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Lighting Ballasts That Direct Patients

An innovative navigation system uses optical signals from hospital lights to guide patients with traumatic brain injuries around hospitals.

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Researchers are developing a high-resolution tracking system that uses PDAs and audio directions to guide patients around hospital wards. The system also helps rehabilitate those with traumatic brain injuries. The system, which is made by Boston startup Talking Lights (http://www.talking-lights.com/index.htm) , uses light fixtures as beacons to send information to a PDA via an optical receiver. The PDA is also loaded with mapping software, information about the building, and user-specific data such as appointment schedules.

Traumatic brain injuries, which might result from car accidents or the detonation of an improvised explosive device, among other possible causes, can lead to cognitive problems that include trouble with abstract thinking, memory, and spatial orientation. The Talking Lights guidance system is "a tremendous asset for someone with traumatic brain injury," says Heechin Chae (http://spauldingrehab.org/staffprofile.printversion.uid=113) , medical director of the brain injury center at Spaulding Rehabilitation Hospital, in Boston. The system has been tested at the hospital over the past two years and is currently used by about 20 patients. It not only helps patients navigate the rehab center, but it also appears to help them relearn how to process visual cues and navigate unfamiliar environments, Chae says.

Installing the indoor guidance system in a building is a simple and fairly cheap process, says Neil Lupton, president of Talking Lights. The light fixtures don't need to be replaced. All that needs to be switched out is the ballast, an electrical component that's normally replaced every few years in all fluorescent lights. The ballast regulates the amount of electricity that goes into the bulb to maintain the light level and keep the bulb from exploding.

Steven Leeb (http://lees-web.mit.edu/lees/leeb-s.htm) , a professor of electrical engineering and computer science at MIT, designed a ballast that modulates the light coming out of the bulb in a set pattern to give each bulb a unique optical signature. No flickering is visible to the naked eye, but off-the-shelf optical receivers can detect these patterns.

Patients at Spaulding Hospital who are participating in the project wear a vest with an optical receiver sewn on the shoulder. The receiver is connected to a PDA that is stored in the vest's pocket. A database containing maps for the building is stored on the device, outlining all the lights and their signatures. Software on the PDA rapidly computes the user's position based on which light she's nearest to. Then, based on the particular patient's location and a unique preloaded schedule, the PDA plays recorded directions. A typical sequence, read in a firm voice, goes, "Katie, go to the gym. Go through the double doors." If the user goes through the wrong double doors, the device provides a correction: "You are going in the wrong direction. Pass the photocopier. Turn to your

right." Information about what's near each light at each particular location can be put into a global database in about a day's time, says Daniel Taub, an engineer with Talking Lights.

The system can be customized to particular users. Depending on their stage of recovery, some brain-trauma patients might need more or less frequent instructions, or they might need to start out with a reminder to put on a helmet or check their shoelaces. Family members can make the audio recordings so that patients can hear a trusted voice, and the recordings can be in any language. User data is recorded during use and analyzed afterward to assess each patient's progress--how many reminders he needed, how much time it took him to reach his destination--and the system is adjusted accordingly.

"The brain is a dynamic organ," says Chae. "The whole basis of rehab is repetition of voice commands and tasks." He believes that the system helps patients learn to adapt to unfamiliar places, and so ultimately, it could benefit the patient outside the hospital, too, by retraining his or her brain.

Leeb and Lupton say that their system processes users' locations more quickly and accurately than do other systems that rely on GPS, radio frequencies, or Wi-Fi triangulation. GPS doesn't work well in buildings, and it only has a resolution of about 30 feet, so it isn't ideal for guiding patients around a hospital. Systems that calculate location based on the local strength of Wi-Fi signals from transmitters in multiple locations require more time-consuming calculations than the lightbulb system does, and this could slow people down and drain the PDA's battery. Conversely, the resolution of Leeb and Lupton's system is limited only by the spacing of the light fixtures. (Signals from the Talking Lights system don't interfere with hospital equipment, much of which is shielded.)

The company is currently developing a system that connects to a robust Wi-Fi mesh network to deliver information about patients' locations to hospital staff. Nurses monitoring people with dementia in an assisted-living facility, for example, could be quickly alerted when a patient wanders into an area that poses a fall risk. Talking Lights will demonstrate this monitoring capability in an Alzheimer's facility in a few months, says Leeb. The company has also installed a system for the blind in Stanford University's department of psychology.

In the coming years, Talking Lights plans to develop software that can run on smart phones and hardware for a Bluetooth headset with an optical receiver. The headset would pick up the optical signals, send them to the phone, and then play back directions to the wearer.
