Technical University of Munich

Human Brain Project Education Programme

3rd HBP CURRICULUM WORKSHOP SPIKING NEURAL NETWORKS: APPLICATIONS TO COMPUTING, ALGORITHMICS, AND ROBOTICS

27-28 June 2019, Technical University Munich, Germany

Speaker Abstract Collection

Alphabetical order according to presenting author

Co-funded by the European Union

List of Abstracts (in alphabetical order)

Neuromorphic hardware for real-time-real-world-robots

Jörg, Conradt
KTH Royal Institute of Technology, Sweden

Spiking Neuronal Networks (SNN) offer a powerful promise to control intricate future robotic systems. Such SNNs need to be executed on reasonable power budgets in real time for any real-world robotic application. The more challenging and complex sensory inputs and control settings become, the more questionable is the execution of (spiking) neuronal networks in real time. Neuromorphic hardware, such as Manchester's SpiNNaker, IBM's TrueNorth, or Intel's Loihi, offer efficient execution of SNNs, but provide various challenges and limitations in software, interfacing, and up-scaling. This talk will highlight several available neuromorphic computing platforms, and present benefits of connecting such to real-time real-world robot scenarios.

Translation of Biomorphic Neural Principles Towards Closed Loop SNN-based Sensomotoric Robot Controls

Dillmann, Rüdiger
Karlsruhe Institute of Techonology, Germany

The long term goal of this research is to model, translate and understand biomorphic neural principles focusing on brain related senso-motoric control tasks and to ground it with the help of real robots. This involves interdisciplinary and collaborating research as it is done within the HBP. Spiking neural networks (SNN) have the potential on replicating real neurons mirroring some of their biological characteristics. SNNs are capable to perform synaptic spike-based communication, they allow modeling of local brain functionalities including learning and plasticity mechanisms. We assume, that the brain is forming sensor-motor primitives as building blocks for prediction, generation and execution of motions. The combination of neural simple motion primitives represent muscle synergies and yield towards more complex and advanced motions. The authors present results of their research on bio-inspired SNN control architectures capable to perform tasks like neural object recognition, object tracking, target reaching and grasping as well as collision- and obstacle avoidance. The experimental evaluation with a robot arm in closed loop control mode is performed without any planning algorithms nor calculation of kinematic transformations. Spiking neural network are used to represent motions in a hierarchy of motor primitives. Biologically plausible reward-learning rules based on synaptic sampling show that the SNNs are capable of learning to perform policies. Neuroscientists have established links between reward-modulated synaptic plasticity and online reinforcement learning.

The hyper-parameters of this neuromodulation and their impact on performance were studied on closed-loop sensor-motor experiments.

The potential of deep reinforcement learning for target reaching affects object interaction, manipulation and grasping tasks and can contribute to adapt its execution to different situations. An active binocular DVS system is used in stereo mode which is driven by micro saccades. The SNN feedback information from the DVS vision system and from proprioception are coupled for executing reaching movements and for general motion generation.

Future work is related to an effective use of neuromorphic vision with emphasis to eye movement, micro saccades, visual affordance learning and visual prediction. Biomorphic navigation and mapping (BSLAM) requires episodic neural memories supported by multi-scale learning capabilities.

Lessons from the brain for enhancing computing and learning capabilities of spiking neural networks

Maass, Wolfgang
University of Technology Germany

Wolfgang Maass will sketch recent progress in boosting the computing capability of spiking neural networks for temporal processing tasks. He will also sketch a recently discovered new learning method for recurrent networks of spiking neurons, called e-prop, which may explain how synaptic plasticity is organised in such networks in the brain. In addition, e-prop enables on-chip learning for neuromorphic chips. Both methods were the result of having a closer look at experimental data on spiking neural networks in the brain.

Details can be found in *G. Bellec, D. Salaj, A. Subramoney, R. Legenstein, and W. Maass. Long short-term memory and learning-to-learn in networks of spiking neurons. 32nd Conference on Neural Information Processing Systems (NeurIPS 2018), Montreal, Canada, 2018.*
https://igi-web.tugraz.at/PDF/243.pdf
and *G. Bellec, F. Scherr, E. Hajek, D. Salaj, R. Legenstein, and W. Maass. A solution of the learning dilemma for recurrent networks of spiking neurons. Biorxiv, August 2019.*

The basics of spiking neurons: Biological facts, models and computational properties

Morin, Fabrice
Technical University of Munich (TUM), Germany

No abstract provided.