Enhancement of Port Functions Utilizing Digital Technology

Ports, as the connection point of marine and land transportation, are social infrastructures that have an impact on trade and economic activities. In response to the global environmental and societal challenges that have emerged in recent years, port terminals in Japan and overseas are facing a variety of challenges, and there is a growing interest in efforts to upgrade their functions. This article presents Hitachi's efforts and concepts addressing the challenges faced by the port industry, and describes the solution technologies developed, application examples, and future prospects.

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1. Introduction

In terms of tonnage (t), ocean freight transport accounts for about 90% of international trade volume and 99.6% of Japan's trade volume (as of 2020)[1]. Greenhouse gas (GHG) emissions from international maritime transport account for about 2.9% of total global emissions[1]. In response to growing environmental awareness in recent years, the International Maritime Organization (IMO) adopted a GHG reduction strategy in 2018 that aims to reduce total GHG emissions from international shipping by more than 50% by 2050 (compared to 2008 levels). At port terminals that accept marine cargo transport, Hitachi is working to improve the infrastructure for accepting hydrogen, fuel ammonia, and other substances, to decarbonize industries located at ports, and to enhance port functions for attaining decarbonization as a part of an effort to form a carbon neutral port (CNP) that will reduce overall GHG emissions to zero[2].

This article describes the efforts to upgrade port functions that are contributing to CNP formation and operations through port operations efficiency.

2. Efforts to Enhance Port Functions

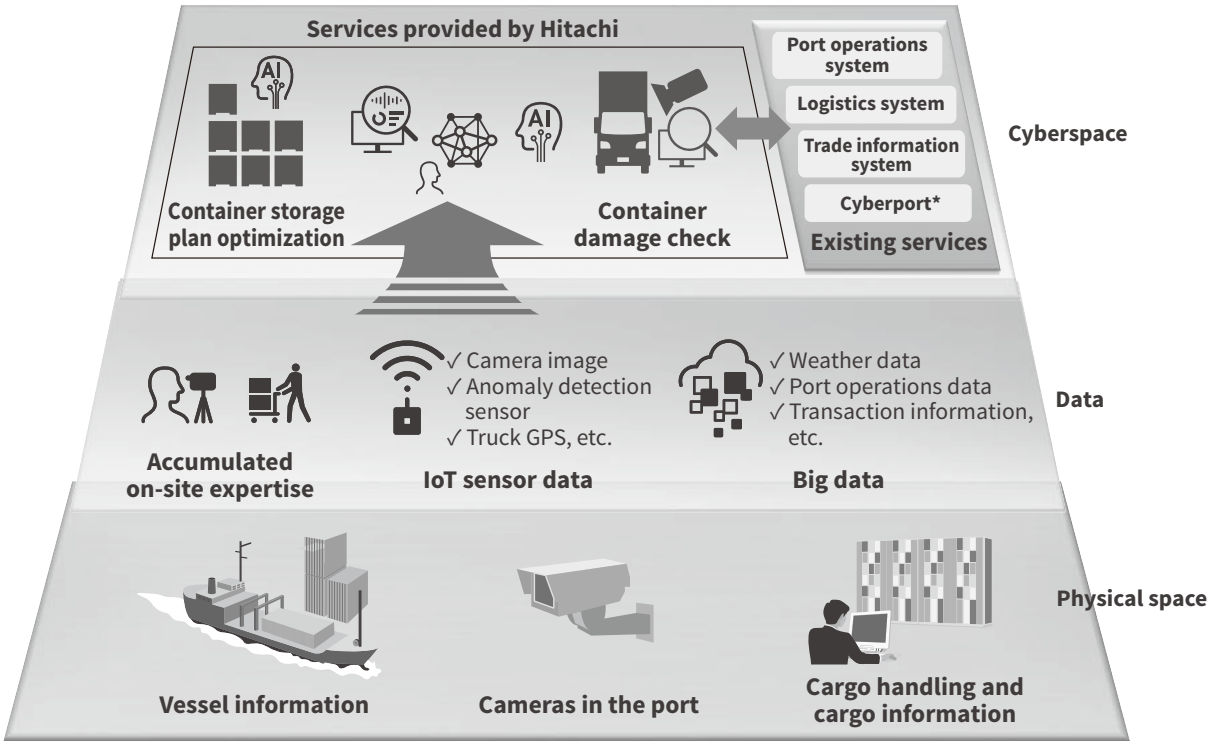
Port terminals are faced with the challenges of minimizing cargo handling time, minimizing turn time, an indicator of operational efficiency, improving the utilization rate of cargo handling machinery, and implementing energy saving measures that contribute to CNP.

Hitachi is implementing Lumada, which is a general term for solutions, services, and technologies that leverage Hitachi's advanced digital technologies to create value from customer data and accelerate digital innovation[3]. In the field of port operations, Hitachi is aiming to realize digital transformation (DX) that supports on-site operations and workers by utilizing digital technology with a variety of real-world information acquired through cameras and other sensors (see **Figure 1**). Hitachi has defined current and future tasks, and is developing a container storage planning optimization solution and a container damage check solution (CDCS), both of which are expected to be highly effective through DX (see **Figure 2**).

In the storage of cargo containers, the number of container tiers tends to be high at Japanese ports due to the

Figure 1 — Hitachi's DX Vision for Ports

Various data obtained from physical space are digitally processed in cyberspace and fed back to the site to enhance port operations and provide new value to operators.



DX: digital transformation AI: artificial intelligence IoT: Internet of Things GPS: global positioning system

*A platform for linking port-related data to improve overall port logistics productivity by streamlining operations through the computerization of port logistics procedures among private operators.

limited land area. Usually, containers that are ready to be unloaded earlier are placed on the higher tiers, and those that are expected to take longer to be unloaded are placed on the lower tiers. Consideration is needed to reduce the number of times containers need to be transshipped (i.e., the number of times they need to be rehandled). Currently, such placement plans are prepared based on the formalized knowledge and the experience of skilled workers. Going forward, in order to cope with increasingly complex supply chains, artificial intelligence (AI) is expected to flexibly adapt to ever-changing cargo information and reduce the burden on workers by supporting their planning work.

When checking for damage to containers, if a marine container shows scratches, dents, corrosion, or other damage, it is necessary to suspect damage to the loaded cargo during the transportation process. At port terminals, checking the damage status of containers and communicating it at the handover stage is an essential management responsibility among the involved parties. Generally, for container terminals, during loading/unloading of the ship and loading/unloading at the gate, the external appearance of loaded containers is inspected, and the inside of empty containers is checked for stains and water leakage. Since inspection is an important task, efficiency must be improved while ensuring a safe and secure working environment. Hitachi believes that it is essential to accumulate data through a remote inspection system as a preliminary step and develop the system step by step, aiming for inspection support in the future by using AI and other technologies to automatically alert the operator of suspected damage locations.

2. 1
Container Storage Optimization Solution

To cope with complex port operations, Hitachi has developed an AI model for planning warehousing by combining multiple AI models and mathematical optimization techniques (see **Figure 3**). Using big data such as container attribute information, the AI model has functions that use machine learning for predicting after how many days import containers will be unloaded and for planning the optimal container placement based on the results of the container unloading prediction date. The system is expected to improve operational efficiency by enabling operators to refer to information such as warehousing plans based on container unloading prediction results or work instructions for cargo handling equipment based on objectives such as reducing environmental impact.

In the verification, a learning model based on container information held by the terminal operation system (TOS), which is a port operation system, will be built and evaluated.

Figure 2 — Overview of Solutions

Hitachi is working to organize its customers' operations and upgrade container damage check operations and container placement planning operations, where DX is expected to be very effective.

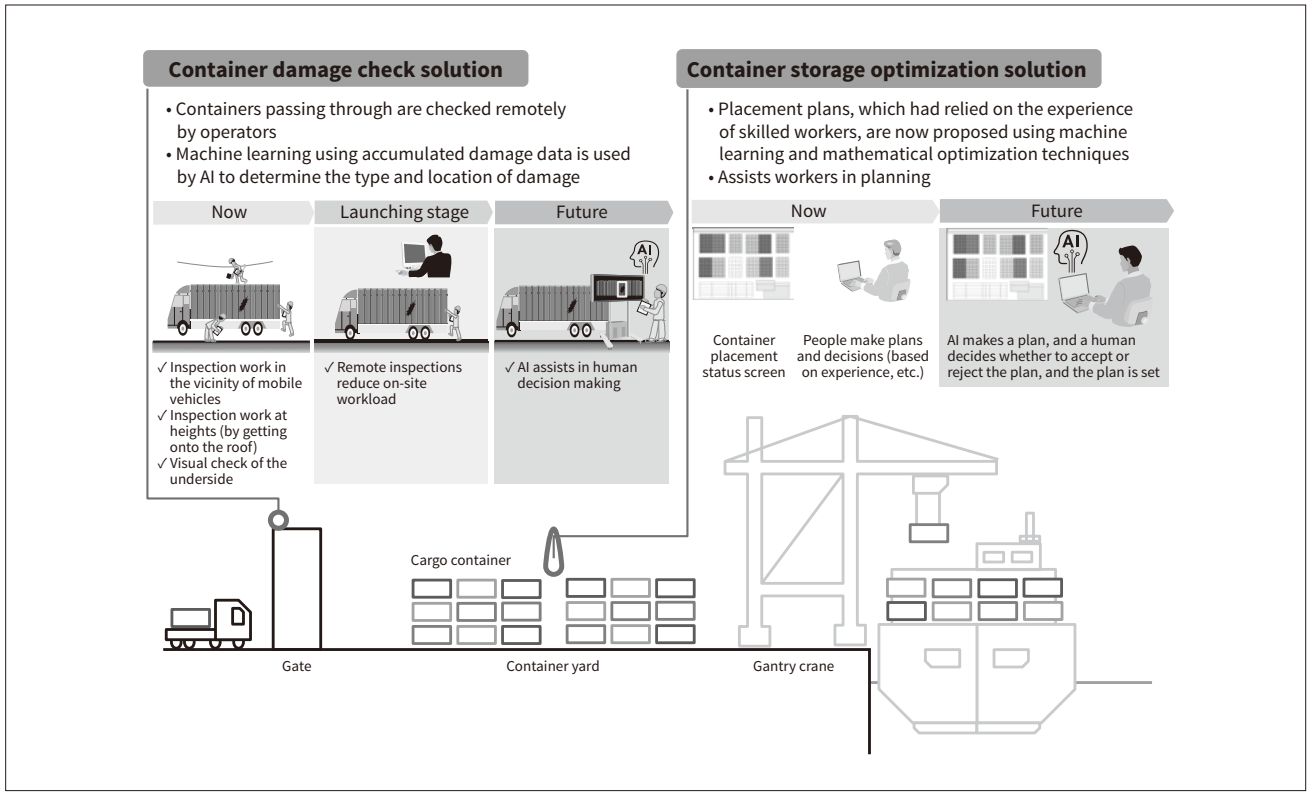
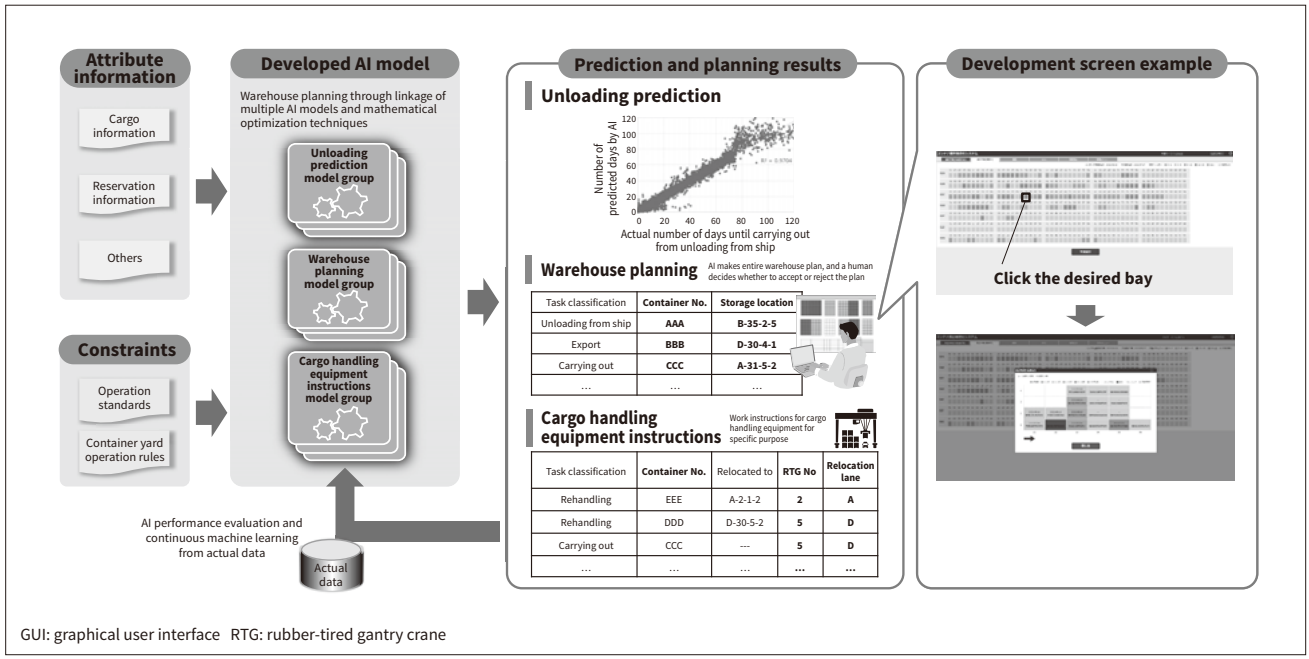


Figure 3 — Container Storage Optimization Solution Diagram

A plan is prepared based on operational constraints from various operation information obtained at the container terminal, and the results are displayed by a Web GUI.

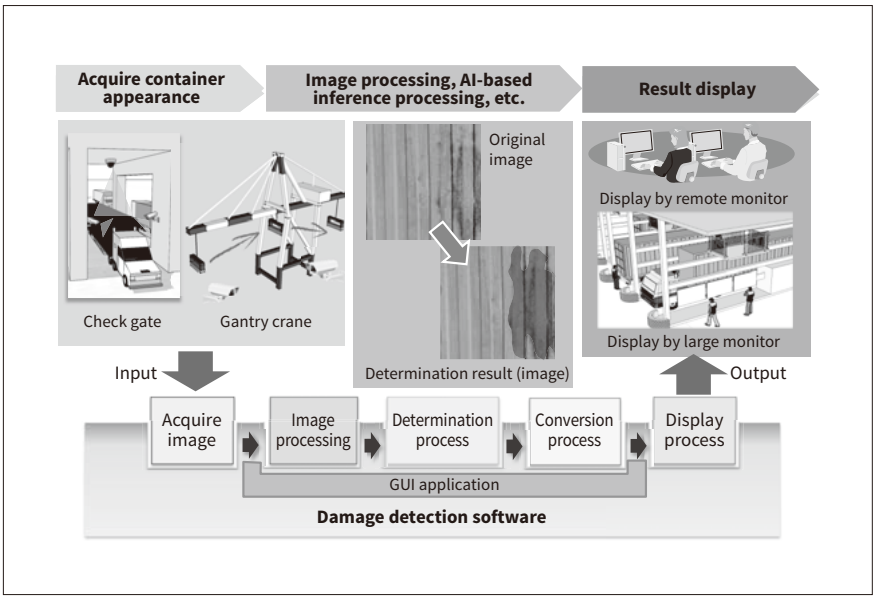


GUI: graphical user interface RTG: rubber-tired gantry crane

One indicator for optimizing storage locations is to evaluate the rate of decrease in the number of times containers are stored by comparing the actual container locations based on historical data and the container locations indicated by the trained AI. Currently, off-line verification using data from multiple port terminals has shown that the number of times containers are rehandled can be reduced by about 10–15%. Since the results obtained at present are based on constraints and assumptions, Hitachi plans to conduct a review of the various conditions and the evaluation system.

Figure 4 — Container Damage Check Solution Diagram

GUI applications are converted into libraries for each process to meet the diverse needs of customers.



Going forward, Hitachi believes that it will be useful to develop an operations planning support application in which AI suggests to the planner the planning methods used by skilled workers.

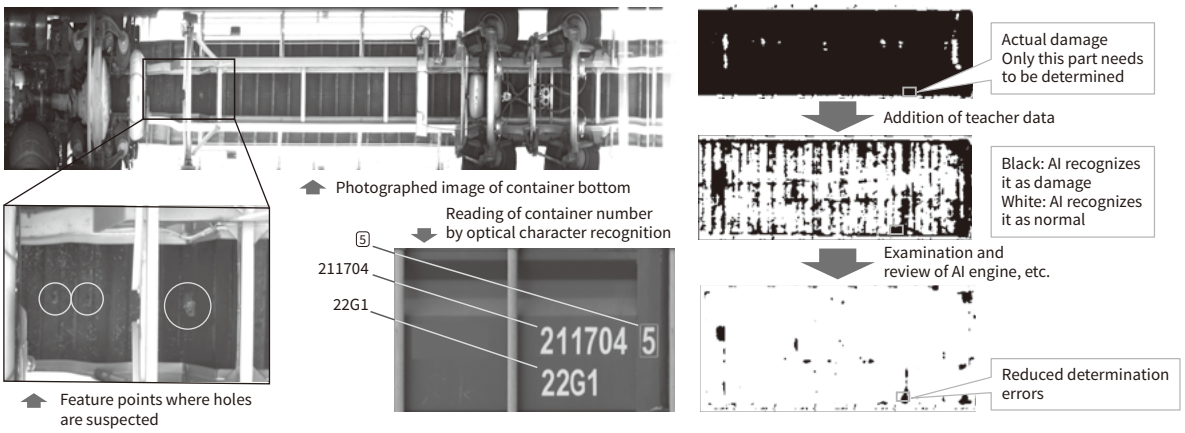
2. 2
Container Damage Check Solution (CDCS)

A schematic diagram of the CDCS is shown in **Figure 4**. Since damage checks are mainly conducted at check gates and during cargo handling operations on the wharf side, Hitachi is developing a system that detects damage locations based on video acquired at each location and that displays the results on a remote monitor or on a monitor at the work site. The damage detection software includes image processing of captured video and image data, determination processing to judge the presence or absence of damage through machine learning, conversion processing to superimpose the results on the image, and display processing to enable the results to be checked by humans. The installation status, setting conditions, and methods differ among service providers. Customized libraries are applied to meet the specific needs of each customer.

Figure 5 shows an example of the results of the study on photographing the bottom of containers in the underside inspection solution, reading container numbers using optical character recognition technology, and study results of damage assessment using AI. Hitachi plans to work toward the practical application and implementation of these technologies in the future.

Figure 5 — Example of Evaluation Results

This shows an example of photographing the bottom of a container (left), result of reading a container number using optical character recognition (middle), and determination of damage using AI (right).



3. Conclusions

This article presented examples of the use of digitalization technologies that utilize operations data and AI as part of efforts to enhance port functions. Hitachi will continue to contribute to resolving societal challenges through more advanced data-based control technology (operational technology) and the development of technologies to implement DX. Through these efforts, Hitachi hopes to contribute to society and people involved in port work through social innovations that will shape the future of the port industry.

References

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