Multi-Agent Simulation of Autonomous Vehicles for Logistics

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Objective

Developing path planning and navigation strategies for autonomous vehicles in multi-agent setting.

Description

It is considered the use of many mobile robots to transport payloads, from point to point, while avoiding fixed obstacles and other vehicles. In this transportation system, each vehicle will focus on its own task, but the evaluation will consider the overall logistics performance of the system.

Possible applications of such autonomous system are:
- Transport of goods inside warehouses, see Figure 1;
- Transport of tools and parts in factory environment;
- Optimisation of airport logistics, luggage transport, transport of passengers between terminals, towing aircraft;
- Package delivery with unmanned aerial vehicles;
- Optimisation of autonomous car traffic in cities.

Figure 1: Multiple mobile robots transporting pallets in a warehouse.
Credits: Kelvin Hoi Kar Wai, https://sipmm.edu.sg/

In a conversation between the supervisor and the student, it will be decided which specific environment will be addressed in the research.

Methodology

The simulation will be in Python, using the PyGame library, see Figure 2. First, it is created a map with obstacles and agents. Each agent receives a task of transporting a payload from spot A to spot B. Different navigation behaviours are generated. Simulations are carried out to evaluate those behaviours. The process of generating and evaluating behaviours will use evolutionary methods, reinforcement learning, or related techniques. From the simulations, data are collected and analysed to understand the best strategies. It is analysed which strategies perform best while looking at a single robot, and while looking at the transport performance of all the robots collectively. The analysis will take into account: least time, shortest path, energy consumption and least collision risk.

At the end, the data is consolidated, and the behaviours that have emerged are clustered in groups, considering, for example, which of them are more selfish, and which are more altruistic.

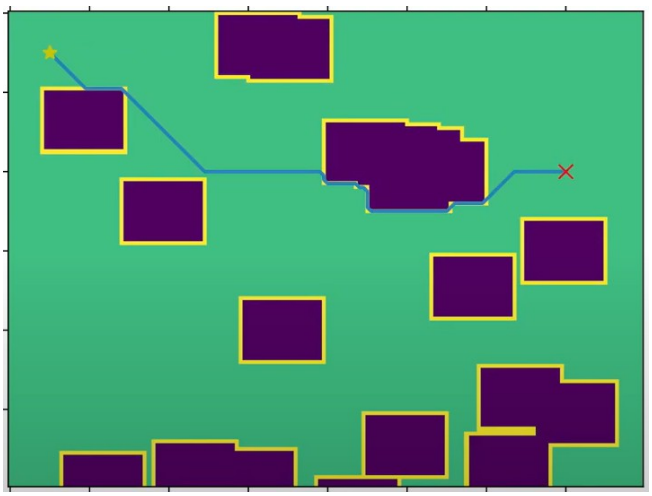

Figure 2: Path planning algorithm using PyGame library.
Credits: Course CT-213 of professor Marcos Maximo.

Another proposal

As a spin-off of this research idea, it is proposed the investigation of different geometries of vehicles in order to optimise the transportation performance. In the case of wheeled vehicles, perform a parameter optimisation of wheelbase and track dimensions, and also motor size and battery capacity. In the case of air vehicles, evaluate a mix of multi-rotor and fixed-wing options, to achieve the best of versatility and energy efficiency of each type of vehicle. Then, perform the search varying wing and tail geometry, number and position of the rotors.

I also consider working in other research topics proposed by the supervisor. I look forward doing research in Artificial Intelligence applied to Mechanical/Transport Engineering problems.