Brain Research Institute

Advanced imaging methods for mapping human brain function

Opportunities at the Brain Research Institute

THE UNIVERSITY OF MELBOURNE

Eligible areas of expertise

- •Physics
- •Engineering
- •Computer Science
- •Software Engineering
- •Medical imaging
- •Neuroinformatics

Overview

Students with expertise in the disciplines listed above are encouraged to undertake postgraduate research projects at the Brain Research Institute (BRI). Such projects can include development of image acquisition and analysis techniques and/or their application to the neurosciences. BRI has an active programme of research in the neurosciences using magnetic resonance imaging (MRI) and spectroscopy to investigate brain function and structure. The institute has a state-of-the-art 3 tesla MRI facility primarily for research of the human brain, and has developed its own state-of-the art simultaneous EEG/fMRI acquisition system. Academic staff within the neuroinformatics team at BRI include physicists, computer scientists and engineers.

Scholarships

A small number of competitive scholarships funded by BRI are available for postgraduate students, including some to supplement the award amounts offered by external scholarships. Candidates should also apply elsewhere for scholarships or grants to perform research at BRI (for example, Australian postgraduate research awards, University postgraduate research awards, NHMRC and ARC fellowships, or other national or international fellowship schemes). Assistance with scholarship and/or grant applications to other granting bodies can be provided for suitable candidates.

Enquiries can be directed to scholarships “at” brain.org.au

A selection from available projects…

Optimisation of functional imaging acquisition and analysis

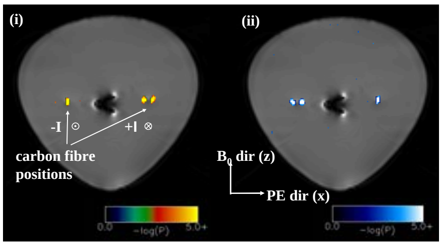
Functional MRI (fMRI) is now so widely accepted as a research tool to help map and understand the functional behaviour of the human brain, that it is easy to forget that the first human fMRI studies were conducted less than fifteen years ago. There are now thousands of published fMRI studies mapping human brain function in health and disease, most driven by clinician neuroscientists successfully applying what are now considered established methods of acquisition and statistical analysis. Too often, however, the methods used are not optimal, nor even appropriate. Recent research in our own laboratory and in others indicates that there is a wealth of information that can be extracted from existing fMRI studies that is currently being ignored. The aim of this project is to systematically investigate a selection of current MRI analysis controversies, develop and evaluate several novel methods of analysis, and investigate brain function and structure using the existing imaging data of healthy individuals and patients. This project requires expertise in one or more of physics, mathematics, computer science, engineering and statistics.

A selection from many available projects…

Direct detection of neuronal currents with MRI

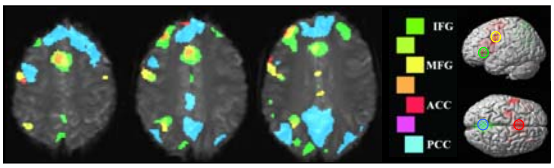
Functional MRI (fMRI) has become one of the most widely used methods for the non-invasive mapping of neuronal activity in the human brain. It is however an indirect technique, measuring changes in the vasculature rather than neuronal activity directly. The response of the vasculature is much slower than the underlying neuronal activity, thus limiting to the temporal resolution of fMRI. The spatial extent of fMRI activation is also generally significantly larger than the presumed localized zone of firing neurons responsible for the change in blood flow. Over the last few years we have developed an MRI technique which could potentially be used to directly detect the localised magnetic effects arising from neuronal currents. This could provide a neuronal mapping method with millimetre spatial resolution and millisecond timing resolution. Our preliminary results are encouraging, however there is much work still to be done to characterise and further develop the method. This project would best suit someone with a physics or engineering degree.

Direct current detection with MRI: Images of a silicon-oil filled container containing a carbon fibre conductor, showing statistical overlay in colour of the (i) positive and (ii) negative magnitude signal change ($p<0.001$) for a current pulse of 100μA amplitude and duration 20 ms.



Exploration of functional synchrony in brain networks using MRI

Functional MRI (fMRI) has been used since the early 1990’s to image the brain’s response to specific stimuli. It is an MRI technique that makes use of an intrinsic contrast mechanism involving the different magnetic states of oxygenated and de-oxygenated haemoglobin. Recently it has been found that the blood-oxygenation level dependant (BOLD) fMRI signal measured whilst a subject is at “rest” contains low frequency (<0.08Hz) fluctuations that appear to be related to functionally connected networks. This project will involve the development of novel image analysis strategies to maximise the information extracted from resting state fMRI data. It will also involve the exploration of these signals in a number of people to determine the degree to which they may vary within and between individuals, and whether the technique can be applied to improve our understanding of brain networks in the healthy and diseased brain. This project would suit candidates with a degree in physics, mathematics, computer science, engineering or statistics.



Functional connectivity of the brain measured with resting-state functional MRI. Three axial-slice images of the brain of a single subject are shown with a colour overlay of regions of synchronous activity whilst the subject was at rest. Four regions of interest were examined, determined with the aid of a conventional fMRI study of a language task (the regions are illustrated by circles in the 3D brain renderings). The colour used in the connectivity map corresponds to that of the circle illustrating the particular region seeded.

Enquiries

If you are interested in these or other projects, please contact:

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