Optimal direct adaptive model-free controller for twin rotor MIMO system using Legendre polynomials and PSO algorithm

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Abstract. The twin rotor multi-input multi-output system (TRMS) is an aerodynamic device with 2-degree-of-freedom (DOF) having striking similarity to a helicopter. It is characterized by highly nonlinearities, cross-coupling dynamics and is subjected to unknown disturbances. Such difficulties require designing robust control algorithms that can deal with these problems. In this paper, an optimal direct adaptive model-free controller (ODAMFC) is proposed for TRMS control problem. Using Legendre polynomials (LPs) and Particle swarm optimization (PSO) algorithm, two ODAMFC are designed to control separately the yaw (θ_h) and the pitch (θ_v) attitude angles of the TRMS. The stability and effectiveness of the proposed controller is demonstrated with the simulation result.

Introduction

The TRMS set-up is a rotary-wing aircraft system designed for the development and the implementation of new controllers. In some aspects, its behavior is similar to a helicopter. Stabilization or trajectory tracking control of a TRMS is a challenging problem because of its nonlinear, strongly coupled, and open-loop unstable dynamics. To deal with those problems, various control methods ranging from classical to advanced have been developed in the literature as in [1,2] and therein references. These approaches have effectively allowed to improve the TRMS performances and to relieve the difficulties from disturbances. However, certain difficulties must be seriously mentioned, such as, in some designed controllers the knowledge of the TRMS model is required leading in fact to a less robustness against unknown dynamics and parameter variations [2]. Also, the stability proof in other works is not guaranteed which decrease the reliability of the controller. The intelligent approaches proposed for the TRMS control are complex and difficult to be implemented in real-time. Finally, we can also mention that the controller design parameters in almost of all these methods are tuned randomly during simulations without any optimization.

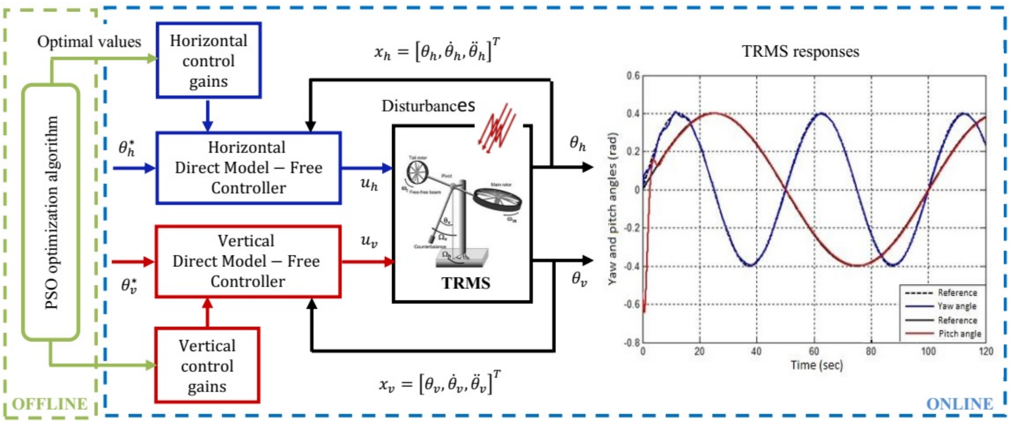

Figure 1: Block diagram of the proposed optimal direct model-free control scheme for TRMS.

Results and discussion

In this paper, we propose an optimal model-free controller based on LPs and PSO algorithm for attitude control of the TRMS in the presence of disturbances. The originality of the proposed approach lies in the design of a simple and robust control law without any prior knowledge of the system's dynamics. Here, the TRMS is considered as large-scale system that can be decoupled into two SISO subsystems describing its motion in vertical and horizontal plane. For each subsystem, an adaptive model-free controller is designed using LPs to approximate directly the ideal control law [3]. Then, the tuning parameters of our controllers are selected by PSO algorithm to maintain best performance of the TRMS even in the presence of unknown dynamics and disturbances. The overall stability of closed-loop control system and boundedness of signals are demonstrated.

References

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