

Analysis of Multi-Bin Storage/Retrieval Strategies in Robotic Compact Storage and Retrieval Systems

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Abstract

Robotic Compact Storage and Retrieval System (RCS/RS) is a contemporary robots-to-pickers solution designed to enhance operational efficiency and space utilization in warehouses. The system employs multiple robots navigating a grid along the x- and y-axes, while performing storage and retrieval operations along the z-axis. Within this system, retrieving a bin involves first removing the bins stacked above it. Then, depending on the storage policy, the displaced bins are either returned to one level below their original locations before the target bin is delivered to a port, or restored to their original locations after the target bin is processed at the workstation and returned. However, sequential removal of stacked bins to reach lower levels results in a notable limitation, while restricting system height reduces space utilization efficiency and increases operational effort in high-rise configurations. This study develops an analytical model for evaluating operational time within RCS/RS under constant motion conditions and investigates the effects of storing and retrieving bins in groups of two or three. The results indicate that system performance depends significantly on the number of bins handled. The proposed computational framework enables warehouse service providers to evaluate the trade-offs between space utilization and operational time associated with storing and retrieving bins collectively. It also contributes to optimizing RCS/RS configurations to achieve improved space efficiency and operational performance.

Keywords

Logistics, Intralogistics, Warehousing, Compact systems, Operation time modeling, Optimal system configuration

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Biographies

Mahmut Tutam is an associate professor in the Department of Industrial Engineering at Erzurum Technical University in Turkey and holds a BSIE degree from Gazi University in Turkey. In 2012, he was awarded a full scholarship from the Ministry of National Education of Turkey to study in the United States. He received his MSIE and Ph.D. from the University of Arkansas (UA) in 2015 and 2018, respectively. He performed research on Warehouse Design problems. A recipient of the 2015 and 2023 ISERC Best Track Paper in Facility Logistics award, he has given

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Turgay Duman is an Assistant Professor in the Department of Electrical and Electronics Engineering at Erzurum Technical University, Türkiye. He received his M.Sc. and Ph.D. degrees from the University of Texas at San Antonio, USA. His research interests include power electronics, grid-connected photovoltaic (PV) systems, multilevel power converters, and real-time simulation (HIL/PHIL). He also works on Robotic Compact Storage and Retrieval Systems (RCS/RS), with a focus on the analytical modeling of operational time and energy consumption, including regenerative energy effects and system optimization. He has teaching and research experience in advanced power electronics and sustainable energy systems, with an emphasis on efficiency and intelligent control.