interview

Carlos Thomaz

"Other non-invasive techniques for measuring activity in the brain, like electroencephalography, might benefit from this priori-driven multivariate statistical approach"

Dr Carlos Thomaz from Centro Universitario da FEI, Brazil, talks about the research behind his paper 'A priori-driven multivariate statistical approach to reduce dimensionality of MEG signals'.

Tell us a bit about your research.

My research interest has been mainly in statistical pattern recognition. More specifically, my research activities have been related to high-dimensional and limited sample size problems. Here the number of samples (or trials) is less than, or comparable to, the dimension of the feature space and so the performance of classical techniques tends to deteriorate. Therefore, in the last ten years, I have been very much involved in developing and applying statistical pattern recognition algorithms to understand the high dimensional and sparse data space.

What have you reported in your *Electronics Letters* paper?

This paper is about magnetoencephalography (MEG) signal processing. MEG is a non-invasive technique for measuring activity in electrical brain cells *in vivo* and is based on the detection of very small (or weak) magnetic fields sampled extremely quickly (1 millisecond or better). In other words, MEG is a high-dimensional signal that might be easily contaminated by other sources of variation not related to the brain activation of interest, including external noise and even internal ones, such as eye-movement. This Letter describes and implements a MEG multivariate data exploratory analysis that combines the typical variance criterion used in principal component analysis with some prior knowledge about the sensory experimental task, separating what is genuine brain information of interest from artefacts.

Why is this significant?

It is known that, owing to linearly superimposing magnetic fields in MEG recordings, feature extraction algorithms are upper bounded by the number of sensors. In practice, however, the number of signal sources of interest has been much smaller than the number of sensors. Since MEG experimental design is often time-locked to a specific task, it is possible to use this information to ensure a compact representation of MEG without compromising its interpretability and allowing subsequent denoising or demixing tasks using only few principal components. Other non-invasive techniques for measuring activity in the brain, like electroencephalography (EEG), might benefit from this priori-driven multivariate statistical approach, reducing significantly the dimensionality of the signals and avoiding the inherent high-dimensional and limited sample size issues related to these types of signals.

What are the biggest challenges that you have had to overcome?

Understanding the main neural dynamics involved in the recordings of MEG and translating this information in a priori-driven multivariate statistical framework was the biggest challenge. In fact, this work has only been possible because I have had the fortunate opportunity to collaborate with the research team of the University of Nottingham composed of young and senior scientists with a strong commitment to investigating non-invasive measures of electrophysiology and projecting sensor space data into the brain. The other challenge was how we could clearly represent our main result of describing distinct brain activation patterns depending on the sensory experimental task.

What are the next steps in this research?

We have restricted our analyses to beta band (13–30 Hz) signals because these waves are associated with the neural areas of the experiments carried out in the current work, such as the motor cortex. However, we could extend this to other frequencies, like alpha (8–13 Hz) and gamma (30–200 Hz) bands. Gamma activity, for instance, is associated with sensory and cognitive tasks and is known to be abnormal in pathology. Perhaps the approach proposed might ensure simultaneous variance and discriminant feature selection helping to visualise and interpret patterns of brain disorders.

How do you see this field progressing over the next few years?

Although the spatial resolution of MEG (approximately 5 mm) is currently lower than that of functional MRI (approximately 1 mm), MEG is based on electrical activity, not on blood flow, which provides direct measurements of brain function with millisecond precision rather than seconds. This is more appropriate for the study of brain dynamics that change in the millisecond range and it is reasonable to expect that this type of non-invasive technique would be more widely used in the near future not only for neuroscientific research, but also clinically for diagnosis. Particularly, I would like to see more of this advanced technology in developing countries like Brazil, disseminating the MEG practice and understanding.

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