New "tricorder" technology might be able to "hear" tumors growing

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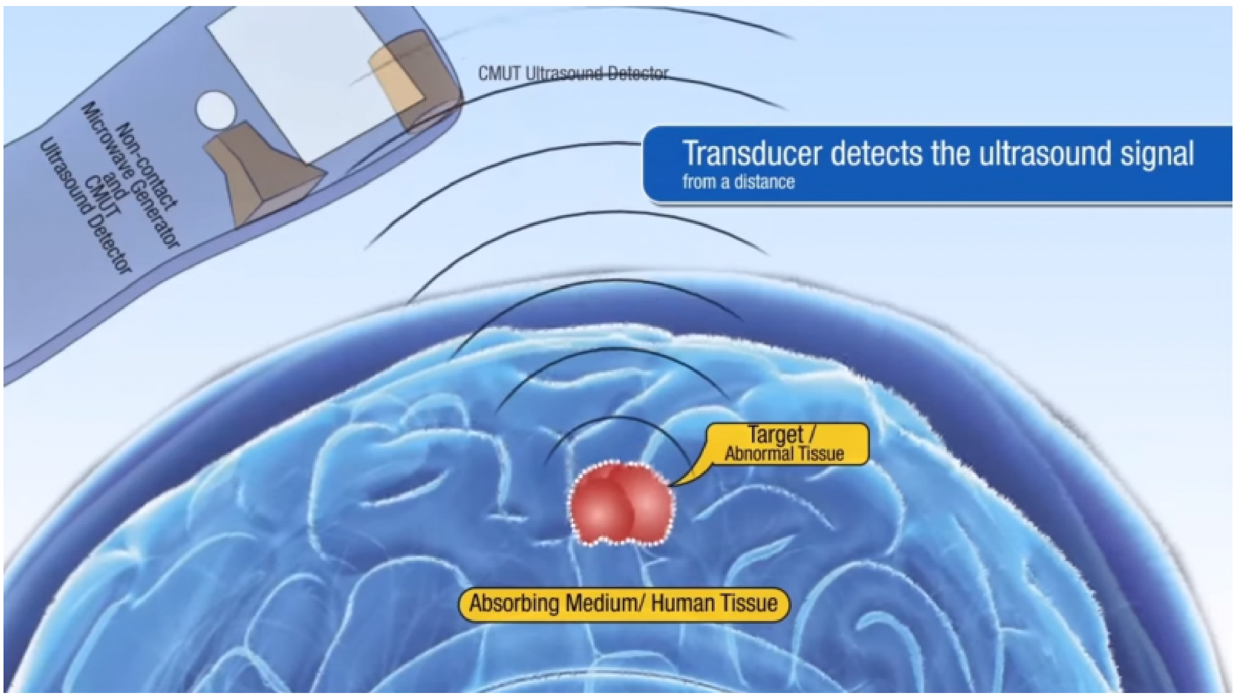

When Dr. Leonard "Bones" McCoy needs to diagnose an ill member of the Starship Enterprise, he simply points his tricorder device at their body and it identifies their malady without probing or prodding. Similarly, when Capt. Kirk beams down to an alien world, his tricorder quickly analyzes if the atmosphere is safe to breathe.

Now Stanford electrical engineers have taken the latest step toward developing such a device through experiments detailed in *Applied Physics Letters* and presented at the International Ultrasonics Symposium in Taipei, Taiwan.

The work, led by Assistant Professor Amin Arbabian and Research Professor Pierre Khuri-Yakub, grows out of research designed to detect buried plastic explosives, but the researchers said the technology could also provide a new way to detect early stage cancers.

The careful manipulation of two scientific principles drives both the military and medical applications of the Stanford work.

First, all materials expand and contract when stimulated with electromagnetic energy, such as light or microwaves. Second, this expansion and contraction produces ultrasound waves that travel to the surface and can be detected remotely.

The basic principle of this interaction was first revealed in 1880 when Alexander Graham Bell was experimenting with wireless transmission of sound via light beams. Bell used light to make sound emanate from a receiver made of carbon black, which replicated a musical tone.

The Stanford engineers built on the principles demonstrated in Bell's experiment to develop a device to "hear" hidden objects.

Proof of principle

The new work was spurred by a challenge posed by the Defense Advanced Research Projects Agency (DARPA), best known for sponsoring the studies that led to the Internet. DARPA sought to develop a system to detect plastic explosives buried underground – improvised explosive devices (IEDs) – that are currently invisible to metal detectors.

The task included one important caveat: The detection device could not touch the surface in question, so as not to trigger an explosion.

All materials expand and contract when heated, but not at identical rates. Ground, especially muddy ground soaked with water, absorbs more heat than plastic.

In a potential battlefield application, the microwaves would heat the suspect area, causing the muddy ground to expand and thus squeeze the plastic. Pulsing the microwaves would generate a series of ultrasound pressure waves that could be detected and interpreted to disclose the presence of buried plastic explosives.

Sound waves propagate differently in solids than air, with a drastic transmission loss occurring when sound jumps from the solid to air. That's why, for instance, ultrasound images of babies in utero must be taken through direct contact with the skin.

The Stanford team accommodated for this loss by building capacitive micromachined ultrasonic transducers, or CMUTs, that can specifically discern the weaker ultrasound signals that jumped from the solid, through the air, to the detector.

"What makes the tricorder the Holy Grail of detection devices is that the instrument never touches the subject," Arbabian said. "All the measurements are made though the air, and that's where we've made the biggest strides."

Solving the technical challenges of detecting ultrasound after it left the ground gave the Stanford researchers the experience to take aim at their ultimate goal – using the device in medical applications without touching the skin.

Touchless ultrasound

Arbabian's team then used brief microwave pulses to heat a flesh-like material that had been implanted with a sample "target." Holding the device from about a foot away, the material was heated by a mere thousandth of a degree, well within safety limits.

Yet even that slight heating caused the material to expand and contract – which, in turn, created ultrasound waves that the Stanford team was able to detect to disclose the location of the target, all without touching the "flesh," just like the Star Trek tricorder.

"We've been working on this for a little over two years," Khuri-Yakub said. "We're still at an early stage but we're confident that in five to ten to fifteen years, this will become practical and widely available."

Prior medical research has shown that tumors grow additional blood vessels to nourish their cancerous growth. Blood vessels absorb heat differently than surrounding tissue, so tumors should show up as ultrasound hotspots.

"We think we could develop instrumentation sufficiently sensitive to disclose the presence of tumors, and perhaps other health anomalies, much earlier than current detection systems, non-intrusively and with a handheld portable device," Arbabian said.

Moreover, the researchers believe that their microwave and ultrasound detection system will be more portable and less expensive than other medical imaging devices such as MRI or CT, and safer than X-rays.

More information: Hao Nan et al. Non-contact thermoacoustic detection of embedded targets using airborne-capacitive micromachined ultrasonic transducers, *Applied Physics Letters* (2015). DOI:

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