HYBRAIN
Electronic-photonic Architectures for Brain-inspired Computing

PRESS RELEASE

Brain-inspired and out-of-the-cloud: new ways of doing computing

Would you take a ride in an autonomously driving vehicle? What happens if a pedestrian suddenly steps out in the road? Can you trust the vehicle to make that split-second decision that any driver could take in order to save a life or prevent even the most mundane of accidents?

Responding to unexpected situations requires 'ultra-fast response' technologies. These depend on communication and processing 'in the cloud', which can sometimes take too long due to latency. Local, 'edge computing' can speed things up. However, this means installing large and energy-hungry computer systems into vehicles. Of course, this isn't just a problem for vehicles. Ultra-fast responses are essential in many industries and even in your mobile phone.

A new European Commission-funded Pathfinder project HYBRAIN (Hybrid electronic-photonic architectures for brain-inspired computing) aims to overcome these barriers by delivering a new computing system that is inspired by the human brain. Coordinated by Professor Wilfred van der Wiel, University of Twente, the project gathers key partners from Oxford, Münster, Pisa and Zürich. The project will develop a "HYBRAIN system" that that is both super-fast, consumes very little energy and which can make real impact on 'ultra-fast response' technologies.

Although cloud computing has been considered the best solution to keep the data and computer processing at a distance, it is now increasingly important to move it close to the actual 'operation' and start working locally again; this is also called 'edge computing'. By doing so, you avoid a delay, '*latency*', that is too long: despite the upcoming and fast mobile standards like 5G and 6G, the delay can still be too long. There is a dilemma, though: moving heavy computing power to the local application is undesirable as well. The classic computer approach involves a lot of data traffic between the processor and memory. This is, in fact, not how our brain works, where memory and processing are part of the same process. Within the new HYBRAIN project, the researchers will combine a number of highly innovative solutions, based on how our brain works. These solutions include '*in memory computing*' and an *evolutionary system* that is disordered by itself but can nevertheless detect complex patterns.

Photonics, memristors and an 'evolutionary' network

It all starts by gathering huge amounts of data. This, for example, can be visual data. Integrated photonics is very good at this. That is why the input of the artificial intelligence system consists of a photonic processor, working with light. The data will be divided among two learning

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networks: one is a network based on in-memory computing, consisting of so called 'memristors': resistors that can memorize their settings even when switched off. A network like this is capable of performing linear operations, like multiplying and adding large streams of data.

Disordered

Apart from that, a basically disordered network built of nano materials, developed at the University of Twente, has proven to be able to deal with complex, non-linear operations. These two types of networks will first get a learning phase (*inference*), after that they can make choices by themselves. Of course, in this approach, there are connections between systems, but there is no large-scale data transport in two directions, such as in the computers that we are used to.

Innovative new methods

The question we can even pose could be: **Can't the entire system be built in photonics?** The problem there is the size: photonic components and circuits are relatively bit. However, it is true that no conversion to electric signals would be needed. "Still, it will be very exciting indeed", Wilfred van der Wiel says. "We connect three types of technology that each are in a very experimental stage. They don't have the 'history' and huge industrial power that the current CMOS chips do have". Still, if the project results in a new system succeeds in reaching an energy consumption that comes even close to that of the human brain – a few hundred Watts – a major step will have been made.

Edge computing in your phone

Except for autonomously driving vehicles, edge computing can be necessary in particle accelerators such as in CERN in Geneva and other 'ultrafast response' technologies. Even in our smart phones, some of the apps use local computing power again, instead of cloud computing.

Partners

The HYBRAIN project is led by the Center for Brain-Inspired Nano Systems (BRAINS) of the University of Twente's MESA+ Institute. Supporting the coordinator in this ambitious endeavour is a lean consortium with specific skills from the University of Münster (WWU, Germany), the University of Oxford (UK), the Italian SME, Trust-IT and IBM Research in Zürich (CH). The University of Twente has a clear focus on sustainable hardware and for strategic partnerships: HYBRAIN perfectly fits in this core strategy and mission.

HYBRAIN is the first UT project awarded within the new Horizon Europe programme, running for four years with a budget of 3 million euros. The kick-off meeting will be on May 23 and 24 at the University of Twente.

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