Nonconvex Sparse Representation Of Ultrasonic Ndt Signals For Flaw Detection And De-Noising

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Ultrasonic testing has been an important tool for the detection of hidden defects in materials yet its effectiveness is usually compromised by the noise originated from both the testing system and the material under inspection. Motivated by prior knowledge that only a small number of defects or reflectors exist within the tested material thus the measured signal can be viewed as a linear combination of a few echoes, sparse signal representation (SSR) has been widely exploited as a promising strategy to process ultrasonic NDT signals. Aiming at drawbacks suffered by existing SSR techniques such as being ineffective enough against noise or too computationally slow, the present work proposes a nonconvex sparse regularization method based on lp-norm ($0<p<1$) penalty to seek an efficient and accurate representation of ultrasonic signals for the purpose of flaw detection. First, a Gabor dictionary is designed based on the information of the noisy signal, then the nonconvex sparse regularization method is introduced to sparsely represent the signal. After signal representation, flaw-reflected echoes are identified following a criterion which is designed based on prior knowledge of the wave propagation characteristics in the inspected material. The performance of the proposed method is quantitatively evaluated and compared with competing algorithms using synthetic noisy ultrasonic signals. Their performance such as ultrasonic flaw detection, noise suppression and computation efficiency is investigated and compared in a statistical manner. Representative experimental results are also presented for demonstration.