Design and Implementation of Robust Hybrid Control of Vision Based Underactuated Mechanical Nonminimum Phase Systems

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Abstract: This paper presents a vision based Cart-Inverted Pendulum (CIP) system under a hybrid feedback configuration: the continuous cart's position measured by encoder and the delayed & sampled inverted pendulum's upper coordinates, obtained from a visual sensor. The challenge here is to stabilize the CIP from a big inclined initial angle by using a low cost CCD camera. Under this scheme, we propose a hybrid control which consists in a Jumping-up (Bang-Bang) control and a two causal stabilization loops control: the first one (inner loop) realizes a linearization and the stabilization control of the pendulum based on an innovative Piecewise Continuous Reduced Order Luenberger Observer coupled with a linearization module, the second one (the outer loop) realizes a Lyapunov based control for the unstable internal system with lower dynamics than that of the pendulum. This hybrid control method is capable of balancing the CIP system within small cart's displacement. Performances issues of the proposed method are illustrated by the experimental figures and videos.

Keywords: Visual servoing, underacturated mechanical systems, nonminimum phase systems, Lyapunov functions, piecewise continuous systems.

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