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Improving cooperative pathfinding using a path oracle

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1 Introduction

The order picking process is the number one expense in the operating cost of warehouse systems [De Koster et al. \(2007\)](#). This project will look at warehouse automation, whereby the order-picking process is performed by automated vehicles. In particular we will be exploring Kiva systems which employs warehouse automation. More detail about Kiva systems is provided in [Section 2](#).

When improving on the part-to-picker systems, we look at the system as a Multi-agent pathfinding (MAPF) problem.

These include: introducing an intermediate dropping zone, optimizing order processing and adding the capability for robots to maneuver under storage pods.

The results of this project will help identify how we should position storage and picking stations in a warehouse. Additionally, we will be looking at developing a MAPF method which uses a pre-computed path oracle.

2 Background

3 Multi-agent Pathfinding

Multi-agent pathfinding (MAPF) involves finding a path for every agent to their goal. Warehouse Automation is commonly modeled on an orthogonal undirected grid [?](#) . Formally defining this, we look at k agents on a graph $G = (V, E)$ where V is the set of vertices and E is the set of edges within the graph.

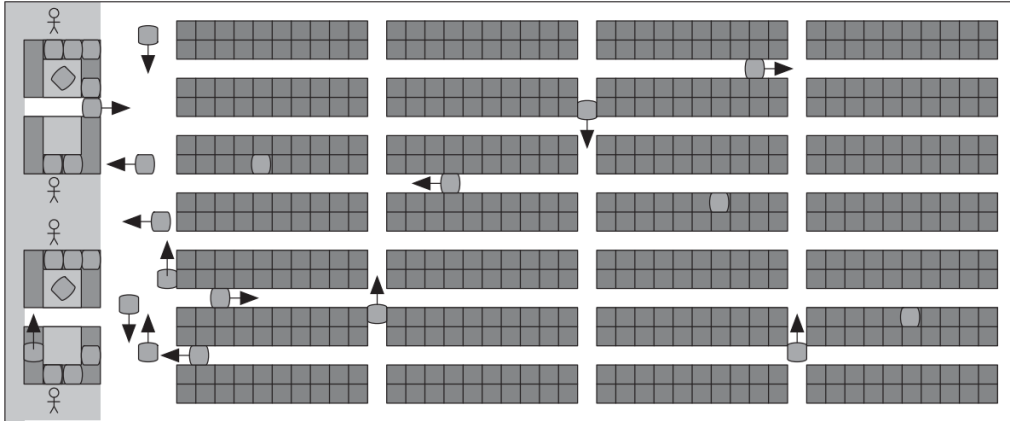


Figure 1: A Small Region of a Kiva Layout ([Wurman et al. \(2008\)](#)). Picking stations located on the left and storage pods laid out in rows.

Within MAPF, we are focusing on an optimal solution. The following sections will focus on optimal MAPF algorithms as well as suboptimal variants of these algorithms.

4 Conflict-based Search

The state-of-the-art in MAPF, Conflict-based search is

5 Mixed Integer Programming

Mixed Integer Programming is an optimization technique that looks at objective function which is subject to a list of constraints.

6 Other areas in Warehouse Automation

7 Conclusion

References

- De Koster, R., Le-Duc, T. and Roodbergen, K. J. (2007). Design and control of warehouse order picking: A literature review, *European Journal of Operational Research* **182**(2): 481–501.
- Wurman, P. R., D’Andrea, R. and Mountz, M. (2008). Coordinating hundreds of cooperative, autonomous vehicles in warehouses, *AI magazine* **29**(1): 9.