Research internship November 2018

Title

Nonlinear waves for programmable surface haptics

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Context

The global context is "programmable surface haptics" which corresponds to tangible interfaces on which the textures can be designed numerically and controlled in real-time. A company based in Grenoble, hap2U, is specialized in this field. Their approach is based on the so-called ultrasonic lubrication principle [1] which consists in using a vibration of the surface in the ultrasonic frequency range to modify the friction coefficient of the finger of a user exploring the surface. hap2U, which is leading a strong activity of research, is always looking for innovative techniques that could offer new functionalities to its products.
In this context, recent discoveries in the field of non-linear acoustics, in particular the possibility to localize vibrational or elastic energy using non-linear metamaterials [2], could be of great interest as it offers new possibilities in term of control of vibrations. The purpose of this internship is to evaluate the contribution that non-linear energy localization can have on the phenomenon of ultrasonic lubrication and its real-time control.

Plan of work

A given experimental setup will be the basis of the study. It is made of an ensemble of piezoelectric actuators coupled to a substrate that create a suitable acoustic wavefield to obtain the ultrasonic lubrification effect (haptic feedback).
The student will have to develop a semi-analytical model of the experiment that takes into account the non-linearities of vibration. This model will be used to determine the feasibility of a spatio-temporal control of a nonlinear wave-packet using the piezoelectric actuators. Several questions have to be answered:

* What maximum amplitude of vibration can be reached?
* Under which conditions does an extended mode destabilize in the form of a nonlinear wave packet ?
* In that case, what type of actuation allows to move the wavepacket from one position to an other, and what time is necessary ?
* How sensitive the system is to perturbations (in particular, the presence of the finger)?

The student will be working at Inria Grenoble Rhône-Alpes within the Tripop research team for the mathematical modelling part, and will carry out the experiments in the office of hap2U located nearby (few kilometers away). The mathematical modelling and experiments will be conducted simultaneously.

References:
[1] M. Biet, F. Giraud, B. Lemaire-Semail. IEEE UFFC, 54, 12 (2007).
[2] M.A. Porter, P.G. Kevrekidis, C. Daraio, Physics Today 68, 44 (2015).

Profile of the candidate

Master 2 or third-year engineering student. Candidates with background in applied mathematics (PDE, waves, dynamical systems), mechanics (deformable bodies, acoustics) and physics are welcome. Skills in programming and simulation (Matlab, Scilab or Python, time-integration schemes) will be highly appreciated.

How to apply

Send an email to matthieu.rupin@hap2u.net and guillaume.james@inria.fr.
Applications must include a CV, a cover letter and grade transcripts.

General information

Contract type : internship agreement
Duration of contract : 5 to 6 months
Starting date : March 1st, 2019
Remuneration : average monthly stipend 550 euros
Location :
-Tripop team, Inria Grenoble Rhône-Alpes, Inovallée de Montbonnot, 655 avenue de l'Europe, 38334 Saint Ismier Cedex.
-hap2U, 20 rue du Tour de l'Eau - 38400 Saint Martin d'Hères