Non linear control Design of the 2-DOF Helicopter (TRMS system)

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Abstract- **In this paper, a backstepping controller is designed to position the yaw and pitch angles of a Twin Rotor Multi-input Multi-output System (TRMS). With the coupling effects considered as the uncertainties, the highly coupled nonlinear TRMS is decomposed into a horizontal subsystem and a vertical subsystem. The reaching conditions and the stability of the TRMS with the proposed controller are guaranteed. Finally Simulation results are included to indicate that TRMS with the proposed controller can remain robust to the external disturbances.**

Keywords: TRMS system, Backstepping control, Dynamic model,

I- INTRODUCTION

Helicopters are one of the most manoeuvrable and versatile platforms. They can take-off and landing without a runway and can hover in place. These capabilities have brought about the use of autonomous miniature helicopters. For these reasons, there is currently great interest in using these platforms in a wide range of civil and military applications that include traffic surveillance, search and rescue, air pollution monitoring, area mapping, agriculture applications, bridge and building construction inspection. For performing safely many types of these tasks, high manoeuvrability and robustness of the controllers with respect to disturbances and modelling errors are required. This has generated considerable interest in the robust flight control design. The twin rotor multi-input multi-output system (TRMS) is an aero-dynamical system similar to a helicopter it is characterized by the complicated nonlinearity and the high coupling effect between two propellers [1],[2], many efforts have been made to control the TRMS and some strategies have been developed to solve the path following problems for this type of system. First of this works is in [3] the authors present a comparison of classical control and intelligent control based on fuzzy logic control and genetic algorithm applied to the TRMS system. In [4] presents the evolutionary computation based the genetic algorithm for the parameters optimization of the proportional-integral differential (PID) control to the TRMS system. The goals of control are to stabilize the TRMS in significant cross-couplings. In [5] the design procedures of the fuzzy takagi-sugeno model of TRMS are detailed. Based on the derived fuzzy takagi-sugeno model, parallel distributed fuzzy LQR controller are designed to control the position of the pitch and yaw angles in TRMS.

In [6] a multivariable nonlinear H_∞ controller is designed for the angle control of the TRMS. Since the rotor speeds are assumed to be constant, in [7] investigates the development of an adaptive dynamic nonlinear model inversion control law for a TRMS system utilizing artificial neural networks and genetic algorithms, In [8] a stable neural network based observer for TRMS system is proposed to approximate the nonlinearities of the system. A learning rule for neural network is given which guarantee robustness of the observer. In [9], fuzzy controllers are designed for the tracking of pitch and yaw angles of the TRMS system.

On the other hand, the sliding mode control has been applied extensively to control the non linear system, The advantage of this approach is its insensitivity to the model errors, parametric uncertainties, ability to globally stabilize the system and other disturbances [10], [11]. In [12] a fuzzy sliding and fuzzy integral sliding controller is designed to position the yaw and pitch angles of a TRMS system using the linear surface. To simplify the design of an effective controller for the position control of the pitch and yaw angles, the TRMS is pseudo-decomposed into the horizontal and vertical subsystems. Instead of ignoring the coupling effects between the horizontal and the vertical subsystems, the coupling effects are considered as the uncertainties in the horizontal and the vertical subsystems.

The contribution of our work is used the backstepping control in order to ensuring the locally asymptotic stability and desired tracking trajectories. Unlike to However, Finally all the control laws synthesized are highlighted by simulations which gave results considered to be satisfactory.

The remainder of this paper is organized as follows. The dynamics of the TRMS is described in Section II. In Section III, the decomposed model of the TRMS is introduced. Section IV present the backstepping designed and simulation results to demonstrate the effectiveness of our approach. Finally we arrive to the conclusion of the whole work in section V.

II- MODEL DESCRIPTION OF THE TRMS

Similar to most flight vehicles, the helicopter consists of several elastic parts such as rotor, engine and control surfaces. The nonlinear aerodynamic forces and gravity act on