Restoring tactile sensation
to upper limb amputees

Hand or arm amputation is a traumatic event that results in major consequences in terms of routine activities and the quality of life. Major causes of hand amputation are trauma and cancer. The Nano-Tera WiseSkin project aims at improving the situation. The goal is to develop a sensor skin that provides information to stimulate the amputee in a way that he or she regains a sense of touch.

Current prostheses cannot meet the needs

Although hand prostheses have been available for decades, ranging from body-powered hooks to myoelectrically controlled robotic prostheses, their functions are still quite limited. One reason is the fact that prostheses currently available lack tactile sensation. Thus, a prosthesis wearer cannot sense an object when holding it. How does it feel when holding something without sensing it? Consider how awkward it is to use numb hands when unlocking the door after staying outside for too long in extremely cold weather.

Fig. 1: Once amputees have an improved sense of touch, they are able to apply the right force level to hold objects. Picture: Robotic hand by Prensilia, Italy, taken by arteplus.ch

Therefore, in order to hold an object securely to avoid dropping it, a prosthesis wearer needs to constantly look at an object and apply more force than is needed. Thus using such prostheses often requires high levels of concentration and is both mentally and physically tiring. As a result, many hand amputees choose not to use prosthetic hands.

Restoring tactile sensation

Recent advances in the fields of micro- and nanosensors, machine learning, and haptics enable new solutions to provide sensory functions to hand prostheses. The Nano-Tera WiseSkin project, led by Dr John Farserotu of CSEM in Neuchâtel, aims at providing natural tactile sensation to hand amputees. To achieve this goal, a high-density wireless tactile micro sensor network, a control unit, and a non-invasive haptic display are integrated into a myoelectric hand prosthesis.

The sensor network is embedded into a soft silicone glove, covering the hand prostheses. The sensor data is wirelessly sent to the data processor, which interprets the sensor data and generates proper commands for the stimulator. The stimulator array (or tactile display) is placed non-invasively on the skin of intact body parts, which could be the remaining upper arm, the back of the body, or the region around the neck.

Phantom hand map

An interesting region to place the stimulator is the remaining stump. Here, some amputees have a phantom hand map: When touching certain areas of the stump, this feels like touching individual fingers of the lost hand. Fig. 1 illustrates this.

WiseSkin project

This project brings together expertise from CSEM (Dr John Farserotu and Prof. Dr Jean-Dominique Decotignie), EPFL (Prof. Dr Christian Enz and Prof. Dr Stéphanie Lacour), BFH (see Fig. 3), Lund University (Dr Christian Antfolk), and industrial partners. We also collaborate with medical doctors, e.g., at Balgrist University Hospital. The project is funded by Nano-Tera (SNF) and the State Secretariat for Education, Research, and Innovation (SERI).

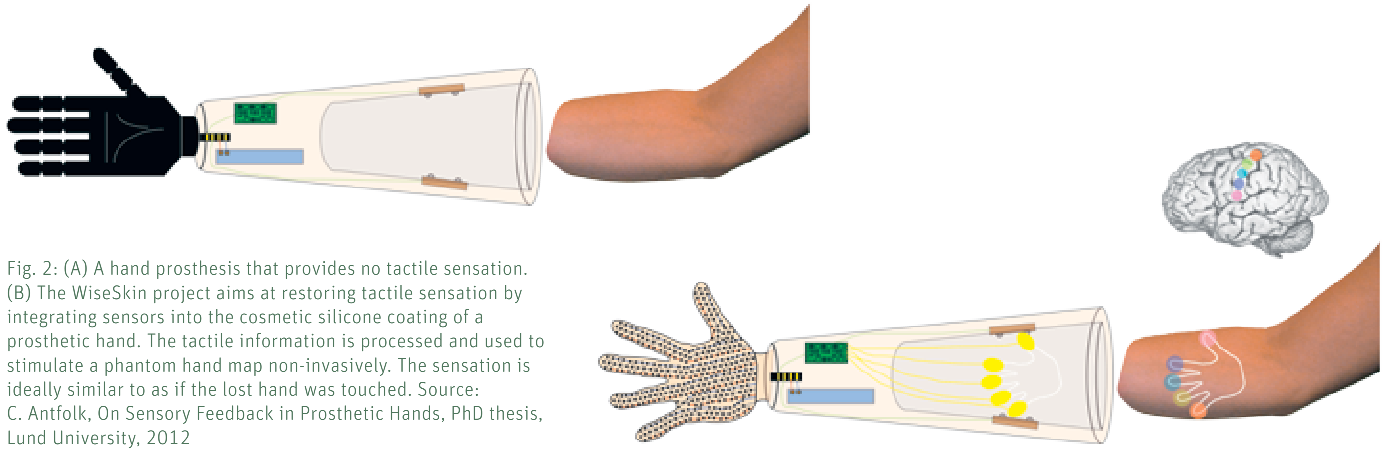

Fig. 2: (A) A hand prosthesis that provides no tactile sensation. (B) The WiseSkin project aims at restoring tactile sensation by integrating sensors into the cosmetic silicone coating of a prosthetic hand. The tactile information is processed and used to stimulate a phantom hand map non-invasively. The sensation is ideally similar to as if the lost hand was touched. Source: C. Antfolk, On Sensory Feedback in Prosthetic Hands, PhD thesis, Lund University, 2012

BFH's part

The project part at the BFH HuCE – BME Lab is lead by professors Volker Koch and Jörn Justiz. While our partners concentrate mostly on the flexible sensor skin, BFH's focus is the development of a demonstrator system that substitutes the tactile functions of the lost hand. The ultimate goal is to have a myoelectric prosthesis with a sensor skin and a tactile display. When a certain finger is touched, the amputee should know which finger it was – without looking. This requires integration of the various components, a good understanding of the physiology of sense and includes research on the determination of the optimal kind of stimulation, the stimulation patterns and the actuator density to convey as much information as possible to the amputee. These problems are tackled with prototypical mechanical actuator setups that we test on non-amputees and amputees. Furthermore, as part of a PhD project, we aim to model the sensor-to-actuator chain and the sensational reaction of prostheses wearers in order to develop and optimize learning algorithms. The function of these learning algorithms is to find a good mapping between sensor data and a stimulation pattern based on feedback from the amputee.

Be part of our team

In order to develop such a hand prosthesis with a sensor skin, we need the participation of hand or arm amputees, especially those who have a full or partial phantom hand map. In case any reader knows a hand or arm amputee who would be interested in joining our non-invasive and pain-free study, please help us by forwarding the message.

Contact
– nano-tera.ch/projects/353.php
– volker.koch@bfh.ch

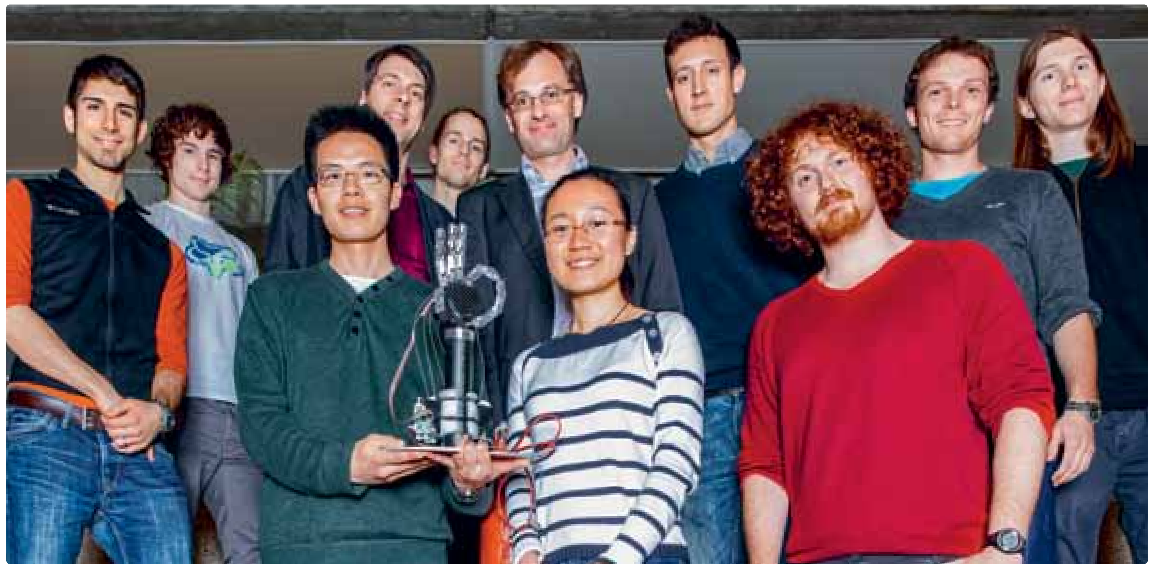

Fig. 3: The WiseSkin project team of BFH, consisting of two professors, one post-doc, one PhD student, four master's students, and three bachelor's students. From left to right: Martin Grambone, Adrian Sallaz, Dr Tao Li, Prof. Dr Jörn Justiz, Adrian Stirnimann, Prof. Dr Volker M. Koch, Huaiqi Huang, Gerhard Kuert, Ozan Ünsal, Daniel Bold, and Daniel Berger. Photo: arteplus.ch