Footsteps to preventing falls

April 5 2018, by Alexandra George

One of four elderly persons falls every year in the United States. With more than 37 million hospitalizations every year, roughly one million falls occur in hospitals and can lead to serious injury and even death. Patients often fall while trying to get out of bed or when they walk for longer than they are able. Nurses can't constantly monitor individual patients because of the number of patients they attend to. Sensors can continuously monitor patients, but many only detect the fall as it happens without leaving enough time for a nurse to intervene.

Carnegie Mellon University civil and environmental engineering Professor Hae Young Noh is developing sensors that predict when a person is about to fall by sensing the vibrations from a person's movement. Using signal processing and machine learning, her sensors detect the movement of a person and characterize what those movements mean: if they will exit the bed, if they will take another step, and if they will fall.

Unlike other sensors that monitor patient movement or vital signs, Noh's sensors identify the intent of a person's movements—whether they are preparing to exit the bed or just rolling over and sitting up. These sensors, placed on the bed frame, will then alert the nurse when it predicts that a patient may be getting up, so the nurse can get to the patient in time.

Just like a pebble creates waves when dropped into water, our movement and contact with objects also create waves that a sensor can detect. The sensors contain accelerometers that detect wave signals that propagate

through the bedframe. They utilize signal processing methods and machine learning techniques to classify the vibration, determining whether the patient has an intent to exit or not.

Highly accurate and highly sensitive, the sensors are also placed on the floor to detect when a person's gait, or manner of walking, is deteriorating.

"Some people can only walk about 10 steps," said Noh. "And they used to be healthy, so they are going to try to take the 11th step. Because it's over their limit, the risk for a fall increases, and it shows in the gait deterioration pattern before it actually happens. We're trying to detect that pattern."

The sensors can locate each footstep with less than 0.34 meter of error, about the size of a foot, which allows them to detect walking speed, stride length, and step frequency—factors related to predicting fall risk. The system can also estimate individual footstep forces and left-right balance of footstep forces within 5% error of body weight. The sensors can even use the vibrational signals to detect mood, because behavioral patterns suggest how people feel.

The team will soon deploy the sensors in hospitals for testing. In the future, the sensors can be used for various applications, such as animal sensing and studying gait deterioration in different populations including children and those who have genetic diseases that affect their muscle function and walking ability. Ph.D. students Mostafa Mirshekari, Jonathon Fagert, and Shijia Pan, as well as electrical and computer engineering Professor Pei Zhang also collaborate on the hospital bed sensors project.

"Patients may be too shy and don't want to worry others," says Noh, "But information about their symptoms is sometimes critical. So, if a sensor

can pick them up and notify the caregivers, families, or doctors, it could help with prevention and treatment."

Provided by Carnegie Mellon University, Department of Civil and Environmental Engineering

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