Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

"CMOL CrossNets as Defect-Tolerant Classifiers"

By

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Hybrid circuits consisting of a CMOS chip and add-on nanowire crossbar have gained much attention recently since this concept can compensate for the limited functionality of nanodevices fabricated with the reproducibility necessary for integrated circuits. In this concept, two perpendicular layers of nanowire of crossbar are connected with two-terminal latching switches formed at every cross point. In the 'CMOL' variety of hybrid circuits, each individual nanowire can be addressed using a CMOS subsystem through an interconnect pin; as a result, each latching switch can be turned on or off independently. The main advantage of such systems comes from the unprecedented potential density of the nanodevices. According to our estimates, CrossNets-mixed-signal neuromorphic networks, based on CMOL technology, may eventually outperform the cortical circuits in density and speed.

This fact encouraged us to explore the possible performance and defect tolerance of the CrossNets. This dissertation is focused on CrossNet-based multi-layer perceptrons (MLP) working as pattern classifiers, including their training options. The simplest training procedure here is "weight import": after training a software-implemented precursor network, synaptic weights are imported to the discrete synapses of CrossNets, with the necessary quantization. This rule has been applied successfully to a large-scale benchmark task MNIST. However, weight import training with a precursor network may become impracticably slow when the required network size is too large. In order to train such large networks, weights should be computed inside a CrossNet. Our idea of such "in-situ" training is based on the stochastic multiplication, implemented with the latching switches of the CrossNet. In particular, we have shown that the in-situ algorithm can be used to train CrossNet MLPs to perform handwritten digit recognition. Moreover, we have shown that such CrossNet may have high defect tolerance.

We believe our research may help to design in future more complex (hierarchical/modular) systems working similarly to our brain.

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