GRASPING FRAGILE OBJECTS USING A MYOELECTRIC HAND HAVING COMPLIANT TACTILE SENSORS WITH CONTACT DETECTION

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INTRODUCTION

Despite advancements in prosthetic hand technology, many users often struggle with tasks requiring low and precise grip force, such as grasping fragile or easily deformed objects. Previous studies have demonstrated the difficulty in controlling grip forces at these low levels (Engeberg, 2008). While these tasks would be trivial for able-bodied subjects, with currently available myoelectric hands obtaining even mediocre performance in these tasks requires high levels of concentration, good visual feedback, and is time-consuming. In this study we explore the use of compliant tactile sensors to improve performance of grasping fragile and deformable objects while alleviating this cognitive burden from the user.

METHOD

Subject: One twenty year-old male unilateral trans-radial amputee and myoelectric prosthetic user (height = 172cm; weight = 70kg).

Apparatus: A myoelectric hand (Motion Control) was equipped with BioTac sensors (SynTouch). The sensors are a fluid-filled tactile sensor that mimic the sensory capabilities of the human fingertip and have exquisite sensitivity to light contact detection (Fishel, 2012). The myoelectric hand was modified to redirect EMG signals from the subjects socket along with data from the tactile sensors to a computer for processing. A contact detection algorithm was developed to reduce control signals to the motors once contact was detected. This greatly reduced the need for the patient to recognize contact was made visually and automated the signal to stop closing the hand. The subject also used his own myoelectric hand (VariPlus Speed, OttoBock) as a control.

Procedures: The subject conducted a variety of grasping speed tests to pick up and set down fragile objects as quickly as possible (foam packing peanuts, crackers, eggs, a ball of clay). This was done with the subject's current myoelectric prosthesis (VS), the modified prosthesis with tactile sensors, and the subject's dominant hand (DH). For the modified prosthesis, two trials were run, one with the contact detection algorithm (CD) and another without to investigate the effects of compliant fingertips in handling fragile objects (C). The subject was allowed sufficient time to train on these tasks over many weeks with much improvement. After performance stabilized, five trials were conducted for each test.

Data Analysis: The mean and standard deviation for each test were computed and a one-way ANOVA was computed across all tests.

RESULTS

Results for all tests indicated that subjects were able to perform tasks more rapidly when using compliant fingertips over the subject's own myoelectric hand. However, without contact detection the standard deviation was high, indicating unreliable performance. Using contact detection further improved performance and consistency nearing the performance of the subject's in-tact dominant hand. This trend was seen across all test objects. Using contact detection, the subject was even able to reliably grasp the fragile objects used in this study with little visual feedback.

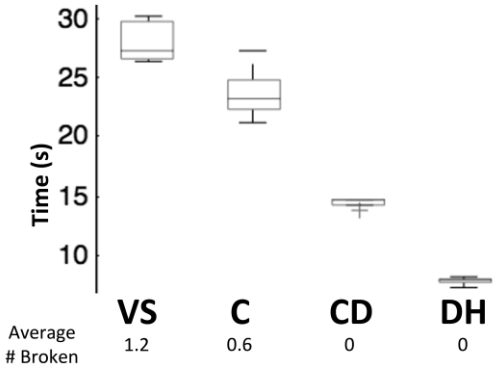

Figure 1. Time for subject to grasp 10 foam peanuts from the table and place them in a container without breaking them.

DISCUSSION

From the results, it is clear that compliance greatly improves the ability to grasp objects, as does the use contact detection algorithms. The subject was able to perform these tasks with substantially less cognitive burden, and instead of thinking how much force to deliver or how much further to close the hand in order to grasp the object without damaging it, the subject only needed to think "open" and "close" which was reported as a more natural behaviour. Further research will focus on the utility of tactile feedback for conscious perception of touch.

REFERENCES

Engeberg, E. IEEE Trans. on Biomed. Engr. 2008.
Fishel J. IEEE Conf BioRob and BioMech. 2012.