6-months Internship Proposal

Strasbourg University - Laboratoire ICube

March-August 2022

Development of portable digital holography setup for non-contact elastography of biological tissue

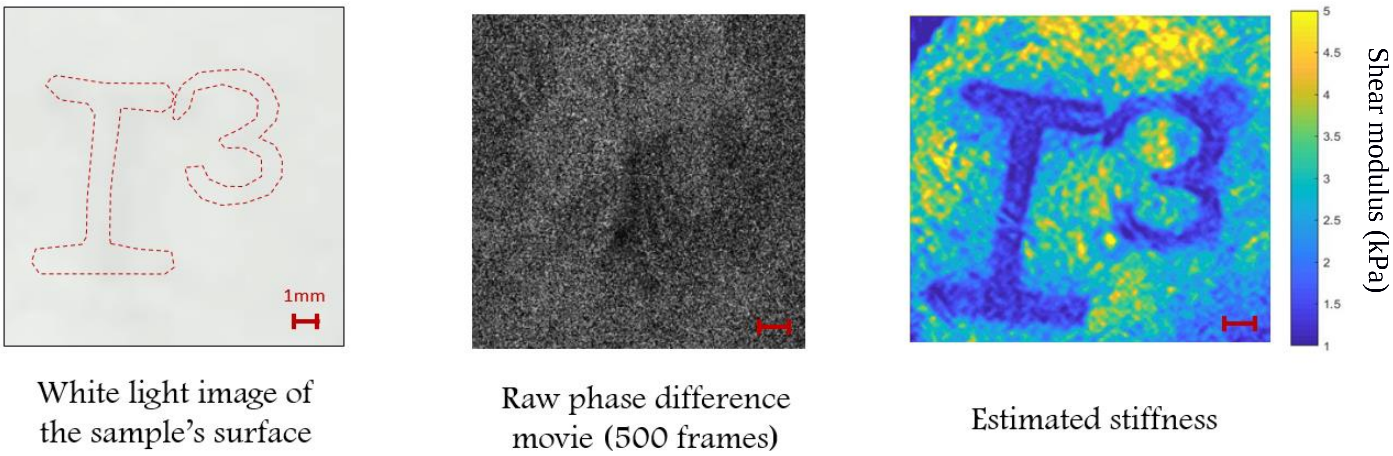
Lab: Laboratoire ICube, Strasbourg, France

Team: Instrumentation et Procédés Photoniques (IPP)

Context: The structure of biological tissues can be altered by certain pathologies such as malignant tumors, metastasis or inflammatory diseases. This change of structure leads to the modification of the mechanical properties of tissues whether it is local, in the case of a tumor, or affects the whole organ, for example in liver fibrosis. When the tissues are accessible, experienced physicians can detect those structural anomalies through palpation. The information provided by touch is thus imprecise and qualitative. Adding quantitative stiffness to medical imaging systems could be a strong aid in diagnosis, particularly in cases of small lesions or inaccessible tissues.

In our group, we currently develop a new optical approach to image quantitative mechanical properties of biological tissues using digital holography (Figure 1). This approach, based on the time-reversal of diffuse shear wave field naturally generated inside the body, is totally passive, non-contact and real time. This makes this approach especially promising tool for localizing and characterizing tumors *in-vivo* during surgery. The method was validated on polymer samples and first results on *ex-vivo* biological tissue were recently obtained [1]. The next step in this project is now preclinical testing.

Figure 1: Images of an agarose sample with a softer inclusion [1]. The inclusion is not visible on the white light image as the sample is optically homogeneous (left). With the digital holography setup, a movie of the displacement induced by the mechanical noise within the sample was captured. This is illustrated by a frame from this raw phase movie (center). The time-reversal algorithm retrieves the sample's stiffness quantitatively from this movie (right).



Description: The objective of this internship is to develop a robust, compact and portable version of the current optical system for preclinical testing. After evaluating the constraints of the medical context and technical limitations of the system, the student will work to accommodate those in the optical system design. The student will also work on the optimization of the existing image processing algorithm.

Knowledge in optical instrumentation and experience in image processing with Matlab or Python are strongly recommended.

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Possible PhD position: yes (ANR grant)

References:

[1] Marmin, A., Catheline, S., & Nahas, A. (2020). Full-field passive elastography using digital holography. Optics Letters, 45(11), 2965-2968.

[2] Marmin, A., Laloy-Borgna, G., Facca, S., Gioux, S., Catheline, S., & Nahas, A. (2021). Time-of-flight and noise-correlation-inspired algorithms for full-field shear-wave elastography using digital holography. Journal of Biomedical Optics, 26(8), 086006.

[3] Kennedy, B. F., Wijesinghe, P., & Sampson, D. D. (2017). The emergence of optical elastography in biomedicine. Nature Photonics, 11(4), 215-221.