Fast Reversible Ultrasonic Imaging for Defect Discrimination in Highly Scattering Materials

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Background, Motivation and Objective

Ultrasonic phased-arrays are used in nondestructive evaluation for detection and characterization of defects. Over the last decade, provided solutions have been based on the post-processing of the full matrix of transmit-receive signals, involving application of various imaging techniques and scattering matrix analysis for defect characterization. Conventional imaging methods convert the array data into an image, which facilitates the interpretation of the data but losing essential information needed for defect characterization. The study of the scattering matrix is a more suitable alternative because it preserves the necessary information required to describe a defect. However, when other scatterers are located close to the target, the measured scattering descriptor is contaminated due to the overlapping of time responses. This is the case in coarse grained structures where grains act as randomly distributed scatterers adding a coherent structural noise to the signal reflected from the defect. This paper investigates how to isolate the target time responses from those of the background noise in order to measure reliably the defect scattering matrix.

Statement of Contribution/Methods

In this work, we present an approach to efficiently extract the scattering field from the transmit-receive array data based on a reversible imaging concept. In this paper the back-propagation method is used. First, an image is produced using the forward imaging method. Then, the image is spatially filtered according to the region of interest. After that, the inverse imaging operation is performed in order to recover the desired temporal responses corresponding to the signals scattered from the defect. Finally, the target scattering information is extracted from the filtered array data. Two implementations of this procedure are developed on a graphics processing unit (GPU), using delay-and-sum and f-k approaches. A study in a grained structure is carried out in order to compare the performance of the proposed algorithms with other available techniques.

Results/Discussion

Unlike conventional approaches, the proposed procedure provides the whole frequency spectrum of the scattering matrix, preserves phase information and reduces the effects of multiple scattering. It is shown that the two suggested implementations of the back-propagation algorithm extract scattering coefficients with the similar accuracy. The parallelized implementation is suitable for real-time characterization. The high rate allows to analyze hundreds of locations in a few seconds. The use of the filtered dataset shows that the probability of detection is enhanced in highly scattering materials in comparison with standard imaging techniques.