SYNDROME: SYNergetic DROne Delivery Network in MEtropolis

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Project URL: http://naira.mechse.illinois.edu/research-outline/#synergetic-drone-delivery-network-in-metropolis-syndrome

Motivation

The rapid growth of e-commerce demands has resulted in increased traffic of delivery trucks while slowing down the pace of delivery operations.

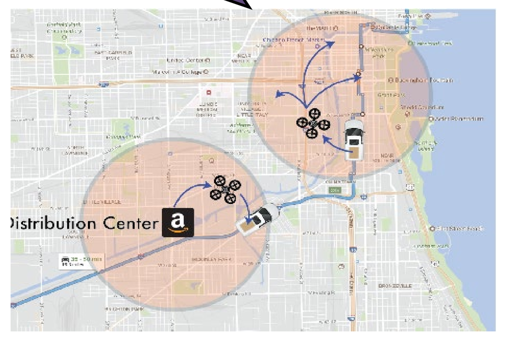
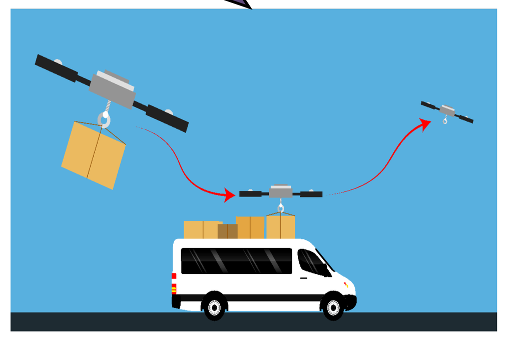


The proposed delivery network is comprised of **autonomous flying robots** and **existing transport networks** (public and private ground vehicles).

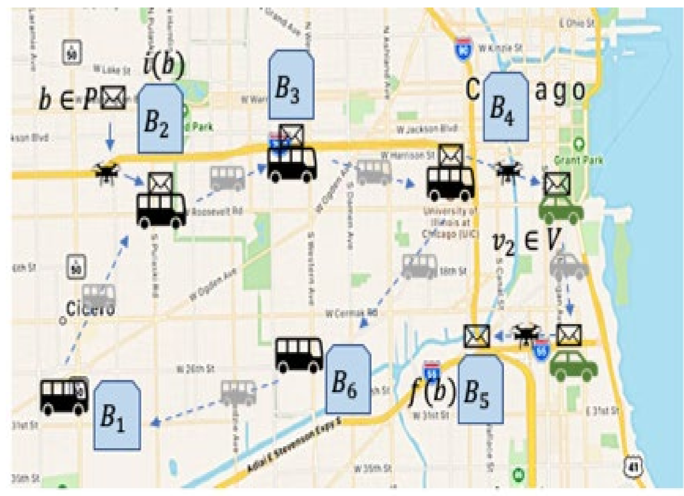
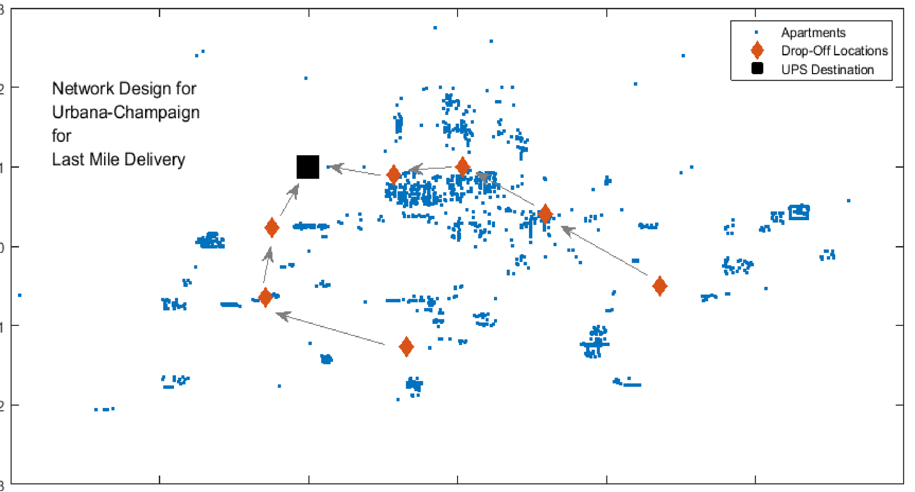
Dispatch a package over the delivery network

Use space on a ground vehicle's roof

Fly last-mile to the target position


Optimizing Commodity Flow[1]

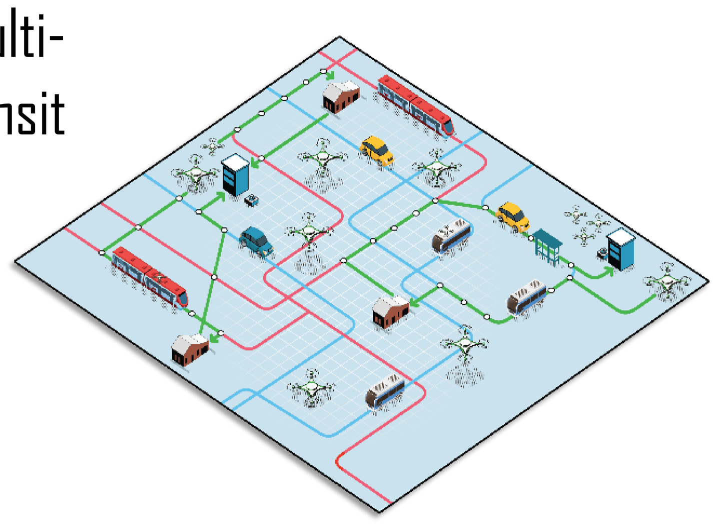



Addressing the **network design problem** in Last Mile Delivery. Network design requires allocating pick-up/drop-off facilities and determining vehicle routes. Optimization is done via **maximum entropy principle.**

Large Scale Multi-Drone Delivery[2]

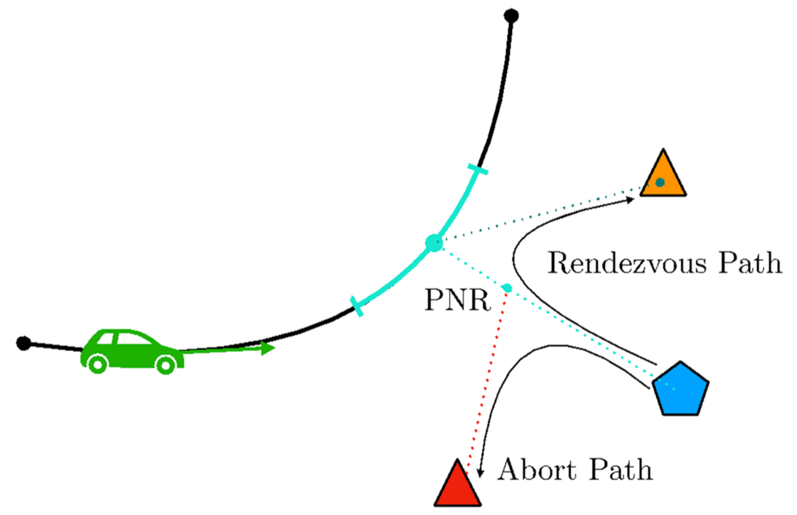
An efficient and **scalable** framework for multi-drone delivery utilizing **existing** public transit network over large urban areas.

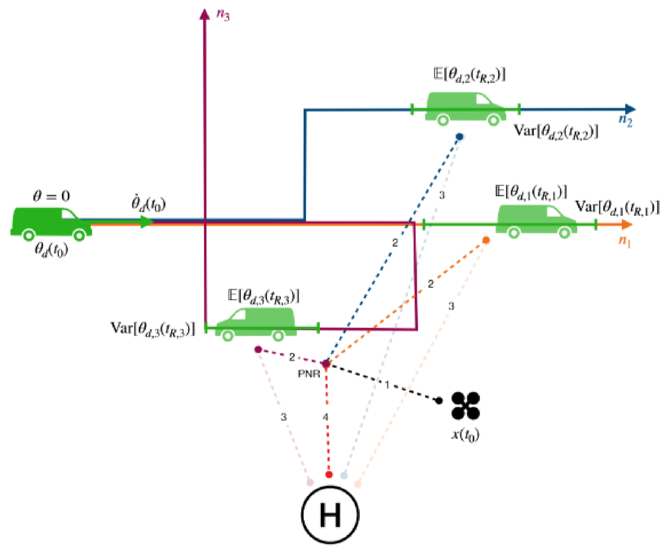
- Assigns drone routes to deliver packages while **avoiding** inter-drone conflicts.
- **Minimizes** overall delivery time.



Risk Sensitive Rendezvous[3]

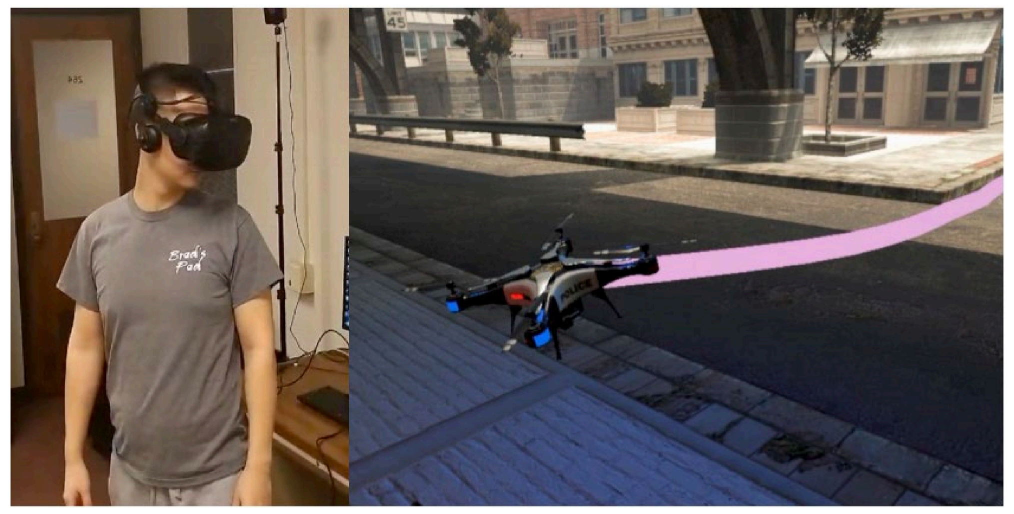
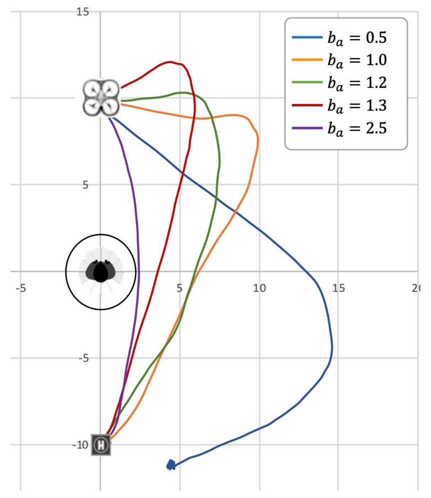
Driver behavior uncertainty and limited battery life pose a risk during rendezvous.





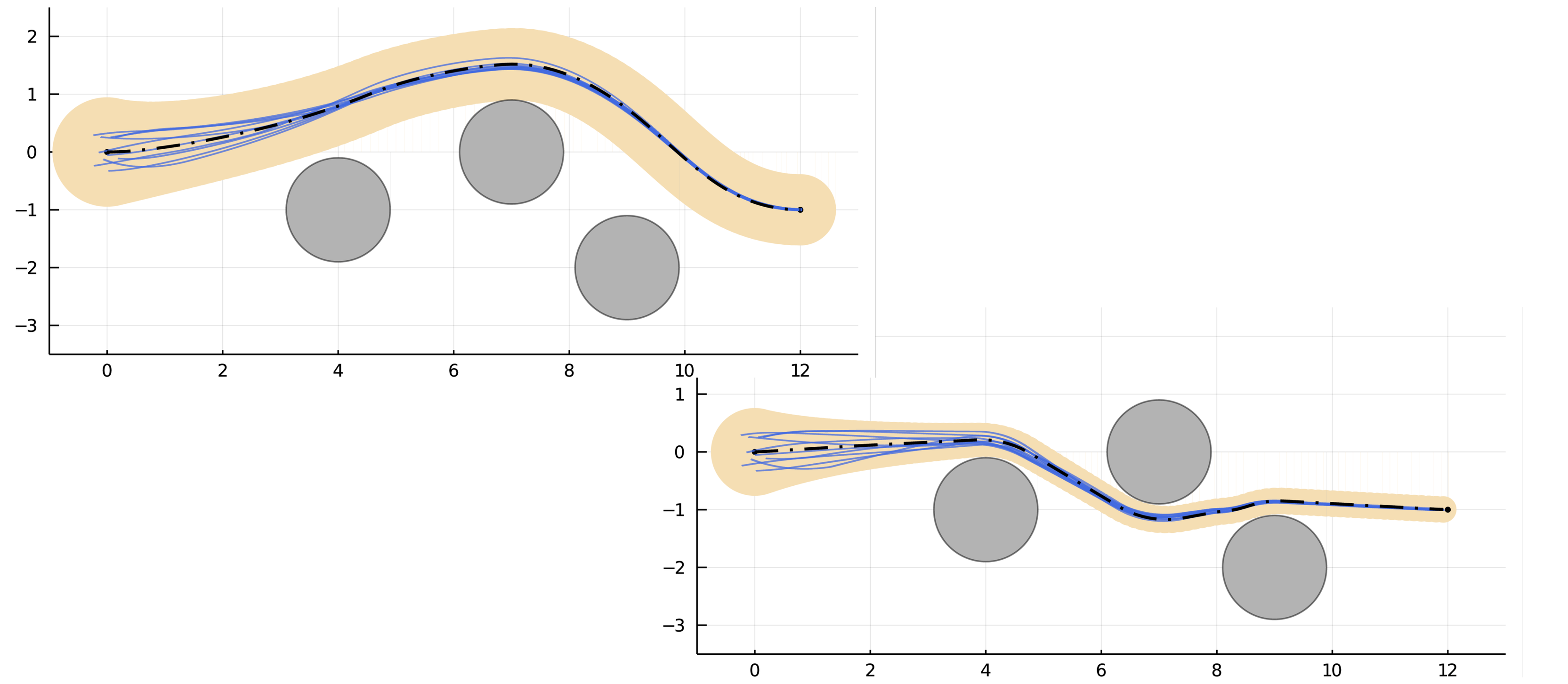
- Considers drone-vehicle rendezvous over **multiple** possible paths.
- **Robust** heuristics that combine Bayesian learning and MPC.

Socially-Aware Motion Planning[4]

- On-line motion planning using **MPPI** based on physiological data collected in a VR environment.
- Explicitly considers **humans' safety perception** and environmental changes in **real-time**.

Safe Learning Based Control[5]



- Guaranteed safety **decoupled** from the state of learning.
- Certifies **safe tubes** around desired trajectories using **contraction theory** and **robust adaptive controllers**.

Outreach

PI Hovakimyan visit to Montessori school of C-U to showcase robotics to elementary-age students.

[1] A. Srivastava and S. M. Salapaka. "Simultaneous Facility Location and Path Optimization in Static and Dynamic Networks." IEEE Transactions on Control of Network Systems7.4 (2020): 1700-1711

[2] S. Choudhury, K. Solovey, M. Kochenderfer and M. Pavone, "Efficient Large-Scale Multi-Drone Delivery Using Transit Networks," ICRA 2020: 4543-4550.

[3] G. Haberfeld, A. Gahlawat, and N. Hovakimyan, "Safe Sampling-Based Air-Ground Rendezvous Algorithm for Complex Urban Environments," in preparation for ICUAS 2021.

[4] H. J. Yoon, P. Zhao, C. Tao, C. Widdowson, R. F. Wang, N. Hovakimyan, and E. Theodorou, "Socially Aware Motion Planning for a Flying Robot with Model Predictive Path Integral Control," ICRA 2019 Workshop.

[5] A. Gahlawat, A. Lakshmanan, L. Song, A. Patterson, Z. Wu, N. Hovakimyan, and E. Theodorou, "S2LC: Safe Simultaneous Learning and Control," under review at L4DC 2021

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