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Tracking control of trim trajectories of a blimp for ascent and descent flight manoeuvres

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A blimp is a small airship that has no metal framework and collapses when deflated. It belongs to family of unmanned aerial vehicles (UAVs). In this paper we address the problem of designing tracking feedback control of an underactuated autonomous UAV. The ascent and descent flight conditions as one in which the rate of change (of magnitude) of the airship's state vector is zero and the resultant of the applied forces and moments is constant lead to trimmed flight trajectories. The subject of the tracking control is to stabilize the engine around the planned flight. Using a combined integrator backstepping approach and Lyapunov theory, the stability results are local and overcome the minimum number of actuators (inputs) with respect to the blimp's six degrees of freedom. Considering physic limits in UAVs, other trimmed flights are investigated and compared.

1. Introduction

The feedback control of automatic flying machines has attracted the attention of many researches in the past few years. Due to inherent tasks of these engines, they must cooperate with a minimum of load onboard and with the maximum of autonomy. The load of the system can be reduced by decreasing the number of actuators. In counter balance, this will complicate the autonomy (control) in flight due to the presence of six degrees of freedom in UAVs. Generally, autonomous systems are characterized by the fact that there are more degrees of freedom than actuators, known as under-actuated systems. Under-actuated systems regroup indoor/outdoor blimps (airships) (De Paiva *et al.* 1999, Khoury and Gillet 1999, Hygounenc 2000, Bestaoui and Hamel 2000, Beji *et al.* 2003), the four-rotor vertical take off and landing (VTOL) named as X4-flyer (Pound *et al.* 2002, Hamel *et al.* 2002), the quad-rotor helicopter (Altug *et al.* 2002), the planar vertical take off and landing (PVTOL) aircraft (Hauser *et al.* 1992, Fantoni and lozano 2001, Marconi *et al.* 2002), and unmanned underwater vehicles (UUVs) (Fossen 1994, Boskovic and Krstic 1999, Pettersen and Nijmeijer 2001).

The dirigible adapts itself and becomes a vector to be taken into account in the future. A current use was in Kosovo (2000) for the location of mines. For this purpose, a UWB radar is integrated to the blimp. The exact position of the detected mines is recorded for the establishment of a chart of the minefields. As the buoyancy force provides an energy-free form of lift, blimps are well suited for long-duration missions like intercontinental transportation. Blimps are present in the accesses of the large cities throughout the world. Monitoring became a new mission where they excel. Thus, with the Olympic games of Atlanta a blimp was employed like an airborne platform monitoring the Olympic site. In zones at risk, one can use the airship to inspect the electric lines; difficult to achieve with helicopters. All these examples are radio controlled.

Blimps referred to as UAVs have been used in various contexts including some experimental work (Coelho *et al.* 1998, Elfes *et al.* 1998, Zhang and Ostrowski 1999, Hygounenc *et al.* 2000, Bestaoui and Hamel 2000 and Beji *et al.* 2003). Their capability is considerable in increasing manoeuvrability for tasks such as

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