WS 2017-2018, SMT, DISAL-SP109 Project Summary

Market-based Coordination for Social Robots in Highly Dynamic Environment based on CBBA

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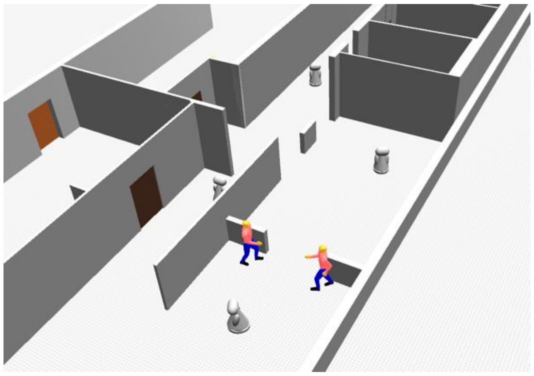
Task allocation and effective coordination among a group of robots is essential to successfully complete complex tasks while improving overall robustness and speed of an assignment. To distribute tasks to different members of a team, many algorithms already exist, both intentional and self-organized, but we are interested in a particular algorithm.

To study the problem of task allocation, I implemented the consensus-based bundle algorithm (CBBA) in order to determine its efficiency in different scenarios. The algorithm uses an intentional approach, where robots coordinate with the clear intent to accomplish a goal as a team. It uses market-based decision strategies to determine the assignment of tasks and the robots communicate on a peer-to-peer basis for conflict resolution, avoiding central points of failure while insuring the conflict-free assignment property of CBBA.

I implemented the algorithm in a new package of ROS while using previous projects that manage various aspects of the MOnarCH robot such as path planning and obstacle avoidance. The package runs with the use of Webots to visualize simulations and I varied parameters such as the starting positions, the number of robots, the tasks, the bundle of tasks size and the cost function to assess performance.



Interface of the Webots software

In the end, I have an algorithm that allows multiple robots to retrieve the same list of tasks and place bids on all tasks that represent their expected performance, using a path planning algorithm to determine the cost of completing a task. The robots are able communicate directly with each other using ROS topics to reach consensus in task allocation, and they can move to their respective tasks once their own assignment process is over.

The performance of the consensus-based bundle algorithm is quite optimistic. The algorithm reached conflict-free assignments that are at least 50% optimal given that the situational awareness is correct. However, the time taken to calculate bids is critical as it impacts communication frequency and the speed to reach consensus. The project contains two algorithms to calculate bids with varying levels of situational awareness and speed. The first algorithm predicts the robot's exact path to calculate distance traveled and is very slow to compute whereas the second, with very limited situational awareness, ignores obstacles but is fast to compute. With reduced situational awareness, bundle construction is achieved much faster, allowing frequent communications, fast responses to new information and requiring little time to reach full consensus at the expense of the 50% optimality rule. However, slow auction phases negatively impacted the speed to reach consensus, and thus, both the performance in time-critical situations and allocation correctness due to infrequent communications are poor.

The algorithm allows the possibility to add infinitely many factors affecting the bidding process and increasing situational awareness but they must be fast to compute in order to obtain satisfying results. A large bundle size is shown to increase allocation performance but also increases the time required for auctions. Finally, the algorithm is not flexible for task removal and robots can only lose tasks when outbid, which is not always optimal if tasks are added as the assignment progresses.