LOW-COST PATTERN RECOGNITION BASED MULTI-DIGIT MYOELECTRIC HAND PROSTHESIS

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INTRODUCTION

Upper extremity prosthetics devices range from high-cost thought controlled dexterous prosthetic limbs [Hotson 2016] to low-cost 3d printed devices with limited dexterity. This effort addresses the gap between these two extremes by incorporating low-cost and open-source components with advanced concepts in prosthetic control to create a low-cost pattern recognition based multi-digit myoelectric hand prosthesis. This study represents not only prototype devices, but also provides resources, documentation, and tools for the community to replicate, customize, and improve prosthetic devices for upper extremities.

METHOD

Advanced prosthetic devices incorporate high fidelity sensor technologies for Electromyography (EMG), sophisticated signal processing using machine learning, and multi-degree of freedom (DOF) actuation. However, each technology domain has vibrant open-source options thanks to the "maker" community. We developed a custom-interface for the Thalmic Labs Myo armband (Myo) for signal acquisition, developed a pattern recognition controller using the Raspberry Pi system-on-a-chip, and incorporated multi-digit actuation using up to 6 independent servos adapted to the eNABLE Raptor Reloaded 3d printed hand (Raptor).

Integration for all these components was achieved using an open-source version of the Johns Hopkins University Applied Physics Lab's Virtual Integration Environment (VIE) [Armiger 2011], written in MATLAB and Python (https://bitbucket.org/rarmiger/minivie).

Pattern recognition based control was achieved using Linear Discriminant Analysis of EMG signals characterized using four features: mean average value, slope sign change, zero crossing, and signal length. A custom Myo driver was developed to detect and stream up to 16 raw EMG channels (8 channels per Myo) simultaneously at a rate up to 300Hz wirelessly over a Bluetooth low-energy connection.

The Raptor hand was retrofit with universal servo mount interfaces to accommodate a variety of servo motors allowing either individual finger control, or four unique grasps: cylindrical grasp, point grasp, lateral pinch, and open hand. The device was evaluated by one individual with intact limbs and one individual with congenital limb deficiency (right hand with only a partial palm and thumb).

RESULTS

The advanced prosthesis cost on the order of $300 with 1 Myo or $500 with 2 Myos. An initial design concept offers a 6-DOF prosthesis using 8 EMG signals from 1 Myo streaming at 200Hz in a partially-embedded system. A custom design offers a 4-DOF prosthesis which will control four independent phalanges based on 16 EMG signals from 2 Myos streaming at 300Hz in a fully embedded system. Leveraging rapid prototyping from extruded polylactic acid (PLA) material, design improvement and customization was possible from multiple part reprints within hours of functional evaluation.

DISCUSSION

This development effort sought to act as a proof of concept for bringing advanced concepts in upper extremity prostheses such as pattern recognition, wireless control, machine learning and multi-digit actuation to the open-source community at low cost. Clinical EMG systems can cost several thousands of dollars and prosthetic hands can cost tens of thousands with only basic mode-switching control. The results represent a lower-bound for cost while incorporating advanced prosthetic capabilities. Improvements to this proof of concept effort are endless including substituting extruded plastic for sintered metal parts.

A significant gain from this effort is the ability to obtain 16 discrete EMG signals from non-invasive, intuitive, and comfortable sensor devices. The custom system allowed one user to experience independent finger articulation in his right hand for the first time in his life. The open source architecture presented is being leveraged by other researchers for development of additional modular prosthesis sensors.

CONCLUSION

A low-cost open source advanced intent-based prosthesis design is possible for ~$300. The open source modularity concept presented expands the trade space between device cost and prosthesis performance. All aspects of this design effort have been documented as an open-source reference for others to utilize and extend as necessary.

CLINICAL APPLICATIONS

This effort offers users access to an intuitive prosthesis that has increased functionality with access to increased activities of daily living.

REFERENCES

Hotson, Guy, et al. "Individual finger control of a modular prosthetic limb using high-density electrocorticography in a human subject." Journal of neural engineering 13.2 (2016): 026017.

Armiger RS, "A Real-Time Virtual Integration Environment for Neuroprosthetics and Rehabilitation" Johns Hopkins APL Technical Digest Volume 30, Number 3 (December 2011)

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