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Adaptive Backstepping Control in the Presence of Quantization: Application to a 2-DOF Helicopter System

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Abstract:
Recent years have witnessed a growing interest in investigating quantized control systems. In quantized control system, the control signal to the system is a piece-wise constant function of time and the system is interacted with information quantization. The main motivation is its theoretical and practical importance in the area of digital control systems, hybrid systems, and networked control systems. An important aspect is to use quantization schemes that have sufficient precision and require low communication rate. This paper proposes a quantized adaptive control algorithm for a helicopter system in the presence of quantization. A nonlinear mathematical model is derived for the 2-DOF helicopter system based on Euler-Lagrange equations, where the system parameters and the control coefficients are uncertain. The input and states are quantized by a class of bounded error quantizers. It is a nonlinear multiple-input multiple-output system, with challenges in controller design due to its nonlinear behavior, its coupling, and with uncertainties both in the model and the parameters, and with disturbance from the quantized inputs. A new adaptive control algorithm is developed by using backstepping technique to track the pitch and yaw position references independently. Only quantized signals are used in the developed control which reduces communication rate and costs. It is shown that not only the ultimate stability is guaranteed by the proposed controller, but also the designers can tune the design parameters in an explicit way to obtain the required closed loop behavior. Experiments are carried out on the Quanser Aero system to validate the effectiveness, robustness and control capability of the proposed scheme.

Keywords: adaptive control, backstepping, quantization, 2-Degree of Freedom helicopter, position control