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WiseSkin **RTD 2013**

WiseSkin for tactile prosthetics

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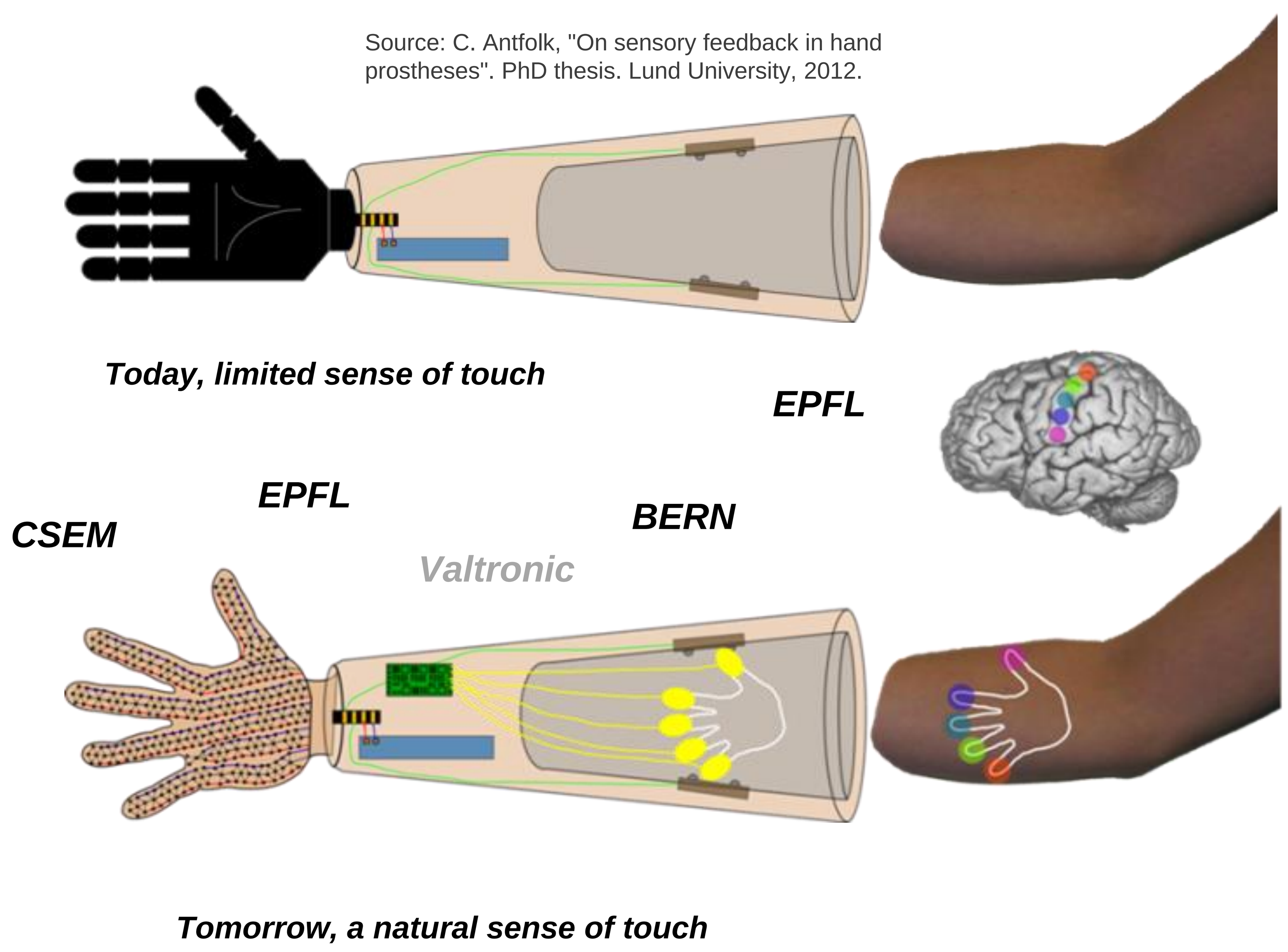
Problem: Amputation of a hand or limb is a catastrophic event resulting in significant disability with major consequences for amputees in terms of daily activities and quality of life. Although functional myoelectric prostheses are available today (e.g. hand), their use remains limited due, in part, to a lack of sensory function in the prostheses. At the same time, as the world's population is growing and aging, the number of people living with disabilities, including lost limbs due to trauma, diabetes or cancer is increasing. A sense of tactility is needed to provide feedback for control of prosthetic limbs and to perceive the prosthesis as a real part of the body; a sense of "body owner ship".

Today, there is no solution for restoration of a natural sense of touch for persons using prosthetic limbs

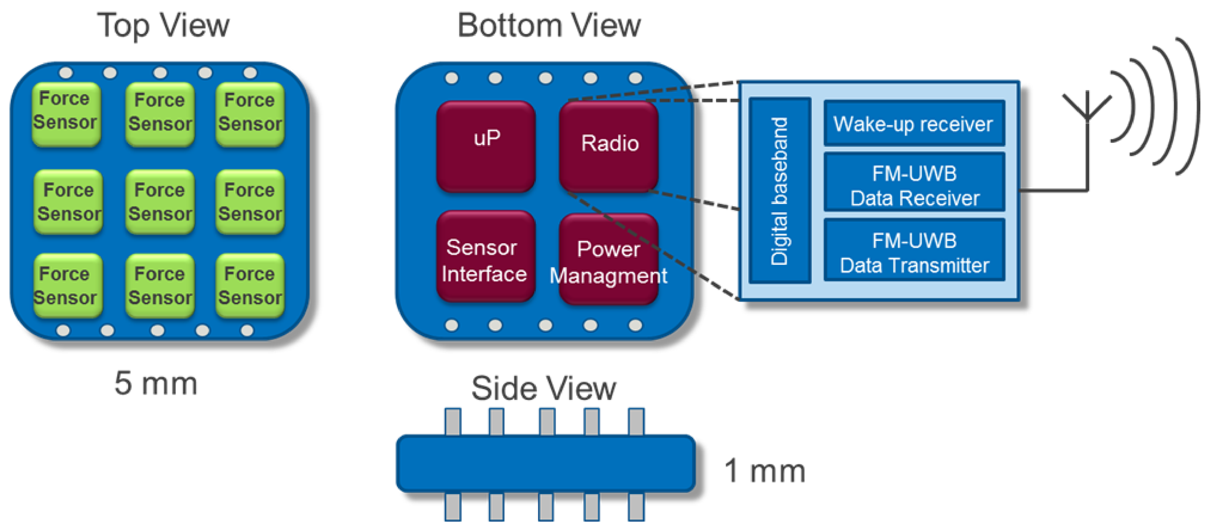
Solution: WiseSkin provides a solution for restoration of the sensation of touch. It embeds tactility sensors into the cosmetic silicone coating of prostheses, which acts like a sensory "skin" providing the sensation of touch, enabling improved gripping, manipulation of objects and mobility (walking) 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 (e.g. gold, liquid metal)
- a system for sensory feedback based on a tactile display (i.e., on the amputation stump or the back) using miniature actuators
- Proof-of-Concept demonstrator (i.e., tested on volunteers) combined with brain imaging to investigate neural mechanisms of tactile perception.



Transduce the artificial skin outputs into appropriate tactile signals to be applied on the phantom map of amputees.

Impact: *WiseSkin* pushes the forefront of technology in miniature, ULP sensor and communication devices, materials and sensory feedback systems. It enables new prosthetic products, with enhanced functionality, hopefully offering improved quality of life for amputees. It also opens the door for new solutions made of intelligent materials (e.g. smart gloves) artificial skin for tactile robots able to more safely work along side people (e.g. in factories and homes robots) and haptic interfaces (e.g. gaming).

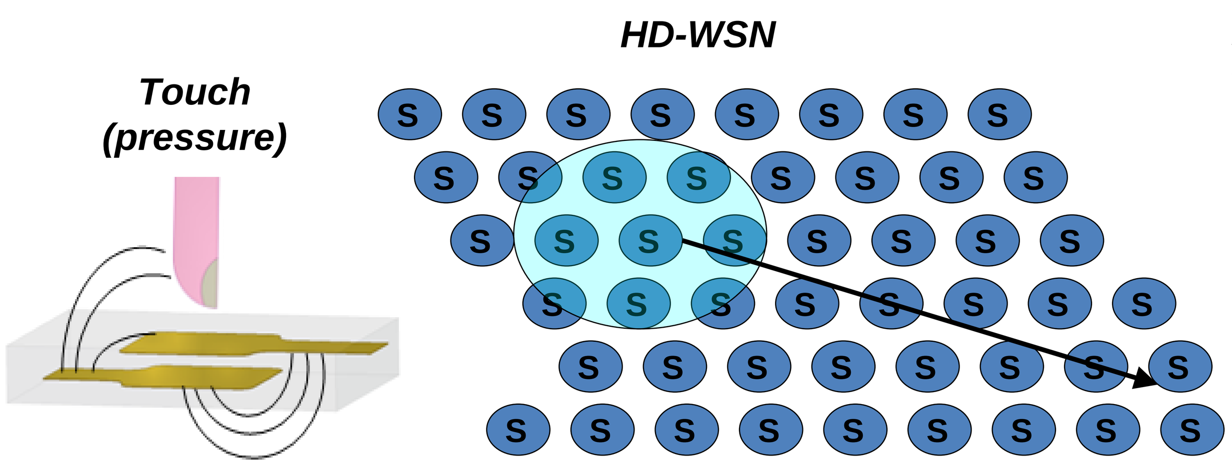


Phantom mapping

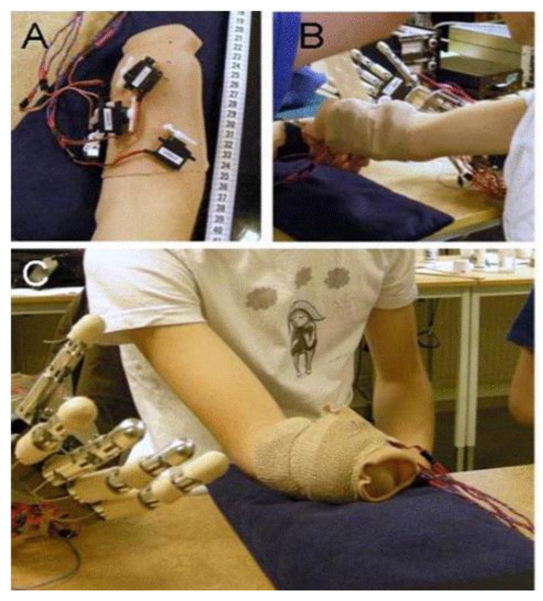
Miniature, tactile sensors with communication & processing + stretchable power distribution & signal transmission layers

Technical challenges:

- **Reliable sensors** / sensing (e.g. pressure and shear) to feel objects, grip and rapidly adjust (moving hand).
- **Ease of use**, freedom of movement, **natural look and feel** of the prosthetic demand highly miniaturized sensors placed almost anywhere
- Minimum impact on **autonomy** of the myoelectric prosthesis.
- **Scalability / modularity** are critical (e.g. communication, processing); potentially many sensors (100-150 mechanoreceptors/cm^2 at fingertip of human hand).
- **Real-time** response and **low latency** are needed to react to slipping or falling, use of the prosthesis without actually watching
- **Sensory feedback / actuation** is essential and the **Human–electronics interface** is key (e.g. electrodes, vibration).
- Advanced **material engineering** for sensing: piezoelectric AlN on elastomers, metallized PDMS waveguide, stretchable sensors



Tactile display and feedback
A) Tactile display applied on a subject's stump.
B) Elastic bandage keeps servomotors in place.
C) Tactile feedback experiments scenario



Scalable, event driven, very short range, robust, HD-WSN with sensors anywhere

Key innovations:

- Wireless and sensor technology
  - Scalable routing, adaptable MAC, robust, event driven, new solutions for High Density Wireless Sensor Network (HD-WSN)
  - Reliable, miniature, soft-MEMS sensors (e.g. pressure)
- Conformal power distribution system
  - Stretchable power distribution and signal transmission layers
  - Electro-mechanical sensor integration and miniature flexible antenna
- Tactile sensory perception and human-electronics interface (HEI)
  - Study and test of a non-invasive HEI on real patients
  - Multi-sensory perception, MRI brain imaging analysis (e.g. phantom finger somatotopy)
- WiseSkin system and technology integration
  - A flexible, stretchable artificial skin / smart material that is relatively easy to manufacture
  - Restore a natural sensation of touch, ease of sensor placement and coverage of large areas

WiseSkin provides a natural sense of touch