PORTLAND, Ore. — Cognitive computers, artificial neural networks, neuromorphic systems, and similar efforts to cast the intelligence of the human brain into silicon chips is all the rage at major corporations, from IBM to Qualcomm, and at major government-sponsored efforts, including the US Defense Advance Research Project's (DARPA's) Systems of Neuromorphic Adaptive Plastic Scalable Electronics Human Brain Project. Now researchers at Georgia Tech have created a roadmap for the development of brain-like neuromorphic systems that, they say, can serve as a guide to all players.

Professor Jennifer Hasler (left) and doctoral candidate Suma George examine a field-programmable gate array board.

Jerry G What is even more amazing is that it always seems to come back to this 'ressurected dead guy'. That in itself says much! If he is who he said he is, then he is more marvelous...
"If you look at the technology we have now, and forward to that which will soon be available -- for instance, 11 nanometer processes -- then you come to the conclusion that eventually we really could build a human-like cortex in something that could use as little as 50 watts of power and be small enough to put on your desk," Georgia Tech professor Jennifer Hasler told EETimes.

The roadmap is authored by Hasler and Georgia Tech doctoral candidate Harry Bo Marr, now graduated and working at Raytheon Co. in El Segundo, Calif., as the technical lead of DARPA’s Arrays at Commercial Timescales (ACT) program and lead electronic warfare digital architect. Hasler and Marr’s roadmap also relied upon results obtained by Georgia Tech doctoral candidate Suma George, who experimentally demonstrated, for the first time, that neuromorphic systems based on circuits that tightly model biological principles have clear advantages over other approaches, including typical analog signal processing techniques.

Hasler’s own research emphasizes the key role that properly designed analog processing elements will have on neuromorphic systems, specifically field-programmable analog arrays (FPAA) that she and colleagues at Georgia Tech have been perfecting for several years.

FPAA are similar to field-programmable gate arrays (FPGA) but include reconfigurable analog elements. FPAA are commercially available from Mesa, Az.-based Anadigm, but Hasler claims Georgia Tech’s FPAA “dwarf the programmability and capability of the Anadigm components” by virtue of housing “hundreds of thousands of programmable parameters, enabling them to be used for system-level computing, not just analog glue logic.”

Hasler believes the clear path to desktop neuromorphic systems will require such analog system-on-chip (SoC) approaches to computation in order to achieve the low-power devices necessary to emulate billions of brain-like neurons connected by trillions of learning synapses. In all, she predicts that desktop neuromorphic systems that rival the compactness of the human brain will require “eight orders-of-magnitude” (100 million times) reduction in power over the digital supercomputers simulating them today. Going to configurable analog-digital systems, like FPAA, gets you “four orders-of-magnitude” (10,000 times) improvement, but the remaining four orders-of-magnitude will have to come from milestones along the neuromorphic systems roadmap.
Neuromorphic Roadmap Plots Analog Path

R. Colin Johnson
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In Hasler and Marr's roadmap they describe the specific computational milestones that have already been achieved -- such as the single-transistor synapse and the FPAA -- as well as the algorithms and computational models that have been proven out so far. The roadmap then proceeds to detail the areal density of artificial neurons and synapses that will be necessary to realize a low-power neuromorphic system whose size rivals that of a human brain.

FPAA developed at Georgia Tech by professor Jennifer Hasler as a power-efficient, mixed-signal SoC for neuromorphic computing.

(Source: Rob Felt courtesy of Georgia Tech)

Finally, the roadmap addresses the software tools that will be necessary to design these neuromorphic chips as well as the learning techniques, network topologies, novel interconnection devices -- such as memristors -- and how these components could...
be developed into usable chip arrays. For instance, memristors could serve for slow-scale modulatory parameters in neuromorphic systems.

Throughout, the roadmap emphasizes a modular approach, such as successfully emulating one layer of a human brain cortex before attempting multilayer devices, as well as the major engineering hurdles that need to be surmounted, such as using local-interconnection techniques to reduce the complexity of communications traffic among billions of neurons and trillions of synapses. The paper's overall conclusion is that "useful neural computation machines based on biological principles at the size of the human brain seems technically within our grasp."

Funding was provided, in part, by DARPA's SyNAPSE program.

— R. Colin Johnson, Advanced Technology Editor, EE Times

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