Master's internship

Removal of ultrasound artefacts using neural networks

I Scientific context

Ultrasound imaging is obtained by transmitting and receiving ultrasound waves, using an ultrasound probe made up of piezoelectric elements. The physical physical constraints associated with the construction of such a probe impose artefacts on the signals obtained, linked to the size of the elements, their spacing and their emission frequency.

In this project, the aim is to overcome the physical constraints of the probes thanks to simulation of ultrasonic signals, in order to obtain simulated images of better quality than those which can be obtained in reality, which we will call 'idealised'. These idealised images will then serve as training data for a neural network, taking realistically simulated signals as input, to reconstruct these idealised images.

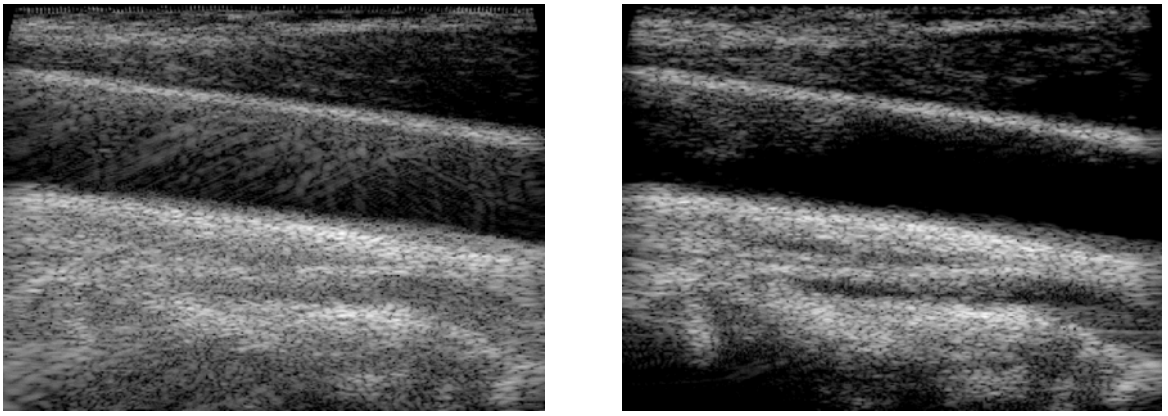

FIGURE 1 – Example of a simulated image with real (left) or idealised probe (right)

Deep learning requires a large amount of good quality reference data. In medical imaging, access to reference data is rare. It is therefore interesting to use realistic, perfectly controlled simulated images as a replacement. Previous work in the laboratory has already demonstrated the effectiveness of this approach, whether for estimating the movement of the heart [1] or the speed of the blood [2].

II Objectives of the internship

The aim of this internship is to train a neural network to reconstruct idealised ultrasound images from realistic simulated acquisitions. We will use an existing realistic simulator, SIMUS [3, 4], which is part of the Matlab Ultrasound toolbox MUST [5], and adapt it to obtain these idealised image simulations.

The work involves several stages :

— Familiarize yourself with the SIMUS simulator

— Understand the physics of ultrasound signal acquisition
— Simulate realistic/idealistic image pairs
— Train and evaluate neural networks on this data

III Required skills

— Good Python programming skills (Pytorch, NumPy, SciPy)
— Knowledge of deep learning
— Interest in medical imaging in general, and ultrasound in particular
— Knowledge of Matlab is a plus

IV Informations

— Duration of the internship : 5 to 6 months
— Location : Creatis laboratory, 21 Avenue Jean Capelle, Villeurbanne
— Supervisors : Damien Garcia (damien.garcia@creatis.insa-lyon.fr) and Fabien Millioz (fabien.millioz@creatis.insa-lyon.fr)
— Send CV, cover letter and last transcript of marks

Références

[1] Jingfeng Lu, Fabien Millioz, François Varray, Jonathan Porée, Jean Provost, Olivier Bernard, Damien Garcia, and Denis Friboulet, "Ultrafast cardiac imaging using deep learning for speckle-tracking echocardiography," *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, 2023.

[2] Julia Puig, Fabien Millioz, Damien Garcia, and Denis Friboulet, "Estimation du déphasage et réduction du repliement par apprentissage profond pour l'imagerie ultrasonore," in *Gretsi*, GRETSI Groupe de Recherche en Traitement du Signal et des Images, Ed., Grenoble, France, Aug. 2023, number 2023-1332, pp. p. 1001–1004.

[3] Damien Garcia, "SIMUS : An open-source simulator for medical ultrasound imaging. Part I : Theory & examples," *Computer Methods and Programs in Biomedicine*, vol. 218, pp. 106726, 2022.

[4] Amanda Cigier, François Varray, and Damien Garcia, "SIMUS : An open-source simulator for medical ultrasound imaging. Part II : Comparison with four simulators," *Computer Methods and Programs in Biomedicine*, vol. 220, pp. 106774, 2022.

[5] Damien Garcia, "Matlab ultrasound toolbox," https://www.biomecardio.com/MUST/.