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Centre de Recherche en Acquisition et Traitement de l'Image pour la Santé

Unité CNRS UMR 5220 – INSERM U1206 – Université Lyon 1 – INSA Lyon - Université Jean Monnet Saint-Etienne.

PhD thesis: Coded emission in medical ultrasound imaging

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Co-PhD supervisors: Hervé LIEBGOTT and Denis FRIBOULET

Scientific context: Medical Ultrasound Imaging
Keywords: Image formation, coded emissions, beamforming, inverse problem.

Objectives of the thesis: To realize ultrasound imaging at high frame rate without sacrificing image quality
Scientific challenge: the increase in image quality is at the expense of the imaging rate. Coded emission approaches must be considered, allowing simultaneous transmission and then decoding of the information received in order to estimate an image of the medium.
Expected original contributions: proposal of an original emission scheme, emission chain modeling, inverse problem resolution, environmental imaging

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Research program:
The subject of the thesis concerns the development of new acquisition methods (transmission strategy and reception signal processing) for ultrasound imaging.
The aim is to develop ultrasound sequences that optimally acquire the information needed to reconstruct a sequence of high quality ultrasound images. It therefore has the dual objective of accelerating the acquisition rates and to maintain or even improve the quality of the images obtained.
In ultrasound, major changes have occurred in recent years with the emergence of ultra-fast imaging. This technique aims at increasing the rate of imaging. Unfortunately, it also results in a degradation of image quality.
In this context, we want to propose a coded emissions approach that would improve image quality at a fixed rate. These emission techniques are still little used in ultrasonic medical imaging.
Several tracks are envisaged. A first would be based on the synthetic aperture-coded emission, which would improve the imaging rate. The idea is to simultaneously send several different signals, called codes, on several transmitters. Thanks to a mathematical modeling of the direct problem and thanks to the use of inverse problem techniques, it will then be possible to use all the information to reconstruct the image.

Scientific supervision :

- Description of the management committee: This thesis will be supervised by three people: Barbara Nicolas (thesis director, Créatis laboratory 40%), Hervé Liebgott (co-supervisor, 30%) and Denis Friboulet (co-supervisor, 30%).

- This multidisciplinary subject requires the skills of each member of the management team:
    - Barbara Nicolas: signal processing and antenna processing,
    - Hervé Liebgott: ultrasound imaging, emission and coding.
    - Denis Friboulet: modeling, inverse methods, compressed sensing.

- Integration within the laboratory: The doctoral student will be full-time at the Créatis laboratory in which all the supervisors work.

Bibliography:

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[2] Besson, A., Perdios, D., Martinez, F., Chen, Z., Carrillo, R. E., Arditi, M., ... & Thiran, J. P. (2017). Ultrafast ultrasound imaging as an inverse problem: Matrix-free sparse image reconstruction. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*.

[3] Gran, F., Udesen, J., Nielsen, M. B., & Jensen, J. A. (2008). Coded ultrasound for blood flow estimation using subband processing. *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*, *55*(10).

[4] D. Bujoreanu, D. Friboulet, H. Liebgott, and B. Nicolas. Simultaneous coded plane wave imaging in ultrasound : Problem formulation and constrains. In IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), New Orleans, Etats Unis, March 2017.

[5] D. Bujoreanu, A. Bernard, B. Nicolas , H. Liebgott, and D. Friboulet. Simultaneous coded plane wave imaging : Implementation on a research echograph. In IEEE International Ultrasonics Symposium (IUS), Washington, Etats-Unis, Septembre 2017.