Ultrasound Computed Tomography to Image Objects Including Bone using RF Data Recovery with Deep Neural Network

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Background, Motivation and Objective

USCT (Ultrasound Computed Tomography) is an imaging modality which has advantage of high spatial resolution and independency on inspector's skill. But most target of USCT researches are breast region. The biggest difficulty of application to the other region is that the mediums include bones which cause artifacts. The solution of this problem has not been established yet and some thesis reports that the difficulty is to design formula for general condition. For such kind of noise reduction task, some researches apply machine learning to B-mode image. But it is expected that B-mode image reconstructed from RF signal has reduced amount of information and raw RF signal has much physical information. In my research, we apply machine learning to RF signal for the purpose of bone artifact removal.

Statement of Contribution/Methods

Artifacts were caused by presence of signal from bones and the task of proposed method is to remove the signal from RF signal. To solve this problem, deep neural network (DNN) with U-Net architecture was trained with the training RF data simulated with/without bone as input and output, respectively. Training RF data were given by numerical simulation which solves wave equation by using pseudo-spectral method (MATLAB k-Wave toolbox). RF signal for training was created from whole three-dimensional RF signal by cropping around two-dimensional surface regions of data space according to one pixel of reconstructed B-mode image. This method has advantage that even fewer simulations can give large amount of high-quality data. Nonlinear transformation on amplitude was applied as preprocessing for input RF signals having large dynamic range to extract useful information of weak-amplitude components.

As the result, artifact removal by the trained model was confirmed on not only test data given by simulation but also data acquired by actual USCT system by proposed method using DNN trained on only simulation data.

Results/Discussion

A medium and the reconstructed image of test data was shown in Fig. 1. On test data given by simulation with pulse wave of 1.6 MHz center frequency, proposed method improved a B-mode image by 102 μm on spatial resolution and by 8.1 dB on S/N. But the training and test data medium used for this study include only water, bone and wire. Then, soft tissue boundary should be considered in a future work.

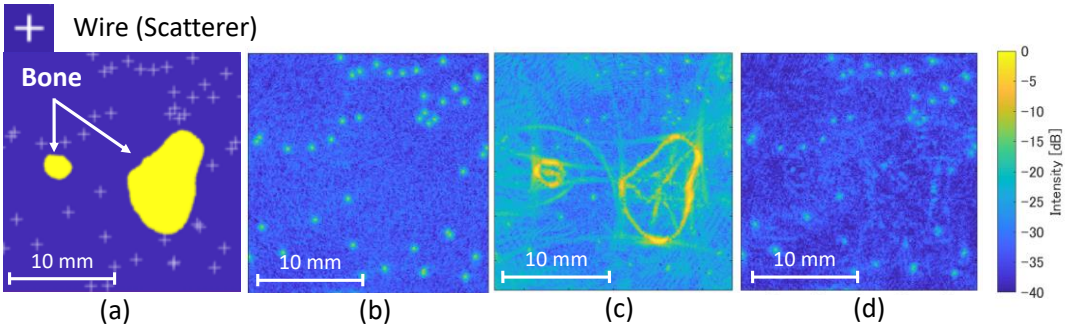

Fig. 1. Acoustic medium of test data and its Reconstructed B-mode images. Bone image and its liner shape artifact and smog like one was removed. (a) Acoustical medium of a test data (b) B-mode image of no-bone condition data (c) B-mode image of bone including condition (d) B-mode image reconstructed from recovered RF signal applied proposed method