Implementation of a Robot Behaviour Learning Simulator

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Introduction

A collection of two or more autonomous mobile robots working together are termed as teams or societies of mobile robots. In multi robot systems (MRS) simple robots are allowed to coordinate with each other to achieve some well defined goals. In these kinds of systems robots are far less capable as an entity, but the real power lies in cooperation of multiple robots.

What are Multi Robot Systems?

The collective coordiantion, cooperation and collaboration of these multiple robots is constituted to be in the domain of Multi Robot Systems. It is more of a subfield of Multi Agent Systems than of Robotics, as here the robot is nothing but a point object (having only 4 movements and 360°field of motion). On the contrary, a robot is normally visualized as someone with more than one joint. In our scenario, a robot is nothing but a physical embodiment of an agent with goals and beliefs. (Please correct me if I am wrong).

[Aristotle] "The whole is definitely more than it is parts."

How to execute path planning?

Path Planning is done in the same fashion as single robot systems. The usual SLAM (Simultaneous Localization and Mapping) is executed, and the map is saved. The map is then used for doing the path planning.

Complications

Designing a path planning algorithm is hard in multiple robot systems. There are complications, but it totally depends on us if we wish to include those shortcomings in the simulation or wish to care about them. I will describe the complications in the subsequent slides.

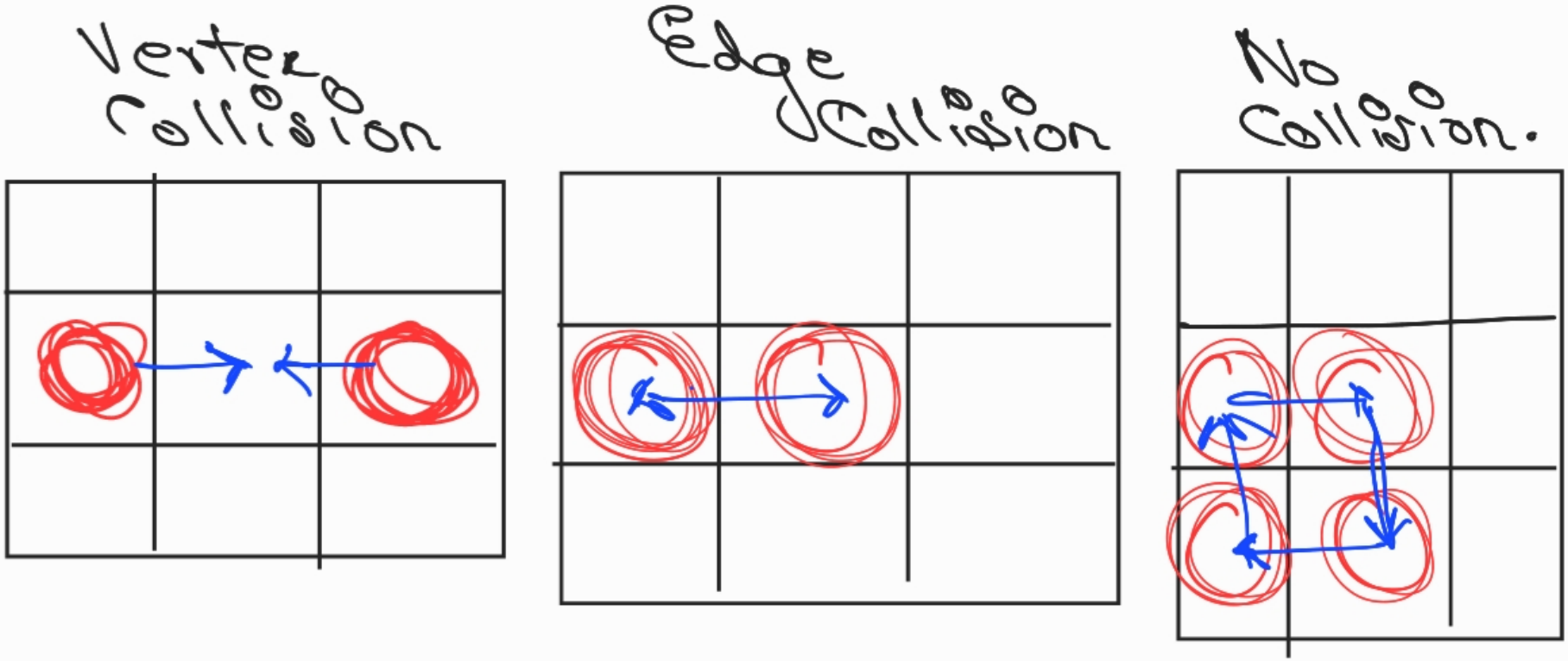
Major Questions in MRS

- If the robot is in continous domain or discrete domain?
- If the robots are labelled or unlabelled?
- If the architecture is centralized or decentralized?
- If the communication is explicit or implicit?
- If the robots are homogenous?

What happens if there is a collision?

If there are multiple robots moving in an environment, we can assign different goals to different robots but, the issue lies 'if' there is a collision, and if there is, then how should one deal with it? (I am not sure, if this will be important to our application, but I read to inform you about the constraints.)

Types of Possible Collisions



Coupled Path Planning

In a coupled path planning algorithm, the robots share the same space time whereas the space time is different in the decoupled path planning algorithms. The robot has a configuration space in Coupled path planning, and the joint space is given by the cartesian product of each robot's configuration space. The dimensionality thus, increases with the number of robots. A* algorithm in this case requires time which is atleast exponential with the search space The worst case complexity in A^* in the case will be $O(M^N)$ where N is the number of robots. It is an NP hard problem to solve to make the problem optimal, but I don't think we should focus on optimality, but rather the functioning first.
I have attached 3 papers related to path planning and MRS in the mail.

Decoupled Path Planning

Decoupled path planning is in a well informed environment, and the goals are arranged in a way such that any robot standing for a goal will not prevent other robot from reaching it's goal. The robot is always able to find a trajectory which is collision free with other robot.

Prioritization

In a decoupled path planning, Prioritization is very important as it helps you decide collision management. Prioritization is majorly done following,

- Ideal Path Length
- Planning Time.
- The clutter present in the workspace.
- The prospects of the path.

Note

I am sure, these problems are not very important if we try to do the simulation with 2 robots, but if we go for more than 2, we will have to consider these issues.

Consensus Algorithm

There is also a consensus algorithm where all the robots follow the pose and path of one single robot and decide to follow the same path, developing a swarm-like movement.

Simulation

Let us see the videos for the simulation now.

Optimizing the existing Path Planning in ROS

On a different note, I am also trying to optimize the path planning that we did in our previous meetings, namely Dijkstra, GBFS and A^* algorithms. I am trying to make a function in which we can clearly decide the motion in 4 directions and then also decide a buffer time (0.5 seconds) of stopping before making a movement left or right.

System Requirements

As we want to simulate more than one robot, the system Requirements are high computationally than simulation of a single robot.

Regarding the log file

The costmap2D is represented as a One Dimensional Array with values ranging from 255 (black) to 0-1 (white) and values in between. The number of grid cells constitute the number of values in that specific array. I will try writing a function which uses the values and declares the obstacles/not obstacle nearing the robot.

Thank you for your time.