The BioRC Biomimetic Real-Time Cortex Project Progress Report

Alice C. Parker, Principal Investigator

Viterbi Research Innovation Fund and USC WiSE Major Funding

March 12, 2012

The BioRC Biomimetic Real-Time Cortex Project is an interdisciplinary project that involves application of neuroscience research to electronic circuits that mimic neurons in the brain, using nanotechnology and CMOS. The BioRC project has been funded for the past 21 months by the Viterbi Research Innovation Fund and USC WiSE Major Funding, invaluable for the continuation of this exciting research. During this period of time, significant research progress has been made on the project, with funding focused on structural plasticity. We have extended the project website to include recent results including the successful defense by three Ph.D. students, along with continuing research performed by 5 other students. We have a number of publications resulting from this research as shown on the website, and we received significant press coverage on the nanotube synapse fabricated in Chongwu Zhou's nanolab through a collaboration between us and our students (see Physics.org for an example).

During the period of funding there were 8 Ph.D. students on the BioRC project, 7 supervised by me and 1 jointly supervised by me and Chongwu Zhou. Ben Raskob, Mohammad Mahvash and Adi Azar have completed their dissertations.

Dissertation results by Ben Raskob included a method for detecting and refining the locations of edges in stereo images that relies on mathematical analysis of the image pair using wavelets. In addition to the mathematical foundations of the approach, the bioinspired approach emulates the processing in simple and complex cells that is believed to occur in the visual cortex. A journal paper on this topic is in preparation.

Dissertation results by Mohammad Mahvash included neural circuits modeled with carbon nanotube transistors extended to embed noise or chaotic behavior. A circuit was constructed to mimic chaotic behavior.

Extensive experimental results were obtained illustrating the behavior of the neurons with inserted noise and chaotic signals. Two journal papers are in preparation. Mahvash also produced a SPICE simulation model of a memristor.

Dissertation results by Adi Azar involve simulation of the retina at the cellular level with a custom event-oriented simulator along with techniques to make the simulations more efficient without sacrificing significant accuracy.

Research by Jon Joshi, collaborating with Jialu Zhang and with additional support from Chuan Wang, Chih-Chieh Hsu, and Master's degree student Udhay Ravishankar produced a carbon nanotube synapse referred to earlier. Research by Rebecca Lee (in collaboration with Zhou's student Jialu Zhang) produced a variation on the synapse previously published with a different form of nanotubes. Ko-Chung Tseng researched electronic neurons to model the retina, with a publication on directional selectivity in collaboration with Jon Joshi. Chih-Chieh Hsu continued her research in synaptic and dendritic computations and plasticity.

Research is continuing for the five Ph.D. students and a number of MSEE candidates performing directed research. New and continued research directions will be described in a separate document.