Chair: Physics of Fluids group

Non-invasive ambient pressure detection using ultrasound and physics-informed deep learning

Description

Microbubbles exhibit a unique, nonlinear resonance to pressure waves [1], which makes them excellent ultrasound scatterers. They are therefore used as blood pool contrast agents for ultrasound imaging. As a result of their nonlinear properties, microbubble echoes contain frequencies that are not present in the ultrasound driving signal (harmonics and subharmonics in particular). The ambient pressure is known to affect the bubble behaviour and, in particular, the generation of these harmonics. These changes in the microbubble response could be harnessed for non-invasive blood pressure estimation: local blood pressure is a key indicator of many vascular diseases that remain difficult to assess.

Physical models exist that can accurately predict the microbubble response for a given ambient pressure. However, the inverse problem (estimating the ambient pressure from the microbubble response) is far more challenging. Deep-learning-based methods have proven effective in solving inverse problems. A limitation of many deep-learning methods is that they do not make use of known theories from physics.

Assignment

Neural networks can solve such inverse problems much more effectively when the known governing physical equations are integrated: this is physics-informed deep learning. The goal of the project is two-fold:

1. You will measure the response of microbubbles to ultrasound as a function of the ambient pressure using a state-of-the-art research ultrasound machine.
2. With the help of our team, you will develop a physics-informed neural network that can estimate the ambient pressure in your experiments.

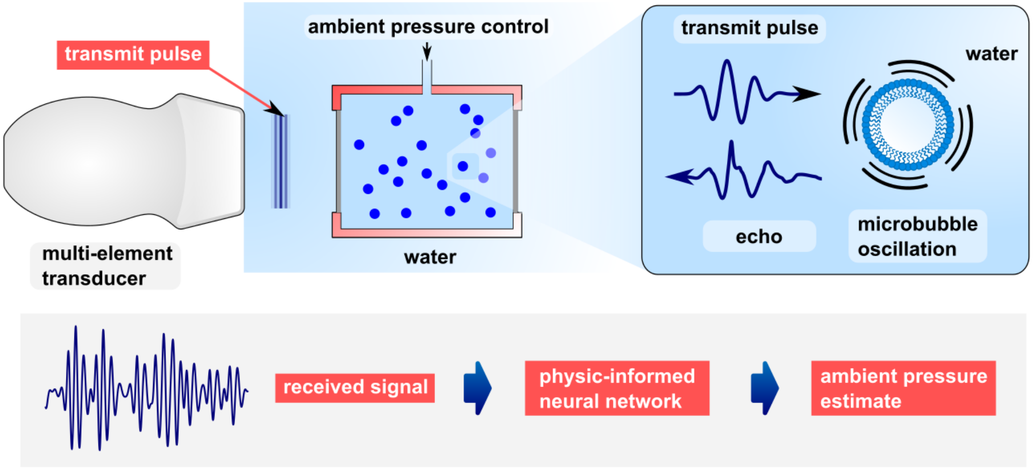

Figure 1: schematic of data acquisition and processing

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References

[1] T. Segers, E. Gaud, M. Versluis, and P. Frinking, "High-precision acoustic measurements of the nonlinear dilatational elasticity of phospholipid coated monodisperse microbubbles," *Soft Matter*, vol. 14, no. 47, pp. 9550–9561, 2018