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An Over-Actuated Modular Platform for Aerial Inspection and Manipulation

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***Abstract*— This video shows an innovative over-actuated aerial vehicle specifically designed for tasks requiring high maneuverability such as aerial inspection of infrastructure and aerial manipulation. The main feature of the system is the fact that the redundancy of actuators allows to obtain maneuvers otherwise impossible for other aerial systems such helicopters or quadrotors. The experiments proposed in the video demonstrate how this improved maneuverability can be exploited both during free-flight operations or when physical interaction with the environment is required.**

I. INTRODUCTION

Miniature aerial vehicles are spreading through either scientific and industrial scenarios [1], becoming a standard solution in many civil and military applications. Most aerial configurations, including helicopters and quadrotors, are under-actuated dynamical systems. This means that not all their degrees of freedom can be controlled simultaneously through their own actuators. Despite this limitation, which turns out to affect the design of the stabilizing control law, those systems are characterized by a high level of maneuverability and performances in particular during free-flight [2].

Recent research efforts however are shifting the attention towards scenarios in which physical interaction with the environment is mandatory. Examples of such applications are inspection by contact of infrastructure, aerial grasping and aerial manipulation [3], [4], [5]. In all those operations, the system may be equipped with robotic manipulators in order to accomplish complex tasks. However, standard manipulators are usually fixed on the ground rather than on an under-actuated platform such as the vehicles described above. The idea is then to start investigating the design of a different kind of aerial systems characterized by additional control inputs so as to achieve improved performances in such control scenarios.

Drawing inspiration from the modular aerial platform proposed in [6] and [7], this video focuses on a specific prototype of aerial vehicle characterized by a redundant number of actuators. The specific configuration has been designed to obtain an additional control input in order to render the longitudinal dynamics fully-actuated. The system has also been equipped with a robotic manipulator so as to perform aerial manipulation tasks.

The video starts by presenting the main advantages of employing modular configurations in order to improve the dynamical characteristics with respect to a standard ducted-fan aerial vehicle [8]. A control strategy is then proposed in order to take advantage of the additional control input both during free-flight and during physical interaction. To show this feature the video presents two free-flight experiments. The first is showing how the vehicle can change its position maintaining a constant attitude. The second is showing how, conversely, a constant position can be maintained while tilting the vehicle. Finally a physical interaction experiment is proposed to compare the behavior of the vehicle with a more standard under-actuated configuration. The experiment shows how a stable docking to a vertical surface can be achieved by simply controlling the force applied to the environment by means of the new control input. Thanks to this stability, the system is then able to employ the onboard manipulator to perform an aerial writing task.

Future works will be focused on the design of different modular configurations suitable to achieve other more complex robotics manipulation task.

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