Unobtrusive Air-Coupled Ultrasound Tomography (ACUT) System

Very high frequency sound waves—beyond the range of human hearing—are used everyday in a variety of natural (bat echolocation) and manmade systems (fetal imaging, autofocus cameras). We have been developing ultrasound computer-aided tomography (CAT) scanners for rapidly and non-invasively detecting cracks, corrosion and other flaws in aging aircraft structures. That technology, along with our sophisticated reconstruction and processing algorithms, can be adapted to augment existing metal detectors and similar screening devices in airports, government buildings, etc.

Medical CAT scanners use x-rays to image inside the human body. Although effective, x-rays carry some risk because of the ionizing nature of the radiation. While that risk is balanced by the medical benefit of improved disease detection and diagnosis, x-rays cannot be used to screen large populations as they enter an airport terminal or a government building. Ultrasound, on the other hand, carries no such risks. Indeed, it is so safe that we use it to check the health and growth of unborn babies. There is no sensation associated with ultrasound: you don't feel or hear anything.

The cartoon at the right shows a large number of ultrasound transducers (the circles) built into a door frame. Each emits, in turn, a burst of ultrasound that is picked up by each of the other transducers. In simple terms, each transducer acts both like a speaker and a microphone, except that neither humans nor dogs can hear anything because the frequencies used are too high. Because of powerful computers, millions of these criss-cross pings can be sorted out essentially instantaneously and a cross-section of the object passing through the doorway can be reconstructed. A series of cross sections are then rendered as a 3D image of the immediate exterior (and even the relevant interior) of the body. Contraband secreted about the body (whether a gun or a duck) is then identified by sophisticated artificial intelligence (AI) software.

Tomographic reconstructions are straightforward to interpret, and are often amenable to automatic computer analysis and interpretation. When screening large moving populations it is necessary to have the computers automatically "flag" anything suspicious. Slowing pedestrian traffic to the pace with which human observers can scrutinize images is usually unacceptable. When imaging through garments it is also necessary to preserve modesty, something that is not a concern if only the computer "looks" at the image without displaying it for humans.

Ultrasound has an inherent advantage over magnetic and radar-based imaging techniques which are only sensitive to hidden metallic items. Ultrasound can just as easily detect hard plastic items hidden about the body. Indeed, ultrasound is just as sensitive to unfilled gaps as it is to discrete hard objects. Every material—solid, liquid or gas—affects ultrasound in a distinct way. Although that physics is extremely complex, our expertise lies in precisely the esoteric science and technology necessary to harness the complexity and sort it out in computers that are used to automatically process the scan results and identify the suspicious items in real time.

A rapid, high-intensity development program which builds on our many decades of combined experience and expertise, can result in a commercializable product that fills the now obvious need for better screening devices that can be widely deployed in airports, public buildings and elsewhere.