WePO2S-16.6

Safe and Distributed Multi-Agent Motion Planning under Minimum Speed Constraints

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1. Summary

- We propose a **multi-agent motion planning** algorithm for a team of robots **without braking capabilities**.
- The proposed algorithm is **safe**, **persistently feasible**, **distributed**, and runs in **real-time**.
- We validate the method through **simulation experiments**.

2. Safety Guarantee using Loops

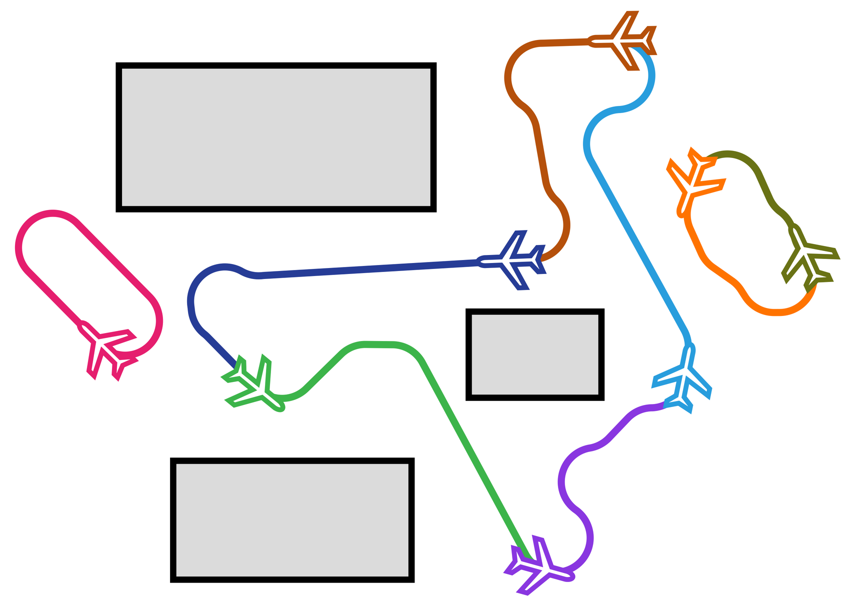


Fig 1. An example of a collision-free loop structure.

- The agents can permanently stay safe within a **collision-free loop structure**.
- The agents are always required to follow an agent through a collision-free leader-pursuing trajectory.

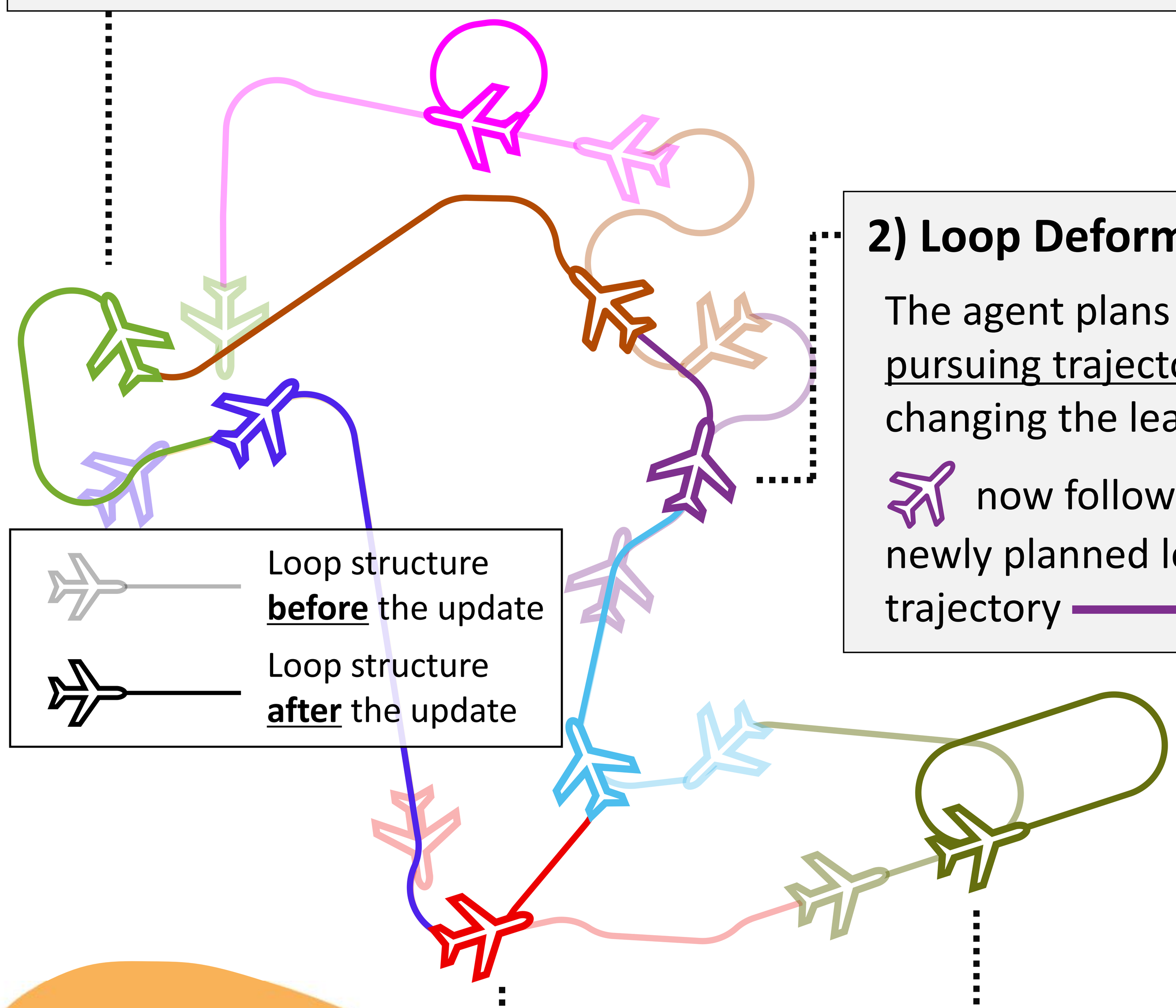
3. Loop-Preserving Trajectory Manipulations

- The agents move only by committing actions that preserve the collision-free loop structure.
- The agents generate loop-preserving action candidates in a distributed manner. Then, the best set of actions are chosen through the action deconfliction step.
- We introduce three different types of loop-preserving trajectory manipulations.

1) Hold Trajectory

The agent continues to follow its leader along its original trajectory.

continues to follow its leader along .



2) Loop Deformation

The agent plans a new leader-pursuing trajectory, without changing the leader.

now follows along the newly planned leader-pursuing trajectory .

3) Transposition

Two agents swap leaders.

4. Planning Algorithm

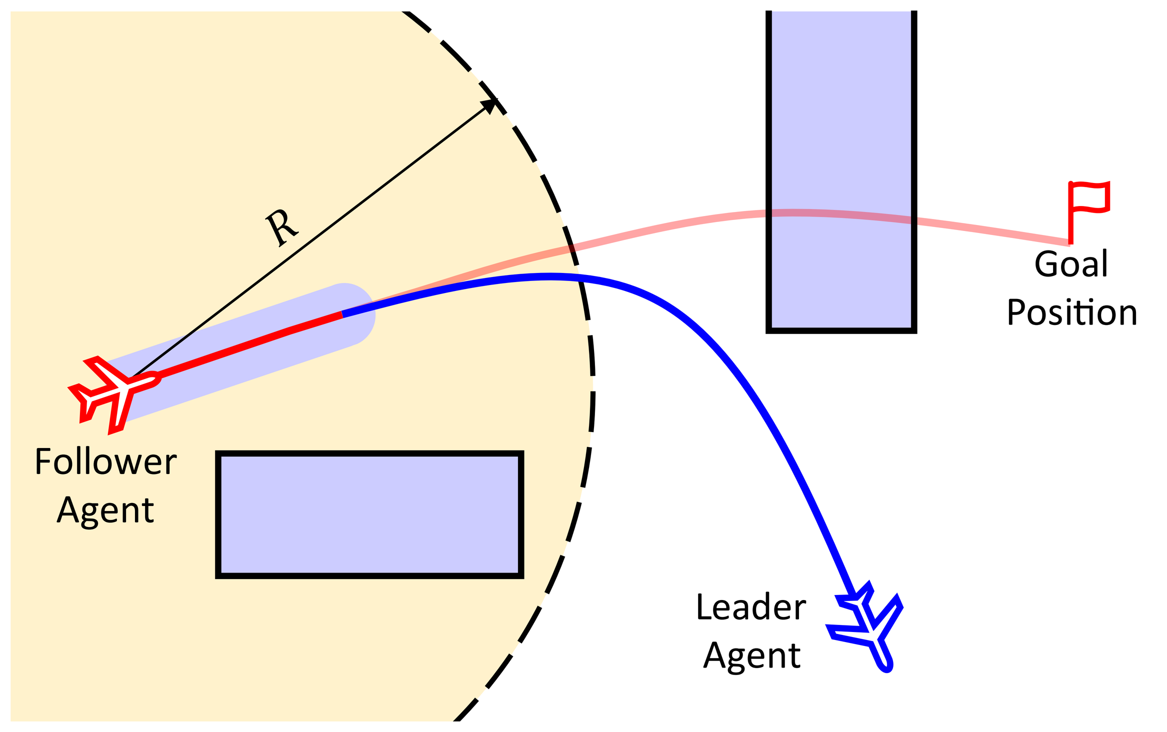


Fig 2. A brief illustration of the trajectory generation procedure.

1. Plan trajectory to the goal position, consider only static obstacles within radius R .
2. Complete the leader-pursuing trajectory starting from the beginning portion of the goal-pursuing trajectory. Consider all static obstacles and trajectory occupancies .

5. Simulation Results

- Navigation through obstacle-cluttered space

The agents move across square-shaped obstacles .

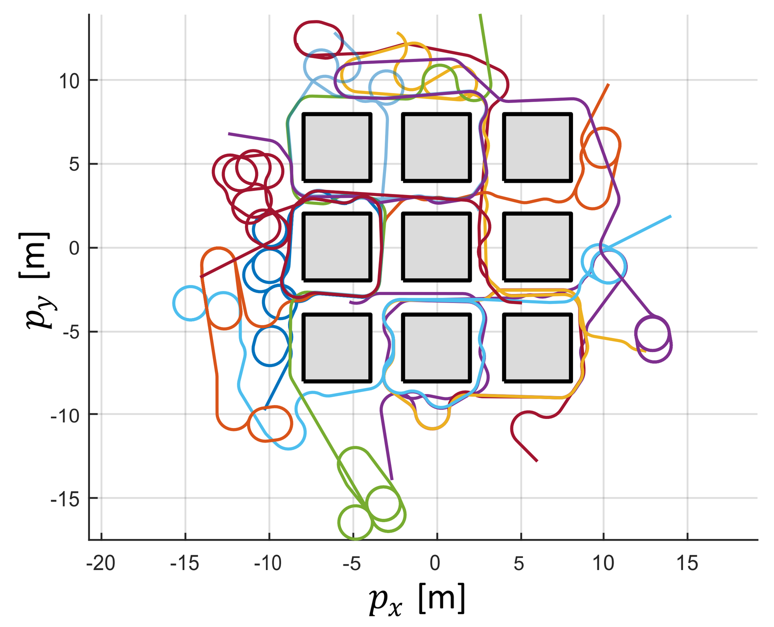
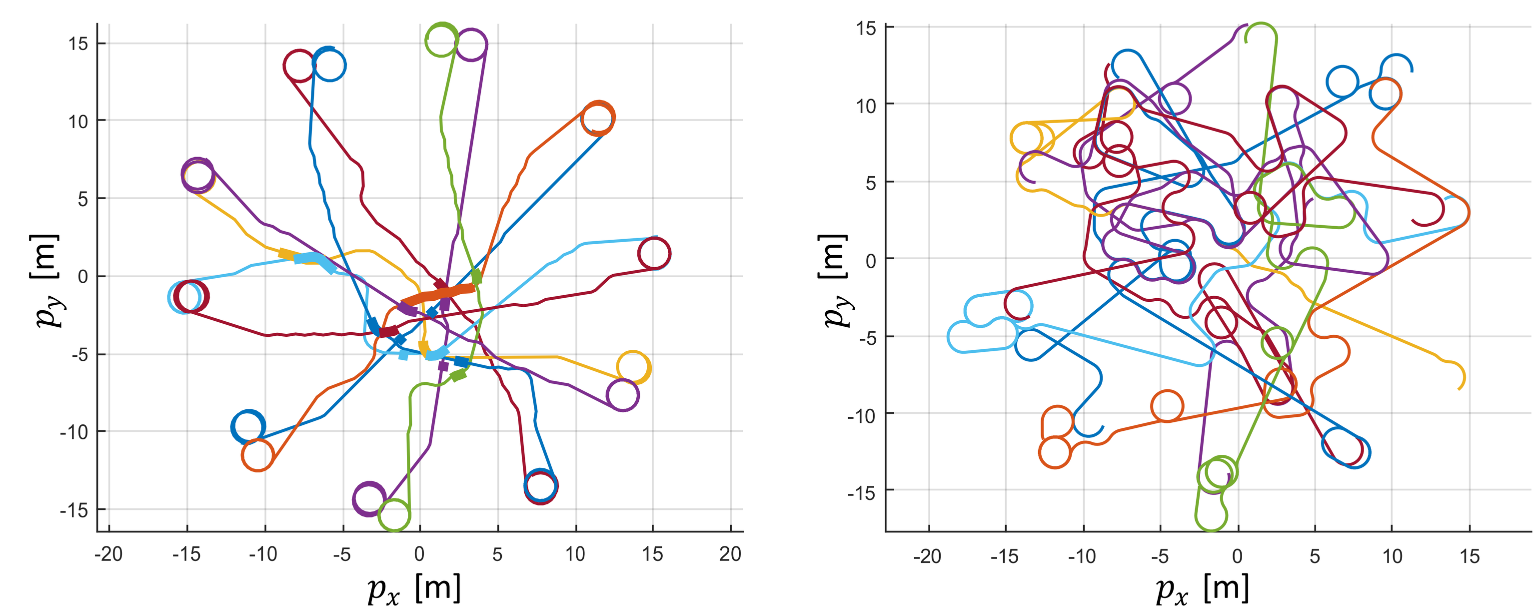


Fig 3. Simulation result. The proposed method does not permit any collision.

Simulation Settings
- 10 agents
- Dubins car model with fixed speed
- Real-time trajectory update every second
- Only one agent at a time can pass between the obstacles.

- Comparison with CSORCA [1]

The agents move to their antipodal positions.



a) CSORCA [1] b) Proposed

Fig 4. Comparison scenario. The thick portions of the trajectories denote where collisions occurred. The proposed method does not permit any collision.

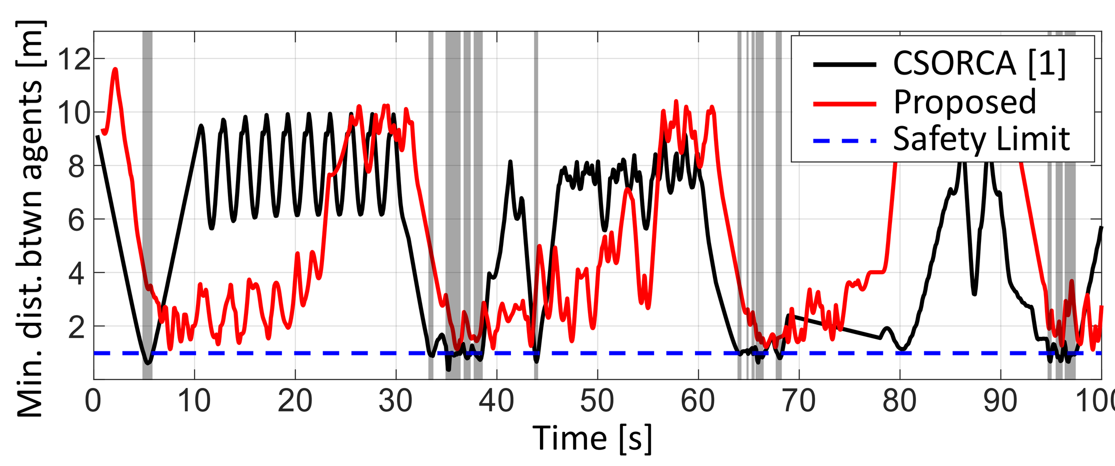


Fig 5. Minimum among the inter-agent distances in the comparison experiment, plotted as a function of time.

[1] N. Durand, "Constant speed optimal reciprocal collision avoidance," *Transportation research part C: emerging technologies*, vol. 96, pp. 366–379, 2018.