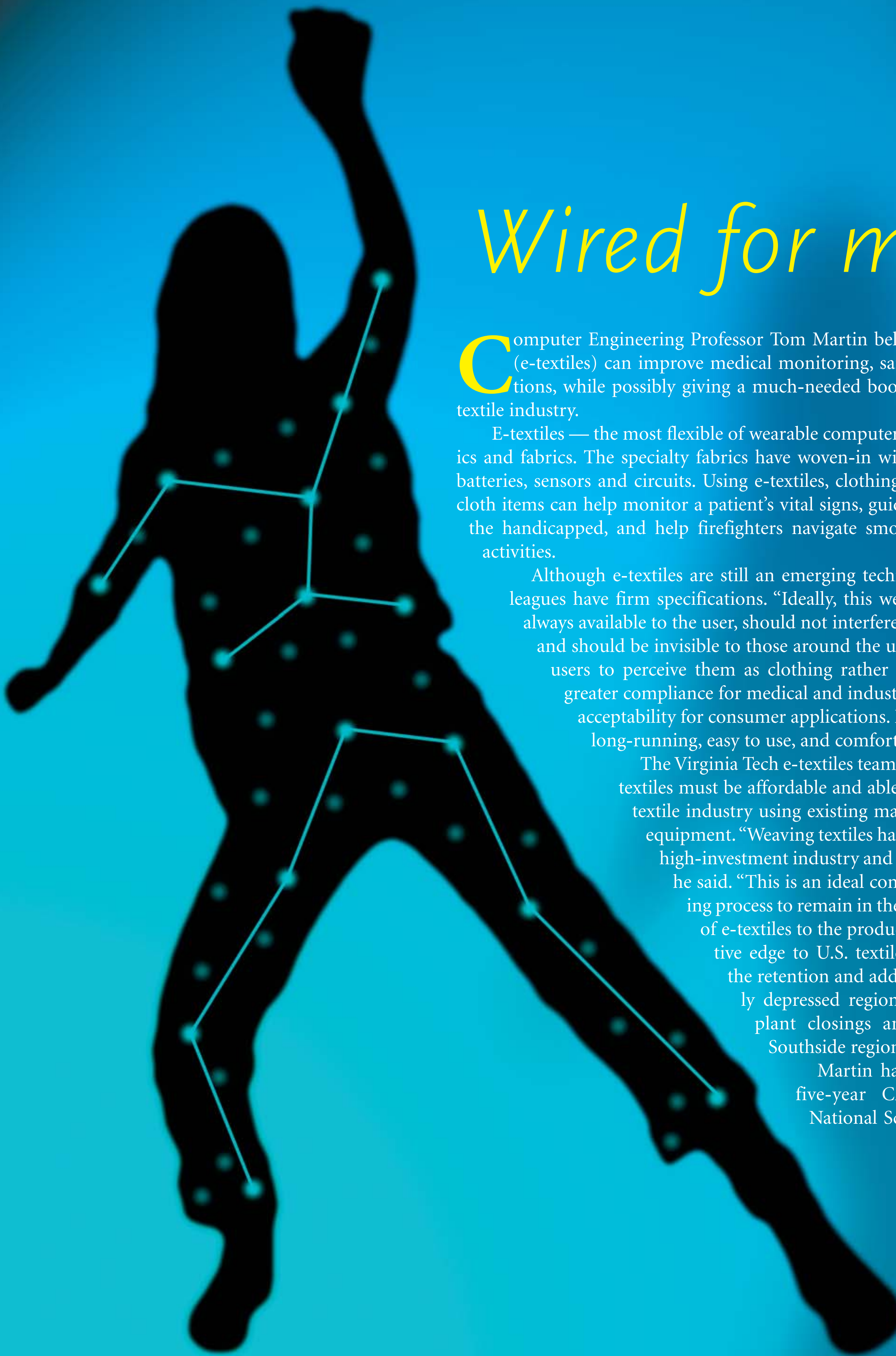

Wired for motion

Computer Engineering Professor Tom Martin believes that electronic textiles (e-textiles) can improve medical monitoring, safety, and consumer applications, while possibly giving a much-needed boost to the region's struggling textile industry.

E-textiles — the most flexible of wearable computers — are a blend of electronics and fabrics. The specialty fabrics have woven-in wiring and can accommodate batteries, sensors and circuits. Using e-textiles, clothing, draperies, tents and other cloth items can help monitor a patient's vital signs, guide or measure movement of the handicapped, and help firefighters navigate smoky buildings, among other activities.

Although e-textiles are still an emerging technology, Martin and his colleagues have firm specifications. "Ideally, this wearable computer should be always available to the user, should not interfere with the user's movements, and should be invisible to those around the user," he explained. "We want users to perceive them as clothing rather than computers, leading to greater compliance for medical and industrial applications and greater acceptability for consumer applications. E-textiles should be durable, long-running, easy to use, and comfortable," he added.

The Virginia Tech e-textiles team has two more conditions: e-textiles must be affordable and able to be processed by the U.S. textile industry using existing manufacturing techniques and equipment. "Weaving textiles has become a high-technology, high-investment industry and is no longer labor intensive," he said. "This is an ideal combination for a manufacturing process to remain in the United States. The addition of e-textiles to the product line could give a competitive edge to U.S. textile manufacturers, leading to the retention and addition of jobs in economically depressed regions that have suffered textile plant closings and cut-backs, such as the Southside region of Virginia."

Martin has recently won a $400,000, five-year CAREER award from the National Science Foundation (NSF) to pursue advances so that e-textile garments can function robustly in applications for people of all ages, plus meet his manufacturability and affordability goals.

The project builds on recent prototype successes from the E-Textiles Laboratory, co-directed by Martin and Mark Jones. Their team has developed a 30-foot fabric acoustic array to detect the location of vehicles, a glove to demonstrate typing without a keyboard, a garment for mapping a building using ultrasound, an acoustic beamformer shirt to localize sound, a software simulation system for designing electronic fabric, and a vest-and-pants outfit to monitor heart rate, and motion.

The CAREER project goals include improving the technology so that e-garments can be mass-produced instead of custom-designed. Martin's team is also developing the ability for e-garments to sense their own shapes as well as the positions and locations of their sensing and processing elements. "We want the garment to track the location of the electronics so that it can configure itself and adapt to changes in how the user is wearing the garment," Martin said. "When a user rolls up her sleeves, the electronics should adapt." He described how garments should not have to be skin tight to accomplish their tasks and that eventually, he hopes to solve the difficult problem of accounting for the draping and flowing clothes.

The first tasks include determining the types and placement of sensors that will be used for determining the shape of the garment, location of the elements, and activity of the wearer. Then, the team plans to create software services for the electronics to automatically identify their own location on the body and balance the power and computational loads. Martin hopes this will lead ultimately to the ability to produce e-textiles in bulk, with the electronic sensors and computation devices built in. The garments would then be constructed as though made of conventional fabric and the function programs installed like firmware.

Martin plans to implement the technology on two test-bed applications. The first is a prototype garment for indoor navigation that not only uses ultrasonic sensors, but also dead reckoning. The garment would sense the direction and distance traveled and compare it to a preinstalled map. The second prototype would be an automatic activity diary that could determine the activities of the wearer and monitor environmental conditions such as temperature. The diary garment would help with medical diagnoses as most patients are notoriously bad at self-reporting their activities, according to Martin.

E-textile garments should be easier to use and more versatile than similar mobile systems using wireless technology, Martin explained. E-textiles will use much less battery power than wireless systems. "Wireless transmission costs more energy," he commented. "The technology is at the point where a wireless sensor node can be the size of a thumb, but it requires a camcorder battery to power it for 20 minutes. With interconnections in the fabric, a 9-volt battery will power the system for hours." He cited the 30-foot-long beamformer fabric that runs for 20 hours nonstop on a 9 volt battery with no power management.

Martin also said that consumers may have concerns about being surrounded by wireless fields and that privacy is also an issue with wireless. "Eavesdropping and interference are a problem for wearable wireless devices. If I'm sitting next to you on a bus, I don't want you to be able to control my devices or to snoop on their communications. With e-textiles, all the communication is in the wires, so eavesdropping isn't an issue," he said.

E-textile researchers are not alone in their enthusiasm regarding the technology. A textile manufacturer in the region supported the CAREER proposal and offered to weave the e-textile fabric for the prototyopes in their mills without cost. "E-textiles could give domestic textile makers an opportunity to create a product with a high-tech advantage over imports," Martin said. "So as we develop e-textiles we are trying to stay as close as possible to existing manufacturing techniques in the textile and garment industries."

Every CAREER project has an educational component and Martin plans to go beyond research/education integration. He is developing instructional models to help students improve their debugging skills.

After participating in a faculty study group sponsored by Tech's Center for Excellence in Undergraduate Teaching that focused on student learning styles and theories of learning, Martin has concluded that poor debugging skills are the result of more than inexperience. "Debugging requires a different form of thinking than what students are used to exercising for most of their courses," Martin said.

Most courses present general principles, then derive particular facts, he explained. "Most of the time students use this deductive thinking and so they tend to be better at it than inductive thinking. Good debugging, however, is an inductive process." He described how the programmer observes a system's response, then abstracts from those observations to form a hypothesis about what is causing an error. Then the programmer devises a test for the hypothesis and observes whether the test supports the hypothesis. Students, on the other hand, tend to make a change to a program, see if the changes fixes the problem, and then make another change, without stopping to consider how the change should have affected the program or what makes sense to be changed next.

The modules will be available on the internet for instructors at all levels.