Optimal acoustic sensing in complex scattering media

Research internship (2024)

Laboratory: Laboratoire Interdisciplinaire de Physique (LIPhy), Grenoble, France
Supervisors: Dr. Dorian Bouchet and Prof. Emmanuel Bossy

Project description

Medical ultrasound imaging is based on a simple principle: an array of sources emit acoustic waves into the medium to be imaged, and these waves are reflected back to a sensor by the object of interest. Acoustic waves propagate in a simple way in soft biological tissues, which allows doctors to easily examine pregnant women using ultrasound waves. However, **it remains extremely challenging to perform ultrasound imaging when acoustic waves propagate in complex media**. For instance, it is very difficult to visualize the activity of the brain using ultrasounds, because the skull distorts acoustic waves in an uncontrolled way. **This challenge motivates us to get a better fundamental understanding of how acoustic waves propagate in complex media.**

In the last decades, the possibility to control many independent sources has been widely employed to maximize the acoustic energy anywhere inside complex scattering media. Instead of maximizing the acoustic energy, this internship project will now tackle the following question: **how can we take advantage of these numerous acoustic sources in order to maximize the amount of information delivered to the observer?** On the conceptual side, the project associates tools from wave theory and information theory in order to understand how information propagates in complex scattering systems, in both space and time. On the experimental side, the project involves the development of a proof-of-principle system designed to measure the position of a target hidden inside a random scattering medium composed of acoustic scatterers. Using a state-of-the-art array of transducers, the acoustic field will be shaped in space and time in order to measure the properties of the hidden target in the most precise way.

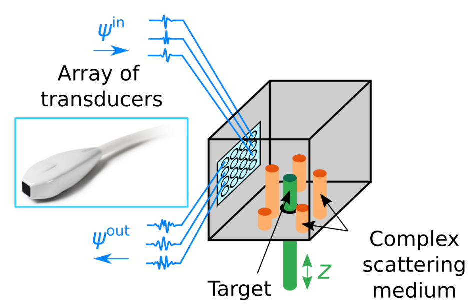

Fig. 1: Principle of the acoustic experiment that will be developed in order to maximize the amount of information enclosed in measured waves regarding the properties of a hidden target, such as its position z.

Profile of the candidate

This project can be carried out as a M2 internship, or as part of Graduate Schools requirements. Candidates with academic backgrounds in physics or engineering are expected. Specific skills in numerical modeling (Python, Matlab,...) will be a strong advantage for the project.

For further information

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References:

- D. Bouchet and E. Bossy, Physical Review Research 5, 013144 (2023)
- G. Godefroy, B. Arnal, and E. Bossy, Scientific Reports 13, 2961 (2023)