School: Mathematics, Statistics and Actuarial Science

Supervisor: Professor Jian Zhang

Project title: Statistical analysis of brain connectivity with electromagnetic brain imaging data

Project description: Electrophysiological activity of neurons in the brain generates both electric potentials on the scalp and magnetic field outside the scalp. Direct non-invasive measurements of these neuronal activities can be made by using arrays of electroencephalography (EEG) or magnetoencephalography (MEG) sensors (Baillet et al., 2001; Hamalainen et al., 1993). Applications of EEG/MEG include basic research into perceptual and cognitive brain processes, localizing regions affected by pathology, and determining the function of various parts of the brain. While EEG/MEG offers a direct measurement of neural activity with very high temporal resolution, its spatial resolution is relatively low. Concerns over its spatial resolution have raised foundational issues of methodology and theory. In fact, improving its resolution by virtue of source reconstruction is lying at the heart of the entire EEG/MEG-based brain mapping enterprise. Reconstructing neural activities based on the measurements outside the brain is an ill-posed inverse problem since the observed magnetic field could result from an infinite number of possible neuronal sources. It has long been known that the sensor measurements are linked to the source magnitude vector by the so-called gain matrix. Despite remarkable progress on source reconstruction, it remains largely unknown on the theoretical behaviour of existing procedures for inferring brain connectivity and on what can and cannot be inferred from electromagnetic brain imaging (Moiseev et al., 2011; Quraan et al., 2011; Zhang et al., 2014).

In the proposed project, the research will focus on exploring properties of the gain matrix and address the problem under which conditions the underlying brain connectivity is recoverable. Some new methods will be proposed to improve the robustness of the existing methods to the so-called source leakage or interference. The proposed methods will be applied to study functional connectivity in a human brain.

References:


