BIG DATA ANALYTICS FRAMEWORK FOR RESOURCES EVALUATION OF CONTAINER TERMINALS

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（コンテナターミナルにおける経営資源評価のためのビッグデータ分析のフレームワークに関する研究）

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論　文　内　容　の　要　旨

This paper presents a state-of-art resource-measurement analysis of a container-terminal handling operation using big-data analysis.

The daily operations in a container-terminal yard face many challenges on the incoming and outgoing containers, and when container repositioning is necessary. The common goal of any container terminal is to increase the effectiveness and efficiency of yard operations. Because of the trade-off between the land size and number of operations, many different techniques and algorithms have been used through the years to solve the stack rehandling problem, which is one of the NP-hard problems with no optimum solution within a reasonable time.

To perform and monitor the container operation in a terminal, each transfer-crane (T/C) movement is recorded. Consolidation of the handling operation in a year reveals massive data that cannot be analyzed using the common tools that are currently used by companies. A big-data analytics framework must be developed to extract useful information from the raw data. This research uses approximately 1.3 million container movements in the raw data, and the number of columns in the data is considered, i.e., 34 columns, including the dates, operations, positions, and worker names. The total number of cells is approximately 44.2 million after the outliers, missing values, and duplicate information have been deleted.

From the perspective of new planning and design of container terminals that include conventional types or a new trend for container terminals to become semi or fully automated in the future, an excellent technology is being pursued that analyzes an enormous source of cargo-handling data to verify and evaluate not only the daily operations but also the original terminal design. Internet of Things (IoT) is also a trend in future terminal operation. However, the application of IoT data in container terminals has been underused.

By considering the storage area and equipment used to manage the containers in a terminal as a resource, big-data analysis can be advantageously employed to improve the efficiency of container-terminal resources. This research focuses on a big-data analytics framework to support the increasing data generated from non-automated terminals. The challenge is how to use the existing big data of terminals when they were not previously designed for this situation.

The developed framework incorporates the learned knowledge from the container-terminal T/C daily operation report to the process of stacking and retrieving containers using the following data-science technology: 1) data filter extracts a specific part of a large dataset based on complex expressions, which is also used to assemble and clean up the data; 2) correlation is a process adopted from statistics to calculate the relationship strength among variables used to understand the global effect of each type of movement; 3) visualization has three different

applications: a) terminal-operation video recordings are used for comparison with the daily report and for evaluating the operations; b) a database is used to build the stack-behavior animation for extracting and understanding the stacking patterns; c) the key performance indicator presents visualization using graphs for easier comparison among the indicators; 4) curation uses expert knowledge in the field to select, organize, calculate, and estimate the main parameters to evaluate the container-handling operation; and 5) simulation and evaluation are computational methods used to evaluate the different strategies applied to complex systems in which operational optimization and cost reduction are expected. The simulation is used on the stacking process, which excludes unnecessary rehandling and setting of strict rules in container positioning, thus reducing the total number of movements and the energy consumption.

The thesis consists six chapters, and the outline is described as follows:

Chapter 1 presents a brief introduction of the research topic, which is the overview of the container traffic around the world, and the complexity of a terminal-yard operation is explained. This chapter also describes the research motivation, objectives, and main contributions of publications throughout this research.

Chapter 2 describes in detail the flow of container operation. It is divided into two main sections. The first section provides an overview of the flow of maritime container transportation worldwide with the main trends and market situations. In the second section the main inefficient parameters in a daily container-terminal operation are presented, and every type of movement found in the operational report data of Hakata Island City Container Terminal (HICCT) is explained.

In Chapter 3, experiences from earlier cases and information background from literature research is presented. Data science is initially explained. Thereafter, a survey on the applications of big data and the simulations applied to container-terminal operation are presented.

According to the results, a framework for a big-data analysis approach is introduced in Chapter 4, which is the core idea of this thesis. A big-data analytics framework is developed to challenge the existing performance measurement applied to the daily reports on T/C equipment. Implementing this framework can potentially provide profound understanding of the container-handling operation in a terminal, as well as the specific movement of each container, their correlations, and the role of each container-yard region, bay, lane, and driver behavior, allowing the classification of all different behavioral characteristics and measurements.

Chapter 5 presents the application of the proposed approach to the HICCT data report for analysis and the evaluations made to demonstrate the effectiveness of this container-handling framework not only for resource analysis but also for understanding how the operation is carried out. Subsequently, a method is introduced using the knowledge acquired from the big-data analysis, which is developed to reduce the total number of movements necessary to perform the main task in a container terminal, i.e., storing and picking up containers to and for the stacking area. Section 5 also presents the simulator developed to compare the proposed method with an actual operation. This simulation is important because it highlights the significance of profoundly studying and understanding the data.

Finally, Chapter 6 presents the conclusions and recommendations for further research.