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D. Mascarenas, S.Y. Chong, G. Park, J.-R. Lee, C. Farrar

Application of Compressed Sensing to 2-D Ultrasonic Propagation Imaging System Data

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The Ultrasonic Propagation Imaging (UPI) System is a unique, non-contact, laser-based ultrasonic excitation and measurement system developed for structural health monitoring applications. The UPI system imparts laser-induced ultrasonic excitations at user -defined locations on a structure of interest. The response of these excitations is then measured by piezoelectric transducers. By using appropriate data reconstruction techniques, a time-evolving image of the response can be generated. A representative measurement of a plate might contain 800x800 spatial data measurement locations and each measurement location might be sampled at 500 instances in time. The result is a total of 640,000 measurement locations and 320,000,000 unique measurements. This is clearly a very large set of data to collect, store in memory and process. The value of these ultrasonic response images for structural health monitoring applications makes tackling these challenges worthwhile.

Recently compressed sensing has presented itself as a candidate solution for directly collecting relevant information from sparse, high-dimensional measurements. The main idea behind compressed sensing is that by directly collecting a relatively small number of coefficients it is possible to reconstruct the original measurement. The coefficients are obtained from linear combinations of (what would have been the original direct) measurements. Often compressed sensing research is simulated by generating compressed coefficients from conventionally collected measurements. The simulation approach is necessary because the direct collection of compressed coefficients often requires compressed sensing analog front-ends that are currently not commercially available. The ability of the UPI system to make measurements at user-defined locations presents a unique capability on which compressed measurement techniques may be directly applied. The application of compressed sensing techniques on this data holds the potential to reduce the number of required measurement locations, reduce the time to make measurements, reduce the memory required to store the measurements, and possibly reduce the computational burden to classify the measurements. This work considers the appropriate selection of the signal dictionary used for signal reconstruction, and performs an evaluation of compressed sensing technique's ability to reconstruct ultrasonic images using fewer measurements than would be needed using traditional Nyquist-limited data collection techniques.

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Ключевые слова:

Содержание