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Assignment 0

Warehouse Mobile Robots Motion Planning

Introduction

Motion Planning in warehousing is what fascinates me. Not only do the mobile robots (MRs) have to navigate through obstacles but also avoid other MRs in its neighborhood. One might assume that since the path is fixed (somewhat) for the robots, planning is not difficult. For sure developing the Probabilistic Roadmap for such a complex task seems daunting yet exciting! Another dimension to these robots is their interaction with humans - Amazon Robotics estimated a multi-fold boost in productivity of their employees when working in a human-robot environment.

Apart from the planning side of things, to fit mechanisms that can lift anything between **1000-3000 pounds** in a 2 feet by 2.5 feet, and 18 inches high package itself is mind boggling.

Figure 1: Amazon Robotics Warehouse Robot

State of the Art

The planning algorithms for such problems can be segregated into:

1. Centralized

2. Decoupled

Centralized algorithms plan in the joint space of all robots (high level abstraction) whereas decoupled approaches only consider the space for each individual robot (like swarm robots)[1].

Overcoming the shortcomings of previous algorithms, discrete RRT ($dRRT$) [3] and its optimal variant $dRRT*$ [4] improve computational efficiency by offloading computations to offline tasks when possible and relying on implicit representations on the planning space. These algorithms have their limitations, nonetheless they provide for fast and efficient path planning.

Unmet Needs

Decoupling robots can allow for fast (faster than centralized) and efficient path planning but there is a possibility for a robot to collide with another robot. Conversely a centralized planner will ensure a collision free trajectory but at the cost of efficiency and scalability, as the number of robots increase the joint space increases exponentially.

Keeping in mind that these robots will be working in an environment with humans present, safety is paramount. Hence centralized planners are generally preferred. But as explained above centralized planners have their limitations that need to be dealt with. Working with a global and a local costmap with dynamic obstacles could be an exciting area to explore.

Discussion

Since these path planning algorithms are developed for MRs in general, the algorithm has varied use-cases. I found an interesting application of Warehouse Oriented Motion Planning for Fire Fighting Robots in this paper [2]

I would love to develop a planning strategy for MRs in constrained environments with dynamic obstales and validate its feasibility to be deployed in the real world.

References

[1] Clayton Mangette and Pratap Tokekar: Multi-Robot Coordinated Planning in Confined Environments under Kinematic Constraints

[2] Yong-tao Liu et. al: Warehouse-Oriented Optimal Path Planning for Autonomous Mobile Fire-Fighting Robots

[3] K. Solovey, O. Salzman, and D. Halperin, "Finding a needle in an exponential haystack: Discrete RRT for exploration of implicit roadmaps in multi-robot motion planning," CoRR, vol. abs/1305.2889, 2013. [Online]. Available: http://arxiv.org/abs/1305.2889

[4] R. Shome, K. Solovey, A. Dobson, D. Halperin, and K. E. Bekris, "drrt*: Scalable and informed asymptotically-optimal multi-robot motion planning," CoRR, vol. abs/1903.00994, 2019. [Online]. Available: http://arxiv.org/abs/1903.00994