Title of the internship's project:

3D imaging of biological currents in the heart

Professional domain:

Ultrasound imaging and data analysis

Host laboratory / Company:

Laboratoire Physique pour la Médecine Paris
(anciennement Institut Langevin, Equipe "Physique des Ondes pour la Médecine")

Lab / Office location:

Physique pour la Médecine Paris,
17 rue Moreau
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Daily intern supervisor(s):

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Start date/End date / Number of weeks: 6 months (adjustable)

Description of the Project

Objective (s) of the project:

The project aims to translate a recently developed novel imaging method into the 3D domain, for 3D visualisation and mapping of the electrical currents in the heart.

State of the art & rationale:

It is crucial to be able to visualize and measure the electrical activation in the heart for the detection and diagnosis of a number of pathologies leading to potential cardiac arrest. However there is currently no technique that allows for direct imaging of the electrical activation non-invasively.

Ultrafast acoustoelectric imaging (UAI) has recently been proposed as a novel method for providing 2D images of biological current densities [1]. The technique leverages the acoustoelectric effect, a modulation of a medium's electrical impedance when a pressure wave propagates through it. At the Institut Langevin, an integrated custom prototype was developed using existing programmable ultrasound systems, which allowed for the generation of 2D images of the electrical activation in the rat heart for the first time [2] [3]. However the technique is currently limited to the field of view of the ultrasound probe, which hampers its sensitivity. As a consequence, electrical current densities are only detected in some parts of the heart, while the electrical activation in the cardiac muscle is complex and anisotropic.

Methods and tools:

The Institut Langevin has recently acquired several 3D ultrasound acquisition devices together with matrix transducer arrays which allow for ultrafast ultrasound emission and image formation in 3D. The programmable ultrasound devices are run using Matlab. The Institut Langevin is also equipped with fully certified facilities for small animal imaging and a range of phantom material which allows for experimental ultrasound imaging.

Main tasks:

Preliminary tests have already been conducted for 3D UAI, but the main task remaining is to optimize the acquisition and image formation process to allow precise visualisation of the biological currents in the whole organ.

Anticipated outcomes and potentials:

We believe that 3D ultrasound emissions mays highly increase the sensitivity of the technique and provide full temporal 3D views of the electrical activation in-vivo. This would pave the way for the development of a new 3D prototype, which in the future could be used in the clinic to diagnose cardiac activation dysfunctions such as arrhythmias.

Role of the student:

The student will become familiar with 3D ultrafast ultrasound emission and acquisition, and with the custom UAI system. She/he will be responsible for implementing and optimising the acquisition and image analysis processes, and mainly for designing phantom and leading ex-vivo and in-vivo experiments to validate the image acquisition and formation.

References:

[1]. Olafsson et al. *IEEE Trans Ultrason Ferroelectr Freq Control.* 2009

[2]. Berthon et al. *Physics in Medicine and Biology* 2018

[3]. Berthon et al. *The Journal of the Acoustical Society of America* **142**, 2697 (2017)