Interactive Hologram

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Abstract—**Holographic displays have been realised recently, however the degree of interaction has been limited. This project aims to conquer that hurdle. Holographic displays for personal smart phones can be implemented using the Pepper's Ghost effect. This same hologram can be interacted with using a marker tracking software. In effect we can interact and manipulate objects that happen to be displayed in thin air.**

Keywords— **Interactive, Displays, Holographic, Pepper's, Ghost.**

I. INTRODUCTION

Touch panel displays were the first ones to become interactive with the user. Displays are slowly becoming holographic though the interactivity problems remain. We propose an interactive system using a peppers ghost hologram. Interaction can be done using a webcam to track the movements of a selected marker.

II. COMPONENTS

A. Hardware

- Monitor
- Webcam
- Tracking Marker
- Display Pyramid

B. Software

- Unity 3D
- Holographic Videos/Games

III. A CLOSE LOOK AT INTERACTIVE DISPLAYS

A. Truly Interactive Hologram

Holography is a 3D display method that doesn't require any sort of scanning or processing as light waves emitted from the object reconstruct it's shape in the presence of a medium. The pattern is recorded as an interference pattern on to photosensitive material for later viewing. The shape remains in mid-air with no other particular screen needed for it's display.

Interaction with a hologram is a fairly new concept as so far holograms have mainly served for visual purposes. However as we move towards more interactive modes of communication. Interactive holographic displays have been proposed all across the world.

A true hologram is a complex pattern of light waves in dispersion medium. To interact with such a hologram, motion sensors, multiple displays, rotating displays and large scale projectors may be needed.

B. Pepper's Ghost Effect

It is an optical illusion technique invented and named after John Henry Pepper who popularized it in 1862. The Pepper's Ghost optical illusion has been used to create so called 'holograms' for a long time, In 2012, the California based music festival Coachella used this technique to bring about the illusion of a late musician performing on stage.

A Pepper's Ghost Hologram can be created simply by creating a projection pyramid with plexiglass or acetate as per the display's measurements.
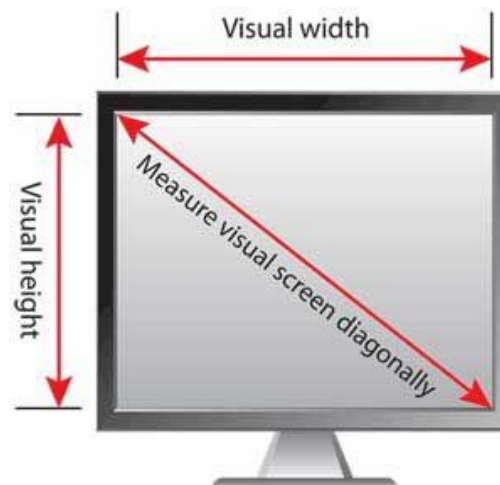

Fig. 1 Taking measurements of a display monitor for the projection pyramid

Each of the four faces of the pyramid is an equilateral triangle of side length half as that of the diagonal screen length. The triangle is cut horizontal by a line that is about three-tenth of the triangle side length to form a trapezium. The four trapeziums are finally joined to create the projection pyramid. This pyramid is kept with the largest bottom open side up on top of the screen to create out display.
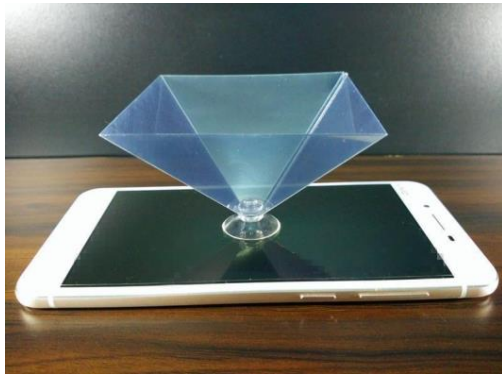

Fig. 2 A sample projection pyramid designed for a smartphone screen.

It is important to note however that a Pepper's Ghost hologram is not a true hologram. It is merely an optical illusion viewed through the pyramid as light waves do not actually create the object displayed in thin air.

IV. PROPOSED METHOD

A. Using Unity to create a 3-D object

So far, the hologram can now be created up to the extent of simply viewing. The problem of interaction arises when we look into the fact that these holograms aren't real. The Pepper's Ghost effect is achieved by placing the pyramid amidst four images representing the four sides of the image. When viewed through the pyramid, the inclination of the pyramid along with the clear view makes it appear three dimensional.

Therefore, in order to be able to interact with this set of images, all four images must be manipulated in such a way that the object appears to be moving.

Unity3D is used, a game engine used for three-dimensional modelling. The holographic effect is achieved using an imported open source package which means the same script can be applied to one 3-D object instead of four separate 2-D images.
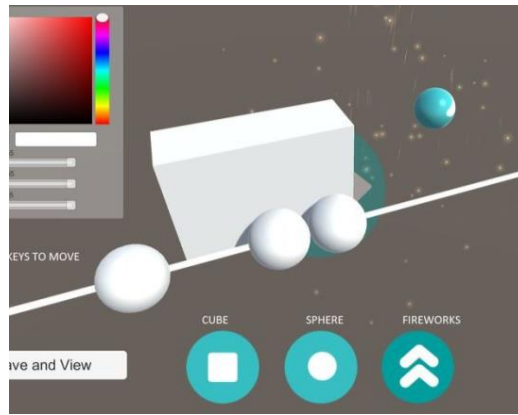

Fig. 3 Creating holographic 3-D objects in Unity3D

C. Interaction using a Marker and Webcam

The next problem arises with the interaction tool. This method uses a marker which is tracked using a webcam and a tracking software. The marker is first shown to the camera feed. The camera feed is frozen, the marker is isolated and it's coordinate locations saved. When the camera feed is unfrozen, the marker is now continuously tracked.

Finally, the saved Unity holographic application is linked with the tracking software by linking it's data file to the application. When the 3-D application is live, the image moves alongside with the marker's movement.

Depending on the lighting used and how sensitive the camera is, the smoothness in movements can vary. However, care must be taken that the Pepper's Ghost hologram is displayed in a dark area so the hologram is seen clearly.

Fig. 4 Interaction done using a marker

D. Additional Information

The system remains limited due to the fact that there are no images to represent the top and bottom of the object. Therefore the object cannot be viewed from top or bottom. As a result of this, interaction will also be limited to back, front, left and right movements. Beyond the spectrum of the pyramid, the object may appear distorted or cut off at certain points.

However, a true holographic display is not cost effective in the current market. This method can serve as a headway to create more interactive displays which can have application in teaching aids, game development, theatrical arts and so on.

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V. CONCLUSIONS

Holographic Displays will have a major scope in the coming years where more display methods are being implemented for the purpose of user-device interaction. Our paper serves to pave the way towards this goal by making it understandable and accessible to all at a low cost.

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REFERENCES

[1] Yamamoto, H., Tomiyama, Y. & Suyama, S. Floating aerial LED signage based on aerial imaging by retro-reflection (AIRR). *Opt. Express* 22, 26919–26924 (2014).

[2] Hirayama, R. *et al*. Design, Implementation and Characterization of a Quantum-Dot-Based Volumetric Display. *Sci. Rep.* 5, 8472 (2015).

[3] Andrew, M., Andreas, G. & Joel, S. K. Holographic Near-Eye Displays for Virtual and Augmented Reality. *ACM Trans. Graph.* 36, No.4, Article85 (2017).

[4] Narita, Y. *et al*. Usefulness of a glass-free medical three-dimensional autostereoscopic display in neurosurgery. *Int. J. Comput. Assist Radiol Surg* 9, 905–911 (2015).

[5] Zhao, D., Ma, L., Ma, C., Tang, J. & Liao, H. Floating autostereoscopic 3D display with multidimensional images for telesurgical visualization. *Int. J. Comput. Assist Radiol Surg* 11, 207–215 (2016).

[6] Fan, Z., Weng, Y., Chen, G. & Liao, H. 3D interactive surgical visualization system using mobile spatial information acquisition and autostereoscopic display. *J. Biomed. Inform.* 71, 154–164 (2017).

[7] Gabor, D. A new microscopic principle. *Nature* 161, 777–778 (1948).

[8] Dallas, W. J. In digital holography and three-dimensional display: Principles and Applications (ed. Poon, T. C.) 1–49 (Springer, 2006).

[9] Tokuda, Y., Norasikin, M. A., Subramanian, S. & Plasencia, D. M. MistForm: Adaptive shape changing fog screens. *Proc. CHI' 17*, 4383–4395 (2017).

[10] Grossman, T., Wigdor, D. & Balakrishnan, R. Multi-finger gestural interaction with 3D volumetric displays. *Proc. UIST' 04*, 61–70 (2004).

[11] Stavness, I., Lam, B. & Fels, S. pCubee: A perspective-corrected handled cubic display. *Proc. CHI' 10*, 381–1390 (2010).

[12] Ichihashi, Y. *et al*. HORN-6 special-purpose clustered computing system for electroholography. *Opt. Express* 17, 13895–13903 (2009).

[13] Pan, Y. *et al*. C. Fast CGH computation using S-LUT on GPU. *Opt. Express* 17, 18543–18555 (2009).

[14] Shimobaba, T., Ito, T., Masuda, N., Ichihashi, Y. & Takada, N. Fast calculation of computer-generated-hologram on AMD HD5000 series GPU and

[15] OpenCL. *Opt. Express* 18, 9955–9960 (2010).

[16] Son, J.-Y., Lee, B.-R., Chernyshov, O. O., Moon, K.-A. & Lee, H. Holographic display based on a spatial DMD array. *Opt. Lett.* 38, 3173–3176 (2013).

[17] Xue, G. *et al*. Multiplexing encoding method for full-color dynamic 3D holographic display. *Opt. Express* 22, 18473–18482 (2014).

[18] Tsang, P. W. M., Chow, Y.-T. & Poon, T.-C. Generation of phase-only Fresnel hologram based on down-sampling. *Opt. Express* 22, 25208–25214 (2014).

[19] Niwase, H. *et al*. Real-time spatiotemporal division multiplexing electroholography with a single graphics processing unit utilizing movie features. *Opt. Express* 22, 28052–28057 (2014).

[20] Im, D. *et al*. Phase-regularized polygon computer-generated holograms. *Opt. Lett.* 39, 3642–3645 (2014).

[21] Kakue, T. *et al*. Aerial projection of three-dimensional motion pictures by electro-holography and parabolic mirrors. *Sci. Rep.* 5, 11750 (2015).

[22] Igarashi, S., Nakamura, T. & Yamaguchi, M. Fast method of calculating a photorealistic hologram based on orthographic ray-wavefront conversion. *Opt.*

[23] *Lett.* 41, 1396–1399 (2016).

[24] Lim, Y. *et al*. 360-degree tabletop electronic holographic display. *Opt. Express* 24, 24999–25009 (2016).

[25] Li, X., Liu, J. & Wang, Y. High resolution real-time projection display using a half-overlap-pixel method. *Opt. Commun.* 296, 156–159 (2017).

[26] Tomori, Z. *et al*. Holographic raman tweezers controlled by hand gestures and voice commands. *Opt. Photon. J.* 3, 331–336 (2013).

[27] Shaw, L., Preece, D. & Rubinsztein-Dunlop, H. Kinect the dots: 3D control of optical tweezers. *J. Opt.* 15, 075703 (2013).

[28] Adhikarla, V. K., Sodnik, J., Szolgay, P. & Jakus, G. Exploring direct 3D interaction for full horizontal parallax light field displays using leap motion controller. *Sensors* 15, 8642–8663 (2013).

[29] Adhikarla, V. K. *et al*. Freehand interaction with large-scale 3D map data. *Proc. IEEE True Vis.- Capture Transmiss. Display 3D Video*, 1–4 (2014)

[30] Yamaguchi, M. Light-field and holographic three-dimensional displays [Invited]. *J. Opt. Soc. Am. A* 33, 2348–2364 (2016).

[31] Yamaguchi, M. Full-parallax holographic light-field 3-D displays and interactive 3-D touch. *Proceedings of the IEEE.* 105, 947–959 (2017)

[32] Shimobaba, T., Shiraki, A., Ichihashi, Y., Masuda, N. & Ito, T. Interactive color electroholography using the FPGA technology and time division switching method. *IEICE Electron. Express* 5, 271–277 (2008).

[33] Leap Motion Inc. *Leap Motion*, https://www.leapmotion.com/

[34] Nakayama, H. *et al*. Real-time colour electroholography using multiple graphics processing units and multiple high-definition liquid-crystal display panels. *Appl. Opt.* 49, 5993–5996 (2010).

[35] Ichihashi, Y., Oi, R., Senoh, T., Yamamoto, K. & Kurita, T. Real-time capture and reconstruction system with multiple GPUs for a 3D live scene by a generation from 4K IP images to 8K holograms. *Opt. Express* 20, 21645–21655 (2012).

[36] Shimobaba, T. & Ito, T. Fast generation of computer-generated holograms using wavelet shrinkage. *Opt. Express* 25, 77–86 (2017).

[37] Oikawa, M. *et al*. Time-division colour electroholography using one-chip RGB LED and synchronizing controller. *Opt. Express* 19, 12008–12013 (2011).

[38] Makowski, M. *et al*. Simple holographic projection in color. *Opt. Express* 20, 25130–25136 (2012).

[39] Makowski, M. *et al*. Experimental evaluation of a full-color compact lensless holographic display. *Opt. Express* 17, 20840–20846 (2009).

[40] Jesacher, A., Bernet, S. & Ritsch-Marte, M. Colour hologram projection with an SLM by exploiting its full phase modulation range. *Opt. Express* 22, 20530–20541 (2014).

[41] .

[42] Sasaki, H., Yamamoto, K., Wakunami, K., Ichihashi, Y. & Senoh, T. Large size three-dimensional video by electronic holography using multiple spatial light modulators. *Sci. Rep.* 4, 6177 (2014).

[43] Buckley, E. Holographic laser projection. *J. Display Technol.* 7, 135–140 (2010).

[44] Shimobaba, T. *et al*. Lensless zoomable holographic projection using scaled Fresnel diffraction. *Opt. Express* 21, 25285–25290 (2013).