Cooperative Dynamic Manipulation of Unknown Flexible Objects

Abstract:
Cooperative dynamic manipulation enlarges the manipulation repertoire of human--robot teams. By means of synchronized swinging motion, a human and a robot can continuously inject energy into a bulky and flexible object in order to place it onto an elevated location and outside the partners' workspace. Here, we design leader and follower controllers based on the fundamental dynamics of simple pendulums and show that these controllers can regulate the swing energy contained in unknown objects. We consider a complex pendulum-like object controlled via acceleration, and an "arm-flexible object-arm" system controlled via shoulder torque. The derived fundamental dynamics of the desired closed-loop simple pendulum behavior are similar for both systems. We limit the information available to the robotic agent about the state of the object and the partner's intention to the forces measured at its interaction point. In contrast to a leader, a follower does not know the desired energy level and imitates the leader's energy flow to actively contribute to the task. Experiments with a robotic manipulator and real objects show the efficacy of our approach for human--robot
dynamic cooperative object manipulation.

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