Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

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PhD information	
Title	A tactile feedback surface with haptic guidance : introducing non uniform friction distribution
Main topics regards to CSC list (3 topics at maximum)	Mechatronics, control engineering, power electronics
Required skills in science and	Modelling and control of electro-mechanical

engineering	systems, industrial electronics, base of mechanics

Subject description (two pages maximum)

Tablets and smartphones are devices that use touch as the primary way to interact with them. Their Touch Screen Panels (TSP) are so popular, that they also replace physical buttons and knobs into consumer products. However, a side effect of TSP is that interaction relies more and more on sight, because the surface of a TSP is always flat and hard: it is necessary to watch them during command input. Consequently, the cognitive load is increased, which is a major issue in most of applications: in automotive dashboards for instance, the US authorities has to regulate the use of in-vehicule electronic devices to not decrease drivers' attention [1].

Haptic is the science that studies the sense of touch, and a haptic surface is a surface which is able to change how we perceive it. For example, Apple's electromagnetic haptic actuator can simulate a button click by shaking the body of a touchpad. An optimal control of the actuator's force is necessary to achieve a realistic rendering, which can be easily programmed for a versatile implementation of the click. Recently, our laboratory (L2EP-IRCICA) invented the "friction reduction based haptic surfaces" which use ultrasonic vibration of a glass plate to produce the illusion of touching textured surfaces, although the surface remains flat [2]. By controlling the vibration amplitude and modulating it, a tactile feedback is produced on a user's fingertip touching the plate. Virtual knobs can then be rendered physically by using the friction modulation. This technology is now embedded into the commercial TSP's from the company Hap2U (http://www.hap2u.net/).

Thus, if buttons or textures can be accurately simulated on touch surfaces, we do not have yet means to realize virtual forms. For example, it is not possible to go around with eyes closed on the screen of a tablet, because neither the texture information nor the click information can guide the finger. The aim of this PhD thesis is to investigate the question of guidance during the exploration of the surface of a TSP, by giving the illusion of shapes of virtual objects on the screen. With guidance in addition to texture, it will be easier to find buttons and knobs on the screen. This will have beneficial outcomes in many applications such as automotive, usability of TSP by visually impaired people (like elderly people), education, and so on. In this thesis, we propose to investigate the effect of a non-uniform friction distribution on the finger pad during the movement of the finger.

Friction plays an important role for tactile sensing [3], and past few years have seen many papers studying the relationships between friction and tactile sensing, in particular for the case of textures [4]–[7]. Moreover, [8] has demonstrated that a flat surface can be perceived as textured if friction forces induced by vibrations can be generated with the same profile as those measured on the real surface. However in these studies, the authors measure the averaged friction over the finger pulp, without paying attention to the friction distribution. In [9], the effect of a bump or a hole on the finger pad has been analyzed. The authors show that the local force distribution creates stretched and relaxed zones on the finger pulp, which creates the tactile sensation. Following this observation, they proposed a

device which is able to reproduce the local force distribution. Nevertheless, because the finger pulp is fixed on the device, the friction forces are not controlled.
Thus, the local friction force distribution in the case of shape exploration has not been studied yet. The objective of the thesis is to give the guidelines of a tactile display which is able to control the local distribution of local forces in such a way that a user which freely moves his finger on the display is able to follow a specific shape, like a line, a circle or a rectangle. This work will find applications in the next generation of haptic surfaces for TSP's, but also, and more generally, it can be applied in robotic applications, to improve the tactile sensing of robots.
The PhD thesis will be performed within the academic context of Polytech'Lille and L2EP-IRCICA Lab. where tactile feedback devices are designed, realized and controlled since more than 10 years. Our audience in the haptic community is assessed by 30 publications in dedicated journals (IEEE trans. on Haptics, on Mechatronics) and more than 60 presentations in international conferences. Recently we have been involved in a FP7 European project ITM Marie Curie "Prototouch" (https://cordis.europa.eu/project/rcn/105932_en.html) and a new H2020 project will begin in 2019. As for the industrial context, we are in working in close collaboration with two start-ups focused on touch simulation and we are leading projects within the fields of health and e-trading.

Keywords: tactile feedback, haptics, vibrations, ultrasonic, control, acoustic waves, piezo-electricity

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