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Balancing a Rotary Inverted Pendulum System Using Robust Generalized Dynamic Inverse: Design and Experiment

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Abstract : This paper presents a methodology for balancing a rotary inverted pendulum system using Robust Generalized Dynamic Inversion (RGDI) under influence of parametric variations and external disturbances. In GDI control, dynamic constraints are formulated in the form of asymptotically stable differential equation which encapsulates the control objectives. The constraint differential equations are based on the deviation function of the angular position and its rates from their reference values. The constraint dynamics are inverted using Moore-Penrose Generalized Inverse (MPGI) to realize the control expression. The GDI singularity problem is addressed by augmenting a dynamic scale factor in the interpretation of MPGI which guarantee asymptotically stable position tracking. An additional term based on Sliding Mode Control is appended within GDI control to make it robust against parametric variations, disturbances and tracking performance deterioration due to generalized inversion scaling. The stability of the closed loop system is ensured by using positive definite Lyapunov energy function that guarantees semi-global practically stable position tracking. Numerical simulations are conducted on the dynamic model of rotary inverted pendulum system to analyze the efficiency of proposed RGDI control law. The comparative study is also presented, in which the performance of RGDI control is compared with Linear Quadratic Regulator (LQR) and is verified through experiments. Numerical simulations and real-time experiments demonstrate better tracking performance abilities and robustness features of RGDI control in the presence of parametric uncertainties and disturbances.

Keywords : generalized dynamic inversion, lyapunov stability, rotary inverted pendulum system, sliding mode control
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