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Monitoring Atmospheric Phenomena within Low-Altitude Clouds! with a Fleet of Fixed-Wing UAVs

Alessandro Renzaglia, Christophe Reymann, Simon Lacroix

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Monitoring Atmospheric Phenomena within Low-Altitude Clouds with a Fleet of Fixed-Wing UAVs

Alessandro Renzaglia, Christophe Reymann, Simon Lacroix
LAAS-CNRS

Context

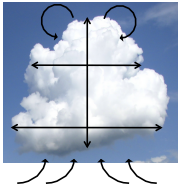
- SkyScanner: 2 years long research project involving atmosphere scientists and drone / robotics scientists
- Refine aerological models of cumulus clouds
 - Enduring agile drone conception and control
 - Fleet control



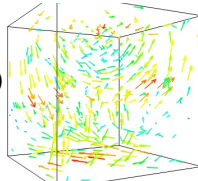
www.laas.fr/projects/skyscanner

2-levels approach

- High level mission planning (coarse macroscopic cloud model, drone allocation to given regions)

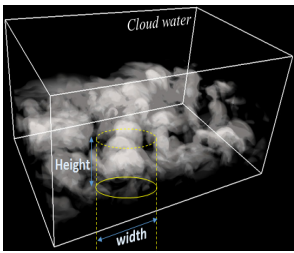


- Local planning (dense cloud model, drone trajectories optimization)

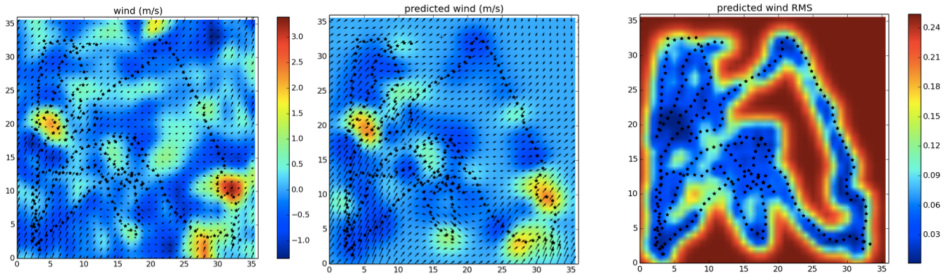


Dense cloud mapping

- Mapping a 4D structure from data perceived over a (small) set of 1D manifolds
- Parameters to estimate: 3D winds, P, T, U, LWC...
 - Sparse information: use of Gaussian regression processes



MesoNH cloud simulation
 Produced by Faycal Lamraoui
 CNRM/GAME Laboratory,
 Toulouse



Challenges:

- Optimize hyper parameters learning (exploit sparsity, develop incremental schemes, ...)
- Choice of the kernel
- Exploit mapped parameters correlations
- Relations with the coarse macroscopic model?

Planning trajectories

Maximizing the utility gathered along the path taking into account the air flows

- Finite-horizon optimization problem

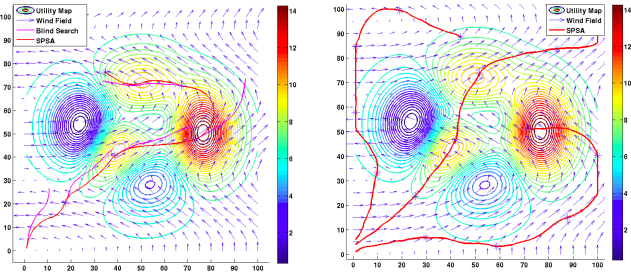
$$\operatorname{argmax}_{\alpha^{(1)}, \dots, \alpha^{(N_r)}} \sum_{t=t_0}^{t_0+\Delta T} U(\mathbf{x}_t^{(1)}, \dots, \mathbf{x}_t^{(N_r)}(\alpha^{(N_r)}))$$

$$s.t. \quad |\alpha_i^{(j)} - \alpha_{i-1}^{(j)}| \leq \Delta \alpha_{max} \quad \forall i, j$$

- Planning in the control space composed of two phases:
 1. blind Random Search to initialize the trajectories
 2. constrained Simultaneous Perturbation Stochastic Approximation algorithm to converge to a local maximum

Challenges:

- Sound definition of the utility
- Exploiting a realistic energetic model
- Multi-criteria optimization scheme
- Learn planning hyperparameters ($\delta x, \delta t$)



Experiments @ENAC

- Aircraft modeling: aerodynamic and propulsion models, polar curve
- On-line wind estimation

Vane to measure the angle of attack



Paparazzi autopilot

