Ultrasound image compounding with deep learning
Postdoctoral Position

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Duration: 18 months
Starting Date: Oct-Dec 2022
Application deadline: 1st of oct 2022

Ultrasound is a medical imaging modality appreciated for being real-time, nonradiative, low-cost, and portable. Typical B-mode ultrasound images are formed line by line by transmitting focused ultrasound waves and recording the reflected echo signal. Being sequential, such acquisition schemes are slow. Recently, schemes such as Plane-Wave Imaging (PWI) accelerate the acquisition by transmitting and receiving a single unfocused plane wave with all the elements simultaneously, or multiple unfocused planes from different steering angles. However, in both B-mode and PWI, the field of view of such 2D ultrasound images remains a limitation for certain vascular, obstetrical, or skeleto-muscular applications where the object of interests falls beyond of the field of view. One way to overcome the field-of-view limitation is by acquiring a sequence of 2D images while tracking the probe position. Knowing the probe position is possible to geometrically compounding (combining) the 2D ultrasound images into a volume. This process is known as 3D freehand ultrasound [Solberg 2007]

Existing compounding algorithms suffer from several issues. First, they still rely on very simple interpolation algorithms to determine the intensity within each voxel. Such simple approaches are fast but suffer from information loss and viewing angle differences. There have been some efforts to improve the quality of the compounded images taking into account the view orientation dependency [Hennersperger 2015] or relying on signal/image processing [Hung 2021]. We will with this project investigate how deep-learning approaches can help in modelling more complex compounding functions while remaining fast.

A second assumption in freehand ultrasound is the tracked probe positions obtained from optical or electromagnetic devices are of sufficiently good quality. Recent methods aim to reduce the need of expensive tracking devices either with model or learning-based approaches [Esposito 2019, Luo 2021]. In this project, we plan to integrate image-based alignment strategies to improve consistency and compounding quality.

The successful candidate will take advantage of a research ultrasound machine capable of parallel acquisitions with 128 channels at a high throughput rate while giving access to raw data. A 3D probe is also available. This material will enable us to make changes to the low-level control and processing of the ultrasound signals. She/he will work in close collaboration with other researchers from the SIMS team. There is potential for establishing collaborations with the CAMP team at the Technical University of Munich (TUM) and local industrial partners. The postdoc will also have the opportunity to teach (optional) and to supervise undergraduate students.

Mission
Study and propose new freehand ultrasound compounding algorithms,

- For B-mode and plane-wave images,
- With 2D and 3D probes,
- Seeking to lower storage and/or time requirements,
- Towards improving the spatial resolution of compounded volumes,
- Relying on computer vision, signal processing and deep learning methods.

Hosting environment

The position will be hosted by the laboratory of digital sciences of Nantes ("Laboratoire des Sciences du Numérique de Nantes: LS2N" in French) at the Centrale Nantes University. The candidate will integrate the SIMS (www.ls2n.fr/equipe/sims, https://sims.ls2n.fr) research team, specialist in inverse problems and learning methods conception of methodological tools and the exploitation of the intrinsic structure of data through statistical processing of signal and images.

"Regularly quoted in newspapers as being one of the nicest cities in France, Nantes is also renowned for being a rich, lively and innovative city. Its economic clout makes Nantes France's 3rd largest industrial city and 2nd most successful city in terms of employment growth." (https://en.nantes.fr/home.html)

Requirements

- A PhD in signal/image processing, computer vision, biomedical engineering or related fields.
- Good programming skills (e.g., in Python)
- Good written and spoken scientific communication skills (English)
- Any experience in the following fields will be will be considered important plus:
    - Signal and Image processing, Computer Vision
    - Machine / Deep learning
    - Medical image analysis, in particular ultrasound.

Salary and duration

The position is for 12 months (renewable + 6 months). Remuneration and social benefits are based on the collective wage agreement for public-sector employees at the national French level, considering previous years of experience.

How to apply: Send an e-mail to diana.mateus@ls2n.fr with your CV, publication list, references and motivation letter.

Bibliography:

[Solberg 2007] Solberg OV, Lindseth F, Torp H, Blake RE, Nagelhus Hernes TA. Freehand 3D ultrasound reconstruction algorithms--a review. Ultrasound Med Biol.

[Esposito 2019] M. Esposito et al., "Total Variation Regularization of Pose Signals With an Application to 3D Freehand Ultrasound," in IEEE Transactions on Medical Imaging, vol. 38, no. 10, pp. 2245-2258, Oct. 2019, doi: 10.1109/TMI.2019.2898480.

[Hennersperger 2015] Hennersperger, C., Baust, M., Mateus, D., Navab, N. (2015). Computational Sonography. Medical Image Computing and Computer-Assisted Intervention -- MICCAI 2015.

[Hung 2021] Hung, Alex & Galeotti, John. (2021). Good and bad boundaries in ultrasound compounding: preserving anatomic boundaries while suppressing artifacts. International Journal of Computer Assisted Radiology and Surgery. 16. 10.1007/s11548-021-02464-4.

[Luo 2021] Luo, Mingyuan & Yang, Xin & Huang, Xiaoqiong & Huang, Yuhao & Yuxin, Zou & Hu, Xindi & Ravikumar, Nishant & Frangi, Alejandro & Ni, Dong. (2021). Self Context and Shape Prior for Sensorless Freehand 3D Ultrasound Reconstruction. 10.1007/978-3-030-87231-1_20.