PhD Thesis Presentation

Candidate: BUJOREANU Denis

Title: Compressed Ultrasound Imaging: a novel method for ultrafast image acquisition

Supervisor: FRIBOULET Denis

Co-Supervisor 1: NICOLAS Barbara

Co-Supervisor 2: LIEBGOTT Hervé

Compressed Ultrasound Imaging: a novel method for ultrafast image acquisition

Introduction

Ultrasound imaging has become one of the major diagnostic tools in the medical world. This trend is mainly due to its low cost and real-time imaging capability. Numerous researches have been conducted to increase the data acquisition rate in medical ultrasound imaging. An important milestone in this field was the introduction of the plane wave insonification that led to high frame rate ultrasound imaging [2]. My PhD project aims to develop this concept further, and our goal is to establish a new method for even faster ultrasound imaging.

Background

Current medical ultrasound scanners have an acquisition rate around 30 to 40 frames per second (FPS) and this number is limited by the propagation velocity of the sound through soft tissue ($c \approx 1540m/s$) and the number of scan lines to be made (N_l). For instance, to be able construct a $d = 10cm$ depth image with $N_l = 128$ lines, $t = N \times \frac{2d}{c} = 17ms$ are needed, which will give an approximate FPS_0 of 59 (see figure 1a).

In the concept of plane wave ultrasound imaging, the transmission of a focused beam for each line of the image is not employed anymore, thus the time needed to construct the same image as before is $t = \frac{2d}{c} = 0.13ms$ which gives us theoretically a FPS_1 of 7700. However as we can see in the figure 1b the overall quality of the image is lower.

Montaldo et al. [1] demonstrated that a coherent compounding of images obtained from several steered plane wave insonifications of the same medium provides a final image with higher quality. The main idea of their concept was to reconstruct N_i images of the same medium, using N_i plane waves, each steered in different directions, and then to coherently add them. In figure 1c,d and e are shown $N_i = 3$ low resolution images and the resulting high quality image (see figure 1f), obtained at a frame rate of $FPS_2 = \frac{7700}{N_i} = 2567$.

In the race for the best balance between higher temporal resolution and better image quality, our goal is to develop a method that will obtain the same image as in figure 1e by emitting all of the N_i plane waves at the same time, which will increase the frame rate by an factor of N_i, $FPS_3 = N_i \times FPS_2$.

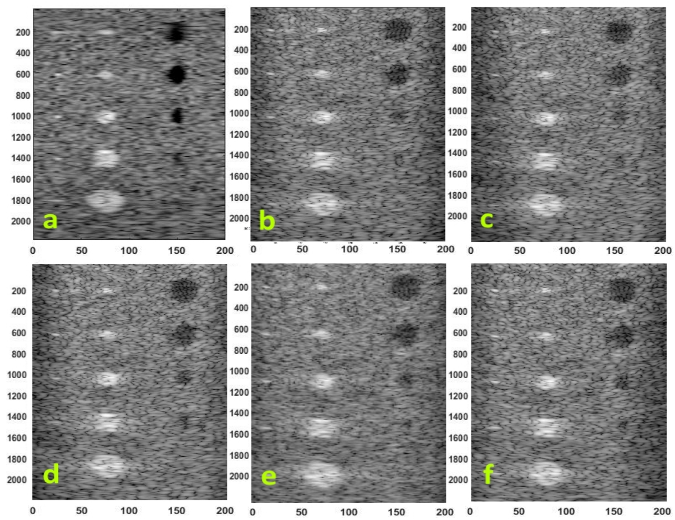

Figure 1: *a - Image obtained using focusing at emission, b, c, d, e - Images obtained using plane waves steered at* $0°$, $-2°$, $-1°$, $1°$, *f - Compounded image*

Methods

To be able to transmit, receive and detect a certain number of plane waves, we decided to encode them using random sequences. However the resulting inverse problem is ill-posed so a regularization technique has to be used. Due to the specificity of the problem, we are trying to adapt existing regularization techniques that will find the best fitting solution without violating physical properties of the ideal solution.

References

[1] Gabriel Montaldo, Mickaël Tanter, Jérémy Bercoff, Nicolas Benech, and Mathias Fink. Coherent plane-wave compounding for very high frame rate ultrasonography and transient elastography. *Ultrasonics, Ferroelectrics, and Frequency Control, IEEE Transactions on*, 56(3):489–506, 2009.

[2] Laurent Sandrin, S Catheline, M Tanter, X Hennequin, and M Fink. Time-resolved pulsed elastography with ultrafast ultrasonic imaging. *Ultrasonic imaging*, 21(4):259–272, 1999.