Abstract: Beamforming Sub-Sampled Raw Ultrasound Data with DeepFormer

Walter Simson[1], Magdalini Paschali[1], Guillaume Zahnd[1], Nassir Navab[1,2]

[1]Computer Aided Medical Procedures, Technische Universität München, Germany
[2]Computer Aided Medical Procedures, Johns Hopkins University, USA
walter.simson@tum.de

Converting reflected sonic signals to an ultrasound image, beaforming, has been traditionally formulated mathematically via the simple process of delay and sum (DAS). Recent research has aimed to improve ultrasound beamforming via advanced mathematical models for increased contrast, resolution and speckle filtering. These formulations, such as minimum variance, add minor improvement over the current real-time, state-of-the-art DAS, while requiring drastically increased computational time and therefore excluding them from wide-spread adoption. Simultaneously, there is a parallel drive to increase ultrasound frame acquisition rates, for applications such as cardiac imaging, where high frame rates are required to accurately capture the complete subject motion.

In order to improve contrast, resolution and accuracy of reconstructed ultrasound images while increasing acquisition speed, a new paradigm, *DeepForming* [1], has been developed to leverage the strengths of deep learning for accelerated sub-sampled ultrasound reconstruction. In this novel work, a fully-convolutional neural network [2] trained with a composite loss of L_1 and $L_{\text{MS-SSIM}}$ [3], is utilized to map sub-sampled raw channel data from an ultrasound transducer to a fully sampled beamformed signal. Experiments were conducted on an in-vivo dataset of 19 participants including scans of a variety of anatomies. Results showed that all anatomies were successfully reconstructed by DeepFormer while using both sub- or fully-sampled raw data with a high relative structural similarity, suggesting that the lateral resolution of the reconstructed images can be maintained even with sparsely sampled channel data. The overall similarity between the reconstructed images and the ground truth for fully- and sub-sampled raw data remained similar with an SSIM of 0.5554 and 0.5550 respectively, highlighting the potential of DeepFormer to serve as a step towards arbitrary reconstruction based on sub-sampled raw ultrasound signals.

References

1. Simson W, Paschali M, Navab N, et al. Deep learning beamforming for sub-sampled ultrasound data. IEEE Int Ultrasonics Symp (IUS). 2018;.
2. Roy AG, Conjeti S, Navab N, et al. QuickNAT: segmenting MRI neuroanatomy in 20 seconds. ArXiv e-prints. 2018;ArXiv: 1801.04161.
3. Zhao H, Gallo O, Frosio I, et al. Loss functions for image restoration with neural networks. IEEE Trans Comput Imaging. 2017;3(1):47–57.