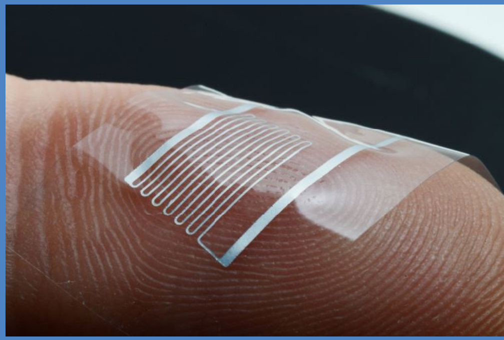
WiseSkin

WISE SKIN FOR TACTILE PROSTHETICS



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What it's about…

Providing a non-invasive solution for restoration of a natural sensation of touch by embedding miniature tactility sensors into the cosmetic silicone coating of prostheses, which acts like a sensory "skin".

Context and project goals

Amputation of a hand or limb is a catastrophic event resulting in significant disability with major consequences for amputees in terms of daily activities and quality of life. Although functional myoelectric prostheses are available today (e.g. hand), their use remains limited due, in part, to a lack of sensory function in the prostheses. At the same time, as the world population both grows and ages, the number of people living with disabilities, such as persons who have lost limbs for whatever reason e.g. trauma, diabetes or cancer, also increases. A sense of tactility is needed for providing feedback for control of prosthetic limbs and to perceive the prosthesis as a real part of the body, inducing a sense of "body ownership". Today, there is no solution for restoration of a natural sense of touch for persons using prosthetic limbs.

WiseSkin provides a solution for restoration of the sensation of touch. It embeds tactility sensors into the cosmetic silicone coating of prostheses, which acts like a sensory 'skin' providing the sensation of touch, enabling improved gripping, manipulation of objects and mobility (walking) for amputees. Flexibility, freedom of movement and comfort demand unobtrusive, highly miniaturized, ultra-low power (ULP) sensing capabilities built into the 'skin', which is then integrated with a sensory feedback system. The focus is on non-invasive (external actuation) sensory feedback mechanisms. The main elements of the project are:

- flexible, skin-like, material embedded with tactility sensors
- miniature, flexible, soft-MEMS based sensors (e.g. pressure, shear)
- ULP, event driven wireless communication (radio and protocol) between the sensors and processing / control module
- a conformal, stretchable powering system based on a metallic mesh grid
- use of the metallization layers as a waveguide
- a system for sensory feedback based on a tactile display (i.e., on the amputation stump or the back) using miniature actuators / electrodes
- Proof-of-Concept demonstrator (i.e., tested on volunteers) combined with brain imaging to investigate neural mechanisms of tactile perception

WiseSkin pushes the forefront of technology in miniature, ULP sensor and communication devices, materials and sensory feedback systems; putting nano-tera research at the forefront. It enhances the competitiveness of Swiss organizations in these domains, helping to open the door for Swiss industry to capture an early and substantial share in the market for advanced, high-density body sensor networks towards artificial skin and tactile robots. Importantly, WiseSkin enables new prosthetic products, with improved functionality, hopefully offering improved quality of life for amputees.

How it differentiates from similar projects in the field

Today, there is no solution for restoring a natural sense of touch to persons using prosthetic limbs. WiseSkin provides a non-invasive solution for restoration of a natural sensation of touch. The approach targets scalability to potentially many sensors, in a high density sensor network, and the ability to cover large areas (i.e. much more than a sensor node at the tip of a finger).

It does so by embedding wireless tactility sensors (and potentially other sensors) into a mechanically robust, flexible, stretchable "skin" which provides for powering, RF waveguide and shielding against interference. The solution supports real-time response and low latency (e.g. as needed for fast reaction to something slipping or falling).

Quick summary of the project status

The design of the Tx for the target FM-UWB radio is ready for tapeout. The simulated power consumption of the radio is 420 μW and the estimated sensitivity is -80 dBm at 200 kb/s.

Design of the optimized routing protocol is in progress; developing a proactive (Node Initiated) routing protocol with high reliability and testing the embedded code with simulations.

Research has confirmed the sensing approach through the skin and design of the electro-mechanical interface to the skin, which is in testing.

A novel approach for the flexible, stretchable metallic layers constituting the "skin" has been developed and tested and the performance of the flexible "waveguide" has also been confirmed and shown to provide low loss with high interference protection.

Testing of the skin shows that it can tolerate a fracture strain larger than 20%.

Further, PDMS-PDMS bonding strength was found to be five times higher than that of PDMS to TangoBlack.

Part of the team is developing the stimulation and sensor feedback concept. They have investigated algorithms to achieve intuitive and versatile control of hand prostheses by detecting hand movement intentions by real-time recording and processing of sEMG signals.

Success stories

- Design of the Tx for the target FM-UWB radio and start of the routing protocol design.
- Confirmation of the sensing approach through the skin
- Design of the electro-mechanical interface to the skin (soft-soft bonding)
- Design of a novel approach for the flexible, stretchable metallic layers
- Flexible "waveguide" performance confirmed
- Development of the stimulation and sensor feedback concept

Main publications

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M. Grambone, O. Ünsal, C. Enz, J. Justiz, H. Huang, T. Li and V. M. Koch, A non-invasive tactile display system with multiple stimulation patterns (2014 Swiss Society for Biomedical Engineering Annual Meeting), SSBE '14.

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