



Stage proposé aux étudiants de Master 2ème année

High-quality ultrasound imaging of bone

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Project description : Tremendous progress has been made during the last decade in ultrasound (US) medical imaging leading to more quantitative measurements, higher resolution images and novel clinical applications. These advances were triggered by the availability of novel instrumentation (programmable US scanners, probes with high sensitivity) and increasing computational power enabling the use of sophisticated signal processing techniques.

Quantitative ultrasound (US) imaging of cortical bone is an emerging research topic for which we are expecting rapid developments [1,2]. The current quality of bone images is low, preventing the identification of tissue heterogeneities and a proper description of the bone-marrow interface which is of clinical importance. The lower quality of bone ultrasound images, compared to soft tissue images, is due to the limited efficiency of standard image reconstruction techniques to account for the complexity of US propagation in bone (refraction at the soft tissues-bone interface, strong attenuation, coupling of different wave types propagating in a solid).

Our group (LIB) has recently obtained the first in vivo images of human cortical bone, enabling a measurement of bone thickness and material properties [2]. However, the images are of relatively poor quality. **Novel methods to reconstruct the ultrasound image from radiofrequency signals, including inverse problem and machine learning approaches have a high potential to improve the image quality.**

The **objective of the project is to propose a framework for bone imaging using an inverse problem (IP) approach based on the matrix form of the imaging operator** [3,4]. The trainee will program the related algorithms and evaluate their performance using US acquisitions on artificial objects and bones.

The trainee will work in the "Bone Quality" group in the Laboratoire d'Imagerie Biomédicale which is developing novel quantitative imaging methods for bone, investigates the determinants of bone quality and considers applications in orthopedics and bone physiology. The project is a collaboration with Institut d'Alembert.

The successful candidate is expected to have a **strong interest in biomedical research and signal processing. He/She should have basic experimental, computer, and writing skills. Ideally, he/she will have a background in acoustics, signal processing or computer science.**

References :

- [1] Q. Grimal and P. Laugier, "Quantitative Ultrasound Assessment of Cortical Bone Properties Beyond Bone Mineral Density," IRBM, vol. 40, no. 1. pp. 16–24, 2019.
- [2] G. Renaud, P. Kruizinga, D. Cassereau, and P. Laugier, "In vivo ultrasound imaging of the bone cortex," Phys. Med. Biol., 2018.
- [3] B. Berthon et al., "Spatiotemporal matrix image formation for programmable ultrasound scanners," Phys. Med. Biol., vol. 63, no. 3, 2018.
- [4] E. Ozkan, V. Vishnevsky, and O. Goksel, "Inverse Problem of Ultrasound Beamforming with Sparsity Constraints and Regularization," IEEE Trans. Ultrason. Ferroelectr. 65, no. 3, pp. 356–365, 2018.