Road to scalability for efficient graph search on massively parallel neuromorphic hardware

Oskar von Seeler[(1,2)], Jannik Luboeinski[(1,2)], Andrew B. Lehr[(1,2)], Christian Tetzlaff[(1,2)]

[(1)] Department of Neuro- and Sensory Physiology, University Medical Center Göttingen, Germany, [(2)] CIDAS, University of Göttingen, Germany

Efficient computation of shortest paths in weighted graphs is a fundamental problem with many applications. Neuromorphic hardware platforms promise massively parallel, efficient computation, changing parallelism tradeoffs. In this work, We introduce NEURO-MAPP (Neuromorphic-based Min-Add Parallel Propagation), a distributed shortest path algorithm designed to use local computation and network communication available in neuromorphic systems. We provide an optimized implementation of the algorithm on the SpiNNaker 2 platform and evaluate its performance on a selection of synthetic and real-world graphs, including street maps for navigation and protein interaction networks. These results are compared to the established Dijkstra's algorithm on a modern CPU. We find that the NEURO-MAPP implementation scales favorably in terms of runtime for many graph types while consuming less energy per shortest-path query than the CPU implementation in almost all cases. Furthermore, we show that NEURO-MAPP can be seamlessly integrated into larger mathematical frameworks. In particular our results demonstrate that NEURO-MAPP improves dimensionality reduction methods such as Isomap, for the efficient analyses of large data sets. These findings highlight the potential of neuromorphic hardware featuring sparse, spike-based communication as a scalable and energy-efficient platform for computation in graph search and related tasks.

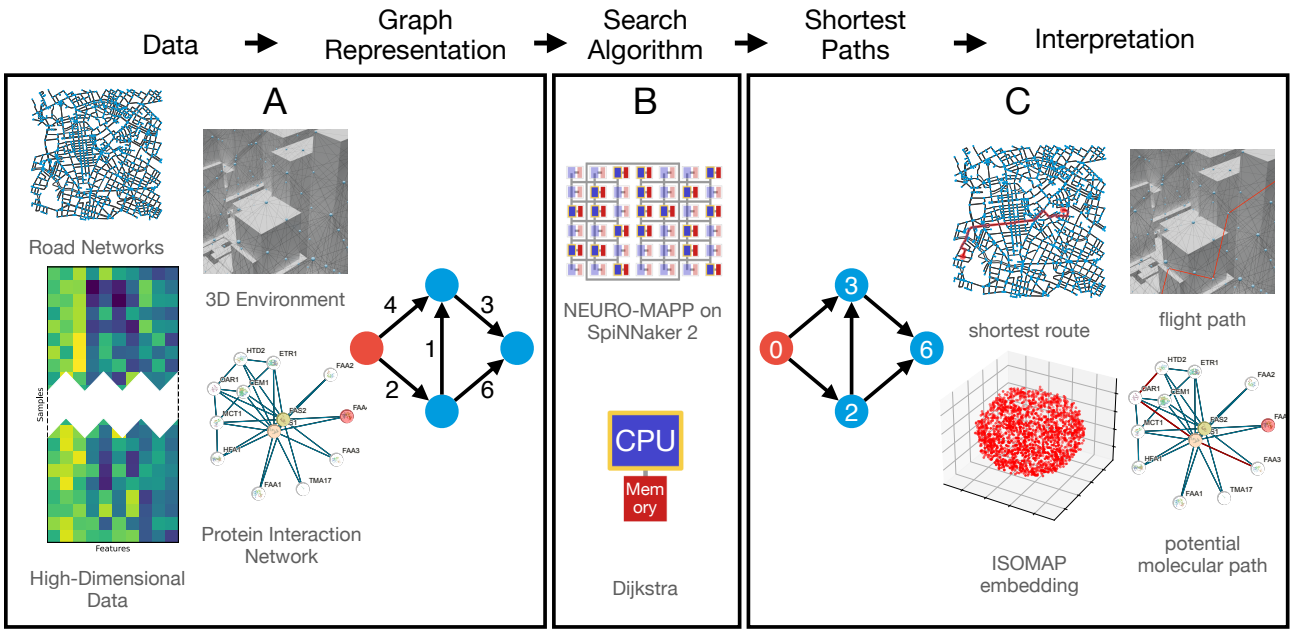

Figure 1: Overview of this work. **A** Multiple real-world problems can be formulated as shortest path queries on weighted graphs. **B** Two options for finding shortest path in the graphs: Our NEURO-MAPP implementation on the SpiNNaker 2 chip and Dijkstra's algorithm on a modern CPU. **C** With the obtained shortest paths from either algorithm, the stated problems are solved.