Nanocomputing with Delays

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Abstract

The push to obtain smaller and denser circuits solely based on lithography and silicon technology is quickly reaching limits imposed by device physics and processing technology. It is anticipated that these limits will invalidate Moore's law and lead to unacceptable manufacturing costs, unreliable devices, and hard-to-manage power dissipation and interconnect problems. Nanotechnologies that rely on self-assembly, biomolecular components, and nanoelectronics are promising alternatives to silicon-based microelectronics. They will eventually enable levels of integration that exceed that of today's silicon-based microelectronics by three orders of magnitude.

These nascent technologies present intriguing challenges and exciting opportunities to use biologically inspired solutions to address system architecture questions. Biological computation is capable of sensing and reacting to a time-varying redundant environment without the benefit of logic gates and formal systems. It does so by using coupled nonlinear dynamic systems which, while consisting of simple distributed components, have emergent complex and rich behavior. Applying models of the nonlinear dynamics of biological (neuro) computing to the design of nanocomputers and nanocomponents will make nanosystems ideal for applications for which von-Neumann architectures and microelectronic circuits are ill suited. These applications include pattern recognition, image processing, olfactory sensing, information filtering, and other forms of processing of sensorial information. They will be critical in bringing about extremely small, highly integrated intelligent sensors and actuators that combine micro-electrical-mechanical, chemical, and other forms of sensing with signal processing for purposes of perception, motion, and autonomous navigation.

This talk discusses recent results of an ongoing collaborative research effort by nanotechnologists, neurocomputing experts, and computer and circuit designers to explore novel architectures for nanoscale neuromorphic systems. The focus will be on implementations whose behavior depends on how propagation delays affect communication among system components. The components under considerations are reminiscent of spiking neurons and, unlike in classical systems, interconnect is used for computation as well as communication purposes. Hybrid systems will also be briefly discussed.

*Research funded, in part, by NSF award EIA-0135946.

Proceedings of the IEEE International Conference on Application-Specific Systems, Architectures, and Processors (ASAP'02)
1063-6862/02 $17.00 © 2002 **IEEE**

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Fortes' research interests are in the areas of network computing, biologically inspired nanocomputing, advanced computing architecture, and distributed information processing systems. He has authored or coauthored over 130 technical papers. His research has been funded by the Office of Naval Research, AT&T Foundation, IBM, General Electric, and the National Science Foundation.

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