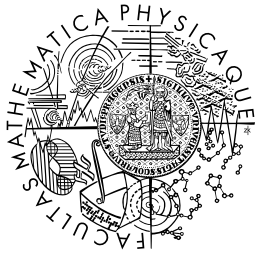

FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

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.

I understand that my work relates to the rights and obligations under the Act No. 121/2000 Sb., the Copyright Act, as amended, in particular the fact that the Charles University has the right to conclude a license agreement on the use of this work as a school work pursuant to Section 60 subsection 1 of the Copyright Act.

In ..... date ....

Author's signature

fill later.

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 we 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. It 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 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. Big part of these environments are obstacles which have to be avoided by agents. These obstacles can act as buildings if the environment is a city or pillars if the environment is a warehouse. In one step agents area ble to move in four directions – up, down, left or right.

Every task is characterized by its pickup location, delivery location and a release time. We 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]

Technologies

In software project I will focus on creating a simulation tool for this problem using Python programming language, more specifically *Pyglet* graphics library. I will focus on Linux platform, but final program should work on any operating system thanks to *Pyglet*. Another library that I will use is *argparse*, which is a very famous Python library for parsing command-line arguments. I will also use *python3-tk* (tkinter) library which allows to open windows of host operating system to open or save files. This will be used for loading and saving environments. Also I will use python virtual environment for better package organization and avoidance of conflicts with packages in my main python directory.

Graphical user interface and settings

The simulation tool will contain a graphical interface which will be rendering agents as they perform their tasks. A goal will be to create a robust tool, making it easily adjustable for similiar multi-agent pathfinding problems. User will be able to create or edit environment by drawing using mouse or load existing environment from a file. Environments will be created on rectangular grids. I will try to implement features that will make an analysis "by eye" easier – for example, a user will be able to track an agent, which will display currently planned path for a selected agent. Also, information about state of the simulation (current average delivery time, number of occupied agents, delivered packages,..) will be displayed in the control panel aswell. Agents will be respresented as circles distinguished by colors. Agents with assigned tasks will be marked by a small circle on top of their main representational circle.

Algorithms

TODO.

Limitations

TODO.

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

List of Tables

List of Abbreviations

A. Attachments

A.1 First Attachment