Tactile Feedback for Object Discrimination

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INTRODUCTION

An area of rising interest is in tactile sensing for prosthetic limbs (Hsiao, Fettiplace et al. 2011). The sense of touch plays a crucial role in daily activities, particularly for grasping and manipulating objects. A primary goal of prostheses is the ability to enable an amputee and improve functionality. Especially for myoelectric devices, prosthesis control is of major interest and with good reason. As prosthetic limbs become more functional and realistic it is important to investigate the possibility and benefit of providing tactile feedback as a form of sensory perception for the both the user and the limb.

The use of tactile sensors have been demonstrated for prosthesis applications (Osborn, Kaliki et al. 2016, Tan, Schiefer et al. 2014). The continued development of tactile sensors will play an important role in the future functionality and overall benefit of upper limb prostheses.

Here we demonstrate sensory feedback to an able-bodied user to discriminate between objects grasped by a prosthesis.

METHOD

A fingertip tactile sensor was fabricated using a piezoresistive textile (Eeonyx, USA) sandwiched between stretchable conductive fabrics (LessEMF, USA) to carry the signal to a circuit for reading the sensor output. The sensor is covered with 1 mm silicone layer (Dragon Skin 10, USA). This is similar to methods described in (Osborn, Kaliki et al. 2016) and (Osborn, Lee et al. 2014). The tactile sensors were placed on the thumb, index, and middle fingers of a bebionic3 prosthetic hand (Steeper, UK). The prosthesis was controlled using a customized development board (Infinite Biomedical Technologies, USA), which also measured and recorded the tactile signals.

An Ag/AgCl electrode was placed over the median nerve on the forearm of an able-bodied subject. A constant current isolated stimulator (ADInstruments, Australia) was used to provide transcutaneous electrical nerve stimulation to the subject at 2 mA.

Three different objects of similar size but varying stiffness (soft, medium, and hard) were grasped by the prosthetic hand. Each object was presented 10 times. The prosthesis controller used the tactile signal to classify the object being grasped and subsequently chose one of three stimulation patterns (2 Hz, 15 Hz, or 30 Hz), which corresponded to the different objects. The subject was blindfolded and verbally classified the object being grasped by the prosthesis based solely on the stimulation.

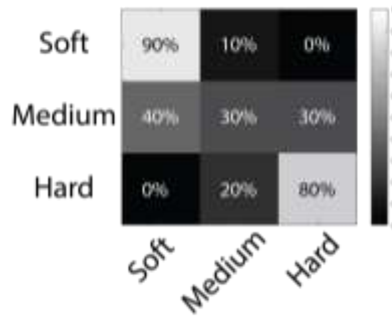

Figure 1. Results from the object discrimination task. The subject was able to identify the soft and hard objects, but was unable to reliably determine the object with medium stiffness.

RESULTS

Results show the ability of the subject to reliably identify the objects with either soft or hard stiffness. The subject was unable to reliably identify the object with medium stiffness.

DISCUSSION

The subject was able to successfully identify the hard and soft objects. This is likely due to the large difference in the two stimulation paradigms used when the prosthesis grasped these objects. This work demonstrates the feasibility of combining tactile sensors with existing prosthetic limbs for sensory feedback.

CONCLUSION

Sensory feedback via nerve stimulation allows a prosthesis user to distinguish between different objects based on varying stimulation paradigms.

CLINICAL APPLICATIONS

Tactile sensors can be used in conjunction with upper limb prostheses to provide information to the limb and the user during grasping tasks. Sensory feedback will play an important role in prosthesis functionality.

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