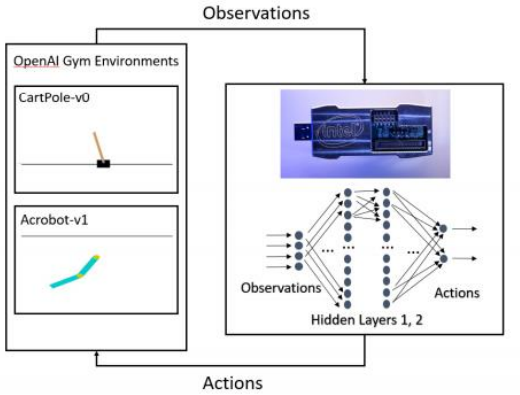
Robotics and Embedded Systems

Human Brain Project

Master Thesis

Deep Spiking Reinforcement Learning

BACKGROUND



Spiking Neural Networks (SNN) are often referred to as the third generation of neural networks as they closely resemble biological neurons. They are less widespread than Artificial Neural Networks (ANN) mainly due to the lack of learning rules for this class of networks. Over the past few years, however, multiple efforts resulted in gradient approximations for SNNs [2] that opened the door for utilizing powerful learning algorithms, such as backpropagation, in this class of neural networks.
In a recent study [1], we concluded that such learning rules can be combined with SNNs to train reinforcement learning agents, and that trained networks can be deployed to neuromorphic hardware without loss in performance. There are still, however, open questions regarding the efficacy of SNNs based on the chosen RL algorithm, the chosen network architecture, and the ability to generalize to new environments.

YOUR TASK

In this thesis, you will develop multiple agents using state-of-the-art RL algorithms and SNNs that solve OpenAI Gym environments of various complexity, and input modalities (e.g., ground truth data or pixels) that require different network architectures. The trained networks will be deployed on neuromorphic hardware and the results will be compared with conventional ANN implementations in terms of performance and energy efficiency.

Required Skills

- Good Knowledge of Python and Linux
- Experience with Deep Learning frameworks and reinforcement learning
- Experience with Spiking Neural Networks is preferred

References

[1] M. Akl, Y. Sandamirskaya, F. Walter, and A. Knoll, *Porting Deep Spiking Q-Networks to Loihi*, International Conference on Neuromorphic Systems, 2021.

[2] M. Pfeiffer and T. Pfeil, “Deep Learning with Spiking Neurons: Opportunities and Challenges,” *Front. Neurosci.*, vol. 12, no. October, 2018.

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