International Workshop on Holography and related technologies 2011 (IWH2011), Utsunomiya, A1, pp.1-2 (2011.11.16, Invited).

Computer holography: 3D imaging of virtual and real objects

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1. Introduction

The technology of computer-generated holograms (CGH) for display purposes is sometimes called the final 3D technology, because reconstructed 3D images give viewers almost all depth cues. However, the technique of CGH could not create fine 3D images equal with that by classical holography for a long time. This is due to the gigantic display resolution required for reconstructing fine 3D images accompanied with a large viewing-angle. Recently, we presented some brilliant CGHs that are calculated by techniques called the polygon-based method[1] and silhouette method[2] and fabricated by laser lithography technology. These digitally synthetic holograms, referred to as *Computer Holograms* in this paper, have extremely high-definition and reconstruct spatial 3D images compared favorably with classical holograms[3,4]. The reconstructed images thus give viewers a strong sensation of depth that never has been achieved by conventional 3D systems providing only binocular disparity.

Some new techniques introduced into our computer holograms are presented and demonstrated.

2. New techniques

2.1 Embedding the field of real-existing objects[5,6]

The wave-fields of real-existing objects are captured by using the technique of phase-shifting digital holography and embedded in a virtual 3D scene build of 3D mesh objects and 2D images. Since sensor pitches and sizes of currently available image sensors do not meet the requirements for high-definition computer holography, synthetic aperture techniques are used to capture the wide area wave-fields with high sampling density. Examples of optical reconstruction of a computer hologram using this technique are shown in Fig.1. Here, photographs are taken from different view-points.

2.2 Rendering specular smooth surfaces[7]

Some early computer holograms created by the polygon-based method reconstructed only diffuse surfaces. Specular surfaces also can be reconstructed by controlling the spatial spectrum of individual polygons[5]. However, the shading technique is limited to flat-shading. This new technique makes it possible to create specular and smooth surfaces without any tessellation technique of polygons, which obviously increases the computation time. Figure 2 shows optical reconstruction of a computer hologram by the technique.

2.3 Hidden-surface removal of severe self-occluded objects

Hidden-surface removal is a very difficult and important problem in computer holography, because viewers can take various view-points of holograms unlike computer graphics (CG) whose view-points are fixed in still images. In our computer holograms, the silhouette method enables us to properly reconstruct mutual-occlusion. This means that light of objects hidden behind other objects are shielded properly in any view-point. However, in some cases where the object itself has occlusion, for example concave objects, this technique fails to hide the surfaces should not be seen. To achieve exact hidden-surface removal, the light should be shielded polygon by polygon. However, this is very time-consuming because the conventional silhouette method requires the same number of numerical operation of field propagation as that of polygons. The new technique is for avoiding unnecessary field propagation and reducing the computation time. Optical reconstruction of a computer hologram created by the proposed technique is shown in Fig. 3.

3. Conclusion

Three techniques are newly introduced into high-definition computer holography. These techniques most

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likely enhance power of expression of computer holograms.

This work was supported in part by research grants from the JSPS (KAKENHI, 21500114) and Kansai University (Grant-in-aid for Joint Research 2011-2012).

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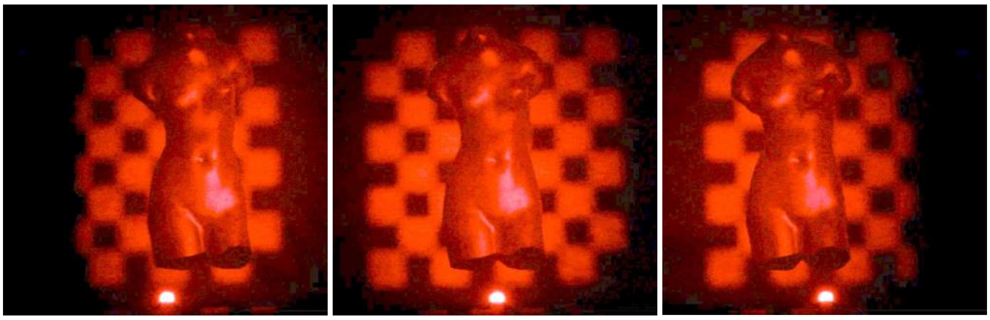
(a) Left (b) Center (c) Right

Fig.1 Optical reconstruction of “Bear II”.



(a) Left (b) Center (c) Right

Fig.1 Optical reconstruction of “The Metal Venus II”.

(a) Left (b) Center (c) Right

Fig.1 Optical reconstruction of “The Hands”.