

Blind Phase-aberrated Baseband Point Spread Function Estimator Using Complex-valued Convolutional Neural Network

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Background, Motivation and Objective

Many methods used to improve clinical ultrasound image quality require precise estimation of point spread function (PSF), e.g., deconvolution. However, the PSF cannot be well estimated even with prior knowledge of the system setting because the unknown property of inhomogeneous sound velocity in human tissue leads to phase-aberrated PSF. In addition, most image quality improving techniques are performed over beamformed baseband data (i.e., IQ data) and most portable ultrasound systems only allows the access of beamformed baseband data because of limited data transfer bandwidth. Thus, blind phase-aberrated PSF estimation directly from the beamformed baseband data is beneficial for portable ultrasound to leverage these image quality improving techniques.

Statement of Contribution/Methods

For this purpose, we introduce a novel complex-valued convolutional neural network (CNN) based blind estimator of phase-aberrated PSF using beamformed baseband data. We train a complex-valued U-Net which takes a beamformed baseband patch in a speckle region as the input and predicts its corresponding baseband PSF with phase aberration. Complex-valued mean squared error loss function and Adam optimizer are utilized to update parameters and reduce pixel-wise difference. Based on near field phase screen model, the phase-aberrated baseband PSFs and their corresponding beamformed baseband patches in speckle regions are simulated using Field II and formed the training pairs. For comparison, RF training pairs were further employed in a real-valued U-Net counterpart with the same architecture and physically receptive field, whereas the baseband training pairs have lower data size because of the baseband data nature.

Results/Discussion

Fig. 1 shows the results of the two PSF estimators – complex-valued U-Net with baseband patches and real-valued U-Net with RF patches. They are tested by unseen simulated pairs and predict phase-aberrated PSFs with the associated data types. The proposed complex-valued U-Net estimator produces an aberrated PSF with higher similarity to the ground truth PSF than RF-based one. The proposed blind complex-valued U-Net PSF estimator rivals its real-valued RF counterpart while it requires lower data size because of the beamformed baseband data nature.

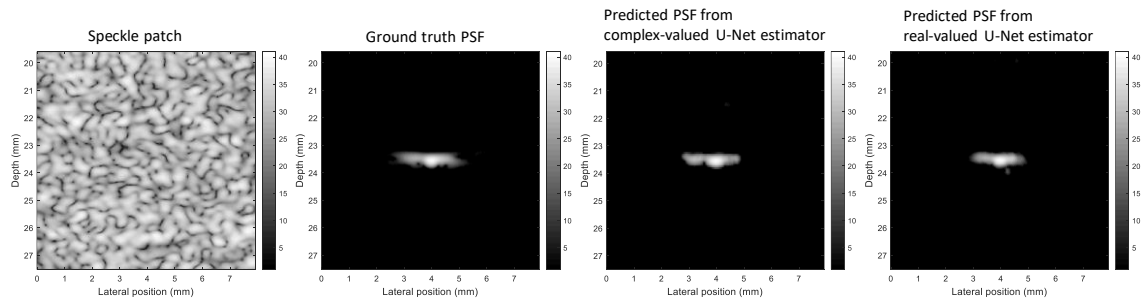


Fig 1. From left to right: Estimator input – speckle patch, ground truth PSF, predicted PSF from the proposed complex-valued U-Net estimator, predicted PSF from real-valued U-Net estimator.