NEUROMORPHIC ENGINEERING: UNRAVELLING THE BRAIN'S ELECTRONIC CONNECTIONS

Wilfred van der Wiel, professor of nanoelectronics, is working on a computer that functions similarly to the human brain – or, fed with big data, can even outperform our brain. "If we pull this off, the possibilities are endless." BY **Frederike Krommendijk** PHOTOGRAPHY **Rikkert Harink**

SMARTER THAN OUR BRAIN

Computers can do virtually everything, often better than humans. Even a thirty-year-old calculator can beat any man at maths. However, the way today's computers are constructed has one major downside: the entire process is handled one step at a time, sequentially. Our brain, on the other hand, can do thousands of things at once in parallel. Our brain's neural network is extensively branched and interwoven. "Neurons fire when they receive a certain stimulus, which in turn activates other neurons. That allows us to recognise patterns or faces or evaluate situations in the blink of an eye," Van der Wiel explains.

"We focus on the many wonderful potential applications, for example in the medical world"

Of course, if you want a computer to perform a complicated task that consists of multiple simultaneous processes, e.g. driving a car, you could theoretically link hundreds of computers together and have each one perform a single small task very quickly. "Aside from the fact that this quantity of hardware could never fit into e.g. a smartphone or an airplane, it is also a tremendous waste of energy. Our brain has another major advantage besides its parallel processing capacities: it is exceptionally efficient and requires just ten to twenty Watt. To compare, a simple laptop uses between one and two hundred Watt. By creating connections that mimic the human brain's neural network, we can make our computers far more energy-efficient and effective." This process is called neuromorphic engineering. As part of the research programme, physicists Van der Wiel and three colleagues in his department focus on unravelling the electronic connections that allow our brain to transmit signals so efficiently.

Should the MESA+ (institute for nanotechnology) and the CTIT (institute for IT research) succeed in mimicking the neural transmission of information, major corporations will line up outside the UT's door to apply this technology. "Take self-driving cars, for example. Driving a car is a prime example of a dynamic process that requires you to interpret signals quickly and take the appropriate action. Our brain's parallel processing method is excellently suited for this. Our challenge is to translate our brain's rapid, efficient processes into usable and efficient hardware."

A self-driving car must have the brains to correctly assess any situation. "As a basic structure, a neuromorphic computer cannot do anything yet. You can, however, feed it data on millions of traffic situations and how to act correctly in each one. A human would have to spend three hundred years driving day and night to learn how to drive that well. Similarly, a computer can learn to play chess far better than any man once you feed it data on millions of chess matches. Artificial intelligence can dedicate itself entirely to a single task, without distractions or emotions. That makes it better than humans."

"How can we translate our brain's rapid, efficient processes into usable and efficient hardware?"

Van der Wiel understands that people might be a bit intimidated by a computer that can outsmart our own brain. "Those scary stories are everywhere, about cyborgs taking over our planet and such. It is easy to focus on the negative aspects: a hammer can be used for carpentry, but you can also bash someone's head in with it. The same goes for any invention. Instead, we focus on the many wonderful potential applications, for example in the medical world. A chip with neural processing capabilities might take over some of the brain's functions in a patient who suffered brain damage. For a blind person, you might link it to a small video camera and send signals to the brain to allow the patient to see. This technology can be used for everything that we already use our own brain for."

Companies such as Facebook and Google are also working on such applications, because these new computers require less energy and can efficiently process massive quantities of big data. "Many universities and corporations are active in neuromorphic engineering. Processing large quantities of big data is becoming increasingly important. The efficiency and energy requirements of today's computer systems will ultimately become bottlenecks."

At the University of Twente, mathematicians, physicists, neurophysiologists and computer scientists collaborate on this research. The University has also joined hands with the Radboud University. The first breakthrough, a chip that can learn to perform simple tasks through artificial evolution, has already been made. Developing an entire brain-like computer system will require years of additional research, however. Van der Wiel is highly motivated: "This is both socially relevant and scientifically challenging. We learn more every day, from each other as well."