Augmenting variable stiffness actuation using reaction wheels

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Abstract

A branch of robotics, variable impedance actuation, along with one of its subfields variable stiffness actuation (VSA), is gaining momentum recently. There have been many thorough studies earlier in the design and recently in the control of these systems. The performance of these systems is mainly limited by their physical constraints, such as actuator nominal torque and maximum elastic element stiffness. This paper discusses the integration of reaction wheels to VSA systems and using reactive torques to improve the performance of the combined system. Since the compliant nature of VSA mechanisms is often associated with cyclic motion, reactive torques can be used to amplify the robot motion and accumulate more energy in the elastic elements in a given period of time. After presenting our modeling and control framework for reaction wheel-integrated VSA robots, we benchmark the performance of a reaction wheel-integrated VSA system using an explosive ball throwing task. Specifically, extensive simulation and real-world experiments are conducted with three different configurations: VSA-only, reaction wheel-only, and reaction wheel-integrated VSA. The results of these experiments show the benefits of reaction wheel-integrated VSA robots compared with the two other configurations.

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