On the Information Content of Sensor Placement Optimization

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Abstract **Figures of merit are used to estimate the information content and to optimize the sensor placement. They are the key to find an optimal sensor placement, which gives the most available information from a system under investigation with a minimal number of sensors. In this paper we compare figures of merit used in the literature in order to find a suitable one for estimation of the information contained in a sensor network.**

Keywords **Sensor Placement Optimization, Information Content, Figures of Merit**

I. Introduction

The importance of sensor placement optimization arises from the fact that it is impossible to derive more information than what the sensor system yields, even if the best analytic methods are used to get more information from it [1]. In order to find the optimal sensor placement, figures of merit (cost functions) are used to compare sensor scenarios and to estimate the information content in each one [2].

The purpose of this paper is to define a figure of merit for estimation of the information content contained in the lead field matrix $\mathbf{L}$. This matrix contains information about the physical problem and its elements define the relation between the measured data and the unknown sources [3].

II. Methods

In order to find a suitable figure of merit to estimate of the information contained in a sensor network we compare the following three figures of merit used in the literature either to estimate of the information content or to optimize of sensor placement:

- The singular values ratio (SVR) defined as [4]

$$SVR = \frac{\sigma_\mathrm{i}}{\sigma_\mathrm{max}} \tag{1}$$

- The condition number (CN) with respect to the L_2-norm defined as [3]

$$CN = ||\mathbf{L}||_2 \cdot ||\mathbf{L}^{-1}||_2 = \frac{\sigma_\mathrm{max}}{\sigma_\mathrm{min}} \tag{2}$$

- The inverse of squared singular values (ISSV) defined as [5]

$$ISSV = \sum_{i=1}^{r} \frac{1}{\sigma_i^2} \tag{3}$$

where σ_i are the singular values of the lead field matrix $\mathbf{L}$, σ_max and σ_min are the maximum and the minimum singular values, $||\cdot||_2$ is the L_2-norm and $\mathbf{L}^{-1}$ is the inverse of $\mathbf{L}$.

A sensor network provides more information when the decay of its singular values ratio is lower than the one for an another network [4], [5].

III. Simulation

We place one magnetic dipole in the x-y plane and use a sensor network consisting of 12×12 sensors distributed regularly above the x-y plane. The sensors are uniaxial sensors directed in z-direction. We further assume (4×4) dipoles as fictional sources in the x-y plane, which are also distributed regularly. One of them is placed in the same position as the true dipole to check whether the right source can be determined by solving the inverse problem.

IV. Conclusion

It turned out that the decay of singular values ratio is a good indicator for estimation of the information content but probably not for all cases.

References

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