Hardware requirements of the Signal Space Separation method

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The recently introduced Signal Space Separation method (SSS) [1] creates a device-independent representation of multichannel biomagnetic data in terms of multipole components. It has many uses in biomagnetic measurements, such as suppression of external artifacts, movement compensation, conversion of measurements between different instruments and facilitation of source modeling. In the near future, there will be an interest to adapt SSS to a large variety of biomagnetic instruments. However, the method requires a precisely manufactured multichannel instrument, and many instruments currently in use are not optimal for SSS.
In this work, we wished to clarify the requirements the SSS method places on the biomagnetic instrument. We used computer simulations of a helmet-shaped gradiometer array to investigate the effect of different parameters such as gradiometer imbalance, calibration and inaccurate sensor array geometry data on SSS.
The results show that well-balanced gradiometers are required for effective application of SSS. In an unshielded environment with faraway disturbance sources, imbalance as low as 0.1% may be necessary, while 0.5% to 1% may be sufficient for measurements in a shielded room. It is possible that most wire-wound gradiometers have too high imbalance for optimal SSS performance, while thin-film gradiometers are easier to manufacture to the required precision. In contrast, the effect of sensor calibration errors of a typical magnitude is negligible. Accuracy of sensor array geometry data was found to be important for representation of fields with high spatial frequency.

[1] S. Taulu, J. Simola, and M. Kajola, “Applications of the signal space separation method,” IEEE Transactions on Signal Processing, vol. 53, no. 9, 2005.