RADIO FREQUENCY IDENTIFICATION FOR THE CONTROL OF DEXTEROUS PROSTHETIC HANDS

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Abstract

Recently, mechanical advances have resulted in the arrival of multi-fingered prosthetic hands capable of interpreting muscle signals and converting them into dexterous motor commands. These devices have far more operable degrees of freedom than previous hands; however, they are effectively restricted to simple open and close behavior due to the continued use of traditional myoelectric signal thresholding techniques and the movement decoding limitations that accompany them. While there is ongoing research into better decoding algorithms, these methods require significant training times on the part of the user, and are largely not robust to real-world conditions affecting users of prosthetic devices.

In response, this work focuses on the development of a system in which the full potential of new prosthetic hands can be utilized without any increase in training or cognitive effort on the part of the amputee. To take advantage of the numerous degrees of freedom (DOFs) possessed by dexterous anthropomorphic hands, the system acquires contextual information from the environment, through radio frequency identification (RFID), which conveys the unique mode appropriate for the task to the hand. Once an object is identified, the hand will automatically form the needed preshape, and then a simplified control scheme will open and close only certain digits, instead of the whole hand. By these means, the amputee can greatly amplify the controllability of the hand or arm with no increase in effort or training. Additionally, the user's previous myoelectric control scheme does not change, such that any socket may be retrofitted to accommodate the new system and provide instant improvements to an amputee's quality of life.

Initially, preliminary experiments were performed with able-bodied subjects and non-dexterous hands to test the plausibility of incorporating an RFID reader with prostheses, and to discover what advantages it may offer. A Clothespin test demonstrated that the mean completion time of a task requiring more than one DOF was completed significantly faster with RFID ($p < 0.01$). Two subject's mean times showed a 27% and 49% improvement compared to a sequentially-controlled system.

In a second study, the mechanical, hardware, and software integration necessary to combine the RFID prototype with an existing prosthetic socket, and a dexterous prosthetic hand, was performed. Functionally dexterous tasks with one amputee subject generated results that were optimistic in favor of the Myoelectrically-Operated RFID Prosthetic Hand (MORPH) as an improvement to traditional signal-thresholding control. Four of the eight tasks showed significant improvement ($p < 0.05$), and the remainder were comparable to the control.

The collective work serves as a novel alternative to the computationally intensive pattern recognition algorithms typically used to control high DOF prosthetic systems. Future work intends to incorporate further automatic lower-level control, such as wrist rotation, through the development of a prototype capable of automatically aligning the wrist with the orientation of an RFID-tagged object. In conclusion, the MORPH technology described forms an important foundation for the functional advancement of one DOF thresholding systems, and will help provide greater independence to amputees in the near future.