Gain-adapting coupling control for a class of underactuated mechanical systems. (English)


Summary: While presenting many advantages in application, the loss of actuators also brings about great challenge to the control of underactuated systems. Specifically, the unactuated DOFs (degrees of freedom) cannot be directly controlled, instead, they have to be stabilized indirectly through appropriate regulation of actuated ones. As an unfortunate fact, the natural couplings between actuated and unactuated states are often relatively weak. Hence, in many practical cases, even the actuated states are well regulated, the performance of the unactuated states still fails to meet expectations. Such phenomenon is particularly obvious when the system faces various disturbances, since the unactuated states are more vulnerable to them and more difficult to be re-stabilized. To deal with the aforementioned issues, a nonlinear gain-adapting controller is proposed for a class of underactuated mechanical systems, which incorporates extra unactuated states-related information into the controller to enhance the state couplings. In this way, the closed-loop system reacts more appropriately and efficiently to the unactuated dynamics, which is expected to obtain improved transient performance and robustness. With a relatively concise structure, the proposed strategy imposes few requirements on the system configuration, which makes it more convenient for practical application. Theoretical analysis and experiment results are presented to demonstrate the performance of the proposed method.

MSC:
93D20 Asymptotic stability in control theory
93C10 Nonlinear systems in control theory
70Q05 Control of mechanical systems

Keywords:
underactuated systems; coupling enhancement; transient performance; nonlinear control; asymptotic stability

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