Autonomous Picking Robot System for Replacing Manual Labor at Logistics Centers

Logistics centers need the ability to rapidly and accurately dispatch products from their huge inventories in accordance with the daily flow of orders and recent years have brought rising demand for automation (ways of operating that do not rely on people) against a background that includes labor shortages, growth in e-commerce, and increases in the quantities of products handled resulting from a shift toward new living practices. Unfortunately, the task of picking is a difficult one to automate as it does not follow fixed patterns and needs to deal with a wide variety of different products. As a result, much of this work still relies on human workers. While this has been going on, Hitachi has been working to develop an autonomous picking robot system for replacing manual labor as part of its efforts to enhance the operation of logistics centers and reduce their labor requirements. This article presents an overview of the system along with example applications.

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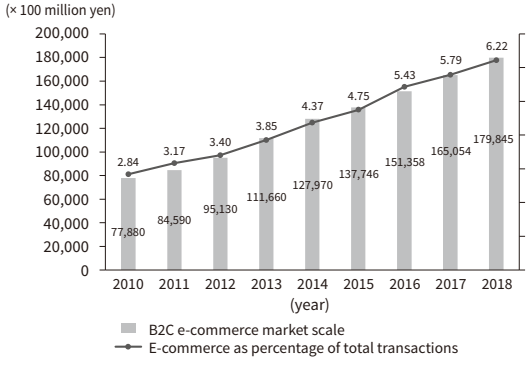
1. Introduction

Japan's declining population means a shrinking workforce, and one industry where this labor shortage is particularly acute is that of logistics. As electronic commerce (e-commerce) grows, the number of items being handled is increasing and new living practices are expected to drive demand higher still (see **Figure 1** and **Figure 2**). This suggests that, should things remain as they are, maintaining the balance between levels of service and demand will become impossible and the industry will reach a point where it is no longer able to cope.

The logistics industry has already made progress on the automation of warehouse operations, with materials handling vendors playing a central role, and an increasing number of companies having computerized their inward

Figure 1 — Trend in Size of B2C E-commerce Market and E-commerce as Percentage of Total Transactions

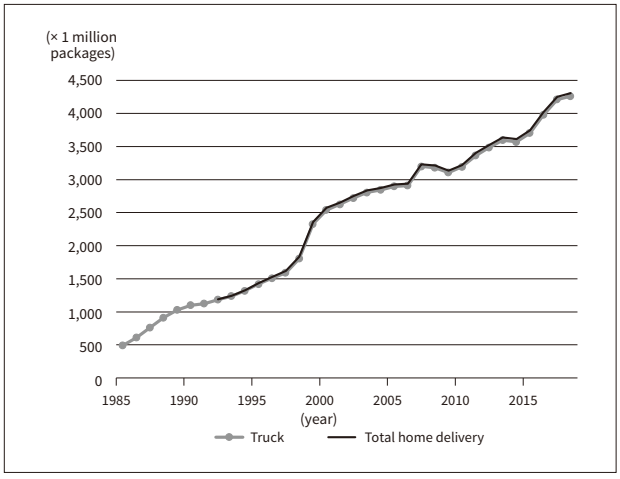
The shift toward electronic retailing continues, with the B2C e-commerce market in Japan reaching 18 trillion yen in 2018 and accounting for a rising percentage of total transactions (6.22%).



B2C: business-to-customer e-commerce: electronic commerce

Figure 2 — Trend in Number of Packages Handled by Home Delivery Services

The number of packages handled by home delivery services reached approximately 4,370.1 million in FY2018, an increase of approximately 55.68 million on the previous year (approximately 1.3%). Growth is expected to continue.



goods, storage, sorting, and dispatch processes, installing automated warehouses, digital picking, and sorting systems. Unfortunately, much of the physical work requires dexterity and so is still done by humans, including tasks like picking and packing goods or loading them onto a trolley or pallet.

This article describes the features of an autonomous picking robot system intended to perform picking work in place of humans and presents examples of its application.

2. Overview of Autonomous Picking Robot System

2. 1
Concept behind Autonomous Picking Robot System

Of all the steps from inward goods handling to dispatch at a logistics center, the task of picking is one where little progress has been made on automation, a consequence of the need to handle individual products and the large number of different product types and work patterns that must be handled. Under these conditions, manual labor remains the best option in terms of adaptability (flexibility) and working speed and setup time (productivity). Nevertheless, the prospect of future labor shortages and increases in the volume of products handled have prompted work to start on developing and installing alternatives to manual labor that use industrial robots.

In response, Hitachi has developed its own autonomous picking robot system that is able to adapt flexibly to new products and changes in work patterns, using software to control the autonomous movements of the robot.

The system's upgradable software means that it is always using the latest algorithms. As a result, it is able to add new types of products or start performing new tasks with only a short shutdown time, while continuing to use the existing equipment.

2. 2
Issues with Use of Industrial Robots at Logistics Centers

In order to operate, industrial robots first need to go through a teaching process in which detailed instructions are given for things like the angles, directions, and distances by which the robot joints should move. This teaching process is very time-consuming and requires specialist expertise.

Once teaching has been done, robots have excellent repeatability, being able to perform the same operation over and over again with high accuracy and speed. As a result, they have come to be widely used in automotive and other manufacturing industries where the requirement is to produce large quantities of a product with consistent quality. Another reason why the use of robots to replace human labor is well advanced in manufacturing is because, once installed, production lines tend to operate for extended period and this provides time to recoup the initial investment in setup work and capital equipment.

Logistics warehouses, on the other hand, require work to be performed under constantly varying conditions, handling a wide variety of different types of products in quantities that fluctuate due to factors such as daily order volumes, and with no consistency in the position and orientation of goods in their storage cases, even for the same product.

For teaching to cover all of the nearly infinite possible patterns of picking work would be an impossibility. This is why conventional robots that use teaching cannot be used for this task, and why little progress has been made on replacing human labor.

2. 3
Robot Control without Teaching

To overcome this problem, Hitachi has developed an autonomous picking robot system in the form of software for controlling robots without teaching. The software enables hardware such as robot arms, cameras, and hands to be selected based on the operating conditions at the customer's facility (the products handled, other nearby equipment, work procedures, space available for installation, etc.), and then packaged together as an autonomous picking robot system.

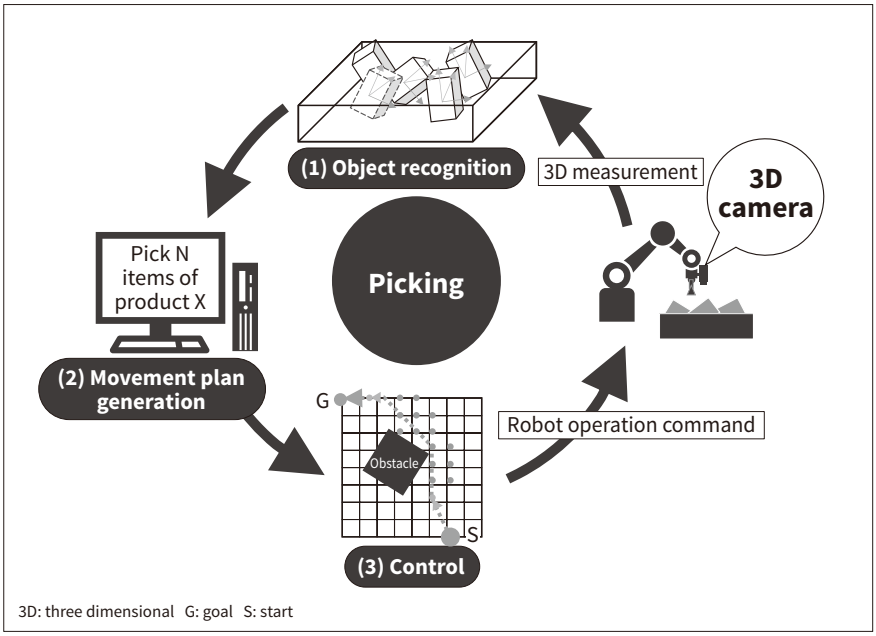
Robots equipped with the system are able to use the following three functions to perform picking work in much the same way as a human worker sees an object and reaches out to pick it up.

(1) Object recognition

Robots can utilize three-dimensional (3D) camera images of products placed in front of them to determine the type of product, its position, and how far away it is. As

Figure 3 — Robot Control without Teaching

Functions for object recognition, movement plan generation, and control enable robots to take over warehouse tasks requiring flexible judgement that have been performed by human workers to date, without teaching.



long as a product remains in the camera's field of view, the system has the flexibility to recognize a product even if it is out of position, and there is no need for a preliminary positioning step or other such setup.

(2) Movement plan generation

This generates the sequence of movements from extending the robot arm to the detected product position, picking up the product at the appropriate grasping point, and moving it to the designated location.

(3) Control

The system issues commands to the robot based on the above sequence of movements. By combining instructions that take such forms as specifying which products to pick and in what quantities with the ability to operate without teaching, robots can take over tasks that require flexible judgement and that have been performed by human workers to date (see **Figure 3**).

3. Example Application Feeding Items into Sorting System at a Logistics Center

3. 1
Overview of Warehouse where System is Deployed

Hitachi Transport System, Ltd. operates a third-party logistics (3PL) service for apparel manufacturers at its Metropolitan East Distribution Center, which is equipped with case sorters, sorting systems, and a variety of conveyors and other equipment (see **Figure 4**).

The center mainly handles apparel, accessories, and other general goods and is among the largest in Japan, having consolidated the distribution operations of around 10 different sites into a single facility to improve the efficiency of this work, which was previously scattered across different locations[(1)].

Figure 4 — Metropolitan East Distribution Center of Hitachi Transport System, Ltd.

The center is one of the largest distribution facilities in Japan for Hitachi Transport System, which operates a third-party logistics (3PL) service.

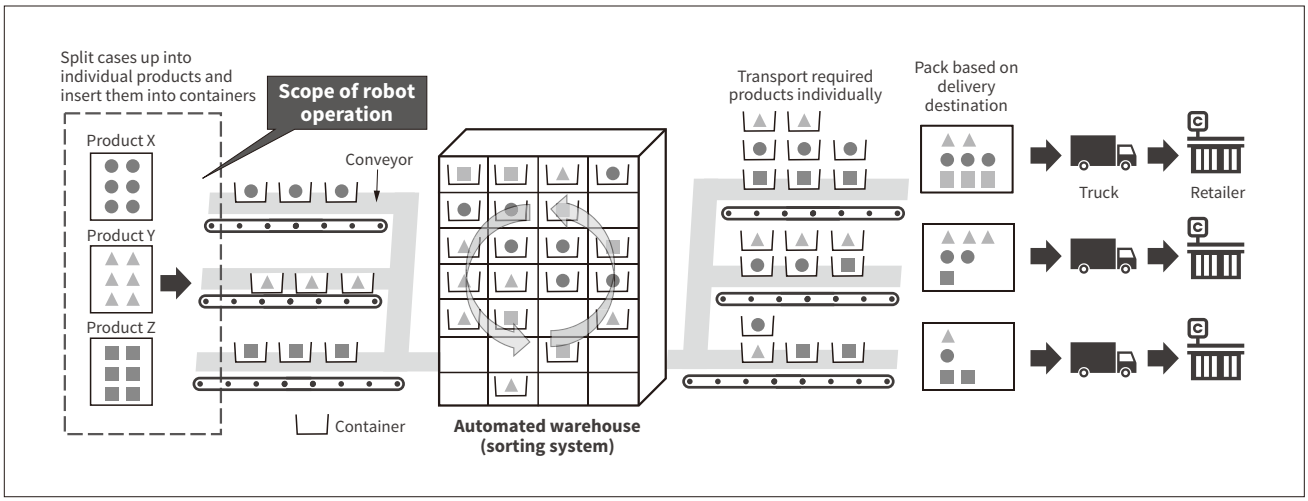
The sorting system comprises both a storage area, in which shelves that make full use of the available ceiling height are used to house containers filled with products, and an automated warehouse with a materials handling system installed between the shelves that can take out the required products at the required time and forward them to the dispatch area by means of conveyors located at the lowest rung (see **Figure 5**).

3. 2
Use of Robot to Feed Items into the Sorting System

To store products in the sorting system, it is necessary to split up the cases that arrive at inward goods into the individual products for sale and insert them into containers. Because past robots that relied on teaching were only capable of performing predetermined actions, it has not

Figure 5 — Relationship between Automated Warehouse and Scope of Autonomous Picking Robot System Operation

Inward goods arrive packed in cases and the autonomous picking robots are used to split these up into the individual products for sale and insert them into containers.



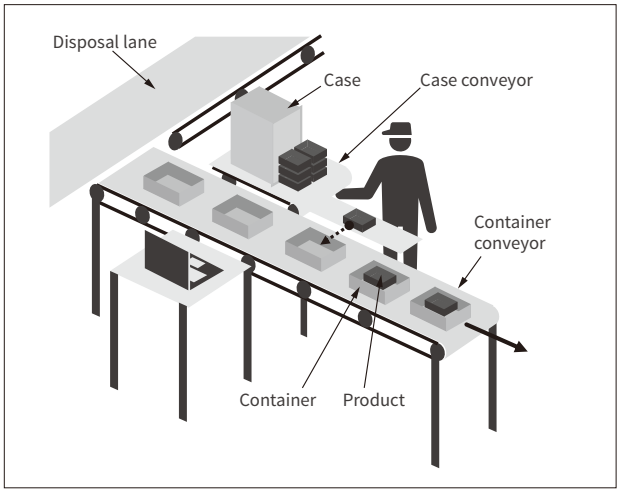
been practical to use them for this insertion task, which requires dealing with a wide variety of products and handling them with care. In order to cope with a shrinking workforce and higher volumes, Hitachi Transport System decided to look into using the autonomous picking robot system to substitute for human labor in this application. Following testing to verify its practical viability, the system has now been installed at a working warehouse.

The work sequence and other features of the autonomous picking robot system are as follows.

(1) When a conveyor delivers a case containing products to the robot, its first action is to determine the size of the case and the type and position of the products inside. It then calculates a route that takes account of factors such as the height of the case and any nearby equipment and then begins smoothly extracting products one by one, starting from the end.

Figure 6 — Picking Work as Performed by Manual Labor

Although products differ by size and type and are arranged differently in their cases, human workers have the flexibility to decide on the spot how best to insert them into containers.



(2) After picking up a product, the robot adjusts its orientation for carrying and then carefully and quickly transfers it to the designated location.

(3) After scanning the product using a barcode reader, the robot places it in a container that is waiting on the conveyer that will take it into the sorting system. Products are placed in the container one at a time. Using the barcode reader to verify all products before putting them into a container improves work accuracy by ensuring that incoming products are accurately identified.

(4) Once all the products have been taken out, the now empty case is removed by means of a disposal lane above the robot. This creates a free space in front of the robot where the next case can arrive in turn, meaning that a single robot can automatically repeat the same operations starting from step (1).

Figure 6 shows the sequence of steps when this work is done by a human worker and **Figure 7** shows the work being done by the picking robot system.

By replacing manual work, this autonomous picking robot system for feeding products into a sorting system can help reduce labor requirements, performing the task in a way that can cope flexibly with the different package designs and sizes of different types of products.

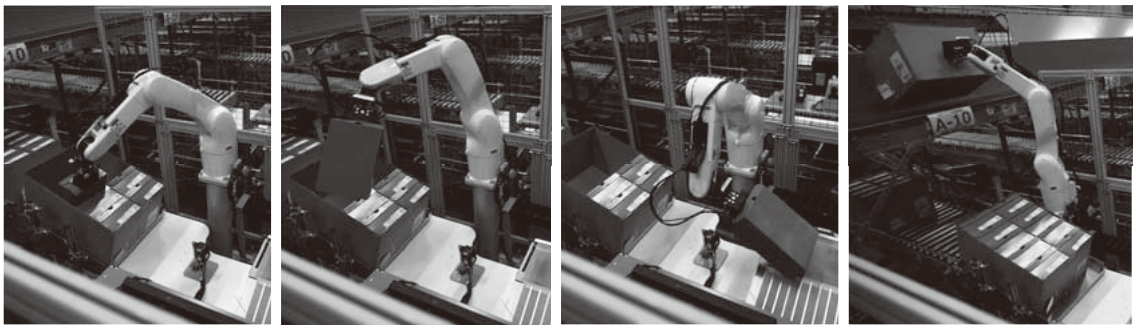
4. Future Outlook

Through these applications, Hitachi has verified the viability of autonomous picking robots equipped with this system software for robot control.

By drawing on experience from actual deployment, Hitachi intends to continue research and development work on enhancing the versatility and productivity of picking work by establishing practices that keep the influence of

Figure 7 — Picking Work as Performed by Picking Robot

Robots use their functions for object recognition, movement plan generation, and control to perform picking in much the same way that a human worker sees an object and reaches out to pick it up.



(1) Product recognition (2) Picking and movement (3) Insertion into container (4) Disposal of empty case

other equipment and the work environment to a minimum while also expanding the variety of products handled.

In order to supply systems that offer greater returns on investment, Hitachi hopes to help reduce the workforce requirements of logistics centers and make their operations more efficient by offering solutions that, rather than simply replicating how humans perform tasks, are based on working practices that assume the use of robots.

5. Conclusions

This article has described Hitachi's work on autonomous picking robot systems that can replace manual labor at logistics centers.

Distribution is playing an increasingly important role in the social infrastructure. Hitachi intends to contribute to improving all aspects of logistics centers through the development of autonomous robots with the flexibility of human workers that can be deployed rapidly without teaching, even for work such as picking at these centers that has previously relied on manual labor.

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