Thermal Sensing and Feedback for Advanced Prostheses

By

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Abstract

Although a lot of advancements have been made on prosthetic technologies, most commercially available prosthetic hands are still hooks or claws, which lack sensory inputs to the user; therefore, users are unable to receive any sensations from the hand. This work attempts to design a more practical and human-hand-like prosthetic system by demonstrating temperature sensing and feedback in a prosthetic system. It also expands upon the understanding of human thermal perception which will assist in the design of improved sensory feedback systems for advanced prostheses.

A custom-made prosthetic cosmesis with temperature sensors embedded, integrated with a wireless sensor platform, is suggested and connected to a heating/cooling device to enable prosthetic wearers to sense temperature objects held in the prosthetic hand. The prosthetic system is demonstrated through both system responses and user experiments. Seven subjects demonstrate that they can use the system, with reasonably high accuracy, to distinguish objects with three different temperature ranges. The results also suggest that further studies on human thermal perception for indirect prosthetic feedback are needed.

Psychophysical experiments are performed to test spatial summation across fingertips of one hand as well as across hands and nerve types. Gender differences in spatial summation are also investigated. Spatial summation of thermal sensations is examined by measuring a minimum rate of temperature changes required for subjects to detect the temperature change on their fingertips. A clear spatial summation of temperature is found as the number of stimulated fingers increases from one to two of one hand in both male and female subjects. In addition, gender differences are noticed

beyond two fingers, but more subjects are needed to confirm these findings. No statistically significant summation is noticed across hands and nerve types. These psychophysical results would help design more practical and realistic temperature feedback schemes for advanced prostheses.

Overall, it is believed that the work described in this thesis will provide motivation to incorporate sensory features, particularly temperature, to the prostheses, with the eventual goal of improving the designs of prosthetic limbs.

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