Clutter Suppressed Deep Beamformer for Echocardiography using Deep Learning

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Background, Motivation and Objective

Due to non-invasive, radiation-free, and real-time imaging features, echocardiography (ECHO) is considered an excellent tool for the evaluation of cardiac functions. Herein, we propose a fully data-driven deep learning-based beamformer (BF) for US cardio imaging that greatly enhances the flexibility and image quality of ECHO. Specifically, the network is designed not only to produce the standard DAS BF results, but also to suppress the clutter by decomposing the low-rank (LR) and sparse (Sp) components from US scan. This technique helps to suppress noise that is typically encountered in conventional ECHO. We show that proposed method help improving the visualization quality of the interior borders of the heart (i.e. the endocardium). Unlike conventional image domain methods for clutter removal, which are highly sensitive to apodization and dynamic range selection, the proposed convolutional neural network (CNN) can directly process the RF signal so it has better generalization capability. We believe that direct reconstruction of desired image from RF data can be rapidly deployed for ECHO.

Statement of Contribution/Methods

A typical clutter-removing step in ECHO is to separate the signal of interest (endocardium) from the cluttering tissue IQ signal. Here, we propose a new approach based on direct processing of RF signal using CNN to generate clutter-free images. We first demonstrate that the DAS can be replaced with a CNN that can directly process RF data to generate IQ signals. Then, we model the US signal as a combination of a LR (background) and Sp components (endocardium). Specifically, RF signal from each scan is processed through conventional beamforming pipeline and LR and Sp components of IQ-data were obtained using deep unfolded robust PCA [1]. Using this data as label, a CNN model is trained to estimate Sp component directly from RF data.

Results/Discussion

For experimental verification, samples are acquired from the cardiac region of 7 healthy volunteers using SP1-5 phase array transducer with E-CUBE 12R US system. The proposed deep BF can accurately reproduce DAS results. Moreover, the clutter-suppressed deep BF produced improved quality images by direct estimation of Sp component (endocardium) (see Fig. 1).

[1] Solomon, Oren, et al. arXiv:1811.08252 (2018).

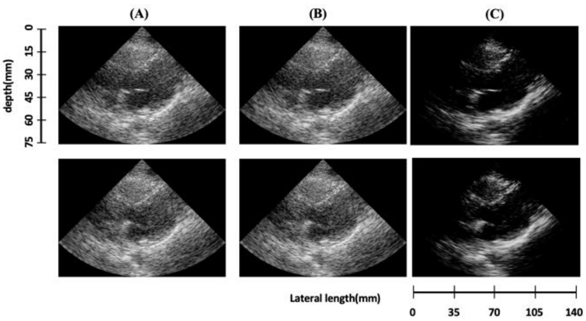

Fig.1 : Beamforming results by (A) DAS, (B) proposed deep beamformer, and (C) proposed clutter suppressed deep beamformer.