Biologically sound neural networks for embedded systems using OpenCL

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Introduction

Biologically sound spiking neural networks are powerful but require high performance computing. New embedded chips with OpenCL support are perfectly suitable for this kind of tasks.

Spiking Neural Networks

We implemented and simulated biologically plausible spiking neural networks with the following spike response model:

$$u_i(t) = \eta(t - \hat{t}_i) + \sum_j w_{ij} \sum_k \varepsilon_{ij}(t - \hat{t}_i, t - t_j^k)$$

Membrane potential function

$$\varepsilon(x,y) = \frac{e^{-t/\tau_x}}{\tau_s} \int_0^x e^{-\tau(1/\tau_m - 1/\tau_s)} H(t-\tau)\, d\tau$$

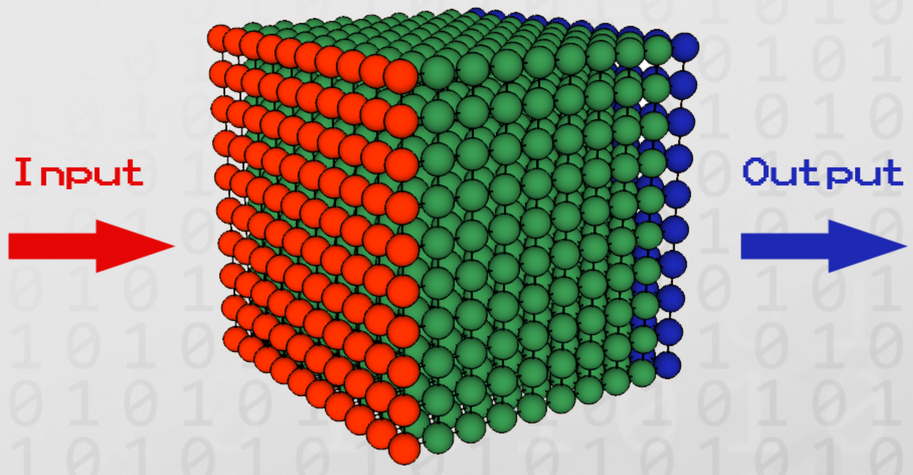
Postsynaptic potential function

$$\eta(x) = -\eta_0 e^{-x/\tau_f} H(x)$$

Refractory response function

Network structure

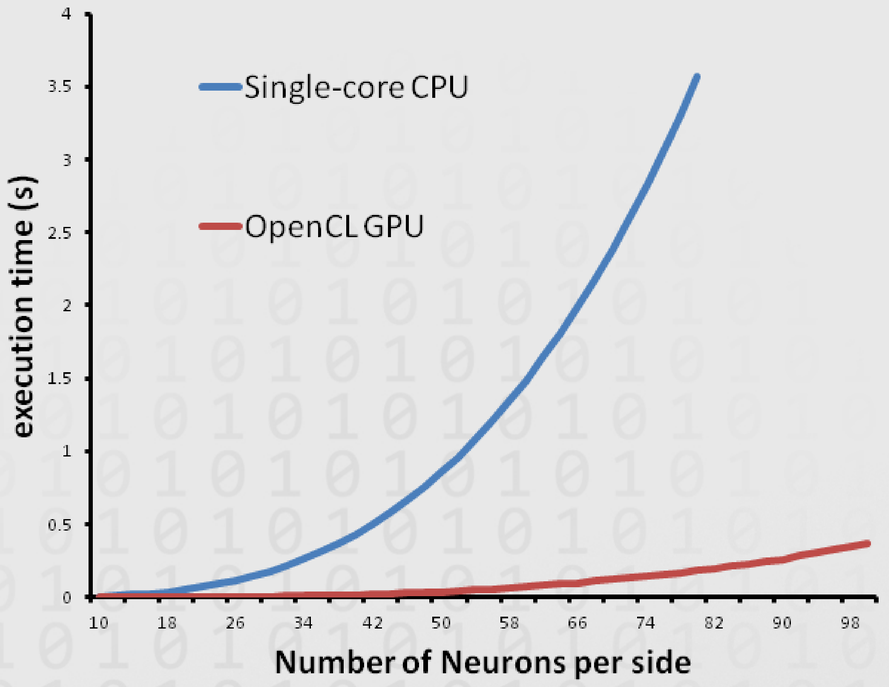
- Spatially homogeneous N × N × N network
- Neurons connect to the local Moore neighborhood (range 2)
- 5^3-1 = 124 synapses per neuron
- Neurons on the front are used as input
- Neurons on the back are used as outputs
- Best fit for processing sequence of images



Parallel computing with OpenCL

- Neural networks are easily parallelizable
- OpenCL allows for implementing portable data-parallel code
- For maximum performance data transfer between host and chip has to be minimized
- Hardware's memory buffers are an upper limit for network size

Results



- Iterated the network 1000 times, grid size N=10..100
- Measured the execution time of one step of the network
- Input 8 bit grayscale images

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