Comfortable collision-free navigation in dense environment

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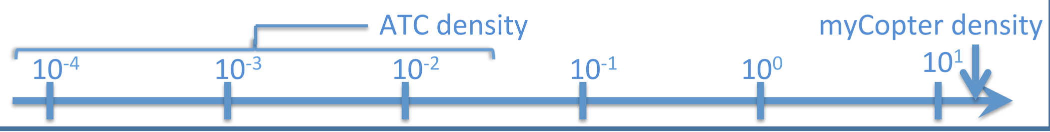
Challenges in PAV automation

The automation challenge for PATS raises critical issues.

1. The high density of PAVs
   - create a highly dynamic environment
   - give limited time to compute/perform collision avoidance
2. As the platforms as manned but automatically piloted, this raises
   - comfort issues
   - safety issues



Real-time simulator

In order to test extensively the collision avoidance strategy, a real-time swarm simulator was developed. The simulator can simulated in real-time the dynamics of hundreds of PAVs. It can also be run faster to collect statistical meaningful data.

Real sensors and no-flying zones can also be modeled and their influence on the overall performance can be addressed.

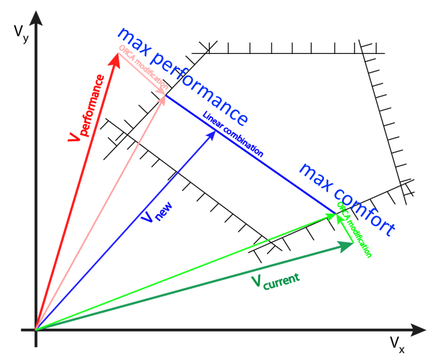
Comfortable collision avoidance

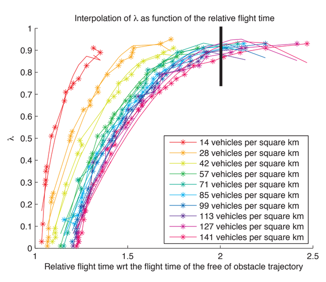
We developed a collision avoidance strategy able to deal with user-defined level of comfort based on crowd modeling.

Definition of comfort: "The comfort has both psychological and physiological components, but it involves a sense of subjective well-being and the absence of discomfort, stress or pain" Richards L.G., *Human factors in transport research.*

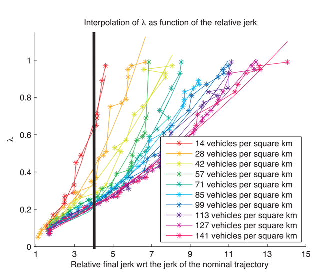
In this work, we focus the physiological component. It has been shown that discomfort increases with the magnitude of accelerations and jerk (the time derivative of accelerations).

Our solution extends an existing strategy incorporating this notion of comfort. Each user can even freely choose between a more comfortable or a more direct flight.





Density	Min λ	Max λ
14	0.05	0.63
28	0.05	0.35
42	0.05	0.25
57	0.07	0.25
71	0.09	0.25
85	0.11	0.23
99	0.11	0.23
113	0.11	0.23
127	0.13	0.21
141	0.15	0.21

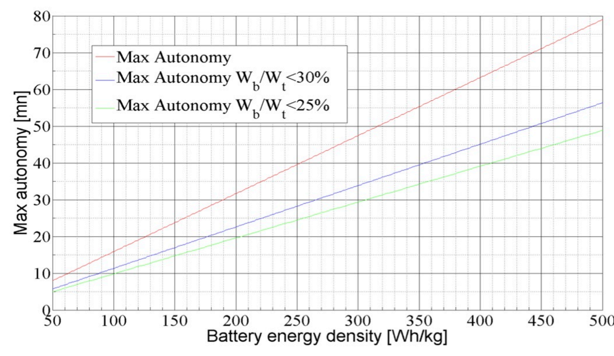


Pendul'air, a flying PAV

A full-scale demonstrator of a flying PAV was designed and a low-scale model of it was built.

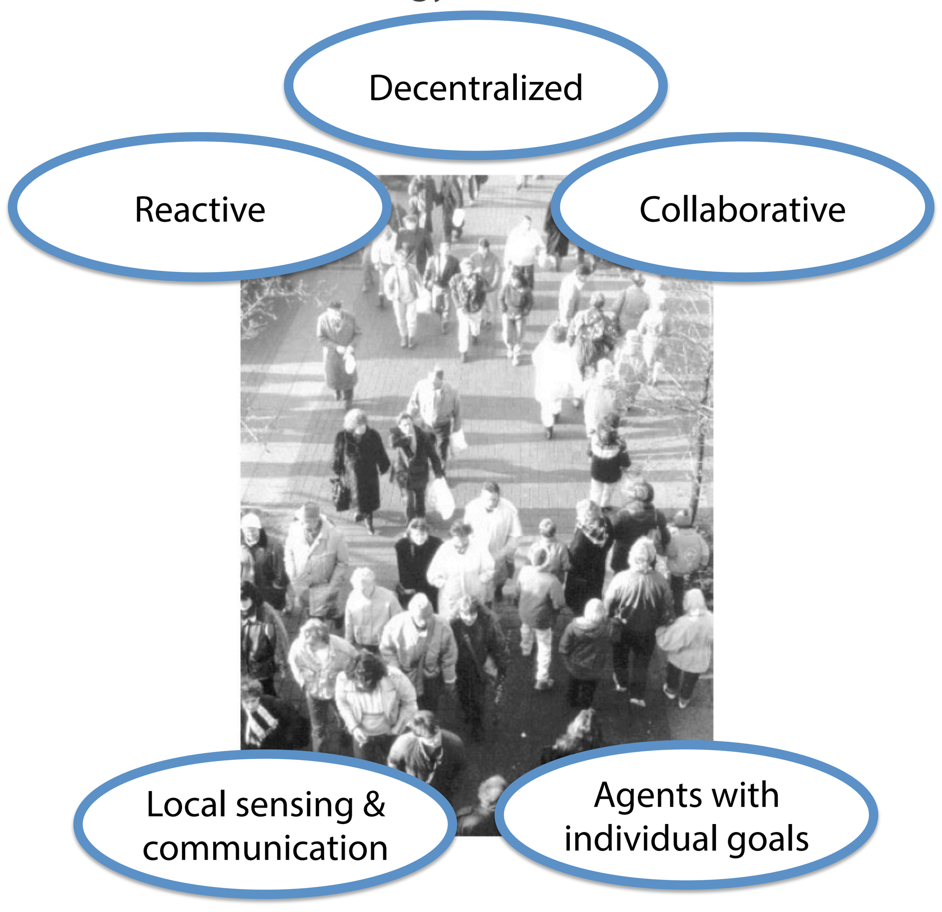
The Pendul'air is a VTOL platform carrying 1-2 passengers for about 20 minutes at about 100 km/h.

It was shown, by an iterative process, that a lower bound can be given on the minimal energy density required to guarantee a certain time autonomy for the platform.



Crowd inspired approach

We take inspiration from Crowd modeling to design a collision avoidance strategy that will be:



http://lis.epfl.ch/Mycopter

MAV'RIC framework

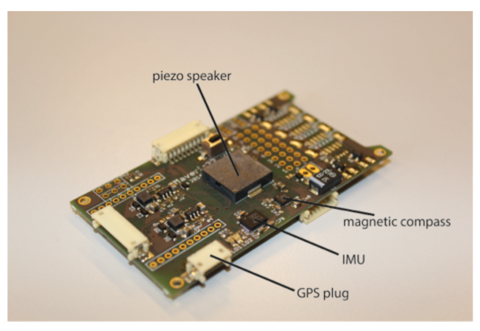
MAVRIC

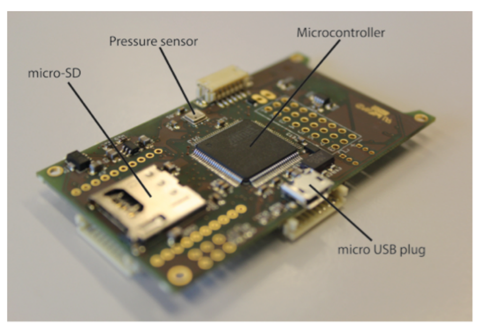
The development of a flying MAV leaded to the establishment of a framework named MAV'RIC.

This framework is now a basis for multiple projects in our lab.

This framework is soon to be released as an open-source autopilot software. It is designed to fit any kind of flying platform (multi-rotor, flying wing, transition platform, etc.).

It is also a teaching tool for a Mobile Robot class here at EPFL. All the practicals were designed using this framework. At the end of the semester, one month mini-project will allow students to extend one aspect they have seen in the class.





LE quadrotor

To test collision-free navigation, we developed a MAV: the LE (LIS-EPFL) quadrotor of about 450gr and 50cm span. It is based on the MAV'RIC framework.

The mechanical design and the software were developed having multi MAV experiments in mind. The quadrotors are easily built by putting together carbon rods and 3D printed pieces.

The quadrotors are able to takeoff, navigate between waypoints and land autonomously. At any time, the control can be taken manually on one or many MAV to ensure the safety. The navigation can also be stopped/resumed if any issue occur.

mycopter

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