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Ultrasonic structural health monitoring by multiple-input-single-output minimum variance processing

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This work concerns ultrasonic detection and localization of defects in plate-like metal structures such as airfoils. In previous work, MIMO delay-and-sum beamforming has been used to image these defects using change-detected ultrasonic signals between a sparse array of transmitters and receivers. However, mismatch of medium dispersion and unknown scattering properties of the defects can lead to significant imaging artifacts. To reduce imaging artifacts and sidelobes, a multiple-input-single-output (MISO) minimum variance (MV) approach is proposed here. MV-MISO imaging involves electronically scanning a transmit beam over the area of interest while, at each point being imaged, virutal transmit nulls are adaptively steered in the directions of interfering scatterers. For each imaging cell, this is achieved by adjusting transmit weights to minimize the variance of signals received at a single receiver subject to the constraint of achieving constant insonification. Using a model of dispersive Lamb wave propagation, the proposed algorithm has been successfully applied to change-detected data gathered with a six-sensor transmit-receive array coupled to a thin aluminum plate with artificial defects (e.g., drilled holes).