TRAJECTORY OPTIMIZATION FOR DRONES IN AN URBAN ENVIRONMENT UNDER UNCERTAINTIES

Denis Bereziat
Advisors : Sonia Cafieri, Andrija Vidosavljevic

ENAC, Optim research group, Toulouse, France.

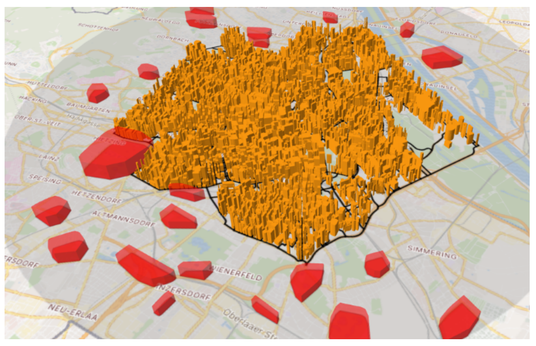
Motivation

Urban Air Traffic Management relying on drones is receiving an increasing attention:

- New drone technologies and possibilities
- Increase in city population and congestioned road traffic
- Safety critical system

$\Rightarrow$ **Need for trajectory optimization of drones in urban environements**

Context



Urban context

- Dynamic forbidden areas
- Narrow passages
- ...

$\Rightarrow$ Specific constraints to be taken into account

Airspace structure

- Either highly constrained
- Or leaving a high degree of freedom in trajectories design

$\Rightarrow$ Impact on the route design

Drone Missions

- Deliveries
- Surveillance, Security
- Personnal transport
- ...

$\Rightarrow$ Different route constraints and requirements

Thesis Objectives

The objective of this thesis is to design **flight trajectories of a set of drones** that are optimal with respect to some **cost functions** (e.g. flown distance, flight time...) and that avoid **congestions, under operational constraints** taking into account different **uncertainty sources**.

Envisionned Methods

Different optimization models and methods will be explored, based on :

- **Graph models**
- **Integer/Combinatorial optimization**
- **Mixed-integer optimization**.

Uncertainties

Uncertainties may be caused by :

- Weather
- Delays on departure
- ...

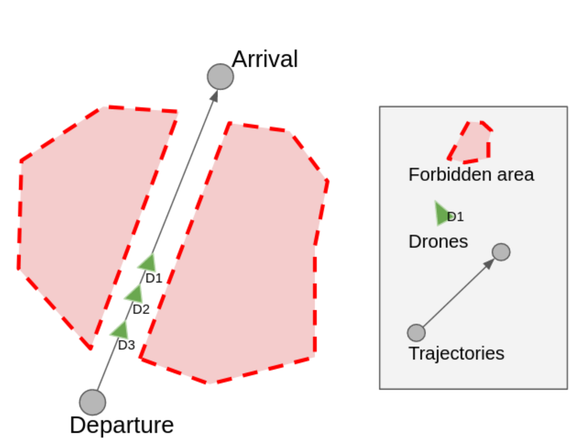
These uncertaintes may be **critical to drones in an urban environnement** :

- Drones may fly close to obstacles (between buildings)
- Uncertainty on drones speed may impact the safety distances constraint

Methods to be explored:

- **Robust optimisation** : Optimize with regard to the worst case scenario.
- **Stochastic optimisation** : Optimize based on knowledge of the probability laws of the uncertainties.

Example



Here, uncertainties in the trajectory of D1 (speed, position) may lead to loss of separation with the following drones.

References and Acknowledgement

References:
Robust Optimization, Aharon Ben-Tal, Laurent El Ghaoui, and Arkadi Nemirovski. Princeton 2009
Urban Air Mobility: From Complex Tactical Conflict Resolution to Network Design and Fairness Insights. Mercedes Pelegrín, Claudia d'Ambrosio, Rémi Delmas, Youssef Hamadi. HAL 2021.
Optimisation de croisière sous incertitude de contrôle aérien ROADEF, congrès annuel, Clément Bouttier, HAL 2016
Acknowledgment : This thesis is funded by the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement no 892928 (project Metropolis 2)