APPLICATION OF DATA COLLECTED IN IOT ENVIRONMENT

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Abstract: *The fourth industrial revolution, Industry 4.0, is a collective term for several technologies involving automation, data exchange, and manufacturing that include cyber-physical systems, the internet of things (IoT) and cloud computing. Usually data collected via devices such as sensors or RFID are used for operations especially for material handling in manufacturing systems and constructing a cyber-physical system. Herein, it is stressed that operations management is the third application of collected data. In addition, real applied examples are introduced for transferring collected data via sensors to a personal computer.*

Key words: *IoT, Industry 4.0, Data, Sensor, RFID.*

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1. Introduction

Internet technologies have been applied to both manufacturing systems and service systems. Since the 2010s, the fourth industrial revolution or Industry 4.0 has been a collective term for a number of data exchange, manufacturing automation, and supply chain technologies in the internet of things (IoT). In an Industry 4.0 environment, cyber-physical systems (CPS) communicate with each other and with human participants in real-time via IoT. In addition, both internal and cross-organizational services are offered and used by members of the supply chain.

The business environment in the manufacturing industry has become extensively complicated, and thus environmental changes have been pushing forward for a manufacturing evolution. The diversification and sophistication of customer needs result in mass customization, reduction in operating costs, automation, and quality improvement. To cope with these recent drastic business environment changes, manufacturers should use big data and perform data analytics in the IoT environment. The data handling procedure consists of data gathering, data communication, data processing, and data analytics techniques. Data gathering technology is sensing including sensors and radio frequency identification (RFID) technology. Data communication technology is referred to equipment between high-speed communications. Data processing technology includes cloud and edge computing. In addition, simulation relates to data analytics techniques.

By the way, Gartner expects more than 15 billion global IoT devices to connect to the enterprise infrastructure by 2029 (Gartner, 2021). Sensors and RFID technologies play important roles, especially from the standpoint of data gathering. Hence, in this paper, these two devices are mainly treated in the IoT environment.

This study describes the relationship between data collection via a sensor or RFID technology and the related application. Then, operations put in the manufacturing and cyber-physical systems are illustrated as the two major applications of collected data. Furthermore, the methods of transferring collected data to a personal computer are described to perform operations management.

2. Data-Collecting Devices and Its Application in IoT Environment

In an IoT environment, sensors and RFID technologies are the primary devices to collect data from manufacturing and service systems. Nevertheless, first, sensors and RFID systems are described below.

- According to Merriam-Webster Unabridged Dictionary, a sensor is a device that responds to a physical stimulus (such as heat, light, sound, pressure, magnetism, or a particular motion) and transmits a resulting impulse (for measurement or operating a control) (Merriam Webster).
- As Investopedia explains, RFID is a technology that uses radio waves to identify a tagged object passively. It is used in several commercial and industrial applications, from tracking items along a supply chain to keeping track of items checked out of a library (Investopedia).

After collecting data via sensors or RFID technologies, applications can be classified into three main kinds: operations put in a manufacturing system, the cyber-physical system, and operations management. A simulation model is developed to reflect the physical system using a sensor (Yang et al., 2017; Takakuwa, 2018). In addition, the application of RFID technology is introduced in a hospital (Barbora & Hromada, 2020).

First, two examples of operations put in manufacturing systems are introduced. For the sake of description, a real manufacturing system or plant is replaced with a physical model provided by Fischertechnik or FESTO in a university laboratory. In Fischertechnik ® Factory Simulation v9, parts are grouped into three sorting lanes based on their colour (Fischertechnik). An optical colour sensor is installed to detect colour based on a surface reflection of a part. Thus, the optical colour sensor performs the colour detection. After checking the part colour, it is routed and then sorted into the appropriate lane. In this case, a sensor is equipped in a production line for performing manufacturing activities. The sorting line with detection using sensors in Fischertechnik ® Factory Simulation v9 is shown in Fig. 1,

Fig. 1. Sorting line with detection using sensors in Fischertechnik ® Factory Simulation v9.

Similarly, as an example, the RFID system is installed to process customized parts in small batch sizes in sorting lines with detection using RFID read/write head in FESTO ® MPS System203 Industry 4.0. In the distributing/conveyor station Industry 4.0, the RFID read/write head writes the work order, the item (part) number, and the functions to the RFID tag in the part base. According to FESTO, highly flexible, RFID-based production lines are used as a major Industry 4.0 breakthrough (FESTO, 2017). These two systems are typical examples of applying sensors and RFID technologies incorporated in manufacturing systems to perform operations in processes. The sorting

line with detection using RFID read/write head in FESTO ® MPS System203 Industry4.0 is shown in Fig.2.

Fig. 2. Sorting line with detection using RFID read/write head in FESTO ® MPS System203 Industry 4.0.

Regarding Industry 4.0, the Japanese government, in 2016, introduced the new concept of “Society 5.0 (Super Smart Society)” in the “Fifth Science and Technology Basic Plan,” taking Industry 4.0 into consideration (Cabinet office of Japan, 2016). Society 5.0 succeeds Society 1.0 as the hunting society, Society 2.0 as the agrarian society, Society 3.0 as the industrial society, and Society 4.0 as the information society, as evolution of IoT and artificial intelligence. In Society 5.0, products and services would be provided to satisfy various customers’ needs by intensively merging the cyber space and physical space. A human-oriented society would be realized so that people would enjoy comfortability and vitality. Thus, the cyber-physical system is also a major application of collected data.

The concept of Society 5.0 is original and broader compared with those proposed in other countries. The overall scheme is illustrated in Fig. 3. Automatic operation, for example, is one of the key technologies that aims at the realization of Society 5.0. It needs the automated operation technology to process three actions: recognition, judgment, and operation, linked to each other. The recognition is to understand the exact position and surrounding conditions of one's car, and the judgement is to choose acceleration, deceleration, or turning. Lastly, the operation does the one that a person was doing so far literally automatically.

Fig. 3. Industries in the era of “Society 5.0” proposed by Japanese government.

3. Data Collection in Terms of Operations Management Using Sensors

In this section, the logic of processing collected data to Excel is described. Some sensors including colour sensors are equipped to detect the colour of parts for sorting and routing them to the designated associated separated lanes in Fischertechnik’s factory simulation 9V model. These sensors are used to execute the actual operations in the manufacturing system, as mentioned in section 2.

A light sensor is placed at the appropriate position to sense a part passing in real-time mode. Data collected by a light sensor is transferred to the module of an Arduino microcomputer, and then transferred to a PC to process with Excel VBA programs. The scheme is illustrated on the systems for sensing objects through a wired or wireless connection in Fig. 4. As shown in Fig.4, the sequential process consists of sensing an object, sending the signal to a microcomputer, checking the status with an algorithm, sending the signal through a wired or wireless connection, and writing the data to a digital sheet in a personal computer.

Grove Light Sensor v1.2 sends a changed value to the Arduino depending on the light intensity. In addition, an XBee ZB (S2C), Digi's product, is attached to the Arduino that has an application development. The Arduino receives signals sent from the sensors according to the programmed algorithm in Arduino, as shown in Fig. 5 and then sends the associated data to the microcomputer if the condition defined by the algorithm is satisfied.

Fig. 4. Sensing objects through wired or wireless connections.

In the microcomputer, threshold values are predetermined, and the sensor value is converted into two kinds of values. For the light sensor, there are two cases, “light” and “dark.” By combining these two reactions, the specific movement of a part is sensed in front of the sensor. The algorithm has the function of sending a signal to detect the object to Excel. Therefore, the algorithm must eliminate sensor's unnecessary reaction and measure the object's actual moving time. The general flow of the Excel algorithm of is shown in Fig. 6.

4. Applications

4.1 Examples of Sensing Objects through Wireless Connection

As shown in Fig. 4, there are two ways of sensing objects through a wired or wireless connection. In this section, real examples for each case are introduced.

1) Sensing systems through a wireless connection

The Fischertechnik® Factory Simulation 9V is used to apply the proposed system as sensing objects through a wireless connection. This is originated and furnished as a physical system to study how manufacturing systems work in a university or an institute laboratory. This system consists of three main subsystems: the Controller

Automated High-Bay Warehouse with a Vacuum Gripper Robot, Controller Multiprocessing Station with Oven, and Controller Sorting Line with Detection.

First, parts are stored at the high-bay warehouse as the receiving station. Then, the parts are routed on the conveyor to a series of the processing area. After the parts are processed, they are conveyed to the sorting site. The sorting line is used to separate different coloured parts by colour detection automatically; a colour sensor detects colour based on different surface reflections. The Fischertechnik® Factory Simulation 9V with sensing system through a wireless connection is shown in Fig. 7. In Fig. 7, A-H are routing parts from the high-bay warehouse to the sorting area, and numbers 1-8 are light sensor locations to collect data when a part passes in front of the associated sensor.

Fig. 5. The Arduino process flow diagram.

In Excel, the associated signal is received from the microcomputer, and then the corresponding reacted time is filled in the designated cell. Finally, filling the same interval time in the exact column is executed in stages to obtain the associated aggregated data. A selected result of the worksheet by performing the Excel-Macro procedure is shown in Fig. 8.

4.2 Examples of Sensing Objects through a Wired Connection

A sensing system through a wired connection is applied to collect data for sensing parts on a conveyor system. The parts are routed on a belt conveyor sequentially from station to station. A sensor is located beside the belt conveyor. After the sensor detects an object or the part passing in front of the sensor, it sends a signal to the microcomputer. The sensing system through the wired connection is shown in Fig. 9 together with the belt conveyor.

5. Conclusion

Data is collected via sensors or RFID technologies for manufacturing or service systems in an IoT environment. Collected data are usually used for operations especially for material handling in manufacturing systems and constructing a cyber-

Fig. 6. The Excel process flow diagram.

Fig. 7. Example of wired-connection sensors.

Moving time or processing time is filled as a part moves.

	A	B	C	D	E	F	G	H	I
1		No. 1-No. 2	No. 2-No. 3	No. 3-No. 4	No. 4-No. 5	No. 5-No. 6	No. 6-No. 7	No. 7-No. 8	
2		17.938	3.230	20.496	18.621	9.008	9.629	7.813	
3		21.844	3.418	20.227	18.223	9.086	9.773	7.199	
4		23.910	3.297	20.426	18.047	9.094	9.574	7.141	
5		14.047	3.391	20.176	17.953	9.055	9.840	7.105	
6		16.512	3.375	20.293	18.023	9.090	9.438	6.977	
7		21.160	3.273	20.238	18.078	8.832	9.613	6.816	
8			3			9.199	9.715	7.441	
9			3			9.316	9.734	10.414	
10			3			8.980	9.660	6.609	
11									

Figures of each row are on each part.

Figures of each column are on measurement-point interval.

Fig. 8. Selected Results of Performing Excel-Macro Procedure.

Fig. 9. Example of wireless-connection sensors.

physical system. In this paper, it is indicated that operations management is the third application of collected data. Hence, applications on collected data can be classified into three main kinds: operations incorporated in the manufacturing system, the cyber-physical system, and the operations management. Regarding an essential operations management procedure, organizing the collected data via a light sensor is proposed in both wired and wireless modes.

A light sensor is placed at the appropriate originally constructed to sense a part passing in real-time mode. Data collected by a light sensor is transferred to an Arduino microcomputer module and then to a personal computer to process with the Excel VBA program. In addition, actual applications are introduced to demonstrate the systems. By using the proposed systems, effective process control is performed with Andon that is a visual management tool to highlight the status of operations in each station at a single glance. Furthermore, point of production (POP) will be conducted by installing them systematically.

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