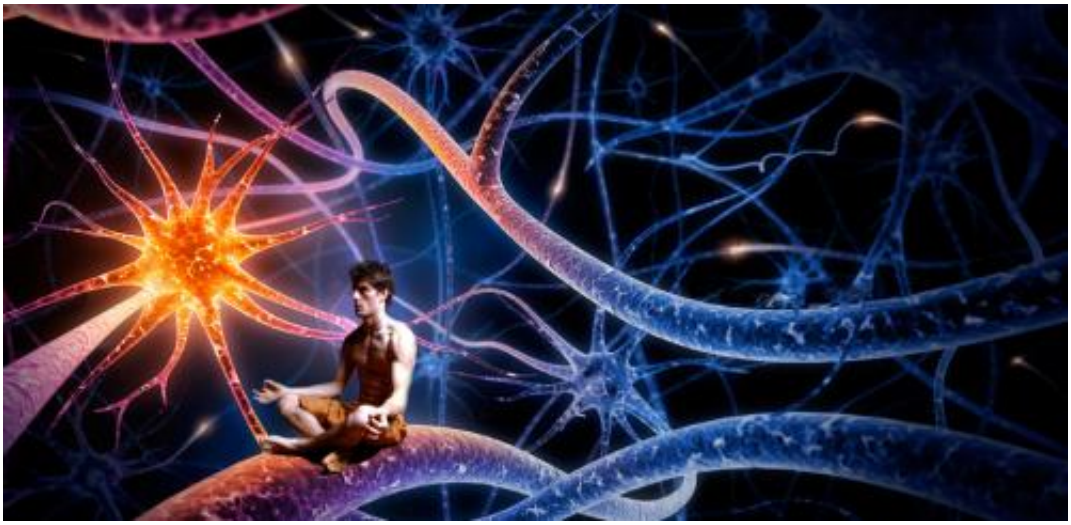
Simulating biological thought process within a computer system

February 25 2014, by Andrew Barron



To really get into the brain's mechanisms, we need to build a working model. Credit: Tankakern/Flickr

The structure of the brain reveals a network of massively interconnected electrochemically active cells. It is known that information can be represented by changes of state within this network, but that statement falls far short of revealing how the brain supports thought, feelings, memory, intention and action.

How then to solve this problem? The physicist Richard Feynmann famously said "What I cannot create, I do not understand". A report published today by the Australian Academy of Science proposes

applying this approach to the study of the brain by simulating the biological thought process within a new computer system.

In short: build a bionic brain.

The device could be truly revolutionary. A bionic brain built on biological principles could suggest entirely new approaches to artificial intelligence. It would be a new computer resource inspiring new solutions for fail-safe smart machines. Simulating thought in a bionic brain would also provide a whole new tool with which to investigate the operation of neural circuits.

A bionic brain would provide a whole new approach to the study of not just normal mental function, but also mental disorder such as psychosis, addiction and anxiety. It would provide a new resource to examine the causes of these disorders and even test proposed therapies.

Ultimately a bionic brain may even provide a solution for victims of brain damage or stroke by outsourcing some aspects of brain function to a prosthetic device.

Big neuroscience

Is this proposal realistic or simply science fiction? Neuroscience is currently experiencing a revolution and the bounds of what is realistic are changing rapidly.

Revolutionary innovations in proteomics (the study of proteins), informatics, microscopy and imaging techniques are providing radical new approaches to map neural networks and relate function to network activity within the brain.

This has seen the birth of the new energetic field of connectomics,

which promises entirely new synthetic approaches to understanding how the brain works. Neuroscience is experiencing a technical revolution that is analogous to the impact of genomics on molecular biology.

Consider that in the 1990s sequencing the human genome was considered by many an impossibility: the human genome was simply too big to comprehend. New sequencing and computing technologies changed the limits of possibility, and the first draft human genome sequence was published by just 2003.

Similarly, discussion of mapping the networks of the human brain has changed form considering the endeavour a fantasy to wondering when it will be done, and by whom.

To capitalise on this revolution both the US and Europe have embarked on multi-billion dollar brain research initiatives. Special research funds have been set aside to transform neuroscience into Big Neuroscience by supporting bold and large scale interdisciplinary projects.

The US program is focused on developing and using new methods to map the human connectome. The European program is exploring how to understand and simulate brain function by use of supercomputers to model neural networks.

Inspiring smarter brain research in Australia

The glaring question is: what is Australia doing?

In July 2013 the Australian Academy of Science hosted a Think Tank for neuroscience researchers (including me) to consider exactly this question.

Obviously Australia is not in a position to launch its own multi-billion

brain initiative (nor would that be strategic), but how can Australian neuroscientists best capitalise on the changing international neuroscience landscape?

The good news is that currently Australian neuroscience is vibrant. As a result of strong university, medical research and healthcare systems Australia punches above its weight in neuroscience research.

But the Think Tank recognised that Australian neuroscience is typified by discipline-specific research conducted by strong but independent teams. The Think Tank recognised that to stay competitive it will be essential that Australian neuroscience rallies to larger-scale and interdisciplinary challenges.

A call for a strategic investment of funds in neuroscience was made to facilitate new forms of collaboration and enable better exchange between the wealth of information gathered within the health care system and medical research.

Focus groups identified specific challenges for targeted investment to galvanise research in the next decade. The bionic brain proposal was presented by one of these focus groups.

A bionic brain: can Australia do it?

Understanding the human brain well enough to simulate it may be some way off, but the group argued that rapid and incisive progress could be made by examination of animal systems.

Even simple animals with small brains are capable of solving complex problems.

Consider the myriad decisions a foraging honey bee must make in order

to successfully harvest nectar from thousands of scattered flowers and find its way back to the hive. A bee does all this with a brain of just a few cubic millimetres. Whether a bee thinks could be an abstract question, but a bee certainly demonstrates spontaneous action, evaluation and decision.

Understanding how these functions emerged from the circuitry of something the scale of a bee brain, is an accessible question and would be the foundational work for understanding more complex brains.

Looking ahead for Australian neuroscience

The think tank concluded with a unanimous call that Australia simply cannot afford not to become involved in the new Big Neuroscience. Failure to engage would see Australia falling far behind at the most exciting time of this seminal field.

The benefits from an investment in neuroscience now must be weighed against the costs of inaction. These would be the costs to the Australian economy from lost intellectual property, and the consequences to Australian people of delayed solutions for mental illness.

The Think Tank showed that Australian neuroscience is strong, outward looking and certainly capable of the big ideas. Let us hope the community receives the support it needs to put these ideas into action.

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