VLSCI SCIENCE STORY 1

FINDING THE EPICENTRE OF A BRAINQUAKE

Victoria's new supercomputer facility is helping to create a new monitoring system for epilepsy. The researchers hope to identify the seat of an epileptic seizure and open up opportunities for surgical intervention.

Tim Thwaites, Science Writer

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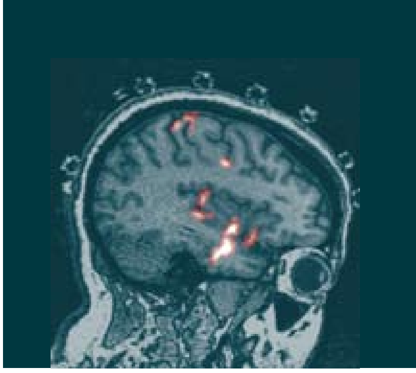
“We can build models for individual patients”

From l to r: Emma Steele, Stephan Lau, Simon Vogrin.
Image credit: David Paul

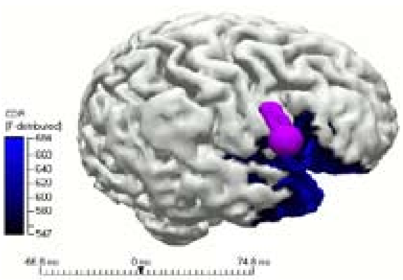


Preliminary fMRI data of an epileptic event. The coloured regions indicate increases in blood oxygenation (brain activity).
Image credit: Simon Vogrin and Stephan Lau

Nearly one Australian in fifty suffers from epilepsy, and about one third of them cannot be treated effectively with drugs. For these people, the only alternative is some form of brain surgery. But in fewer than 10 per cent of them is the area which triggers the epilepsy clearly enough defined to allow such an operation to take place.

University of Melbourne PhD student Stephan Lau is working to increase the accuracy of the information provided to surgeons as to where they should operate – but he needs a supercomputer to do it.

At present, pre-clinical assessment of patients for surgery includes two sets of measurements, which can help track the focus of epileptic seizures. But doctors face a similar problem to geophysicists trying to infer the epicentre of an earthquake from seismic data at the surface. They need to determine the epicentre of the epileptic brainquake from these measurements external to the brain.



Localisation of the electrical source of an epileptic event of the above patient recorded during fMRI scanning. Two different EEG analyses were performed: The blue area represents the source projected onto the surface of the cortex of the brain. The purple sphere represents the most probable equivalent location if the source were point-like. The purple bar points in the direction of the current flow.
Image credit: Stephan Lau and Simon Vogrin

The first measurement is an electroencephalogram (EEG), in which a grid of external sensors is used to record the changes in electrical potential that signal underlying activity in the brain. In this case, the assessment takes place over a week in hospital, during which the brain is actually exposed and recordings are taken literally from its surface. The second measurement is functional magnetic resonance imaging (fMRI) which records when different parts of the brain become active.

The aim of Stephan’s work is to integrate information from EEG, magnetic resonance imaging (MRI) and fMRI examinations into a computer model, which will generate an accurate estimate of the focal point of the seizure in three dimensions.

But things aren’t that easy. One difficulty is that each source provides only partial information and they often do not seem to match. The consequences of being wrong, where surgery and brains are concerned, can be dire.

Stephan’s approach is to use tools available in the open source software package SimBio to construct a 3D model of the electrical conductivity at any point in a patient’s head. It is the conductivity of the brain, fluid and bone tissues between the electrical discharges of the nerves and the EEG sensors that determines what is picked up. So, overlaid on an accurate model of the head, the EEG data should be able to provide information on the location, strength, orientation, and distribution of the signal that generated it.

SimBio uses the engineering technique known as finite element analysis, where a complex material or system is modelled by breaking it into smaller, simpler elements. The actual size of the elements depends on the needs of the model and the computing power available.

Making SimBio suitable for use on the Victorian Life Sciences Computation Initiative’s (VLSCI) IBM Blue Gene supercomputer is one of Stephan’s first tasks, as is determining the optimum size of the elements to be employed. Given that the supercomputer gains its power by breaking the analysis of problems into a set of operations that can be run in parallel, another issue is to determine the optimum way of doing so.

The overall computation involved is fierce, but using the supercomputer allows finer resolution than would be possible using less powerful computers. And the speed provides other advantages. “Because the analysis can be done within 24 hours rather than six months, models can be built for individual patients,” says Stephan’s supervisor, Prof. Tony Burkitt. “The work now becomes useful to clinicians as a diagnostic tool, and that gives the research a whole different focus.”

Once the model and diagnosis techniques are running smoothly on the Blue Gene supercomputer, Stephan hopes to determine the level of measurement and analysis necessary for robust and accurate outcomes. It is likely that in the end fewer elements and measurements will be needed, requiring far less computation. Then the diagnosis technique could be within the reach of the computer resources of major surgical hospitals.

In addition, the skills and techniques acquired during the project should be applicable to other brain disorders.

For further information about this research contact Stephan Lau at stephanl@unimelb.edu.au.

To contact VLSCI, go to www.vlsci.org.au

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