Post-Doctoral Position at the Laboratory of Therapeutic Applications of Ultrasound (LabTAU)

Development of a 3D platform for Passive Acoustic Mapping of cavitation

Description

Therapeutic ultrasound offers great perspectives for minimally invasive surgery, enhanced drug delivery or cancer immunotherapy. It now addresses an extensive range of indications, from prostate or brain tumors to glaucoma. Among other mechanisms, various emerging applications rely on the phenomenon of ultrasound cavitation, which represents the oscillation of ultrasound-induced microbubbles. In any of these applications, monitoring the treatment in real-time is required for potential clinical applications. While active ultrasound B-mode imaging is well suited to monitor thermal or mechanical permanent alteration of tissues, the microbubble activity – directly actuated by high-intensity ultrasound – cannot be characterized in real-time using an active ultrasound scanner because of dazzling effects.

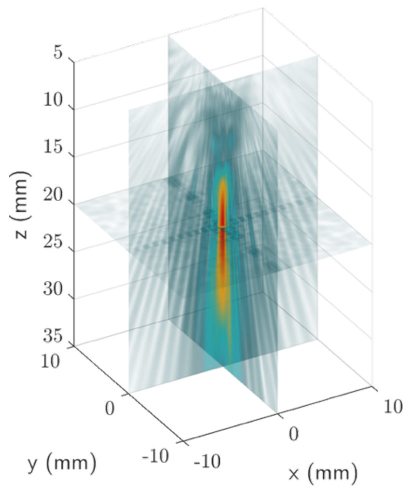

Figure 1: 3D Passive Mapping of a point source at position (0,0,20) mm. Main lobe size is an order of magnitude larger in the axial direction than in the transverse directions.

To localize and quantify the cavitation activity, Passive Acoustic Mapping (PAM) beamforming techniques have been used, but they suffer from weak spatial resolution in the axial direction, perpendicular to the array, when conventional imaging arrays are used. This is even more critical for applications requiring a 3D monitoring of the cavitation activity. Indeed, even if a few works have demonstrated the feasibility of 3D passive acoustic mapping of cavitation, especially in the context of transcranial therapy with very specific hemispherical arrays, 3D mapping with conventional matrix arrays suffers from very low axial resolutions due to diffraction effects associated to the low apertures of the probes. Adaptive beamformers have proven to be an effective way to enhance PAM resolution but do not entirely compensate for those diffraction effects and complimentary research avenues such as dual array mapping have to be considered to achieve millimetric or sub-millimetric resolutions in any direction.

Within the CAVIIAR ANR Project framework, the candidate will have to **evaluate the feasibility of a dual-probe mapping based on two commercial matrix arrays with electromagnetic tracking of their positions**. He will then **develop a 3D navigation and imaging platform** combining one or two open ultrasound scanners connected to two matrix arrays, a tracking unit giving translational and rotational data of each probe, a 7-axis robot that will give reference positions of the probes in an evaluation step, and a 3D navigation station providing tools for communication with other devices, reconstruction and visualization in a 3D virtual environment with fusion capability of active and passive US images. The platform will aim at **providing dual-array 3D PAM of cavitation events triggered in agar-based phantoms** with millimetric or sub-millimetric resolution in any direction using two commercial matrix-array probes. This project is a collaboration between the “Laboratory of Therapeutic Applications of Ultrasound” (LabTAU) and the “Centre de Recherche en Acquisition et Traitement de l'Image pour la Santé” (CREATIS), the candidate will work with researchers of both teams.

Profile

Candidates will typically have a **PhD degree in biomedical engineering or acoustics with a strong experience in instrumentation, device interface, communication and programming in the field of medical imaging.** Data analysis (interpretation, discussions and presentation of scientific results, writing of technical reports and scientific papers) as well as programming skills in C++ (ideally ITK, VTK), MATLAB, CAD (ideally 3DSlicer) and signal processing/transfer (ideally OpenIGTLink) are desirable. The position is funded by the LabEx CELYA (Centre Lyonnais d'Acoustique, https://celya.universite-lyon.fr) for 1 year. An additional 1 year funding can be considered within the CAVIIAR project.

Contact

Interested candidates should send a CV and cover letter to **Barbara Nicolas** (barbara.nicolas@creatis.insa-lyon.fr) and **Bruno Gilles** (bruno.gilles@inserm.fr).

Références

[1] Polichetti, M., Varray, F., Gilles B., Béra J. C. and Nicolas, B. (2021). Use of the cross-spectral density matrix for enhanced passive ultrasound imaging of cavitation. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, *68*(4), 910.

[2] Sivadon, A., Varray F., Nicolas B., Béra J. C. and Gilles B. (2020). Using Sparse Array for 3D Passive Cavitation Imaging. 2020 IEEE International Ultrasonics Symposium (IUS), Las Vegas, NV, USA, 2020, pp. 1-4, doi: 10.1109/IUS46767.2020.9251562.

[3] Daunizeau, L., Nguyen, A., Le Garrec, M., Chapelon, J. Y. and N'Djin, W. A. (2020). Robot-assisted ultrasound navigation platform for 3D HIFU treatment planning: Initial evaluation for conformal interstitial ablation. *Computers in Biology and Medicine*, 124, 103941.