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Frequency-Domain Blind Source Separation of Biomagnetic Signals Measured with an OPM Array

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Optically pumped magnetometers (OPMs) are highly sensitive sensors that can detect minute biomagnetic fields. However, OPM signals are often degraded by ambient magnetic interference and motion artifacts. To address such noisy signals, we apply independent low-rank matrix analysis (ILRMA), a multichannel blind source separation (BSS) method that leverages the low-rank structure of source power spectrograms in the time-frequency domain. Periodic biomagnetic signals, such as cardiac signals, exhibit clear harmonic structures in their power spectrograms (Figs. (a) and (b)), which can be approximated as low-rank matrices. By exploiting the time-frequency and spatial characteristics of sources, ILRMA effectively separates target physiological signals from noisy multichannel OPM signals.

We conducted a magnetocardiography experiment in a magnetically shielded room using an array of four SERF-type OPMs manufactured by Hamamatsu Photonics K.K. To suppress noise from commercial power sources, the signals were filtered with a 0.5–50 Hz band-pass filter. ILRMA was compared to conventional time-domain independent component analysis (ICA) under determined conditions (equal number of sources and channels). With ICA, cardiac QRS complex patterns appeared across multiple estimated sources (two of four shown in Fig. (c)). In contrast, ILRMA successfully separated the cardiac QRS complex signal from periodic noise as distinct sources (Fig. (d)), demonstrating its superior performance for multichannel magnetocardiography with OPMs.

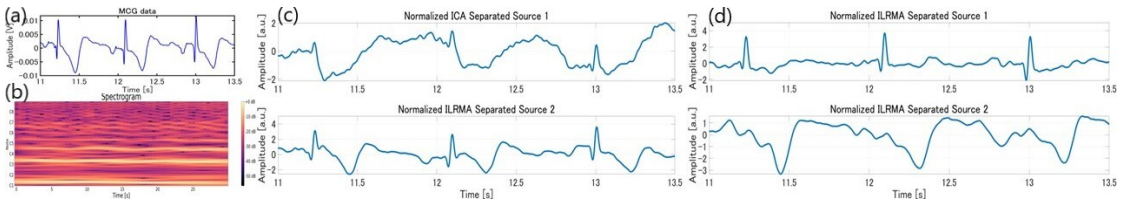

Figure 1: (a)MCG signal (b)Log-frequency spectrogram (c)ICA separated signals (d)ILRMA separated signals

Reference

[1] D. Kitamura, *et al. EURASIP J. Adv. Signal Process.*, vol.2018, no.28 (2018)

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