An alternative to diagonal loading for implementation of a white noise array gain constrained robust beamformer

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An alternative to diagonal loading for implementation of a white noise array gain constrained robust beamformer

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Abstract

Diagonal loading is one of the most popular methods of robust adaptive beamforming, and the solution to many different problems aimed at producing beamformers which are robust to finite samples effects or/and steering vector errors. Among the latter, constraining the white noise array gain (WNAG) is a meaningful approach. However, relating the loading level to the desired WNAG is not straightforward. In this communication, using a generalized sidelobe canceler structure of the beamformer, we prove that the WNAG constraint can be encoded directly in the beamformer, and the latter can be obtained in a rather simple way from a specific eigenvector and without going through the diagonal loading step.

Keywords: robust adaptive beamforming, white noise array gain, generalized sidelobe canceler.

1. Problem statement

For about forty years, driven by the practical need to cope with uncertainties that unavoidably arise in any radar, sonar or communication system, an uninterrupted thread of research about robust adaptive beamforming has given rise to a vast literature and a myriad of techniques, with many different approaches proposed [1–4]. Yet, one of the earliest proposed methods, namely diagonal loading (DL) [5–8], still stands as a reference to which any newly proposed method is systematically compared. The main reason for such a preeminence is that 1)it performs very well and 2)diagonal loading emerges naturally as the solution to various and different optimization problems, all aimed at producing beamformers robust to either finite samples effects or steering vector errors, or both. Indeed, let us start with the minimum power distortionless response (MPDR) beamformer which solves [1]

$$\min_{\boldsymbol{w}} \boldsymbol{w}^H \hat{\boldsymbol{R}} \boldsymbol{w} \text{ subject to } \boldsymbol{w}^H \boldsymbol{a}_0 = 1 \tag{1}$$

where $\hat{\boldsymbol{R}} = K^{-1} \sum_{k=1}^{K} \boldsymbol{x}_k \boldsymbol{x}_k^H$ stands for the sample covariance matrix computed from K independent snapshots $\boldsymbol{x}_k \in \mathbb{C}^N$ and $\boldsymbol{a}_0$ is the assumed signal of interest (SOI) steering vector. Assuming that $K \geq N$, the

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