

# Computer-Generated Holographic Stereograms

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**Abstract:** We examine one type of holographic stereogram and its implementation on two widely different media. The first medium is photoresist for a conventional computer-generated hologram. The second medium is photo-refractive polymer for re-writable holograms.

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## 1. The image-plane hologram

The image-plane CGH records the wavefield at the object or image plane in the propagation path. A strictly image-plane CGH is of course two-dimensional. The interesting variation should be called a near-image-plane CGH. The object may be two-dimensional and slightly removed from the image plane, or it may be three-dimensional but with its entire extent located near, or embedded in, the image plane. The output of the propagation is the wavefield just after exiting the object. It is this wavefield that is encoded into the CGH. The CGH itself looks like a coherently defocused picture. When illuminated, the diffraction pattern separates into viewing ports. The proper port is then selected for viewing. This selection is commonly done by correctly locating the pupil of the eye in preparation for viewing. Any one of many types of CGH [1, 2] types can be used to record wavefront. There are two main ways of calculating the wavefront that the CGH should encode: lumped-model beam propagation method, and holographic stereogram. We focus here on the holographic stereogram.

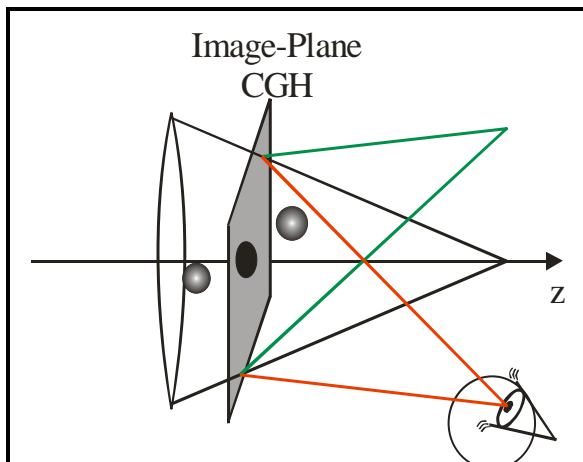


Figure 1: Reconstructing an Image-Plane CGH

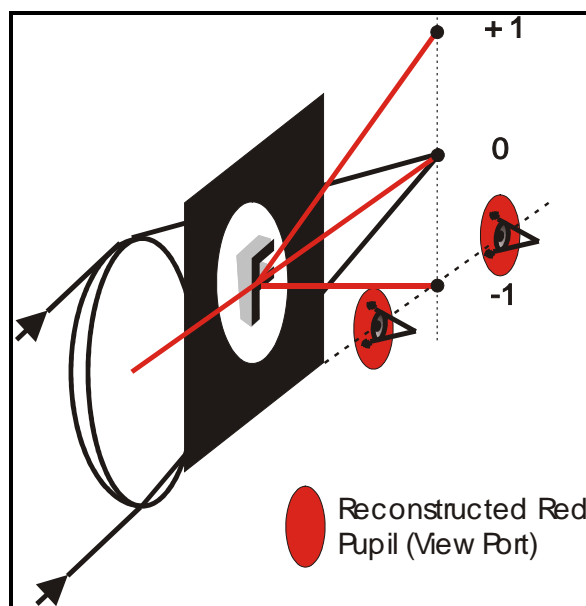


Figure 2: Holographic Stereogram

## 2. Holographic stereogram

The holographic stereogram [3] can actually record multiple perspectives; it is not restricted to the two that the term “stereo” would suggest. The basic setup is shown in Figs 1&2. You might consider the image-plane CGH to be reconstructing the viewing portals. Fig 3a shows one image from a set of twenty-three spine perspectives that were extracted from a pediatric computer tomogram (CT). Fig 3b is the corresponding viewing portal. We have used this data set to record two very different hologram realizations. The first is a static CGH written on photoresist using the

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Maskless Lithography Tool (MLT) located here at the University of Arizona. The second is a re-writable hologram composed on a photo-polymer-based device developed at the University of Arizona.



Fig 3a: Perspective view



Fig 3b: Viewing Portal

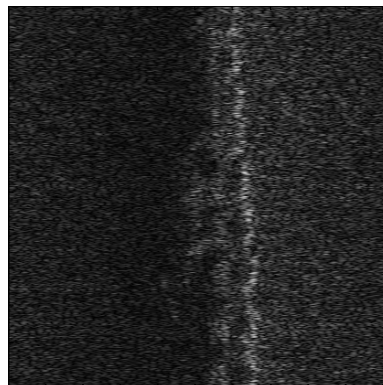


Fig 3c: Simulated reconstruction

### 3. The maskless lithography tool (MLT)

We have fabricated a holographic stereogram using the CT image set from the mentioned in the as a binary phase CGH. We used the MLT [3] shown in Fig 4.

<ul style="list-style-type: none"> <li>● 20 mm Scan Line Length</li> <li>● 2.5 micron laser spot size (<math>\lambda=365\text{nm}</math>)</li> <li>● 2.1 <math>\mu\text{m}</math> pixel size</li> <li>● 2 Watt multi line CW Argon Ion Laser</li> <li>● 30% transmission efficiency</li> <li>● A/O modulation</li> <li>● 24 Mpixel/sec data rate</li> <li>● 10-bit Grayscale Modulation</li> <li>● 3000 RPM, 12-facet Polygon Mirror on air bearing spindle</li> <li>● Achromatic optical system from 350-380 nm</li> <li>● Telecentric image plane</li> </ul>	
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Figure 4: Specifications and Picture of the Maskless Lithography Tool

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In Fig 5 we have a 3-D reconstruction from a binary phase CGH fabricated on the MLT. The CGH is not a holographic stereogram but rather a parallel-plane lumped-element model. The method is to model the 3-D object as consisting of discrete planes separated by free space. The planes are assigned transmittance and radiance components. An incident wave is multiplied by the complex-amplitude transmittance of the plane and then complex-amplitude is added according to the radiance. The resulting wave propagates through free space to the next plane where the transmittance and radiance-related operations are repeated.

### 3. The photorefractive polymer display

The method used by the updatable holographic 3-D display [4, 5] is fundamentally the holographic stereogram described above, though the technical realization is much more complicated. Fig 6 shows a Graytone computer projection and color photographs of several actual perspective-view of reconstructed images from the updatable holographic display.



Figure 5: 3-D CGH Reconstruction

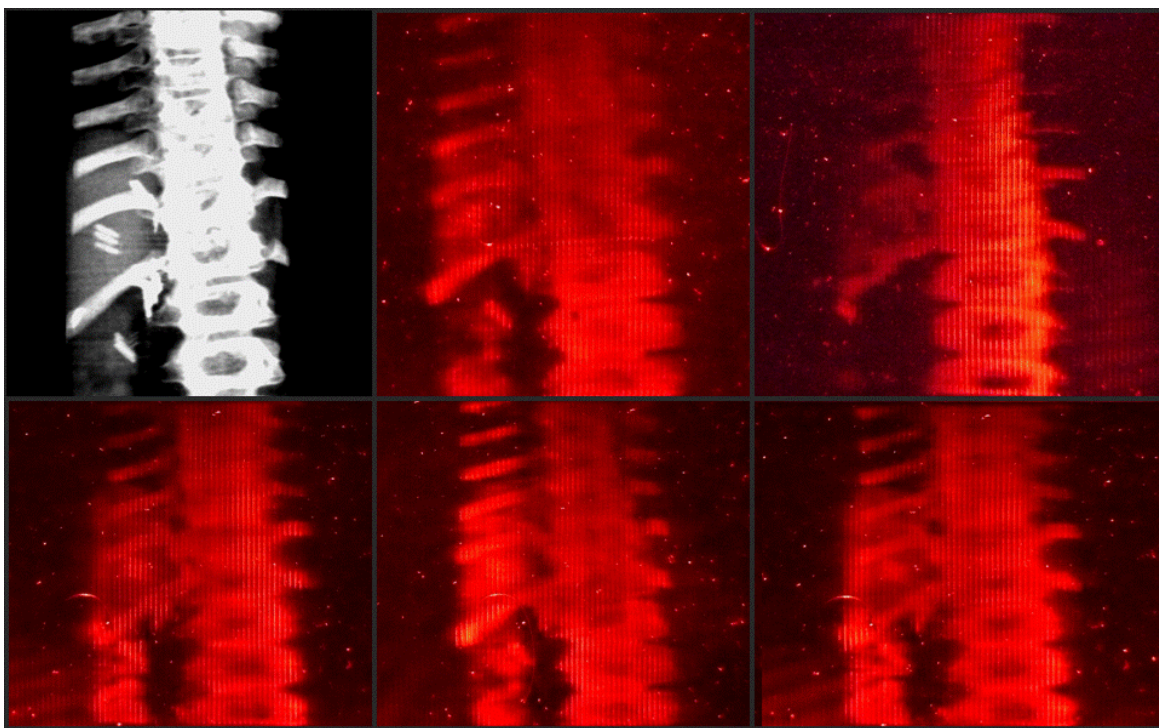


Figure 6: Actual reconstructed perspective view from the photo-polymer device

### 4. References

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