FACETS-ITN NEWSLETTER

May 2011

The Network

FACETS-ITN (www.facets-itn.eu) is an initial training network for graduate students in the emerging field of neural computation. It offers a unique research opportunity to 22 graduate students working in 14 partner institutions in 6 European countries. Scientifically the network reaches from neurobiology and modelling to theory and novel computing architectures in hardware. As such it covers many individual subjects usually well established at European universities. The added value of FACETS-ITN is a new interdisciplinary link to get the best experts in the fields and making their knowledge available to all students. The joint work includes scientific research but also training in scientific subjects and in additional skills as well as extended secondments to partner laboratories. In research the network is closely linked to existing EU funded interdisciplinary projects like Brain-i-Nets (www.brain-i-nets.eu) and BrainScaleS (www.BrainScaleS.eu). It emerged from the highly successful FACETS project (www.facets-project.org), which was the largest integrated project supported by the FET (Future Emerging Technologies) programme of the European Commission during the years 2005 to 2010. FACETS addressed the scientific challenges of FACETS-ITN and formed the foundation for the work carried out by our students. It is remarkable, that this coherent European approach to neural computation over more than 5 years is now developing a new even longer-term perspective with the first phase of FET Technology Flagships. The students of FACETS-ITN will be closely connected to one of the most exciting and innovative development of European research of the coming decade.

The Students

Experience during the recruiting phase has shown, that students are well aware of the exciting scientific challenge underlying brain science and in particular it's connection to information technology. Consequently the response to the calls has been very good and the positions have been filled by now with only one exception. The 2 female and 19 male students are highly motivated and of excellent quality. Thesis work has progressed well and during 2011 most of the students will go through their secondment phase that is an essential part of FACETS-ITN underlining the European perspective. The network training programme has a good start with a scientific course (Workshop on Experimental Neurobiology), a course teaching additional skills (IP matters) and a technology conference in Paris providing the essential connection to industrial applications.

Selected Scientific Achievements

FACETS-ITN students are now in their second year of thesis projects. This is the time when first scientific publications start to appear and intermediate results are presented at conferences. In this newsletter we present 4 such papers, which demonstrate well the strong interdisciplinary nature of the research performed in FACETS-ITN. The papers represent the work of Gerald Hahn (CNRS-UNIC, Gif-sur-Yvette). Johannes Bill (Technical University Graz), Marc-Olivier Schwarz (Heidelberg University) and Filippo Grassia (Bordeaux).

Neuronal avalanches in spontaneous activity in vivo

Hahn, G., Petermann, T., Havenith, M.N., Yu, S., Singer, W., Plenz, D. and Nikolic, D.
J. Neurophysiol. 2010 Dec; 104(6):3312-22.

Complex natural systems can generate dynamics that are characterized by cascades spreading from one site to another. Importantly, the system can evolve into a specific state (physicists call it the critical state), in which cascade size distributions follow a power law and long-range spatiotemporal correlations emerge. Recently, studies on neuronal networks in vitro (acute slices and cultures) and in vivo (rats and monkeys) uncovered avalanches dynamics with properties similar to a critical state. We investigated the presence of criticality in spontaneous spiking activity of the cat visual cortex under anaesthesia and indeed found a power law in avalanche size distributions that was accompanied by long-range correlations. In a few cases, however, we did not find sufficient evidence for a critical state, as the avalanche sizes followed a more exponential distribution and correlations were weak. Sub-sampling analysis indicated that the lack of critical features might be due to an insufficient number of recorded neurons and spikes. In summary, spontaneous activity in the anesthetized visual cortex of the cat is consistent with a critical state, but its expression may depend on sufficient sampling of neuronal activity.

Compensating inhomogeneities of neuromorphic VLSI devices via short-term synaptic plasticity

Bill, J., Schuch, K, Brüderle, D., Schemmel, J., Maass, W. and Meier, K.
Front. Comput. Neurosci. 4 (2010), 129

Neuromorphic hardware systems display an auspicious approach towards novel neuroscientific research tools and massively parallel computing devices. In these systems neuron and synapse models are integrated as physical entities in electronic circuitry. For a successful application of neuromorphic hardware as embedded systems, a high integration density is crucial since powerful spiking neural network models typically comprise a large number of neurons and synapses. Inevitably, these ever-smaller electronic circuits suffer from production-related fluctuations and inhomogeneities on the level of single units. Therefore the utilization of self-regulation properties of spiking neural networks offers a promising technique to overcome the perturbing effect of such hardware variations on the network level.

We show that cortically inspired, generic spiking neural networks emulated on a neuromorphic hardware system can keep their activity within a biologically realistic firing regime and gain a remarkable robustness against transistor-level variations. Our network model – based on theoretical studies of Sussillo et al. (2007) – makes use of dynamic properties of synapses on short time-scales, so-called short-term synaptic plasticity (STP). The examined architecture is based on randomly connected networks and imposes only little constraints on the network structure. Thus the setup is likely to be applicable to various specialized network topologies for which it can serve as a substrate on the network level.

A VLSI Implementation of the Adaptive Exponential Integrate-and-Fire Neuron Model.

Millner, S., Grübl, A., Meier, K., Schemmel, J. and **Schwartz, M.-O.**
Advances in Neural Information Processing Systems (NIPS), Vancouver, 2010.

We describe a hardware implementation of a neuron model, called the Adaptive Exponential Integrate-and-Fire model, using analogue circuits. Like its biological counterpart, this artificial neuron is capable of emitting action potentials – also called spikes – and to reproduce behaviours comparable to biological neurons. These neuron circuits are implemented in a chip featuring 512 neurons and can be connected to each other via artificial synapses. The goal is then to interconnect many of these chips to build a system with approximately 200.000 neurons. Compared to classical computer simulations of neuron models, this approach allows building low-power and highly accelerated systems. The paper describes the technical implementation of the neuron circuits, and how it can reproduce typical spiking patterns observed in biology. For example, stimulated with a constant input, the neuron can emit spikes at a constant frequency, but can also adapt itself to the input and decrease its frequency over time, thus reproducing the so-called spike-frequency adaptation, which has been observed in biological neurons. A method is also proposed to automatically convert model parameters to parameters usable by the hardware, assuring the reproduction of the same result in simulation and on the hardware system.

A Neuromimetic Spiking Neural Network for Simulating Cortical Circuits

Grassia, F., Lévi, T., Tomas, J., Renaud, S. and Saïghi, S.
CISS 2011, *45th Annual* International Conference of the IEEE on Information Sciences and Systems (Baltimore , USA)

We present an hardware implementation of spiking neural networks based on analog integrated circuits. These ICs compute in real-time biologically realistic cortical neuron models. Each integrated circuit includes five neurons and analog memory cells to set and store the conductance model parameters. The system allows switching online the model of cortical neuron. Circuits are embedded in a multi-board system all connected to a backplane with daisy-chain facilities. Each action potential computed by analog neuromimetic chips is time-stamped when detected by digital device (FPGA). These FPGAs are also in charge of the real-time plasticity computation and of controlling inter-boards communication. The implemented neural plasticity is also biological relevant thanks to its time dependent computation. The whole system is designed to compute programmable models and connectivity schemes in biological real-time. It will allow extending the hybrid technique (connection between biological and artificial neurons) to Micro Electrode Array.

Outreach

The excellent integration of the FACETS-ITN student network into major research collaborations has been demonstrated and strengthened by several joint events with the former FACETS project and its successor BrainScaleS.

The FACETS organized conference “Frontiers in Neuromorphic Computation” in Paris 2010 has been complemented by a FACETS-ITN poster session and a joint industry event. The industry event was of particular importance as is enabled contacts with potential employees and future users of the ideas emerging from the student work. Also, at that occasion a first informal get-together took place with the students and supervisors during a common dinner.

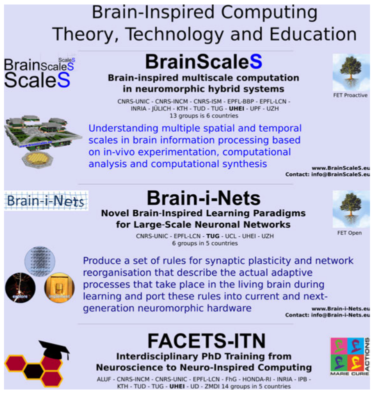
The BrainScales Kick-Off meeting 2011 in Barcelona saw a training event for FACETS-ITN student presented by the European Patent Office in Munich. Also here, posters from network students were shown during the BrainScaleS plenary meeting and received great interest. The poster session was combined with a “hands-on” dinner that lasted well into the late evening.

FACETS-ITN IP course, 22 March 2011 in Barcelona

Poster-dinner with BrainScaleS, 24 March 2011

Towards the public FACETS, BrainScaleS and FACETS-ITN presented themselves in a joint stand at the ICT2010 conference in Brussels.

The large interest received motivated the involved groups to repeat this kind of joint presentation at the FET11 event in Budapest 2011. Brain-i-Nets, BrainScaleS and FACETS-ITN will show a stand under the title “Brain-Inspired Computing - Theory, Technology and Education“



PEOPLE

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MARIE CURIE ACTIONS