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Adaptive Backstepping Control of Uncertain Nonlinear Systems with Input Backlash

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Abstract : In this paper a generic model of perturbed nonlinear systems is considered which is affected by hard backlash nonlinearity at the input. The nonlinearity is modelled by a dynamic differential equation which presents a more precise shape as compared to the existing linear models and is compatible with nonlinear design technique such as backstepping. Moreover, a novel backstepping based nonlinear control law is designed which explicitly incorporates a continuous-time adaptive backlash inverse model. It provides a significant flexibility to control engineers, whereby they can use the estimated backlash spacing value specified on actuators such as gears etc. in the adaptive Backlash Inverse model during the control design. It ensures not only global stability but also stringent transient performance with desired precision. It is also robust to external disturbances upon which the bounds are taken as unknown and traverses the backlash spacing efficiently with underestimated information about the actual value. The continuous-time backlash inverse model is distinguished in the sense that other models are either discrete-time or involve complex computations. Furthermore, numerical simulations are presented which not only illustrate the effectiveness of proposed control law but also its comparison with PID and other backstepping controllers.

Keywords : adaptive control, hysteresis, backlash inverse, nonlinear system, robust control, backstepping
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