WiseSkin for the Restoration of Natural Sense of Touch

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Today, there is no solution for the restoration of a natural sense of touch to persons using prosthetic limbs. WiseSkin combines ultra-low power (ULP) wireless sensor networks, smart materials and sensory feedback to develop sensing skin that can be attached to artificial limbs. The solution has a high potential impact in the field of hand and arm prostheses, as well as rehabilitation of nerve injuries, stroke recovery and in the field of cognitive neuroscience. WiseSkin technology also has industrial applications in the domains of robotics (tactile robots), health and safety (e.g. Smart Gloves).

As the population of the world continues to grow and age, the number of people suffering amputations is expected to increase, placing a strong demand for solutions to improve their quality of life. The target of the WiseSkin project is to provide a non-invasive, ULP and scalable solution for the restoration of natural sense of touch to persons who have lost a limb and are using prosthetics [1].

The first functional WiseSkin prototype (prototype 1) has been developed and tested. The core elements of the system are:

- A miniature sensor-communication module (SCM) integrating an ST-Microelectronics pressure sensor, an icyTRx radio [2] and a Planar Inverted-F Antenna matched at 2.45 GHz. Wireless communication is based on the Bluetooth Low Energy (BTLE) protocol. The SCM size is 12×17×1.73 mm^3.
- A flexible and stretchable silicone scaffold substrate in which the SCMs are integrated to form the sensing artificial skin. The substrate is encapsulated on both sides with a thin and flexible metallized foil in order to provide power and shielding to the SCMs and additionally to function as a waveguide for data propagation (Figure 1).
- A non-invasive sensory feedback based on the stimulation of the patient's phantom map achieved through a vibro-/electro-tactile actuation display attached to the patient's residual limb

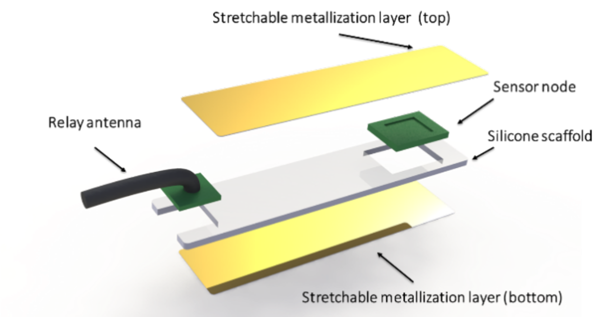

Figure 1: 3D rendering of WiseSkin prototype 1.

For the purposes of the WiseSkin prototype 1, five SCMs (one per fingertip) have been integrated in the silicone substrate, which covers the palm of the MyoHand prosthesis (Figure 2). The test configuration and communication flow are illustrated by Figure 3.

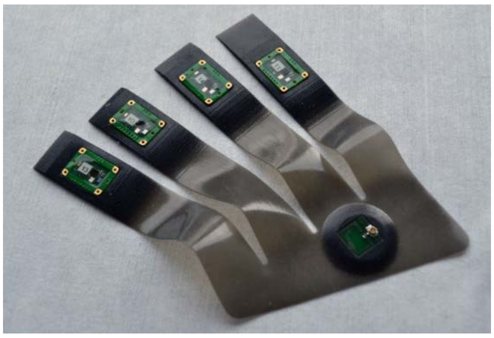

Figure 2: WiseSkin with sensor nodes integrated into the substrate.

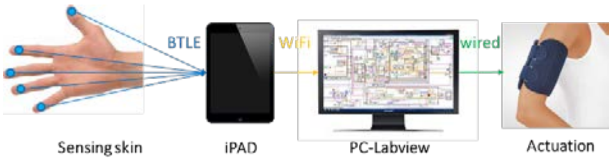

Figure 3: WiseSkin prototype 1 test configuration.

The "skin" is nominally 2-3 mm thick, including the sensor nodes, but it is thinned down to 0.3 mm in regions without sensor nodes in order to improve the mechanical flexibility (i.e. where the fingers bend).The metallic layers are overlayed on the scaffold and connected to a 3V DC power supply (in the future, the power supply of the myoelectric prosthesis would be utilized).

The sensor data propagates between the metallization layers to a relay antenna on the palm and then to an iPAD. The iPAD functions as the master node to which the SCMs are connected via BTLE in a star topology. The sensor data is then transmitted via WiFi from the iPAD to a PC, which drives the tactile feedback display attached to the patient's residual arm. In the future, it is envisioned to replace the antenna relay node by a bridge-gateway that is integrated into the skin, and the skin depicted in Figure 2 would be replaced by a new soft skin designed by EPFL with integrated metalization layer.

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[1] J. R. Farserotu, C. Anfolk, J.-D. Decotignie, D. C. Rojas Quiros, V. Kopta, "Wiseskin for tactile prosthetics", CSEM Scientific and Technical Report (2014) 135.

[2] V. Peiris, M. Kucera, N. Scolari, A. Vouilloz, E. Le Roux, "An ultra-low power bluetooth smart integrated solution", CSEM Scientific and Technical Report (2012) 97.