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Stabilization of the experimental cart-pendulum system with proven domain of attraction.
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Summary: The immersion and invariance methodology has proven to be a very effective theoretical tool for the stabilization of nonlinear systems. However, its applicability depends on the solvability of a set of Partial Differential Equations (PDEs). In order to tackle this problem it was recently proposed to consider these PDEs as parameterized algebraic equations. This approach was illustrated for the cart-pendulum system with satisfactory results. However, no estimate of the domain of attraction of the equilibrium was given. In this paper, we complement the aforementioned work first, by proving that the domain of attraction contains the open upper-half plane and secondly, by showing the validation of the proposed controller when applied to an experimental set-up of the cart-pendulum system. Moreover, it is shown that the controller designed herein is simpler than others considered so far in the literature. Finally, it is pointed out that taking into consideration the presence of friction in the experimental set-up is crucial to attain the required performance and make the stabilization robust.

MSC:

93D21  Adaptive or robust stabilization
93C10  Nonlinear systems in control theory
93C20  Control/observation systems governed by partial differential equations

Keywords:
cart-pendulum system; immersion and invariance; stabilization; experimental results

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