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Adaptive noise blocking in a reduced-rank beamforming-based index for brain source localization

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***Abstract*— We present a source localization method for electroencephalography (EEG) data based on the structure of the generalized sidelobe canceler (GSC) in which we use an adaptive blocking matrix (ABM) to determine the optimum reduction of the rank. Our realistic simulations show that we can achieve a more consistent source localization than the full-rank multi-source activity index (MAI) when brain sources are embedded in high background activity.**

I. INTRODUCTION

Beamforming techniques have been used in electroencephalography (EEG) for signal reconstruction and localization of sources of brain electrical activity. The aim of this paper is then to propose an alternative for the selection of the optimal value for a reduced-rank beamforming approach. For that purpose, we propose a neural index based on the rank of an adaptive blocking matrix (ABM). This approach relies on the idea of cancelling signal components that are correlated between the sources output and the interferences path channels on the generalized sidelobe canceller (GSC) beamformer structure.

II. METHODS

In [1], we introduced an index based on the structure of the GSC beamformer, which is shown in Figure 1. Here, we introduce a new index given by

$$\eta_{\text{RR}}(\theta) = \operatorname{tr}\left\{ \left[\widetilde{W}_0^T \widehat{R}^{-1} \widetilde{W}_0 \right]^{-1} \right\}, \tag{1}$$

where the reduced-rank estimator is $Q_o = \widetilde{W}_0^T Y_k$ and $\widehat{R}$ is a consistent estimator of the measurements' covariance. This new index only takes into account the contribution of the noise and interference components that affects the output of the GSC filter. Furthermore, in (1) it is of utmost importance the blocking of background brain activity and other interferences X_0 through $C_\perp$. It has been shown in [2] that such blocking can be optimally achieved with the use of an ABM, mainly due to the suppression of spatially correlated interference. Therefore, we propose to use the rank of the ABM in (1) by considering that $C_\perp = \mathbf{I} - \mathbf{b} W_h$, where $\mathbf{b} = R_{0y} R_{00}^{-}$, with $R_{0y} = \widehat{R} W_h$, $R_{00} = W_h^T \widehat{R} W_h$. and $(\cdot)^{-}$ denotes the Moore–Penrose generalized inverse.

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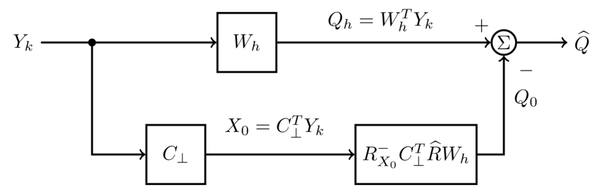

Fig. 1: Structure of the generalized sidelobe canceler.

III. NUMERICAL EXAMPLES

We evaluated the performance on estimating the position of three brain sources similar to those used in [1]. An example of such evaluation is shown in Figure 2. The evaluation is expressed in terms of the standard deviation of the maximum bias in the estimation of the true location of the brain sources (denoted as $\sigma_{b_{\text{MAX}}}$).

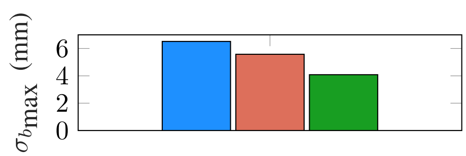

Fig. 2: Results of evaluating $\sigma_{b_{\max}}$ for signal-to-biological-noise ratio of -5 dB and signal-to-measurements-noise ratio of 0 dB. Blue, red, and green bars correspond to index proposed in [3], reduced-rank approach proposed in [1], and new index (1), respectively.

IV. CONCLUDING REMARKS

The index in (1) offers a more consistent localization of the neural sources than the multi-source activity index (MAI) proposed in [3]. Our filter does not seem to be affected by different levels of background neural activity and estimation keeps low variance in cases when background noise is high.

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