Research team developing new noninvasive brain-mapping technology

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Two Japanese scientists will arrive at the University of Houston next month to help develop a unique brain-mapping device that promises to deliver more comprehensive and accurate insights into the mind at a fraction of the cost of current technologies.

In April, Mikio Kubota of Seijo University and Mayako Inouchi of Waseda University will join the research team at UH's Biomedical Imaging Lab. There they will work as visiting faculty members with lab director George Zouridakis in expanding a noninvasive technology that may offer a more thorough understanding of brain activities and help diagnose traumatic brain injuries in emergency rooms and on the battlefield.

"We are excited to arrive to Houston, which is a place with the largest medical center in the world and home to so many universities and research labs. It provides a unique opportunity for collaboration," said Kubota.

The device the team has in the works fits on a patient's head, Zouridakis explained, and its configuration of fiber optics and special electrodes sends light, via laser diodes, into the brain. The light, which becomes scattered as it travels through the layers of the brain tissue, is then reflected back out of the brain and is measured by a set of sensors. It is the reflected light's unique properties that indicate what's going on in the brain, he said.

"The typical approach currently used for brain mapping is functional magnetic resonance imaging, or fMRI," said Zouridakis, associate professor at UH's College of Technology. "However, an fMRI scanner is expensive, on the order of millions of dollars, and confined in one place, as it requires a shielded room because of the strong magnetic fields. It also requires specialized personnel to maintain and operate."

Zouridakis said his team aims to eliminate such obstacles.

"Our technology marries high-density electroencephalography, or EEG, which measures the electrophysiological activity of the brain, with near-infrared spectroscopy, or NIRS, which provides information about cerebral blood flow," Zouridakis said. "Like the EEG, NIRS is portable, costs only about $200,000, does not need a special room or personnel to maintain, and can quantify both direct and indirect measures of brain activity."

Combining the merits of EEG and NIRS, Zouridakis explained, will allow the team to study both electrical and metabolic activities at the same time and improve patient benefits.

"Typically, two separate tests are done on a patient at two different times - probably on different days - one to get the metabolic aspects and another to capture the electrophysiological aspects of brain activation," Zouridakis said. "However, the brain is dynamic, and, thus, the two recordings do not represent the same brain activity. What we propose is to get both aspects simultaneously so that the information obtained is truly complementary."

Dr. Luca Pollonini, who joined Zouridakis' team in September as a research associate, said he hopes one day the combination of the EEG and NIRS will more accurately diagnose brain damage in hospitals and on the battlefield.

"What I envision is a very portable device that, by combining two or more techniques, can be used, for example, for rapid assessment of traumatic brain injury," said Pollonini, who collaborates with Nirox, an Italian company established in 2005 to commercialize NIRS technologies. "If I rush into the ER because my kid fell off his bike, and I want to be sure he is fine, the only way now to assess brain injury is to run a CT scan, which delivers radiation to the body, or a MRI scan, for which you have to be immobile. With pain and emotional distress emerging after a traumatic episode, it is hard for everybody to stay still during these examinations," Pollonini said.

Research projects that Kubota and Inouchi have under way in Tokyo focus on visual and language processing.

"Our projects can reveal what is happening in the brain when we process language, and these findings could be applied, for instance, to developing a new language-teaching methodology or to clinical settings, such as bipolar disorder in psychiatric patients," Kubota said.

While the EEG and NIRS have existed for a number of years individually, Zouridakis said, using them together requires special headgear to house the disparate sensors. Creating such a device has been the team's mission for years.

In 2002, Zouridakis was instrumental in developing the first truly portable EEG equipped with 256 data-recording sensors, or electrodes. Built by BioSemi in The Netherlands, it employs active electrodes, which are loaded with microchips, to eliminate environmental noise. The group will harness that capability in the next prototype, too.

"Typical electrodes are simple metallic disks. When placed on the scalp, they record brain activity but also noise signals from the environment, because they act as antennas," he said. "Since the electrical activity of the brain is very small, one needs to minimize the noise."

The lab already is equipped with one of the most sensitive NIRS scanners available, paid for with a grant from the National Science Foundation. Pollonini has contributed a portable NIRS device that was designed by Nirox, and Kubota is working with Japanese company Shimadzu to facilitate the installation of up to two others.

Pollonini said having multiple NIRS machines with varying resolution allows the team to refine its data and to perform multiple experiments in lab and clinical settings.

William Fitzgibbon, dean of the UH College of Technology, praised the team's collaborative efforts.

"The college is very excited about the translational research of Dr. Zouridakis in computational biomedicine and biomedical imaging," he said. "His effort in noninvasive brain imaging brings together multinational effort, which includes researchers from Spain, Japan and UH, as well as Japanese and Italian firms. His facility, when augmented by a team of two Japanese scientists who will be visiting, will be state of the art by all standards."

Zouridakis, a former faculty member at the University of Texas Medical School who has worked with neurophysiological procedures in the operating room, said "understanding the interplay between surface-recorded signals and information processing in the brain is the holy grail of neuroscience."

"All the methodologies I work with are noninvasive - that is, there are no holes to drill, no electrodes to implant in the brain of a patient," he said. "My hope is to one day see the current invasive and expensive gold-standard procedures used in clinical neurophysiology for brain mapping replaced by completely noninvasive ones. This will improve the quality of life of patients and, at the same time, reduce the cost of health care delivery."

Source: University of Houston

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