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White light viewable silver-halide holograms in design applications

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A human-centered design is an important factor for improvement quality of human life all over the world. This work presents application of holography in human-centred design in view of the unique properties holography demonstrates for 3D imaging. Holography enables design solutions with highly positive impact and supports design diversity. The paper shows how holographic art-work can be used for creation of idea-based design. It proposes different types of holograms suitable for environmental and interior design as outdoor holographic installation, artworks from rainbow holograms or cylindrical holograms and presents their real implementation. Potential of the wavefront holographic printing technique in holographic design is also discussed.

Keywords: holography, white light viewable holograms, holographic design

INTRODUCTION

Design is of crucial importance for human society. Holography, as an optical tool with unique properties, is a perspective candidate for human-centered design because it enables solutions with highly positive impact. It has also a potential to support design diversity. The holograms make possible accurate photorealistic 3D imaging with all depth cues provided and thus enrich our perception by expanding information capacity [1]. This intrinsic property of the holograms can be used to produce efficient and well-harmonized environment, to change the interior design and to improve quality of life [2]. Although holographic optical elements are already widely used for labelling products and security purposes, a lot of research and practical implementations are needed before the holograms can steadily step in environmental and interior design. This task requires understanding of 3D space perspectives provided by the hologram.

This paper presents various types of white-light viewable silver-halide holograms created recently by the holographic artist Ray Park (or Joosup Park, the first author of the paper) and discusses perspectives of their usage in holographic design. Potential of the recently developed wavefront holographic printing techniques for production of white-light viewable holograms in holographic design is also addressed.

HOLOGRAPHIC ARTWORKS

In holography, the light scattered from three-dimensional (3D) objects is recorded onto a 2D plate with a photosensitive layer or encoded as a 2D numerical array under coherent illumination. Both real and virtual objects can get holographic representation, and a variety of effects as e.g. directionally dependent motion can be introduced in the encoding process. Reconstruction of 3D images from 2D holograms allows for development of new design components and combinations leading to irreplaceable design solutions. One may argue that this really great advantage is counterbalanced by the necessity to provide special lighting to obtain high quality reconstructions. Nevertheless, plane or curved holographic panels which generate 3D reconstructions of objects always impress the general public. The white-light viewable holograms make possible outdoor installations or indoor decorations by applying inexpensive illumination with a point light source as Sun or light-emitting diodes respectively. Rainbow holograms allow for construction of decorations which change their coloring with the viewer position. Holographic displays are autostereoscopic displays and no special means are required to view the 3D images. Additional attractive feature the holographic artwork has is

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ability to be easily combined with other design solutions. In the following we present several holographic design solutions with the photographs of real holograms produced during the recent years.

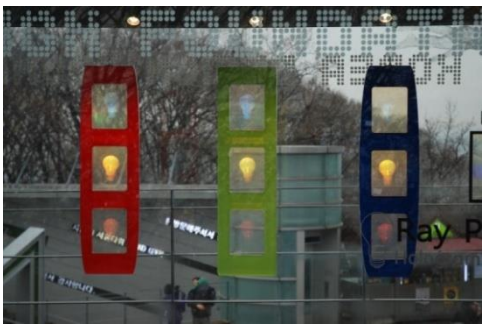

Fig. 1. Holographic installation 'Holographic Lighting Design'.

Fig. 2. Holographic lighting with the hologram attached to a glass wall.

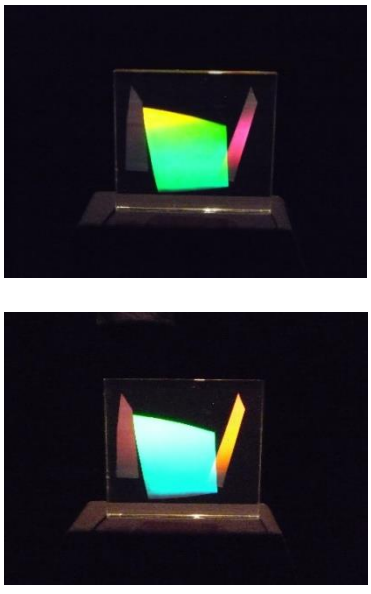

Fig. 3. Rainbow configuration: top view and bottom view.

Holography makes possible design of holographic lighting which can be a part of large outdoor installation. Fig. 1 shows a large size holographic installation 'Holographic Lighting Design' that has been presented at the Design Cube competition held at Korean Foundation of Design Culture in 2008. The author Ray Park was selected for the 'Designer of December'. The holograms in this design work are attached to a glass pane; they can be installed on a wall or in space. The size of each panel in Fig. 1 is 250 mm by 820 mm. Another holographic lighting design introduced to the Design Cube was exhibited at the outdoor space of the Namsan Tower in Seoul, South Korea (Fig. 2). The size of the hologram was 140 mm by 210 mm. The holograms presented in Fig. 1 and Fig. 2 are analogue transmission type holograms recorded on a silver-halide emulsion VRP-M (produced by Slavich) with a diode pumped solid state laser (DPSS) at a wavelength of 532 nm and laser power of 150 mW. The holograms diffract light coming from a light source and reconstruct incandescent lamps floating in the air; the created impression is of reemitted light.

A basic rainbow hologram configuration design work has been developed by cutting the holographic films used to record rainbow holograms and arranging them as is shown in Fig. 3. The holograms were recorded on the VRP-M emulsion. Their size is 160 mm by 140 mm. The different parts of this composition reflect different colors which vary with the viewing angle. By overlaying the colors, a rainbow hologram design of additive color mixture is formed. Fig. 4 shows such rainbow hologram configuration of size 200 mm by 180 mm. When observed from the front, varying colors can be seen by moving up and down. The additive mixture of red, green and blue colors in the middle creates perception of a white color. Such rainbow hologram design works may be coated on tiles, blocks, furniture, or walls.

Fig. 4. Composition made from rainbow holograms (left) and its magnified view (right).

Impressive design solution is to use a static holographic display which provides a 3D image floating in space. A holographic display design work was manufactured in 2013 by combining projection mapping with a 360 degrees cylindrical hologram. Projection mapping experiences limitations related to projector location and objects shape that hamper 3D observation of objects. A cylindrical hologram is an attractive choice to make all-directional observation available. Fig. 5 represents the cylindrical hologram of the Turtle Ship used by Royal Korean Navy from 15th to 19th century that is combined with projection mapping. The hologram was recorded using a DPSS laser (532 nm) on a silver-halide emulsion U08 (produced by Ultimate). The hologram enables observation of the floating in the air 3D object from all directions. The 2D representation of the Turtle Ship is observed on the floor. One may expect application of this method to the advertisement design.

Fig. 5. Holographic display design by combining a cylindrical hologram of a 3D object with its 2D projection mapping.

HOLOGRAPHIC WAVEFRONT PRINTING

Advances in optical technology open new prospects for holographic design. Nowadays, analogue holography is available practically to anyone and can be applied to the art and design work. However, difficulties are arising when modifying the already complicated optical set-up to capture large scenes on the holographic plate. The holographic printers are successful solution to this problem [3, 4]. They record a white light viewable hologram by partitioning it into 2D array of elemental holograms and forming digital 3D contents for each of them from the information acquired about the 3D object. The numerical data for each elemental hologram are fed to a spatial-light modulator (SLM) which forms the object beam for recording the hologram on the silver-halide holographic emulsion. The holographic stereogram printer has already proved its capability to print large size horizontal parallax only color holograms and so to be used for 3D advertisement and visual design [4]. The 3D contents are composed as parallax-related images from multi-view incoherent capture of 3D objects. However, the holographic stereogram records only directional and color information, and quality of reconstruction is not equivalent to that from the analogue hologram.

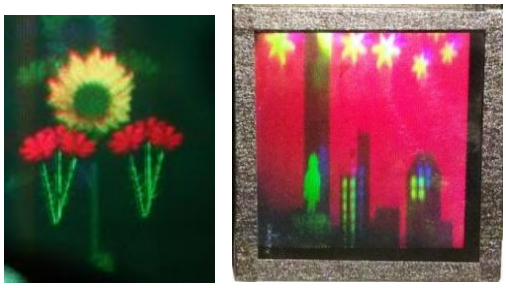

Fig. 6. Reconstruction from the first printed color hologram by the wavefront printer (left); printed hologram “Night of passion”, holographic artist Ray Park (right).

Recently, we proposed and built a wavefront holographic printer whose input is a computer-generated hologram (CGH) [5]. The printed hologram is partitioned into a 2D array of elemental holograms. A set of CGHs is generated to make 3D contents for the printer by using accelerated computation of the fringe patterns. The CGHs fed to the amplitude SLM encode the wavefront of light coming from the 3D object and the latter is extracted optically by a spatial filter and a telecentric lens system to impinge the holographic emulsion. This printer allows for manufacture of Denisyuk and transmission type holograms with the same quality of reconstruction as in analogue holography. By using three continuous wave DPSS lasers emitting at 640 nm, 532 nm and 473 nm it is possible to print color holograms. The main advantage of this printing modality is its ability to produce holograms from virtual objects by using their computer graphic models. This creates a lot of opportunities for advertisement or design which rely on 3D imaging. The photographs of reconstructions from two holograms printed by our wavefront printer are shown in Fig. 6. Actually, Fig. 6(a) presents reconstruction from the first color hologram printed this way. The bright saturated colors of the reconstructed image are achieved by

mosaic recording of the primary colors when an elemental hologram gets a single color [5]. The printed output can be used also as a master hologram.

CONCLUSIONS

Unique properties of holographic 3D imaging provided by white-light viewable analogue holograms and recent achievements in computer generation of holograms create rich platform for developing impressive design solutions. The holographically manufactured artworks can be used for outdoor and interior decorations. The main advantage of the outdoor white-light viewable holographic installations is no need of a special light source for their reconstruction. Recently developed holographic wavefront printing makes possible producing of white light viewable reflection holograms from digital contents encoding 3D information about virtual objects. The paper included various original holographic examples to illustrate the potential of holographic artworks based on white-light viewable analogue holography in design applications.

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ХОЛОГРАФСКИ ДИЗАЙН С ВЪЗСТАНОВЯВАНИ В БЯЛА СВЕТЛИНА ОТРАЖАТЕЛНИ ХОЛОГРАМИ ВЪРХУ СРЕБЪРНО-ХАЛОГЕНИДНА ЕМУЛСИЯ

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(Резюме)

Дизайн, ориентиран към човека, е важен фактор за подобряване на качеството на живот по света. Работата представя използването на холографията в ориентиран към човека дизайн предвид уникалните свойства, които демонстрира за тримерно визуализиране. Холографията дава възможност да се осъществят дизайнерски решения с голямо положително въздействие и помага за увеличаване на тяхното разнообразие. Работата представя използването на холографски артистични творби за създаване на идеен дизайн. Тя предлага различни видове холограми, подходящи за вписване в околната среда и за интериорен дизайн като холографски инсталации на открито, художествени творби от дъгови или цилиндрични холограми и представя реалното им изработване. Обсъжда се потенциалът на холографска принтираща техника за случая на принтер на вълновия фронт за целите на дизайна.