Architecting Co-existence: Scalable Integration of Autonomy in Shared Spaces

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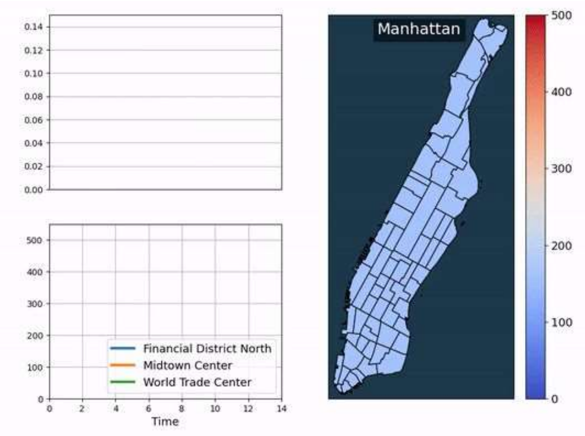
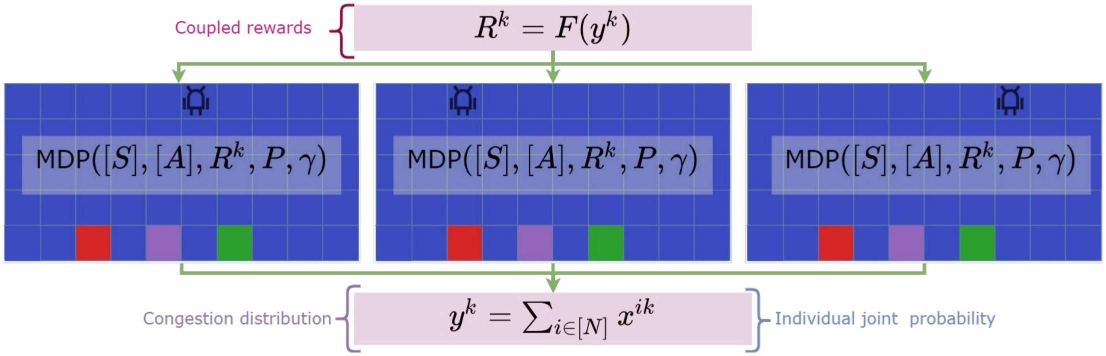
Autonomous Controls Lab

Incentivizing Preferential Group Behavior



Competitive urban transportation
- **Players**: ride-share drivers
- **Actions**: wait for a rider or go to neighboring zone
- **Objectives**: earn maximum profit
- **Random factor**: zone-based stochastic ride demand with unknown destinations

We can iteratively find the minimum toll needed to ensure any linear constraint on the competitive population.



Research objective

Enable autonomous vehicles to safely co-exist at scale in competitive and human-interactive environments

Tremendous advances in autonomy has enabled aerospace vehicles to achieve high precision and accuracy under self-guidance in isolated environments. As autonomous technology rapidly matures, we must consider how aerospace vehicles can be deployed in **shared spaces** and supported by **existing infrastructure**.

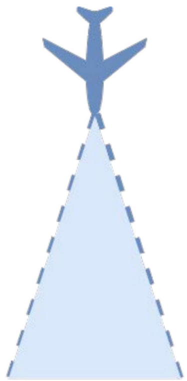
Robust decision-making against uncoordinated vehicles

With no information on an uncoordinated player's actions, players experience **cost uncertainty** in their learning.

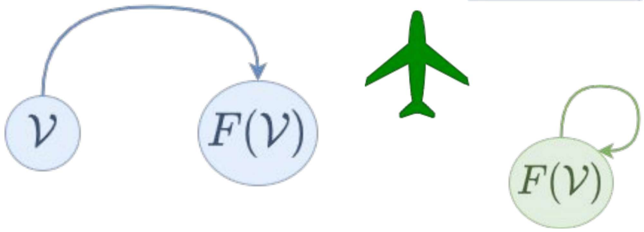
Value function set

$$[F(\mathcal{V})]_s = \bigcup_{\mathcal{C}\times\mathcal{V}} \min_a C_{sa} + \gamma \textstyle\sum_{s'} P_{s'sa} V_{s'}$$

Cost uncertainty set



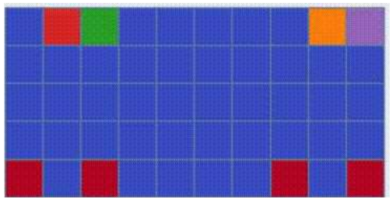
We develop a set-based Bellman operator and derive a fixed value function set that remains **invariant** with respect to cost uncertainties during learning.



Competitive policy synthesis at scale

We developed a distributed algorithm that solves **congested Markov decision processes**
- Individual optimization complexity is **constant**
- Total optimization is **linear**

Warehouse path planning with **uncertain package drop off times**
- **Players**: warehouse robots
- **Actions**: up/down/left/right
- **Objectives**: ensure all packages are dropped off while avoiding collision
- **Random factor**: stochastic package arrival time



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