

4.5.16. TIME-VARYING INVERSE FILTERING FOR HIGH RESOLUTION IMAGING WITH ULTRASONIC GUIDED WAVES

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Abstract. Active strategies for Structural Health Monitoring using ultrasonic guided waves mainly deal with excitation signals that are band-limited in order to minimize the effect of dispersion. The underlying idea is to activate only the fundamental wave-modes so that the signal complexity decreases. However, it would be advantageous to increase the temporal resolution of the signal in order to enhance the performance of the post-processing algorithms.

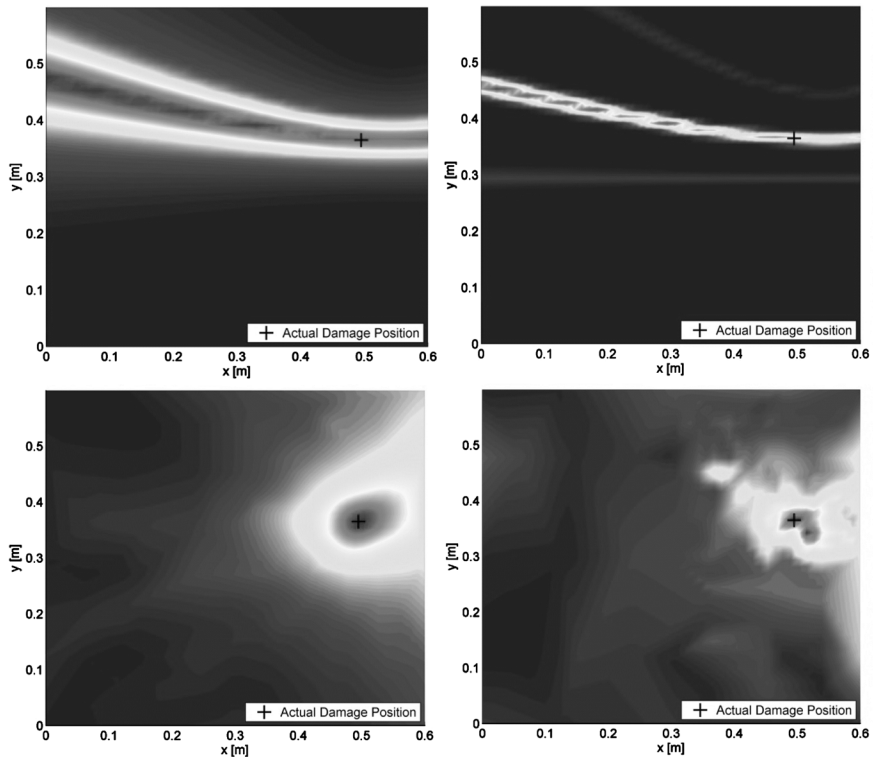


Fig. 1. Imaging a single Actuator-Sensor-Sensor combination with the TDOA-Algorithm using the envelope-detected (top left) and inverse filtered ultrasonic signals (top right)

This paper suggests a new technique that deconvolves narrowband and non-stationary ultrasonic signals by means of a time-varying Inverse Filter. The filter is realized through the application of the Matching Pursuit Decomposition Algorithm. As a result one attains ultrasonic signals where the waveforms have a significantly smaller temporal extent compared to the original signals, resulting in a much higher resolution. After automatically deconvolving the ultrasonic signals they are applied on the Time-Difference-of-Arrival (TDOA) and Time-of-Arrival (TOA) imaging algorithms. It can be observed from the images that the point spread function becomes smaller and the contrast of the image higher. Thus, it can be possible in the future to image not only the correct position of the damage but also the size and in case of a crack the corresponding orientation.

The top part of Figure 1 illustrates the damage map of a single Actuator-Sensor-Sensor combination using the TDOA algorithm. The width of the hyperbola corresponds to the temporal extent of the envelope-detected ultrasonic signals. Now, the same configuration as before is used with the deconvolved signals. It can be clearly seen from the top right of Figure 1 that the width of the hyperbola decreases. Processing all possible Actuator-Sensor-Sensor combinations improves the results of the final image for the inversely filtered signals. These can be seen in the bottom left and bottom right part of Fig. 1.

The width of the hyperbola corresponds to the temporal extend of the ultrasonic signals. Processing all Actuator-Sensor-Sensor combinations results in the final images for the envelope-detected case (bottom left) and the inversely filtered case (bottom right). The extent of the point spread function and the image contrast are higher in the bottom right section.