Multiple Robots Motion Planning with RRT

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Two Solutions

1. Motion planners independently find a valid path for each single robot.
   - Predefined protocol is required to deal with the case when robots are on other robots' way.
   - Motion planners only need to deal with two-dimensional configurations space.
   - The protocol is ad hoc.

2. Motion planners consider the collision among robots when finding valid path
   - The dimensionality of manifolds increases proportionally to the number of the robots
   - Generalized solution

Concepts

```
Vertex{
    number; // the number of robots
    parent_index; // its parent's index
    positions; // the positions of all robots
}
```

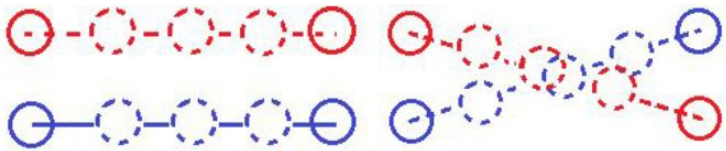
```
Edge{
    Vertex start;
    Vertex end;
}
```

```
Tree{
    vector<Vertex> vertexes;
}
```

It's unnecessary to add Edge into Tree since each Vertex in Tree contains the index (in the vector) of its parent. These indices can replace the Edge to describe the Tree.

Collision Checking

1. Sampled Vertex from configuration space first needs to be converted into workspace, and then be checked whether it is collided with the obstacles in the map. That means every position in the Vertex is required to be checked.
2. The self-collision checking is to check the collision among the robots along the Edge in every step_size



RRT

1. Build Trees
2. Extend Trees
3. Merge Trees
4. Get Path

Sampling Strategies

- Selecting a Vertex uniformly at random from configuration space--uniform one
- Building a sampling function that alternates between uniform samples and samples biased toward regions that contain the initial or goal Vertex--bias one

Results:

- Simple Map: bias one is much more efficient
- Complex Map: uniform one is a little more efficient

Results

1. Simple Map

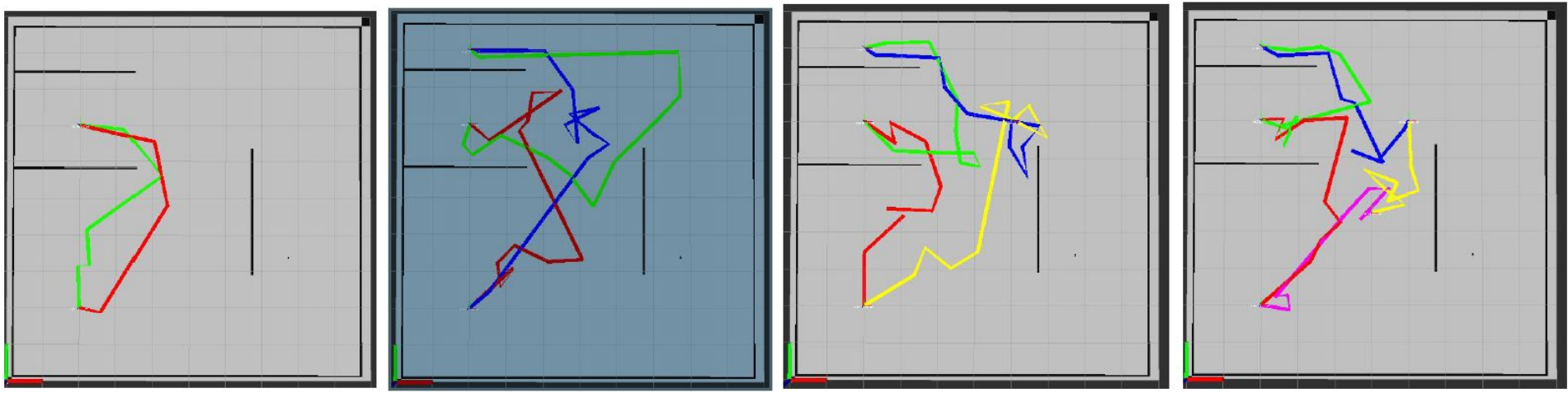


Figure 2

Figure2. From left to right, the number of the robots varies from 2 to 5. And the convergence time are 0.0050, 0.0305, 0.0309 0.0350 seconds.

Results

2. Complex Map

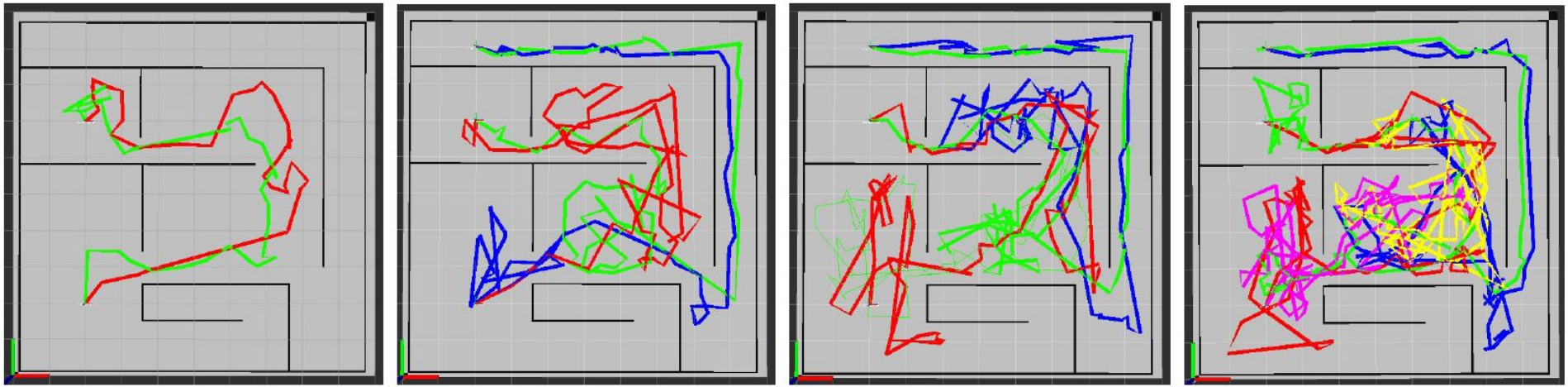


Figure 3

Figure 3. From left to right, the number of the robots varies from 2 to 5. And the convergence time are 0.2115, 2.6954, 23.944, 326.27 seconds.

Results

3. Complex and Large Map

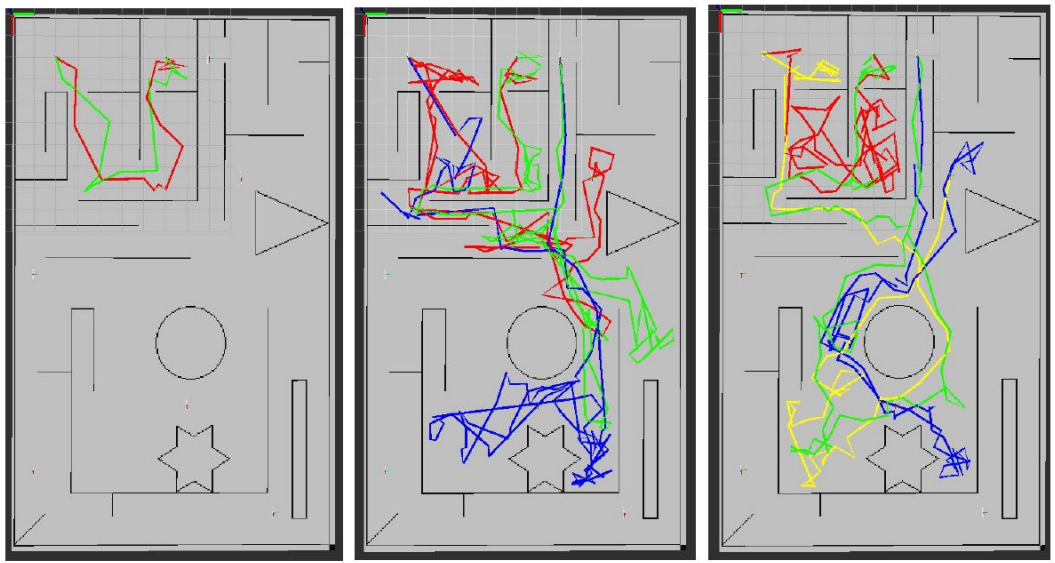


Figure 4

Figure 4. From left to right, the number of the robots varies from 2 to 4. And the convergence time are 0.8329, 134.97, 62.29 seconds. This map is expanded based on the map in figure 3. They have almost the same complexity, but RRT did better with smaller configuration space.