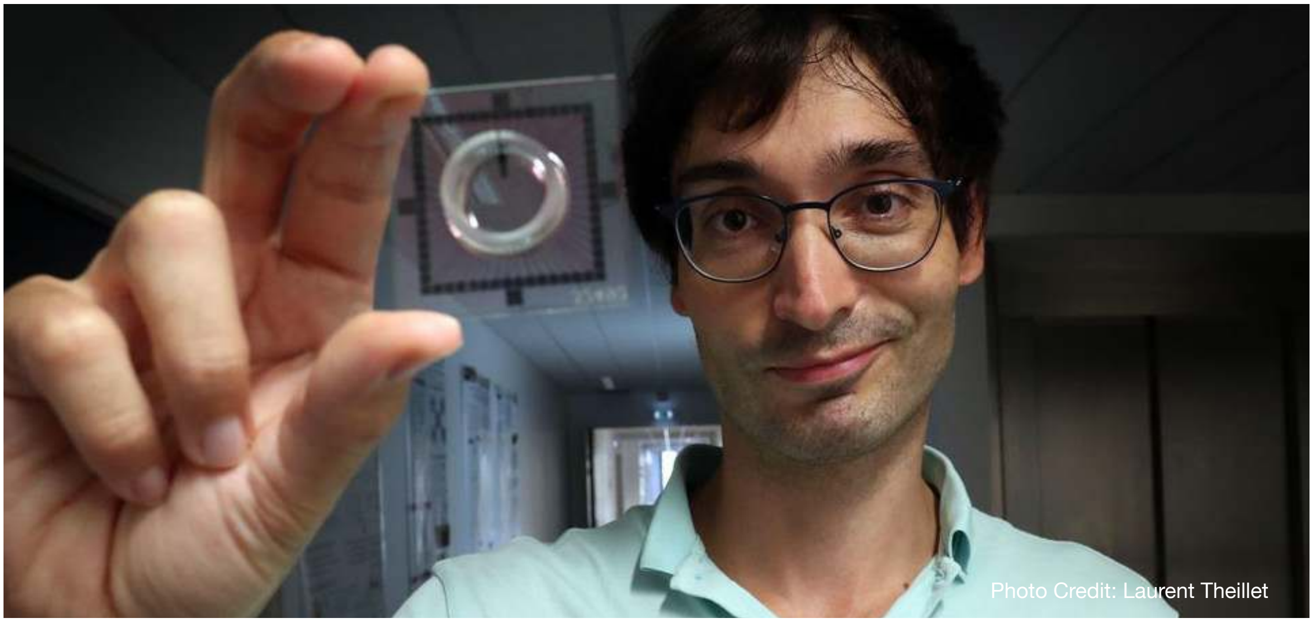

CASE STUDY

At Work in the Lab:

Advancing the Architecting of Silicon Neural Networks and Reuse

The IMS Laboratory (CNRS/ENSEIRB, University Bordeaux) is dedicated to cutting-edge, neurological research focused on the architecture of silicon, neural networks and reuse methodologies, such as those in neuron prosthetics. The team works with a multitude of neurological disease modeling protocols. Their research includes use of electrical stimulation to recover functionality, such as with neuron prosthetics. Recently, they have been incorporating optogenetics into their work, and anticipating that this could allow future devices to communicate with specific type of neurons or within specific neuronal circuits.

The Challenge

Neurological disorders and traumas impact the structural and functional properties of brain networks and circuits. These disorders can cause cell death, loss of synapses as well as the impairment of the ability of axons to communicate within microcircuits or to other brain regions.

While cellular therapies have shown promise in engrafting and refilling circuitries, regenerating lost, long-distance connections is more challenging. New therapeutic approaches and technologies are needed to promote both cell survival and regeneration of local circuits, as well as to restore long distance communication between disconnected brain regions and circuits.

> "Our [Multi Channel System] MEA recording functionality is excellent. The system always works, we never have issues with the recordings and we do a lot of stuff with it."
>
> – *Timothée Levi, Associate Professor, University of Bordeaux, Bordeaux, France, IMS Lab member since 2010*

The Solution

Major progress has been made in the field of neuron prosthesis over the past decade, where artificial spiking neural network (SNN) circuits are locally capable of receiving and processing input in real time. Similarly, SNN output can be delivered locally or remotely, either through electrical or optogenetic stimulation. This enables fast, bi-directional control of multiple cell types. Critical to research in this area is the ability to accurately record, interpret and manage SNN activity data.

Recently, the IMS Lab presented compelling evidence of real-time, communication and information transfer possibilities. They used an SNN implemented on an FPGA board and an in-vitro biological neuronal network (BNN) with real-time encoding of the SNN dynamics in patterns for optogenetic stimulation of the BNN.

To synchronize the timing of the different devices, the Lab relied on neural behavior recordings via their Multi Channel Systems Multielectrode Array (MEA) system. The spontaneous and evoked activity of the BNN was recorded using their MEA in conjunction with calcium imaging. The overall results revealed that targeted, information transmission control could be achieved if network responses to stimulus intensity were considered linearly. With this approach, over-shooting responses were discarded.

The Outcome

Restoration of the communication between brain circuitry is a crucial step in the recovery of brain damage induced by traumatic injuries or neurological insults.

The IMS Lab presented a study of real-time communication between an SNN implemented on digital platform and an in-vitro biologic BNN generating similar spontaneous patterns of activity both spatial and temporal. Developing a generalized approach stems from a future perspective that creating a cerebral, neuroprosthesis for direct implantation in the brain that could be used by patients affected by stroke or brain injury. Their proof-of-principle results are the first for a next-generation neurobiohybrid system to restore brain functions.

With their MEA System in place, the Lab benefits from consistent delivery of the accurate, neural behavior activity recordings critical to forwarding their research. According the Levi, "Our [Multi Channel System] MEA recording functionality is excellent. The system always works, we never have issues with the recordings and we do a lot of stuff with it."

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