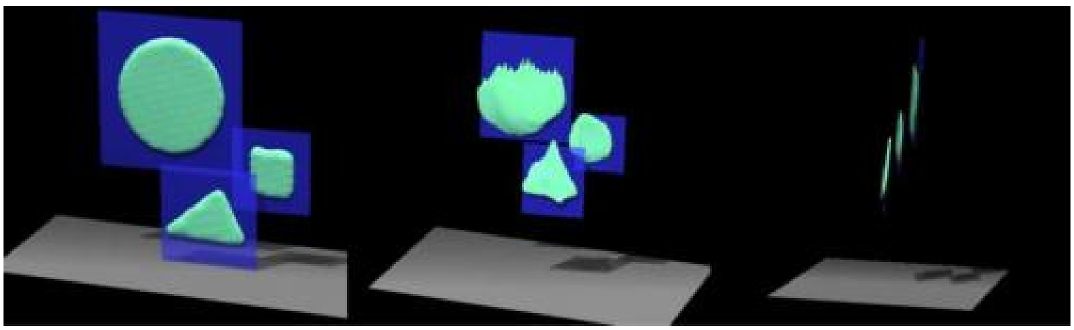
Seeing through walls: Laser system reconstructs objects hidden from sight

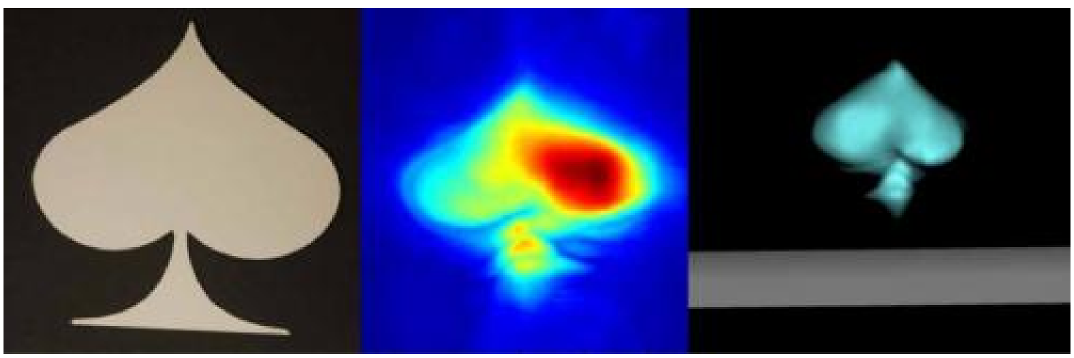
August 6 2012



Three objects -- a disk, triangle, and square - were used to test the acuity of the imaging technique. The left image reveals the objects as they would appear if directly sampled. The middle image is reconstructed for collected photons and shows a distorted disk and a rounded square. The triangle was rendered most clearly. The image on the right shows the objects as they would be seen from the side. Little spatial information is evident from this perspective. Credit: *Optics Express*

Inspired by the erratic behavior of photons zooming around and bouncing off objects and walls inside a room, researchers from the Massachusetts Institute of Technology (MIT), Harvard University, the University of Wisconsin, and Rice University combined these bouncing photons with advanced optics to enable them to "see" what's hidden around the corner. This technique, described in a paper published today in the Optical Society's (OSA) open-access journal *Optics Express*, may one day prove invaluable in disaster recovery situations, as well as in noninvasive biomedical imaging applications.

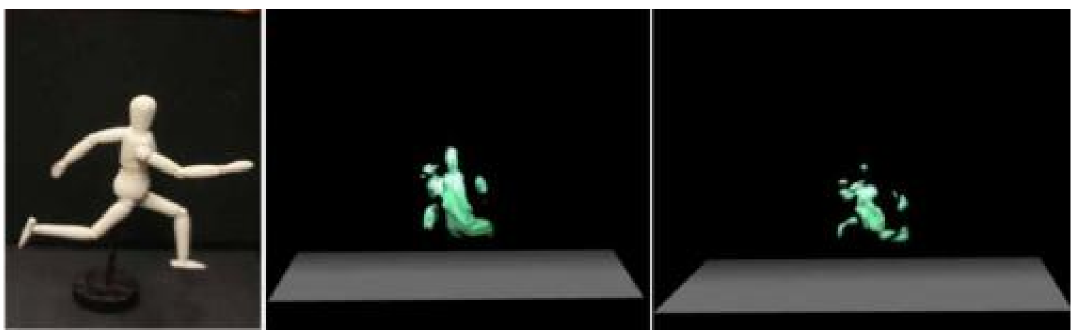
"Imagine photons as particles bouncing right off the walls and down a corridor and around a corner—the ones that hit an object are reflected back. When this happens, we can use the data about the time they take to move around and bounce back to get information about geometry," explains Otkrist Gupta, an MIT graduate student and lead author of today's Optics Express paper.



A 3D version of a spade (left) is first rendered in 2D from the thermal infrared energy emitted by the object. The different colors represent areas of higher and lower temperature as measured by the sensor. The image on right is the optically reconstructed object. The gray ground plane was added to provide context. Credit: *Optics Express*

Using advanced optics in the form of an ultrafast laser and a 2-D streak camera, both of which operate on the order of trillions of cycles per second, the team exploited being able to capture billions of images per second to demonstrate the technology's ability to "see" objects by analyzing the light moving around a corner or through water bottle.

Streak cameras differ from other cameras in that the image it forms is determined by the time profile of the incoming photons. "This type of imaging provides us with a very good idea of how long each of the photons takes to bounce and come back. If there's something around the corner, the photons come back sooner and arrive earlier in time" says Gupta. "We're actually capturing and counting photons. Each image we shoot has three or fewer photons in it. And we take lots of images very quickly to create 'streak' images, which help us determine the distance traveled by the photons in centimeters. Once we collect that data, we can infer the basic geometry of the hidden object(s) and a 3-D picture emerges."



A small wooden figure of a running man hidden from view is revealed by using two different imaging techniques. In the first, back projection is used to tease out the image from reflected photons of light. In the second, another technique known as sparse reconstruction brings the hidden object into view. Credit: *Optics Express*

There are many potential applications for this technology. Among the more simple and obvious are disaster recovery situations. "Say you have a house collapsing and need to know if anyone is inside, our technology would be useful. It's ideal for use in nearly any disaster-type situation, especially fires, in which you need to find out what's going on inside and around corners—but don't want to risk sending someone inside because of dangerous or hazardous conditions. You could use this technology to greatly reduce risking rescue workers' lives," Gupta points out.

It's also quite possible that the technology could be used as a form of noninvasive biomedical imaging to "see" what's going on beneath a patient's skin. That's what the researchers plan to investigate now.

Gupta expects that it will likely be at least another five to 10 years before the technology becomes commercially available—based on the typical timeframe research and development (R&D) demonstrations take to reach a product launch.

More information: "Reconstruction of Hidden 3D Shapes Using Diffuse Reflections, Gupta et al., *Optics Express*, Vol. 20, Issue 17, pp. 19096-19108. www.opticsinfobase.org/oe/abst … m?uri=oe-20-17-19096

Provided by Optical Society of America