Path Planning With Kinematic Constraints For Robot Groups

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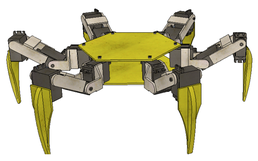
Abstract: Path planning for multiple robots is well studied in the AI and robotics communities. For a given discretized environment, robots need to find collision-free paths to a set of specified goal locations. Robots can be fully anonymous, non-anonymous, or organized in groups. Although powerful solvers for this abstract problem exist, they make simplifying assumptions by ignoring kinematic constraints, making it difficult to use the resulting plans on actual robots. We present a solution which takes kinematic constraints, such as maximum velocities, into account, while guaranteeing a user-specified minimum safety distance between robots. We demonstrate our approach in simulation and on real robots in 2D and 3D environments.

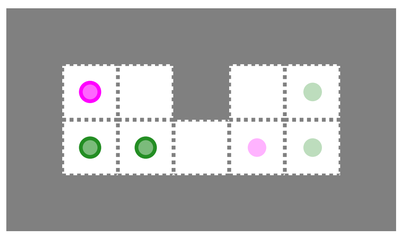
I Robotics and AI

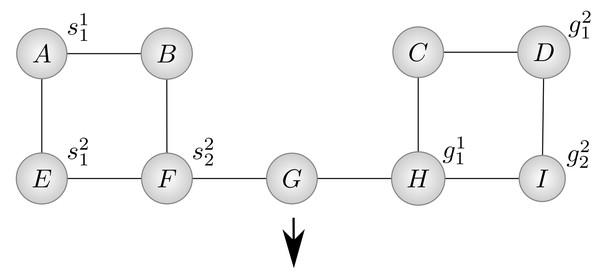
- Robots VS Agents



- Dynamics
- Uncertainty
- Simplistic
- Theoretical Guarantees

II Target Allocation and Path Finding (TAPF)

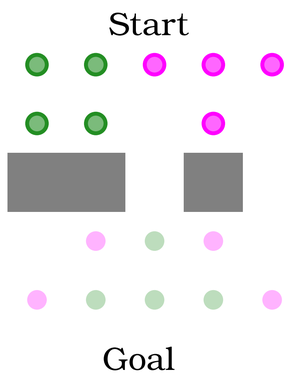




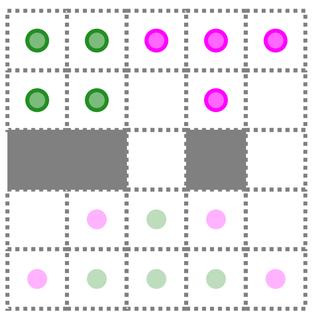
Agent	$t=1$	$t=2$	$t=3$	$t=4$
1	$A \to B$	$B \to F$	$F \to G$	$G \to H$
2	$E \to F$	$F \to G$	$G \to H$	$H \to I$
3	$F \to G$	$G \to H$	$H \to C$	$C \to D$

- Unit-Length Edges
- Discrete Timesteps and Environment
- Solvable with (Sub)Optimality Guarantee

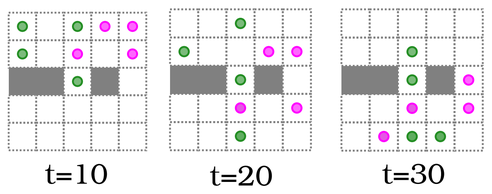
III Approach



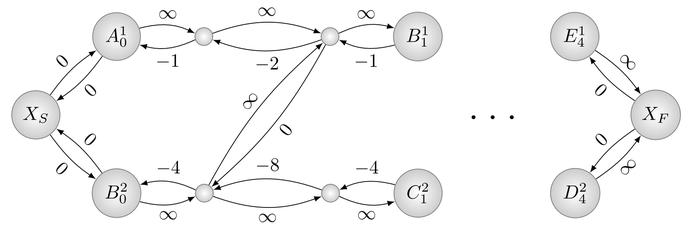
Discretize in Time and Space



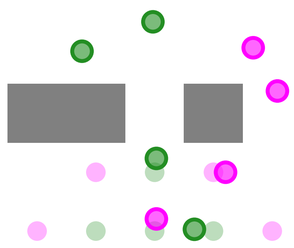
AI Solver (heuristic)



Account for Kinematic Constraints using Simple Temporal Network (STN)

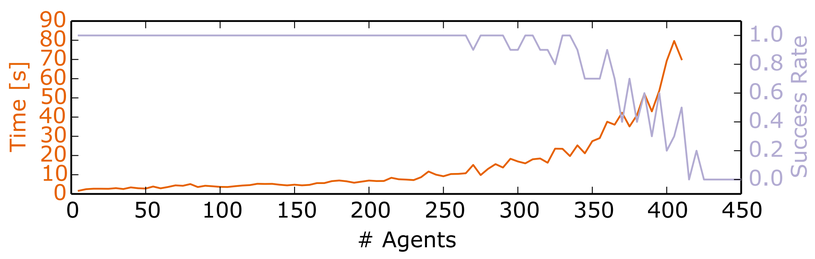


STN Solver (polynomial)

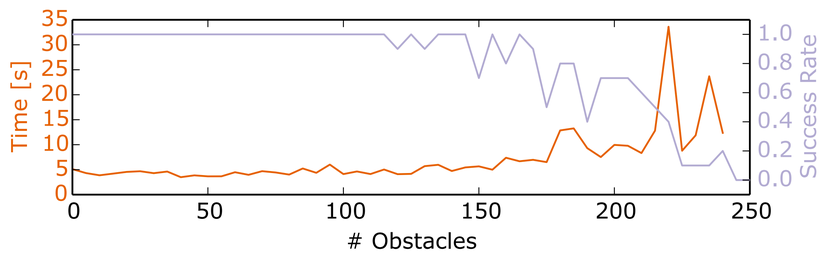


- Continuous Solution (in time and space)
- Guaranteed Safety Distance
- Extensions for Non-Holonomic robots
- Supports 2D and 3D Environments

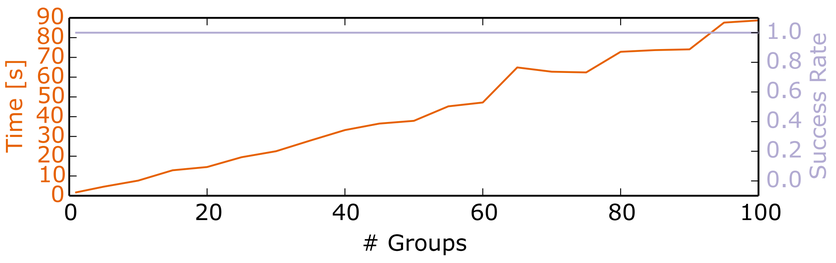
IV Scalability (3D TAPF Solver)



- 5 groups, no obstacles



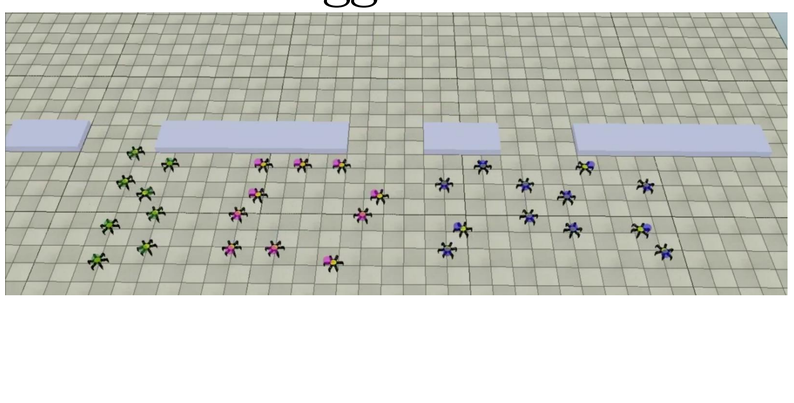
- 100 agents, no obstacles



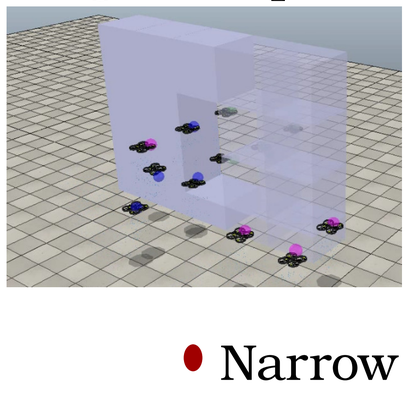
- 5 groups, 100 agents

V Validation

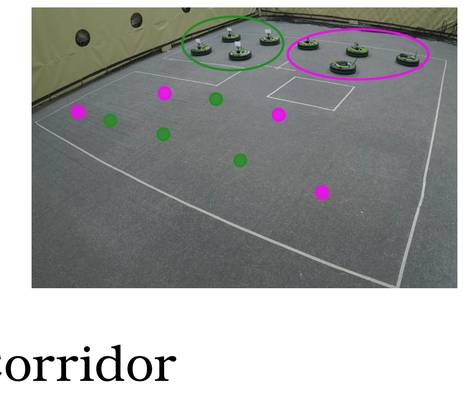
- 6-Legged Robots



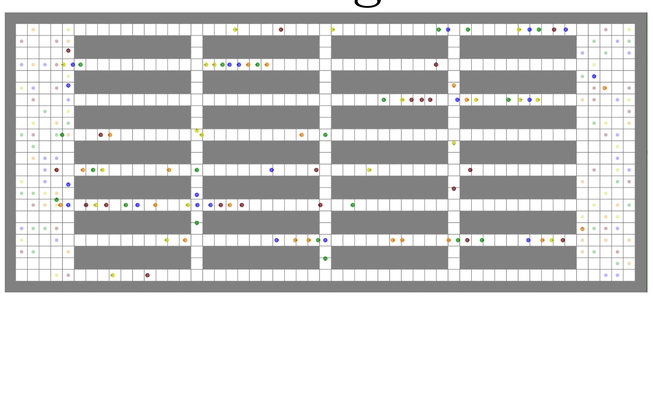
- Quadcopter



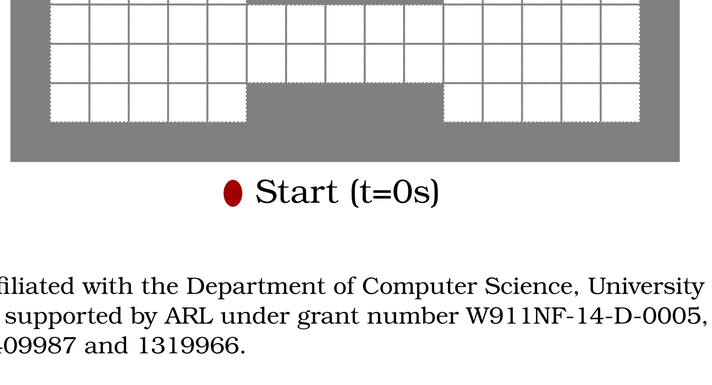
- 8 iRobot Create2



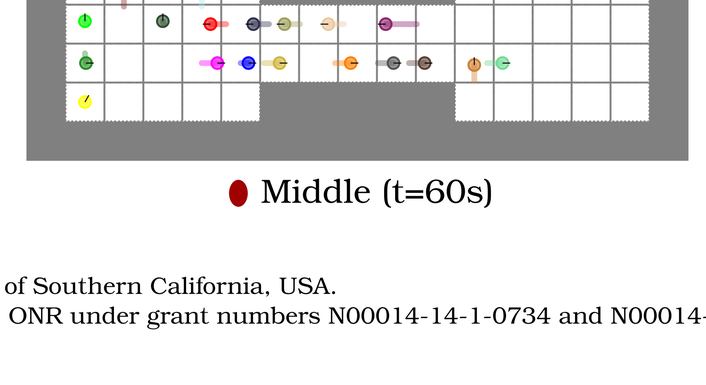
- 100 Agents



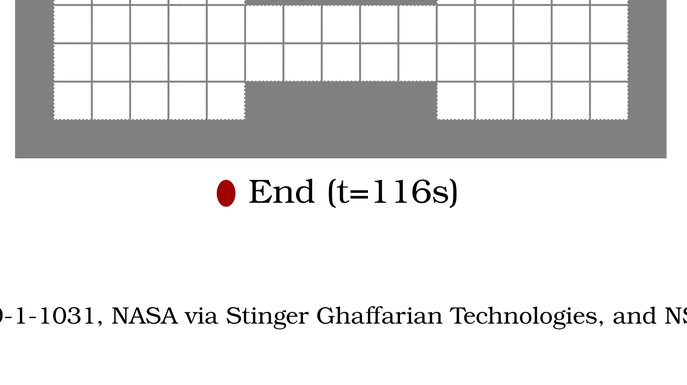
- Narrow Corridor



- Start (t=0s)



- Middle (t=60s)



- End (t=116s)

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