Navigation in Dynamic Environment

UNION COLLEGE

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CS

Introduction

Path planning has been wildly applied in the real world. However, path planning in a dynamic environment where exists moving obstacles is hard, since the path planning agent has zero knowledge about the obstacles. In order to navigate safely in a dynamic environment with low travel time, we want to develop an advanced path planning algorithm in dynamic environment.

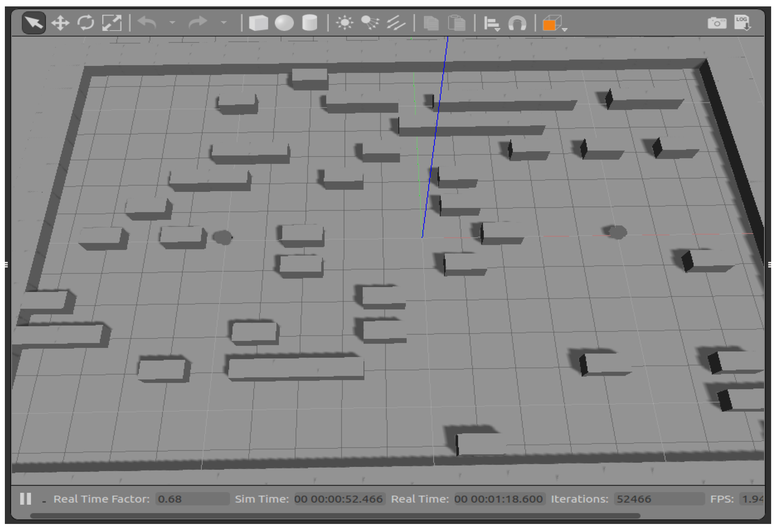


Figure 1. A dynamic world built in Gazebo[1] where a robot and a moving obstacle have been placed.

Goals

- Safe - The planned path should be collision free.
- Low time cost – The time spent on traveling along the path planned by the proposed algorithm should be minimized.

Proposed Algorithm

- Path (re-)plan
  - Use A* algorithm to (re-) plan the path
- Collision Prediction
  - Detect the moving obstacle
  - Predict whether there will be a collision
  - (Update the map and notice the path planning agent to re-plan a path if a collision is predicted)

Experiment Design

- Control variate method
  - Path re-plan
  - Collision Prediction
- Control Group: no path re-plan, no collision prediction
- Experiment Groups:
  - Group 1: Collision prediction only
  - Group 2: Re-plan only
  - Group 3: Proposed algorithm

Methods

Our experiment was carried out in a simulator. We constructed a world with some complexity in terms of topography in the simulator. Two same robots are used to represent the subject and the moving obstacle. They were placed in the world. We implemented the proposed algorithm into the subject robot. We setup 10 groups of starting and goal positions. For each group of positions, we ran the experiment 10 times. Therefore, each group of experiment has been run 100 times in total.

The Subject and the Obstacle

- The subject
  - Assigned an initial velocity, and it is constant during the experiment.
  - Always travel along the planned path
- The Obstacle
  - Assigned an initial velocity and an initial heading direction
  - Change the heading direction over time, but the velocity is constant

Evaluation

- Time for path planning
- Travel time
- Number of collisions

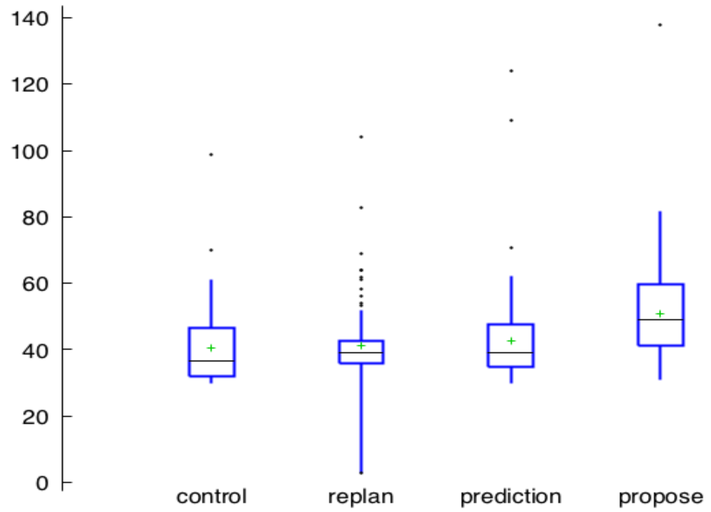
Future Work

- Multiple moving obstacles
- More advanced collision prediction algorithm

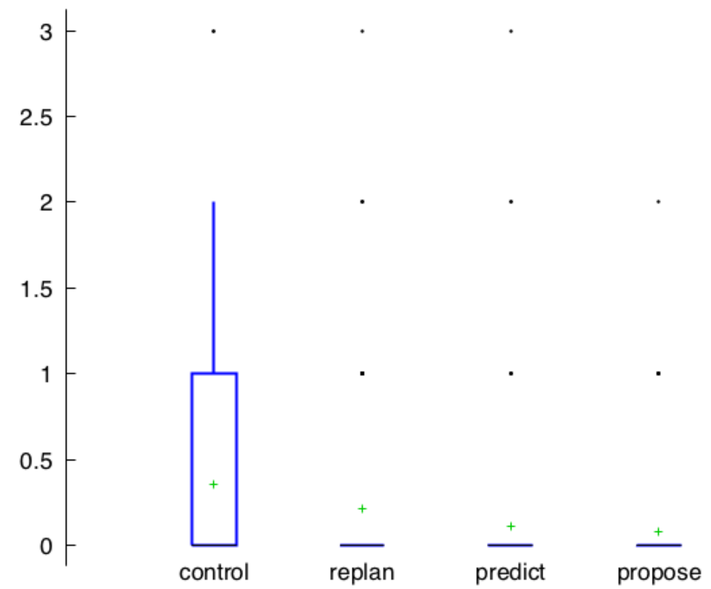
References

[1] Andrew Howard and Nate Koening. Gazebo, 2002.

Result and Conclusion



Graph 1. The distribution of travel time(in seconds) of each group



Graph 2. The distribution of number of collisions of each group

	Control	Re-plan only	Prediction Only	Proposed
Planning Time (sec)	4.10E-05	4.24E-05	4.38E-05	4.41E-05
Travel Time (Sec)	40.61907	41.25087	42.6072	50.965657
# of Collision	0.35	0.21	0.11	0.08

Table 1. The statistic summary(mean) of the data we collected

We did standard t-tests by setting control group as dependent variable, and setting the non-control groups as regressors. The underlined data are statistically significant.