MLSP 2006 Competition: Denoising of Magnetoencephalographic Data

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1 Introduction

Magnetoencephalography (MEG) is a non-invasive technique used to measure the magnetic fields that result from intracellular neuronal current flow. These spatiotemporal signals are used to study human cognition and, in in clinical settings, for preoperative functional brain mapping. One common method of collecting functional data involves the presentation of a stimulus to a subject. The level of noise that is inherent in the data collection process is large enough that it oftentimes obscures the signal(s) of interest. In order to reduce the level of noise the stimulus is repeated for as many as 100-500 trials, the trials are temporally aligned based on the timing of the stimulus presentation, and then an average is computed. This ubiquitously-used approach works well, but it requires numerous trials. This in turn causes subject fatigue and, therefore, limits the number of conditions that can be tested for a given subject. Improved denoising methods are sought that sufficiently reduce the level of noise without requiring numerous trials.

2 Data

The Matlab data file, *http://www.mrsc.ucsf.edu/∼hild/bdata.html*, contains 10 trials of recorded magnetoencephalographic signals (contact Kenneth if you do not have access to Matlab). The somatosensory stimulus is applied at time $t = 0$ ms. The variables are as follows:

b - magnetic field in fT
t - time in ms
fs - sample rate in Hz
pre - time indices that correspond to the pre-stimulus period
post - time indices that correspond to the post-stimulus period

The first, second, and third dimensions of b correspond to space (274 sensors), time, and trial number, respectively. A simple average over trials can be computed using the following Matlab code,

```
y = zeros(274,length(post));
for k=1:10
   y = y + b(:,post,k);
end
y = y/10;
```

3 Submissions

The submissions should be in the form of a Matlab *.mat file that contains a single variable, y, of size (274×241). This variable should pertain only to the *post-stimulus* period of a single representative trial, as in the previous simple example code. The submission should be e-mailed directly to the MLSP Committee by the deadline. The email should contain the *.mat file as an attachment and should include a one paragraph description of the approach used.

4 Performance Metric

The performance metric used to determine the winner is the output signal-to-interference/noise ratio,

$$Output\ SNIR \triangleq 10 \log_{10} \left(\frac{1}{K} \sum_{i=1}^{K} \frac{\sum_{n=1}^{N} (y_{in}^*)^2}{\sum_{n=1}^{N} (y_{in}^* - y_{in})^2} \right) (dB)$$

where $N = 241$, $K = 274$, y_{in} is the submitted data matrix, y_{in}^* is based on the mean magnetic field resulting from 525 trials, and the gain of both y_{in} and y_{in}^* are first modified to have unit variance. Larger values of output SNIR indicate better performance.

5 Hints

The signal of interest is active mainly in the post-stimulus portion of the data, the power is concentrated in the 1-50 Hz range, there are two peaks of activation occuring at approximately 50 ms and 100 ms after the stimulus onset, and temporal filtering alone is usually not sufficient to produce a large value of output SNIR.