Control Strategy Using Vision for the Stabilization of an Experimental PVTOL Aircraft Setup

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Summary. In this chapter, we stabilize the planar vertical takeoff and landing (PVTOL) aircraft using a camera. The camera is used to measure the position and orientation of the PVTOL moving on an inclined plane. We have developed a simple control strategy to stabilize the system in order to facilitate the real experiments. The proposed control law ensures convergence of the state to the origin.

1 Introduction

The planar vertical takeoff and landing (PVTOL) aircraft system is based on a simplified aircraft model with a minimal number of states and inputs. In the last few years, numerous control designs for the stabilization and trajectory tracking of the PVTOL aircraft model have been proposed. The proposed control techniques include the approximate I-O linearization procedure by [2], stabilization algorithm for nonlinear systems in so-called feedforward form by [12], output tracking of nonminimum phase flat systems in [6], linear high gain approximation of backstepping proposed by [10], robust hovering control of the PVTOL using nonlinear state feedback based on optimal control presented by [3]. Furthermore, a paper on an internal model based approach for the autonomous vertical landing on an oscillating platform has been proposed by Marconi et al. [5]. They presented an error-feedback dynamic regulator that is robust with respect to uncertainties of the model parameters and they provided global convergence to the zero-error manifold. Olfati-Saber [7] proposed a global configuration stabilization for the VTOL aircraft with a strong input coupling using a smooth static state feedback. Recently, control methodologies using embedded saturation functions have been proposed for the stabilization of the PVTOL aircraft. Indeed, Zavala et al. in [13] developed a new control strategy that coped with (arbitrarily) bounded inputs and provided global convergence to the origin. Lozano et al. [4] presented a simple control algorithm for stabilizing the PVTOL aircraft using Lyapunov convergence analysis. Experimental results have been provided using a four-rotor mini-helicopter.

The PVTOL system dynamics commonly used are quite simple and constitute a challenging nonlinear control problem. Moreover, the PVTOL problem is important because it retains the main features that must be considered when designing control laws for a real aircraft. It represents a good test bed for researchers, teachers and students working on flying vehicles.

Due to the difficulties in building an experimental platform of the PVTOL, there are very few experimental tests published in the literature. Note that, as far as we are aware, only M. Saeki et al. [9] carried out a real experiment of the PVTOL aircraft. Indeed, they offered a new design method, making use of the center of oscillation and a two-step linearization, and they provided some experimental results for a twin rotor helicopter model.

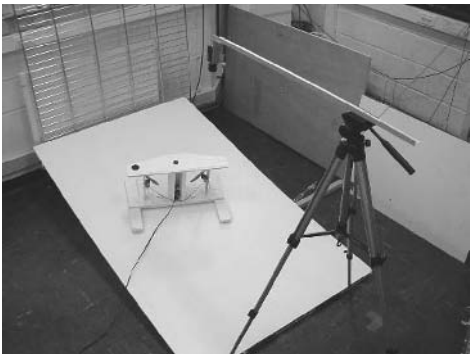

Fig. 1. Experimental setup.

In this chapter, we present both a simple control strategy and experimental results on the stabilization of the PVTOL aircraft, by using a camera for measuring the position and the orientation of the aircraft. We have developed an experimental setup for the PVTOL system. The platform is composed of a two-rotor radio-controlled object moving on an inclined plane (see Figure 1). The control strategy that has been used comes from [1] and [8]. The methodology is relatively simple and gives a satisfactory behavior. The PVTOL aircraft dynamics depicted in Figure 2 are given by the following equations:

$$\begin{aligned}\ddot{x} &= -u_1 \sin\theta + \varepsilon u_2 \cos\theta \\ \ddot{y} &= u_1 \cos\theta + \varepsilon u_2 \sin\theta - 1 \\ \ddot{\theta} &= u_2 \,,\end{aligned} \tag{1}$$