DEPARTMENT OF ELECTRONIC
AND ELECTRICAL ENGINEERING

Neuromorphic computing: Enabling a future AI world?

Reduction in energy use for computing

Conventional computers use up to a million times more power than the human brain, even though they perform fewer operations.

Neuromorphic computers will be vastly more efficient and could use 100,000 times less power than conventional computers.

Significant reductions in energy use would result in extended battery life for applications such as temperature or position sensors.

Current estimates suggest data centres will use 20% of all electricity in the world by 2025. Benefits would arise from a reduction in greenhouse gas emissions from computing power demand.

Improved computational capability/capacity

Neuromorphic computers are inspired by what we know about how the human brain works.

They will be better at dealing with unstructured 'messy' data than conventional computers.

Applications might include improved speech and facial recognition.

Increased on-device computing power

Cloud-based services like Google and Siri use large data centres to process requests. Devices require a constant network connection to access these services. Neuromorphic computing systems have greater on-device processing power and will operate independently without the need for data centres.

Increased on-device processing would be advantageous for the growing network of 'Internet of Things' devices which will then operate independently of the cloud for speed and privacy.

Healthcare applications that might benefit from increased on-device processing power include use in pacemakers and medical diagnostics. The on-device processing power means data would be shared in real time.

Systems requiring reduced latency (the time delay while data is sent to and from the cloud) could benefit from increased computational capacity. For example, autonomous vehicles which require split second decisions.

What is neuromorphic computing?

Neuromorphic computers are inspired by biology. They are designed to mimic the neural systems found in the human brain. Neuromorphic chips operate in a fundamentally different way to the silicon chips found in traditional computers. In the brain, processing and memory functions are performed by neurons and synapses in a single location. Conventional computers that we use today have separate memory and processing units. Neuromorphic computers will perform these tasks on one chip. This will remove the need to transfer data between memory and processing units, which will speed up processing time and reduce the energy use involved.

In the medium term, hybrid conventional computers with neuromorphic chips could vastly improve performance relative to conventional machines. Long term, a new, fully neuromorphic computer will be fundamentally different and powerful for specific applications (from natural language processing to the operation of driverless cars). New programming languages and software will be needed to operate neuromorphic hardware.

What's wrong with conventional computers?

Computers have become essential to all aspects of modern life but conventional computers are reaching their limits in terms of efficiency, speed and computing power. Conventional computers are much better than humans at specific applications (such as crunching large volumes of numerical data). However, these computers are not ideally suited to particular tasks that humans find easy, such as image/voice recognition and reasoning.

Although conventional computing has advanced in these tasks (for example Google Deepmind's AI programme AlphaGo beating the world champion at an ancient board game, Go) this required megawatts of power on expensive technology. For these sorts of applications to be more widely available, a fundamentally different technology is needed: a calculator will work better on a conventional computer, but for something like recognising a dog or a cat, neuromorphic is the better option.

The state of play

Researchers at UCL have already built prototype neuromorphic chips – a major step in developing this new technology. Other countries, including the USA, Switzerland and Italy, have invested heavily and are making significant progress.

In the next 3-5 years, researchers at UCL expect to be using their chips to increase the efficiency of conventional computers by creating 'hybrid' machines.

In the next 10-15 years, we expect UK researchers to develop a full neuromorphic computer.

Key questions

- What are the risks to current investment commitments in conventional AI (which assume continued dominance of conventional computing hardware)? Do these risks change if other countries overtake the UK in developing these technologies?
- What potential is there for neuromorphic computing advances to outperform the current development of AI on existing computing systems?
- What are the economic opportunities associated with developing neuromorphic computing technologies?
- What are the applications for neuromorphic computing technology in 21st century society? And what are the wider implications for society and policy?

Mehonic A and Kenyon AJ (2016) Emulating the Electrical Activity of the Neuron Using a Silicon Oxide RRAM Cell. Front. Neurosci. 10:57. doi: 10.3389/fnins.2016.00057

Our research

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Project webpages

https://www.ucl.ac.uk/electronic-electrical-engineering/research/nanoelectronics-and-nanophotonics-lab

https://www.ucl.ac.uk/iccs/research-projects/2018/jun/next-generation-adaptive-electronics-neuromorphic-engineering

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