Low-power Wi-Fi signal tracks movement—even behind walls

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Credit: Cristine Daniloff/MIT

The comic-book hero Superman uses his X-ray vision to spot bad guys lurking behind walls and other objects. Now we could all have X-ray vision, thanks to researchers at MIT's Computer Science and Artificial

Intelligence Laboratory.

Researchers have long attempted to build a device capable of seeing people through walls. However, previous efforts to develop such a system have involved the use of expensive and bulky radar technology that uses a part of the electromagnetic spectrum only available to the military.

Now a system being developed by Dina Katabi, a professor in MIT's Department of Electrical Engineering and Computer Science, and her graduate student Fadel Adib, could give all of us the ability to spot people in different rooms using low-cost Wi-Fi technology. "We wanted to create a device that is low-power, portable and simple enough for anyone to use, to give people the ability to see through walls and closed doors," Katabi says.

The system, called "Wi-Vi," is based on a concept similar to radar and sonar imaging. But in contrast to radar and sonar, it transmits a low-power Wi-Fi signal and uses its reflections to track moving humans. It can do so even if the humans are in closed rooms or hiding behind a wall.

As a Wi-Fi signal is transmitted at a wall, a portion of the signal penetrates through it, reflecting off any humans on the other side. However, only a tiny fraction of the signal makes it through to the other room, with the rest being reflected by the wall, or by other objects. "So we had to come up with a technology that could cancel out all these other reflections, and keep only those from the moving human body," Katabi says.

Motion detector

To do this, the system uses two transmit antennas and a single receiver.

The two antennas transmit almost identical signals, except that the signal from the second receiver is the inverse of the first. As a result, the two signals interfere with each other in such a way as to cancel each other out. Since any static objects that the signals hit—including the wall—create identical reflections, they too are cancelled out by this nulling effect.

In this way, only those reflections that change between the two signals, such as those from a moving object, arrive back at the receiver, Adib says. "So, if the person moves behind the wall, all reflections from static objects are cancelled out, and the only thing registered by the device is the moving human."

Once the system has cancelled out all of the reflections from static objects, it can then concentrate on tracking the person as he or she moves around the room. Most previous attempts to track moving targets through walls have done so using an array of spaced antennas, which each capture the signal reflected off a person moving through the environment. But this would be too expensive and bulky for use in a handheld device.

So instead Wi-Vi uses just one receiver. As the person moves through the room, his or her distance from the receiver changes, meaning the time it takes for the reflected signal to make its way back to the receiver changes too. The system then uses this information to calculate where the person is at any one time.

Possible uses in disaster recovery, personal safety, gaming

Wi-Vi, being presented at the Sigcomm conference in Hong Kong in August, could be used to help search-and-rescue teams to find survivors

trapped in rubble after an earthquake, say, or to allow police officers to identify the number and movement of criminals within a building to avoid walking into an ambush.

It could also be used as a personal safety device, Katabi says: "If you are walking at night and you have the feeling that someone is following you, then you could use it to check if there is someone behind the fence or behind a corner."

The device can also detect gestures or movements by a person standing behind a wall, such as a wave of the arm, Katabi says. This would allow it to be used as a gesture-based interface for controlling lighting or appliances within the home, such as turning off the lights in another room with a wave of the arm.

Unlike today's interactive gaming devices, where users must stay in front of the console and its camera at all times, users could still interact with the system while in another room, for example. This could open up the possibility of more complex and interesting games, Katabi says.

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