A Deep Learning Approach for Ultrasound Computed Tomography Image Reconstruction Based on a Ring Transducer Array

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Background, Motivation and Objective

Ultrasound computed tomography (USCT) technique has been developed as a quantitative tool for the measurement of sound-speed of biological soft tissue, which has been considered as an effective biomarker for medical diagnosis, such as breast tumor characterization. To our knowledge, previous USCT image reconstruction methods such as ray-tracing algebraic reconstruction technique and waveform inversion method lead to intensity inhomogeneity and streaking artifacts induced by the sparsity of transducer elements or the limitations of the theoretical models. In this study, a learning optimized reaction diffusion network is proposed to eliminate streaking artifacts and noises in the degraded reconstruction image.

Statement of Contribution/Methods

The schematic of the proposed approach is shown in Fig.1(A). The degraded images are recovered by several stages of diffusion processes. In each stage, two-dimensional filters parametrized by the discrete cosine transformation basis are used to recognize the structures of kinds of streaking artifacts and noises in degrade images. Then the corresponded influence functions parametrized by the Gaussian radial basis functions are used to control the diffusion degree of artifacts and noises recognized by filters. A data fidelity term that measures the similarity to the network input is set in each stage. Classical simultaneous algebraic method is used to reconstruct images. The dataset of complex sound-speed images is generated using k-Wave toolbox. The parameters of filters and the influence functions are trained by a loss minimization approach. As shown in Fig.1(B), in the phantom experiment, the image of an agar-glycerin phantom is reconstructed and recovered by the diffusion network.

Results/Discussion

The simulated origin ground truth images, degraded input images and recovered images are shown in Fig.1(C). Compared to the degraded images, mean square error of recovered images decreases 29.2%. The improvement of average peak signal-to-noise ratio and structured similarity index is 16.9 % and 45.6%, respectively. Fig.1(D) shows the reconstruction and recovered image of the phantom experiment. It is apparent that our trained network has good abilities of generalization and is able to eliminate streaking artifacts and remove noises in the degraded image effectively both in simulation and phantom experiment.

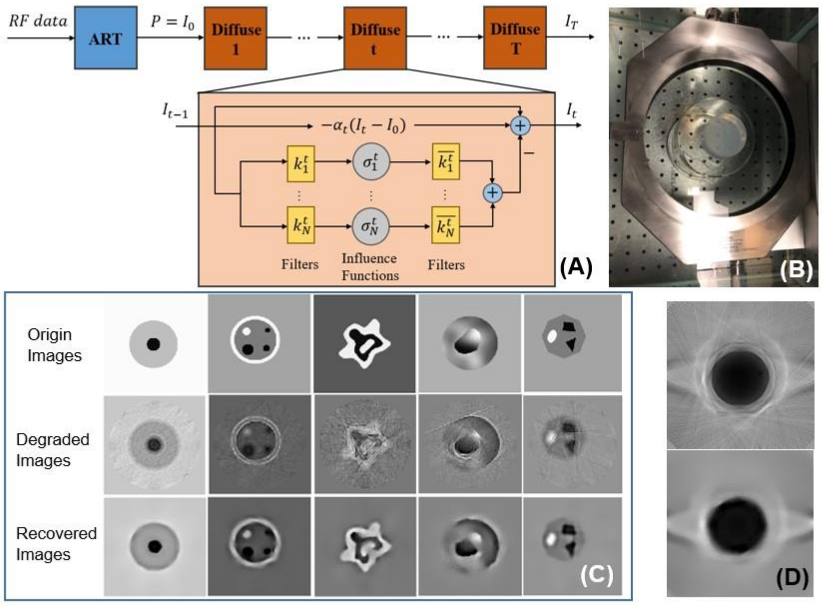

Fig.1(A) Schematic of the learning optimized reaction diffusion network; (B) The photograph of the phantom experiment setup; (C) The simulated origin ground truth images, degraded input reconstruction images and recovered images; (D) The degraded reconstruction image with streaking artifacts and noises and the recovered image by diffusion network in phantom experiment.