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Electronic synapses that can learn: towards an artificial brain?

Researchers from the CNRS, Thales, and the Universities of Bordeaux, Paris-Sud, and Evry have created an artificial synapse capable of learning autonomously. They were also able to model the device, which is essential for developing more complex circuits. The research was published in *Nature Communications* on 3 April 2017.

One of the goals of biomimetics is to take inspiration from the functioning of the brain in order to design increasingly intelligent machines. This principle is already at work in information technology, in the form of the algorithms used for completing certain tasks, such as image recognition; this, for instance, is what Facebook uses to identify photos. However, the procedure consumes a lot of energy. Vincent Garcia (Unit  mixte de physique CNRS/Thales) and his colleagues have just taken a step forward in this area by creating directly on a chip an artificial synapse that is capable of learning. They have also developed a physical model that explains this learning capacity. This discovery opens the way to creating a network of synapses and hence intelligent systems requiring less time and energy.

Our brain's learning process is linked to our synapses, which serve as connections between our neurons. The more the synapse is stimulated, the more the connection is reinforced and learning improved. Researchers took inspiration from this mechanism to design an artificial synapse, called a memristor. This electronic nanocomponent consists of a thin ferroelectric layer sandwiched between two electrodes, and whose resistance can be tuned using voltage pulses similar to those in neurons. If the resistance is low the synaptic connection will be strong, and if the resistance is high the connection will be weak. This capacity to adapt its resistance enables the synapse to learn.

Although research focusing on these artificial synapses is central to the concerns of many laboratories, the functioning of these devices remained largely unknown. The researchers have succeeded, for the first time, in developing a physical model able to predict how they function. This understanding of the process will make it possible to create more complex systems, such as a series of artificial neurons interconnected by these memristors.

As part of the [ULPEC H2020](#) European project, this discovery will be used for real-time shape recognition using an innovative camera¹: the pixels remain inactive, except when they see a change in the angle of vision. The data processing procedure will require less energy, and will take less time to detect the selected objects. The research involved teams from the CNRS/Thales physics joint research unit, the Laboratoire de l'int gration du mat riau au syst me (CNRS/Universit  de Bordeaux/Bordeaux INP), the University of Arkansas (US), the Centre de nanosciences et nanotechnologies (CNRS/Universit  Paris-Sud), the Universit  d'Evry, and Thales.

¹ Provided by project partner Chronocam.



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Artist's impression of the electronic synapse: the particles represent electrons circulating through oxide, by analogy with neurotransmitters in biological synapses. The flow of electrons depends on the oxide's ferroelectric domain structure, which is controlled by electric voltage pulses. © Sören Boyn / CNRS/Thales physics joint research unit.

Bibliography

Learning through ferroelectric domain dynamics in solid-state synapses. Sören Boyn, Julie Grollier, Gwendal Lecerf, Bin Xu, Nicolas Locatelli, Stéphane Fusil, Stéphanie Girod, Cécile Carrétéro, Karin Garcia, Stéphane Xavier, Jean Tomas, Laurent Bellaïche, Manuel Bibes, Agnès Barthélémy, Sylvain Saïghi, Vincent Garcia. *Nature communications*, 3 April 2017. DOI : 10.1038/NCOMMS14736.

Contacts

CNRS Researcher | Vincent Garcia | T + 33 (0)1 69 41 58 59 | vincent.garcia@cnrs-thales.fr
CNRS Press Officer | Alexiane Agullo | T + 33 (0)1 44 96 43 90 | alexiane.agullo@cnrs-dir.fr