COHERENT MULTIPLE SIGNAL CLASSIFICATION FOR TARGET LOCATION USING ANTENNA ARRAYS

Marengo, E.A.
Department of Electrical and Computer Engineering ,
Northeastern University, Boston, MA 02115

Abstract Submission Form

2004 National Radio Science Meeting

Abstract: marengo22931

Date Received: August 27, 2004

It has been shown in a number of recent papers (Gruber et. al., *J. Acoust. Soc. Am.*, **115**, 3042-3047, 2004; T. Miwa and I. Arai, *IEEE Trans. Antenn. Propagat.*, **52**, 220-229, 2004) how multiple signal classification (MUSIC) can be employed in the problem of estimating the locations of M scattering material inhomogeneities or targets that are small in the scale of the relevant wavelength from knowledge of the scattering matrix K, henceforth to be referred to as 'the multistatic response matrix (MRM) K', of the system of targets, as measured by an array of $N > M$ same-transmit, same receive electromagnetic antennas or acoustic transducers (transceivers) actively probing the targets. This method enables the super-resolved location of very closely spaced targets beyond the diffraction limit and remains valid even if there is significant multiple scattering between the targets.

In the form of MUSIC for target location with active arrays available in the literature the so-called time-reversal matrix $T = K^\dagger K$, where $\dagger$ denotes the adjoint, plays a central role, which is analogous to that of the autocorrelation matrix of the signals received by a passive array in the familiar MUSIC algorithm for direction-of-arrival estimation. For time-harmonic signals with a supressed $e^{-i\omega t}$ time-dependence where ω is the angular oscillation frequency, the corresponding $(N - M)$-dimensional noise subspace W appearing in the calculation of the MUSIC pseudospectrum is the orthogonal complement of the signal subspace S spanned by $M < N$ linearly independent Green function vectors or 'propagators' associated with the different target locations, so that $S \oplus W = \mathcal{C}^N$ where $\mathcal{C}^N$ is the N-dimensional space of complex signals measured by the array. This method is useful only if the number of targets $M < N$ so that it can be used to locate up to only $N - 1$ targets. The central aim of this presentation is to show that actually one can do much better and that, in particular, theoretically one can locate up to $N(N + 1)/2 - 1$ targets embedded in a given linear and reciprocal but otherwise arbitrary background medium from knowledge of the entire MRM K. Two forms of MUSIC are considered: 1) A variant of the usual incoherent MUSIC method adapted to active scattering data instead of passive data only, for cases when many scattering measurements (random realizations) are available, as well as 2) a new form of purely coherent MUSIC for cases when a single data set (realization) is available. The new coherent MUSIC uses a pseudospectrum steering vector that steers in a single step in the entire parameter space of all target locations. These findings establish a fundamental bound on the information about target locations that is contained in a scattering data set.

1. (a)
Edwin Marengo
Department of Electrical and Computer Engineering
Northeastern University
Boston, MA
02115 USA
`emarengo@ece.neu.edu`
   (b) 617-373-3358
   (c) 617-373-3358
2. F - Wave Propagation and Remote Sensing
3. (a)
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