Australian Brain Alliance

CRACK THE BRAIN'S CODE

BRAIN INSPIRED COMPUTING NEUROMORPHIC CHIPS

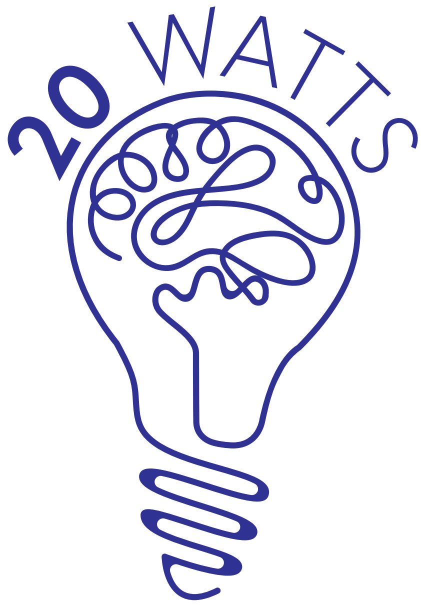
What are neuromorphic chips?

The human brain uses less energy than a light bulb. However, it is capable of computational activity such as intuitive natural language understanding, a task which would require the world's most powerful computers that consume megawatts of power.

One approach is to mimic the 'hardware' of the brain—replicating neural structure (synapses and neurons), mechanisms for parallel processing, or processing for cognition and learning.

Brains are massively parallel—they process and store many pieces of information simultaneously. Seeking to emulate this in a computer chip has already seen dramatic increases in processing speeds and memory, along with decrease in power consumption.

A brain uses as much power as a 20W light globe.



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Neuromorphic computing chips draw heavily on what we know about brain function. Rather than storing information digitally in a binary system of '0's and '1's, with only two options, neuromorphic chips store information with multiple states attainable in a single cell. Memristors ('memory' + 'resistor') can store information as multiple resistance states, enabling them to carry continuous (nearly-analogue) memory states.

This has led to the development of neuromorphic computer chips that can replicate the mechanics of biological neuron signalling. The latest neuromorphic chips show behaviour with just 10% variation from human measurements and have been trained to efficiently recognise and identify patterns.

Neuromorphic computing also emulates the signalling that occurs at the synaptic interfaces of neurons within the brain. Current CPUs have a fixed connectivity, while neural synapses in our brains adapt their connection strength through learning. As it is the synapses that store memories, memory is embedded in the network that processes the neural signals. This architecture has significant advantages over current computers for some tasks, where memory is stored on chips (such as RAM) separate from the CPU.

The IBM TrueNorth chip combines millions of digital transistors to create artificial 'neurons' that integrate their inputs and produce an output only if a threshold is reached, just as biological neurons do.

This allows the communication of probabilities and uncertainties, which is a critical step in progressing from the binary state of traditional CPUs to realise the huge advantages of continuous analogue memory. Recent advances allowed the design of neurons that not only integrate and threshold their inputs, but also have a random component to their output. Such randomness is thought to be important in how our neurons represent and process complex and uncertain information.

There are still some major research objectives yet to be solved. Current state-of-the-art is still relatively limited in computational power. Research is ongoing to increase the computational power and range of application of neuromorphic chips.

Another goal is improving neuromorphic chips' efficiency. Their power requirements are still far in excess of biological hardware of comparable scale. For example, if the TrueNorth chip were scaled up to the size of the human brain it would require more than 100 kW of power—equivalent to the power use of a dozen households.

The Australian Brain Initiative has been developed to help Australia capture the opportunities in brain-inspired computational innovation and neuroengineering for a myriad of purposes—our fundamental understanding of human brain function and the benefits to health, cyber-security, smart embedded machines that this will feed. These opportunities present many innovative areas of growth that could be developed into new industries in Australia, as well as expanding and supporting the capabilities of existing businesses.

Current supercomputers use as much power as a small suburb but can't do what a brain does.