Proposal for a PhD

Understanding the mechanisms behind the tactile perception of micro-textured surfaces

Context

Most of our daily interactions with the environment are based on tactile exploration. Tactile perception relies on the stimulation of mechanoreceptors in the skin and on the processing of the response induced by the brain. So far, only few studies have been devoted to uncover the overall "perception chain", i.e. from mechanical stimuli, via signal conversion and transmission, to higher order neural processes related to the interaction of the human body with the touched surface. Surprisingly, most research in the field of sensorimotor control has ignored the mechanical characteristics of the surface in contact with the body. At the same time, most studies in the fields of surface engineering and mechanics have ignored the brain mechanisms involved in the processing of tactile inputs. This is a serious limitation in understanding the sense of touch.

The proposed PhD is part of the **COMTACT project**, which brings together 6 laboratories and is funded by the French National Research Agency (ANR). The overall objective of COMTACT is **to "decode" how the brain constructs the tactile perception** and the internal representation of a textured surface as a function of mechanical stimuli and responses of the biological mechanoreceptors. The 6 partners will combine their skills and work in close collaboration through different fields of investigation such as psychophysics, brain imaging, micro-neurography, tribology and vibrations.

The PhD student's role in the project will be **to reach a better understanding of the mechanical behaviour of the fingerpad/surface contact that drives tactile perception**, in relation to the properties of the texture and finger. In connection with the investigations of the other project partners, he/she will then contribute to the identification of the essential mechanical characteristics of the finger/surface contact involved in the neuronal transmission of signals, brain activity and the perception of the explored textures. This work will therefore focus on the dynamics of tribological contact, but will require strong interaction with other scientific fields in a very multidisciplinary framework.

Working Environments: FEMTO-ST & LaMCoS

The proposed PhD will be carried out **successively in half periods of 18 months** in 2 laboratories specialised in Tribology and Structural Dynamics: firstly, **in the Applied Mechanics Department of the Femto-ST Institute in Besancon**, and more particularly in the "Tribology, Functionalisation and Characterisation of Surfaces" (TFCS) group, and secondly **in the LaMCoS** laboratory, in the Tribology and Mechanics of Interfaces (TMI) and Dynamics and Control of Structures (DCS) teams of the **INSA-Lyon**.

These 2 research entities bring together several dozen people (researchers, engineers, doctoral students and post-doctoral fellows) who are specialists in tribology, dynamics and materials science, and who are equipped with numerous surface characterisation tools as well as custom-made experimental devices dedicated to the study of fingerpad/surface friction (tactile tribometers).

Tasks and objectives of the thesis

The two Femto-ST/LaMCoS laboratories have the technical expertise to produce samples with finely controlled textures, to characterise skin surface properties in vivo, to measure the local dynamics of the contact and to compare it with a numerical model predicting the stresses and strains between the skin and the textured samples.

The PhD will be structured around the following main tasks:

- **Production and characterisation of micro-scale textured surfaces** using clean room technologies (photolithography, plasma etching).
- ***In vivo* characterisation of finger surface properties** (morphology, topography, mechanical and physicochemical properties).
- **Use of a numerical model** of the interaction between the finger and the texture to analyse the dynamic evolution of the real contact area and the contact pressure as well as stresses distribution.
- ***In vivo* fingerpad/texture friction tests** using 2 dedicated tribometers to measure contact forces and induced vibrations under various contact conditions.

These different approaches will allow the PhD student to define and quantify **mechanical descriptors** in order to characterise the behaviour of tactile contact. Strong interactions between the PhD student and the other project partners will be crucial in order to correlate the mechanical descriptors with **biological signals** obtained by electroencephalography and micro-neurography on the one hand, and **texture perception** measured by psychophysical methods on the other hand. In this respect, *in vivo* test campaigns involving all the partners will be implemented. The overall objective will be **to achieve a detailed understanding of the mechanisms linked to perception during touch.**

Perspectives

The PhD student will benefit from scientific experience in the fields of **materials, tribology, surface characterisation, vibration and data post-processing**. These skills are highly valued in **the R&D departments** of many industrial companies, but also in academic research laboratories if the doctoral student wishes to follow a career as a **researcher**. If desired, the doctoral student may also do teaching assignments in mechanics/materials/vibrations.

Skill requirements

Main Skills: Mechanics, Tribology, Vibrations, Signal processing, Surfaces, Materials.

Teamwork in a multidisciplinary context - Precision and rigour - Interest for experimental work Autonomy and initiative - Motivation and keenness - Good English skills (reading, writing, speaking)

Information and applications forms

- Applications (CV, letter of motivation, letter(s) of support, school results) should be sent to:
  - Pierre-Henri CORNUAULT : pierre-henri.cornuault@ens2m.fr
  - Eric CHATELET : eric.chatelet@insa-lyon.fr
- 3-year contract. Net salary: approx. 1700 € net / month + teaching vacations if desired but not obligatory nor guaranteed (approx. 200 € net / month)

References

- Cornuault P-H, Carpentier L, Bueno M-A, Cote J-M, Monteil G **(2015)** *J. Royal Soc. Interface* 10.1098/rsif.2015.0495
- Faucheu J, Weiland B, Juganaru-Mathieu M, Witt A, Cornuault P-H **(2019)** *Acta Psychologica* 10.1016/j.actpsy.2019.102950
- Fagiani R, Massi F, Chatelet E, Berthier Y, Akay A **(2011)** *Tribology Int.* 10.1016/j.triboint.2011.03.019
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