Speaker	Asst. Prof. Arindam Basu
Talk Title	How can Dendritic Computation be useful in Neuromorphic Systems?
Institution	Nanyang Technological University
Department	EEE
E-mail	arindam.basu@ntu.edu.sg
Webpage	http://www3.ntu.edu.sg/home/arindam.basu/

1. Tentative Abstract

Most neuromorphic IC designed so far have largely ignored the role of nonlinear dendritic processing while choosing to focus on synaptic plasticity and nonlinear integration at the soma. Here, we shall present some of our recent work that includes dendritic nonlinearities in increasing level of detail. First, we show that even with lumped branch nonlinearity, dendritic neurons can have high memory capacity even with binary synapses. Since we employ binary synapses, learning involves formation or elimination of connections--hence, it modifies network structure and the algorithm can be called structural plasticity. We show architectures for binary and multi-class classification and present results on standard databases like MNIST where inputs are rate encoded binary vectors.

Second, we show extensions of the above method for classifying spatio-temporal spike patterns in supervised and unsupervised manner. We compare our supervised method with tempotron learning and our unsupervised method with STDP.

Next, we mention how spatio temporal spike trains can be classified even more efficiently if multi-compartmental dendritic models are considered. We present some initial results of combining delay learning with structural plasticity and comment on future directions of work.

Finally, we show some results from VLSI implementations of the dendritic neurons where learning is performed in software while the learnt connections are downloaded to hardware. We analyze performance limits and conclude with future research directions in this area.

2. Brief Biography

Arindam Basu received the B.Tech and M.Tech degrees in Electronics and Electrical Communication Engineering from the Indian Institute of Technology, Kharagpur in 2005, the M.S. degree in Mathematics and PhD. degree in Electrical Engineering from the Georgia Institute of Technology, Atlanta in 2009 and 2010 respectively. Dr. Basu received the Prime Minister of India Gold Medal in 2005 from I.I.T Kharagpur (awarded to the top student).
He joined Nanyang Technological University as an Assistant professor in June 2010.

Dr. Basu received the best student paper award at Ultrasonics symposium, 2006, best live demonstration at ISCAS 2010 and a finalist position in the best student paper contest at ISCAS 2008. He was awarded MIT Technology Review's inaugural TR35@Singapore award in 2012 for being among the top 12 innovators under the age of 35 in SE Asia, Australia and New Zealand. His research interests include bio-inspired neuromorphic circuits, non-linear dynamics in neural systems, low power analog IC design and programmable circuits and devices.

3. List of Representative Publications

- Chen Yi, Yao Enyi and Arindam Basu, "A 128 Channel 290 GMACs/W Machine Learning Based Co-Processor for Intention Decoding in Brain Machine Interfaces," *IEEE ISCAS,* Portugal, May, 2015.
- Roshan Gopalakrishnan and A. Basu, "Triplet Spike Time Dependent Plasticity in a Floating-Gate Synapse," *IEEE ISCAS,* Portugal, May, 2015.
- S. Roy, A. Banerjee and A. Basu, "Liquid State Machine with Dendritically Enhanced Readout for Low-power, Neuromorphic VLSI Implementations," *IEEE Trans. on Biomedical Circuits & Systems* , vol. 8, no. 5, pp. 681-695, 2014.
- S. Hussain, S. C. Liu and A. Basu, "Biologically plausible, Hardware-friendly Structural

Learning for Spike-based pattern classification using a simple model of Active Dendrites," *Neural Computation* , April, 2015.

- P.P. San, A. Basu and S. Hussain, "Hardware-Friendly Morphological Learning for Spiking-Neuron with Dendritic Nonlinearity," *IEEE IJCNN,* Beijing, July, 2014.
- A. Basu, S. Shuo, H. Zhou, G. Huang and M. Lim, "Silicon Spiking Neurons for Hardware Implementation of Extreme Learning Machines," *Neurocomputing* , vol. 102, pp. 125-134, Feb. 2013.
- Chen Yi, A. Basu, M. Je, L. Liu, X. Zou, R. Ramamurthy and G. Dawe, "A Digitally Assisted, Signal Folding Neural Recording Amplifier," *IEEE Trans. on Biomedical Circuits & Systems*, vol. 8, no. 4, Aug 2014.