Recovery of ultrasound image with transmission beam lines decimation by using computationally low cost convolutional neural network

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Background, Motivation and Objective

Recent advances in deep learning have enabled us to ease the trade-off between frame rate and image quality of diagnostic ultrasound imaging. Most studies have applied a neural network on radio frequency (rf) data before synthetic aperture operation to fully take advantage of uncompressed information. However, processing on rf data significantly increases the computational burden for real-time image generation on an ultrasound device. To reduce this burden, we explored the effectiveness of deep learning on final image data instead of rf data since the amount of data is an order of magnitude smaller for image data compared to rf data.

Statement of Contribution/Methods

We constructed training data and test data sets from phantom data. We acquired rf data and reconstructed two types of B-mode images: (1) a reference image using full transmission (tx) beam lines and (2) a decimated image using one fourth of tx beam lines. A total of 500 image pairs were divided into 420 training-image pairs and 80 test-image pairs.

With the training data, we trained a convolutional neural network composed of only three layers of 2D convolution filters, which is based on the network architecture designed for single-image super resolution in computer vision. Not only the amount of data but also the network architecture was small to attain real-time performance. The trained network was tested on the test data set to evaluate the image quality of a neural network output image.

Results/Discussion

Figure 1 shows (a) a decimated image, (b) a reference image, and (c) a trained neural network output image of multi-purpose phantom. The network significantly decreased the blocky artifacts and noise in hypoechoic region while maintaining spatial resolution. Contrast and contrast-to-noise ratio (CNR) between the cyst and parenchyma region indicated with red and blue circles in Fig. 1(a) were recovered from 18.1 to 19.9 dB and from 4.4 to 5.1, respectively, which are close to the values of the reference image (contrast = 21.7 dB and CNR = 5.2). The network can output an image within 14 ms using a medium spec desktop computer and graphical processing unit (NVIDIA, GTX1080). The results indicate that deep learning on ultrasound images can ease the trade-off between frame rate and image quality with reasonable computational burden.

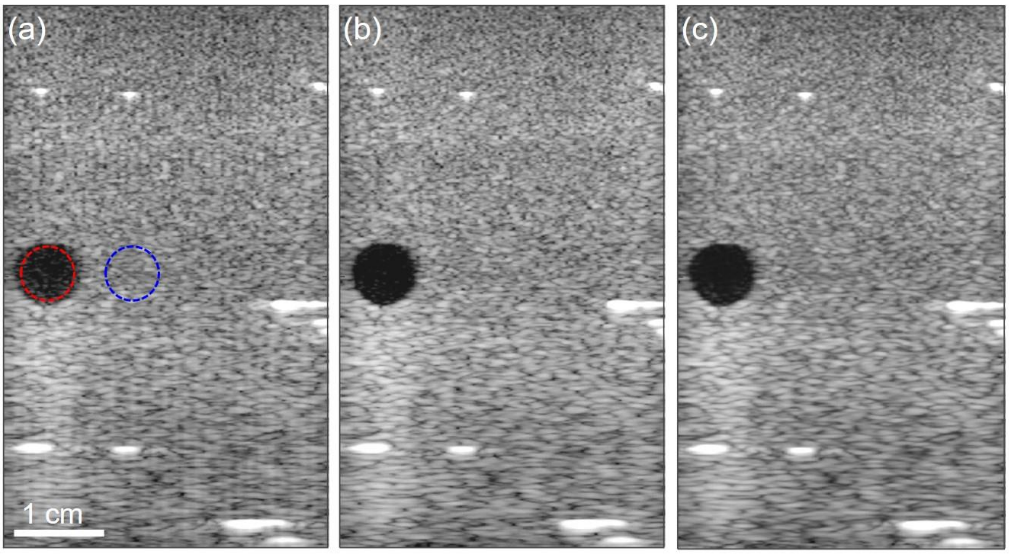

Figure 1. Test set images of multi-purpose phantom. (a) Decimated image, (b) reference image, and (c) trained neural network output.