Researchers merge game theory with wireless networks, create 'smarter' garments

April 28 2005

Using economic theory to improve wireless communications networks and designing garments that can sense their own shapes are among the goals of two National Science Foundation Faculty Early Career Development Program (CAREER) Award projects recently funded at Virginia Tech.

Allen MacKenzie and Tom Martin, assistant professors in Virginia Tech's Bradley Department of Electrical and Computer Engineering

(ECE), each have won five-year CAREER awards worth $400,000. These grants are the National Science Foundation's most prestigious awards for creative junior faculty who are considered likely to become academic leaders of the future.

Image: Hokie suit

Economic theory and wireless communications technology coalesce in MacKenzie's project. Wireless networks provide a wide range of services from Internet access to public safety monitoring. MacKenzie is among a number of engineering researchers working to advance wireless network technology, but his approach has a distinct twist -- he is investigating the use of game theory to create an analytical framework for wireless networks.

"Game theory is an analysis tool that has been widely used to explain complex economic systems," MacKenzie said. "Wireless networks are complex systems with dynamic interactions that make it difficult to analyze and predict system performance."

MacKenzie's research is aimed at developing a theory to explain how wireless network components, which operate with disparate and limited information, can cooperate more effectively to achieve network-common goals. Such a theory could lead to more efficient power control and interference avoidance for wireless networks, and also could provide analytical tools to other researchers who are working to create more powerful networks for a variety of applications.

As an undergraduate studying electrical and computer engineering at Vanderbilt University, where he earned his bachelor's in 1999, MacKenzie took some economics courses and became interested in game theory. When he began graduate studies at Cornell University, where he completed his Ph.D. in 2003, he knew he wanted to focus on

wireless communications and decided to try to use game theory in his wireless research.

"Applying game theory to wireless communications is more difficult than applying it to economics," MacKenzie said. By the time he joined the Virginia Tech faculty in fall 2003, he wasn't sure that game theory and wireless were a good mix. "But since coming here, I've found new avenues to continue this work."

In addition to having a research focus, all CAREER projects include an educational component. MacKenzie is developing educational modules on wireless communications for university courses. He also is planning outreach classes in the subject for the College of Engineering's summer camps for middle school and high school students.

Improving the design of electronic textiles (e-textiles) while giving a boost to Southside Virginia's textiles industry is the goal of Martin's CAREER project. This is a continuance of his work in designing e-textiles -- cloth interwoven with electronic components -- for use as wearable computers.

Martin and his colleagues in the Virginia Tech E-Textiles Lab are attempting to develop "smart" clothes that appear and feel normal but provide sensing and computing capabilities. Because the wires and sensors in e-textiles are woven into the fabric, wearable computers can be constructed as shirts, pants, hats, gloves or other clothing items to monitor an impressive range of factors -- from how fast and far a jogger is running to the blood pressure and heart rate of a cardiac patient.

Martin will use his CAREER grant to design e-textiles that can sense their own shapes, the wearer's motions, and the positions of the sensing elements.

"In working with e-textiles, we've found some problems associated with the placement and movement of sensors," Martin said. For example, some sensors work well only if they are placed a certain distance apart on a garment. If shirt sleeves or pants legs are rolled up or other changes occur while an e-textile garment is being worn, the network of sensors needs to be able to "sense" the reconfiguration in order to perform effectively.

In addition to investigating ways of improving e-textiles technology, Martin has been working with representatives from Dan River Inc., a textile manufacturer in Danville, Va. "If e-textiles can be manufactured using traditional techniques, it might help rejuvenate the textile industry in Southside Virginia," he said.

Martin is developing a prototype e-textiles fabric that Dan River Inc. will attempt to set up on looms. If this works, wiring will be woven into the fabric on the company's looms and then sensors will be attached after the garments are completed.

During the past few years, Martin and colleague Mark Jones, an associate professor of electrical and computer engineering, have secured a number of grants supporting their work in developing e-textiles for military, industrial, and medical uses. Martin and Jones also are collaborating with Thurmon Lockhart, assistant professor of industrial and systems engineering and director of the Locomotion Research Laboratory. The researchers are using e-textiles to study the human gait.

The ultimate goal of the e-textiles research at Virginia Tech is to create a complete design framework that will enable novel applications that are not possible with existing e-textiles technology.

For the educational component of his CAREER project, Martin plans to create a learning module for computer engineering classes that will use

deductive learning styles to help students improve their hardware and software debugging skills.

Martin came to Virginia Tech in 2001 after serving two years on the faculty of the University of Alabama in Huntsville. He received his bachelor's degree in electrical engineering from the University of Cincinnati. He earned his master's and Ph.D. in electrical and computer engineering from Carnegie Mellon University.

Source: Virginia Tech