Simple Stereoscopic Image System based on Fresnel Plate

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ABSTRACT

A simple configuration for reflective floating images by using the Fresnel plate is demonstrated. The virtual images can be generated by active and passive strategies. Results show that the method can generate a scenario for small meeting discussion. Mathematical formulation to eliminate distortion is addressed.

1. INTRODUCTION

There is demand for the integration between the existing projection system and the compatible 3D strategies [1-3]. In this report, a simple configuration for floating images by using the Fresnel plate is demonstrated. The virtual images can be generated by active and passive strategies. Results indicate that the method can generate a scenario for small meeting. Mathematical formulation for distortion elimination is discussed. The light source of the projector is projected onto the curtain, and the Fresnel Plate is placed between the two to reflect the light source of the screen on the Fresnel lens, such that the stereoscopic 3D projection image can be generated for the naked eye – while the projection image is upside down and opposite. This result offers a viable path for the commercialized low cost projector a new application.

2. THEORY

2.1 System configurations

Figure 1 is the schematic of the small 3D imaging meeting room. A commercialized projector is projecting the image on the screen, while a Fresnel Plate is located on the table to generate the appropriate 3D imaging to the audience. The report can report both the standard 2D PowerPoint on the screen, and indicate the specialized materials to the agents in the meeting rooms by the calculated images that generated on the top of the Fresnel lens. This is a kind of mixing reporting scenario, such that can directly integrate with the existing projection system, with only the requirement on the calculation on the distorted images on the PowerPoints.

2.2 Microstructures of Fresnel plate

Figure 2 is the Fresnel plate for the present study, figure 3 gives the typical configurations for interlaced micro-structures on the plate. Configurations and algorithms for most literatures are too simple to cover a wider range of design requirements. In addition, some of the previous generalized formulations represented in vector form are not easy to directly implement. Most importantly, there is still no general exact solution for a prism-like structure for arbitrary arrangements. Thus, a fundamental solution of the prism structures such that the behavior of the prism like structures for Fresnel Plate can be analysis and design for the stereoscopic image system in a more delicate way. The fundamental solutions can be referring to [4].

$$
\begin{aligned}
&F(a,b) = F(a,b;n_A,n_B,n_C,h,p) \\
&\equiv b - \sin^{-1}\left(\frac{n_B}{n_C}\sin\left(\phi - \sin^{-1}\left(\frac{n_A}{n_B}\sin a\right)\right)\right) \qquad (1) \\
&+ \tan^{-1}\left(\frac{h}{p/2}\right) = 0
\end{aligned}
$$

2.3 complex function mapping

Equation 1 is eventually as the transformation function between the incident rays and the output rays. Note that although equation 1 is derived for the transmission rays, the principle can be implemented to the reflected rays as well. In the later figures one will see that the images are distorted by the Fresnel plate, therefore the concept to eliminate the distortion can be refer to figure 4, which demonstrate that a curved bar in (x, y) plane can be mapping in to a straight bar in the (u, v) plane through the following complex function:

$$W = u + iv = f(x + iz) = f(Z) \quad (2)$$

$$W = R\ln(Z / R) \quad (3)$$

The inverse operation indicates the mapping from the projector into the 3D virtual images, thus equation (2) and (3) can produced the required images, such that after the projection a *designed images* can be produced - various kinds of mapping function can be found in the literatures for the determination of the mapping parameters for the images generating purpose. Up to now, the transformation is mostly accomplished by the Mote-Carlo ray tracing, without clear and easy-of use theoretical demonstration.

2.4 illuminating conditions

Although some of the previous documents provide analytical expression, most of the derivation and mathematical representation methods are exclusively for academic use - too complex to be actually provided to engineers as component design applications. In the design of the present display systems, energy-based efficiency considerations are very important for the calculation of the solid angles that corresponding to screen and Fresnel plate components, as well as the distribution of emitting energy from the projector. Therefore, we adopt the analytical expression on Illuminations on finite surface, which is derived based on the energy conservation. Previous reports already complete the basic definition, and complete the formulae through the component element by means of finite area and emitting Apodization in the differential form [5].

Regarding to the different light sources with the luminescence behaviors and emits mechanisms; different spatial and angular distributions will be generated. After passing through the display element, the designed images are distorted and the energy from the projector light source will transform into a new distribution. To deal with this, this report gives a very clear and simple derivation that based on the elementary algebraic to construct the mathematical argument, such that the spreadsheet based program can be provided to the engineers to design the display components for generating the correct images and the corresponding illuminance [5].

$$\Delta\Omega = 4\tan^{-1}\left(\sqrt{\tan(\frac{S}{2})\tan(\frac{S-\alpha}{2})\tan(\frac{S-\beta}{2})\tan(\frac{S-\gamma}{2})}\right) \quad (4)$$

3. DISCUSSIONS

Figure 5 give the results of the generating 3D images, and figure 6 provide the basic solutions for some images, while figure 7 give the comparison between the original images on the screen and the generated images. The parameters for the complex mapping function can be determined by the two images for design the specific target display information. This system is proposed that can implement and integrated with the existing projector system, such that increase the adding values of the present architectures.

4. CONCLUSION

In this report, we apply a simple Fresnel plate configuration to produce a three-dimensional image display with a projection system. In the demonstration, mathematical and numerical formulae for inverse transformation can be complete through the microchips, such that the corresponding algorithm can complete the real time image correction.

REFERENCES

1. Jason Geng, Design of a Single Projector Multiview 3D Display System, Proc. of SPIE Vol. 8979 89790K-1, 2014.
2. Pietro Cipresso et al., The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature, Front Psychol. 9: 2086, 2018.
3. https://www.christiedigital.com/en-us/3d/products-and-solutions/3d-projection-solutions
4. Chung-Jen Ou et al, Fundamental Solutions of Interlaced Microstructures for Photo-Electric Device and the Pseudo Negative Refractive Index Modeling for Display Component, IDW2018-International Display Workshop, FMCp2-1, Nagoya, Japan.
5. Chung-Jen Ou et al., Analytical form of Light Source Apodization Distribution through Display Element, IDW2018-2018 International Display Workshop, PRJp1-8, Nagoya, Japan.
6. https://optiwave.com/optibpm-manuals/bpm-conformal-mapping-regions-introduction/

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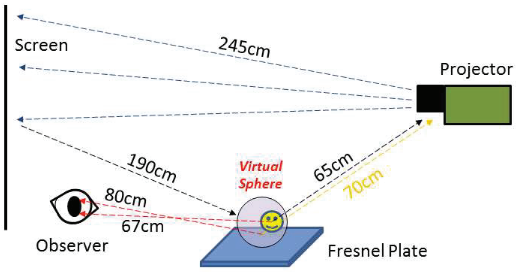

Fig. 1 measurement system

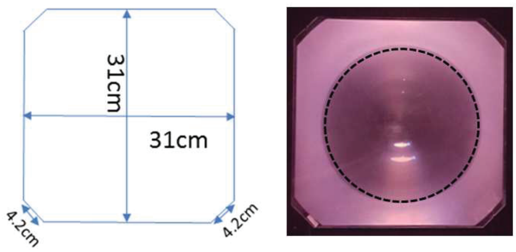

Fig. 2 Fresnel plate for the present study

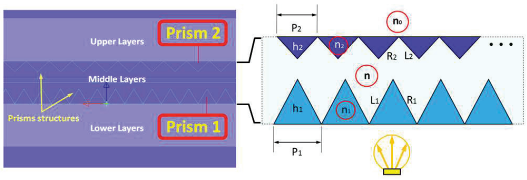

Fig. 3 Typical configurations for interlaced micro-structures [4]

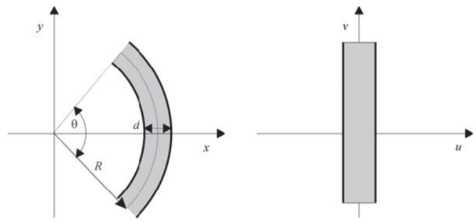

Fig. 4 complex function mapping [6]

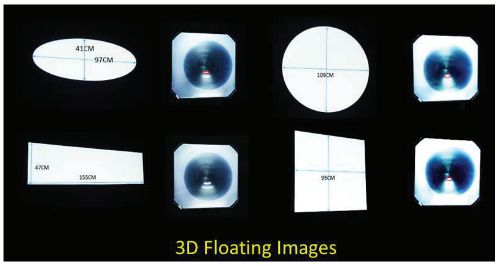

Fig. 5 Images formation by the Fresnel lens and Projected Objects

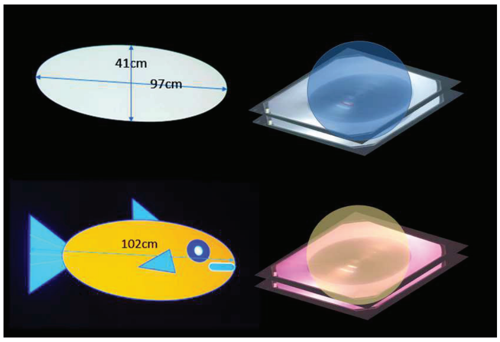

Fig. 6 images floating on a virtual sphere

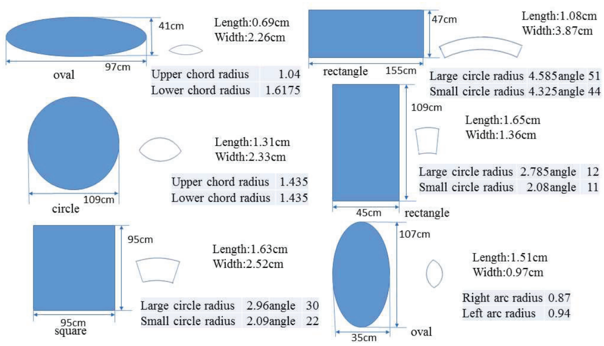

Fig. 7 Mapping between images on the screen the 3D floating imagining