Aalto-yliopisto
Perustieteiden
korkeakoulu

Expectation-Maximization algorithm to estimate activity in regions of interest from MEG-data

Subject presentation

Hilkka Hännikäinen

11.06.2018

Advisor: *Narayan Subramaniyam*
Supervisor: *Harri Ehtamo*

Systeemianalyysin
laboratorio

Project

- The objective of the project BrainTrack is to develop methods to jointly estimate the neural source activity and their connectivity from data collected with EEG or MEG

Abbreviations used:

- MEG = magnetoencephalography
- EEG = electroencephalography

Background

- Function of brain is based on electric currents flowing through neurons
- The activity of a large number of neurons with coherent activation is approximated with a current dipole
- The activity of brain is modelled with distributed source model
  - The neural currents are modelled as a continuous vector field which is discretized into small, densely placed elements
  - A current dipole is assign to each element with constrained orientation
- Data is obtained with EEG or MEG
  - EEG: electric potential difference
  - MEG: magnetic field

Background

- Solving inverse problem

$$\bar{y}(t) = L\bar{x}(t) + \bar{\varepsilon}$$

where

$\bar{y}(t)$ = measured data

L = lead field matrix

$\bar{x}(t)$ = the amplitudes of the dipoles

$\bar{\varepsilon}$ = noise from the measurement

- The area which is mainly active is called region of interest (ROI)

  → studying the connectivity between different regions

Objective

- Implement expectation-maximization algorithm to determine the activity of the ROIs as a single time series
- Form a matrix, call it A, so that

$$\bar{z}(t) = A\bar{x}(t) + \bar{\eta}$$

Where

$\bar{z}(t) \in \mathbb{R}^{n_{ROI}}$=activity of the ROIs

$\bar{x}(t) \in \mathbb{R}^{n}$=activity of the dipoles

$A \in \mathbb{R}^{n_{ROI} \times n}$=the matrix containing the weights for the amplitudes

$\bar{\eta}$=additional noise of the activity of the dipoles

Methods

- Expectation-maximization algorithm
  - Iterative method to estimate maximum likelihood parameters with incomplete data
  - Consists of
    - E-step: calculate natural logarithm of the likelihood function which tells the probability to obtain certain data in the presence of the lastest estimate for the parameters
    - M-step: maximize the expression with respect to the chosen parameters: the values which maximize the expression form a new estimate for the parameters

Tools

- MATLAB, Python
- Triton

Materials

- Baillet, S., Mosher, J., Leahy, R. 2001: Electromagnetic Brain Mapping. IEEE Signal Processing Magazine.
- Do, C., Batzoglou, S. 8/2008: What is expectation maximization algorithm?. Nature Biotechnology.
- Shumway, R., Stoffer, D. 2006: Time Series Analysis and Its Applications. Springer, USA.
- Other material when needed

Timetable

- 05-06/18: Background research and literature review
- 06-08/18: Implementation and verification of the algorithm
- 08-10/18: Writing
- by 12/18: Presenting the thesis