A Modified Decentralized Adaptive Control For Twin Rotor MIMO System using hyperstability theory

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Abstract
In this paper, a new decentralized adaptive control with modified Minimal Controller Synthesis MCS is proposed to position the beam of the Twin Rotor Multi-input multi-output System (TRMS) at the desired positions quickly and accurately. A new hyperstability based adaptive control technique, called decentralized Error-based minimal controller synthesis with integral action (DEr-MCSI), is developed to deal with disadvantages of MCS algorithm and using the specifications model of TRMS to elaborate the simplified control system. First, the physical model is divided in two cascade blocs presents the electrical and mechanical models of the TRMS. The motor and propeller systems is considered a decoupled electrical system, and its control is achieved by inversion model. The mechanical model is considered as a coupled large-scale system which is decoupled into its vertical and horizontal two SISO sub-model. For each subsystem, an Er-MCSI adaptive controller is designed, and the coupling terms are considered as disturbances to each other. Finally, a two blocs controllers in cascade are applied to original model of TRMS and evaluated in simulations. The results are encouraging and showing that the purpose controlled system is easier to be applied, more robust, and remove gain ‘wind-up’ effects due to plant disturbances and signal offsets.

Keywords
model reference adaptive control; decentralized; hyperstability; TRMS system.

1. Introduction
The twin-rotor multiple input multiple output system (TRMS) developed by Feedback Instruments Limited 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]. It is a popular and challenging experimental platform for the development and design of different types of controllers for either posture stabilization or trajectory tracking. Many efforts have been made to control the TRMS and some strategies, ranges from classical to advanced and intelligent techniques, have been developed [2-8]. Almost all the algorithms available in the literature deal with the case of decoupling control for which two separate horizontal and vertical subsystems are considered, and the effects of the couplings are considered as subsystems uncertainties and perturbations [2-5]. In [2], robust deadbeat control technique is applied to TRMS in vertical and horizontal subsystems. In [3] parallel distributed fuzzy LQR controllers are designed to control the position of the pitch and yaw angles to cover various operating regions. In [4] a fuzzy sliding and fuzzy integral sliding controller is designed to position the yaw and pitch angles of a TRMS system using linear surface. A comparison between classical control techniques and intelligent control based on fuzzy logic and genetic algorithm is presented in [5]. In [6, 7] authors presented the evolutionary computation based on genetic algorithm for the parameters optimization of the proportional-integral differential (PID) control to the TRMS system. In [8] only the pitch channel of the TRMS is considered for which one degree of freedom inversion control is developed combined with an adaptive neural network to compensate for inversion errors. All presented works consider the states of the TRMS available for measurement, however in [9] a predictive controller is developed where the states are estimated using unscented Kalman filter. In [10] and [11] authors developed nonlinear estimator of the TRMS states based on neural networks without dealing with the control problem. In parallel with the above research effort, an adaptive control scheme based on the minimal control synthesis (MCS) algorithm has been applied in [20]. This control strategy realise a decentralized control of TRMS via minimal control synthesis (DMCS) which has a good tracking performances. However, it have been two significant and recurring issues relating to the basic MCS : that there is no explicit integral term in the control equation and that the gain equations contain operating-point dependent terms. In particular, the MCS algorithm can be sensitive to a lack of explicit integral adaption (in that the gains can exhibit wind-up problems) and the adaptive effort can vary with a changing operating point [17].

In this paper, a new adaptive control scheme based upon the error-based minimal control synthesis with integral action (Er-MCSI) algorithm [17]. The Er-MCSI is a modification of MCS algorithm, which removes the operating-point sensitivity that is a feature of the original MCS algorithm. Thus, adaptive parameters can be set without reference to plant operating regimes. The Decentralized adaptive controller based on the Er-MCSI (DEr-MCS) is presented to deal with the attitude stabilization and control of Twin Rotor MIMO System (TRMS). Motivated by the advantages of the DEr-MCSI controller to deal with uncertain nonlinear systems by controller synthesis to achieve excellent closed-loop control despite the presence of plant parameter variations, external disturbances and dynamic models couplings [13-20], a decoupling architecture control form used Er-MCSI algorithm is developed for the TRMS.