Stabilization of Underactuated Mechanical Systems via Interconnection and Damping Assignment

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Abstract

In this paper we consider the application of a new formulation of Passivity Based Control, known as Interconnection and Damping Assignment, or IDA-PBC, to the problem of stabilization of *underactuated mechanical systems*, which requires the modification of both the potential and the kinetic energies. Our main contribution is the characterization of a class of systems for which IDA-PBC yields a smooth asymptotically stabilizing controller with a guaranteed domain of attraction. The class is given in terms of solvability of certain partial differential equations. One important feature of IDA–PBC, stemming from its Hamiltonian (as opposed to the more classical Lagrangian) formulation, is that it provides additional degrees of freedom for the solution of these equations. Using this additional freedom, we are able to show that the method of "controlled Lagrangians" may be viewed as a special case of our approach. As illustrations we design asymptotically stabilizing IDA-PBCs for the classical ball and beam system and a novel inertia wheel pendulum. For the latter we prove that it is possible to swing up and balance this pendulum without switching between separately derived swing up and balance controllers and without measurement of velocities.