DESIGN AND INTEGRATION OF AN INEXPENSIVE WEARABLE TACTOR SYSTEM

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ABSTRACT

Commercial myoelectric prostheses do not provide sensory feedback to the user; developing an inexpensive feedback system that can be easily retrofit onto existing prosthetic components may reduce barriers to clinical translation and testing. We describe the development of an inexpensive and wearable tactor-integrated prosthesis, including the (i) evaluation of sensors that can be retrofit onto existing commercial terminal devices, (ii) design and evaluation of custom mechanotactile tactors, and (iii) design of a custom electronics controller which translates sensor input to tactor output.

Three commercial sensors were evaluated for their ability to instrument individual digits, minimize cost, maximize accuracy, and avoid significant alterations to the prosthetic hand. Evaluated technologies include an FSR (Interlink, FSR 400), a subminiature load cell (Honeywell, FSG020WNPB), and a capacitance sensor (SingleTact, S8-10N). A full-factorial design of experiments was conducted to evaluate sensor responses under different loading conditions including material stiffness, loading rate, sensor contact, and indenter curvature. For low-accuracy applications, the FSR is recommended; for high-accuracy applications, the load cell is recommended where modifications to the prosthetic fingertips are possible, otherwise the SingleTact sensor is recommended.

Two mechanotactile haptic displays were designed; a linear and a cable-driven tactor. Both models use the same servo motor (HiTec, HS-35HD), with a rack and pinion gear system to convert rotational motion to linear, where contact to the residual limb is made via an 8 mm diameter domed head. The cable-driven tactor offers a reduced vertical profile at the tactor head site, however it has a larger overall footprint and draws more current. Tactors can be controlled to set a specific displacement or force, with time delays and output accuracies quantified for each system.

A custom electronic controller was designed to map forces from the sensors on the prosthetic fingertips to the haptic display. The system integrates with the existing prosthetic components and can control up to eight individually mapped tactors, where settings can be adjusted wirelessly. It contains four custom boards in addition to a commercial wireless transmitter (SparkFun, WRL-12580); all boards are contained within a custom electronics enclosure which fits into the forearm of the prosthesis.

The sensors, tactors, and electronics were integrated into a commercial prosthetic arm with minimal increases to cost (material cost \$300 plus \$125 per tactor, excluding assembly time) and weight (100 g plus < 50 g per tactor). Evaluation with an amputee participant will be discussed along with limitations and suggestions for improvements.