DES4/3D3-3L
(Late-News Paper)
Invited

The Long-Awaited Arrival of Holographic Interfaces

Shawn Frayne[1]

smf@lookingglassfactory.com
[1]CEO & Co-founder of Looking Glass Factory Inc., 190 West St. Brooklyn NY 11222 USA
Keywords: Light field, holographic display, 3D, autostereoscopic

ABSTRACT

Holographic or light field generating devices that could enable groups of people to see and interact with genuinely three-dimensional content have long been held as a "holy grail" by those inventors and engineers that work in the field of perfecting the human-computer interface. Now after decades of work, real-time holographic interfaces are at last commercially available. The driving forces behind the emergence of holographic interfaces, the advantages of these headset-free systems compared to head-mounted displays, and the unique characteristics of the first commercially-viable approaches to come to market will be covered here.

1 Introduction

The earliest conception and prototype of a volumetric form of media device dates back to the year 1838 when Charles Wheatstone proved the principle of stereoscopy that had, until that point, only been speculated about in treatises dating back to Ancient Greece[1]. The proof of this simple and incredibly powerful idea -- that the key to how and why we view the world in three-dimensional form lay in the multitude of perspectives generated by the world -- occurred at precisely the same time as the emergence of the other mediums of 2D photography and cinema.

Fig. 1 The oldest surviving three-dimensional image, in this case a stereo daguerreotype of Michael Faraday taken in 1848 by an unknown photographer.[2]

This is not a coincidence. The techniques that make cinema possible are very similar to those that make three-dimensional representation possible. In cinema, thanks to the physiological phenomenon of *persistence of vision*, a series of images presented to a group of people in quick succession (at least one image every 1/12th of a second) leads to the magical reproduction of movement. Likewise, thanks to the phenomenon of binocular vision and how our brains being presented with an array of slightly different perspectives perceive that scene to have dimensionality, a series of images captured from different perspectives leads to the equally magical reproduction of three-dimensional reality.

However, while those other wonderful mediums of photography and cinema caught hold and went on to transform the world, the pioneering 3D mediums where space (and in the ideal form, *both* space and time) could be captured and reproduced, languished. This was due in part to the encumbrances needed to view them (such as glasses or head-worn gear) and also in part to the typically solitary, single-viewer nature of the two-view stereoscopic systems.

Fig. 2 Louis Lumière's photostereosynthesis experiments, in which he used a large depth-of-field camera and pulled the camera focus across the depth of a number of subjects. The result was six to eight photographic slides that when stacked on one another approximated a static volumetric photograph of a person.[3]

Some pioneers pushed forward the field with the intention to create three-dimensional reproductions and three-dimensional interfaces that could be viewed by multiple people – such as Louis Lumière with his photostereosynthesis analog focal-stack approach, the invention of integral photography by Gabriel Lippman, or much later Dennis Gabor with his renowned interference pattern capture methods using coherent light. More recently over the past few decades, there have been numerous attempts at applying other techniques, such as eye-tracked autostereoscopic systems, tensor-based stacked displays, electro-acoustic holographic systems, and many more to the problem of developing a commercially-viable group-viewable three-dimensional interface. Unfortunately, none of these group-viewable approaches reached far outside of niche audiences or the laboratory due to limitations in the quality achievable, the complicated nature of the capture and viewing apparata, and most notably because of the rapid ascent in quality and ease of use of the 2D mediums of photography and film that far outpaced those mediums of the third dimension.

Now that is changing, and at long last after nearly two centuries of development and exploration, systems that reproduce both space and time of both real world and synthetic scenes are coming to market.

2 A real-time holographic light field interface comes to market

Newer approaches that have found success at reproducing both the temporal and spatial qualities of the real world simultaneously do so by controlling the directionality of light in order to reproduce an approximation of the light field that gives reality its vital spatial details like specularity and dimensionality.

While there is not quite a universal format for these holographic light field interfaces yet, most types of three-dimensional content can be imported into these systems. This includes the most widespread intermediate holographic light field format used at present - a “quilt” - which is an array of images representing a variety of real-world captures or synthetically generated perspectives, or “views”, of a three-dimensional scene.

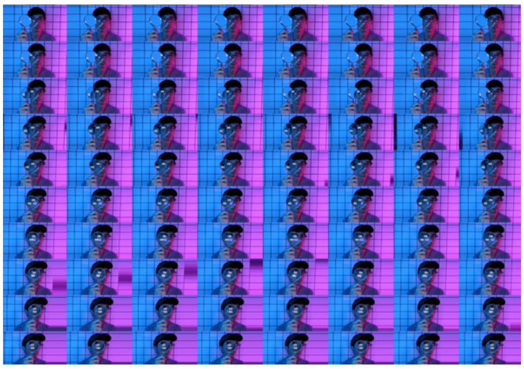

Fig. 3 An example of an 8x10 “quilt”, an intermediate format used with the first generation of holographic light field interfaces. This quilt is a recording of a light field capture from 80 different vantage points of the author.

Fig. 4 When the “quilt” as noted in Fig 3 is processed in real-time, the results are a high-fidelity reproduction of the original three-dimensional scene. Shown here in the 7.9” Looking Glass Portrait holographic display.[4]

These new interfaces are *superstereoscopic*, generating a multitude of views of a three-dimensional scene from a variety of perspectives viewable in 3D by any number of viewers within a 58-degree viewing zone.

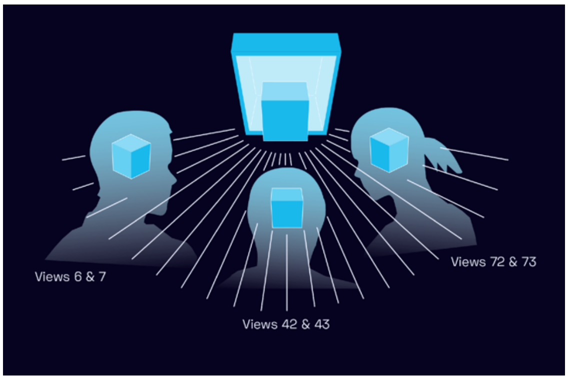

Fig. 5 Between 45 – 100 horizontal parallax views are used to generate the superstereoscopic scenes of the Looking Glass systems. These are viewable by groups of people without 3D glasses or headsets.

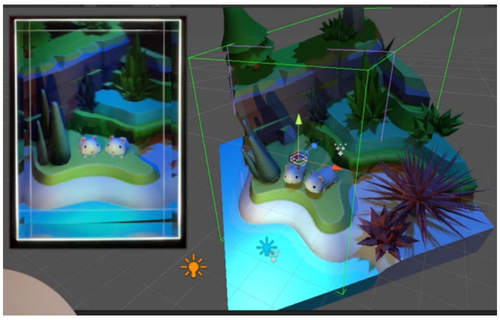

Fig. 6. Computer-generated synthetic interactive holographic content can be easily generated for this first generation of holographic interfaces with the help of plugins running within popular 3D engines such as Unity (as shown here) and Unreal.

Fig. 7 These new interfaces are innately real-time systems, meaning fully dynamic holographic video can be played back. Shown here are three light field frames of a quilt video recording, which can be directly played back on the Looking Glass devices, or through a tethered PC or Mac.[5]

Larger format holographic light field systems are also coming to market to complement the smaller desktop offerings, including a 32” 8K Looking Glass system announced in July 2021. In this new system, the directionality of approximately 100 million points of light is indexed in a factory calibration procedure and controlled through Looking Glass’ software running on a powerful PC (Nvidia RTX 3080). Each of those 100 million points of light then contributes to generating the largest commercially-available synthetic light field, with that field of light being updatable at up to 60FPS for playback of holographic video and applications in addition to images.

Fig. 8 The author shown next to a light field capture of himself being played back in a 32” 8K Looking Glass. 2021.[6]

3 The near future

There are a few factors at play now that did not exist when pioneers like Louis Lumière and Charles Wheatstone started down the path of building universal 3D interfaces:

- The emergence of massive display densities needed for light field systems, as a result of the tablet and smartphone industries;
- The prevalence of high horsepower GPUs thanks to the gaming market;
- The widespread adoption of 3D app development engines like Unity and Unreal.

These factors together with the foundational work of tens of thousands of inventors and researchers over nearly two hundred years, have led to the dream of a fully real-time, full color depth, holographic light field interface with a full suite of creative software finally being realized on the market today.

The next step is combining these new holographic platforms with a global communication platform in order to network these holographic end points to one another. Ultimately this will allow any three-dimensional content, whether real or synthetic, to be shared in both the same physical location as friends, family, and colleagues -- and also with others across the world.

New formats and standards are likely to emerge over the coming few years, and with a little luck, this new class of long-sought-after holographic interfaces is finally here to stay.

Fig. 9 A screenshot of an experimental live depth video stream of the author's children from a Microsoft Azure Kinect depth camera into a Looking Glass Portrait, where RGB-D video is transformed on-the-fly into the dozens of perspectives needed for this type of holographic interface. Dec 2020.

References

[1] "The Quest for Stereoscopic Movement: Was the First Film in 3D?". Dennis Pellerin. London Stereoscopic Company. International Journal on Stereo & Immersive Media Vol 1 No. 1. 2017.

[2] Credit: Robert Sabine, Wheatstone Collection, Kings College.

[3] *Représentation photographique d'un solide dans l'espace. Photo-stéréo-synthèse*, Académie des Sciences, November 8th 1920.

[4] www.lookingglassfactory.com. 2021

[5] Credit: Volumetric video provided by Microsoft Reality Capture Studios. 2020.

[6] Sample video footage of this scene can be found here: https://www.dropbox.com/sh/gp80pxtmrpb23nf/AADkTP39Nfqebt7HOoyRVpX_a?dl=0