Computer holography: a perfect digital 3D technique for real and virtual objects

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Summary

Recent developments in computer holography are reviewed. In computer holography, the holographic fringe pattern is generated as a digital 2D image in extremely high-definition and printed by using a laser lithography system. The 3D scenes include CG model objects as well as physical objects captured by digital holography.

Introduction

Techniques in high-definition computer holography are rapidly developed in past several years [1-4]. The high-definition computer-generated holograms (CGH) created by the techniques are composed of more than billions pixels and reconstruct fine 3D images comparable to that in conventional optical holography. Whereas optical holography records/reconstructs only real-existing physical objects and unable to store and transmit the images in digital media, computer holography reconstructs virtual objects as well as real objects without any limitation on use of digital media.

Objects reconstructed in computer holography are mainly classified in two categories. One is the CG-modeled virtual objects given by numerical data such as polygon meshes. In this case, the object wave is obtained from much time-consuming numerical calculation. The polygon-based method [5] and silhouette method [6] successfully resolve the problem and allow us to create occluded virtual 3D scenes. Figure 1 shows the 3D scene of the optical reconstruction of a high-definition CGH, named “Brothers” and exhibited at MIT museum in Boston, USA [7].

The other is real-existing physical objects like optical holography. In this case, the object wave is digitally recorded by the technique of digital holography using image sensors. This technique is sometimes called *Digitized Holography*, because of replacing the whole process in optical holography by digital counterparts. These two types of objects are freely arranged in a given 3D scene by field-based digital editing.

Techniques in computer holography

The polygon-based method is used for computing the wave-field (object wave) of an object given by polygon-mesh data and definitely reduces computation time as

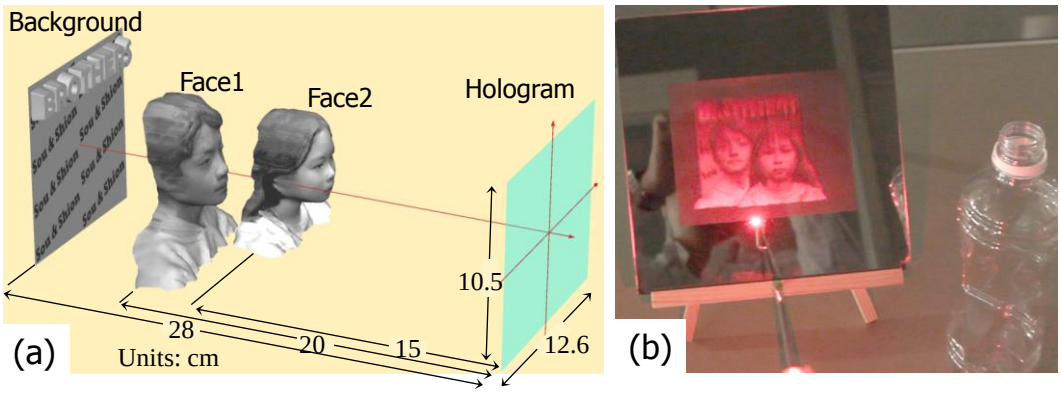

Fig.1 An example of the high-definition CGH [7]. (a) 3D scene, (b) optical reconstruction.

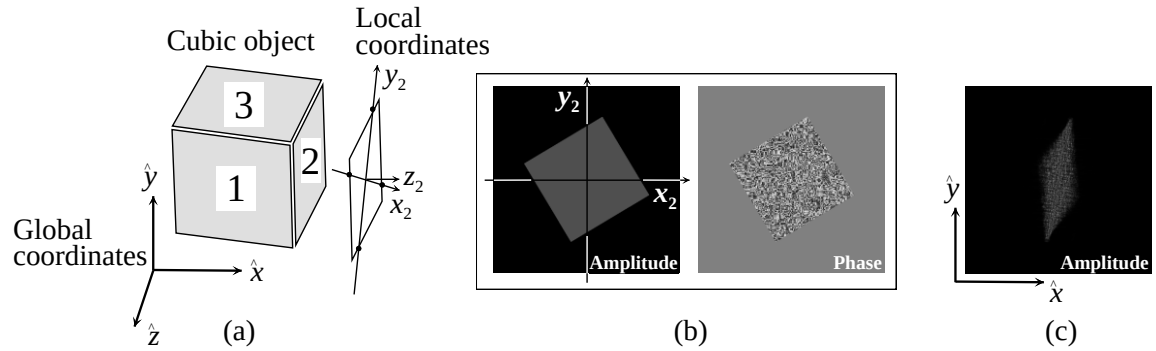

Fig.2 The principle of the polygon-based method [4]. (a) object model, (b) surface function for polygon #2, (c) amplitude image of wave-field calculated for polygon #2.

compared with point-based methods commonly used [5]. Figure 2 shows the principle for calculating the wave-fields of surface sources of light.

In digitized holography, the wave-fields of physical objects are captured by digital holography. However, current image sensors cannot satisfy requirements for high-definition computer holography, which are more than 10^9 of the number of pixels and less than 1 μm of the pixel pitch. Therefore, the technique of lensless-Fourier synthetic aperture is used for capturing. In contrast with traditional optical holography, we can easily edit the captured image and scene in digitized holography. For example, the object images can be duplicated and resized [8], as shown in Fig.3.

The wave-fields of objects, calculated or captured, are mixed according to the design of the 3D scene. The silhouette method is used for shielding light behind objects and preventing the reconstructed objects from being see-through image [2,6].

Conclusion

Computer holography makes it possible to create perfect 3D images without any confliction of depth cues unlike conventional 3D systems.

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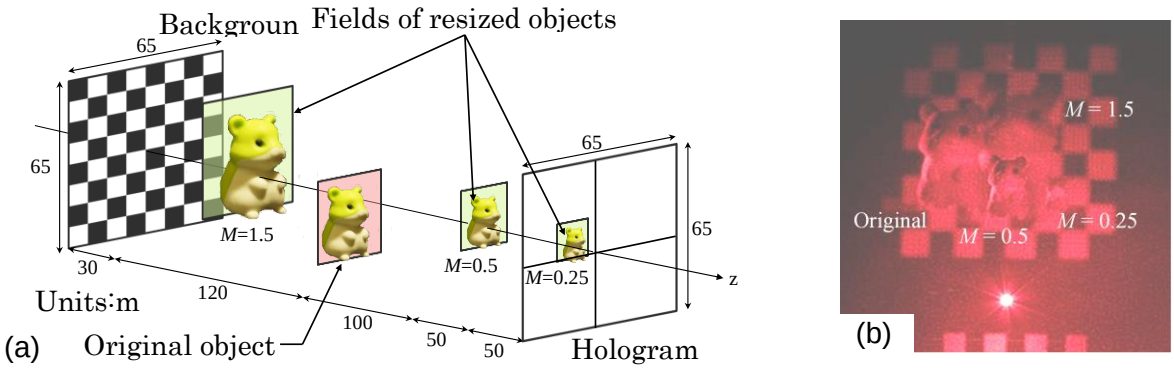

Fig. 3. An example of digitized holography [8]. (a) 3D scene, (b) optical reconstruction.