Live Demonstration: Handwritten Digit Recognition Using Spiking Deep Belief Networks on SpiNNaker

Evangelos Stromatias*, Daniel Neil‡, Francesco Galluppi†, Michael Pfeiffer‡,
Shih-Chii Liu‡ and Steve Furber*
*Advanced Processor Technologies Group, School of Computer Science, University of Manchester, UK
M13 9PL, Manchester, United Kingdom
Email: stromate@cs.man.ac.uk
†Equipe de Vision et Calcul Naturel, Vision Institute, Université Pierre et Marie Curie
UMR S968 Inserm, UPMC, CNRS UMR 7210, CHNO des Quinze-Vingts, Paris, France
‡Institute of Neuroinformatics, University of Zurich and ETH Zurich
Winterthurerstrasse 190, CH-8057 Zurich, Switzerland

***Abstract*—We demonstrate an interactive handwritten digit recognition system with a spike-based deep belief network running in real-time on SpiNNaker, a biologically inspired many-core architecture. Results show that during the simulation a SpiNNaker chip can deliver spikes in under 1 µs, with a classification latency in the order of tens of milliseconds, while consuming less than 0.3 W.**

Associated Track 8.1: Neural Networks and Systems: Spiking Neural Network circuits and systems

I. Demonstration

Deep neural network architectures such as Deep Belief Networks (DBNs), are a very active research topic in machine learning and achieve state-of-the-art classification results. However, simulating large-scale DBNs has large computational demands, which means high energy requirements and long latencies, and thus limits their use in real-time applications for mobile or robotic platforms. A recently published study [1] developed the theory to map an offline-trained DBN into a spiking neural network composed of Leaky Integrate-and-Fire (LIF) neurons, exploiting the so-called Siegert approximation for the firing rate of an LIF neuron. Spiking neural networks running on an appropriate hardware platform can allow asynchronous and massively parallel energy-efficient processing [2]. SpiNNaker [3] is a biologically-inspired many-core scalable architecture designed to enable large-scale simulations of heterogeneous models of spiking neurons efficiently and in real-time. In this demonstration, we show an application of SpiNNaker as a real-time event-based hardware prototyping platform to enable interactive handwritten digit recognition with a spiking deep belief network.

II. Demonstration setup

The demonstration setup consists of a four-chip SpiNNaker board [3], a wireless router, a laptop, and a mobile device which for the purpose of this demonstration is a tablet device, Fig 1. The user interface, which runs on the mobile device, allows the user to draw a digit and receive the classified output of the spiking deep belief network running on SpiNNaker.

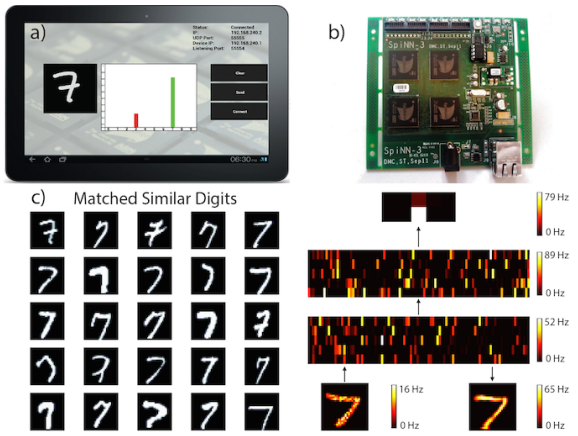

Fig. 1. Handwritten digit recognition setup. a) The user interface running on a mobile device, showing a finger-drawn digit (left) and a correct classification. b) A 4-chip SpiNNaker board. c) The output of the laptop monitor, showing network-classified similar digits from the training set, as well as the firing rates of neurons within each layer during classification

III. Visitor experience

Visitors can draw digits using a tablet and the spike-based DBN will run on SpiNNaker in real-time producing a result within tens of milliseconds, while dissipating less than 0.3 W power. The classified output will be presented on the tablet as a normalised histogram of the spikes of the output population. In particular, they will see the conversion of static images to spike-trains, the propagation of neural spikes through multilayer spiking DBNs, and the resulting output of a correctly-classified handwritten digit. Additionally, the network recognizes different styles of handwriting accurately.

References

[1] P. O'Connor, D. Neil, S.-C. Liu, T. Delbruck, and M. Pfeiffer, "Real-time classification and sensor fusion with a spiking deep belief network," Frontiers in Neuroscience, vol. 7, no. 178, 2013.
[2] D. Neil and S.-C. Liu, "Minitaur, an event-driven fpga-based spiking network accelerator," IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. PP, no. 99, pp. 1–1, 2014.
[3] S. Furber, F. Galluppi, S. Temple, and L. Plana, "The SpiNNaker project," Proceedings of the IEEE, vol. 102, no. 5, pp. 652–665, May 2014.