Future computing technologies: the role for neuromorphic computing

Policy roundtable: 5th December 2019

This event brought together 15 participants from UCL, Government, Parliament, professional institutions and not for profit organisations to consider the UK’s technological future. In particular, the role that new types of computing hardware, specifically neuromorphic computing, could play in a world where new technologies that fuse the physical, digital and biological worlds are increasingly the norm.

The roundtable was chaired by Alok Jha, Science and Technology Correspondent for *The Economist.* It offered attendees an introduction to neuromorphic computing from leading UCL researcher Professor Tony Kenyon. Through discussions, a presentation and question and answer session with Prof Kenyon, delegates explored the challenges facing the future of computing and the potential opportunities that advanced technologies could provide. It also considered the role that neuromorphic computing could potentially play in the UK’s technological future, during a topical discussion on the cross-cutting implications and opportunities of this and other emerging computing technologies.

Applications of computing technologies

The event began with an ‘evidence safari’ - an activity designed to encourage attendees to consider the applications of computing technologies, or barriers that may impede their uptake and challenges that might be associated with increased use of digital and computing technologies. The consideration of these challenges and opportunities preceded a discussion on why the UK needs new types of hardware, and what this could mean for society.

Evidence safari activity

Challenges for current computing methods

Participants highlighted the following challenges in the discussion:

1. Energy, climate change and natural resources

The rapidly growing power consumption of computing systems is a challenge for the sector. Data centres currently consume about 1% of global energy demand, and this is expected to rise with increased use of technologies like machine learning.[1]

The cost of supplying the energy is significant – it has been estimated that the energy bill associated with training the AlphaGo supercomputer was $35

[1] Engerati “*Artificial intelligence – the energy challenge for data centres*” 26 September 2018

million.[2] These costs are likely to prohibit the widespread use of this sort of computer. Energy use associated with digital technologies is also a significant and growing source of greenhouse gas emissions.

A separate concern is the natural resources required for current computing methods: metals required for computing will soon be depleted, and alternatives will need to be found.[3] Continued growth in the use of data, AI and internet-connected devices will not be sustainable unless these challenges are addressed.

2. Privacy and security

Wide ranging privacy and security issues are emerging around new technologies. For example, organisations and individuals using the cloud can have little control over the movement of their data through different data centres.[4]

There are also risks associated with cyber-crime, such as efficient, mass-tailored cyber-attacks, enabled by AI and other new computing technologies. Computing technologies have a role to play in assessing cyber safety, resilience and possible systematic failures.

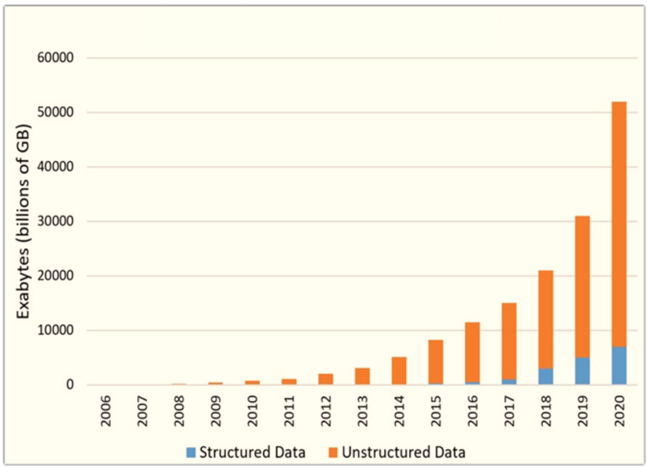
3. Limitations of conventional computing ability

a) The end of 'Moore's Law'

Conventional computers are reaching their limits in terms of efficiency, speed and computing power. Historically, the number of transistors on a silicon chip has doubled roughly every two years ('Moore's law'). This has meant that processing power for computers has doubled every two years. However, physical limits mean that it is becoming increasingly difficult to continue increasing the number of transistors at this rate.

Society has adapted to the rapidly increasing capabilities of smart phones, personal computers and internet-connected devices (termed 'IoT'). How would a stagnation in these improvements be noticed or affect society? What impact would it have on the many new applications for digital technologies that are currently planned or in development?

b) The rise of unstructured data



Proportion of data structured and unstructured. [5]

Conventional computers prefer information to be highly structured and are much better at dealing with processing structured data (for example, high quantities of precise numbers), but the proportion of data that is unstructured (such as photographs and video, spoken language, or analyses of x-ray images) is increasing rapidly as shown in the above graph.

Issues around the quality of data also need to be addressed, particularly in the public sector, so that the data can be put to better use. For example, greater consideration should be given to how data cleaning could be automated.

The potential role for neuromorphic computing in addressing these challenges

A talk from Professor Tony Kenyon, UCL, introduced neuromorphic computing technology and its potential to address the challenges faced by conventional computing methods.

[2] G. Marcus "*Deep Mind's Losses and the future of Artificial Intelligence*" Wired (14/08/2019)

[3] MOD (2018). *Global Strategic Trends – The Future Starts Today*.

[4] Deloitte (2016). Data privacy in the cloud. Available at: https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/risk/ca-en-risk-privacy-in-the-cloud-pov.PDF

[5] B. Scalzo "What is NoSQL and why should I care?", IDERA. Available at: https://community.idera.com/database-tools/blog/b/community_blog/posts/what-is-nosql-and-why-should-i-care (Last accessed31/8/2018)

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.

Neuromorphic computers could use up to 100,000 times less power than conventional computers. Neuromorphic computing is inspired by the brain, which operates at around 20 watts compared to a conventional computer's 7.9 Megawatts. This could drastically reduce the energy consumption of some computing tasks and improve battery life for devices.

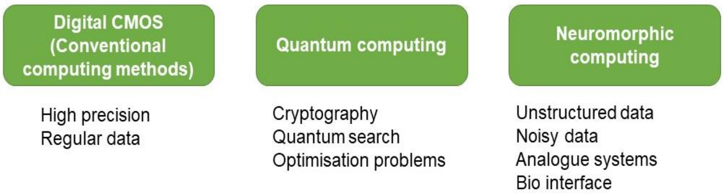
On-device processing would improve privacy and security by removing the need to utilise data centres. This would be particularly beneficial for IoT and edge devices which could operate independently of the cloud to improve their reliability, speed, and safety and security.

The limitations of reaching the end of Moore's Law would be alleviated by using new hardware. Neuromorphic technology does not face the same challenges of conventional computers in respect to the end of Moore's Law.

New hardware would have improved capabilities to deal with unstructured data. Neuromorphic computers would be far better at dealing with unstructured data while using less power than conventional computers.

Next steps for neuromorphic computing

Neuromorphic systems are not going to be universal and will not replace conventional computers, but they could complement conventional computing and other emerging hardware like quantum. The graphic below illustrates the strengths of different types of hardware.



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Policy challenges

An insightful discussion was held around the timing of policy interventions in emerging technologies. How do we ensure that they don't lag behind technological innovation and uptake by society, but equally do not move too quickly before the technology is ready?

Anticipatory regulation

Technological innovations in society can work well. A recent example is the rise of contactless payment technology in the UK, which could be considered a success: the underlying technology was sound and fully ready to be utilised by consumers. There was acceptance from the public and the change was adopted almost overnight. However, regulating for the future is difficult. Some impacts of existing technologies are still not fully understood and are not regulated, such as potential long term impacts of social media on mental health and wellbeing.

There is currently no best practice for how to regulate in anticipation of new technologies, as it is difficult to predict the future. The ongoing work by Nesta on anticipatory regulation in this space was highlighted by participants in this regard.[6] In addition, research councils are being challenged to undertake responsible research and innovation. There is also a Government ‘Centre for Data Ethics and Innovation’ which is working to develop the right governance regime for data-driven technologies.

One example of a negative consequence of new technologies driving behaviour is the case of takeaway convenience food: companies like Deliveroo and Uber Eats have made it easier for people to access food without going out. This has consequences for the environment (the carbon footprint and packaging implications) and public health issues associated with easier access to processed fast foods.

Government should continue to work with academia and industry to explore understand future uses of emerging computing technologies. This ongoing dialogue should be used to inform future regulation.

Maturity of technology

It is essential that technology is ready before being mandated in policy. For example, in the UK, the Government mandated energy companies to rollout smart meters before the technology was fully mature.[7] As a result, early adopters will have to replace their smart meters with a newer model. This was a waste of money and has undermined confidence in the programme. The timing of regulation around new technologies is essential to their implementation in society and should be considered alongside technological development.

Lessons should be learnt from previous successes and failures when rolling out new technologies.

Conclusion

There are exciting opportunities for new hardware like neuromorphic computing - in particular the need to reduce the energy consumed by IT and for the UK and the world to transition to a low carbon economy. Many challenges, including security and privacy concerns and the end of Moore’s Law, have the potential to be mitigated to some extent by the use of neuromorphic hardware in the future mix of computing technologies.

Roundtable participants

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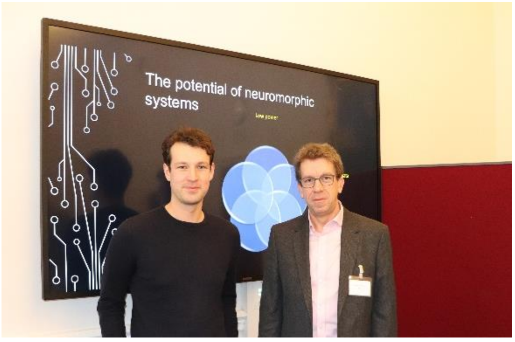
David Barber	UCL
Jenny Bird	UCL
Florence Greatrix	UCL
Martin Hamilton	Jisc
Alok Jha	The Economist
Vas Khan	UCL
Ahmed Kotb	The IET
Alasdair Love	House of Lords
Professor Tony Kenyon	UCL
Dr Natasha McCarthy	The Royal Society
Dr Adnan Mehonic	UCL
Andrew Powell	Office of the CSA
Philippa Westbury	RAEng

Researchers



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UCL STEaPP Policy Impact Unit

This workshop was organized by UCL STEaPP’s Policy Impact Unit (PIU). The PIU provides professional policy engagement expertise and collaborates with researchers to help feed research-based evidence into the policymaking process.

www.ucl.ac.uk/steapp/PIU

[6] https://www.nesta.org.uk/feature/innovation-methods/anticipatory-regulation/

[7] https://www.nao.org.uk/wp-content/uploads/2018/11/Rolling-out-smart-meters.pdf