PhD thesis

MOMASKIN
Modular skin mOdel for the conception of textile Material in contact with the SKIN

Modèle de peau modulaire pour l'aide à la conception de textiles en contact avec la peau

Keywords: material design, smart textiles, skin model, friction, health and wellbeing

Project environment

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Context

Skin damages like pressure ulcers or blisters are very often due to a complex interplay of several factors like pressure, shear due to friction, moisture accumulation, temperature, and duration of the strain in the different skin layers. Pressure ulcers affect around 30% of the paraplegics and occur when blood vessels in the dermis are compressed in conjunction with moisture accumulation in the epidermis and shear forces at the dermis-epidermis interface. These wounds heal very slowly or even become chronic and therefore, increasing efforts have been made to develop preventive measures like pressure-distributing mattresses or low friction bed sheets. However, the effectiveness of such preventive products is very difficult to prove, as large clinical trials are necessary to show a statistically significant benefit of a newly developed product. This difficulty is similar for the development of socks preventing blister formation for soldiers or professional or amateur sportpersons.

Therefore, realistic skin models are urgently needed to accelerate product development. In particular, these skin-mimicking structures have to represent the heterogeneity and elastic anisotropy of the skin to be able to analyze the mechanical conditions, especially at the dermis level.

Scientific project

The goal of this project is the development of a bio-inspired modular and instrumented skin model, integrating three key elements to account for the heterogeneity/anisotropy of the human skin and to be able to assess mechanical parameters in deeper skin layers (especially in the dermis), as done in previous studies but with taken into account the important effect of humidity (*1-3*). This skin model will be a composite structure consisting of a textile containing fibre sensors, embedded into a textile, following the method developed in a previous PhD between LPMT and Empa (*4, 5*). The sensors will be made of different optical fibres with high sensitivity to the specific stresses (pressure/shear forces, and temperature/humidity). These fibres will be integrated into a textile (woven or knitted fabrics) for increased mechanical stability. The fabrics will finally be embedded into a hydrogel matrix. with mechanical properties similar to the human skin. Specific composite fibre/fabric/hydrogel structures will be developed to mimic the epidermis and the dermis.

The effectiveness of the newly developed skin model will be validated using data from former studies of the supervisors with distinct scenarios like the application of a mechanical load on the skin or tactile experiments.

This new physical skin model aims at reducing human experiments and can serve as a universal method for the investigation of the mechanical interactions within the skin-material, respectively the body-device interfaces under various conditions including scenarios leading to skin damages. It will thus contribute to the understanding of the risks of skin injuries and provide an essential feedback loop for the development of new preventive products and therefore will be a tool for textile aided design.

Références bibliographiques

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2. Guerra C, Schwartz CJ. Development of a Synthetic Skin Simulant Platform for the Investigation of Dermal Blistering Mechanics. Tribol Lett. 2011;44(2):223.
3. Guerra C, Schwartz CJ. Investigation of the influence of textiles and surface treatments on blistering using a novel simulant. Skin Research and Technology. 2012;18(1):94-100.
4. Bahin L. Instrumentation de textiles par fibres optiques polymériques pour mesure in-situ de compression et de frottement [PhD thesis]. Mulhouse: Université de Haute Alsace; 2023.
5. Bahin L, Tourlonias M, Bueno M-A, Sharma K, Rossi RM. Smart textiles with polymer optical fibre implementation for in-situ measurements of compression and bending. Sensors and Actuators A: Physical. 2023;350:114117.

Applicant skills

Background: master in textile, material science or mechanics.

Application process:
The following elements should be e-mailed to the supervisor and the co-supervisors (see the e-mail address above)

- CV,
- Motivation letter,

- Master marks and diploma.

Deadline: 2023 July 5th