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Non-glasses Stereoscopic 3D Floating Hologram System using Polarization Technique

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Abstract

The image projected onto the screen of the floating hologram is no more than a two-dimensional image. Although it creates an illusion that an object appears to float in space as it moves around while showing its different parts. This paper has proposed a novel method of floating 3D hologram display to view stereoscopic three-dimensional images without putting on glasses. The system is comprised of a sharkstooth scrim screen, projector, polarizing filter for the projector, and a polarizing film to block the image projected from the sham screen. As part of the polarization characteristics, the background image and the front object have completely been separated from each other with the stereoscopic 3D effect successfully implemented by the binocular disparity caused by the distance between the two screens.

Key words: *Floating hologram, Polarization, Holography, Projection hologram, Sharkstooth scrim*

1. INTRODUCTION

The holography was first invented by a Hungarian scientist named Dennis Gabor in the 1940s [1]. The name hologram came from a combination of 'Holo' meaning the whole in Greek and 'gram' meaning the 'message' in Greek as well, collectively meaning the 'whole message'. The narrow definition of the hologram is to record the interference pattern of light on the sensitized medium, which requires a laser. Two scientists at the University of Michigan named Emmet Leith and Juris Upatnieks created the world's first hologram using a special optical device, anti-vibration table, and laser to record holograms [2]. At around the same time, Denisyuk from Russia developed a reflection type holography using a different method from Gabor's [3]. Most of these analog holograms are required to use actual objects to make holograms while the latest digital hologram technologies allow one to create holograms with digital data alone [4].

Hologram experts say that it will take at least a decade before even a small-scale commercial application is

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developed despite significant progress in developing an actual hologram video in a cost-effective manner [5]. The development of various projection technologies and spatial displays in recent years makes the current floating hologram system expected to serve as a bridge to achieve the goal of a fully three-dimensional video hologram. For this, a variety of techniques are utilized, including high-resolution shooting, incredible CG work to use a body double, special effects, and high power projectors. However, the contents used in floating holograms are nothing more than two-dimensional images although the lead character or an object facilitates an illusion that the object is floating in space by moving around and showing its different parts. People will find a system that projects stereoscopic 3D images viewable without glasses considerably effective and attractive and those who have never seen a hologram will believe that it is a hologram.

Against this backdrop, this paper has proposed a glassless floating 3D hologram display system that separates the background image from the object image and projects them onto two different screens using polarization to prevent them from being overlapped onto each other. Since the background image from the object image are separated before they are projected onto two different screens, you can enjoy viewing stereo 3D images without wearing glasses.

2. Floating hologram

The floating hologram that makes a two-dimensional object appear to float in open space is also called a pseudo-hologram or projection hologram and is widely used in various performances, including concert and musical. To create a floating hologram effect, a projector is installed on the stage ceiling and a mirror inclined at a certain angle is placed in front of the projector. If the light emitted from the projector is reflected by the mirror and then by the reflecting plate installed on the stage floor and is projected by the half mirror onto the space, the audience will be able to see the image as if a three-dimensional object were floating in the space. That is, the floating hologram method gives a special viewing effect of creating an image in the open space, which gives an optical illusion that makes views believe that an object or a person actually exists and this optical illusion effect is widely used in performances and exhibitions.

A transparent screen called ‘half mirror’ or ‘foil’ is often used to project an object onto an open space in a floating hologram. Both of these has a shortcoming, which is to require a larger installation area than a regular screen does as either a half mirror or a transparent foil must be tilted at 45 degrees and the screen must be installed either on the floor or the ceiling. Figure 1 shows a typical floating hologram system that adopts a 45-degree half-mirror [6].

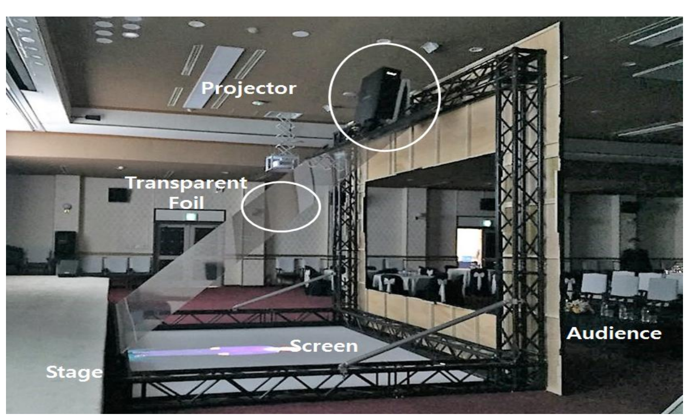


Figure 1. Floating hologram system using half mirror or foil

The method of using a sharkstooth scrim features a vertical installation like a regular screen, resulting in floating effect as well as more efficiency in space-use as compare to adopting a half mirror or transparent foil[7]. The sharkstooth scrim is like a transparent screen that comes down in the middle of a performance. The sharkstooth scrim is used for various purposes, including inserting subtitles, creating stage effect with lighting or image reflected on the screen and expressing the separation of space. The sharkstooth scrim screen in Figure 2 (a) comes in mesh type and the images are shown in certain section if reflected as in Figure 2(b) and are penetrated in rest of the section. If an image is projected onto the sharkstooth scrim in dark condition, it creates a clear effect as shown in Figure 2 (c). However, since this method projects the image onto the rear wall surface, it causes a problem of having the same image shown on the back wall surface.

(a) (b) (c)

Figure 2. Floating hologram system using sharkstooth scrim
(a) Sharkstooth scrim (b) Implementation Image without illumination control
(c) Implementation Image with illumination control

In a bid to resolve this problem, you may install a projector near the screen on the ceiling or on the floor to project an image at an angle and thus to send it to the floor or the ceiling. This, however, causes a space restriction issue as it requires a certain distance for the image that is projected between the screen and the rear wall. Alternatively, as shown in Figure 3 (b), you may place a black material that features a diffused reflection on the rear wall surface to make the projected image look blur and further vague with another source strong light. In this case, strong light that illuminates the wall raises luminance in the surrounding area and makes the mesh of the sharkstooth scrim screen visible, resulting in degradation of the floating effect. However, all floating holograms that use a half mirror, transparent foil, and/or sharkstooth scrim are still essentially two-dimensional images even though 3D modelled content or an actor creates the illusion of floating in open space by moving around and showing different parts.

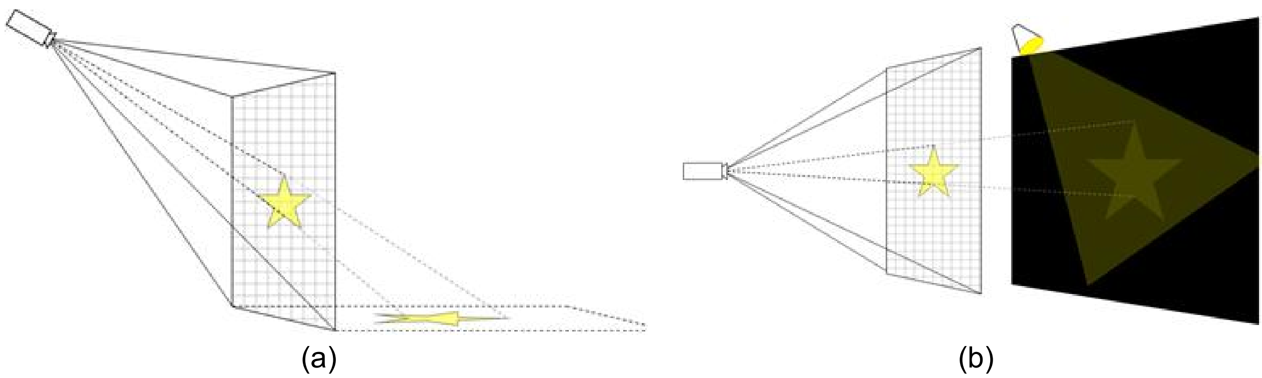


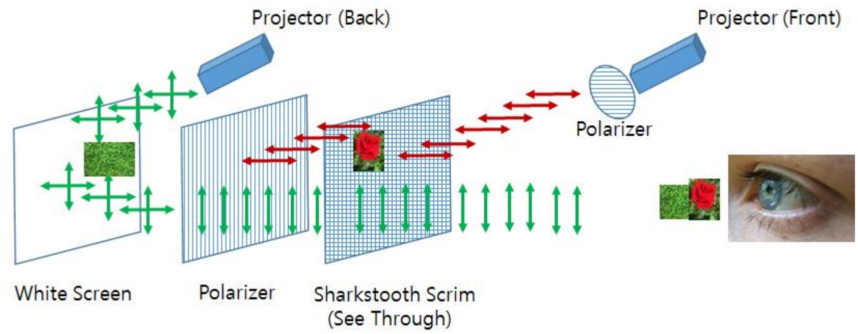
Figure 3. Two methods to solve the problem of floating hologram method using sharkstooth scrim (a) Projection to the floor (b) Use background lighting

3. NON-GLASSES STEREOSCOPIC 3D FLOATING HOLOGRAM SYSTEM

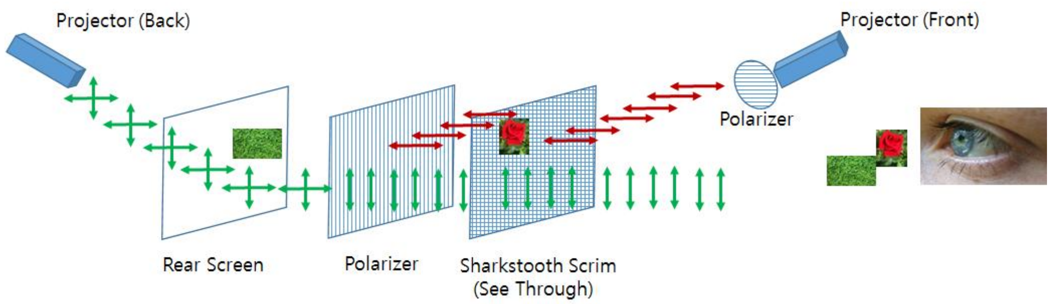
This paper introduces a system that displays stereoscopic 3D images that can be viewed without glasses while overcoming the issue of space restriction and degraded floating effect by adopting the floating hologram along with the polarization. Figure 4 (a) illustrates a two-layer screen system that uses a front projection projector. The front projector projects a rose image while the rear projector projects a grass forest image. The rose image projected from the front projector penetrates the first polarizing filter and is projected onto the sharkstooth scrim screen. The image that penetrates through the sharkstooth scrim screen is blocked by the second polarizing filter with the longitudinal direction of penetration. That is, the sharkstooth scrim screen is basically the same as the mesh material, and the image penetrated through the mesh can be projected onto the screen placed behind the sharkstooth scrim screen or the wall surface.

According to the system configuration presented in this paper, the image penetrated through the sharkstooth scrim screen is comprised of light in the horizontal direction only due to the first polarizing filter while the second polarizing filter has the vertical direction of penetration. Therefore, the light in the horizontal direction cannot penetrate and thus the second polarizing filter blocks the rose image from being projected onto the wall surface or the screen. Therefore, the observer can view the rose image projected onto the sharkstooth scrim screen only. The grass forest image coming from the rear projector is projected directly onto the rear screen. The grass forest image projected onto the rear screen penetrates through the vertical polarization component only due to the second polarizing filter before it reaches the observer's eyes through the sharkstooth scrim screen. That is how the observer is able to see the grass forest image projected on the rear projection screen. Figure 4 (b) illustrates a two-layer screen system that uses a rear projection projector. In the same manner, the front projector projects a rose image while the rear projector projects a grass forest image. The process of the observer being able to see the rose image coming from the front projector is the same as in Figure 6 (a). That is, the grass forest image coming from the rear projector, which is a rear projection screen, is projected on the rear screen, which is in rear projection type. The rear image is reflected and penetrates through the second polarizing filter and the sharkstooth scrim screen before it reaches the observer's eyes.

Consequentially, the observer is able to see the rose image projected onto the sharkstooth scrim screen and the grass forest image projected on the front projection rear screen. The rose appears protruded in a three-dimensional manner against the background of grass forest depending on the distance between the sharkstooth scrim screen and the rear screen.



(a)



(b)

Figure 4. The proposed Non-glasses stereoscopic 3D floating hologram system (a) When using the front projector (b) When using the rear projector

4. Implementation Result

Figure 5 illustrates a 3D floating hologram system with the system of Figure 4 as the basis. It uses two DLP projectors with the rear projector adopting a uni-focal lens. The front projector is equipped with a horizontal polarizing filter with the sharkstooth scrim used as the front screen. Behind the sharkstooth scrim screen in front is arranged a vertical polarizing film, a rear screen on the back away from the film and a uni-focal projector behind the rear screen.

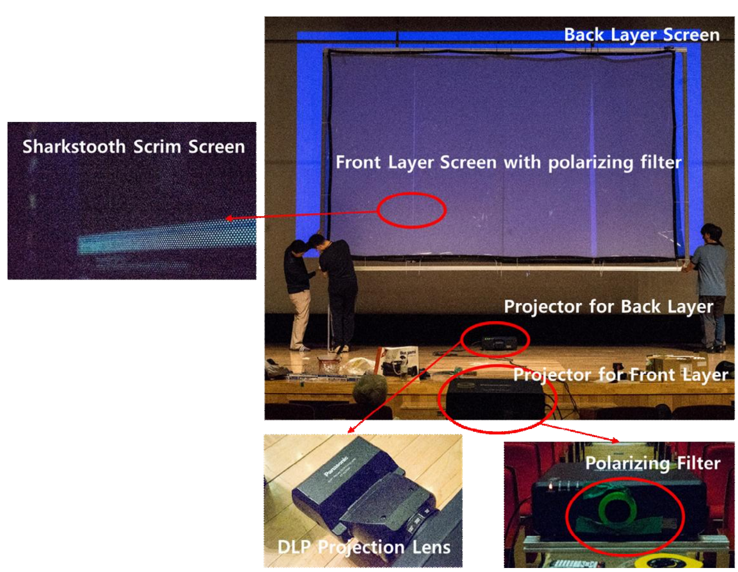
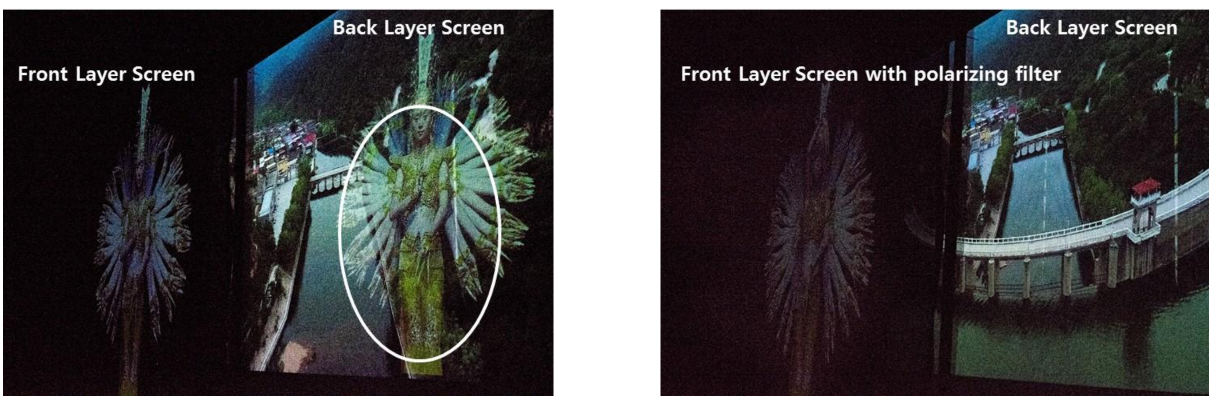


Figure 5. The experimental environment of the proposed system

The front projector chromakeys the image of dancers and projects it onto the front screen while the rear projector uses a full-screen landscape image as the background. Figure 6 (a) illustrates the image of dancers displayed on the sharkstooth scrim with no vertical polarizing film installed behind the sharkstooth scrim with a part of the dancer image that penetrates through the sharkstooth scrim overlapped with the background image.

Figure 6 (b) illustrates the dancer image shown on the sharkstooth scrim and the background image shown on the rear screen in a completely separate manner as the image that penetrates through the sharkstooth scrim is blocked after the installation of the vertical polarizing film. Therefore, the audience sitting on the audience seat is able to see the dancer image appearing on the sharkstooth scrim and the background image on the rear screen at the same time. That is, the dancer image projected on the sharkstooth scrim looks closer than it actually is while the background image projected on the rear screen appears to be located farther than it actually is depending on the difference in depth of the two layers, resulting in a sense of three-dimensional space.



(a) (b)

Figure 6. Implementation Result
(a) When polarizing filter is not used (b) When using polarizing filter

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