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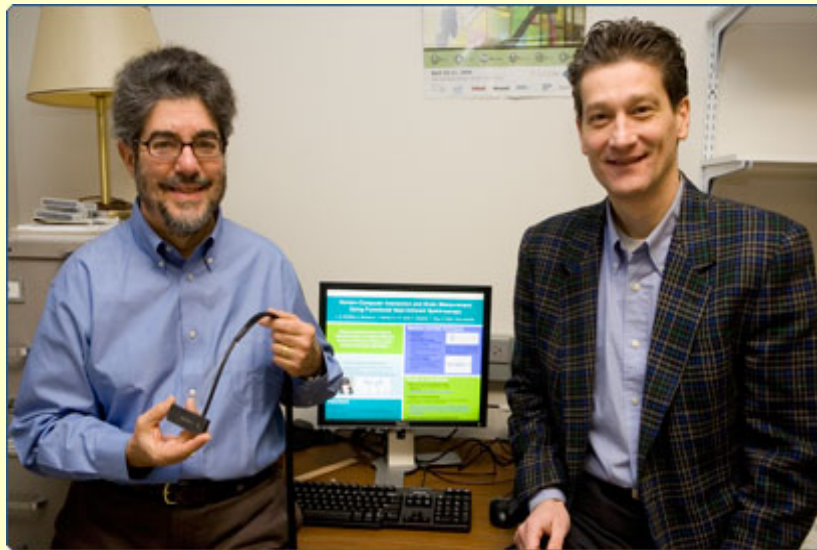
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Mind-reading Computers

It may sound like sci-fi, but one day a computer may sense when you're stressed and tell you to take a break

By **Marjorie Howard**

Imagine this scene at Logan's air control tower on a late Friday afternoon: it's the peak travel time at the busy airport, but one air traffic controller is managing to stifle some yawns. No one notices her—everyone else is too busy. Now imagine this: that same controller is wearing a special headband that allows a computer to register the blood flow in her brain, which signals that she is fatigued. The computer automatically reassigns her flights to other controllers who are more rested—and the skies are once again friendly and safe.



Robert Jacob and Sergio Fantini (from left), professors in the School of Engineering, are developing technology that one day might be able to detect whether a person is tired, under stress or even disoriented. Jacob is holding a prototype of the device that would measure brain activity.

PHOTO: ALONSO NICHOLS

Sergio Fantini and Robert Jacob, both professors in the School of Engineering, are developing just this kind of technology, which one day might be able to detect whether a person is tired, under stress or even disoriented. Using light to measure blood flow in the brain, the technology measures how much oxygen various areas of the brain receive, a marker for how much activity there is in those regions.

The two began collaborating when Jacob, a computer scientist, learned that Fantini, a biomedical engineer, was measuring brain information optically. Jacob hadn't thought that using optics—which studies the behavior and properties of light—could illuminate neurological states.

But it does. "When you walk under the sun," says Fantini, "believe it or not, there is light reaching your brain. You would not think that's the case, but the skull does not block light."

Light, he explains, not only goes through the skull and interacts with the brain, but it goes back outside "so you can illuminate the head and then collect a signal at a short distance of about three centimeters, or 1.2 inches. The signal provides information associated with blood, its amount, its concentration, its oxygenation."

Fantini uses what's known as functional near-infrared spectroscopy, or fNIRS

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(pronounced eff-nears). It is similar to magnetic resonance imaging (MRI), which requires patients to be completely motionless in a noisy environment at a dedicated facility, but is portable and lightweight. Fantini has been using fNIRS to detect breast tumors and to investigate the optical response of peripheral nerves to electrical stimulation.

Jacob, for his part, studies how humans interact with computers. "We're trying to find better ways for people and computers to communicate," he says. "We study user interfaces and find ways to improve them. In the back of my head, I've always thought brain-computer interaction would be wonderful, but knew nothing about it. This seemed like a good way to do it."

Fantini and Jacob are still in the early stages of their research, but have already demonstrated that the concept can work. They used a headband with near-infrared sensors—the fNIRS detectors—and eight laser diodes, which send light through the forehead to interact with the brain's frontal lobe. The light waves are absorbed by the active, blood-filled areas of the brain, and the remaining light is reflected to the fNIRS detectors.



Graduate student Audrey Girouard models the optical device and head strap that Fantini and Jacob are developing to measure blood flow in the brain. PHOTO: ALONSO NICHOLS

In a study, subjects wearing the headband were presented different patterns on Rubik's cubes. They were given nine seconds to identify how many squares of color were present on the sides of each cube. The results showed that as the number of colors increased, so did brain activity measured by the fNIRS.

Fantini and Jacob were both pleased and a little surprised at the attention their work received when they won a \$445,000 grant from the National Science Foundation in October to

pursue their studies. "We were on every obscure website you can imagine—and a few real ones," says Jacob. "You could Google 'Tufts and brain,' and the whole first page was us."

But, they are quick to point out, they haven't perfected the technology. "It's quite early," says Fantini. "We've got one experiment, and it seemed to work. We're not ready to install this on everybody's PC. That's a long way off."

"We also don't know how specific we can be about identifying users' different emotional states," he adds. "However, the particular area of the brain where the blood-flow change occurs should provide indications of the brain's metabolic changes and by extension, workload, which could be a proxy for emotions like frustration."

One of the benefits of the project is interdisciplinary collaboration. Leanne Hirshfield, Erin Solovey and Audrey Girouard, all graduate students in the computer science department, are involved in the project, as are Angelo Sassaroli, an assistant research professor, and Yunjie Tong, a graduate student, both from the department of biomedical engineering.

"It's a three-year grant, and we won't be done in three years," says Jacob. "It's an ambitious project, and if we get some initial scientific questions answered, we'll be happy."

So, besides air traffic controllers, who else might be helped?

"The next step is bond traders," says Jacob. "Imagine putting on these geeky headbands and beating the other guy."

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