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Model-based algorithms for detecting damage in ultrasonic nondestructive evaluation measurements

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This work addresses the "As-Built" modeling problem in ultrasonic nondestructive evaluation (NDE), in which one is given measurements of a mechanical part before and after use. The condition of the "as-built" part (prior to use) is known, so that after the part has been used, it can be tested for damage. This enables a two-step model-based approach: (1) Given input-output measurements (A-Scans), estimate a dynamic prediction-error model of the "as-built" measurement(s) using system identification algorithms. The model is validated by testing the innovations (residuals) for statistical whiteness and then stored for future use. (2) Later, when testing the part for damage, the error between the measurement and the output of the stored model is tested against a short-term whiteness confidence interval test statistic. If the part passes the test, this implies that the model remains valid and the part is declared undamaged. If the part fails the test, this indicates a model mismatch, which means that the part's acoustic properties have changed, and the part is declared damaged. Performance of the algorithms is demonstrated using real measurements, receiver operating characteristic (ROC) curves and a confidence interval about the probability of correct classification.