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Abstract

CONTROL OF DOUBLE LINK INVERTED PENDULUM WITH NONLINEAR FRICTION

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The inverted pendulum system has long been considered an intriguing problem for control theory and its application. The stabilization of such a system is a primary challenge for researchers in this field because the degree of difficulty of each problem depends on the type of the chosen system and the feasibility of the controller designed for that specific system. In this research, the real-time stabilization of a double inverted pendulum system is theoretically and experimentally investigated and achieved. First, the nonlinear equations of motion for multi-link inverted pendulum systems are developed with static friction models integrated. Thereafter, a controller is designed based on a discrete time linear regulator theory. The different system behaviors between experimental observations and simulation results without friction are analyzed. It is shown that friction in the system causes limit cycles, which are also predicted by common friction models, and can not be neglected in the control design. Dither, a heuristic smoothing technique, is used to compensate the friction between the cart and its rail of a single link inverted pendulum. For the more unstable double inverted pendulum system, a friction compensator based on modified first-order Dahl model is developed which enables model based friction compensation. The compensator is combined with linear quadratic regulator and smooth control signal is obtained. Experiments performed show that reduction of the effects of friction is accomplished and the designed controller outperforms all linear controllers reported in the available literature at present. The thesis will be valuable to practicing engineers to design enhanced controls for a variety of systems with friction.