Revolutionary technology enables objects to know how they are being touched (w/ Video)

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A doorknob that knows whether to lock or unlock based on how it is grasped, a smartphone that silences itself if the user holds a finger to her lips and a chair that adjusts room lighting based on recognizing if a user is reclining or leaning forward are among the many possible applications of Touché, a new sensing technique developed by a team at Disney Research, Pittsburgh, and Carnegie Mellon University.

Touché is a form of capacitive touch sensing, the same principle underlying the types of touchscreens used in most smartphones. But instead of sensing electrical signals at a single frequency, like the typical touchscreen, Touché monitors capacitive signals across a broad range of frequencies.

This Swept Frequency Capacitive Sensing (SFCS) makes it possible to not only detect a "touch event," but to recognize complex configurations of the hand or body that is doing the touching. An object thus could sense how it is being touched, or might sense the body configuration of the person doing the touching.

SFCS is robust and can enhance everyday objects by using just a single sensing electrode. Sometimes, as in the case of a doorknob or other conductive objects, the object itself can serve as a sensor and no modifications are required. Even the human body or a body of water can be a sensor.

"Signal frequency sweeps have been used for decades in wireless

communication, but as far as we know, nobody previously has attempted to apply this technique to touch interaction," said Ivan Poupyrev, senior research scientist at Disney Research, Pittsburgh. "Yet, in our laboratory experiments, we were able to enhance a broad variety of objects with high-fidelity touch sensitivity. When combined with gesture recognition techniques, Touché demonstrated recognition rates approaching 100 percent. That suggests it could immediately be used to create new and exciting ways for people to interact with objects and the world at large."

In addition to Poupyrev, the research team included Chris Harrison, a Ph.D. student in Carnegie Mellon's Human-Computer Interaction Institute, and Munehiko Sato, a Disney intern and a Ph.D. student in engineering at the University of Tokyo. The researchers will present their findings May 7 at CHI 2012, the Conference on Human Factors in Computing Systems, in Austin, Texas, where it has been recognized with a prestigious Best Paper Award.

Both Touché and smartphone touchscreens are based on the phenomenon known as capacitive coupling. In a capacitive touchscreen, the surface is coated with a transparent conductor that carries an electrical signal. That signal is altered when a person's finger touches it, providing an alternative path for the electrical charge. By monitoring the change in the signal, the device can determine if a touch occurs.

By monitoring a range of signal frequencies, however, Touché can derive much more information. Different body tissues have different capacitive properties, so monitoring a range of frequencies can detect a number of different paths that the electrical charge takes through the body.

Making sense of all of that SFCS information, however, requires analyzing hundreds of data points. As microprocessors have become steadily faster and less expensive, it now is feasible to use SFCS in touch

interfaces, the researchers said.

"Devices keep getting smaller and increasingly are embedded throughout the environment, which has made it necessary for us to find ways to control or interact with them, and that is where Touché could really shine," Harrison said.

Sato said Touché could make computer interfaces as invisible to users as the embedded computers themselves. "This might enable us to one day do away with keyboards, mice and perhaps even conventional touchscreens for many applications," he said.

Among the proof-of-concept applications the researchers have investigated is a smart doorknob. Depending on whether the knob was grasped, touched with one finger or two, or pinched, a door could be programmed to lock or unlock itself, admit a guest, or even leave a reply message, such as "I'll be back in five minutes."

In another proof-of-concept experiment, they showed that SFCS could enhance a traditional touchscreen by sensing not just the fingertip, but the configuration of the rest of the hand. They created the equivalent of a mouse "right click," zoom in/out and copy/paste functions depending on whether the user pinched the phone's screen and back with one finger or two, or used a thumb.

The researchers also were able to monitor body gestures, such as touching fingers, grasping hands and covering ears by having subjects wear electrodes similar to wristwatches on both arms. Such gestures could be used to control a smartphone or other device.

They also showed that a single electrode attached to any water vessel could detect a number of gestures, such as fingertip submerged, hand submerged and hand on bottom. Sensing touch in liquids might be

particularly suited to toys, games and food appliances.

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