Implementation of shortest path finding in weighted graphs on the neuromorphic chip Loihi 2

The Group of Computational Synaptic Physiology led by Prof. Dr. Christian Tetzlaff at the University Medical Center Göttingen (https://tetzlab.com) offers a Master’s thesis project on single-source shortest path (SSSP) finding with neuromorphic hardware. The project will encompass the implementation of a novel algorithm to solve the SSSP problem in a local computation paradigm with Intel’s neuromorphic chip Loihi 2. The project shall start as soon as a suitable candidate is found.

Description
Finding the shortest path through a graph is an optimization problem relevant to a wide array of applications. These include routing of vehicles, planning layouts of facilities such as telecommunication networks and power grids, and robotics. Such problems can be mapped to a graph structure with nodes representing system states such as physical locations and edges representing the paths or actions to move between them. Importantly, in many applications there are large differences in the cost associated with particular paths or actions, for example, for a city street with traffic lights compared to a highway. Costs can be represented by introducing a specific weight for each edge in the graph, which can generally take into account factors like time, monetary cost, energy, or resources. One key problem in this setting is to find the optimal sequence of weighted edges between a source node and all other nodes in the graph, called single-source shortest path problem (SSSP). Up to now, no solution to this problem for weighted graphs has been implemented on neuromorphic hardware.

The goal of the proposed project is to implement a novel neuromorphic algorithm for shortest path finding in weighted graphs. The implementation shall be based on the Lava neuromorphic computing framework and run on Intel’s neuromorphic chip Loihi 2. To target weighted graphs, complementing previous efforts that have targeted unweighted graphs with a neuromorphic algorithm based on synaptic delays and a propagating wavefront (Aimone et al., 2021; Davies et al., 2021), an algorithm based on local summation and minimization of cost shall be used (cf. Michaelis, 2022, section 5.1). The project will be supported and co-supervised by Dr. Andrew Lehr and Dr. Jannik Luboeinski.

Specific objectives
• Implementing the algorithm in the Lava framework for test runs on CPU.
• Designing the algorithmic implementation for the Loihi 2 chip (together with the supervisors).
• Implementing the algorithm in the Lava framework to run on the Loihi 2 chip.
• Testing and benchmarking the implementation in different task paradigms.

Requirements
• Programming experience, preferably in Python.
• English skills sufficient for reading papers and scientific interaction.
• Experience with graph search algorithms (preferable but not mandatory).
• Experience with neuromorphic or fixed-point computation (preferable but not mandatory).

Key references
Architectures (SPAA). ACM, New York/NY, USA.
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