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Superresolution of Echo Image Using DDSRCNN and TecoGAN

Yiran Li, Mengfei Zhang, Chikayoshi Sumi, *Senior Member, IEEE*

Abstract— **In our accompanying paper [1], for achieving high accuracy deep learning (DL) segmentation on an ultrasound echo image, we propose to perform (i) speckle reduction and (ii) superresolution as preprocessing. For the speckle reduction, the Auto-Encorder (AE) model is effectively used, whereas for the superresolution, an effective model must be searched for. In this report, the performances of new models such as the Deep Denoising Super Resolution CNN (DDSRCNN) [2] and the Temporal Coherence Generative Adversarial Network (TecoGAN) [3] are evaluated for human *in vivo* carotid echo images.**

Clinical Relevance— **Method effectiveness is confirmed for *in vivo* data.**

I. Introduction

In our accompanying paper [1], for achieving high accuracy deep learning (DL) segmentation on an ultrasound echo image, we propose to perform (i) speckle reduction and (ii) superresolution as preprocessing. For the speckle reduction, the Auto-Encorder (AE) model is used, whereas for the superresolution, the well-known Super-Resolution Convolutional Neural Network (SRCNN), Fast SRCNN (FSRCNN) and Efficient sub-pixel CNN (ESPCN) are used, respectively. Since the superresolution results are not so effective for echo images, we are searching for an effective DL model. In this report, we evaluate the performances of the Deep Denoising Super Resolution CNN (DDSRCNN) [2] and the Temporal Coherence Generative Adversarial Network (TecoGAN) [3] for human *in vivo* carotid echo images [1].

II. Methods

A. DDSRCNN and TecoGAN

The DDSRCNN can perform noise reduction as well as superresolution. By learning convolution and deconvolution layers' parameters for restoring from a low-resolution noisy image toward the original image, removing a noise and increasing a spatial resolution can be achieved. The TecoGAN was first applied to video superresolution, which was able to substantially increase the spatial resolution while preserving the continuity of successive frames.

B. Human in vivo carotid experiment

The distributed echo data [4] of human *in vivo* carotid arteries were used, of which pixel sizes were 256 × 256 pixels and 24 bits per pixel. Different linear-array-type transducers with two frequencies (10 and 14 MHz) were used. The original carotid data were used as a ground truth (GT) data, from which low resolution (LR) same pixel-size data were made specifically with a low spatial resolution and a low contrast resolution by interpolating thinned 75 × 75 pixel ones and by subsequently decreasing the contrast resolution down to 8 bits. The data were different from those used in ref. 1 in which the GT data were up-sampled to 390 × 330 pixels. All parameters for DLs were set as follows: the number of learning data including flipped ones = 100 (original, 32); the epoch number = 400, the batch size = 4, and the learning rate = 0.0004.

Y. Li. is with the graduate school of Sophia University, Tokyo, 102-8554 JAPAN, e-mail: c-sumi@sophia.ac.jp.

III. Results

Figure 1 shows the obtained superresolution images with the LR and ESPCN result, in which PSNR defined in ref. 1 is also depicted for a reference. Visually, the results of DDSRCNN and TecoGAN have higher spatial resolutions than previous ESPCN, particularly DDSRCNN for the low contrast resolution data.

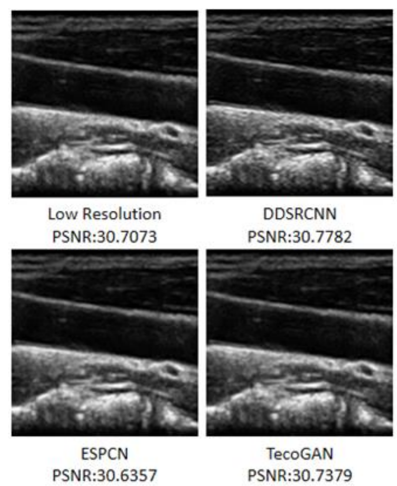

Figure 1. LR, DDSRCNN, TecoGAN and ESPCN results on human *in vivo* carotid.

IV. Conclusion

We obtained higher spatial resolution images with DDSRCNN and TecoGAN than ESPCN. In another accompanying paper [5], the effectiveness of the new models are evaluated with the AE.

References

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