Ph.D. Position (3 Years):

Identification of a complex ultrasound cavitation field using passive imaging

Context of the Study

The development of new extracorporeal focused ultrasound therapies based on cavitation requires to spatially monitor and control the cavitation activity in tissue. Precisely, the literature shows that adaptive imaging approaches can be rather efficient to localize a point-like cavitation cloud with a good resolution. However, the convergence of such methods in case of more complex cavitation fields remains a challenging issue. In this context, an implementation of such methods for therapeutic applications could encounter problems, for example, in case of a large cavitation cloud, or in case of separate secondary cavitation spots, which could induce damage on tissue outside the targeted zone.
Researchers from the LabTAU (Laboratory for Therapeutic Application of Ultrasound, http://labtau.univ-lyon1.fr) and CREATIS (Centre de Recherche en Acquisition et Traitement de l'Image pour la Santé, https://www.creatis.insa-lyon.fr/) developed expertise in the development of extracorporeal therapeutic devices based on ultrasound cavitation phenomenon, as well as in the implementation of passive techniques for cavitation imaging during high intensity focused ultrasound sonication.

Overview of the Subject

On the basis of this expertise, adaptive approaches for cavitation localization will be tested in the case of complex cavitation fields, and compared to robust approaches already implemented in our groups. Specifically, the capacity of those methods to discriminate several cavitation spots, and to evaluate the size of a large cavitation cloud will be studied. New monitoring strategies will have to be defined to obtain the best 3D characterization of any complex cavitation field, without any a priori knowledge of its structure. Ultimately, the objective will be to develop a real-time cavitation mapping device, with the aim of regulating both spatially and temporally the cavitation activity during a therapy sonication.

The first tests won't address the specific aspects of a complete 3D characterization of the cavitation clouds, and will focus on the refinement of the axial resolution of the mapping, and on the identification of non point-like conformations of the cavitation clouds, in simple geometric configurations.
Then, to take into account more realistic configurations, matrix probes will be used to develop a 3D imaging technique for the whole volume under study. This should enable to suppress artifacts due to the 2D mapping of an intrinsically 3D cavitation cloud.

Skill Requirements

Expected skills for the candidates include:

- Signal and image processing
- Instrumentation
- Acoustics

An additional training or an internship in the field of medical imaging or of biomedical engineering will be an asset.

If necessary, skills in the fields of ultrasound or echography will be developed within the laboratory during the first year, especially based on the courses of the Master of Science in Acoustics offered by the Université de Lyon.

Host laboratory

The work will be conducted in both laboratories: the Laboratory for Therapeutic Application of Ultrasound (LabTAU) and the Centre de Recherche en Acquisition et Traitement de l'Image pour la Santé (CREATIS – site INSA), in Lyon-Villeurbanne.
The Ph.D. position is funded by LabEx CELYA (Centre Lyonnais d'Acoustique, https://celya.universite-lyon.fr).

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Contacts

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References:

[1] Boulos, P., Varray, F., Poizat, A., Ramalli, A., Gilles, B., Bera, J. C., & Cachard, C. (2018). Weighting the passive acoustic mapping technique with the phase coherence factor for passive ultrasound imaging of ultrasound-induced cavitation. *IEEE transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, *65*(12), 2301-2310.

[2] Polichetti, M., Varray, F., Béra, J. C., Cachard, C., & Nicolas, B. (2018). A Nonlinear Beamformer Based on p-th Root Compression—Application to Plane Wave Ultrasound Imaging. *Applied Sciences*, *8*(4), 599.

[3] Desjouy, C., Poizat, A., Gilles, B., Inserra, C., Bera, J.C. (2013). Control of inertial acoustic cavitation in pulsed sonication using a real-time feedback loop system. *Journal of the Acoustical Society of America, 134(2),* 1640-1646.