy, production site, equipment, and process data characteristics are factors that determine data quality. These are reflected in the quality management infrastructure in the planning and construction process and quality management policy and organization in the operation and utilization process.

The data quality management policy is established in consideration of the organizational data quality management policy and the principle of maintaining consistency, and the quality management organization means a system that effectively supports the institution's policy and data quality management activities. Data quality management infrastructure refers to data quality management system and metadata management system for effectively performing data quality management activities. The characteristics of big data are volume, variety, velocity, and reliability[12].

3.5. International Standardization Trend

International Organization for Standardization (ISO) Technical Committees (TC) 184 and International Electrotechnical Commission (IEC) TC 65 are major international standardization bodies for smart manufacturing, and ISO / IEC Joint Technical Committee 1 (JTC 1), Institute of Electrical and Electronics Engineers (IEEE), Open Connectivity Foundation (OCF), Industrial Internet Consortium (ICI), and others include IoT, Big Data, Cloud Computing, Security, We are developing standards for information and communication technology related to manufacturing. Recently, JWG 21, a joint working group, was established to standardize the manufacturing structure of IEC TC 65 and ISO TC 184 gas marts[13].

3.5.1. ISO TC 184/SC 4(Industry data)

ISO TC 184 / Standard Committees (SC) 4 develops industry data standards for general manufacturing, shipbuilding, offshore, plant, and nuclear power plants, and domestic and overseas industries, research institutes, and universities are using them to exchange product design information. Product data and quality quantification standards are key resources for smart manufacturing support, and can be used for interoperability between systems, integration of automated systems, inspection and maintenance, and decentralization and review of smart manufacturing functions.

3.5.2. ISO TC 184 / SC 5(Interoperability, integration and architecture for enterprise systems and automation applications)

The purpose of this group is to develop evaluation indicators and methods for assessing the level of information and industrial convergence in a three-tier manufacturing operation system on an existing IEC 62264 layer model. In addition, the objective is to develop application guidelines to apply the developed methodology to various industries.

3.5.3. ISO SMCC

The ISO Technical Management Board (TMB) establishes the Smart Manufacturing Coordinating Committee (SMCC) to review the definitions of terms for smart manufacturing and industry 4.0, and to prepare a list of existing or ongoing standards, standard projects and use cases. This study was designed to analyze items and promote future standardization work.

3.5.4. IEC SEG 7

SEG 7 is a group to discuss existing standardization trends and discuss future countermeasures for the standardization items common to IEC-related standardization groups related to smart manufacturing.

3.5.5. IECTC65 (Industrial process measurement, control and automation)

IEC TC 65 establishes technical standards to ensure interoperability among smart plant components[14].

3.6. Big Data Building Consulting

In constructing a big data system, we need to convert the existing information system into a big data environment or build a data lake by collecting the data that will be the material of the future analysis. Most big data building projects design analytical models to obtain the desired analytical results and modify or modify the analytical models until they are satisfied with the results. The process of verifying the results should be repeated. It is very difficult to perform on a fixed schedule like a general information system building project, so you should take this into account when planning a project. Figure 6 illustrates the framework for building a big data analytics platform.

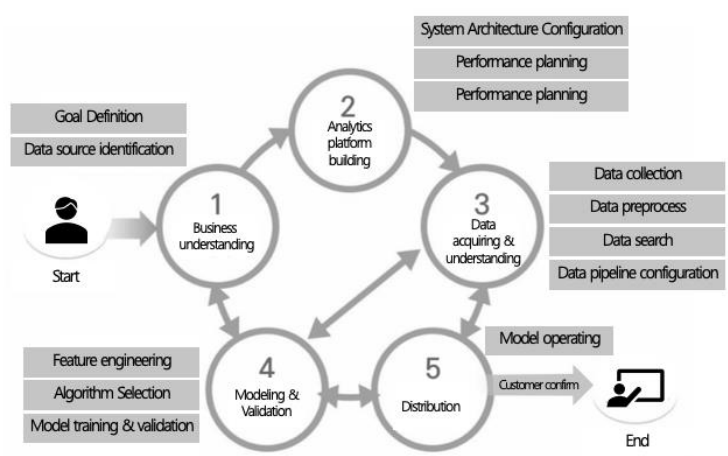

Figure 6. Big Data Analysis Platform Building Framework

The framework provides guidelines and frameworks for working with project members, and every step can be repeated as needed. In particular, the process of data acquisition and understanding and modeling and verification should be repeated until target analysis results are obtained. Each step is described in detail as follows[6].

- **Business understanding**: Define goal definitions and business target variables, identify the corresponding data sources, and determine the size of the system to build.
- **Analytics platform building**: If an information strategy plan has been implemented in advance and the technical architecture has been determined, then the system architecture should be constructed based on it. In other words, the system architecture is defined and introduced based on the technical architecture defined in the project proposal stage and the data types and sizes identified in the previous stage. Plan the performance test of the constructed system to be performed in the future deployment stage, and establish, change and manage the future system operation plan.
- **Data Acquisition and Understanding**: For modeling purposes, create high-quality data sets related to target variables and place them on a built analysis platform. Develop a data pipeline that updates data regularly and scores new.
- **Modeling and Validation**: Feature engineering and model training determine optimal data variables for machine learning models. Set up a model that most accurately predicts your targets to create a machine learning model for your production environment.
- **Distribution**: Perform implementation and acquisition of the analysis platform environment to finalize the model containing the built data pipeline. At this stage, the performance and operational policies of the platform built are finally checked and system implementation is performed[15].

4. Conclusion

The key to smart factory is data analysis through securing internal and external big data. For this, it was confirmed that it is very important to build a big data infrastructure that can secure high-quality big data. In this study, manufacturing innovation by major country, smart factory construction framework, factors influencing smart factory implementation, and big data analysis and visualization were first examined. In addition, big data infrastructure construction process for smart factory introduction, big data platform components for securing big data, big data standardization for smart factory communication, big data quality management components, big data construction consulting, etc. were presented. This will serve as a guide to building a big data infrastructure for companies that want to introduce a smart factory.

In future research, continuous algorithm development is needed to build a more intelligent smart factory by utilizing accumulated data assets.

Acknowledgement

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