

Applications of Digital Holographic 3D Video Displays with 5G transmissions

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Abstract

3D holographic technique is a widely used technique in most of the everyday fields like education, entertainment, sports, medical etc. It is not so far that it will be most dominant technology in the world and will influence everything even our lives. The big advantage of this technology is that it is not using any visible/solid source to generate holograms and creates pure optical object. In this paper, we present the 3D display technology with the new and advanced paradigms in holographic video displays and their interaction and transmission with 5G networks. The object is shown by light reflection and constructive interference of lasers for commercial use. The proposed work comprised of cameras of 20 MP resolution for 3D video recordings, processed in MATLAB using Statistics and Machine Learning Toolbox for video processing and applying K-means clustering, morphological operations and stitching to get composite video hologram. In our work, no special background screen or background environment is required. Results were successfully achieved using K-mean clustering where the 3D holographic object was successfully created with the constructive interference of light from the object. Video processing was executed step by step with the moving object without any noticeable time delay in the output. Further, our video can also be transmitted over the network.

Keywords: Hologram, 5G networks, Constructive Interference, K-mean clustering

1. Introduction

Holographic is different from other 3D techniques. This difference between holography and other 3D image technologies becoming common in movie theaters is overlooked.

Digital Holographic technology can capture full scene in a single shot, which is 3D and has phase information. This feature is not in conventional 3D technology. Holographic reconstruct the whole wave front from the captured 3D scene. In other technology, it is possible only with certain

conditions e.g. requiring the users to be tracked by some technology or intelligence that is built into the display.

There is also a problem in 3D technology called ‘Accommodation vergence’, this problem is due the fact when the viewer’s eyes, between left and right images, converge or diverge. It gives the illusion that the part of the object or the scene is coming at the front of the screen or behind the screen. But all the time eyes must focus on the screen. This causes some other problem such as

strain to the visual system. In holographic, each object in the 3D comes to a focus in its plane.

Digital holographic is produced using the method called Computer generated holograms (CGH). However, they require large amount of computational power [1]. Holographic image is generated by computing the holographic interference pattern digitally. Resulting holographic image is shown as the real one by using holographic 3D display [2].

The main challenge in the holographic video for real time videos is the collection of data, the intensity of light of image pixels and the distance from camera to the object and then converting the data to the set of fringe patterns.

The purpose of our study is to enlighten the new paradigms of the holographic technology and the processing of videos and its use in military as Unmanned Ariel Vehicles (UAV) [3], [4], medical [5], [6], ground robotics [7], [8] and many other areas. It also compares and removes the flaws in the existing technology which mostly depends on images without any special hardware requirements. Existing work in holography technology has a very rear concept, processing 360 degree rendering of color hologram moving image [9] and working about video display and video objects and mostly use the dark or black environment for the displaying purpose, large output display screens, blurring effects, more cost effective due to hardware requirements of the displays, less depth cues so cause blurring and less information of the object.

2. Digital 3-D Holographic

3D holographic projection technology is loosely based on an illusionary technique called “Peppers Ghost” and was first used in Victorian theatres across London in the 1860s. Figure 1 shows the pepper Ghost effect [10].

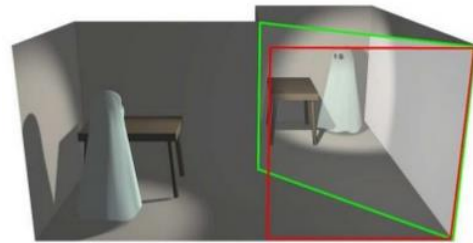


Figure 1 A setup for the pepper Ghost effect [11]

For creating special effects in the postproduction, CGI (Computer generated imaginary) animation, use of special HD film techniques and use of HD projectors is common. CGI animation and High definition video is beamed directly onto the HD projector that is specially designed instead of the use of reflection of the object onto the plate of glass [12] and [13].

This modern holographic approach gives much better results although is much more expensive as compared to other technologies. Anything is possible due to the pre-coded footage and projecting CGI animation.

In 2015, world's first holographic protest was recorded in the Spain which can be seen in Figure 2.



Figure 2 The-world's hologram protest [14]

Digital holography can be explained as the technology to acquiring and capturing and processing of the holographic data, normally by using CCD cameras, lasers or similar device. Digital holography is also described as 3D techniques for the real-world objects and used in scientific research for the inspection of 3D components and microscopic objects. Existing and conventional 3D techniques are

based on the combination of 2D perspectives like light strips. The benefit of the hologram is that we can optically combined multiple 2D/3D perspectives in parallel in single step independent of the size of the holograms. Digital holography also called as holography by using digital cameras has been become more feasible due to the new advances in the CCD camera technology. Digital holograms can be processed, transmitted, analyzed electronically.

3. Experimental Work

We proposed the working and outputs of our work that consists of recording the moving object/video under favorable conditions and then got a dynamic synthetic 3D hologram scene. In our case, the video has all the advantageous attributes that are associated with the holographic video display i.e. showing all depth cues of the object, remove dark environment requirement. The proposed method is suitable for the 3D scenes reconstructions.

3.1 Methodology

This includes the browsing and data acquisition of the videos, processing of the videos and playing for the 3D holographic videos. First step is the data acquisition i.e. record the videos from all sided of the object then these recorded videos will be processed in the MATLAB simulation tool for background removal and getting the output video hologram that can be projected on the projection screen to view the object optically.

We divided the practical work in three parts as following.

1. Recoding
- 2.Processing
3. Projection

The work is divided into three parts as shown in Figure 3. First is the Recording system. The four sides of the video captured from each direction would be sending to the computer for MATLAB processing. The processed 3D integrated video

could be projected through the special laser projectors. Block diagram of the holographic technology is shown in Figure 4.

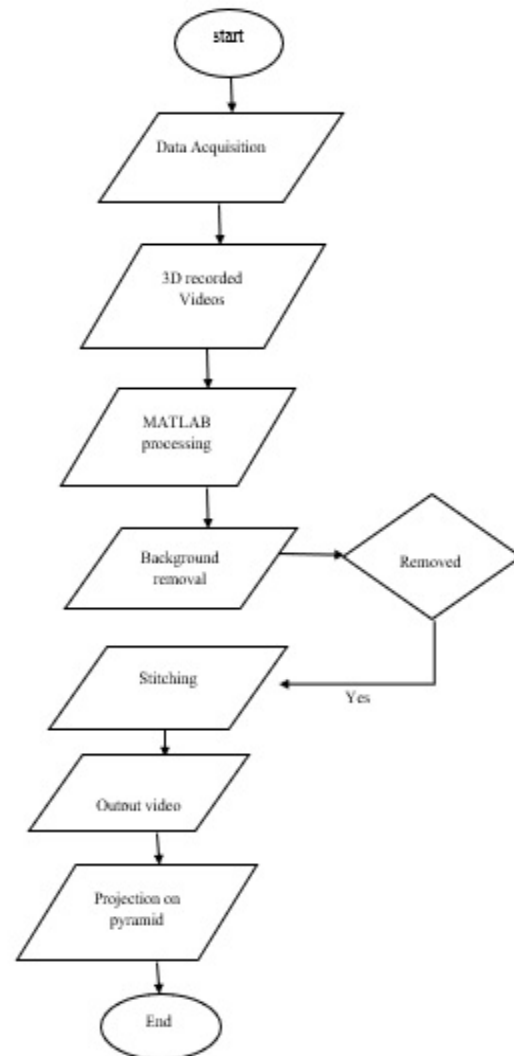


Figure 3 3D Video holographic system flowchart

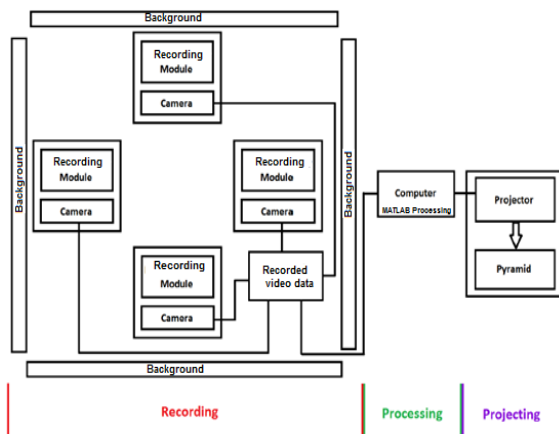


Figure 4 Block diagram for subsystems

3.2 Data Acquisition

The key of the whole holographic system is the production of the 3D video source. 3D scene is broken down into 3D/4D by capturing it from all four sides and then proceeds the frame synchronization synthesis process for the final output video.

In order to show the 3D objects as they are real, the research work design a camera array structure for the capturing of the scene, it takes pictures from the four sides of the object and then provide them to the processing algorithms.

We record the movement of the object in 360 degree from all direction and need four cameras for every side front, back, left and right and the distance between every camera to the object is same so the object is at the center. A sample setup for the cameras position is observed in Figure 5.

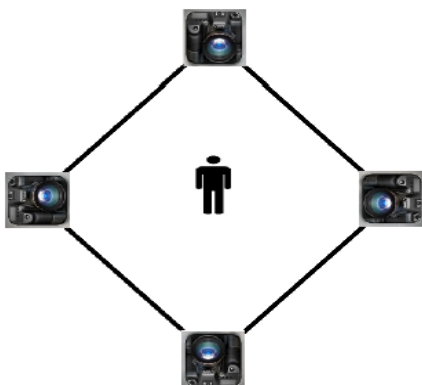


Figure 5 Arrangement of the cameras

This part comprises of two sub modules that are background removal in MATLAB by K-means clustering processing technique [15] for the colored objects and the integration of the videos.

The second step in the processing section is the integration. I integrate the four videos that are got from the four cameras and then processed them for the background removal, into a composite video that is called hologram. Each input video is 640 x 480 so the output composite video as same resolution.

The Four output video of the object and their combine hologram output is shown in Figure 6 to realize the synchronous display output of the 3D model screen. Figures 7 and 8 also show the hologram of butterfly and globe object by pyramid.

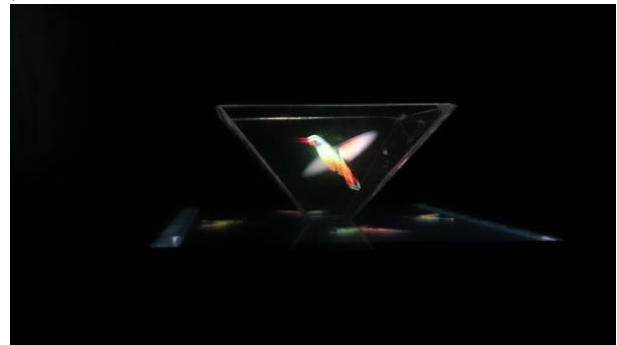


Figure 6 Pyramid holographic projector – bird

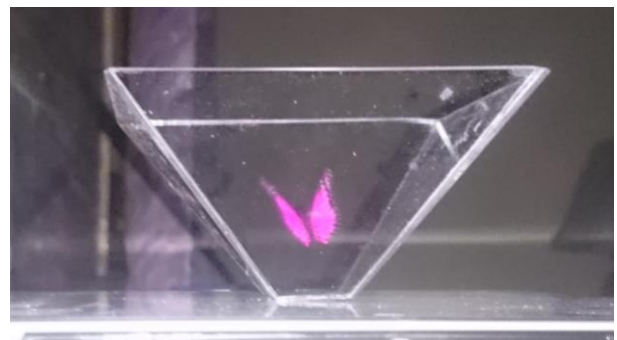


Figure 7 Pyramid holographic projector - butterfly



Figure 8 Pyramid holographic projector - globe

4. Results and Discussion

Figure 9 shows the video of the bird which spins, and we record it from the four sided to show the complete hologram.

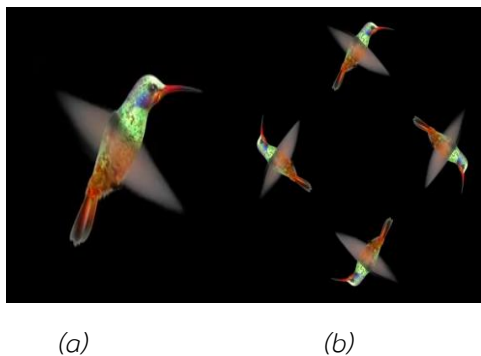


Figure 9 Hologram of bird before (a) and after processing (b)

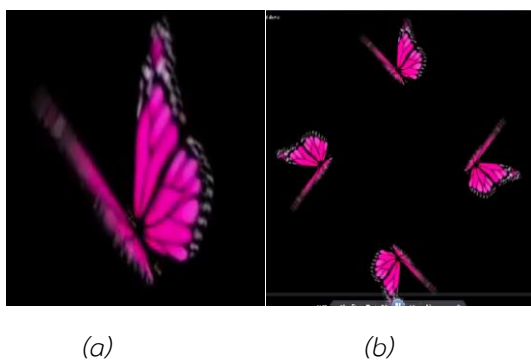


Figure 10 Hologram of butterfly before (a) and after processing (b)

In Figures 10 (b) and 11(b), we see the output video hologram of a butterfly and a globe object after processing for the four input videos and then stitched them for a composite video. These

holograms can further be processed on projection screen.

Below is a brief comparison between previous displays and the current work.

Table-I Feature Comparison

Features		Previous Displays	3D Digital Display
1.	Green Screen for background removal	Yes	No (background will be removed in processing by K- MEAN clustering)
2.	Noise Factor	Yes	Minimum (0.01%)
3.	Glasses free display	Required glasses	No glass to see hologram
4.	Digital display	No	Yes
5.	Projection Screen	Yes	No, can be displayed by laser interference (optical illusion)
6.	Interactive Displays	No	Yes
7.	Data acquisition	Analogue cameras	CCD Camera
8.	High resolution	Yes	Yes

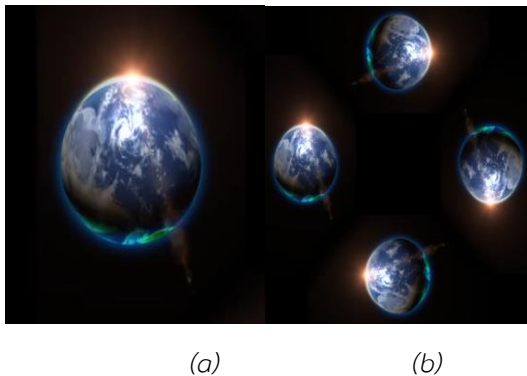


Figure 11 Hologram of globe object before (a) and after processing (b)

Our research work resulted a 3D video hologram that is sharp, with less noise factor and very less distortion as seen in the results above. Physical video object that is moving 3D is reconstructed successfully in MATLAB using techniques such as K-means, morphological operations and stitching algorithms.

During the processing, we removed the background and set it to black color because it would be clearer, and we don't need a specific dark environment for our display. If background is set white or colored, it's difficult to see the video and we need to make it dark to observe.

K-mean clustering method was applied in MATLAB to remove the background and noise from the hologram while in the past, special green screens were used to remove background. Hence, in our work no physical device were used unlike before reducing the cost and hardware requirements. In K-mean clustering, the algorithm splits the data set to a fixed number called k of clusters. Then the center of each cluster was chosen to be unique. Each cluster centroid classifies repeatedly until a stable value of the cluster is obtained and vice versa. Clusters centroid were used to form the input data, which converted the anonymous data set into reliable and stable data set with a class identity of a centroid.

5. Conclusion

During this study, we observed that for the pyramid like display videos are not too good so that's why LED is used in our color video holography displays. The LED spectrum is wider compared to the spectrum of the lasers but instead of this difference the quality of LED output video is good and satisfactory. It is less cost effective as compared to other techniques that use microcontrollers, lasers and special green screens for good output videos. Many flaws and requirements are removed in our proposed work that are removal of green screen, work with videos instead of static image, remove blur effect. So, this work depicts that it is economically feasible as compares to spatial light modular (SLM) based holography and others displays based on lasers.

6. Future Work

There is still some work that can be done to improve the video quality projected on the pyramid. Further, we can provide better environment for recording purpose. Improve the background removing techniques faster and more robust. Use of advanced CCD camera and high processor systems.

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