Image reconstruction from compressed measurements for ultrasound NDT

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In ultrasound NDT, Delay-and-Sum schemes are commonly used to reconstruct images from the measurement data. For single channel pulse-echo measurements, this is called Synthetic Aperture Focusing Technique (SAFT). In a multi-channel setup, SAFT is extended to the Total Focusing Method (TFM), where the focused image is reconstructed from measurements of all transmit-receive combinations, an acquisition scheme referred to as Full Matrix Capture (FMC). In previous work, we showed that the underlying assumptions of both SAFT and TFM can used to define a forward model in a sparse recovery problem. The solution of this problem as well as enhancing the simple Delay-and-Sum scheme to a physically motivated forward model leads to improved image quality and more precise sizing of inclusions compared to Delay-and-Sum algorithms. The reconstruction is performed using l1 minimization. Further, this also allows to perform the reconstruction from compressed/subsampled measurements following compressed sensing theory. This subsampling was achieved by only measuring a subset of the frequency coefficients of the signal. In both the single channel and the multi-channel setup, the amount of measurement data is thereby significantly reduced. Additionally, for the TFM, we added a spatial subsampling by only considering a subset of transmit and receive pairs, further reducing the measurement data and at the same time also reducing the measurement time. In our previous work, the frequency and spatial dimensions were considered separately for simplicity, using the same compression strategy for all spatial measurements. Further, the selection of frequency coefficients was based on a simple heuristic. In this work, we present improved selection strategies for the set of Fourier coefficients in single and multi-channel setups and the set of transmit/receive channels in the multi-channel setup that are based on theoretic analysis. Further, in the multi-channel case, the selection of the Fourier coefficients and the channels can be treated jointly across dimensions. Example reconstructions are presented to showcase the improved imaging quality of the optimized (multi-dimensional) measurement strategies.