Neuromorphic Photonic Devices for All-Optical Information Processing

CentraleSupélec + Chaire Photonique

NICOLAS BAUDIN
INTERNSHIPS IN FRANCE INITIATIVE

Name of the hosting institution in France	CentraleSupélec
Name of the host laboratory / research team	Chair Photonics and LMOPS EA 4423 Laboratory LMOPS
Address	Campus de Metz , 2 Rue Edouard Belin, F-57070 Metz France (EU)
Web site	http://www.chairphotonics.eu
Name of the supervisor	Dr. Damien Rontani / Dr. Nicolas Marsal
Function	Assistant Professors
Email	damien.rontani@centralesupelec.fr

Internship offer

Topic of the internship (title)	Neuromorphic Photonic Devices for All-Optical Information Processing			
Proposed dates of the internship	**Start:**	2019-11-03	**End**	2020-02-28

Scientific and academic objectives of the internship (detailed description of the internship content, work expected from the intern and expected outcomes):

There have been multiple demonstrations that neuromorphic systems can achieve computation with high-energy efficiency [Merolla14], while performing complex tasks such as pattern recognition, or data mining. The definite objective being to provide learning and cognitive capacities to engineered photonics architectures comparable to those of complex neural architectures such as the mammal brain. Amongst the many existing proposal in cognitive computing, reservoir computing has focused significant attention since its initial discovery a decade ago [Jaeger02]. The main idea consists of a three-layer architecture: (i) an input layer detect the data and transmit it first to the second layer (ii) a dynamical networks with a complex topology including recurring loops and finally transmitted to (iii) an output layer. This generic structure, also known as an echo-state network (ESN) correspond to that of an artificial neural network (ANN) mapping the original input data to a higher-dimensional space before being processed by the output nodes, which apply a simple readout function with optimized coefficients (weights) via training. The trained output allows for the input to be mapped to its corresponding class. The training is similar to that of an ANN, except here the only part of the reservoir computer to be trained is the output. Reservoir computing has proven to be particularly effective in complex computation benchmark tasks such as spoken digit recognition and time-series (e.g.: chaotic, financial) forecasting but was mostly realized in simulations. Work and outcomes expected The objective of the intern will be to help a research team at CentraleSupélec to finalize an experimental prototype of photonics neuromorphic hardware currently under construction in the LMOPS Laboratory. The candidate will also analyze its performance on various benchmark tasks. During the internship, various experimental topologies for the photonics artificial neural network will be tested, and different strategies to inject data in the system (electronically or optically) will be investigated. Finally, the candidate will help the research team to find an optimal working point to achieve (close to) state-of-art performance on the chosen benchmark tasks.

References [Merolla14] P. A. Merolla, J. V. Arthur, R. Alvarez-Icaza, A. S. Cassidy, J. Sawada, F. Akopyan, B.L. Jackson, N. Imam, C. Guo, Y. Nakamura, B. Brezzo, I. Vo, S.K. Esser, R. Appuswamy, B Taba, A. Amir, M.D. Flickner, W.P. Risk, R. Manohar, and D.S. Modha, "A million spiking-neuron integrated circuit with a scalable communication network and interface", Science 345, 668 (2014). [Jaeger02] H. Jaeger, "Short Term Memory in Echo State Networks". Fraunhofer Institute for Autonomous Intelligent Systems, Tech. Rep. 152 (2002). [Appeltant11] L. Appeltant, M.C. Soriano, G. Van der Sande, J. Danckaert, S. Massar, J. Dambre, B. Schrauwen, C.R. Mirasso, and I. Fischer, "Information processing using a single dynamical node as complex system," Nat. Commun. 2, 468 (2011)

Name of industrial partner	Chaire Photonique
Role of the industrial partner in the internship project	The contact with public institutions and companies will be through the activities of the research chair: - Région Grand Est - Moselle Department - Airbus Group
Main contact at the French industrial partner	marc.sciamanna@centralesupelec.fr
Targeted Australian university	Any

Expected profile of applicant

Level of study	Bachelor's degree with honours or Master's student
Discipline	Electrical Engineering, Applied Physics, Engineering Physics, Experimental Photonics, Machine Learning, and Signal Processing
Required qualities, knowledge and skills	Rigorous, creative, and interested by interdisciplinary research. Skills: Programming in Matlab and/or Python and data analysis. Knowledge: Signal Processing, Basic understanding of dynamical systems (e.g.: differential equations, recurrent maps) and linear regression. Basic understanding of electromagnetic wave physics and photonics devices (e.g.: amplitude modulator, photo-detector…)
Other specific eligibility criteria	A good level in oral and written English required. Basic knowledge in French is not required but will make the experience more interesting for the candidate fully immersed in a French academic environment. Preferably student from Flinders University, University of Queensland, University of Technology Sydney, Macquarie University welcome

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