Ultrasonic multi-frequency time reversal based imaging algorithm for noisy material

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In this paper, two multi-frequency time reversal based imaging algorithms are explored for imaging defect in noisy material: time reversal with multiple signal classification (TR-MUSIC) and a related phase-coherent form (PC-MUSIC). These algorithms are tested with experimental ultrasonic array data acquired using the full matrix capture (FMC) process. In the experiment, copper is chosen as the noisy material because it is isotropic but exhibits a high degree of material backscatter at typical ultrasonic frequencies. Firstly, a pre-processed method based on the concept of delay and sum (DAS) is proposed to extract the scattered signals reflected by the defect under the noisy case. Secondly, the multi-static response matrix at the given frequency component can be directly constructed from the frequency spectrum of scattered signals. Thirdly, the singular value decomposition (SVD) of multi-static response matrix is implemented to obtain the singular values and related singular vectors, and the characteristic of singular values is analyzed to divide the singular vectors into signal subspace and noise subspace. Lastly, the multi-frequency time reversal based imaging function is defined to achieve the ultrasonic image of the noisy material. It is shown that when the dimension of signal subspace is chosen, both TR-MUISC and PC-MUSIC over the given frequency range can locate the position of defect in noisy material. In addition, the feature of PC-MUSIC image is different from that of TR-MUISC image because the phase information is considered in the imaging function.