Université Lille Nord de France
Pôle de Recherche et d'Enseignement Supérieur

Ecole doctorale régionale Sciences Pour l'Ingénieur
Lille Nord-de-France - 072

Titre Thèse	Design, fabrication and characterisation of new integrated modules interfacing living and artificial neurons dedicated to human therapies	
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Résumé du sujet :

Context

In the context of Artificial Intelligence (A.I.), a new trend called 'Human Enhancement' is attracting a lot of interest. Today, technology brings new therapeutic opportunities to overcome specific neurologic diseases. Based on previous works, our objective is to study the behavior of various types of living neuron cells that will be bridged to artificial neurons in order to explore the wide scope of therapy. The artificial neurons emulate the electrical activity of human brain neuron cells. The interactive living/artificial interfaces have to be optimized driving by the applications. The long-term target is to build ultra-low power autonomous new networks embedded in human body as biosensors, neural prostheses and brain interface.

The work will be down in accordance with previous obtained results, in the frame of two research projects funded by CNRS and CPER Photonics 4 Society and the creation of Axorus start-up. The work will be managed at Lille University more specifically at IEMN laboratory as part of the two flagships: "Life On Chip" and "Neuromorphic Technologies" and also in the context of the humAIn Alliance in the Hauts-de-France.

Originality of this approach

This thesis aims to bridge neuroscience, nanoelectronic and biomems engineering through the development of some new interfaces between artificial neural networks and few different living neurons to address diseases without actual curative solutions. In the scope of neurosystems engineering, the idea of implanting chips was developed firstly by Jose Delgado who has been a pioneer in this thematic since the 1970's. Nowadays, scientists develop solutions quite far from the brain Action Potential (A.P.) shape generation. We believe that our artificial neuron will offer new and original relevant issues where no cure are available.

Based on two patents filled and preliminary results, ultra-low power artificial neurons are available in order to offer the flexibility needed by neural implants. Because our spike shapes fit with very good accuracy the human ones, we believe that our future artificial networks could be embedded in the human body to detect neural activity and/or bridge missing links between living neurons.

The proposed work is aimed to enhance our studies bring to demonstrate the communication between artificial and living neurons. The PhD student will improve the existing solutions such as design a specific spiking biomems prototype to bring closer biological and artificial neurons in the prime step. In the second one, he will try to demonstrate if it is possible to make firing other biological neurons by the means of exciting artificial ones, and vice-versa. It will be necessary to develop (i) an in-vitro cellular growth knowhow on our electronic spiking hardware and (ii) an ultra-high sensitive instrumentation setup for the characterization of the propagating signal. The long term outcomes of this

work could be divided in several applications such as: (a) bio-sensors to monitor electrical spiking activities, (b) brain interfaces as a direct communication pathway between an enhanced or wired brain.

PhD requirements

Talented, enthusiastic candidates with excellent analytical and communication skills are encouraged to apply. A strong background in electronic devices and circuit design and/or in neuroscience as well as skills in neuronal cell cultures or electrophysiology would be an advantage, full training in other aspects will be provided within the multidisciplinary environment at University of Lille.