Multi-Agent RRT*: Sampling-based Cooperative Pathfinding

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Problem

Find an optimal set of conflict-free trajectories for n mobile agents.

Solution is a path in joint state space of all n agents:

\[ J = C_1 \times \ldots \times C_n \]

where \( C_i \) is d-dimensional configuration space of agent \( i \).

Existing methods use A* to search for a path in \( J \). However, in many cases A* exhibits poor performance in \( J \), which is high-dimensional space that contains large basins of attraction to local minima. Due to the basin filling behaviour of A*, it takes long time to escape such regions during the search.

Solution

Use RRT* to search for a path in \( J \)

RRT* is a recently proposed (Karaman 2011) anytime variant of rapidly-exploring random trees (RRT), a sampling-based algorithm widely used for motion planning in high-dimensional robotic spaces.

Graph RRT* -- To allow fair comparison with the state-of-the-art anytime algorithm for cooperative pathfinding (Standley 2011), which works on graphs, we adapted RRT* to also plan on graphs.

Experiment

We generated 6000 problem instances:
- agents' motions discretized as a 4-grid
- grid sizes: 10x10, 30x30, 50x50, 70x70, 90x90
- no of agents: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
- for each combination of the grid size and the number of agents, we generated 120 instances with random obstacles (obstructing 10% of space) and random start and destination positions for each agent
- each algorithm allowed max 5s to find a solution

Results

JA = A* in \( J \)
OA = Optimal Anytime (Standley 2011)
MA-RRT* = RRT* in \( J \)
isMA-RRT* = RRT* in \( J \) with sampling biased towards single-agent optimal paths

Performance

Scalability

% of instances solved / agents

% of instances solved / grid size

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References