EXPLORING METHODOLOGIES FOR
INTERACTIVE AND IMMERSIVE 3D SYSTEMS

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Exploring Methodologies
for Interactive and Immersive 3D Systems

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New technologies are creating interactive virtual reality experiences for users on a variety of technology platforms and mediums. Despite the increasing popularity of these technologies, not enough research has been carried out about user interactions, user experience, and the limitations of different technologies. There are many ways to use holographic projections, and one of them is to integrate information to display in the background of an environment. This paper aims to explore the limitations of the *Light-field Display*, the potential enhancement, and user interactions, while considering the psychological, behavioral perspectives of the users as well as the technological challenges. This research explores different methodologies that can be more effective in creating an immersive experience.

DEDICATION

This research paper is dedicated to Irma Lam, Nicole Guentzel and Dr. Marisa Suhm, for their unconditional love and endless support.

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KEY WORDS

UX	User Experience
UI	User Interface
VR	Virtual Reality
AR	Augmented Reality
MSQ	Motion Sickness Questionnaire
SSQ	Simulator Sickness Questionnaire
VRSQ	Virtual Reality Symptom Questionnaire
2D	Two-dimensional
3D	Three-dimensional

SECTION I

RESEARCH QUESTION/MOTIVATION/ARTIFACT

In recent years, new technologies for image display have created a multitude of platforms, systems and displays. The creation of Augmented-Reality, Virtual Reality, and Mixed Reality technologies are changing the way that people experience the virtual and physical environments. Portable and embodied devices, and highly interactive, physical-virtual connections are developing new innovative hybrid experiences and new environments for the user. Despite the new popularity of these technologies, it could be said that not enough research has been done in relation to Light-field Display technology as part of the interactive space, user experience, and the limitations of different technologies. Little research has been conducted to investigate different methodologies that can be more effective in creating an immersive experience using this new display platform. This paper aims to explore the limitations of the *Light-field Display 3D* technology, the potential enhancement, and user interactions, while considering the psychological, behavioral, and technological perspectives of the users.

SECTION II

LITERATURE REVIEW/BACKGROUND/HISTORY/SOURCES

In developing theories around interactive media, "it is important to look at how the development of interactive technologies can be seen as a new field of engagement" (Cover 140). Today, the idea that interaction is strictly focused on a human being interacting with a mouse and keyboard in front of a desktop computer is "rapidly changing to also include bodily movement that enables the user to experience the world through physically and socially engaging activities" (Hillerup 89). Enhanced reality technologies can highly affect the users experience, defined as the user's emotional, behavioral, sensorial, cognitive, and social responses. Newer interactive spaces mix technological devices and physical spaces. Many interactive spaces "include wall-size interactive surfaces, surround-sound speaker systems, and specialized input devices to facilitate group interaction" (Pering 54). One of our core objectives is to make it simple for users to define applications quickly and easily, such that they could understand a mobile application quickly and at the same time engage with a physical environment. "It is important to understand the ways that our social action and behavior are influenced by our spatial configuration with respect to others and objects" (O'hara 5).

Interactive art is an interaction between the user and the art piece by using technology to place viewers in the art itself. "In the late 90's, Ishii and Ulmer highlighted the noticeable shift in interactive experiences from 'traditional' graphical user interfaces to more participatory and pervasive tangible experiences" (Hespanhol 33). According to Schiphorst, "as our bodily experience is physically materialized more and more directly through technology, the need to account for the body and its experience continues to gain significance" (2428).

This is not to say that Interaction Design does not also aim to provide more experiences, or that all artists strive for these outcomes. "In art installations the focus is often on providing an experience that is outside of an everyday experience, rather than a focus on function, utility, or process" (Morrison 502). Public interactive installations are effective in addressing and engaging multiple people with different background experiences and displays and projections are often used for these installations as output devices. However, some installations tend to do single projections, but the problem of that is that it limits the interaction between the space and viewers. Interactive installations are becoming trendy; however, interaction is usually unidirectional and the actual experience not very rich. "By connecting visitors and computers physiologically, the installation has a clear impact on social interaction and it also shows the attractiveness to people from aspects such as creativity, novelty, inviting and motivating" (Hu 430). "Interactive art has successfully allied with technology and transformed itself from an aesthetic concept to a common feature of art within new media" (Simanowski vii). In an increasingly digital world, "art is transferred from a physical to a virtual space" (Enhuber 2).

According to Kurniawan, augmented reality can enhance and increase learning. He researched the impact of an enhanced environment on medical students. He found that students tended to have difficulties in learning different parts of the human anatomy due to "constraints to visualize the body anatomy from 2D into 3D images" (Kurniawan et al.). Currently, technology has been improving rapidly, especially in the area of augmented reality that includes new medical learning processes. Many students still use textbooks with images and text, but many researchers have been trying to incorporate some 3D images to improve their learning experiences. Medical universities still use cadavers and it is proven that it is an effective method for learning human anatomy, but it is extremely expensive. In this research, they proposed the use of augmented reality to help with the human anatomy learning process. The main goal of augmented reality is to incorporate 3D images into the real world. Therefore, it can help students visualize the human anatomy structure in an easier way. They would have another option to learn human anatomy parts without the need of having a cadaver, augmented reality allows the user to have a more portable solution in which they can take their phone or other mobile device such as a tablet. AR can also be used in other fields such as business, architecture and education.

Studies have shown that majority learning experiences can be enhanced in a new learning method using Information and communication technology. According to Huang, in the future, human-computer interaction "is predicted to advance and the gap between (technology) and the user should gradually close" (445). The use of three-dimensional (3D) images within the human brain is difficult for the brain to process because it requires an extensive use of the brain's working memory. One of the solutions can be to use holography to show medical content. Holography allows the user to view fully parallax, and auto-stereoscopic 3D images. There are studies that have shown that incorporation of simulation improves training outcomes (Okuda,2019), and more medical schools are using simulations as a key component to their curriculum. Research avenues are opening to apply new technologies in medical education (Hackett 3).

Existing Technologies

New innovations in display technologies have allowed new human and computer interaction experiences such as augmented reality, holographic projection, projection mapping, and virtual reality. These display technologies allow users to interact with a three-dimensional environment.

Virtual Reality, sometimes referred to as immersive multimedia, is a combination of computer software and hardware that show different characteristics of the physical word to a user in real time. It is a computer-simulated environment that can imitate a physical presence in real or imagined worlds. VR gives the user the opportunity to experience an immersed environment that is impossible to see in the real world. The creation of VR gadgets such as Oculus Rift, HTC Vive, and Google Cardboard transport the users into different worlds. There are other types of reality experiences like Extended, Augmented, and Mixed realities which provide users the ability to experience different mediums.

"Augmented reality is the integration of interactive digital elements – like dazzling visual overlays, buzzy haptic feedback, or other sensory projections – into our real-world environments" (Bonsor 1). Augmented Reality uses cameras on smartphones or other smart mobile devices to add digital components to a live view. Some examples of AR experiences include Google Sky Map, Google Glass, and Snapchat Lenses. The phone game Pokemon Go, was a popular example of augmented reality. Users of this game could use the real surrounding world using their smartphone cameras and at the same time project game overlay items, such as scores, screen icons and Pokémon characters. The result was that players could experience the overplayed creatures as if they were part of the real-world location. Players were so immersed in the game, that millions of them walked around their neighborhoods looking to "catch" the creatures and get the rewards. The Gatwick passenger app uses AR to help travelers navigate the complex and crowded airport.

Another popular Augmented reality app is Google SkyMap. When you point the phone or tablet camera to the sky, it overlays information about celestial bodies, planets, moons, constellations and more. The home store giant, IKEA, has an app called the IKEA Place app that helps users visualize if and how pieces of furniture may look or fit in your home before you buy them. The user can find information about a landmark or object on the street just by pointing your smartphone camera.

In addition, AR has significant applications in medicine, military, and businesses. The U.S. Army for example, uses AR to train soldiers using enhanced operations, missions and exercise. In the future, AR headsets may help soldiers process complex data at fast speed and optimize command decisions in real time. In medical training, AR can optimize the learning process over looking at anatomical features on a textbook. AR technology has great future potential to enhance everyday life.

According to Patrick J. Kiger (2020), “Mixed Reality (MR) is a step beyond Augmented Reality, in which additional information is added to that which a user perceives. In MR, the physical and virtual worlds interact, and users can interact with them as well. As computer chip manufacturer Intel’s website explains, MR “provides the ability to have one foot (or hand) in the real world, and the other in an imaginary place.” While AR enhances a user’s perception of the real world, MR can blur the difference between what is real and what is not”.

Mixed Reality technology uses two different types of devices: Holograms and smart glasses. Holograms create digital objects and locate them in a real environment, so they seem to be there in the real world. Immersive devices replace parts of the real world with created digital images. With holographic smart glasses you may see the real world with projections overplayed onto it; with an immersive headset such as VR goggles, the real world is obscured and only the digitally created world is visible. Mixed reality can be used for exciting games, but also for practical applications such as in medicine, teaching or design. A doctor, for example, could practice complex procedures before performing the actual surgery.

Existing Research of New Technologies

Research in the area of human and enhanced reality interaction has been very limited to date. Two important articles come from Huang (2019) and Yu (2019) who conducted studies on holographic projection and VR glasses respectively.

Holographic Projection Study

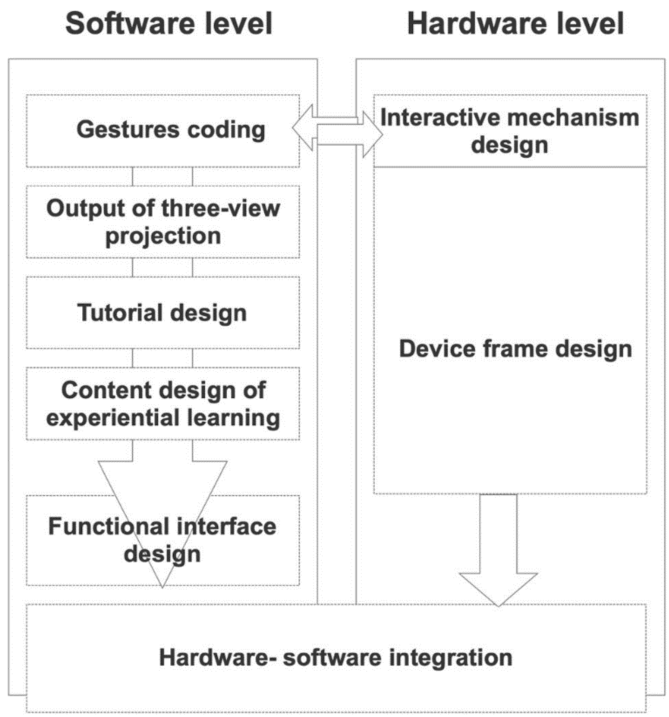

Fig. 1. Hsinfu Huang, *Structure of interactive 3D holographic device*, 2019.

Huang conducted a seminal study to explore the usability factors of 3D holographic projects in relation to learning. “The system was used for experimental learning in psychology and it was integrated with a “somatosensory interaction framework to detect somatosensory gestures. It was designed so that interactive gestures could control 3D objects” (Huang 444). They had a total of 60 college students who participated in the investigation for their interactive 3D holographic projection learning experience. All the participants had experience using some type of technological products such as VR devices, game consoles and smartphones. The experiment included “an interactive 3D holographic projection system, an experiential learning interface, content regarding human physiology and a 5-point Likert scale” (Huang 444). The 3D interactive projection holographic can be divided into software and hardware design (Fig. 1). The gesture recognition of the holographic projection is part of the hardware design; the software includes Leap Motion, 3D perspective image output, and the content of interactive learning of human physiology.

The technology that was used for the holographic projection was based on reflected light that guides a user’s attention to the screen projection. In this case study, in the holographic projection device, the LCD screen located above the pyramid shows a three-view image. The image is later reflected on the stereoscopic transparent projection screen; the black background allows the user to enhance the reflected images.

This research demonstrates the importance of having depth perception that allows the user to get involved with the environment. For the study, they used a three-view projection that was later used for the interactive 3D projection. The entire experiment not only used holographic projection, but they also used interactive design gesture recognition. It allowed the users to study physiology through a different learning process that allowed them to see images in 3D. The use of Leap Motion allows the users control rotation and zoom. They also used a tutorial that gave information to the participants to familiarize themselves with the experiment. The users liked the idea of having the option or rotation and scale because they were able to see more details that they were not able to see in flat books. One problem that I saw with the experiment was that it was not intuitive for the user at first glance because the user needed to practice several times to remember what gestures to use.

The users had access to a variety of body structures through the interface of rounded buttons, including organs, bones, cells, and skin. It lets the user rotate the human skin and rotate the mannequins with gestures. The benefit of using 3D holographic projection is that it allows the user to have an immersive experience because they can experience the human body structure in 3D. In addition, when users selected a certain button, the human skeleton was displayed on the projection screen. Participants had the freedom to scale and rotate the bones and organs through gestures. When the user selected an organ, the projection changed to 3D. The users could clearly understand the position and functionality of the human organs. The organs could also be viewed separately, which aided in understanding the characteristics of each organ. The investigators made sure that the participants were able to read the text while experiencing the images. To this effect, they used the Cronbach's reliability coefficient to make sure the "reliability of the items listed on the 5-point Likert scale" (Huang 448). They created an immersive environment that gave the option to the user to interact with the holographic projection when studying the different parts of the human body. According to Huang, the majority of published articles argued that "flow experiences are paramount to immersed ambiences in digital interactive learning and games" (448). Therefore, user immersion is an essential key factor to create an appropriate learning space that enhances the user learning experience.

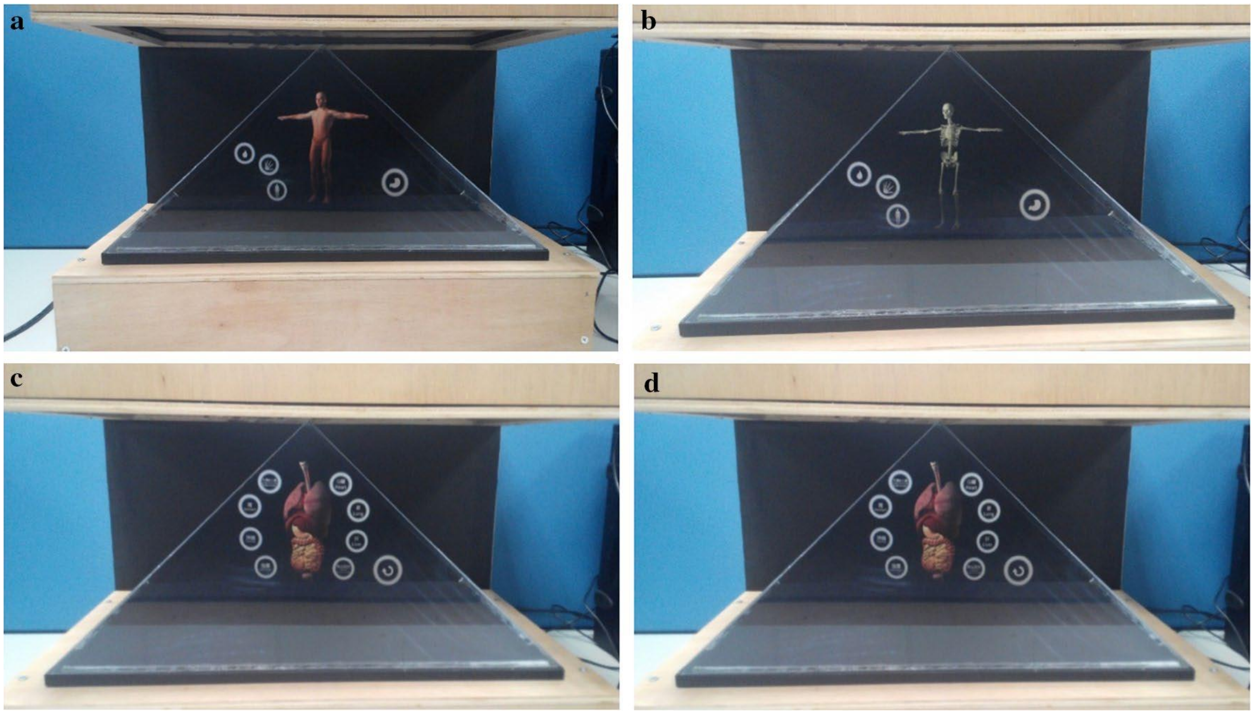

Fig. 2. Hsinfu Huang, *Physiology of the human body in a 3D holographic projection*, 2019.

Participants in the user experiment gave important feedback: First, participants agreed that an immersive experience aided and enhanced their learning process. Second, participants were impressed that they could manipulate the objects that they projected (Fig. 2). Third, they suggested to decrease the brightness of the environment to "optimize stereo perception of 3D projection objects and enhance the immersion of learning through ambience" (Huang 453). Fourth, users noticed that the cursor moved excessively and too fast, which resulted in backlash. Backlash is the ineffective space in any position. However, if there is not enough movement, the cursor movement will be insufficient. The high CR ratio functionality showed that the movements of the controller "were major and the movements of the objects in the display were minor, this was important to the concept of 'fine-adjustment movement" (Huang 450). Huang argues that the law of Fitt's was evident when users were moving the cursor to the targets in the

3D environment; the phenomenon “involves the usability of the interface; for example, the faster the required movement and the smaller the target, the greater is the error because of the speed-accuracy trade of” (452). The investigators said that icons and a cursor reminder helped improve the system usability. In their interviews, the users indicated that the cursor on the projection should be more noticeable. The program would provide sound feedback when a participant clicks a button or icon just to let them know that they successfully selected a function. However, some users did not notice the background music because they felt they should focus on the images to remember the information. In addition, users said that having a larger projection could make it easier for them to see more details of the display object. According to Huang’s study, the image size is the most important factor for usability in the holographic projection, followed by the “cursor’s sensitivity, cursor reminders, ambient brightness, and compatible gestures" (450). They were able to see that users’ favorite item was the size of the projection of the objects. Another functionality that they had to change was the excess of animations that interfered with the “gesture somatosensory operation” (Huang 450). Participants stated that having a 3D projection allowed the users to get involved with the environment that helped them construct spatial and stereoscopic concepts. Many of their participants wanted to have the holographic projection applied in exhibitions or museums because it gives the user a sense of depth that is hard to get with 2D images.

The 3D holographic projection system "provides practical experiential learning features, including interactivity, availability, learnability and attractiveness" (Huang 451). The usability interaction given by the gestures can easily help enhance spatial cognition and comprehensive prior knowledge.

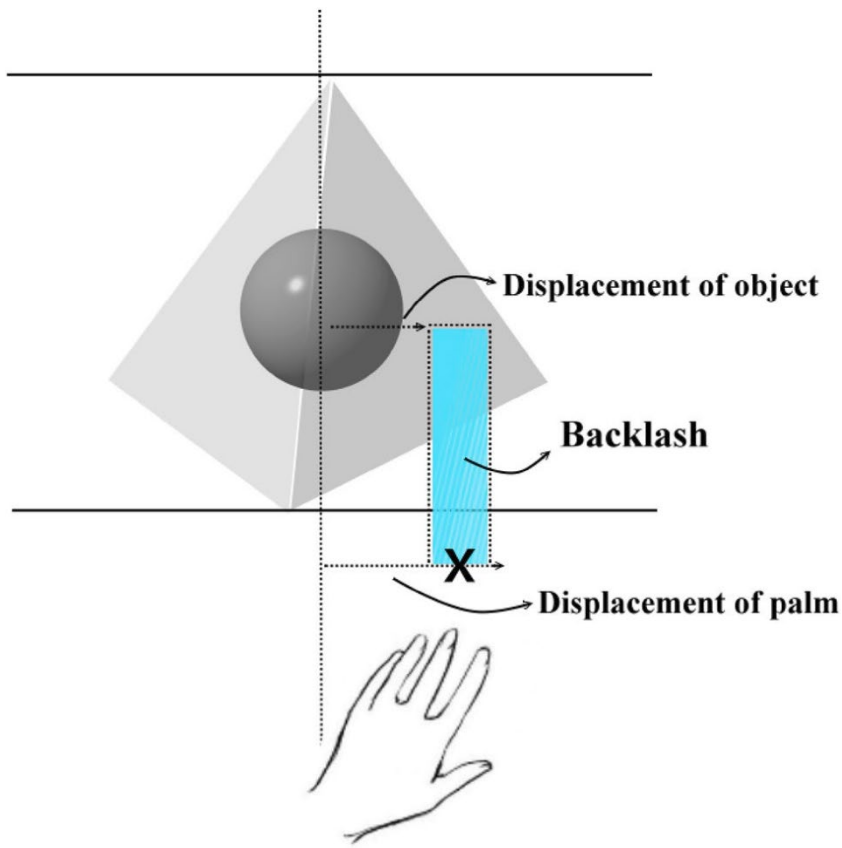

Fig. 3. Hsinfu Huang, *Ineffective displacement between objects and palm*, 2019.

Not all students who participated in the study benefited equally from enhanced reality. Those previously familiar with the subject matter were able to optimize learning; unlike those students unfamiliar with the content. The results demonstrate that this technology is not suitable for everyone, it is better for learning structural and spatial concepts like the topography of anatomy when the user has prior knowledge of the subject (Fig. 3).

According to Huang, in the future, human-computer interaction “is predicted to advance and the gap between holographic projection and the user should gradually close” (445). However, the applications of holographic projection have not been investigated in depth.

This experiment can be used as a design guideline for many 3D displays to create an immersive experience. It can also help improve the efficiency of new interactive interfaces. Many users believed that the project was useful, new, and a fresh way of learning. The results of this project can be used later for many other digital learning environments.

Virtual Reality Glasses Case Study

VR glasses are a new type of Virtual Reality headset. According to Yu “since Google released Cardboard during the Innovation in the Open Conference in June 2014, Virtual Reality glasses have emerged, and they have been adopted for use in many industries as a new type of VR headset” (206). Oculus Quest and Valve Index were also some products shown at the Open Conference. VR glasses have their own software and hardware system, for this reason, some of the UX evaluation rules such as systematic, user centered design, consistency and scientific principles should be considered. However, researchers are still exploring the best VR glasses system that achieves the highest user experience. The user experience (UX) is described as a “person’s perceptions and responses that result from the use or anticipated use of a product, system or service” (ISO 9241-210). It is crucial to understand the importance of the user experience on the Virtual Reality Glasses design. Google released in 2015 a document design guideline for Cardboard, in which issues such as “How to ground the user with fixed objects” and “How to avoid simulator sicknesses are discussed. Many Virtual Reality headsets are connected to a computer like the Oculus. One of the benefits of the VR glasses is that they have a portable hardware that only needs to be installed to a smart device.

Yu designed a study to evaluate the effectiveness of the Virtual Reality glasses user's experience (207). He designed a nine-question survey to measure the VR glasses hardware user experience. He designed a fourteen-question survey to measure the mobile applications of the glasses. The question included interface elements such as screen brightness, navigation, the effect of turning pages, the size of the interface buttons, and the interface design. For motion sickness, they created a thirteenth-question survey to measure the users motion sickness. Another way that they evaluated the interactivity of the operation performance was creating a usability test in which participants were asked to complete several tasks. For example, select a video or change the pages to measure the performance and if it was easy for the user to exit the interface easily when they were playing. In the next study, eight hardware, seven mobile applications with Android system, and four interactive control modes. Some of the hardware that they tested were Samsung Gear, PlayGlass, Dapeen, Living VR, Cardboard 2 and VRbox. According to Yu, some of the most important factors should be considered in designing the hardware such as scope of the head or eye tracking, size of the headset, and it should reduce user motion sickness (207). In terms of software, "VR system design should focus on the quality of interactive, convincing, useful and three-dimensional interface elements (i.e., floating buttons, tabs, and sliders) (Stanney, 2002) (Yu 208)". Some of the VR glasses applications are done through a mobile interface, and the screen of the mobile phone is divided into two vertically halves, and it half displays different frames. Yu argued that "the screen output is the result of two cameras with different position and angles, aiming to emulate the eyes and the human stereoscopic vision" (207). The user experience evaluation for mobile applications can use different usability tests from several interactive ways, such as 3D menus and interface navigation. There have been many investigations with questionnaires to measure motion sickness on VR systems. Some examples include “the Pensacola Motion Sickness Questionnaire (MSQ), the simulator Sickness Questionnaire (SSQ), and the Virtual Reality Symptom Questionnaire (VRSQ)” (Yu 207).

The Pensacola Motion Sickness questionnaire is used to investigate symptoms in the VEs, and the SSQ has been used to measure symptoms with military Virtual Reality simulators (Kennedy 1993). It is more suitable to use the SSQ than the MSQ when investigating different symptoms after a user experiences a VR environment, but it does not cover ocular symptoms. A non-ocular symptom can be headache, fatigue, nausea or dizziness, and an ocular symptom is difficulty focusing, blurred and tired vision. According to Yu, VRSQ is more suitable than MSQ for testing motion sickness symptoms when people use the VR glasses. VR headsets are different to VR glasses.

In previous years, VR headsets always needed to be connected to a computer through physical wires. However, users only need to install a VR app on their smartphones to use the VR glasses. In previous investigations, user experience evaluation has been studied for traditional VR headsets, but they are few studies related to VR glasses. This second investigation aimed to test the usability of the hardware, motion sickness, mobile application and the interactive performance of VR glasses.

They used “lab-based usability test, three self-reported questionnaires that were used to measure hardware UX, mobile application UX, and motion sickness” (Yu 207). For the mobile apps they used Oculus, PlayGlass, Cardboard, and 3D Bobo. For the interactive functionalities, they tested the touchpad, button, handles, and eye control on the VR glasses.

Fig. 4. Mengli Yu, *Screen equipment named WIMo*, 2019.

One of the problems that they faced was that they could only use a Samsung smartphone for their Samsung VR glasses, and they cover the brand to prevent a bias for a specific brand. The investigators always introduced the research background and requirements to each participant, and the hardware and mobile app were tested in two different parts.

In phase one, they tested the hardware of 8 VR glasses, and participants tested the 8 VR glasses in different orders. The users had to install the VR glasses with the mobile phone, they will then wear the glasses, and the participant can also adjust their glasses. Participants are then asked to answer a questionnaire with hardware questions. For the second phase, the VR glasses applications were also tested randomly. They were asked to do the same tasks: prepare the glasses to browse a page on the mobile app, they had the option of selecting a video and then watched them (Fig. 4). After finishing the tasks, they were asked to finish a questionnaire that evaluates if there were motion sickness when participants used the mobile app. According to Yu, at the end of the test, they used a “semi-structured interview to collect participant’s comments or suggestions regarding the testes VR glasses systems” (209). They used SPSS version 22 to analyze all the data that they collected from the interactive performance, motion sickness, mobile app, and the hardware.

The investigators find out that the “glasses of PlayGlass and Dapeen sometimes had fitting problems with the mobile application” (Yu 209). The other applications of 3D Bobo, Xuanjing and Tencent also had similar problems, they sometimes had different bugs when they were trying to complete the tasks. Some of the results that they got were that there was a light leak with some of the VR glasses, and one of the solutions would be to add a sponge in the shape of a circle outside of the VR glasses. Sometimes they could not place the phone in the middle of the VR glasses, and that was causing obstructions on the screen.

For the VR glasses mobile app, the participants had problems with the icons on the interface. One of the feedbacks that they got was to use an icon with some text instead of having just pictures. Yu argued, “it was better to create a multi-row or scene layout because the main interface avoided single-line” (212). Another problem was with the interface of the videos, it was better to have an exit icon at the bottom of the application interface when participants used the eye control. Having the exit icon at the bottom can make the interaction cleaner because it would allow the icon to not interfere with the content on the screen. They also had problems with the 3D videos playing scenarios, the researchers were planning on increasing the number of frames, so the user would be able to control or select scenes conveniently. Having a mute and a full screen functionality would be useful for the video playing interface.

They had an interactive eye control mode, but having it was causing the user to have fatigue. It was better to use the control with another control mode like a handle mode. For the Touchpad that they had, it was sensitive, and it caused problems when the participants were using it. According to Yu, “the interactive operation mode should focus on convenience, easy operation, basic functions, and less operation burden” (212). One of the most important aspects of this research is that icons and buttons should not be small or too many because the user would take longer to learn the tools. The results from the investigation showed that mobile applications can help decrease or increase motion sickness in their users. Having an intuitive and clean user interface can help minimize motion sickness in VR devices.

SECTION III

EXPLANATION OF EXHIBIT/VENUE

Drawing from the incipient literature, from Huang's holographic projection study, and from Yu's research on VR glasses, we propose the design of an interface device to interact with a Light-field Display Table. This interface device will enhance the immersive experience, add few features, facilitate learning, optimize ergonomic comfort, and speed the physical responses of the user, and facilitate communication of multiple users.

The Immersive Light Field Display (FOVI3D) is a prototype device that creates holographic images on a horizontal screen that has controls located in companion displays along the perimeter of the Light-field Display screen surface. Holography allows the user to see fully parallaxed three-dimensional images without supplementary vision aids. It helps the user quickly view and understand complex spatial data and objects. However, the interaction between the user and the holographic projection in this device is limited. With this in mind, we are developing a UX\UI companion interactive console that can be attached to the existing F0VI3D light field display table. This console will allow for better manipulation of data, selective view of specific features, better communication between users, and strategizing on how to use the information.

SECTION IV

REFLECTION

The exhibition of the project was done at Texas A&M Undergraduate Research Scholar Symposium on February 26, 2020. The symposium provided undergraduate students the opportunity to participate in research, creating their own thesis and talking about their experiences with other students at the university. The symposium had two options for students to present their project. They had both oral and poster presentations that graduate students, staff and faculty members were active listeners and they provided feedback of the research presentations skills of each participant.

The exhibit started with an introduction of the Light-field Display functionalities, and their main challenges. After introducing the project and the challenges, I describe the UI console that we are planning on creating and how we are going to attach it to either side of the table.

During the presentation, I was able to have a small display to show the audience how the light-field display table works. This demonstration allowed me to explain the different features and the advantages visually. Then, I talked about how the new functionalities can be used on the medical and military field, and the last part of my exhibit was a small summary of the advantages of creating a user interface that will enhance the user experience.

Some of the feedback I received from people who viewed my exhibit was that they would have liked to have seen more examples of holographic images on the small sample display table that I brought for demonstration purposes. Though I agree that having more images makes the display more interesting. I could not have obliged because what I brought to the exhibit was a small sample version of the actual light-field display table with limited capabilities. An actual light display table is large and expensive.

This research experience helped me learn more about how to conduct research in the field of Interactive Design, research and propose design considerations for devices with practical applications, contribute to my field of UI/UX design, and develop in general as a future professional.

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CREATIVE ARTIFACT

We are proposing the creation of a console that can be attached to either side of the Light Field Display table (up to 4 devices per table). The console consists of a screen with touch icons. Each icon will enable the various features, which will enhance, modify and individualize the image on the table. Having a haptic experience, aids in faster and better learning processes and enhances the user experience. Having four consoles allows for better communication and visualization of the users' ideas and a group collaborative experience.

Special Features and their Advantages

To optimize the use of an interaction with the holographic image on the display table, the proposed console will incorporate several added features.

Zooming is a feature that allows the user to bring an object closer and increase its size. It allows the user to focus on specific targets or to see the whole picture as needed. Zooming allows users to focus on smaller details of the object, or by zooming in and out, the user can have a better sense of the importance, location and relative position of the object. Zooming has been used in both Virtual and Augmented Reality interfaces. Worldviz is one platform that uses zooming. When users try to look at the content in a closer look, "the tracking can sometimes fail as the viewpoint gets too close to the physical object" (Lee 1). Having an intuitive and easy to control zooming option will allow the user to have the possibility to look at the projection in a closeup perspective without losing track of the projection. A user-friendly zooming functionality can be done by "updating the zooming factor on the distance between the viewpoint and the target object" (Bai 1). Zooming is also a useful functionality because it shows closer views without making the participant move to different angles or getting closer to the projected image.

Not having to move optimizes user response, diminishes fatigue, and increases response time. This would be important in battle situations or in critical medical response or prolonged procedures. Depending on the hardware that the developer decides to use, users can interact with the product in different ways. Some of the functionalities that they have to interact with are zoom in, move around the VR space, measure distances, interact with different objects, or use a virtual laser pointer.

Slicing is the ability to section an object and observe its internal structure at different depths. Having a slicing functionality could be an important feature in the medical field because slicing is a tool that assists doctors in an array of different clinical applications. The functionality of a slicer would give access to several segmentation, data and visualization tools and other functionalities to suit the user's needs. Slicing has applications in architecture, design and the military. An architect can demonstrate inner and outer spaces or different levels of a building. A military strategist can visualize the field at different levels or see structures at various discrete levels. Choueib argues that there is a current lack of open-source VR software that is flexible and extensible for the medical field, for this reason having this functionality will give more variety and flexibility for both military and medical field (2). Having the slicer functionality will facilitate more tools to doctors, researchers, and physicians across different platforms.

Layering is a tool that allows the user to access multiple sources of information on the display simultaneously. Having a layering functionality will be useful for displaying text, videos, textures, and information next to the focal objects in one scene. The reason that layering can give a higher visual quality is that it gives the user the possibility to have all the content directly in one space instead of them searching or using different tools just to find the information. As a good example, a doctor would be able to see and manipulate different layers of information and images at the same time during surgery or consultation without the need of going to different folders to find the information. Layering also has practical applications for teaching, engineering and the military where access to multiple sources of information and complex data in a timely fashion are vital. This functionality will allow the user to both save time and have a more efficient option of object, image, or video manipulation. According to Adam Marko Nod, there are “two major branches of software in visual effects composite editing today - layer based and node based. The node-based performs better on a detailed level and lets the user have full control of every aspect of the result while the layer-based has a lower entry level threshold and is faster to work with” (Bargeling 2).

Having multiple layers of information at the same time can also be confusing and difficult to manage, but by allowing the user to segment the layers into groups and giving them the ability to also name the projects will help the user to have a more structured and better understanding of what they are doing. While the order and hierarchy of image layers are straightforward, it can also be trickier. In Virtual Reality, If the user wants to know the content of a specific layer, they would need to select each layer individually. One possible option to solve this problem is creating a system which could allow the user to easily and quickly visualize the relationship between all the layers and the 3D content simultaneously.

Rotating is the feature that allows the user to manipulate the object and see it from different angles. Rotating an object around allows users to interact more with the scene instead of them moving around to see the projection in different views and angles of the scene. Previous VR researches have shown that user self-motion increases the sense of presence and improves the cognition and the perception of the space (Norouzi 1).

Existing rotation programs have certain drawbacks reported in the literature. The time to rotate an object such as a cup, in an interactive virtual environment, is approximately ten seconds or more and this is far longer than it takes to manually orient a "real" object. A series of experiments suggest that two major factors are important: "Having the hand physically in the same location as the virtual object being manipulated and whether the object is being rotated to a new, randomly determined orientation" (Ware and Rose). If the shape of the actual object and the virtual object were the same or not, was not found to be a significant factor.

Blobbing is a feature that allows the user to group or consolidate data into discrete displays (veins vs nerves;mors vs. normal tissue; friends vs adversaries; troupes vs. weapons). Often the term used for this consolidation is blobology where groups of related objects are grouped together for clarification. Blobbing facilitates grouping and organizing assets that are related to one another according to a predefined criterion. According to William Wright (2002) Blobology Visual treatments allows for the consolidation of assets in the battlespace, organizes and simplifies the imagery and lowers the cognitive load of processing and visualizing complex information. Blobology treatments can increase awareness in complex situations. Adding a fading over time feature to blobbing will give the user information about how recent the information is and how it starts to change over time.

Coloring is a feature used for quick identification of specific systems, objects, and other data. When designing a color scheme for virtual reality displays, it is important to carefully consider the choice of colors, the transparency, the texture and the labels. Transparency of objects is important when the background cannot be obscured. Such is the case of the terrain in a battlefield, or an organ or a tumor within the human body. The choice of color impacts the psychological, and often subconscious reaction of the viewer. Psychologists have found that certain colors conjure specific emotions. Texture assists the user in processing and differentiation of objects and provides more vivid and realistic perception. Brightness of colors can highlight the relative importance of objects. The additive color model (red, blue and green) or RGB color system, is the standard used in digital media and on screens (UX Planet, 2017). The mixture of these primary colors in equal proportions create the secondary colors of magenta, cyan and yellow. These colors become brighter and lighter the more light is added to the display.

Sequencing is a feature that allows the development of a plan of action over time and in real time. Having the functionality of sequencing can be helpful for both military and medical fields. This tool would allow users to plan the steps that would work the best for their surgeries or to create strategies for field combat. According to Messner, having the functionality of sequencing in his virtual reality construction engineering education project was vital for optimization of engineering processes (7). For his project, each team was able to use a different sequencing strategy for the construction of different components of a power plant. All the teams developed a sequence that focuses on different aspects of the installation. For the teams, having an interactive environment where they could share different ideas was valuable. The team members were encouraged to discuss which construction sequencing methodology was better in order to create a successful room. “The enhanced spatial perception offered by the virtual reality system allowed the students to consider workspace interfaces between trades while also planning a number of different parallel activities” (Messner 5). The sequencing option made them save time and they were able to make their installation in less than an hour with no prior knowledge of power plant construction or introduction to the space. Adding the functionality of sequencing will allow surgeons, students, or a commander to have a better and a faster way of communication that will allow them to save time by multitasking.

Sequencing in a virtual environment has also been used successfully in the rehabilitation of patients with brain damage due to injury or stroke. In a virtual kitchen, patients are guided to do and practice daily tasks in a safe environment. Sequencing is a useful tool for planning, teaching or practicing processes in multiple contexts.

Fingerprint is a biometric feature that allows access to the interactive system and adds privacy and security to information. Fingerprint is a biometric system that is easy to use, smaller in size and that requires low power. Fingerprints are one of the first ways of verifications and validations of entry into a task, which is more efficient, reliable and accurate compared with other options. This functionality has been used globally for immigration, law enforcement, forensics, health care, banking and many more purposes. “Application of the fingerprint biometric system in the industries has been accepted widely and used in Europe and some developed countries” (Yahya 1). Biometrics refers to the fact that a person can be identified automatically by their biometric signature and characteristics. Each person will always have their own characteristics that show all the information of who they are rather than what they have. Usually, fingerprint systems are categorized in identification, security, recognition, and control systems, and each system has its own benefits. A normal fingerprint biometric system is divided into four components which consists of feature extraction, database, image capture and pattern matching.

In an image feature extraction, algorithms are used to create feature vectors “which have numerical characterization of biometrics of interest” (Yahya 4). Pattern matching compares features to get a value that gives the similarity between the under investigation and the pair of biometrics data, and image capture is a sensor that captures the biometric data in a digital format with the collection of data.

Applications and Conclusions

This project proposes the creation of an interface device for the Immersive Light-field Display developed by FOVI3D, which creates holographic projections over a horizontal display system. The proposed interface device consists of a console that can be attached to either side of the Display table. Up to four devices could be attached per table. The proposed interface device will contain a series of additional features that would allow the users to enhance the uses, functions, expediency, and the overall experience of the 3D Light-field Display system. The proposed device will let the users zoom, rotate, slice, sequence, group, color, texture and label specific objects or systems, and allow simultaneous access to multiple data sources, while keeping the information private and secure.

The proposed interface device has the potential to optimize medical or military training, facilitate engineering and architectural design, aid in teaching, and foster patient rehabilitation. Used for medical training as well as for designing strategies for complex procedures, the device can section organs, manipulate, highlight or disregard specific parts, offer close-up views and practice procedures. Used for training of army personnel on the ground, it can provide realistic battlefield and terrain experiences, developing faster and independent responses, identification of friend and foe, and strategizing on steps to follow. One of the major benefits of such a system is the fact that users can view complex 3D spaces while interacting in physical reality and collaborating. The projects can also be shared across multiple FoVI3D systems, this collaborative environment allows for large groups of individuals reviewing and examining complex 3D environments across multiple devices at any distance.