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A case based reasoning based multi-agent system for the reactive container stacking in seaport terminals

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Abstract

With the continuous development of seaports, problems related to the storage of containers in terminals have emerged. Unfortunately, existing systems suffer limitations related to the distributed monitoring and control, real-time stacking strategies efficiency and their ability to handle dangerous containers. In this paper, we suggest a multi-agent architecture based on a set of knowledge models and learning mechanisms for disturbance and reactive decision making management. The suggested system is able to capture, store and reuse knowledge in order to detect disturbances and select the most appropriate container location by using a Case Based Reasoning (CBR) approach. The proposed system takes into account the storage of dangerous containers and combines Multi-Agent Systems (MAS) and case based reasoning to handle different types of containers.

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Keywords: Multi-agent system, Case Based Reasoning, disturbances management, CSP, knowledge representation, learning mechanism.

1 Introduction

Container Stacking Problems (CSP) consist in determining the exact location of containers in the storage area (named the storage yard) of a terminal. A storage yard consists of a number of areas perpendicular or parallel to the berth called blocks. Each block is characterized by a number of bays and each bay is divided into several number of rows (called stacks) characterized by a stack height (named tier) (see Figure 1).

As it will be discussed in section 2, many container stacking systems have been developed in the literature but they suffer from limitations related to the disturbances management, the distributed control of containers allocations and the real-time aspect (Rekik, et al., 2015).

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This paper presents an intelligent multi agent and reactive architecture for the distributed control of the container stacking system in an uncertain and disturbed environment. The system integrates CBR in a multi-agent system for the distributed control of the stacking process. To the best of authors' knowledge, there is no previous work formalizing knowledge using CBR paradigm and integrating this mechanism in a MAS for the reactive stacking of containers in seaport terminals. The system includes five types of agents (interface agent, block agent, bay agent, stack agent and evaluation agent). Each one is in charge of determining a part of the final decision. The proposed system is able to detect disturbances such as those related to dangerous containers and select the most appropriate container location. The system can also learn from past encountered experience and adjust automatically its decisions.

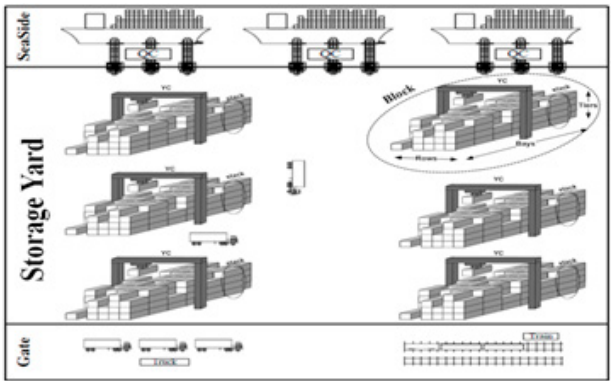

Figure 1: A container terminal

The remainder of this paper is organized as follows: Section 2 gives a brief survey on existing studies related to CSP. Section 3 presents the case representation and the learning mechanisms adopted in this paper. Section 4 presents the global architecture of the proposed multi-agent approach. Section 5 describes the different agents constituting this system. Section 6 reports the experimental results of the proposed system. Finally, a conclusion is drawn and future work is addressed.

2 Related works

To improve terminals performance, several staking rules (strategies) have been developed in the literature. The efficiency of each rule varies from terminal to terminal (van Asperen, et al., 2013). According to (Rekik, et al., 2015), stacking rules are categorized into three main families:

- Block Stacking Rules (BlSR): deal with the selection of the "appropriate" block for incoming containers (import or export containers). These rules include dedicated areas, Role Separation of Blocks, Role Separation of Rows, Role Separation of Bays, No Restriction, the Different Priorities on Blocks for Different Berths, and the Maximum Number of Internal Trucks and Road Trucks in a Block.
- Bay Stacking Rules (BSR): are responsible for the selection of a bay from the pre-selected block. Several bay stacking rules have been studied in the literature, such as Concentrated Location Principle and Sequence rule.
- Slot Stacking Rules (SSR): are related to the selection of the exact storage location in the assigned bay of the assigned block. Several stack stacking rules have been studied in the literature including Random rule, Levelling rule, Closest Position rule, Maximum Remaining Stack height rule.