Warehouse Automation Design for Labor-saving and Automation in Logistics Center Operations

The spread of COVID-19 has heightened the demand for e-commerce. It has also added complexity to logistics center design, with a need for greater operational automation to help avoid close contact between the people who work there. To address these issues, Hitachi has been working toward the establishment of contactless logistics centers. From its perspective as a warehouse automation vendor, this article describes the use of robotics for labor-saving and automation in logistics center operations and the development by Hitachi of warehouse management systems and other such solutions together with a simulator for use in solution design.

Takeshi Endo
Nobutaka Kimura, Ph.D.
Jumpei Nagao
Kei Utsugi, Ph.D.

1. Introduction

The COVID-19 pandemic has had a major impact on public behavior. People have become conscious of the need to stay at home as much as possible to avoid unnecessary contact with others, including by making more use than ever of electronic commerce (e-commerce). This is a trend that looks set to continue as these new habits become a routine part of daily life.

It is also a situation that heightens the importance of logistics centers and their functions of storing goods and enabling timely delivery to consumers. Tasked with the never-ending job of maintaining an uninterrupted flow of goods, logistics centers cannot allow labor shortages to delay or obstruct the dispatch process. While the vision of logistics centers operating without human workers is not yet realistic in practice, the looming prospect of such a world means that work on the associated technologies needs to push ahead.

One example that is happening right now is the urgent need for contactless logistics centers that allow workers to maintain physical distancing and avoid the “Three Cs” of closed spaces, crowded places, and close contact settings, with a number of steps along the path to full automation needing to be taken to lay the necessary groundwork. This article describes what Hitachi is doing to put the prerequisites in place for building contactless logistics centers and achieving full automation, explaining from the perspective of a warehouse automation vendor the relevant considerations in the product, operational technology (OT), and IT layers.

2. Robotics

E-commerce logistics centers handle hundreds of thousands or even millions of different products that come in a wide variety of shapes, sizes, colors, and designs. In a process called “picking,” staff take the ordered products from this inventory of products in accordance with dispatch instructions. Human staff have no difficulty picking up these items and bringing them to the designated location. It comes naturally from past experience, not requiring conscious thought about how a particular product will be oriented inside its case or how and in which direction to pick it up. Getting a robot to perform this same task, however, is far from easy. The use of robots in manufacturing is well advanced, so much so, that on some factory processing lines there are no workers in sight. This is possible because they are continuously producing the same products. That is, the robots are able to use purpose-designed attachments and be programmed to always bring parts or tools to the same location, with the operations they perform at these locations being likewise specified (taught) in advance. The wide product range of logistics centers, in contrast, makes this type of predetermined robot operation impractical. Instead, logistics center robots need to be able to pick the correct products out of cases into which they have been placed in no particular order, and then to pack them into boxes with a different mix of products and layout each time.

To automate this sort of logistics center work, Hitachi has developed intelligent technology that equips robots with a camera and image processing that they can use to identify how products are positioned, enabling the robot to pick up products without bumping into the case or other obstructions and to decide on-the-spot where to place them. Complementing this, Hitachi has also developed a technique that makes it easy to enter new products into the system using a handheld camera, also featuring artificial intelligence (AI) that is able to learn the optimal way to recognize and handle each product. This enables use in logistics centers that need to deal with a steady stream of new products and where the number of products handled continues to increase after the center commences operation (see **Figure 1**).

Unfortunately, it is not yet practical for robots to perform all of the tasks currently performed by humans. For design of contactless logistics centers, where getting up and running quickly is a key consideration, the requirement is to have separate lines staffed by humans for products that are difficult for robots to deal with, while also allowing for the work of robots to gradually expand in scope over time as the technology improves.

3. Development of Integrated WCS

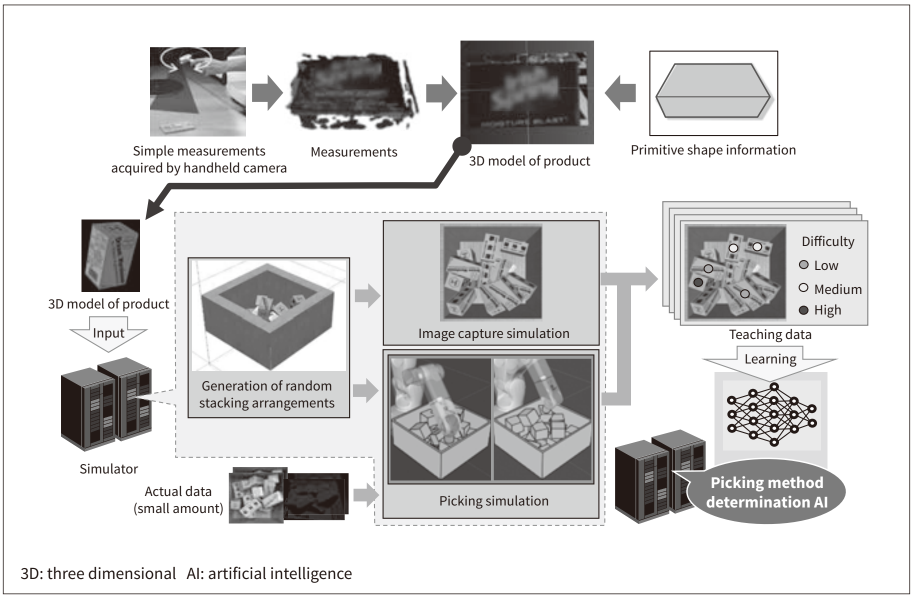
The use of automatic warehousing at logistics centers is growing, involving the storage of products on pallets or in cases. Also on the rise are the use of automated guided vehicles (AGVs) as an alternative to conveyors, picking systems based on AGVs, and the use of robots to pick products directly. This involves use of a warehouse control system (WCS) to control the associated equipment, with the expectation being that the ongoing automation of logistics centers will be accompanied by a need to combine different types of equipment from different vendors. Accordingly, there are many expectations for Hitachi, which has the ability to develop technologies for achieving this.

Controlling all of this different equipment on a standalone basis complicates machine coordination and control of overall progress, also making it more difficult to come up with measures for boosting total warehouse throughput. Instead, the functionality to integrate different forms of control is needed to provide seamless interconnection between the different types of equipment and to allow for use of the plan-do-check-act (PDCA) cycle to achieve system-wide optimization. This led Hitachi to develop practices for system-wide optimization that enable the integrated management of WCSs from different vendors.

Past practice was to issue instructions to workers via a warehouse management system (WMS). Meanwhile, the use of materials handling equipment has grown in recent years and this is controlled from the WMS via the WCS.

Figure 1 — New Product Entry and Learning for Product Recognition and Picking Method Determination

When a new product is entered into the system, a handheld camera is used to generate a precise 3D model from simple measurements. These models are used to generate different simulation scenarios to enable AI learning of product recognition and picking method determination.



As the WMS and automation equipment are in many cases supplied by different vendors, there is a need for these companies to work with one another to determine how equipment should operate. Moreover, the more the operation utilizes a variety of different automation equipment, the greater the number of companies that need to be involved.

As it is rare at logistics centers for initial plans to proceed without modification, it is vital to build a system that can respond flexibly to change. Functions for the integrated management of WCSs are needed to obtain optimal solutions and issue instructions as well as managing the overall process, ensuring the timely provision of operating instructions to materials handling equipment while also tracking work progress and determining the workload for the relevant process. The heavy computational burden of these functions is such that processing may not be able to keep up.

To overcome these problems, Hitachi uses three controller stages operating in tandem: an inward goods controller, an inventory controller, and an outward goods controller (see **Figure 2**). As well as providing an overview of what is happening together with comprehensive efficiency improvement, this also leads to higher efficiency across the logistics chain by, for example, enabling work to be rescheduled to cope with the sort of disruptions that arise on a daily basis, such as urgent dispatch requests or changes in truck arrival times. Likewise, by reducing the amount of custom changes needed to adapt equipment from different automation vendors, the use of international standard communication protocols for equipment interfaces helps logistics centers achieve quality, cost, and delivery (QCD).

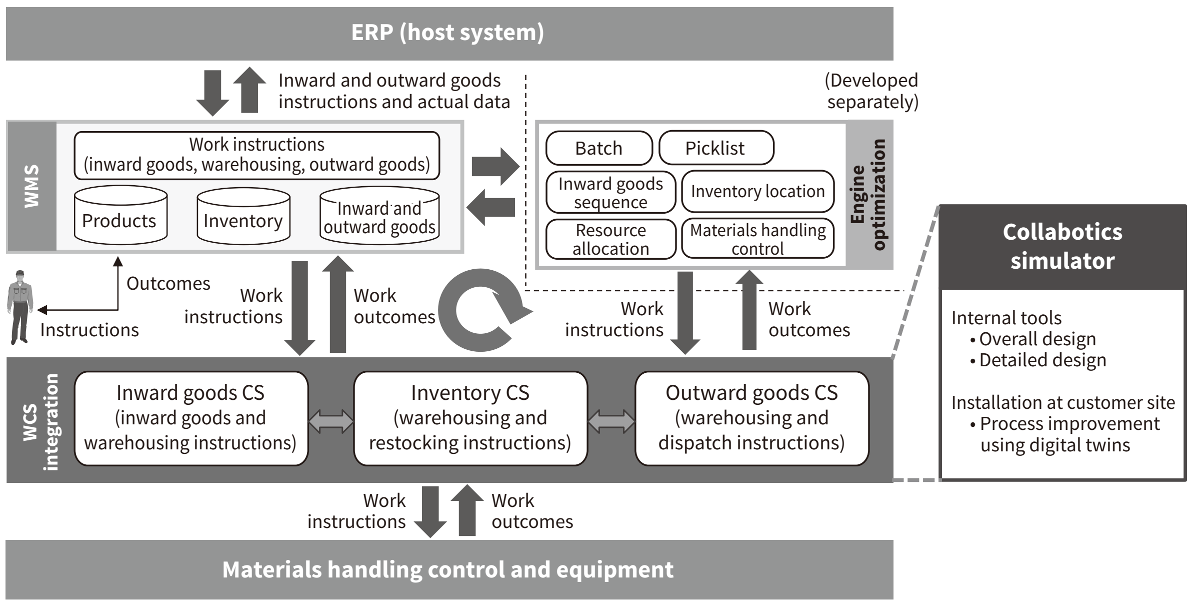
4. Development of Warehouse Automation Design Simulator

As noted above, the use of robots to automate logistics centers is picking up pace, and this in turn is prompting the development of a steady stream of new equipment intended for automation and efficiency improvement. As logistics centers become more complex, it is becoming increasingly difficult for warehouse automation vendors to collect large amounts of information and complete designs quickly when relying on past experience and manual practices alone. If design work is time-consuming, it makes it impossible to keep up with the expansion of customer businesses in a timely manner.

Along with its work on warehouse automation design, work by Hitachi on overcoming these challenges has also included the research and development of collabotics simulators that use digital twins to support customer operations. It is anticipated that these simulators will be put to use in three areas in particular: the proposal phase that involves preparing the overall logistics center design, the development phase where the detailed design work is done, and the commercial operation phase where customers make operational improvements.

Figure 2 — Role of Integrated WCS

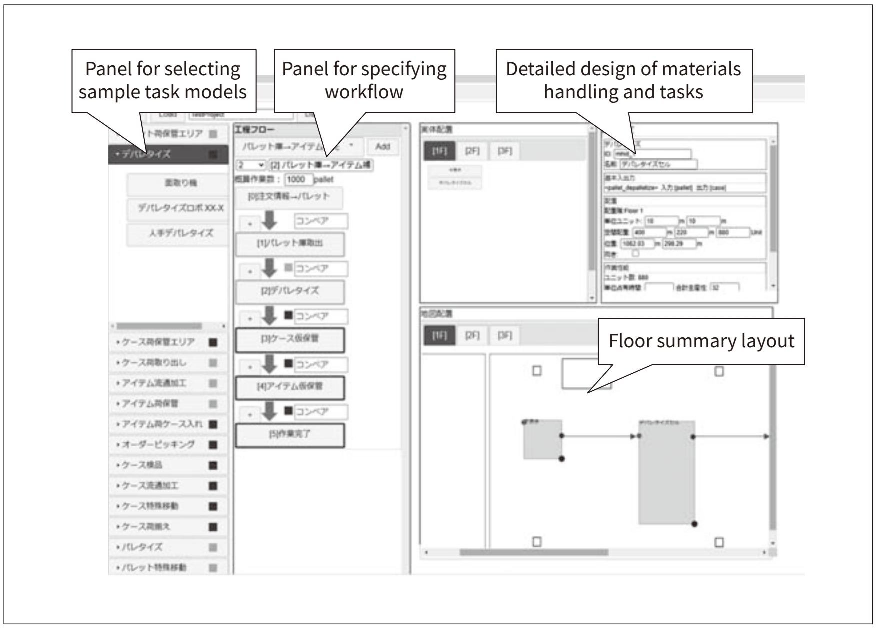
At sites where materials handling equipment is sourced from a variety of different vendors, the integrated WCS is installed between the WMS and materials handling control systems to provide overall management, enabling seamless equipment interconnection and the issuing of instructions based on an overview of what is happening throughout the entire logistics center.



ERP: enterprise resource planning WMS: warehouse management system WCS: warehouse control system CS: control system

Figure 3 — Configuration Screens for Warehouse (Equipment) Layout Overview

This is made up of a screen for specifying the workflow for the items that are dealt with in each section (left) and for allocating the area needed for each task (right). As sample configurations are available as templates, different conditions can be combined to specify warehouse pattern summaries and convert them into models that can run on the simulator.



What matters most during the proposal phase are speed and the ability to gain customer buy-in. This phase involves consultation and the ongoing revision of plans to match the customer's wishes based on considerations such as the use of actual data to determine the number of products and their volumes, the extent of fluctuations in shipment volume due to monthly schedules, and how volumes are likely to change in the future. Hitachi has adopted a user interface configuration that provides a somewhat simplified overview of the logistics center so that this can be determined quickly together with a ball-park price calculation. Simplicity also helps shorten how long it takes for engineers to familiarize themselves with its use, even those who do not have much experience of this work (see **Figure 3**). It uses video graphics to present its results in such a way that customers can easily envisage what form the completed logistics center will take. By presenting tangible images that both parties can observe, this fosters common understanding and agreement and allows the design to proceed on the basis of consensus.

In the subsequent detailed design phase, samples of actual delivery order data are input into the simulation to determine whether, for each order, all steps in the process can be completed within the anticipated time schedule. This is used to study whether optimal system-wide operation has been achieved, or whether any holdups occur at any of the steps, considering different work resources and buffer design values. Information about equipment performance is also made available on the simulation, allowing interoperation between different aspects of control to be checked as development progresses. This helps verify the overall design without having to wait for the actual logistics center to be built.

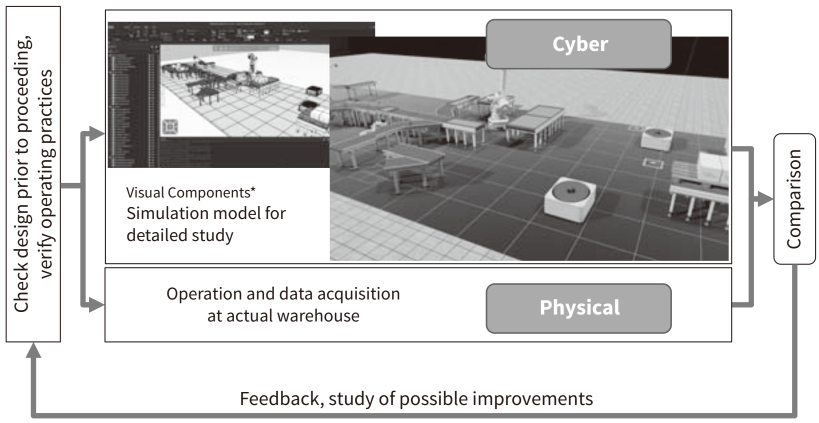


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Figure 4 — Detailed Design and Digital Twin Model

Use of a detailed simulation of each aspect of the work enables testing to be conducted dynamically prior to actual equipment installation, facilitating control development for each system and providing the ability to review the overall design relationships. Utilized in tandem with Visual Components, a digital factory tool kit supplied by the Finnish company of the same name, the equipment simulation can perform this testing at the level of actual robot operation.

Hitachi is also investigating the development of "built-in systems" for use once the logistics center commences commercial operation. This involves building these digital twin models into customer systems so that they operate in tandem. Customer support arrangements are being established to take advantage of this, using these systems to verify whether particular items of equipment are operating as originally intended. By doing so, data on the differences between the models and actual performance can provide a basis for day-to-day operational improvements to customer systems (see **Figure 4**). By drawing on extensive industry knowledge built up over many years along with products and IT-based simulation expertise, Hitachi aims to become an ongoing partner in the improvement of customer performance, providing a boost to use of the PDCA cycle at logistics center operations where costs have a tendency to increase.

5. Conclusions

Statistics issued by Japan's Ministry of Internal Affairs and Communications show a pronounced demographic sag in the number of children ages 14 and under, those who will make up the workforce of the future. What this means is that, without overseas workers or the elderly remaining in employment, business in the near future will cease to be viable. To solve this societal problem, Hitachi intends to face up to the challenges confronting its customers in the logistics industry and elsewhere and to devise and offer solutions.

Hitachi plans to establish a showroom in the near future where visitors will be able to see for themselves the products, OT, and IT described in this article, providing a place where customers can ascertain whether this technology can work with their particular products and also serving as a laboratory for further technical progress, the intention being to continue growing alongside customers.

References

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Authors

Takeshi Endo
Logistics Strategy Planning Department, Logistics Business Promotion Division, Industry & Distribution Business Unit, Hitachi, Ltd. *Current work and research:* Examination of new technologies, proposals, and engineering activities for enhancing logistics operation. *Certifications*: Certified Logistics Master. *Society memberships*: Steering committee of Japan Institute of Logistics Systems (JILS).

Nobutaka Kimura, Ph.D.
Intelligent Information Research Department, Center for Technology Innovation – Artificial Intelligence, Research & Development Group, Hitachi, Ltd. *Current work and research:* Research and development of robotics systems and AI. *Society memberships*: The Institute of Electronics, Information and Communication Engineers (IEICE) and the Robotics Society of Japan (RSJ).

Jumpei Nagao
Logistics Innovation Department, Distribution Systems Management Division, Enterprise Solutions Division, Digital Solutions Division, Industry & Distribution Business Unit, Hitachi, Ltd. *Current work and research:* New business planning and promotion of logistics solutions in general.

Kei Utsugi, Ph.D.
Intelligent Information Research Department, Center for Technology Innovation – Artificial Intelligence, Research & Development Group, Hitachi, Ltd. *Current work and research:* Research and development of simulation systems and human interfaces. *Society memberships*: The Virtual Reality Society of Japan (VRSJ), Information and Communication Engineers (IEICE), and the Information Processing Society of Japan (IPSJ).