TNT: Tracking Network dynamics with Tensor factorisations. Application to the human Chronnectome in Alzheimer’s disease

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TNT: Tracking Network dynamics with Tensor factorisations. Application to the human Chronnectome in Alzheimer's disease

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Research Abstract

Alzheimer’s disease is a major problem to UK society. Because of the ageing population, the number of people with dementia will increase dramatically in the next years: from about 850,000 today to 1,000,000 by 2025. The current annual cost of dementia to the UK is £26 billion even not everybody with dementia receives a diagnosis. Alzheimer’s disease is the most common cause of dementia and it is particularly difficult to diagnose because there are no objective

biomarkers for it and the diagnosis relies on the medical history of the patient. We need better ways to detect and monitor the changes that Alzheimer's disease causes in the brain. To achieve this, we will consider the electroencephalogram (EEG), an affordable piece of equipment that can be used outside hospitals to measure brain activity safely at several locations over the scalp (called "channels"). We will create new signal processing tools to analyse EEG brain networks. Doing so will lead to objective ways to monitor Alzheimer's disease.

Namely, this interdisciplinary project will develop a novel set of processing techniques based on tensor factorisations to inspect how the components of brain activity networks change with time. We will then implement methods to compare the temporal profiles of the components estimated for different groups of people (e.g., healthy people versus patients).

Our project is motivated by the facts that: 1) the EEG can measure fast changes in brain activity, 2) Alzheimer's disease damages brain connections, and 3) preliminary results indicate that Alzheimer's disease affects the temporal behaviour of brain activity.

Indeed, there is an increasing interest in understanding brain activity networks and their evolution with time, as this would open up radically new ways to monitor brain diseases. Promising pilot results have reported in, e.g., Parkinson's and multiple sclerosis but, currently, there are no appropriate ways to inspect how the networks change with time systematially. Instead, we will develop a framework based on tensor factorisations (a set of algebraic and computational techniques to analyse tensors: n-mode data arrays with n>=3) to inspect the components of networks directly from the data without the need for manual intervention. We will then apply it to EEG signals. First, for each person, we will assess the coupling between channels of the EEG as a function of time and frequency. These results naturally fit into a multi-modal representation: a "connectivity tensor". Then, we will decompose the "connectivity tensor" into its underlying components. We will implement constraints to bring previous information into the decompositions, including novel ways to measure the natural organisation of the network components. Finally, we will assess the robustness of the extracted network components and we will inspect how Alzheimer's disease changes them.

We will apply our methods to two different sets of EEG signals measured from patients with Alzheimer's disease, people with mild cognitive impairment (a condition that sometimes precedes Alzheimer's disease), and healthy volunteers. One of the EEG datasets measured the activity of the brain at rest using a small number of channels, whereas the other has been recorded during a short-term memory task that has shown promise in the detection of early Alzheimer's disease with a larger number of EEG channels. Hence, we believe that revealing how the EEG network changes with time during this task could lead to a non-invasive, affordable and portable tool to monitor Alzheimer's disease. Nonetheless, this project will have much wider implications because it will benefit the signal processing, tensor factorisation and network analysis communities and the techniques will be readily applicable to other types of data, both inside and outside clinical settings.

Further information available at:

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