This is your grid on brains

2 October 2008

(PhysOrg.com) -- Managing power networks in the future may involve a little more brain power than it does today, if researchers at Missouri University of Science and Technology succeed in a new project that involves literally tapping brain cells grown on networks of electrodes.

The Missouri S&T group, working with researchers at Georgia Institute of Technology, plans to use the brain power to develop a new method for tracking and managing the constantly changing levels of power supply and demand.

Led by Dr. Ganesh Kumar Venayagamoorthy, associate professor of electrical and computer engineering, the researchers will use living neural networks composed of thousands of brain cells from laboratory rats to control simulated power grids in the lab. From those studies, the researchers hope to create a "biologically inspired" computer program to manage and control complex power grids in Mexico, Brazil, Nigeria and elsewhere.

"We want to develop a totally new architecture than what exists today," says Venayagamoorthy, who also directs the Real-Time Power and Intelligent Systems Laboratory at Missouri S&T. "Power systems control is very complex, and the brain is a very flexible, very adaptable network. The brain is really good at handling uncertainties."

Venayagamoorthy hopes to develop a system that is "inspired by the brain but not a replica. Nobody really understands completely how the brain works."

The research is funded through a $2 million grant from the National Science Foundation's Division of Emerging Frontiers in Research and Innovation.

The Missouri S&T team will work with researchers at Georgia Tech's Laboratory for Neuroengineering, where the living neural networks have been developed and are housed and studied. A high-bandwidth Internet2 connection will connect those brain cells over 600 miles to Venayagamoorthy's Real-Time Power and Intelligent Systems Laboratory. Missouri S&T researchers will transmit signals from that lab in Rolla, Mo., to the brain cells in the Atlanta lab, and will train those brain cells to recognize voltage signals and other information from Missouri S&T's real-time simulator.

Venayagamoorthy's lab is capable of simulating a power grid the size of Nigeria's, or a portion of the combined New England and New York grid in the United States.

Working with Venayagamoorthy on this project at Missouri S&T are Dr. Donald Wunsch, the Mary K. Finley Missouri Distinguished Professor of Computer Engineering, and Dr. Keith Corzine, associate professor of electrical and computer engineering. Georgia Tech researchers involved in the project are Dr. Steve Potter, associate professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University, and Dr. Ronald Harley, the Duke Power Co. Distinguished Professor in Georgia Tech's School of Computer and Electrical Engineering.

Traditional artificial neural networks (ANNs) have been around for years. Modeled after the brain, they are designed to recognize patterns and learn over time. But they don't work well with complex systems, Venayagamoorthy says.

"As electric power and energy systems get larger and larger, the dynamics become more complicated, and the neural networks have to be scaled up," he says. "But as they scale up, they break down. It becomes more difficult for neural networks to learn and change in real time.

"They can learn online, but the learning is slow and sometimes the decision-making is very short-sighted," he says. For instance, if a transmission line is taken out during a severe storm, traditional ANNs cannot react quickly enough to locate the problem and bring the system back online.

Through this research, Venayagamoorthy and his colleagues hope to develop what he calls BIANNs, or biologically inspired artificial neural networks. Based on the brain's adaptability, these networks could control not only power systems, but also other complex systems, such as traffic-control systems or global financial networks.

The Georgia Tech researchers, led by Potter, have developed living neural networks that can control simple robots, but this will be the first time anyone has attempted to tap the brain power to control more complex systems.

After testing the system in simulated environments, the researchers will then test them in actual power grids in Mexico, Brazil, China, Nigeria, Singapore and South Africa. One goal of the project is to develop a system that can be implemented in the "future intelligent power grid," says Venayagamoorthy. The researchers envision that grid integrating a variety of power sources, such as wind and solar farms, energy storage facilities, self-sustainable community or neighborhood micro-grids, and other non-traditional energy sources.

"Our studies are going to be based on what is predicted for the next 20 years," Venayagamoorthy says.

Provided by Missouri University of Science and Technology