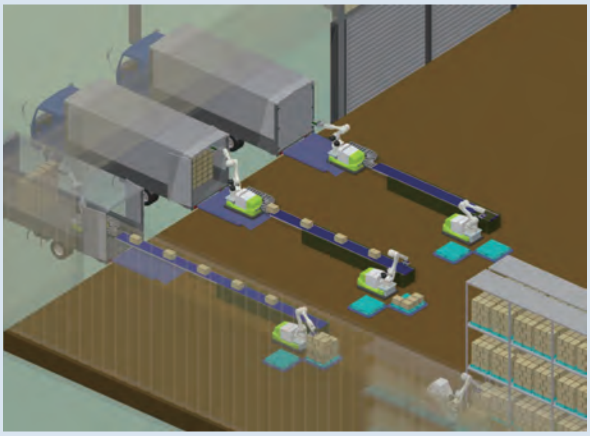
Automating Logistics Centers by Using Robots



Society as a whole is experiencing a labor shortage, and the logistics industry is experiencing a similarly severe shortage. Meanwhile, due to the current problem of the infectious COVID-19 disease, the electronic commerce (EC) business has been growing rapidly. In these situations, the entire logistics industry is extremely interested in automation and there is a strong demand to use automation for devanning, picking bulk workpieces, palletizing and depalletizing. Focusing on these processes first, we are working on automating logistics operations by using 3D vision and other sensing technologies.

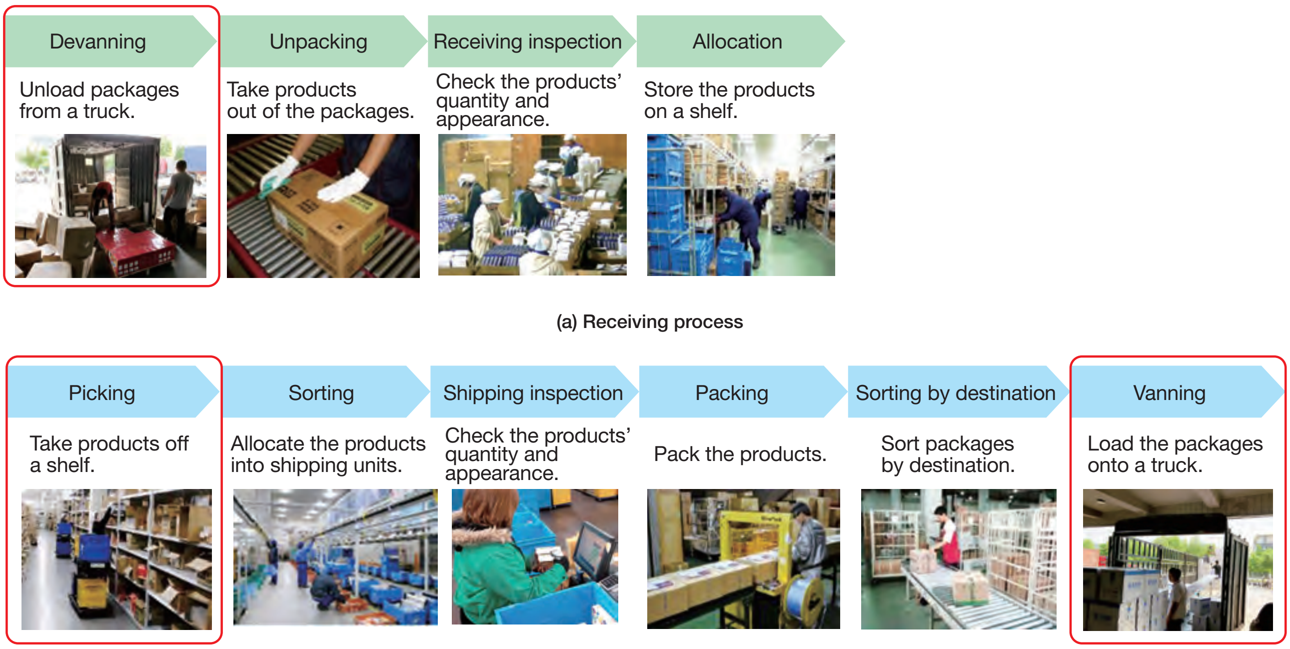
Introduction

Society as a whole is experiencing a labor shortage, and the logistics industry is experiencing a similarly severe shortage. Meanwhile, the demand for EC is growing all the more due to the current problem of the infectious COVID-19 disease. In these situations, the entire logistics industry is more interested in automation than ever before.

1 Background

At a logistics center, received packages are sorted by destination and shipped out. While packages are shipped out directly without being stored at delivery terminals, at logistics centers goods are also unpacked, stored on a shelf and sorted by type.

The operations performed at a logistic center can be



(a) Receiving process

(b) Shipping process

Fig. 1 Processes in a logistics center

roughly divided into receiving and shipping as shown in **Fig. 1**. In these processes, the majority of work is carried out manually although part of it has been automated. An interview on the ratio of employees by process at logistics centers and the need for automation in material handling manufacturers and users found that the demand for the reduction of labor costs and the prevention of human errors is high. Taking these matters into consideration, of all processes, automation is most required in picking followed by allocation, devanning, inspection and vanning.

So far, most automation equipment has been equipped with single-function solutions, which made it difficult to apply automation to all processes. However, all processes can be automated by mixing functions such as an automatic guided vehicle and palletized/depalletized robot and a palletized/depalletized robot and image recognition.

Our ultimate goal is to expand automation to all the processes in logistics centers and delivery terminals. We chose vanning/devanning, palletizing/depalletizing and picking as the processes in which automation has been introduced because automation is feasible in these processes by applying our robot technology and image recognition technology and due to the large market size and urgent need for automation.

2 Vanning/devanning

Loading and unloading cases from a container is dangerous because the work may be carried out at places higher than 2 m and workers may handle heavy items. On top of that, the working area is often outdoors and it is physically intense work. That is why there is such strong demand for automated devanning all over Japan.

(1) Technical challenges

As containers are only accessed from the doors in back, the cases' image recognition, holding and transportation can only be carried out from the back. In addition, the cases inside a container are not necessarily piled up in order. It is often the case that containers can only be at a logistics center for up to two hours, an additional fee being required if they are there longer than that. It is also important to transport cases without damaging them.

The technical challenge to meet these requirements is to transport unstable cases that can only be accessed from one direction within the given amount of time without damaging them.

(2) Activities conducted so far

Ideally we would use vision recognition for cases piled up in a container, but it would be too difficult to obtain information on how they are loaded by viewing them from several directions due to the walls getting in the way and cycle time constraints. Therefore, we adopted K-VStereo, which is software that corrects the position of the cases with a robot using a 3D camera installed in a robot arm by measuring their 3-dimensional position. The system has a simple configuration consisting of a 3D camera, vision computer and robot controller shown in **Fig. 2**. We started by developing a system to recognize one type of case.

The cases' 3-dimensional inclination is measured by calculating the rotation angles of X, Y and Z-axis from a 3-dimensional point cloud of the measured surface, and the robot performs corrective actions according to the rotation angles. The system also has a function to avoid colliding with the walls, and the robot stops when an inclination larger than a set values is detected. In such cases, the workers remove or arrange the cases to continue the automatic operation.

The devanning hand has a servo motor which is the robot's external joint to drive the vacuum unit through a belt as shown in **Fig. 3**. The belt also serves as a conveyor belt on which the suctioned cases are placed, and the cases are gently pulled onto the hand. The vacuum unit's lifting function temporarily lifts cases on the floor, which

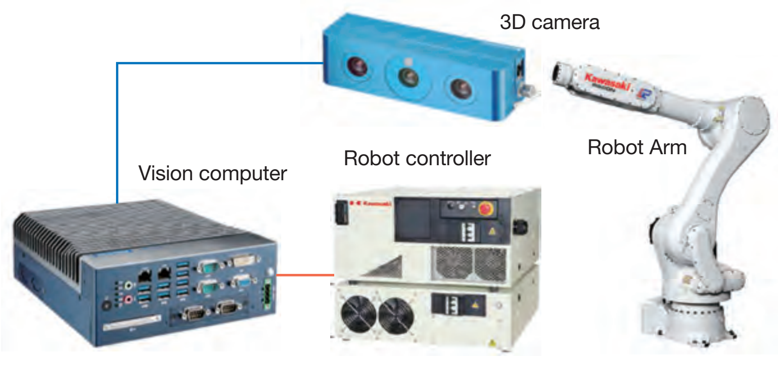


Fig. 2 Configuration of the K-VStereo system for devanning

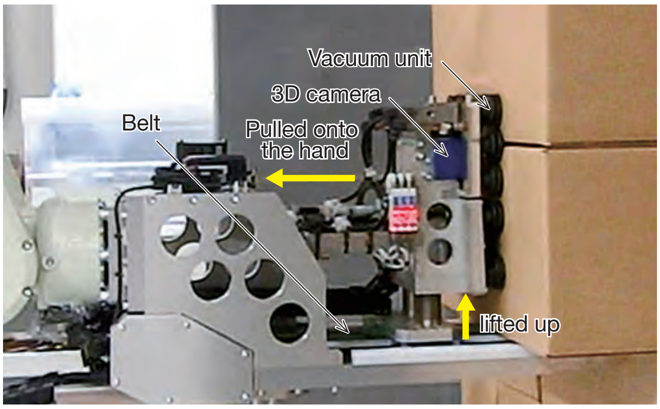


Fig. 3 Devanning hand

are then pulled up onto the hand. The 3D camera is installed inside the vacuum unit.

As a specific example, we set up the system to process a container with 1,000 cases within two hours. This would require the robot to work at a pace of 7.2 sec per case, but it operated at 12.5 sec per case on average, so we considered the simultaneous transportation of a stack of two cases placed side by side to reduce cycle time. When the system recognizes that the cases of both layers are placed horizontally, it judges that the devanning hand can pick up two cases. The system also has a function to automatically pick up one case by setting a threshold for the deviation if the hand cannot pick up two cases because of their orientation. The robot achieved an average of 6.25 sec per case when picking up two cases at the same time.

The travel of the arm shown in **Fig. 4** is the product of a collaboration project with Nakanishi Metal Works Co., Ltd., which planned to install a robot in an automatic guided vehicle for automatic devanning. We adopted the RS080N, a robot with an operating range that makes it usable in several different types of containers with different ceiling heights. Meanwhile, we define devanning in the most basic sense as the round trip of travel between the working area and the area where containers are. This robot does not require a battery as it can be plugged in to a power source in this case. This enabled us to make the automatic guided vehicle smaller.

(3) Activities for the future

We conducted a test using a container in an actual logistics center and performed a demonstration as shown in **Fig. 5**. In addition, this system has been sold as a base machine for testing without a hand or vision.

It provided us with more opportunities to hear a lot of opinions, and we were reminded that the demand for handling several types of models and accelerating the transportation speed is high. Kawasaki will carry out further development to realize faster devanning of several different models via the onboard AI.

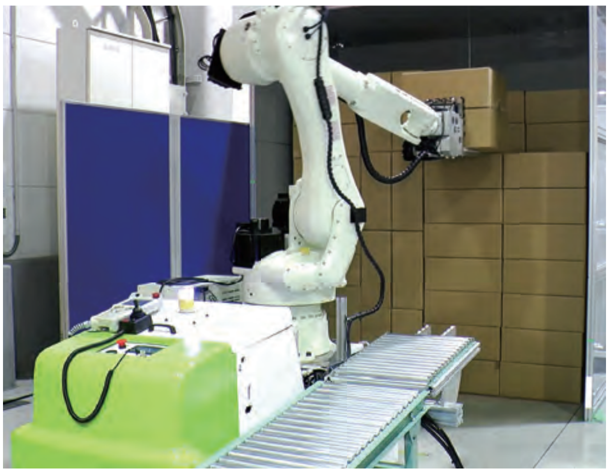


Fig. 4 Traveling arm

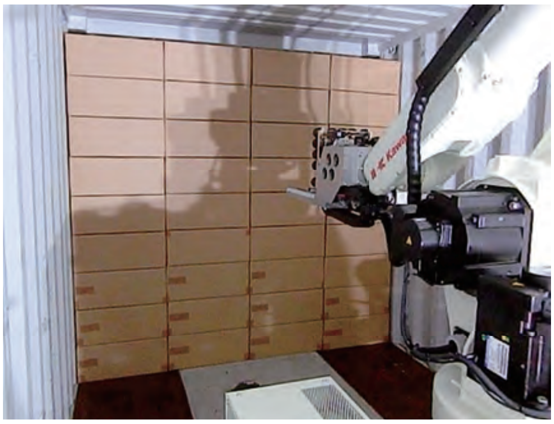


Fig. 5 Verification using actual containers

3 Picking

Picking is the process of picking up and collecting pieces (minimum product unit) to be shipped out based on an invoice or instruction sheet. It requires a huge amount of manual labor in logistics warehouses.

(1) Technical challenges

Automation of the picking process is extremely difficult from a technical perspective. One of the reasons is the irregularity in the supply of pieces in this process. Specifically, pieces are not always well arranged in a folding container or a cardboard box, but may have fallen over or have been piled up at random in the first place. In such cases, the robot must pick up pieces while avoiding collisions with the container as well as with surrounding items. It is nearly impossible, even for experts, to create a robot program to make a robot move in a way that covers all situations as it would take a huge amount of time and work. Reducing the amount of work to create a robot program is essential to automating the picking process. In addition, the robots' picking operation is slow compared to manual operation, so making it work faster is another challenge we have to overcome.

(2) Activities conducted so far

In order to reduce the workload for creating a robot program for picking, we developed a system to automatically create a robot's motion path based on the information from a 3-dimensional visual sensor as shown in **Fig. 6**. The system makes it possible to identify the picking point of a piece in a container using 2- and 3-dimensional images obtained from the visual sensor, and automatically create the robot's motion path with the identified position as an end point.

When creating a motion path, the system searches for

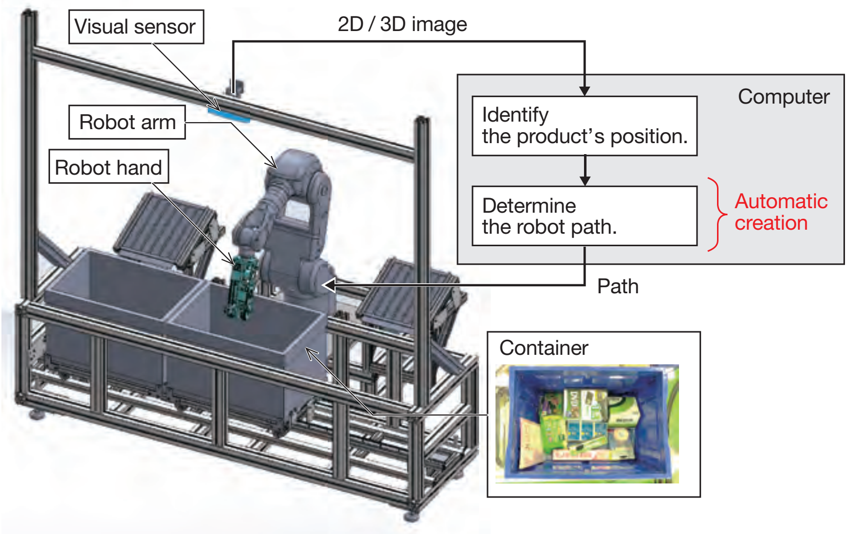


Fig. 6 Configuration of the picking system

a path that avoids collision by reproducing the relative positions of the robot and the surrounding area in 3-dimensions in a simulator. The 3-dimensional information of the robot and other known objects in the simulator is provided as a 3D model in advance, and the relative positions of pieces that change when they fall down is obtained from the visual sensor.

We are also developing technology to pick up several pieces consecutively to increase the throughput when using a robot for picking. This is to pick up several pieces and place them at one time to streamline the operation.

This system works with a robot hand equipped with several movable parts for holding a piece and the technology to create a path with the hand's motion is taken into consideration, as shown in **Fig. 7**. This leads to the creation of a motion path in which the hand does not collide with surrounding objects when picking a piece with movable part B while recognizing the piece held by movable part A. The movable parts enable the robot hand to pick up a piece in the corner of a container. It is expected that the system will reduce the manual labor of organizing items as workers do not need to arrange pieces properly on the supply side.

(3) Activities for the future

Another challenge to picking is how to handle different types of pieces at the same time. At present, the types of pieces have been limited to those of small boxes that are suctioned with vacuum pressure. We will improve the technology used for the visual sensors and robot hands to

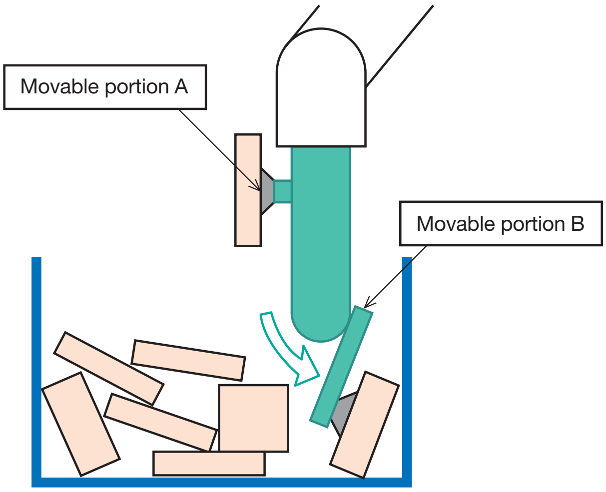


Fig. 7 Picking a piece placed in a corner

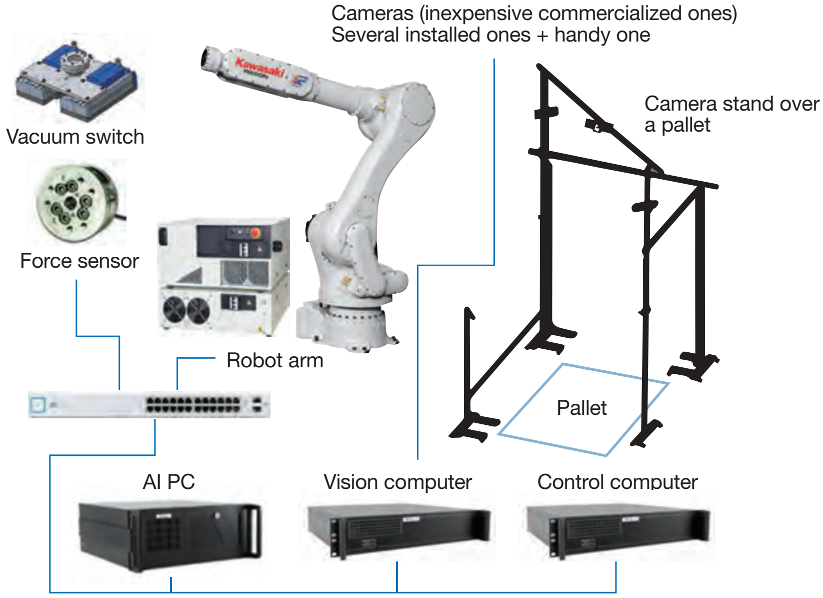


Fig. 8 Configuration of the AI robot vision system for palletizing

expand the scope of the system.

4 Palletizing/depalletizing

(1) Technical challenges

The development of holding and transportation tools is extremely difficult as is that of recognition technology because there are a variety of undetermined objects such as boxes with different sizes and bags in the working area. In addition, as planning a loading strategy is important when palletizing, it is technically very difficult to palletize different types of items with no prior information.

(2) Activities conducted so far

In order to launch a system for palletizing different types of items (which other companies are also developing) as early as possible, Kawasaki decided to commercialize the system early in collaboration with a startup company through a project in which the core technology related to the arm's motion was developed by Kawasaki and the recognition technology was created by the startup. Kawasaki executed a joint development agreement with Dextelity, our startup partner which excels in AI technology for image processing, in 2019, and since then, we have carried out development starting with application to the combination of pallets and cases.

Once a case's size is identified with a 3D camera, it is transported by a robot. Several 3D cameras are installed over the pallet to determine the optimal location to place them based on the loading information. There is no information on the order of transported cases, and they are loaded on a pallet in real time. The system does not require prior learning for cases with a general shape as it automatically creates position to hold and suction them.

As shown in **Fig. 8**, the system consists of a control computer to determine the movements, an AI computer equipped with AI for palletizing different types of items and a vision computer for image processing. The system achieves both appropriate functions and low cost by using several inexpensive 3D cameras.

A system for palletizing/depalletizing different types of items was jointly displayed at the iREX2019, International Robot Exhibition. We have gathered a lot of attention from the Japanese logistics industry since then.

(3) Activities for the future

We will improve the capability of the system by expanding the scope of usage such as the use of a roll-tox pallet and the transportation of items other than boxes.

Conclusion

Kawasaki is working on the automation of logistics centers as part of a solution to the shortage of workers. The challenges common to each process include how to deal with situations with different types of items and how to go faster. We will introduce the developed systems in logistics centers while solving these challenges.

We would like to express our appreciation to the cooperating companies involved in the verification.

Hideshi Yaname
GI System Department,
General Industrial Robot Group,
Robot Business Division,
Precision Machinery & Robot Company

Tianfen Xu
Research and Development Department,
Technology Group, Robot Business Division,
Precision Machinery & Robot Company

Yuuki Takayama
Robotics Technology Department,
System Technology Development Center,
Corporate Technology Division

Keisuke Harukaze
Research and Development Department,
Technology Group, Robot Business Division,
Precision Machinery & Robot Company

Kouhei Morio
General Industrial Robot CS Department,
Kawasaki Robot Service, Ltd.