Optimal Waveform Design for Imaging with an Active Array

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We consider in this paper broadband array imaging of distributed reflectors by sending probing signals from one or more sources at the array and then recording the scattered echoes at all array elements.

We address the question of optimally choosing the waveform send by the array in order to construct the best possible image of the target for a given signal to noise ratio of the data. This is different from the problem of selecting the optimal waveform so as to maximize the received power at the array. The solution to this problem is known and its main drawback is that it corresponds to sending a narrowband waveform that peaks at the resonance frequency of the reflectors. That is because maximizing the power is equivalent to iterative time reversal, or, the singular value decomposition of the impulse response matrix. The resulting narrow-band waveform gives strong scattered echoes, but it is bad for imaging because lack of bandwidth means no range resolution and no statistical stability in clutter.

We propose instead to determine the source power allocation and waveforms with an optimality criterion based on the quality of the image. The main idea is to determine the waveform by solving an optimization problem using an appropriate measure that quantifies the quality of the image. The optimization problem is then solved subject to constraints such as limiting the power at the array and asking for an acceptable signal to instrument noise ratio at the receivers.