Novel Algorithmic Techniques for Drone Flight Planning on a Large Scale

PIs: Sven Koenig and Nora Ayanian, University of Southern California

We build on multi-agent path finding (MAPF) techniques to develop a concept for a robot coordination system that can find collision-free paths for a large number drones of different sizes and capabilities. We use a hierarchical approach, combining centralized and local coordination, to scale to thousands of robots. Additional research integrates several speed-up techniques into the system and generalizes its functionality.

Challenge:

1. Develop a concept for a robot coordination system that can find collision-free paths for a large number drones of different sizes and capabilities
2. Develop a hierarchical approach, combining centralized and local coordination, to scale to thousands of robots

Key innovations:

1. MAPFAST, a deep learning-based MAPF algorithm selector, improves state-of-the art MAPF algorithm selectors by adding single-agent shortest paths to the instance encoding
2. Mutex propagation applied to MAPF improves a state-of-the-art MAPF algorithm by providing stronger constraints for conflict resolution and providing it with the ability to identify and reason with symmetries automatically. This research received an Outstanding Student Paper Award at the International Conference on Automated Planning and Scheduling in 2020
3. Large neighborhood search applied to MAPF improves state-of-the-art anytime MAPF algorithms with respect to scalability, runtime to the first MAPF plan, and speed of improving the MAPF plans

Broader Impacts on Society:

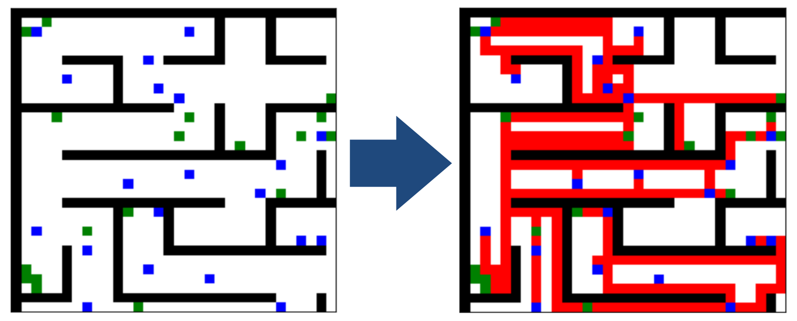
Application impact results from expected high-density drone traffic in the near future, for example on construction sites on a small scale and drone-based last-mile delivery on a large scale. Applications are not restricted to drones and include multi-robot navigation in general, including on rail networks.
We guest co-edited a special AIJ issue on Ethics for Autonomous Systems.

Scientific Impact:

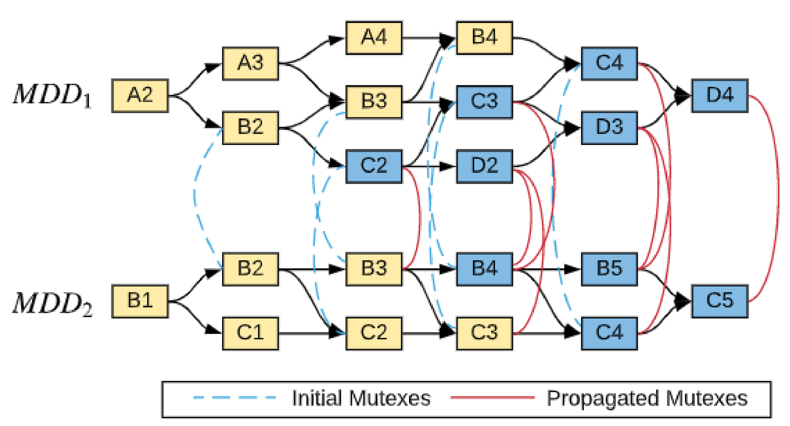
Scientific impact results from the development of a new system concept that allow one to scale up a promising emerging class of new heuristic search algorithms for collision-free navigation to a much larger number of robots than possible before.

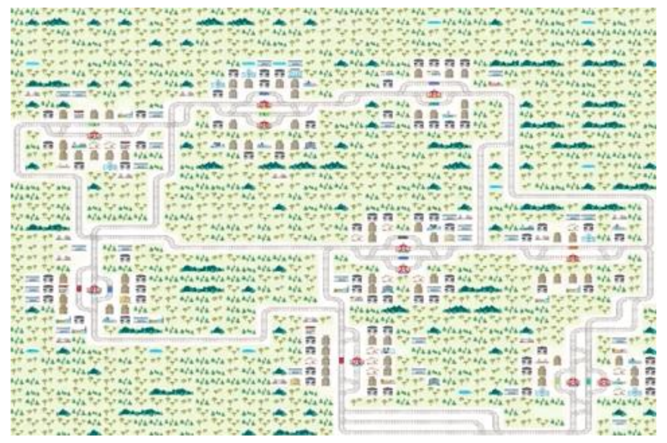
Achievements:

Since our robot lab was operational only to a limited extent during COVID-19, we applied some of our techniques to a railway scheduling contest. A team of three Ph.D. students from USC and one Ph.D. student from Monash University (advised by PI Koenig and others) outperformed 700 participants from 51 countries in both rounds of the NeurIPS-20 Flatland competition, which was held in partnership with German, Swiss, and French railway companies.



Start, goal, and obstacle locations → Single-agent shortest paths





Broader Impacts on Education:

1. Giving demonstrations in the Viterbi Robotics Open House
2. Offering MAPF summer projects to two high school students
3. Co-organizing an International Workshop on Education in AI K-12 in 2019.
4. Giving talks at doctoral consortia and writing an article with advice for graduate students in AI