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

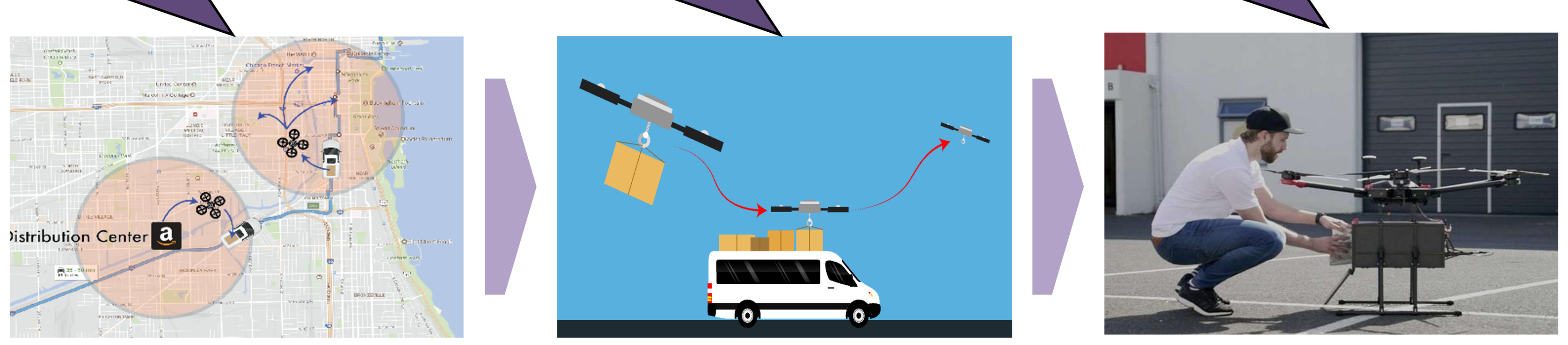
The rapid growth of e-commerce demands has resulted in increased traffic of delivery trucks while **slowing down the pace** of delivery operations.

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

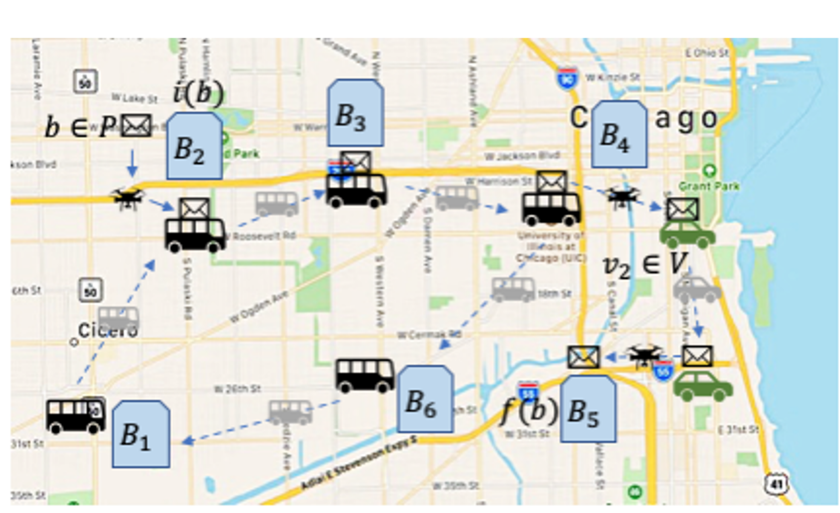
Dispatch a package over the delivery network

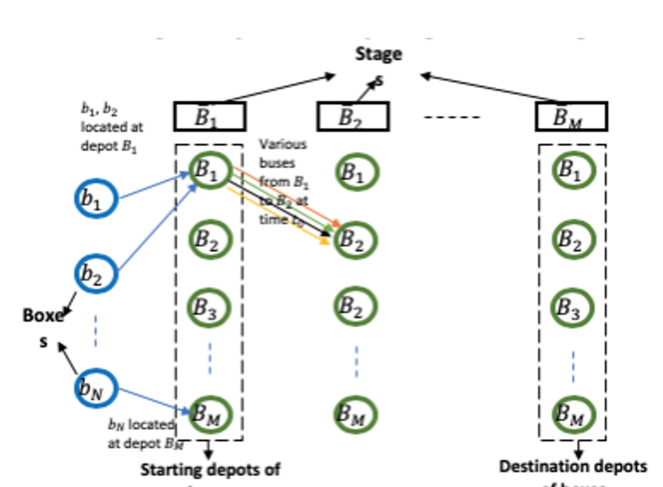
Use space on a ground vehicle's roof

Fly last-mile to the target position



Dynamic Commodity Flow[1]

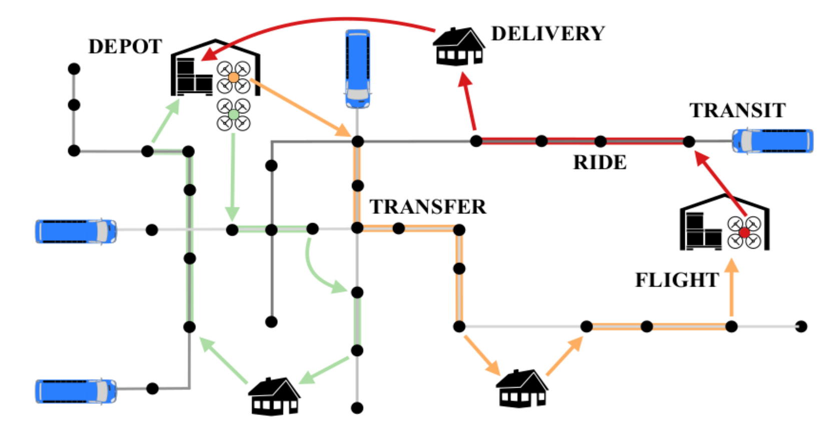




Stage-wise modelling of LMDP and an Entropy-based approach flexible in terms of adding various capacity constraints while keeping the computational feasibility.

Large Scale Multi-Drone Delivery[2]

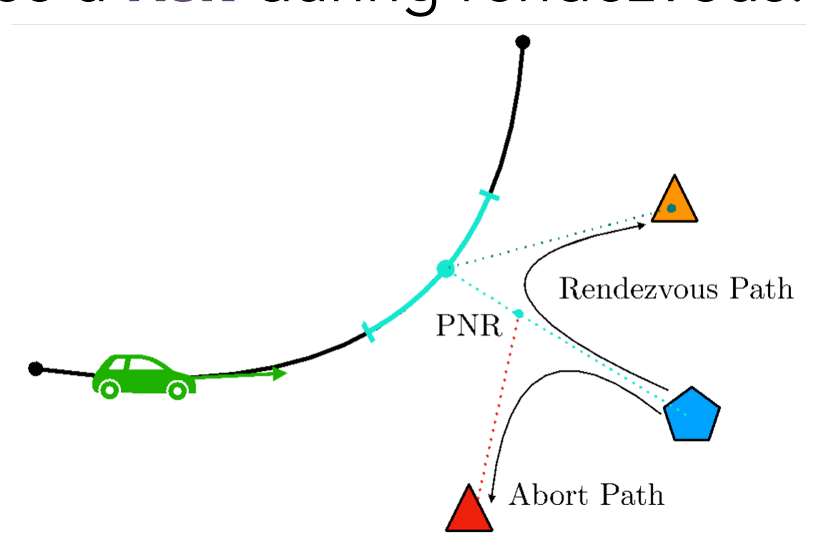
An efficient framework that is **scalable** to hundreds of drones over **complex transportation networks**.



- **2.5x** range increase in San-Francisco.
- **4.5x** range increase in Washington DC.

Risk Sensitive Rendezvous[3]

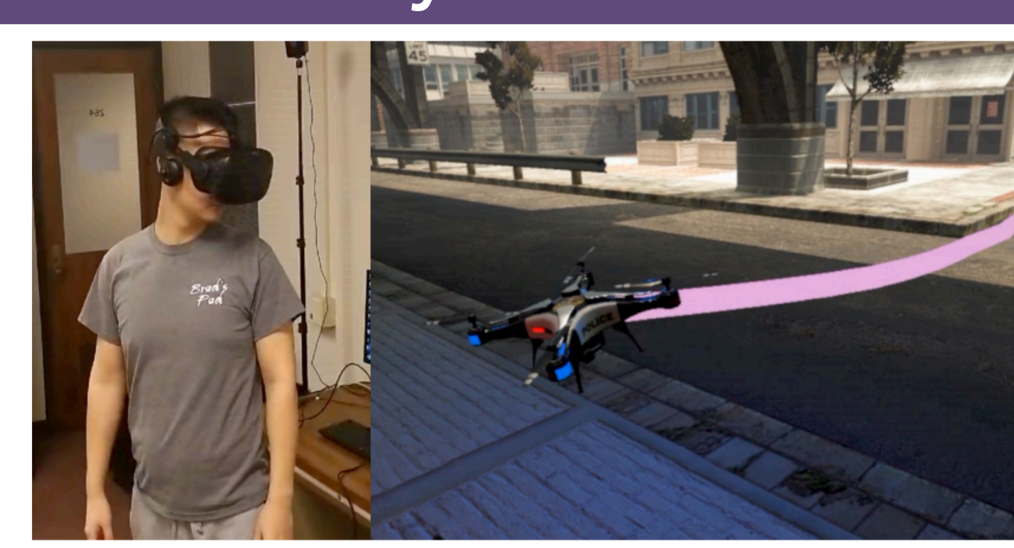
Driver behavior uncertainty and limited battery life pose a **risk** during rendezvous.

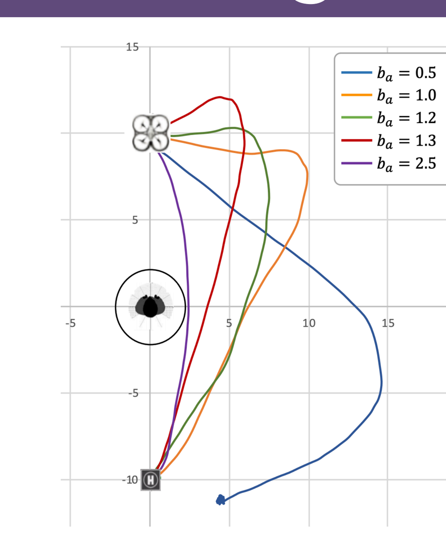


Rendezvous Path Risk: Uncertainty in driver position in the future.
Abort Path Risk: Uncertainty in battery level at the final location.

- A model predictive control algorithm that maximizes the decision time via a **Point-of-No-Return** (PNR).
- **Risk estimate** using Bayesian linear regression.

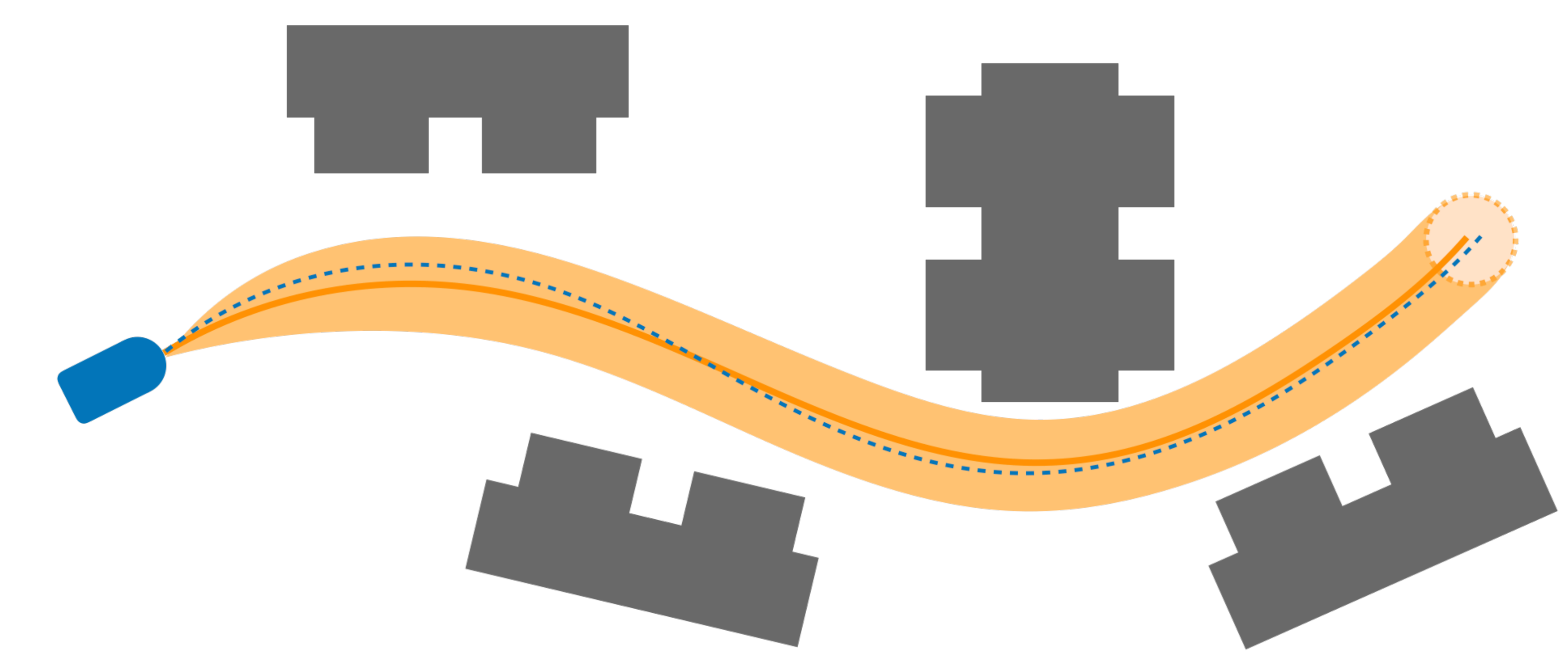
Socially-Aware Motion Planning[4]





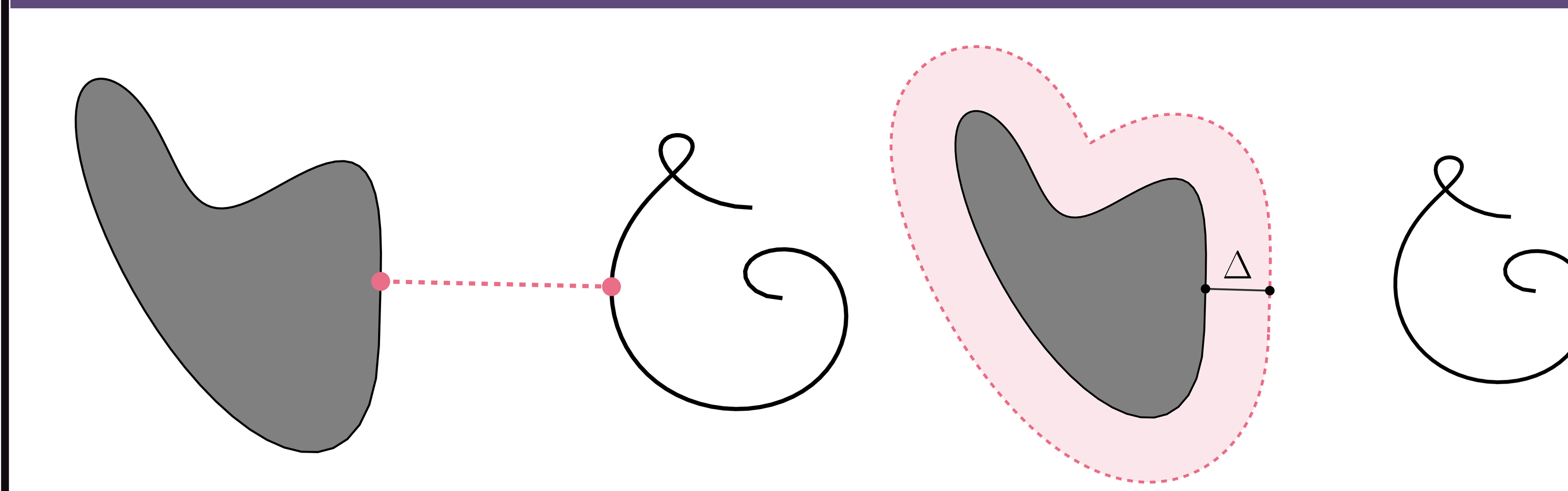
- On-line motion planning using **MPPI** based on physiological data collected in a VR environment.
- Explicitly considers **humans' safety perception** and environmental changes in real-time.

Safe Feedback Motion Planning[5]



- Enables robots to operate in the presence of **modelling inaccuracies** and **external disturbances**.
- Certifies **safe tubes** that can be made arbitrarily small around desired trajectories using **contraction theory** and **robust adaptive controllers**.

Fast Collision Detection[6]



- Evaluates the **proximity of candidate trajectories** generated by a motion planner to nearby obstacles.
- Performs computations for a **large class of parametric curves** without any approximation.

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[2] S. Choudhury, K. Solovey, and M. Pavone, "Efficient Large-Scale Multi-Drone Delivery Using Transit Networks," ICRA 2020.
[3] G. B. Haberfeld, A. Gahlawat, and N. Hovakimyan, "Risk Sensitive Rendezvous Algorithm for Heterogeneous Agents in Urban Environments," WAFR 2020 (submitted).
[4] H. J. Yoon, P. Zhao, C. Tao, R. 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. Lakshmanan, A. Gahlawat, and N. Hovakimyan, "Robust Adaptive Feedback Motion Planning with Safety Gurantees," in preparation for CDC 2020.
[6] A. Lakshmanan, A. Patterson, V. Cichella, and N. Hovakimyan, "Proximity Queries for Absolutely Continuous Parametric Curves," RSS 2019.

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