Researchers analyze performance of first updatable holographic 3D display

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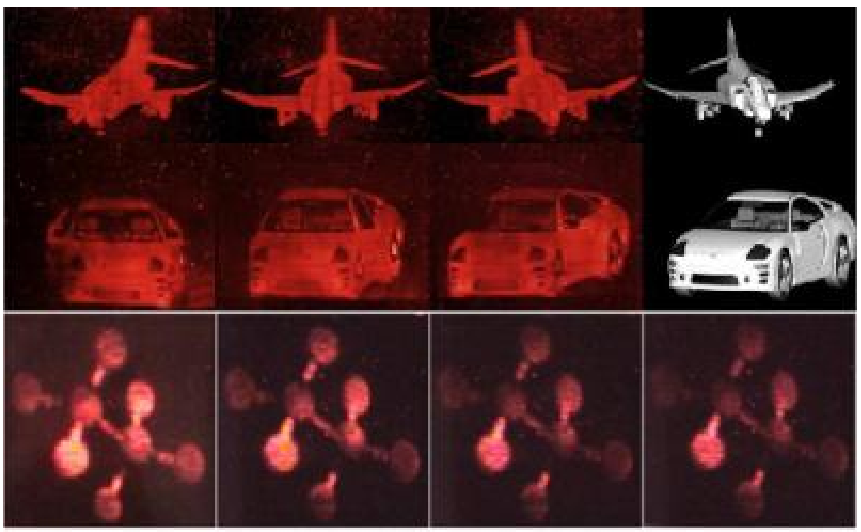

These digital camera images show holograms created with the photorefractive polymer in an updatable holographic 3D display. Image credit: Christenson, et al. ©2010 IEEE.

(PhysOrg.com) -- In 2008, researchers from the University of Arizona created a holographic 3D display that could write and erase images, making it the first updatable (or rewritable) holographic 3D display ever demonstrated. The key to the display was a photorefractive polymer material, which enabled the researchers to take advantage of the potential of holography to a greater extent than previously allowed. Now, in a follow-up study, the researchers have reported the results of their analysis on the performance of the display, including how the polymer enables display enhancements and what more needs to be done before such displays can be widely used.

As the researchers explain, there is a big jump between developing static holograms, such as those that appear on credit cards and drivers' licenses, and updatable holograms. A variety of materials can be used to make full-color, large-size static holograms, but none of these materials are updatable. As the researchers' previous study showed, photorefractive polymers have the potential to offer colorful images and large sizes in an updatable display. The display they demonstrated was, at 4 in. x 4 in., the largest yet created. It could display new images every 3 minutes, and images could be viewed for several hours without the need for refreshing. With these features, the display could serve as the basis for future displays that could offer a variety of glasses-free 3D applications in medical, industrial, military, and entertainment imaging.

"Photorefractive polymers are primarily beneficial because the method for achieving an index of refraction change is reversible and can be very fast, which is necessary for a real-world display," coauthor Cory Christenson from the University of Arizona told *PhysOrg.com*. "Some materials currently used to make holograms are permanent and take hours to write. Additionally, the material permits making displays with large sizes (at least 4 in. x 4 in.), and in principle is scalable. Also, a single display device is stable for many months to a year or more before a noticeable drop in performance is observed. Photorefractive polymers are also attractive because modifying them with different polymers is relatively easy. If we want to test the effects of a different or new polymer to see if it helps increase speed or efficiency, it is not a significant challenge to make that composite."

Holograms, like photographs, are recordings of reflected light. Here, the researchers created a hologram based on a 3D model of an object on a computer, and no real physical object was required. They then generated 2D perspectives of the object on the computer, which were processed and combined to create about 120 holographic pixels, or "hogels." To create a single hogel, the researchers modulated a laser beam with that hogel, focused the beam on a thin vertical line, and made the beam interfere with a second, unmodulated laser beam. The entire hologram could be written by repeating this process with all 120 hogels and positioning them next to each other. After all hogels were written, the researchers could illuminate the sample with a simple LED to make the 3D hologram viewable. The sensation of 3D is created due to parallax: each eye is seeing a different perspective of the object.

Ideally, a polymer material should have a combination of a fast write-erase rate (required for video applications) and a high efficiency (required for bright images). Getting a high efficiency means adding traps for the charges generated, but traps also take time and slow down the write-erase rate, resulting in a tradeoff between these two features. In their study, the researchers tested two slightly different copolymers, each of which exceeded in one of the two areas.

"In looking at both the standard display material composition and one that was slightly different, we were able to study the effects of adding more sensitizer and traps (in the form of C_{60}) to the material," Christenson said. "The greatest significance of this is a more in-depth understanding of the physics that leads to the formation of the hologram. This understanding gives us a better idea of its potential for use in new applications and will guide future studies as we attempt to improve the material."

The researchers determined that improvements could be made by mechanisms such as pulsed writing and reflection geometry, with the ultimate goal of creating realistic 3D holographic applications.

“The primary area for improvement is the sensitivity of the material,” Christenson said. “The media for permanent holograms is more sensitive to light than these photorefractive polymers, which permit better looking holograms. We are trying to find ways of decreasing the light needed to write a hologram, which will make it much easier to expand into the areas mentioned in the paper, such as white-light viewing and writing at video rates.”

More information: -- Cory W. Christenson, et al. “Materials for an Updatable Holographic 3D Display.” Journal of Display Technology. To be published. Doi: 10.1109/JDT.2010.2046620
-- Savaş Tay, et al. “An updatable holographic three-dimensional display.” Nature 451, 694-698. Doi:10.1038/nature06596

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