Comparison of the plane wave and diverging wave in sound speed imaging

Piotr Karwat[1],
[1]Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland.

Background, Motivation and Objective

Information on the speed of sound could be used for aberration correction in classical B-mode imaging. Moreover, as sound speed reflects mechanical properties of tissues, it might also provide additional diagnostic information.
Recent scientific reports introduced an algorithm called Computed Ultrasound Tomography in Echo-mode (CUTE) that is capable of reconstructing sound speed images. It uses images obtained through the Compounded Plane Wave Imaging (CPWI) as the input data. However, due to limited transmit aperture size, the plane wave is distorted which worsens the quality of the input data and resulting sound speed images.
The objective of this work was to improve the input signal of the CUTE algorithm. For this purpose the single-element synthetic transmit aperture (SSTA) scheme was examined as it provides nearly undistorted wave.

Statement of Contribution/Methods

The CUTE algorithm consists of determination of the direct problem transformation matrix (describing the integration of local slowness to produce the local time delays), inversing it, and applying it to the calculation of the sound speed images. The CUTE algorithm is designed to work with CPWI data. In this work it was adapted to SSTA data by modification of the transformation matrix so that it reflects integration paths appropriate for the SSTA scheme.
To collect the input data a numerical model was used. It contained randomly distributed scatterers and the speed of sound was homogenous except for a circular (1 cm in diameter) region in the middle of the imaged region. The ultrasound echoes were simulated for the model for CPWI and SSTA imaging schemes. Input data were the reconstructed low resolution images (LRI), one per each transmission. In the first step of the CUTE, local phase relations between LRIs were determined and converted to time delays. In its further part time delays matrix was multiplied by the pre-calculated inverse transformation matrix giving the final sound speed images.

Results/Discussion

The obtained results show that the SSTA gives better (less disturbed) time delay signal (Fig. 1). It is especially important because solving the inverse problem amplifies disturbances. The CUTE algorithm working with CPWI data did not produce any clear picture of the sound speed map while the SSTA version did.

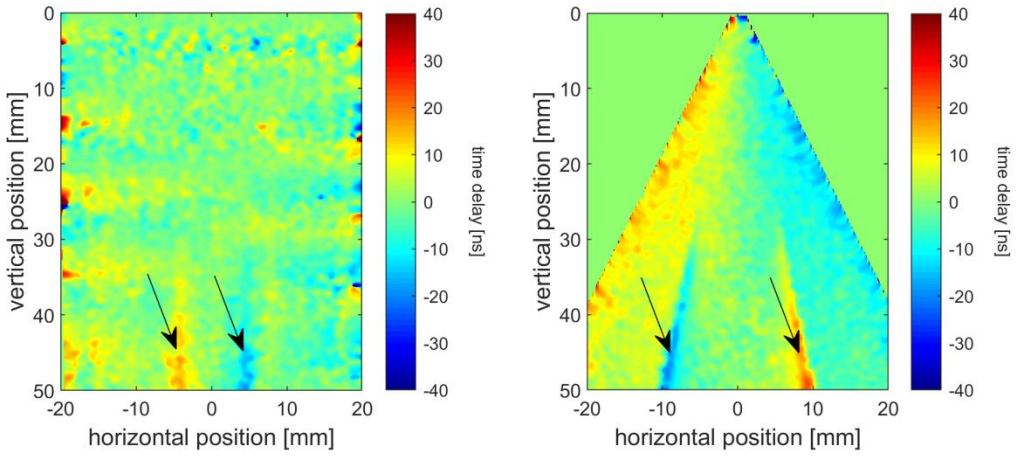

Fig. 1. Comparison of the time delays obtained with use of CPWI (left) and SSTA (right) schemes. Components related to the sound speed inhomogeneity are indicated with arrows. The SSTA scheme provides better ratio of useful signal to interference.