Ph.D. Dissertation Proposal Defense

Candidate: Shruti R. Kulkarni
Date: December 13, 2016
Time: 11.00 AM to 12.00 PM
Venue: ECEC 202
Title: Bio-inspired learning and hardware acceleration using emerging memories

Abstract

One of the grand challenges of this century is to understand the information processing architecture of the brain to develop intelligent computing platforms. It is believed that information processing in biology relies on impulse like signals emitted by neurons called action potentials. Motivated by this form of information representation, Spiking Neural Networks (SNNs) have been proposed where the timing of spikes generated by artificial neurons is central to its learning and inference capabilities. This thesis aims to investigate the computational power of the biologically plausible SNNs and quantify their hardware efficiency on existing/emerging platforms compared to the state-of-the-art artificial neural networks used in machine learning today.

As an exemplary illustration of spike based learning and inference, we have developed an SNN employing the Normalized Approximate Descent (NormAD) supervised learning algorithm to the problem of handwritten digit classification. The network architecture has two layers, one for feature extraction and second one for classification. We benchmark our network's accuracy using the MNIST hand-written digit data-base. Our network currently has achieved a classification accuracy of 97.9% on the MNIST test data-set, with about 4x fewer parameters compared to the state-of-the-art neural networks achieving 99% accuracy. In addition, we also present a scheme for parallelizing and speeding up our SNN simulation on a GPU platform.

In parallel, we are also developing efficient architectural frameworks for realizing the algorithms for SNNs on custom hardware. We have studied schemes and trade-offs in designing the network parameters for on-chip spike based supervised learning on a CMOS digital crossbar based architecture. While this study was done using the ReSuMe (Remote Supervised Method) algorithm, the methodology developed for its realization can be extended to better algorithms such as NormAD and other probabilistic learning algorithms and for emerging non-volatile memories. My presentation will describe the experiments and results on the above mentioned aspects and discuss the future directions of this research work.

Committee members:
Dr. Bipin Rajendran, Associate Professor, Dept. of ECE, NJIT (Advisor)
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Publications:

1. S. R. Kulkarni and B. Rajendran, "Scalable digital CMOS architecture for spike based supervised learning," in Springer LNCS Proceedings of the 16th EANN 2015, Sept 2015.

2. S. R. Kulkarni and B. Rajendran, "Supervised Learning with Spiking Neural Networks on a GPU Platform", submitted to ISCAS 2017.

3. S. R. Kulkarni and B. Rajendran, "Spike Based Supervised Learning for Handwritten Digit Recognition", submitted to IJCNN 2017.

4. S. R. Kulkarni and B. Rajendran, "Comparison of Artificial and Spiking Neural Networks for Supervised Learning", manuscript under preparation.