

Smartwatches can now track your finger in mid-air using sonar

March 15 2016, by Jennifer Langston



FingerIO, a new sonar technology developed by UW computer scientists and electrical engineers, allows you to interact with mobile devices and tiny smartwatch screens by writing or gesturing on any nearby surface -- a tabletop, piece of paper or even in mid-air. Credit: Dennis Wise, University of Washington

As mobile and wearable devices such as smartwatches grow smaller, it gets tougher for people to interact with screens the size of a matchbook.

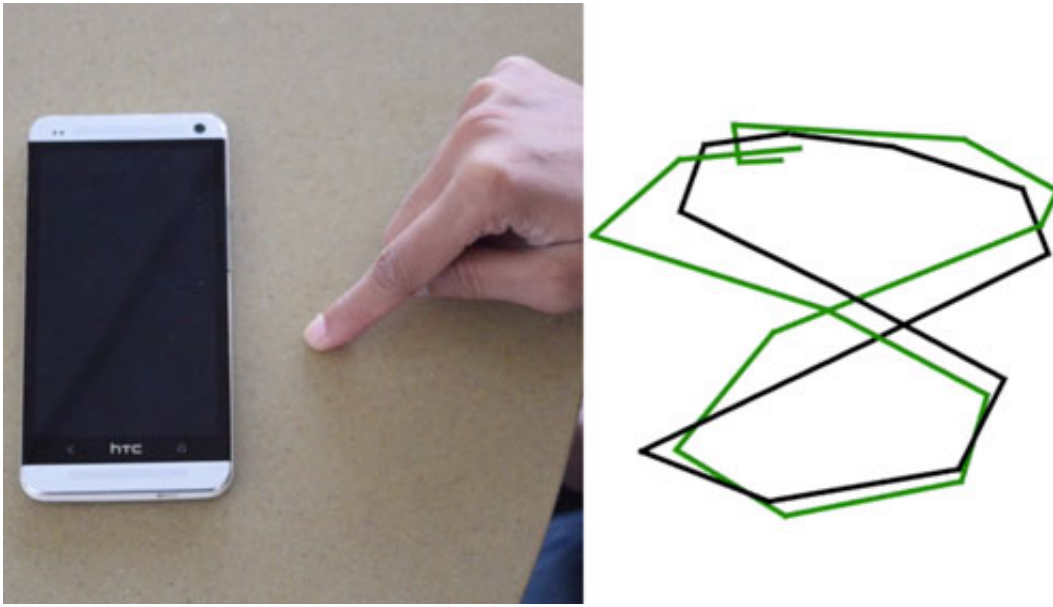
That could change with a new sonar technology developed by University of Washington computer scientists and electrical engineers that allows you to interact with [mobile devices](#) by writing or gesturing on any nearby surface—a tabletop, a sheet of paper or even in mid-air.

[FingerIO](#) tracks fine-grained finger movements by turning a smartphone or smartwatch into an active sonar system using the [device](#)'s own microphones and speakers.

Because sound waves travel through fabric and do not require a line of sight, users can even interact with a phone inside a front pocket or a smartwatch hidden under a sweater sleeve.

In a paper to be presented in May at the Association for Computing Machinery's [CHI 2016 conference](#) in San Jose, California, the UW team demonstrates that FingerIO can accurately track two-dimensional finger movements to within 8mm, which is sufficiently accurate to interact with today's mobile devices. The work was recognized with an honorable mention award by the conference.

"You can't type very easily onto a smartwatch display, so we wanted to transform a desk or any area around a device into an input surface," said lead author Rajalakshmi Nandakumar, a UW doctoral student in computer science and engineering. "I don't need to instrument my fingers with any other sensors—I just use my finger to write something on a desk or any other surface and the device can track it with high resolution."



In user testing with off-the-shelf smartphones, the finger location computed by FingerIO (in green) was accurate to within 8mm of the actual motion recorded on a separate touchscreen (shown in black). Credit: University of Washington

Using FingerIO, one could use the flick of a finger to turn up the volume, press a button, or scroll through menus on a smartphone without touching it, or even write a search command or text in the air rather than typing on a tiny screen.

FingerIO turns a smartwatch or smartphone into a sonar system using the device's own speaker to emit an inaudible sound wave. That signal bounces off the finger, and those "echoes" are recorded by the device's microphones and used to calculate the finger's location in space.

Using sound waves to track finger motion offers several advantages over cameras—which don't work without line-of-sight when the device is hidden by fabric or another obstructions—and other technologies like radar that require both custom sensor hardware and greater computing power, said senior author and UW assistant professor of computer

science and engineering Shyam Gollakota.

"Acoustic signals are great—because [sound waves](#) travel much slower than the radio waves used in radar, you don't need as much processing bandwidth so everything is simpler," said Gollakota, who directs the UW's Networks and Mobile Systems Lab. "And from a cost perspective, almost every device has a speaker and microphones so you can achieve this without any special hardware."

But sonar echoes are weak and typically not accurate enough to track finger motion at a high resolution. Errors of a few centimeters make it impossible to differentiate between writing individual letters or subtle hand gestures.

The UW researchers employed a type of signal typically used in wireless communication—called Orthogonal Frequency Division Multiplexing—and demonstrated that it can be used to achieve high-resolution finger tracking using sound. Their algorithms leverage the properties of OFDM signals to track phase changes in the echoes and correct for any errors in the finger location to achieve sub-centimeter finger tracking.

To test their approach, the researchers created a FingerIO prototype app for Android devices and downloaded it to an off-the-shelf Samsung Galaxy S4 smartphone and a smartwatch customized with two microphones, which are needed to track [finger motion](#) in two dimensions. Today's smartwatches typically only have one, which can be used to track a finger in one dimension.

The researchers asked testers to draw shapes such as stars, squiggles or figure 8s on a touchpad next to a smartphone or smartwatch running FingerIO. Then they compared the touchpad tracings to the shapes created by FingerIO's tracking.

The average difference between the drawings and the FingerIO tracings was 0.8 centimeters for the smartphone and 1.2 centimeters for the smartwatch.

"Given that your finger is already a centimeter thick, that's sufficient to accurately interact with the devices," said co-author and electrical engineering graduate student Vikram Iyer.

Next steps for the research team include demonstrating how FingerIO can be used to track multiple fingers moving at the same time, and extending its tracking abilities into three dimensions by adding additional microphones to the devices.

Provided by University of Washington

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