Elastography: how shear waves can be used to see inside soft bodies

Context

The proposed internship is part of a collaborative research project, supported by Collegium SMYLE, in which are associated Femto-ST (https://www.femto-st.fr/fr @ UBFC), and Soft Transducer Lab (https://www.epfl.ch/labs/lmts/ @ EPFL). This project aims at developing new types of soft gripper able to sense ripeness, firmness and internal flaws of soft bodies, in particular for fruits and vegetables (see Fig. 1). Indeed, rapidly and accurately measuring the properties of each individual piece of fruit and vegetable, while it is handled by an automated soft gripper, will enable smarter and more efficient food production, leading to reduced waste, lower environmental impact, fresher and safer food, and higher value products customized to the client' s preferences. The only way to obtain such information is by direct contact with the food, similar to how humans feel fruit to gauge maturity and quality.

Ultrasound elastography (USE) is an imaging technology sensitive to tissue stiffness that was first described in the 1990s [1]. Elastography-based imaging techniques have received substantial attention in recent years for non-invasive assessment of object mechanical properties [2]. These techniques take advantage of changed soft tissue elasticity in various pathologies to yield qualitative and quantitative information that can be used for evaluation of mechanical purposes. This technique is under investigation for human body imaging as it provides quantitative information about the stiffness of tissues, which is of first importance for health purposes. There are two types of wave propagation in ultrasound: longitudinal waves and shear waves (see Fig. 2). Measurements are acquired in specialized imaging modes that can detect tissue stiffness in response to an applied mechanical force (compression or shear wave). Ultrasound-based methods are of particular interest due to its many inherent advantages, such as wide availability including at the bedside and relatively low cost.

Figure 1: A soft gripper designed by EPFL

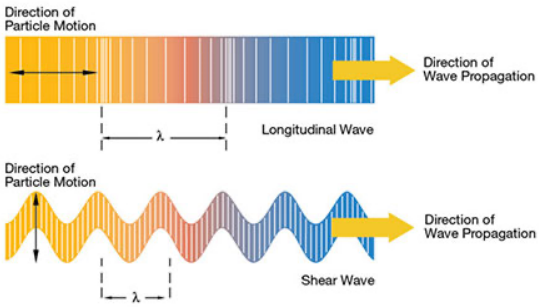

Figure 2: Shear and longitudinal waves.

Work plan

The main objectives of this master internship are to first establish some numerical simulations to assess the best configuration for fruit and vegetable elastography. In particular, the investigation will focus on the number and position of actuators and sensors in order to optimize shear and longitudinal wave propagations [3] which ease elastography. In the meantime, experimental investigations will be performed, by using shakers and other dedicated devices for shear excitation, and 3 scanning vibrometers to measure the resulting signals. Afterwards, the intern will design a first prototype of a test bench, then with the help of mechanical service, the

prototype will be fabricated. It will be equipped with a real time data acquisition system in order to produce data for machine learning classifier.

Internship time schedule

The internship will start in February 2022 and end on July 2022. The time planning of the internship is the following:

1. The intern will first have to do a solid literature review on ultrasound elastography techniques and applications with the help of the project team.
2. The intern will prepare some numerical simulations to assess the best configuration for fruit and vegetable elastography on a benchtop system.
3. The intern will use existing excitation and measurement devices in the lab to perform preliminary experimental investigations.
4. The intern will design and fabricate an experimental setup to produce data for machine learning classifier.

Implementation and supervision team

This master internship will take place in the Applied Mechanics department of FEMTO-ST institute in Besançon and be supervised by Prof. Morvan Ouisse (D-SMART) and Dr. Kanty Rabenorosoa (Micro and Nano Robotics team, AS2M department).

Application

The following candidate profiles is expected for this internship: Mechanics, Mechatronics, etc. The candidate has to send his CV and a cover letter by email to Prof. Morvan Ouisse morvan.ouisse@femto-st.fr and Dr. Kanty Rabenorosoa rkanty@femto-st.fr. The application of the internship will be closed at the end of December 2021.

Bibliography

[1] Gennisson JL, Deffieux T, Fink M, Tanter M. Ultrasound elastography: principles and techniques. Diagnostic and interventional imaging. 2013; 94: 487-95.

[2] Sigrist, R. M., Liau, J., El Kaffas, A., Chammas, M. C., & Willmann, J. K. (2017). Ultrasound elastography: review of techniques and clinical applications. *Theranostics*, *7*(5), 1303.

[3] Bercoff, J., Tanter, M., & Fink, M. (2004). Supersonic shear imaging: a new technique for soft tissue elasticity mapping. *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*, *51*(4), 396-409.