Abstract

- Standard **event-related potentials** (ERP) technique consists in averaging many on-going EEG trials using the same stimuli. We introduce a novel **Blind Source Separation** (BSS) approach based on a **weak exclusion principle** (WEP) to solve the problems. The results show that our BSS algorithm can effectively extract ERPs **using fewer average times** than the traditional methods.
- We can isolate two main ERP components, which are respectively related to an **exogenous process** and a **cognitive process**, and can discriminate between the occipital lobe and the frontal lobe responses from the brain, agreeing with the classical component modeling in ERPs.
- Single-trial ERP separation results have demonstrated the consistency of these two main ERP components.

**Blind Source Separation**

- **Blind Source Separation (BSS):**
  - Blind: No prior knowledge of the measurement.
  \[ X = SA; \text{or, more visually,} \quad Y = X = SA = K + A \]

- **Electroencephalography (EEG):**
  - Non-invasively measures voltage fluctuations resulting from ionic current within the neurons of the brain with very high temporal resolution.

**Previous BSS Methods’ Hypothesis**

- **The signals are statistically independent.**
- **Representative Algorithm:** Independent Component Analysis (ICA).
- When considering the source signals as stochastic processes, the requirement of stationarity is necessary to guarantee the existence of a representative (non-Gaussian) distribution of the sources.
- However, the non-stationarity of EEG signals is well documented.

**The Proposed BSS Method’s Hypothesis**

- **Based on a deterministic principle. Weak Exclusion Principle.**
- **Exclusion Principle (EP):** The Sources are exclusive from each other.
- **Weak Exclusion Principle (WEP):** at each time instance, the EEG signal is dominated by one source which is significantly (e.g. by a factor of 2) larger than the others.

**Event-Related Potentials (ERP)**

- **Standard ERP technique**
  - Tens or even hundreds of trials are necessary to obtain a reliable ERP average waveform.
  - Different electrodes have different ERP waveforms. The standard ERP plots **cannot integrate the global information.**

- **Blind Source Separation based on WEP to extract the ERPs**
  - Performance of BSS on EEG to extract the ERPs under different average times.
  - Isolate two main ERP components: an **exogenous process** and a **cognitive process**.

- **Single-trial ERP separation results** have demonstrated the consistency of these two main ERP components.

**Event-Related Potentials Source Separation based on a Weak Exclusion Principle**

Lan Ma, Thierry Blu, William Shi-yuan Wang
Department of Electronic Engineering, The Chinese University of Hong Kong
malantju@gmail.com