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BIPHOPROC

Brain-Inspired Photonic processor

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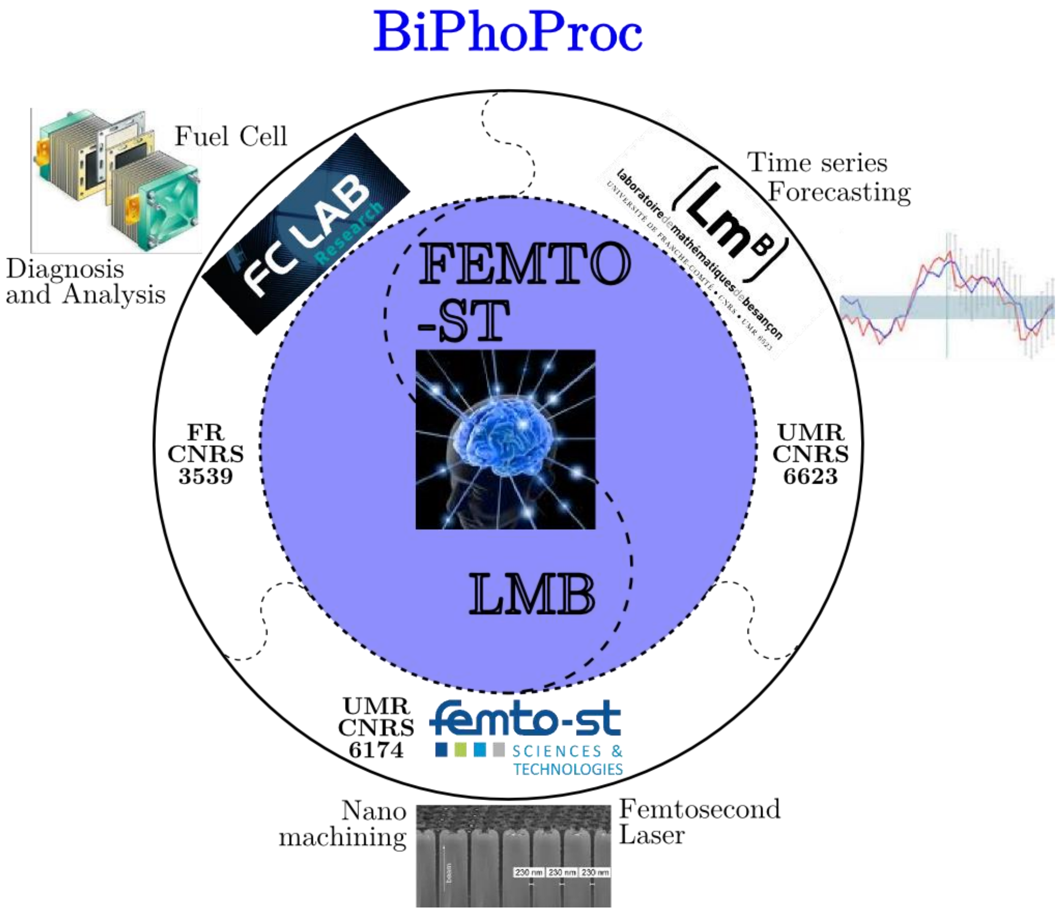
Abstract

BiPhoProc aims to demonstrate a highly innovative self-consistent bio-inspired computer, which hardware architecture is based on a hybrid digital (FPGA) and optoelectronic systems. The computing efficiency will be moreover demonstrated on real-world complex technological tasks, instead of usual standard academic benchmarks, thus demonstrating the actual efficiency and applicability of the unconventional approach. These chosen tasks are chosen because they cannot be solved currently with conventional digital computers. The ability to solve these complex tasks will represent a critical milestone of the project after two years, which could consist in a necessary condition for the continuation of the project for two more years. In case of success, continuation would then address the increase of the computational power, the development of unsupervised learning capabilities, and chip integration of the successful hardware, or of a part of it. The concept of this bio-inspired computer is known in the literature as Reservoir Computer (RC), or also Echo State Network, or even Liquid State Machine. The PI recently developed this approach with photonic hardware, in the framework of a successful EU FET project. The project led to the world first photonic Reservoir, i.e. the first hardware demonstration for the processing core of a RC. It was highlighted in Nature Physics, Nature Photonics, and Optics & Photonics Focus. The aim of BiPhoProc is to demonstrate the first complete photonic RC system, moreover with the capability to solve real-wold complex technological problems. The proposed project consists of a twofold strongly unconventional approach: (i) the computational concept in itself (RC) is not yet widely addressed, despite many successful achievements (the PI's group is the only having already successfully addressed a hardware demonstration of RC in France); (ii) the

physical implementation of such RC concept is also strongly unusual, since it makes use of an optoelectronic nonlinear delay dynamics as the Reservoir classically consisting of a neural network or a network of dynamical nodes. This high risk unconventional purely temporal architecture is however expected to provide efficient practical solutions where the neural network architecture is facing hard experimental difficulties related to the connectivity between the spatial nodes of the network. Delay dynamics practically emulate in the time domain, a virtual spatial dimension, allowing then to use various signal processing tools to implement complex neural network processing functionality (e.g. input layer connectivity can be realized through time division multiplexing, a well-known technique in information transmission). Open issues to be addressed within the project are numerous, since currently obtained results are concerning the Reservoir only, but a whole self-consistent RC processor is far from being operational. This latter point is the main challenge of the project. To successfully achieve it, several points will need to be solved:

- Encoding of the input information will need to properly identified and optimized with respect to the delay dynamics properties;
- The so-called input mask for input information injection into the delay Reservoir will need to be deterministically derived with respect to the addressed problem;
- The output layer and the hardware implementation of the corresponding Read-Out also consists in an open problem (off-line algorithm only are currently used to perform RC), which requires a physical solution if one needs to perform fast real-time RC processing;

The photonic Reservoir was demonstrated to be operational, however currently at the cost of a complex parameter optimization procedure: universal (problem-independent) hardware architecture is still missing, and will need to be addressed.



Site web du projet : http://projects.femto-st.fr/projet-BiPhoProc/en