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A Finite-Horizon Inverse Differential Game Approach for Optimal Trajectory-Tracking Assistance with a Wrist Exoskeleton

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Exoskeletons are appealing robotic devices to physically assist humans in various motor tasks. To provide a part of the effort required for performing a task, they should be intuitive to use and adapt to the user's goal. Differential game theory offers an interesting framework to formalize the shared control problem underlying physical human-robot interaction. In the present paper, we introduce an approach based on finitehorizon inverse differential games, which allows to iteratively infer the user's internal goals and design a Nash-equilibrium control policy. Here, we focus on a case study in which a user has to move a load along a target trajectory while assisted by a wrist exoskeleton. The method is first validated in simulations and then applied to the control of the HRX-1 wrist interface. The results show that the controller has a positive impact tracking performance and reduces the joint torque provided by the users while enabling them to remain active. Interestingly, it also yields to a more balanced sharing of task efforts and a better coordination between the robot and the user compared to a user-agnostic linear-quadratic control guidance.