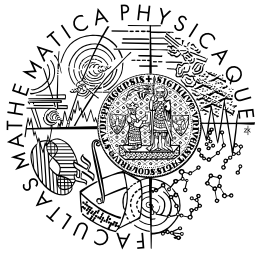

FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

SOFTWARE PROJECT

Matej Straka

Multi agent pickup & delivery

Name of department

Supervisor of the software project: Mgr. Marika Ivanová, PhD.

Study programme: Computer science

Study branch: General computer science

Prague 2021

I declare that I carried out this software project independently, and only with the cited sources, literature and other professional sources. It has not been used to obtain another or the same degree.

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Author's signature

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Title: Multi agent pickup & delivery

Author: Matej Straka

Department: Name of department

Supervisor: Mgr. Marika Ivanová, PhD., Katedra teoretické informatiky a matematické logiky

Abstract: Abstract.

Keywords: multi-agent, pickup&delivery, pathfinding, optimization

Contents

Introduction

In this project I will study a Multi-agent pickup & delivery (MAPD) problem where multiple moving agents are placed into a known environment where they are given potentially infinite stream of tasks – deliveries. In order for an agent to execute a task, it first has to reach a pick-up location and then carry a package to a delivery location in a collision-free manner. The MAPD problem is to assign tasks to agents so that the average time of all deliveries is minimal. The MAPD is a well studied problem which is known to be NP-hard, so approximations and heuristics are developed to address variants of the pick-up & delivery problems. We can distinguish MAPD solutions into two categories. One is centralized where one "entity" is assigning packages to all agents. The other one is decentralized, where every agent decides for himself what he's going to do. We will study MAPD solutions on grids that will be similiar to real world environments, for example grids with tight corridors just like in warehouses with many shelves next to each other. Agents are able to move in four directions – up, down, left or right. Big part of these environments are obstacles which have to be avoided by agents. Every task is characterized by its pickup location, delivery location and a realease time. I will study an online version of the MAPD problem, where package pick-up and delivery locations are known once they are released and not before. This leads to a possibility for agents to change their scheduled tasks but only when they are not already carrying a package. We forbid dropping packages anywhere other than at the delivery location since it is more applicable in real world scenarios. We can see direct analogies of these scenarios to real world problems. Examples include robots in automated warehouses, aircraft-towing vehicles, video-game characters or even taxis who pick up and drop off passengers.[2][3]

In software project I will focus on creating a simulation tool for this problem using Python programming language, more specifically *PyEasyGraphics* library. The simulation tool will contain a graphical interface which will be rendering agents as they perform their tasks. Goal will be to create a robust tool, making it easily adjustable for similiar multi-agent pathfinding problems. User will be able to either create environment by drawing it using mouse or load existing environment from a file. Environments will be created on grids and agents will be able to move in four directions. I will try to implement features that will make analysis "by eye" easier. For example, user will be able to track an agent, which will display currently planned path for selected agent. Agents will be respresented as circles distinguished by colors, making agents with assigned tasks have different color than unemployed agents. Also agents carrying a package will be distinguished by black shape in the middle. In the second part of this project I will implement some existing solutions to this problem and compare them against each other and against my own solution as well. I will compare these models on grids representing various real life instances.

In a potential following bachelor's thesis I would review existing MAPD solutions and compare them to my own solution through experimental evaluation in a greater detail.

1. Title of the first chapter

An example citation: [1]

1.1 Title of the first subchapter of the first chapter

1.2 Title of the second subchapter of the first chapter

2. Title of the second chapter

2.1 Title of the first subchapter of the second chapter

2.2 Title of the second subchapter of the second chapter

Conclusion

Bibliography

[1] J. Anděl. *Základy matematické statistiky.* Druhé opravené vydání. Matfyzpress, Praha, 2007.

[2] B. Coltin. Multi-agent pickup and delivery planning with transfers. page 1, 2014.

[3] S. K. Gang Ma, Jiaoyang Li. Task and path planning for multi-agent pickup and delivery. page 1.

List of Figures

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List of Abbreviations

A. Attachments

A.1 First Attachment