Feynman's quest

Probabilistic computing could provide an energy-efficient way of dealing with big data.

In 1981, physicist Richard Feynman famously talked about the problem of simulating physics with computers. This posed a challenge because machines that make calculations based on binary logic — 1s and 0s — are not very good at capturing the uncertainty inherent in quantum mechanics. One way to tackle this, Feynman suggested, is to use quantum building blocks to make a computer that mirrors quantum behaviour — in other words, a quantum computer.

But Feynman had another idea: a classical computer capable of mimicking the probabilistic behaviour of quantum mechanics. Nearly 40 years on, Shunsuke Fukami and his colleagues at Tohoku University in Japan and Purdue University in Indiana have built the hardware for such a probabilistic computer — also known as a stochastic computer — and they outline their work in this issue (W. A. Borders *et al. Nature* **573**, 390–393; 2019). Among other things, this advance could lead to more-energy-efficient devices capable of faster and more complex calculations.

The researchers combined three conventional silicon transistors with a tiny magnet to create what are called p-bits (or probabilistic bits). These magnets are around just ten atoms thick and, at this size, they start to behave stochastically. One of the team's key advances was to tune the thickness of the magnets to balance stability with thermal noise and introduce stochasticity in a controllable way.

What is remarkable about this stochastic computing scheme is that it can solve some types of problem that are difficult for conventional computers to address, such as machine learning, which involves the processing of ever-increasing amounts of big data. But how do we know that this stochastic computer performs better than conventional approaches?

The research team programmed the device to calculate the factors of integers up to 945. Such calculations are so difficult for standard computers to solve that they have become the basis of public encryption keys used in passwords. A conventional probabilistic computer — one that uses silicon transistors — would require more than 1,000 transistors to complete this task. But Fukami and colleagues' machine did it using just eight p-bits. Moreover, their components needed just one three-hundredth of the surface area and used one-tenth of the energy.

For a while, advances in miniaturization technology meant that the number of operations silicon chips could complete per kilowatt hour of energy was doubling about every 1.6 years. But the trend has been slowing since around 2000, and researchers think it might be approaching a physical limit. The word 'revolutionize' is overused in the tech world, but Fukami and colleagues' demonstration shows that stochastic computing has the potential to drastically improve the energy efficiency of these types of calculation.

"As the demands of big data continue to increase, energy efficiency is becoming harder to ignore."

More widespread use of stochastic computing, however, will need a bigger effort from both public funders and manufacturers of silicon chips. Public funders in the European Union, Japan and the United States do have modest stochastic-computing research programmes. Companies, too, are funding research, through consortia such as the Semiconductor Research Corporation (go.nature.com/2mlhmoo).

But when faced with technology disruptions, governments and large corporations can understandably be slow to change — partly because they have interests to protect. As the demands of big data continue to increase, energy efficiency is becoming harder to ignore, which is why industry and policymakers need to step up the pace.

Fukami's team has come up with a potential solution, and has successfully proved a concept. Going forwards, governments and corporations will need to create funding opportunities to give this innovation — and Feynman's quest — a chance to see the light of day. ■

Ending drought

The battle to combat water shortages and land degradation needs independent scientific advice.

A decade from now, up to 700 million people will be compelled to leave their homes because they will not have enough water, the United Nations estimates. This is a staggering figure. And yet, as *Nature* reports on page 319, drought is relatively under-researched.

The area is so neglected that scientists from Africa last week urged the UN to provide more support for early-warning systems to improve predictions of when a drought might be imminent. This call must be heeded. The Intergovernmental Panel on Climate Change (IPCC) warned last month that the number of droughts in dryland regions has been increasing since 1961. Two years ago, a drought across Africa and the Middle East brought 20 million people close to starvation.

But there is no independent, systematic body of research to show when droughts are likely to strike, for how long, and what their impact is likely to be. A review of the drought literature, published in July, revealed that ecologists have not yet agreed on a precise definition of the phenomenon (I. J. Slette *et al. Glob. Change Biol.* **25**, 3193–3200; 2019).

There are several reasons that drought is poorly researched — and each boils down to choices made by funders and policymakers.

When world leaders gathered in Rio de Janeiro, Brazil, in 1992 for the Earth Summit, they opened for signature three international agreements, two of which addressed climate change and biodiversity loss. The third was the UN Convention to Combat Desertification (UNCCD) — and last week in New Delhi its member states completed their 14th annual conference, 25 years after the convention was adopted.

The UNCCD was agreed at the request of delegates from African countries, who sought better understanding of droughts — and global action against them — to prevent repetition of the devastating dry periods of the 1970s.

But as non-governmental organizations, such as the Centre for Science and Environment in New Delhi, have repeatedly pointed out, the promise made at this convention was never fulfilled. This was partly because funding for efforts to combat desertification never matched that for biodiversity and for climate, and partly because of the absence of an influential scientific advisory mechanism.

The Global Environment Facility is the official funder for each of the three UN conventions. Activities focused on climate and biodiversity attracted more than US$3 billion together in 2014–18. By contrast, funding for action to combat land degradation (including drought) for the UNCCD was $431 million between July 2017 and June 2019.

At the same time, the UN conventions on climate and (eventually) biodiversity have had years of access to independent scientific advice — in the shape of the IPCC and its counterpart for biodiversity, the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services. The IPCC's reports especially have been central to legally binding agreements such as the Kyoto Protocol to reduce greenhouse-gas emissions. But there is no analogous scientific network for land degradation and drought.

As the world gears up for the UN climate summit in New York City on 23 September, the call of scientists from African countries for better research advice needs to be answered. Too many countries are facing a hotter, drier future. The drought in drought research must end. ■