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Abstract #XXX *(to be filled by the organizers)*
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Title

Thrust-Based Flight Stabilization and Guidance for Autonomous Airships

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Abstract

Despite offering often significant advantages with respect to other flying machines, especially in terms of flight endurance, airships are typically harder to control. Technological solutions borrowed from the realm of shipbuilding, such as bow thrusters, have been largely experimented to the aim of increasing maneuverability. More recently, also thrust vectoring has appeared as an effective solution to ameliorate maneuverability. However, with an increasing interest for high-altitude airships (HAAs) and autonomous flight, and the ensuing need to reduce weight and lifting performance, design simplicity is a desirable goal. Besides saving weight, it would reduce complexity and increase time between overhauls (TBO), in turn enabling longer missions [1].
In this perspective, an airship layout based on a set of non-tilting thrusters, optimally placed to be employed for both propulsion and attitude control, appears particularly interesting. If sufficiently effective, such configurations would reduce the need for control surfaces on aerodynamic empennages and the corresponding actuators. Clearly, from an airship design perspective, the adoption of many smaller thrusters instead of a few larger ones allows a potentially significant departure from more classical airship layouts.

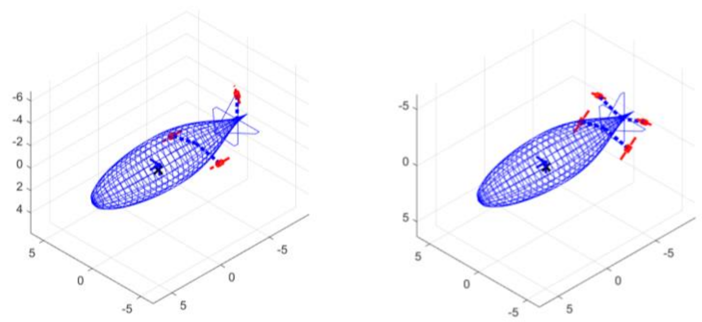

Figure 1. Comparison of optimized propulsive configurations for an airship. Left: 3-thrusters configuration. Right: 4-thrusters X-configuration.

Where on one side attractive, this solution unlocks a number of design variables—for instance, the number of thrusters, as well as their positioning in the general layout, mutual tilt angles, etc.—to be set according simultaneously to propulsion and attitude control goals. In the featured research, we explore the effect of a set of configuration parameters defining three-thrusters and four-thrusters layouts, and trying to capture their respective issues and advantages in control performance.
To this aim, at first a stability augmentation system (SAS) is designed so as to stabilize the airship making use of thrusters instead of aerodynamic surfaces. The system comprises of a pitch-rate damper, yaw damper and

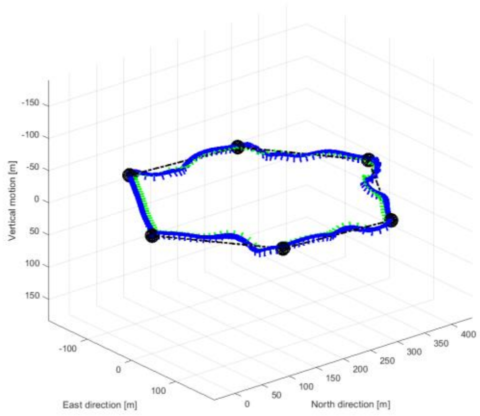

Figure 2. Autonomously-flown trajectory for a thrust-controlled airship (no aerodynamic control surfaces).

roll stabilizer [2]. A non-linear model of the airship is employed to test the airship in a set of virtual simulation scenarios, considering the data of an existing experimental airship as a baseline. The choice of the optimal design values (i.e., the optimal layout) related to the thrusters is demanded to an optimizer.

In a second stage, starting from an optimally-designed airship configuration, stabilized with the help of the stabilization system just introduced, a guidance system capable of driving the airship around along a test navigation pattern in a fully autonomous fashion is introduced.

The system implements a 3D track-following logics [2][3], carefully simulated by means of a non-linear simulator. A comparison between the navigation ability of a reference airship [4][5] with standard aerodynamic controls (elevator, rudder, ailerons) and of one featuring only thrust-based control is finally presented.

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