# Autonomous navigation of a UAV based on multimodal integration

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## I. Introduction

While most of the UAV mission scenarios considered in the literature inherently need the robot to combine multiple and often conflicting objectives, in practice, most of systems finally decompose the problem by switching between exclusive behaviors, i.e. controllers. As an example, the Paparazzi system developed at ENAC [1] provides autonomous flight plan execution by statically selecting the appropriate controller according to the current objective.

When multiple objectives should be simultaneously considered (such as obstacle avoidance and goal seeking), proposed methods mainly focus on estimation fusion techniques in state space [2]. At a high level, it can also be seen as a multiobjective optimization problem where the main goal is to find an optimal point in task-specific performance space [3].

Although these methods show good results, they have been studied separately, resulting in various solutions for individual applications, following a user-designed sequence or using ad-hoc formalisms to describe a complex but non-flexible behavior. Little progress has been made in integrating these competences into a single dynamic system which carries out connection between multiple navigation and action modes.

## II. Our approach

According to a behavior-based control approach, as originally introduced in [4], we propose to decompose the complex global behavior required to accomplish a mission into different navigation modes, each of which independently matching a perceived situation to a command action. In this manner, and considering in a first time basic modes that all provide homogeneous low level commands, the fusion can occur in command space, where the outputs from individual navigation modes are mixed to produce the final command.

We believe this method could be extended to the autonomous execution of complex flight plans requiring sequential or simultaneous fusion of navigation modes, with the following advantages :

- Inherent ability of fusing navigation modes requiring to be designed in specific heterogeneous state space.
- Smooth mode transitions.
- Improved robustness due to parallel operation of multiple modes potentially overlapping in functionalities.
- Real flexibility in mode integration and therefore in mission types.

## III. Current and future work

A first step in investigating the general problem of fusing commands provided by different modes is considered through the case of multiple human operators that can be seen as distinctive navigation modes providing conflicting and simultaneous low level commands (e.g. roll angle $\phi$, pitch angle $\theta$, yaw angular velocity $\dot{\psi}$, and thrust T).

Future work will consist in extending the fusion method to a complex navigation system able to choose the most appropriate and reliable modes according to a high-level flight plan. Then, depending on the current objectives we would like to give the system the capability of choosing in which level fusion would be more relevant. (What could happen in low-level command space as well as for high-level defined objectives).

## References

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