Mechanical Engineering Master's Defense

Human-Robot Cooperation: Communication of goals and leader/follower dynamics

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abstract

As robotic systems are used in increasingly diverse applications, the interaction of humans and robots has become an important area of research. In many of the applications of physical human robot interaction (pHRI), the robot and the human can be seen as cooperating to complete a task with some object of interest. Often these applications are in unstructured environments where many paths can accomplish the desired goal. This creates a need for the ability to communicate a preferred direction of motion between both participants in order to move in coordinated way. This communication method should be bidirectional to be able to fully utilize both the robot and human capabilities. Often in cooperative tasks between two humans, one human will operate as the leader of the task and the other as the follower. These roles may switch during the task as the need arises. The need for communication extends into this area of leader/follower switching. Moreover, not only is there a need to communicate the desire to switch roles but also to control this switching process. Impedance control has been used as a way of dealing with some of the complexities of pHRI. For this investigation, I examined if impedance control can be utilized as a way of communicating a preferred direction between humans and robots. The first set of experiments tested to see if a human could detect a preferred direction of a robot by grasping and moving an object coupled to the robot. The second set tested the reverse case if the robot could detect the preferred direction of the human. For humans detecting the preferred direction of robots this was shown to be effective up to 85% of the time and up to 99% effective in the revers case. Using these results, a control method to allow a human and robot to switch leader and follower roles during a cooperative task was implemented and tested. This method proved successful 84% of the time. This control method was refined using adaptive control resulting in lower interaction forces and a success rate of 95%.

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