Mechanical Engineering Doctoral Defense

Human-Robot Interaction Utilizing Asymmetric Cooperation and the Brain

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abstract

The interaction between humans and robots has become an important area of research as the diversity of robotic applications has grown. The cooperation of a human and robot to achieve a goal is an important area within the physical human-robot interaction (pHRI) field. The expansion of this field is toward moving robotics into applications in unstructured environments. When humans cooperate with each other, often there are leader and follower roles. These roles may change during the task. This creates a need for the robotic system to be able to exchange roles with the human during a cooperative task. The unstructured nature of the new applications in the field creates a need for robotic systems to be able to interact in six degrees of freedom (DOF). Moreover, in these unstructured environments, the robotic system will have incomplete information. This means that it will sometimes perform an incorrect action and control methods need to be able to correct for this. However, the most compelling applications for robotics are where they have capabilities that the human does not, which also creates the need for robotic systems to be able to correct human action when it detects an error. Human action is preceded by activity in the brain. Utilizing this activity in the brain can classify the type of interaction desired by the human. For this dissertation, the cooperation between humans and robots is improved in two main areas. First, the ability for electroencephalogram (EEG) to determine the desired cooperation role with a human is demonstrated with a correct classification rate of 65%. Second, a robotic controller is developed to allow the human and robot to cooperate in six DOF with asymmetric role exchange. This system allowed human-robot cooperation to perform a cooperative task at 100% correct rate. High, medium, and low levels of robotic automation are shown to affect performance, with the human making the greatest numbers of errors when the robotic system has a medium level of automation.

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