Automated Warehouse
Course Project: Milestone 3

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Abstract

Automated warehousing represents a paradigm shift in logistical operations, integrating cutting-edge technologies like robotics, artificial intelligence (AI), and the Internet of Things (IoT) to enhance operational efficiency and accuracy. This project endeavors to develop a sophisticated scheduling algorithm tailored specifically for warehouse robots. The algorithm's primary goal is to optimize product delivery and order fulfillment within the warehouse environment, ultimately minimizing the time required for these processes.

Problem Statement

In the dynamic realm of modern logistics, automated warehousing stands as a cornerstone innovation, employing cutting-edge technologies to revolutionize operational efficiency. Within this context, this project addresses the intricate challenge of optimizing robotic coordination to streamline product delivery within automated warehouse environments.

At its core, the project aims to develop a sophisticated scheduling algorithm tailored explicitly for warehouse robots. This algorithm serves as the backbone of warehouse operations, orchestrating the movement of autonomous vehicles through a grid-based environment. The primary objective is to minimize the time required for order fulfillment while upholding stringent standards of accuracy and safety.

The warehouse environment is envisaged as a complex ecosystem, characterized by a grid structure comprising interconnected cells with diverse functionalities. From storage shelves housing an array of products to designated picking stations for order assembly, each element must seamlessly integrate within the warehouse framework to ensure smooth operations.

To address this challenge effectively, the project delineates key constraints governing warehouse operations, drawing inspiration from established methodologies while striving for innovation. These constraints encompass spatial limitations on robot movement, strategic shelf placement considerations, picking station specifics, spatial integrity requirements, and shelf handling limitations.

Furthermore, the project seeks to leverage insights from prior research and practical applications, such as the Answer Set Programming Challenge 2019, to inform its approach. By synthesizing existing knowledge with novel methodologies, the project aims to develop innovative solutions to optimize robotic orchestration within automated warehouse environments.

In essence, the project represents a concerted effort to push the boundaries of automated warehousing, navigating the complexities of efficient robotic coordination to unlock new levels of speed, precision, and adaptability in supply chain management.

Current Progress

Considerable progress has been achieved in establishing a robust programming framework using Answer Set Programming (ASP) and CLINGO. Key milestones include the initialization of the warehouse environment, the identification of specialized pathways, and the programming of precise robot movements. Notably, the integration of Knowledge Representation and Reasoning (KRR) concepts has significantly enhanced the efficacy of robot actions and visualization within the warehouse.

Issues Encountered

A significant challenge encountered in the project revolves around mitigating robot collisions within the warehouse layout. As the number of operational robots increases, the complexity of path planning escalates, amplifying the risk of collisions. Additionally, inefficiencies in code execution time have been observed, particularly when scaling up to larger warehouse models or handling increased order volumes.

Plan to Resolve Issues

To tackle these challenges effectively, a comprehensive plan has been devised. This includes integrating advanced algorithms, and potentially leveraging machine learning or heuristic methods, to dynamically manage robot paths and prevent collisions. Additionally, strategies for optimizing code execution, such as logic refinement and parallel processing exploration, will be implemented to enhance computational efficiency and facilitate real-time performance.

Tasks Completed

- Acquired fundamental knowledge of ASP and successfully configured CLINGO, a pivotal ASP system.
- Defined the initial warehouse environment and developed essential constraints governing robot movement, shelf management, and order fulfillment.
- Achieved accurate initialization of warehouse objects and addressed complexities associated with coordinating multiple robots within the environment.

Future Tasks

- Develop intricate logic to prevent robot collisions and optimize path planning algorithms for enhanced efficiency.
- Refine algorithms to reduce code execution time, ensuring real-time or near-real-time performance even in complex warehouse scenarios.
- Implement additional functionalities such as shelf handling and product delivery to complete the automated warehouse solution.
- Rigorously test the final program within CLINGO to validate correctness and operational integrity under various operational scenarios.

References

Kavraki, Lydia E., Petr Svestka, and Jean-Claude Latombe. "Probabilistic roadmaps for path planning in high-dimensional configuration spaces." IEEE Transactions on Robotics and Automation 12.4 (1996): 566-580.

Russell, Stuart J., and Peter Norvig. "Artificial Intelligence: A Modern Approach." Pearson, 2016.

Azadeh, Kaveh and de Koster, M.B.M. René and Roy, Debjit, Robotized and Automated Warehouse Systems: Review and Recent Developments (May 30, 2017).

Clingo Documentation

CSE579 Lecture Videos by Dr. Joohyung Lee