Development of an Integrable Tactile Feedback Display for Upper Limb Prostheses

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Myoelectric prosthetics provide upper limb amputees with a remarkable variety of grip patterns but lack proper feedback from touch sensation. The goal of this project is the development of a vibrotactile feedback system, which can be integrated into a prosthetic arm after minor modifications. By that, we anticipate enhancing the controllability of myoelectric prostheses and to strengthen the feeling of body-ownership of the amputee.

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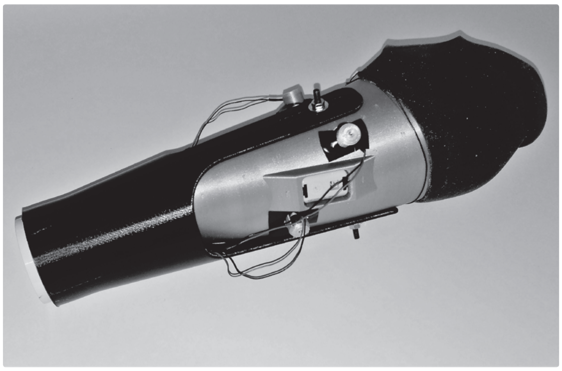
Introduction

Losing a limb through amputation is a tragic event, which results in massive constraints in habitual daily activities and quality of life. The lost limb can be replaced with an artificial one that can either be cosmetic or functional. Functional robotic prosthetics, however, do not always meet the aesthetic image of the amputee and are difficult to pilot since they do not provide the user with visceral feedback. Thus, the amputee relies mostly on visual feedback, which is tiring and can therefore lead to the rejection of the artificial limb.

The project WiseSkin, a collaboration of the EPFL, CSEM and BFH, aims at partially restoring the sensation of touch in upper limb prosthetics with ultra-low power wireless devices, tactile displays and miniaturised pressure sensors. This work covers the development of a tactile feedback display, which includes customisable 3D printed parts. The feedback is generated by actuators that vibrate on the skin surface at variable frequencies and duty-cycles (e.g. high frequency and duty-cycle substitute a high pressure on the sensor of the finger).

Materials and Methods

We designed a non-invasive feedback display as an assembly of five independent vibrotactile devices (one for each finger). Each device consists of an actuator, a damping against vibration propagation, and a shell to mount the actuator on the prosthesis. To ensure easy integration into a prosthetic arm we chose to design the device with the smallest possible actuator that can render a perceivable vibration with a stroke of 1 mm at a maximal frequency of 300 Hz. Additionally, the vibration mostly takes place in the direction normal to the skin, and not lateral. With these prerequisites, we designed the device with the self-built solenoid actuator that was developed by A. Sallaz during his MSc Thesis, because it met the needed specifications and could still be modified. The case of the actuator is held within the shell with a rubber ring, which additionally dampens the vibration against exterior parts. The five shells are then mounted on the prosthesis with an elastic band that pushes the shells and the actuators gently against the residual stump of the amputee.



Self-built prosthetic arm with the integrated vibrotactile feedback display.

Outlook

We will test the device on a voluntary subject (below elbow amputee) and therefore designed a myoelectric prosthesis that fits appropriately his stump. We used 3D scanning, 3D modelling and 3D printing technology to fabricate a sufficiently robust inner and outer socket, and eventually added the myoelectric components. We will test if the subject perceives distinct stimulations on the different sites of the stump with distinct force levels, and if the subject perceives an improvement in handling fragile objects with vibrotactile feedback.