
Level of qualifications required: Master's or equivalent
Function: Internship Research

About Inria

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world's top universities, Inria's 2,700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

About the research centre or Inria department

The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) “Université Côte d’Azur (UCA)”.

Context

Electroencephalography (EEG) is one of the non invasive imaging techniques used in medical engineering for functional or clinical brain exploration. Electrical currents occurring in the brain produce an electrical potential which is recorded at a finite number of pointwise electrodes located on the scalp. From these measures, we approach the inverse problem of localizing in the brain the primary currents (sources) which have produced the records [2].

A dedicated software FindSources3D (http://www-sop.inria.fr/apics/FindSources3D) is currently being developed at INRIA that solves the inverse EEG problem spherical head models and for pointwise dipolar brain sources. It runs two main consecutive steps:

1. EEG records are the superposition of several main time independent activities that first have to be properly separated.
2. Next, each independent time activity (topography) can be seen as a static vector modulated by a time dependent signal. This static vector can be explained as the potential produced at the electrodes locations by one or several pointwise dipolar sources.

Step 1 is relevant of Multiple Signal Classification (MUSIC) techniques. Step 2 is a time harmonic potential inverse problem.

The aim of the internship is to develop the step 1.

Co-advisement: Centre de Mathématiques Appliquées, Mines ParisTech, Athena INRIA team (Sophia Antipolis), Institut Neurosciences de la Timone (INT, Marseille).

Assignment

Multi-channels sampled EEG records are stored in a data matrix. Classification relies on approximate factorization of this matrix, the approximate rank being the number of activities we are looking for. This is classically done using singular values decompositions (SVD). Linear combinations between these activities are then searched in a finite dimensional subspace. Methods may differ on the way to explore this subspace. The way we want to proceed is to look for the linear combinations that minimize the error between the potential generated on the scalp by the associated localized sources and the available EEG measurements. Indeed, from a given static vector, FindSources3D is able to perform dipolar source estimation (solutions to problem 2), for spherical layered models of heads [1]. This can be viewed as a change of basis performed on the static part of the SVD. At present step 1 is solved by dipole fitting, and this may not be optimal as a single activity may be caused by several dipolar sources.

Main activities

- Dipolar sources.
- Solved by dipole fitting, and this may not be optimal as a single activity may be caused by several dipolar sources.
During the internship, a bibliographical study will be pursued concerning principal components analysis techniques and algorithms of MUSIC type [3]. Algorithmical and numerical aspects of the change of basis described above will be studied, while computational developments should be added to the software FindSources3D. The obtained results should be compared with those obtained by more classical combinations of the time independant components. Observe that a similar protocol can be used for magnetoencephalography (MEG) recordings, which may also be considered, if time allows.

Note that quite many softwares and databases are available on the internet such as anywave, eeglab, fieldtrip, brainstorm, and others. They provide free access to some well tested tools for data manipulation and filtering, independant component analysis, and dipole fitting.


Skills
- Strong background in applied mathematics.
- Good knowledge of physics, algorithms and numerical analysis.
- Involvement in numerical simulation (Matlab) and in applications.

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities