

Distributed Architecture for the Dynamic Environment Exploration with a fleet of UAV

Titouan VERDU

Advisors: Gautier Hattenberger (ENAC) Simon Lacroix (LAAS-CNRS)

July 10 2018

Outline

- 1 The context of my PhD
 - Collect data from the clouds
 - Parameterize the clouds
 - New design for a new UAV
- 2 What's a distributed architecture?
 - For what applications?
 - The problems encountered?
- 3 Exploration of an unknown environment
 - A 3D dynamic environments
 - New flight patterns
- 4 Conclusion
- 5 Questions



• The context :

- Gap of knowledge between satellite and ground data
- Uncertainties in the cloud dynamics
- Based on the previous work on Voltige and SkyScanner

The objectives :

- Develop a fleet of autonomous UAVs
- Get different data from the clouds during a given time
- Create a 4D model of the clouds evolution

- The actors :
 - ENAC
 - LAAS-CNRS
 - Météo France



Study entrainment and detrainment (mixing cloudy air and environment air) in cumulus clouds to reduce the time lag in precipitations between observations and models.

Get data from inside and outside :

- Wind : speed and orientation
- Liquid Water Content
- Temperature, pression and humidity
- Luminosity
- Aerosol

Titouan VERDU / The context of my PhD / Collect data from the clouds

ww.enad



The cloud and its parameters (Nicolas MAURY)

For the border cloud/environment :

- Mass (LWC and volume cloud)
- Entrainment/detrainment (horizontal motion)



- For stage life :
 - Vertical velocity
 - Buoyancy (with temperature and specific humidity)





Design the fleet of UAVs (Aurélien CABARBAYE)

- A new UAV to respond to the challenges :
 - Lightness : total weight < 2,5kg with a 800g payload
 - Resistant
 - Easily to mount and to replace a part
 - Cruise speed 25m/s and usual altitude 3000 meters
 - Flying time 2 hours
- A centralized architecture which need to evolve



Ecole Nationale de l'Aviation Civile



• The differents kind of architecture :

Centralized



Decentralized



Distributed



• Several examples in the nature :





www.enac.fr

Titouan VERDU / What's a distributed architecture?



• Added values in NEPHELAE :

- Control the fleet with high level instructions
- The swarm of UAV will be more autonomous
- The fleet wouldn't be affected by a lost of communication

What will evolved ? :

- The communication system (ground control and inter-uav)
- The perception
- The decision
- The action
- \Rightarrow Mostly the strategies and the implementation will be at the software level

ww.enad



What will be the issues encountered?

- Communication in a ad-hoc network :
 - Maximum range
 - Detection of the neighbourhood
 - Manage the Ip table and the route
- Perception :
 - Share the data
 - Data fusion
- Decision :
 - Without a fixed leader
 - Auction method with a token
- Action :
 - Decompose the high level instructions
 - Creation of linked action
- Less processing power



The exploration of an unknown environment

As a first step, I will try to determine the shape, the border of the cloud without a priori information.

Cooperative prediction of time-varying boundaries [David Saldaña, Renato Assunção,...]

New method which are using *polylines* and *piecewise boundary* to determine the curve function.



(a) Initial paths after completing a cycle. The (b) Piccewsies boundary, represented by the dotted (c) Parametrization of the sampled pa actual boundary and polylines are represented by line. The boundary at time t_k is represented by dots) by using the piccewise boundary the dashed line.



The clouds : a 3D dynamic environment !

Several layer of 2D shapes



 \implies requires a lot of UAV

 Develop new adaptive and reactive flight patterns





If we consider that a cloud as a cylinder shape. We can combine a spiral climb in the center of the cloud and several circle fall which have, as center, a point on the border. This result a primary pattern to get data all around the border of the cloud.







ww.enao 12



- Continue the development of my personnal and simple multi-UAV simulator
- Creation and test, in real flight, of new patterns according to the requirement to explore well the clouds
- Implement a multi agent system method (auction) in several UAV to decide and execute action in a distributed way



Thanks for your attention and I still available to answer to any questions !

