Enhancing Distribution Centers Using Robotics and Digital Solution Technologies

The rapid expansion of electronic commerce is driving a shift in how distribution centers operate, away from the delivery of large quantities of goods to retailers and other predetermined destinations, and toward the delivery of small quantities of goods to individual consumers who could be located anywhere, thereby increasing workloads of distribution centers, a situation that is exacerbated by labor shortages. New technologies are expected to be utilized to improve this situation, establishing a robust distribution industry that will support Japanese economic growth and people's livelihoods. Hitachi is working on this distribution revolution by supplying a service for enhancing distribution centers that uses digital solution technologies such as the Internet of Things, big data analytics, and artificial intelligence. This article describes examples of these efforts and the outlook for the technologies.

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1. Introduction

The rapid expansion of electronic commerce (e-commerce) is ushering in an era in which even groceries are purchased via the Internet. For consumers, purchasing practices are changing away from visiting retailers and selecting goods for purchase from the stock available, and toward freely selecting from a vast array of different categories of goods on the Internet. This is accelerating the complexity of work at distribution centers by requiring them to retain a diverse inventory of goods. Moreover, goods need to be delivered wherever and whenever consumers want them, and this is spurring the further acceleration of the trend toward increasing complexity at distribution centers. Meanwhile, the number of people in the workforce in Japan is falling since reaching its peak in the early 1990s, with little hope of any increase in the future as the population of children under 14 years of age, who represent the workforce of the future, also has been falling since the 1980s[(1)].

Recognizing this situation, the Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure, Transport and Tourism in July 2017 formulated the Comprehensive Physical Distribution Policy Outline (FY2017 to FY2020) that was recently issued as a cabinet decision[(2)] seeking to prevent interruptions of distribution systems, which are an important part of the infrastructure that supports Japanese economic growth and people's livelihoods. Among the key points of the policy outline was the establishment of a robust distribution industry that can cope with changes in society such as the fourth industrial revolution and greater use of

e-commerce amid an aging population and falling birthrate.

In response, Hitachi is working on a logistics revolution by supplying services for enhancing distribution centers that use digital solution technologies such as the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) to make the work of distribution centers faster and more efficient.

2. Hitachi's Overall Vision of Distribution Centers

Distribution centers are required to process small shipment orders rapidly and in high volume by picking small quantities of specific goods from a wide variety of inventory. Unfortunately, because this task starts as soon as the order details from the customer are confirmed, it is not possible to make any prior preparations, which places a limit on how much the efficiency of this work can be improved.

While progress has been made on using materials handling equipment to reduce space and labor requirements in the past, much of this work still must be done manually. With the difficulty of obtaining sufficient workers also becoming more severe every year, distribution centers are being called on to raise their work efficiency beyond past levels. Effective ways of achieving this include using data analysis to plan optimizations, using robots to reduce manual work, and using digital solutions like the IoT and AI to improve efficiency. The following sections describe these efforts.

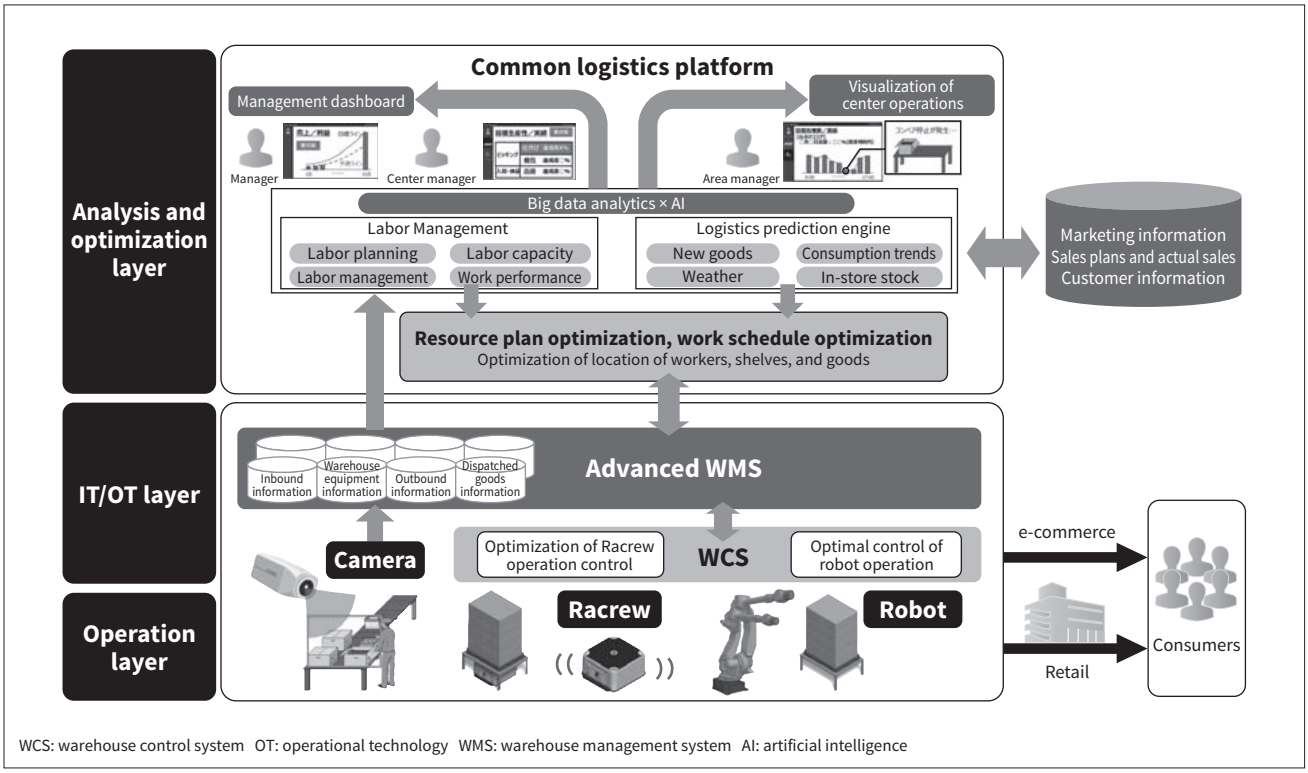
2. 1
Common Logistics Platform and Advanced WMS

While typical distribution centers adopt warehouse management systems (WMSs) to simplify operations and prevent dispatch errors and delays, this involves issuing work instructions based on a shipping schedule, which limits the efficiency improvement. As the trend toward dispatching an increasingly wider variety of products in smaller quantities will continue to intensify, preliminary preparation will become an important factor for improving the efficiency of work at distribution centers beyond past levels.

An effective way to do this is to collect and analyze all sorts of different data, such as market information

Figure 1 — Overview of Distribution Center Enhancements

Optimized resource plans and work schedules are generated and coordinated with the WMS by acquiring a variety of different data from the distribution center and combining it with demand forecast data.



WCS: warehouse control system OT: operational technology WMS: warehouse management system AI: artificial intelligence

that reflects social trends, productivity of the people working at the center, information on aptitudes and allocation of workers, and the efficiency and utilization rate of equipment. Hitachi is building a common logistics platform that, by analyzing this data, can optimize resource plans and the associated work schedules. Along with the locations of shelves and products, the platform can also optimize how many workers to deploy and where to deploy them. This makes it possible to connect the optimized resource plans and work schedules to the WMS and to issue precise preliminary preparation instructions to achieve efficient dispatch operations (see **Figure 1**).

On-site labor savings and improvements in work efficiency can be achieved through the detailed analysis of big data acquired by combining information collected by the WMS with information on the location and actions of people and goods. Furthermore, new measures for improving operations can be identified by using AI to find improvements that have been overlooked in the past, such as changing the sequence of work instructions or making modifications to optimize the layout. These various ways of using data enhance the WMSs currently in use and enable the work of the distribution center to proceed more efficiently.

2. 2 Robotics

At a typical distribution center, workers refer to a picking list or wireless device as they walk around the center collecting goods. This means that most of their time is spent walking, something that is hard to make more efficient. To improve the efficiency of this picking work, Hitachi developed the Racrew automatic guided vehicle (see **Figure 2**). By transporting the shelves that hold the goods to the workers, these Racrew robots significantly reduce the amount of time spent walking around, providing an approximate three-fold improvement in the efficiency of picking compared to conventional practices.

However, as placing and removing goods on shelves is still done manually, Hitachi aims to further reduce the labor demands and improve efficiency through full automation that combines the Racrew with picking robots.

Figure 2 — Racrew

The Racrew automatic guided vehicle is 900 mm wide, 960 mm long, and 380 mm high, with a carrying capacity of 500 kg and a speed when loaded of 80 m/min.

2. 3 Digital Solutions

As work at distribution centers includes processes that are difficult to automate, such as packing goods for shipment, it remains difficult to eliminate manual work entirely using current technology. To make this manual work more efficient, it is necessary to collect data on the actions and work performance of individual workers and to visualize that data. Hitachi supplies the following digital solutions for these purposes.

2. 3. 1 Camera Solution

By installing cameras and sensors at the site to record and measure the whereabouts, actions, level of activity, and handling of goods, and by performing image and data analysis, it is possible to obtain work activity data that is not reliant on manual data input by workers. It is possible, for example, to identify the causes of low-productivity in processes, such as the inappropriate allocation of workers or frequent work delays. This work activity data can be used to facilitate optimal worker allocation, to reduce work delays, and to organize processes appropriately (see **Figure 3**).

2. 3. 2 Wearable Sensors in the Form of Name Tags

It is possible to track the activities of workers by using wearable sensors in the form of name tags and using them to detect other workers and beacons installed in

Figure 3 — Use of Cameras and Sensors to Capture Data on Worker Movements and Goods Handling

By using cameras and sensors at the site to capture data on the movements of workers and the handling of goods for each task in the distribution center workflow, it is possible to use this information for things like measuring the productivity of each process or as feedback for improving planning precision for worker allocation and work volumes over the following days.

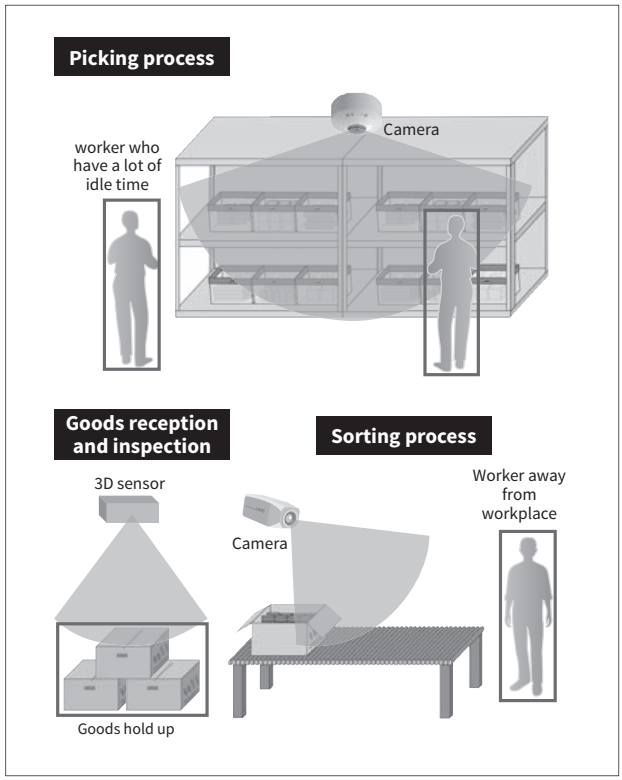


Figure 4 — Wearable Sensors in the Form of Name Tags and Example Application

Wearable sensors in the form of name tags equipped with infrared sensors are used to detect the location of workers in a warehouse, and to identify and analyze interactions between workers or between workers and supervisors.

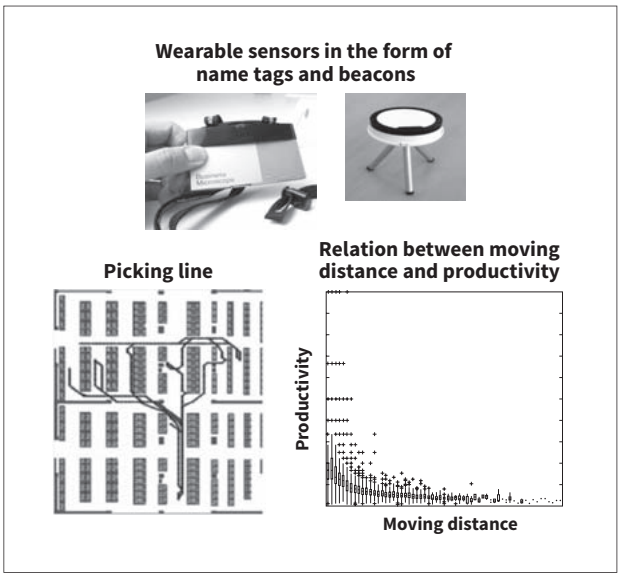
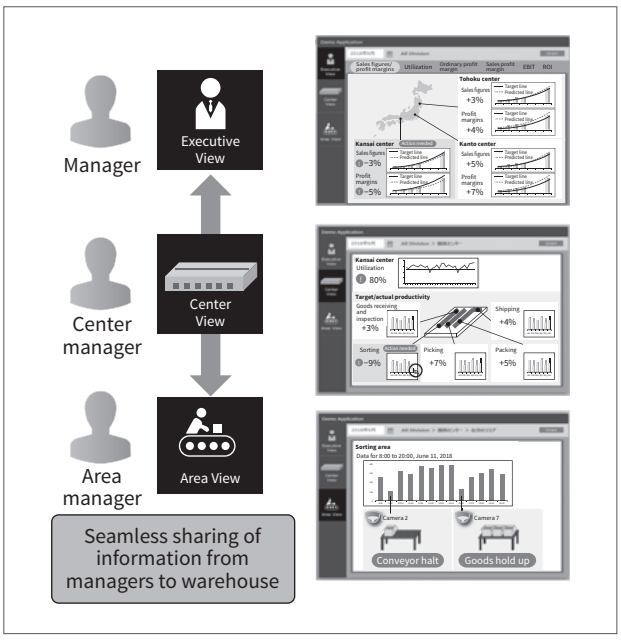


Figure 5 — Overview of the Management Dashboard

Actions can be expedited by providing a real-time display of key performance indicators (KPIs) and divergences in actual performance at each level as well as by providing predictions.



the surrounding area. As each beacon emits a unique identifier, they can be used to record the location of workers at each point in time. This provides information on worker movements, something that was difficult to obtain in the past, and enables the optimization of the center layout and worker allocation by determining the productivity of individual workers (see **Figure 4**).

2. 3. 3 Management Dashboard

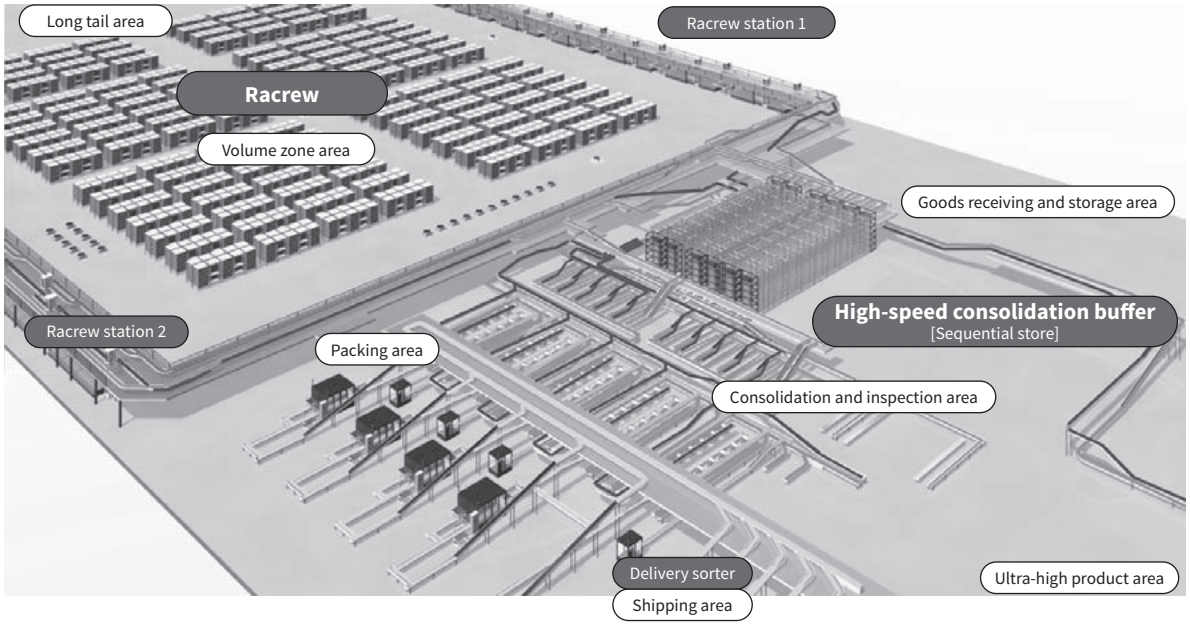
By collecting and archiving big data generated by systems for things like materials handling equipment, robotics, WMSs, and cameras, and presenting the results of statistical and AI analysis based on this big data in a dashboard format that can be visualized at each level, from manager to warehouse, it is possible to provide a real-time display of key performance indicators (KPIs) and divergences in actual performance as well as providing predictions to enable preemptive work on planning (see **Figure 5**).

3. Implementation Methods and Results

Hitachi worked with MonotaRO Co., Ltd., the leader in online sales of maintenance, repair, and operations (MRO) products, to build a distribution center that

Figure 6 — Overview of MonotaRO's Second Distribution Center

The center handles more than 350,000 products in a 400-m × 135-m building, with the aim being to process 40,000 orders per day in the future. It is equipped with 154 Racrew robots, 4,374 shelves, six consolidation buffers with 5,268 shelves, and roughly 4,500 m of conveyors.



was designed to reduce the labor requirements. This represents one model for making enhancements to a distribution center (see **Figure 6**).

Having achieved annual sales growth of more than 20%[4], the capacity of MonotaRO's first distribution center, which makes extensive use of automated warehousing, was unable to keep up with demand, making necessary the construction of a second distribution center.

While this second distribution center was to be vast and would require a large workforce, its suburban location away from the city center would make it difficult to hire enough workers. Accordingly, comprehensive measures for reducing the labor demands were included in the design objectives. MonotaRO handles a huge inventory of more than 350,000 different products, which makes it important to consider which picking method to use to ensure timely dispatch even in such an extensive distribution center. Distribution at MonotaRO has the following three characteristics.

(1) Goods have various sizes and shapes

(2) Follows a "long tail" strategy of selling a large number of unique items in small quantities and a small number of popular items in large quantities

(3) The number of goods handled at the distribution center is continuing to grow

To deal with these characteristics, Hitachi designed and built the second distribution center making extensive use of Racrew robots, which have the flexibility to handle different layouts and shapes of goods. This halved the number of pickers by eliminating the need to walk around to perform picking.

4. Outlook for the Future

4. 1

Measures for Further Reducing Workforce (Use of Robotics to Cut Labor demands)

While the use of picking robots at distribution centers requires that they be taught how to pick up each of the hundreds of thousands of different items that the centers handle, it is not practical to teach them for each item, because it is not known which goods need to be picked until an order is received. Accordingly, Hitachi is using AI so that robots can learn how to pick up goods as they work. By taking people out of the picking process, this can also eliminate delivery inspection work.

4. 2

Pre-emptive Measures for Efficient Dispatch (Use of Demand Forecasting to Improve Efficiency)

One way to further improve picking efficiency is to store those goods that are frequently shipped at a nearby location so that they can be picked in only a short amount of time. Another effective practice is to keep goods that are often purchased together, in the same place. To do so, however, it is necessary to grasp in advance the shipping frequencies of goods and the correlations between them. To achieve this, Hitachi is working on implementing a system that can forecast demand based on market information and past shipment records, and then utilize this information in planning where best to locate stock.

Further efficiency gains can be achieved by using AI to analyze market trends, with the instantaneous analysis of huge amounts of past data on things like the influence of the time of year or the release of new products, and by executing these calculations on a daily basis to improve demand forecasting accuracy. By also incorporating data on the activities of workers obtained using camera images or sensing technologies, it is possible to facilitate, not only preparations for the following days, but also improvements in productivity on the same day, and to utilize this for site-wide optimization of distribution centers in real time by providing feedback to the control of materials handling equipment, robotics, WMS, and other systems.

5. Conclusions

This article has described Hitachi's efforts to enhance distribution centers and the outlook for the future. As the operations of distribution centers vary depending on the goods they handle, methods for improving work efficiency are needed to suit distribution centers of all different types.

Distribution systems will continue to become an even more important part of the social infrastructure that supports consumer livelihoods in the future. Hitachi intends to contribute to the building of distribution systems that can be adapted to a wide variety of distribution centers and can overcome labor shortages, and to improving their services.

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