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Digital Holographic Display (3)

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ABSTRACT

This paper is to describe a color digital holographic projector and this system is comprised of RGB lasers, 3 units of **Digital Micro-Mirror Device (DMD)** and high speed rotating diffuser. In this research, we focused on colorings **Digital holograms** and synchronized RGB digital holograms versus rotated diffuser. To achieve this phenomenon, three of the holograms optical path need to be aligned to pass through a same beam splitter and eventually combined as one colored holograms output. While, this colored hologram will be reconstructed on volumetric screen (rotated diffuser) at the floating manner in free space. To obtain these result 3 key factors is investigated:

1. To configured 1 master and 2 slaves digital micro mirror illumination time
2. To reconstructed holograms orientation angle diffuser versus rotating speed.
3. To synchronize rotating diffuser speed versus DMD frame-rate

Last but not least, the team built a prototype Color Digital Holography Display but more developments are required to follow up such as, enhance system's reliability, robustness, compactness and 3D realistic images floating in the free air space.

1. INTRODUCTION

The increasing interest in interactive Digital Media has fuelled the research and development of 3D images and videos conference and entrainment especially in the area of holography method. A hologram is a 3D image representation in photographic from which records the interference pattern of a laser source from the scattered object and a coherence wave field of the same laser source on film. Conventionally, this information is coded in the form of interference stripes on the holographic plate or frame. The coded plate is then processed using chemicals to get the interference pattern image. Illumination of laser source on the hologram plate creates "layer of images" that appear on the optical axis. This forms the hologram with intensity and phase modulated. The process of making a hologram involves a series of complicated chemical process. This process is non-environmental friendly, time consuming and complex.

In this proposal, a digital holography method will be implemented to replace the complicated conventional process, reference to last paper of Digital Holography Display (1) and (2). A digital hologram can be generated using computer software and projected on a media through spatial light modulation techniques (Digital Micro Mirror Device).

The algorithm is developed based on the last papers Digital Holography Display (1) & (2), and the different is 360° holograms for RGB colors would be downloaded to 3 digital micro mirror device simultaneously as high as 22K frames per second. After which, synchronize and orientate displayed holograms on rotated diffuser.

Keywords: Algorithm Digital Holograms, Digital Micro-Mirror Device (DMD), Optically-pumped semiconductor, Volumetric and Diffuser

★→ Denote Digital Micro Mirror Device (DMD) orientation output image

Fig 1 Prototype 3 DMDs and lasers schematic layout

Fig 2 Digital Micro Mirror image versus laser shining direction

2. METHODOLOGY

The team had developed an up-ward projection display to minimize alignment problems and the optic layout is different from Digital Holography Display (2), a down-ward projection display. The advantage of this technique is to avoid vibration caused by the spinning of the motor and further improvement of image display clarity. Finally, minimize the complicated optical alignment whereby images are needed to transmit up-ward through image conduit and project down-ward for display (Digital Holography Display). The optic schematic layout can be referred to Fig 1 and Fig 2. The equipment consist 2 watts RGB high power optically pumped semiconductor laser, fast switching frame rate digital micro mirror device (ALP4.1) and smart motor (SM34165DT).

The high power of the OPS laser improved the brightness of the holograms while high frame rate ALP4.1 DMD increases the clarity of the images when larger amount of the frames are simultaneously downloaded and displayed at the short duration. Likely, the system's stability will be improved by using a higher torque smart motor. Similarly, image conduit will be removed to simplify optical path. Except, to be downloaded images is still in 256 grey skills, 8 bits binary PNG format. Last but not least, these images are delivered at 22K/s verse PC USB port. The earth holograms are converted from 3D MAX and reconstructed on the high speed rotation diffuser. Refer to Fig 3.

The following 3D MAX earths models are converted to holograms to solve synchronize motor speed versus DMD frame-rate (the various angle hologram images are not showing):

0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
100°	110°	120°	130°	140°	150°	160°	170°	180°	190°
200°	210°	220°	230°	240°	250°	260°	270°	280°	290°

Fig 3

These RGB holograms are reconstructed on rotating diffuser; however the earth model is rotated in z-axis and x-axis at various viewing angle, 0°, 90°, 180°, 270° and 360°. Hence, two factors are still to degrade system performance:

- 1) Images orientation angle before downloaded to DMD;
- 2) Motor speed versus DMD frame-rate.

The fast rotating speed of the reconstructed hologram on the diffuser would cause the difficulty to snap shot by a low speed camera and therefore, apologize for none photo was taken in this paper. After which, the development is carried out to investigate and eliminate the images rotation and speed synchronization. Hence, the final version color hologram display is developed to solve these errors. The simple progress flow chart as show:

Fig 4

These devices consist of:

1. Three 2W high power optically pumped semiconductor R,G and B laser
2. Three ALP 4.1 Digital Micro Mirror Devices, 22K/s frame rate
3. One high torque smart servo motor (SM34165DT)
4. One lot of optical lenses such as converging, diverging, mirrors and 2” bi-beam splitter
5. One lot of lenses, mirrors mounting structures and holders

The “A” created rotate at its z-axis to solve images orientation error (1080 frames):

1-89	90-179	180-269	270-359	360-449	450-539	540-629	630-719
720-809	810-899	900-989	990- 1080				

Fig 5

The “A” created rotate at its z and x-axis to solve images orientation error (1080 frames):

1-89	90-179	180-269	270-359	360-449	450-539	540-629	630-719

720-809	810-899	900-989	990-1080				

Fig 6

Fig 7

The “algorithm” use to convert the “A” character to digital hologram fringe, refer to Fig 8:

$$E(x,y,z)=\frac{e^{ikz}}{i\lambda z}e^{i\frac{\pi}{\lambda z}(x^2+y^2)}\mathcal{F}\left\{E(x',y',0)e^{i\frac{\pi}{\lambda z}(x'^2+y'^2)}\right\}\Big|_{p=\frac{x}{\lambda z};q=\frac{y}{\lambda z}}$$

Fig 8

The calculation step estimates the number of frames to download to the DMD:

Eg: if motor running speed = 900 rpm

1. Converting $900/60 = 15$ rps
2. Duration for motor running 1 cycle = $1/15 = 0.067$ sec = $67000 \mu\text{s}$
3. Duration for 1 bit 22k/s per frame = $60 \mu\text{s}$ (DMD minimum required value)
4. Total number of frames require for 1 cycle = $67000/67 = 1000$ frames

Developed 3- DMD program (LABVIEW 64 bits):

Front Panel

Block Diagram

Fig 9

Optical layout and 3-DMDs configuration:

Fig 10

DMD configuration:

1. Picture time is referred to 1 frame "on" time, minimum requirement is 56μs.
2. Illumination time is referred to mirror "on" and "off" time, the duration should be smaller than picture time. Color mixing ration is depended illumination "on" time

3. CONCLUSION

For this development, the Fresnel diffraction set up is explored from 3 fast switching rate Digital Micro Mirror Device kit (ALP4.1), beam splitter and reconstruct optic components so as to form color hologram. Meanwhile, the upward projection display is demonstrated the rotated Z and X-axis earth hologram. This does not meet the target set and therefore the sub-sequence approach is to prove the orientation of hologram introduced two “A” characters, refer to Fig 5 and Fig 6. Last but not least, author is concluded that the Fig 5 is provided a stable 3D image on the volumetric diffuser however image is rotated in Z and X-axis. On the other hand, Fig 6 is given an unstable image and therefore, it time is permitted; further of synchronize of diffuser spin speed versus DMD display rate is the first priority development.

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