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JOB & TRAINING
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· Finding Repeating Structures - the Secret of Intelligence?

Simon Thorpe

· Spike-based computing and learning in brains, machines, and visual systems in particular

Timothee Masquelier

These two talks cover the field of brain-inspired learning for artificial machine learning algorithms, with special emphasis on vision systems. Brains compute with spikes in a fashion that information seems to be encoded in a highly efficient manner for minimum power, but still with outstanding computing capabilities compared to human made "intelligent" machines. In these talks we will expose how the spiking nature of nervous information encoding can be exploited for learning tasks, with outreach to artificial machine learning systems.

Using simulations, we have first shown that, thanks to the physiological learning mechanism referred to as spike timing-dependent plasticity (STDP), neurons can detect and learn repeating spike patterns, in an unsupervised manner, even when those patterns are embedded in noise, and the detection can be optimal. Importantly, the spike patterns do not need to repeat exactly: it also works when only a firing probability pattern repeats, providing this profile has narrow (10-20ms) temporal peaks. Brain oscillations may help in getting the required temporal precision, in particular when dealing with slowly changing stimuli. All together, these studies show that some envisaged problems associated to spike timing codes, in particular noise-resistance, the need for a reference time, or the decoding issue, might not be as severe as once thought. These generic STDP-based mechanisms are probably at work in particular the visual system, where they can explain how selectivity to visual primitives emerges, leading to efficient object recognition systems. High spike time precision is required, and microsaccades could help.

SIMON THORPE is a CNRS Research Director (recently promoted to Classe Exceptionnelle) who studied Physiology, Psychology & Philosophy (PPP) at Oxford (graduating in 1977), got his PhD with Edmund Rolls, did a postdoc in Canada (with Max Cynader) and then came to France in 1982. Recruited by the CNRS in 1983, he moved from Paris to Toulouse in 1993 to help create the Brain & Cognition Research Center (CerCo). He became the lab director (taking over from Michèle Fabre-Thorpe) in 2014, and also took over the direction of the ISCT from François Chollet in January 2016.
He is very keen on interdisciplinary research, and does a mix of neurophysiolgy, psychophyiscs, computer modeling and theoretical work. He is currently half way through a 5 year ERC advanced grant called "M4 – memory mechanisms in man and machine", which aims to understand how we can store sensory memories that can last for an entire lifetime. His hypothesis is that we store memories in "grandmother cells" that can remain totally silent for months or years – neocortical dark matter.

TIMOTHEE MASQUELIER is a researcher in computational neuroscience. His research is highly interdisciplinary - at the interface between biology, computer science, and physics. He uses numerical simulations and analytical calculations to gain understanding on how the brain works, and more specifically on how neurons process, encode and transmit information through action potentials (a.k.a spikes), in particular in the visual modality. He is also interested in bio-inspired computer vision and neuromorphic engineering.
He was trained at Ecole Centrale Paris (Ingénieur 1999), MIT (M. Sc. 2001), and Univ. Toulouse 3 (PhD 2008). He was recruited by the CNRS in 2012.

Instituto de Microelectrónica de Sevilla IMSE-CNM
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The talks are part of the PhD program at the Faculty of Physics (US)