Docket #: S20-406

Functional ultrasound imaging of the brain using deep learning and sparse data

Stanford researchers at the Airan Lab have developed a new deep learning approach to dramatically reduce the amount of ultrasound data required to produce high quality power Doppler images for functional ultrasound (fUS). Conventional fUS imaging relies on long ultrasound data acquisitions at high frame rates, posing high demands on the sampling and processing hardware. Using sparse sequences reduces data acquisition, storage, and processing demands. Additionally, this method decreases the exposure to ultrasound and makes neonatal brain imaging applications safer.

This invention can facilitate the development of fUS neuroimaging in any setting where dedicated hardware is not available or in clinical scanners, making this technology more affordable and opening the way to new potential applications based on this imaging modality.

Figure:

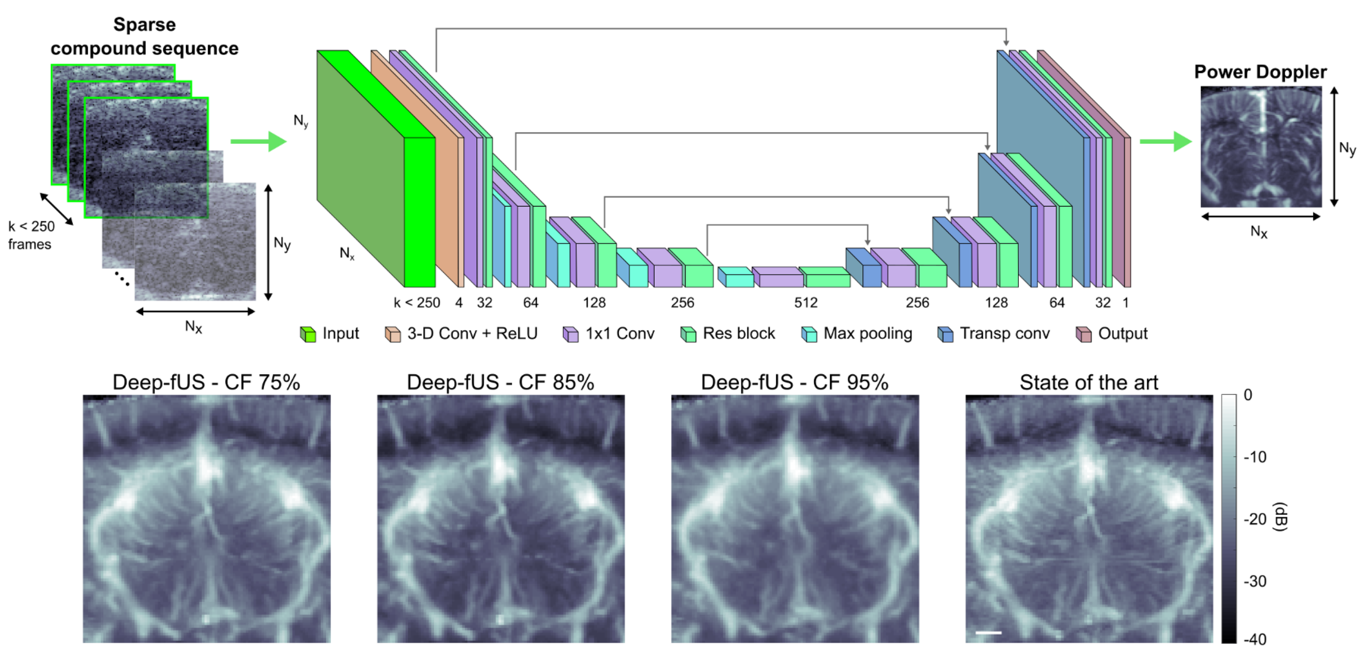

Figure Description:(Top) Deep fUS implements a fully convolutional neural network that learns a reconstruction mapping between the sparse sequence of compound ultrasound data and the power Doppler output image, without requiring any prior model-based knowledge. (Bottom) Representative power Doppler images of a coronal slice of the rat brain reconstructed by Deep-fUS from under-sampled sequences with compression factor (CF) of 75%, 85%, and 95% and comparison with a state-of-the-art image reconstructed using 250 ultrasound frames. In the CF-95% case, only 5% of the ultrasound data was retained. (Readapted from Di Ianni and Airan, "Deep-fUS: functional ultrasound imaging of the brain using deep learning and sparse data")

Stage of Development

- **Prototype** built
- **Successfully tested** on rat brains to image blood flow in the brain microvasculature with high sensitivity in a task-evoked neuroimaging application.

Applications

- **Image construction for fUS using sparse data**– examples include but not limited to neonatal neuroimaging and brain tumor removal surgery
- **Faster and improved imaging processing for ultrasound scanners**
- Can be used in **under-resourced areas** where dedicated scanners are not available

- Can be used in **portable scanners** due to reduced hardware requirements

Advantages

- **Safer** - significantly reduces the exposure time and lowers the risk of harmful bioeffects
- **Lower hardware requirements** due to net reduction in data acquisition, storage, and processing demands
- **Retains image quality even** when using only 5% of the original ultrasound data
- **Can be used with awake and freely behaving subjects since method makes fUS imaging less sensitive to motion**
- **Novel** – Believed to be the first attempt to implement a convolutional neural network approach for power Doppler reconstruction from sparse ultrasonic datasets

Publications

- Di Ianni, Tommaso, and Raag Airan. "Deep-fUS: functional ultrasound imaging of the brain using deep learning and sparse data." bioRxiv (2021): 2020-09.

Patents

- Published Application: 20220096055
- Issued: 12115024 (USA)

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