# Tufts researchers delve into the human brain with cutting-edge 'light imaging' technology

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**Posted: 10/18/07**

The ability to detect your levels of stress, boredom or frustration may soon no longer fall on the shoulders of your close friends, family or psychiatrist. According to a group of seven Tufts researchers from the computer science and biomedical engineering departments, computers have the potential to read brain activity in ways that can be applied, at the very least, to improvements in work efficiency.

Tufts' Human Computer Interaction (HCI) group received a $450,000 grant from the National Science Foundation earlier this month after releasing a study that shows the feasibility of a method for computers to interpret brain activity in real time, using a cutting-edge, non-invasive form of brain-imaging technology known as functional near infrared spectroscopy (fNIRs).

The fNIRs consist of a small headband that users can wear while performing other activities - a stark contrast to MRI and other conventional brain-scanning technology, which requires users to be stationary, lying down or encased in large pieces of equipment.

"The way that this technology works, there is no limitation that forces it to be used in the lab," said Erin Solovey, a graduate student in the Computer Science Department who has been working on fNIRs research for over a year.

"You could have this on and have it attached to a PDA in your pocket," Solovey said. "That's the ideal situation, but right now we're still doing basic research to see how this technology might be used."

The device relies on "light imaging," a technique that uses light from optical fibers to illuminate the brain. Since most brain tissue is relatively transparent to this light, the fNIRs can sense differing levels of blood oxygenation that mark changes associated with neural activity. Light imaging has been around since the 1930s, but has only recently been applied to the brain through fNIRs.

While researchers said they can imagine a variety of potential applications for fNIRs technology, their research thus far has focused on whether or not the device can be used to determine a person's workload while performing a certain task. HCI recently published a research paper titled, "Human-Computer Interaction and Brain Measurement Using Functional Near-Infrared Spectroscopy" in which they demonstrated how fNIRs headband can detect when a person is being under- or over-worked.

In their experiment, four test subjects were asked to wear an fNIRs while performing a simple task: The subjects were shown a rotating three-dimensional image of a cube with different colored squares on each of its faces, "similar to a Rubik's cube," according to Solovey. The cube rotated to show each side once, and subjects had to count and keep track of how many of each color they saw.

The experiment measured their brain activity as they repeated the task on separate cubes with two colors, three colors and four colors. They found that, with relatively high accuracy, the fNIRs data could predict how many colors the test subject had been working with.

"Basically what happened was that, when it was only two colors, it was an easy task," Solovey said. "When it was three colors, it was harder, and when it was four it was impossible, and people just gave up."

Solovey said this particular application of the technology could, someday, have implications for high-stress workers such as air traffic controllers.

"Maybe it picks up your workload level, and it says, 'This person is being overworked,'" she said. "Since this is a high-stress job ... the computer could transfer some of the workload to another controller. So we can have adaptive systems that adapt to the workload of the person."

The study has received attention from national press outlets and a variety of technology blogs for its potential for "building a computer to read your mind," as an MSNBC headline declared. But according to Solovey, the implications of the study are not so clear. She said the research is more about determining how fNIRs may potentially be used than using them for a specific purpose.

"This is really just an initial feasibility study, and now we have a lot more experiments we're working on to see how it can apply," she said, adding that the NSF grant will help by allowing the researchers to buy more fNIRs devices and perform multiple studies simultaneously.

"There are very few people who use fNIRs right now, and it's mainly in research labs, but people agree it has a lot of potential, because it's low-cost and portable," she said. "For the first time, we may be able to get all of that stuff that's hard to measure in someone's brain, and hopefully we can do something helpful with it."

Professor of Biomedical Engineering Sergio Fantini, who is jointly heading the research with Professor of Computer Science Robert Jacob, said the device itself has potential for any number of applications.

"Effectively, using this technology, we can pinpoint what part of the brain is in charge of what movement," he said. "If you raised your left arm, we could find neuron activity responsible for that action at a particular place on the brain."

Both Fantini and Leanne Miller, a graduate student working on the project, said the fNIRs' greatest potential for real-world application comes from its size and portability when compared with other brain-scanning devices.

"When using MRI devices, the subject must be in a confined space with limited movement," Miller said. "This makes it very difficult to measure users' brain activity in real world settings. The fNIRs device is safe, portable, non-invasive and can be worn by users in more realistic, real-world environments."

But in these early stages of research, the device is not without its share of problems, according to Fantini.

"One thing we are always trying to improve is the design of the helmet with optical fibers," he said. "We try to make sure the fibers get through hair that could block out some of the infrared light."

Solovey said the researchers are also working to improve the accuracy of the device in assessing brain activity and its meaning. In the cube study, she said, their results were not perfect.

"Obviously, it wasn't 100 percent accurate all of the time," she said. "We're actually working on ways to improve the accuracy. It's still a difficult problem in terms of the algorithms we need to develop."

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