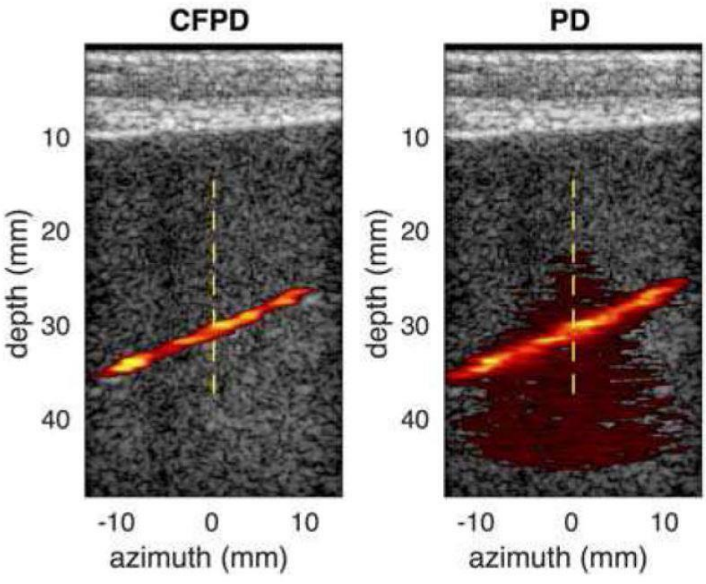
Master Internship
Small vessels imaging using ultrasound coherence

Meniscal tears are the most common injuries treated in the knee joint. During a knee arthroscopy, the choice to perform a meniscectomy is directly linked to the density of vascularization in the tear zone. If the vascularization is too poor, the damaged zone is removed but at the risk of future complications. Currently, surgeons can use fiber optic cameras for estimating the density of vascularization. However, these cameras cannot clearly separate the vascularization from the surrounding tissue, thus resulting in a poor sensitivity and contributing to the low success rate of meniscectomy.

The Meniscare project is a collaboration between CREATIS and the LiPhy lab in Grenoble which aims at finding more efficient imaging methods for visualizing the meniscus vascularization during meniscetomy. In particular, the approach chosen by CREATIS is to use a new type of arthroscopic probe to image the vascularization with ultrafast ultrasound sequences [1]. This probe have already been tested and validated during *in vitro* experiments but there are still questions remaining on the optimal filtering of ultrasound signals.

Indeed, ultrasound imaging of blood flow is inherently limited by numerous source of noise: echoes from surrounding tissues (clutter), electronic noise from the acquisition system, motion artefacts, etc. The clutter noise is particularly problematic in small vessel imaging because it mainly arises from tissue motion that cannot be separated from blood signal using temporal filter. Hence, spatiotemporal filters that also account for the spatial characteristics of tissue motion and blood flow have to be used [2]. For a better isolation of the blood from the tissue, filters that exploit the coherence of the received ultrasound signal i.e. its similarity in a given temporal or spatial window can also be applied [3]. Indeed, the blood signal exhibits different coherence characteristics compared to the tissue signal that can be used to separate the twos.

A Vantage programmable ultrasound scanner



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Ultrasound image of a blood-mimicking flow with (left) and without (right) coherence filtering [3]

The purpose of this internship is to investigate theoretically and experimentally coherent-based approaches for enhancing ultrasound imaging of small vessels. First, the intern will have to understand the coherence characteristics of the ultrasound signal and how it can be exploited to discriminate blood flow and tissues. The intern will also have to identify how coherence filters can improve ultrasound images compared to spatiotemporal filters. In parallel, the intern will familiarize with the ultrasound imaging methods used in the Meniscare project using simulations with the MUST toolbox (https://www.biomecardio.com/MUST/). In a second time, the intern will perform experiments with a programmable ultrasound scanner to test and validate the retained coherence filters. A specific experimental set-up will have to be elaborated for the tests.

The proposed project is at the border of acoustic imaging, signal processing, simulation and experimental acquisitions.

Profile/Skills: Student from a top engineering school or university (generalist or EEA profile) with a speciality in image and signal processing, ultrasound imaging or acoustics.

Start and duration of the course: February/March 2022 for a duration of 6 months.

How to apply

Send CV + cover letter + M1/M2 or engineering school transcripts to:

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References

[1] J. Bercoff *et al.*, « Ultrafast compound Doppler imaging: providing full blood flow characterization », *IEEE Trans. Ultrason. Ferroelectr. Freq. Control*, vol. 58, n° 1, p. 134-147, janv. 2011.

[2] C. Demené *et al.*, « Spatiotemporal Clutter Filtering of Ultrafast Ultrasound Data Highly Increases Doppler and fUltrasound Sensitivity », *IEEE Trans. Med. Imaging*, vol. 34, n° 11, p. 2271-2285, nov. 2015.

[3] Y. L. Li, D. Hyun, L. Abou-Elkacem, J. K. Willmann, et J. J. Dahl, « Visualization of Small-Diameter Vessels by Reduction of Incoherent Reverberation With Coherent Flow Power Doppler », *IEEE Trans. Ultrason. Ferroelectr. Freq. Control*, vol. 63, n° 11, p. 1878-1889, nov. 2016.