Holographic 3D display

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August 2017

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Holographic stereograms (HS) are among the most impressive 3D images in term of parallax and depth rendering. They have the ability to display saturated colors, reproduce occlusion, and approximate the wavefront so some level of accommodation is required. No special glasses are required to view HS, and there exists stunning examples of this technique being used advantageously for medical, architectural, and military applications.

HS is a class of integral imaging where the angular information is stored as holographic pixels (or hogel). Contrary to regular pixels which emit the same color and intensity in every directions, hogels diffract the light in a structured cone where each angles can have a different intensity and/or color. This angular disparity provides different images to each viewer eyes such as the brain can reconstruct the 3D information. Thanks to the large angular density the holographic recording can support, HS provide a smooth transition between different points of view, which is not the case for others integral imaging techniques, such as glass free 3D TV, that presents abrupt jumps.

In 2008, our group introduced the use of a photorefractive polymer to make the HS updatable instead of static.[1] Photorefractive polymers are holographic recording materials where the hologram can be erased and refreshed at will. The technique was subsequently improved to increase the refreshing speed from minutes to seconds, to display full color, and to have the capacity to take live 3D images such as for telepresence.[2]

The use of HS for refreshable 3D display has several advantages over "regular" holography, as well as computer generated holograms (CGH). To be able to record the wavefront of interest, a regular holographic setup requires the actual object to be present on the optical table. In the case of a refreshable display, that has the hologram erased and replaced shortly after recording, one can question the usefulness of the holographic image when the genuine object is directly accessible to the viewer.

Computer generated holographic display is probably the ultimate 3D display. So far, this is the only technique that has been proven capable to reproduce all the visual cues. However, this capacity comes at a very high computational cost. So high that even today, there is no system capable of handling the feed for a large, high resolution, video rate CGH display. Existing solutions, although impressive accomplishments, either scale down size or resolution, or rely on sub aperture holograms and eye tracking.

Our holographic 3D display has the benefits of both very light computational requirement, and is able to render 3D images from any sources. This means that either real or computer generated model can be displayed. Even data cube coming from instruments such as radar, or medical instrument can be used.

With this system, we demonstrated a telepresence application by filming a person in one room and sending the hologram data over the Internet to be printed in another location. There the audience can see that person in 3D.

The current performances we have demonstrated are: 12×12 inches size, full color based on RGB, 2 second recording time for 4×4″, 30 seconds for 12×12″, full parallax, 45° angle of view, no material degradation over 2 years.

We are continuing our development effort by improving the material performances, and the speed at which the image can be refreshed.

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1 S. Tay, P.-A. Blanche, R. Voorakaranam, et al., "An updatable holographic three-dimensional display.," Nature 451, 694–8 (2008).

2 P.-A. Blanche, A. Bablumian, R. Voorakaranam, et al., "Holographic three-dimensional telepresence using large-area photorefractive polymer.," Nature 468, 80–3 (2010).

Figure 1: Color holograms recorded with our refreshable 3D display.

Figure 2: Large photorefractive screen for 3D display

Figure 3: 3D Telepresence.