A Serious Game: *Warped Reality*

by

Haichen Hao, Yichen Li

A Thesis

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In partial fulfillment of the requirements for the

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in

Interactive Media and Game Development

by

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APPROVED:

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Professor Dean O'Donnell, Major Thesis Advisor
Professor Farley James Chery, Major Thesis Advisor

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Abstract

Warped Reality is a VR game aimed at raising awareness that fake news always cheats people, and it is better to do critical thinking when facing something you are not sure. Players could investigate the truth behind some accidents through a first-person perspective. Unlike traditional VR games, players use gestures to interact, which provides players with a more realistic and immersive experience. We also designed and implemented a set of gestures to interact with the game. The gestures are not only designed for this game. Most of them can be applied to all the gesture-controlled VR games. An evaluation with 20 people was done to test if their awareness about fake news has been raised after playing the game and if the gestures help improve the immersive experience. The results show that the game helps players raise awareness that fake news always cheats people and get to know serious problems caused by fake news.

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Chapter 1 Introduction

Fake News is a kind of news that is made up of disinformation and hoaxes. It spreads with an unbelievable speed through online social media currently. In the beginning, fake news was used to make propaganda for some special activities and more viewers represent much money. However, now some newsmakers just post fake news to attack celebrities or politicians. Thousands of related news or information can influence Their life. As a result, fake news becomes the primary weapon for online violence. It hurts the number of people and even destroys their life.

So why do people share fake news? Fake news will not go viral if no one would like to share it. First, it is difficult to identify on the web. As we can see on social media or web, correct information is side by side with false information on an equal footing. Besides, creators of fake news arrange to have it look like real news. Second, our mind plays tricks on us. There is no doubt that we trust our family, our friends, people we admire. If these people post something on social media, we will tend to believe them more easily. Third, fake news plays on our emotions. People who produce fake news know that people are more likely to react and share information motivated by a strong emotion.[1]

A related experiment shows that when facing posts in social media like Facebook or Twitter, people often ignored many posts, especially those they deemed too long, overly political, or not relevant to them. However, certain types of posts made people sceptical. For example, people noticed when a post did not match someone's usual content. Sometimes participants investigated suspicious posts—by looking at who posted it, evaluating the

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[1] "Why do people share fake news" *30Seconders*, https://30secondes.org/en/module/why-do-people-share-fake-news/

content's source, or reading the comments below the post—and other times, people just scrolled past them.[2]

To some degree, getting the knowledge of how fake news is produced can help to raise awareness of fake news and let people avoid sharing that. On the other hand, they can think more before sharing rather than helping spread fake news only based on emotion or families' sharing. Currently, people can acquire such knowledge through websites, books, and games. Nevertheless, these games usually utilize many words to describe events, and players need to make their decisions by reading.

Virtual Reality (VR) is a new kind of technology that provides users with a simulation of the senses, such as vision. It brings users the feeling of immersing in the environment[3]. It uses the computer to simulate and generate a virtual world in a three-dimensional space. Compared with traditional media, VR is considered to be a technology that brings a more intensive feeling of spatial immersion since its ability to elicit a stronger presence experience[4].

VR Headset is a head-mounted device for players to play VR games. The 3D game scene is presented on the head-mounted display (HMD), which is installed inside the headset. Players need to use controllers to play most VR games. In the game, players press buttons to select and use the tool, as well as interact with game objects and the game menu. In some RPG and FPS games, controllers are used to simulate avatars' hands. It can be complicated and confusing for new players to find the mapping between buttons on the controller and the "hand" operations in the game scene. They need to pay more attention to the usage of controllers rather than playing the game, which in some cases affects the user's immersive experience.

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[2] U. Washington. "How do people react to fake news on social media" *Futurity*, https://www.futurity.org/social-media-fake-news-2310832/. Accessed 19 March 2020.

[3] "What Is Virtual Reality? - Virtual Reality Society". *Virtual Reality Society*, 2017, https://www.vrs.org.uk/virtual-reality/what-is-virtual-reality.html. Accessed 20 Mar 2020.

[4] Weibel, David, and Bartholomäus Wissmath. "Immersion in computer games: The role of spatial presence and flow." International Journal of Computer Games Technology 2011 (2011).

Leap Motion Controller (Figure 1-1) is an optical hand tracking module that can capture players hand movements[5]. It provides the SDK to enable users to use Leap Motion Controller in VR, which allows players to use gestures instead of controllers to interact within the VR games[6]. A set of gestures are designed for players to interact with the game. The design is based on the player's daily habits of using gestures so that players can more intuitively understand the meaning of them. This also makes the operation of the game simpler, enable players to pay more attention to the experience of the game and to get the meaning of the serious game.

Figure 1-1 Leap Motion Controller

Warped Reality is a 3D game with a first-person perspective. The main goal is to show that truth can be manipulated by taking pictures at a proper place and perspective in different scenes. Players can investigate the truth behind news by themselves and give out their choice about the reliability of news. Three scenes are combined to make up a significant story about politics. With this game, people who have no idea about the origin of the fake news will gain more knowledge about how fake news is created, and then *Warped Reality* can raise awareness that fake news always cheats people and it is better to do critical thinking when facing

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[5] "Tracking | Leap Motion Controller | Ultraleap". Ultraleap.Com, https://www.ultraleap.com/product/leap-motion-controller/. Accessed 11 May 2020.
[6] "Setup Guide — Leap Motion Developer". *Leap Motion Developer*, 2019, https://developer.leapmotion.com/get-started. Accessed 30 Aug 2019.

something they are not sure. In terms of gaming playing, players wear VR headsets to find and investigate from different angles and find out details without perspective range limitations. At the same time, accompanied by gesture capture devices, players can use their hands to interact with the game in a more intuitive and user-friendly way.

Chapter 2 Background

2.1 History of Fake News

Fake news is not a new word. Rumor and false stories have probably been around as long as humans have lived in groups where power matters. The different thing is the format used to show public fake news. In the past years, the leaders of the group (Emperors, Pharaohs, Incas, Religious, and Military leaders) controlled information spreading. They also created stories to make sure the public would remember their exceptional leadership, prowess, success in battles. However, the public cannot verify or investigate the truth, so it is hard to understand which information is real or fake[7]. Currently, fake news can be utilized by all public because of the Internet. Many websites are built to make fake news. Some of these hoax websites are satire. Others are used to mislead or deliberately spread biased or fake news. The reasons for creating fake news consist of making money, attacking opponents, catching eyes, and becoming famous.

There are some examples of fake news throughout history.

In the sixth century AD, Procopius of Caesarea (500–ca. 554 AD), the principal historian of Byzantium, used fake news to smear the Emperor Justinian. While Procopius supported Justinian during his lifetime, after the emperor's death, Procopius released a treatise called *Secret History* that discredited the emperor and his wife. As the emperor was dead, there could be no retaliation, questioning, or investigations. Since the new emperor did not favor Justinian, it is possible the author had a motivation to distance himself from Justinian's court,

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[7] Joanna M. Burkhardt. "History of Fake News." ALA*TechSource,* Vol. 53, No. 8, 2017, pp. 5-8.

using the stories (often wild and unverifiable) to do so[8]. Although without the printing press, people could still make up stories to flatter people in power. That is a kind of early fake news.

American writer Edgar Allan Poe in 1844, wrote a hoax newspaper article claiming that a balloonist had crossed the Atlantic in a hot air balloon in only three days. His attention to precise details and the plausibility of the idea caused many people to believe the account until reporters failed to find the balloon or the balloonist. The story was retracted four days after publication. Poe is credited with writing at least six stories that turned out to be fake news. Another famous example is Orson Welles's *War of the Worlds* broadcast in 1938. The show became famous for supposedly tricking some of its listeners into believing that a Martian invasion was taking place. Panic was spread among these listeners because of the realistic description in radio show[9]. Based on these two examples, we can see that fake news has the power to challenge the scientific area. Although this kind of information will break down after more people starting to find truth, it influences part of the public for a period.

An article from Public Domain Review, states that "It is in the late 19th-century phenomenon of '*Yellow Journalism*' that if first seems to reach the widespread outcry and fever pitch of scandal familiar today". This article mainly focuses on the effect of "*Yellow Journalism*." This journalism always has scare headlines in huge print and exaggerated comics. It used fake interviews, misleading headlines, pseudoscience, and a parade of false learning from so-called experts, which represents an earlier disseminator of fake news who focuses on war and politics[10].

As we can see from these examples, fake news exists throughout history, and it has the power to affect all fields related to the public, including politics, science, and war. What

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[8] Joanna M. Burkhardt. "History of Fake News." ALA*TechSource,* Vol. 53, No. 8, 2017, pp. 5-8.
[9] Ibid, Vol. 53, No. 8, 2017, pp. 5-8.
[10] "Yellow Journalism: The 'Fake News' of the 19th Century".(n.d.). In the *Public Domain Review*. https://publicdomainreview.org/collections/yellow-journalism-the-fake-news-of-the-19th-century/

stimulates the development of fake news is that people are easily attracted to gossips, rumors, scandals, innuendos, and the unlikely.

2.2 Category of Fake News

Based on the features of fake news, it can be divided into five parts. Some of them are fake(disinformation); others are down to human error or biases(misinformation).

1) Satire or Parody: Sites such as The Onion or Daily Mash publish fake news stories as humorous attempts to satirize the media but have the potential to fool when shared out of context.

2) Misleading news that's sort of real but used in the wrong context: Selectively chosen real facts that are reported to gain headlines but tend to be a misinterpretation of scientific research.

3) Sloppy reporting that fits an agenda: News that contains some grains of truth that are not fully verified, which are used to support a particular position or view.

4) Misleading news that's not based on facts but supports an on-going narrative: News where there is no established baseline for truth, often where ideologies or opinions clash, and unconscious biases come into play. Conspiracy theories tend to fall here!

5) Intentionally deceptive: News that has been fabricated deliberately to either make money through the number of clicks, or to cause confusion or discontent or as sensationalist propaganda. These stories tend to be distributed through imposter news sites designed to look like 'real' news brands, or through fake news sites. They often employ videos and graphic images that have been manipulated in some way[11].

As for sources of fake news, three are three kinds of fake news.

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[11] Nicola Watts. "5 Types of 'Fake News' and Why They Matter" *Ogilvy,* https://www.ogilvy.com/feed/5-types-of-fake-news-and-why-they-matter/. Accessed 5 July 2018.

1) Journalism: Some journalisms use exaggerated comics or large headlines to attract people and make more money. Their stories are filled with unreliable information, and this information can mislead audiences without checking all the facts. Traditionally it is like Yellow Journalism.

2) Politics: People in power will show you what they want you to see and tell you stories that are created to deliberately mislead audiences, which promotes a biased point of view or particular political cause. They use fake news to make propaganda or attack their opponents.

3) Jokers on social media: People on social media posts some ambiguous photos or words to get more followers or become famous. This kind of news is always fun, but it is not real.

2.3 Hardware Review

2.3.1   VR Devices

VR Headset is a head-mounted device for users to explore in the VR scene. All current VR devices contain three necessary parts: the stereoscopic head-mounted display, stereo sound, and head tracking sensors. On the stereoscopic display, different images are shown at the positions corresponding to the left and right eyes. The parallax between the left and right eyes will provide 3D visual effects to the user. Since it is difficult for a human to look at the head-mounted display that is 3 to 7 cm away from the eyes, there are two lenses set between the display and the human eyes to bend and adjust the light to a correct angle, which makes it easier for users to see the image[12]. The head tracking sensors are used to track the user's head or eye movements, adjusting images on display accordingly to reflect the changes in perspective[13].

[12] "How Lenses for Virtual Reality Headsets Work". *VR Lens Lab*, 2016, https://vr-lens-lab.com/lenses-for-virtual-reality-headsets/. Accessed 5 Apr 2020.
[13] Strickland, Jonathan. "How Virtual Reality Works". *Howstuffworks*, https://electronics.howstuffworks.com/gadgets/other-gadgets/virtual-reality.htm. Accessed 5 Apr 2020.

Depending on whether an external device is required to run the VR device, VR headsets can be divided into two categories: standalone headset and tethered headset (Figure 2-1 shows the categories of VR headsets). These two kinds of devices have their advantages and disadvantages. In this article, the superiority and the drawbacks of the two kinds of devices in the field of VR games are mainly discussed.
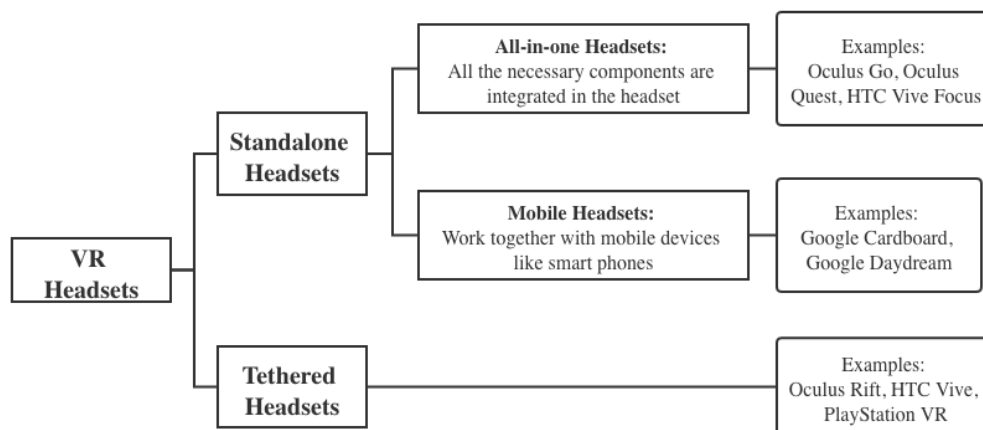
Figure 2-1 Categories of VR headsets

1) Standalone Headset

The VR headsets that can work independently without the assistance of other devices are categorized as the standalone headsets. All the components needed to run the VR program，including the built-in display processor and battery, as well as tracking sensors are integrated into such headsets[14]. Some good examples are Oculus Go (Figure 2-2), Oculus Quest (Figure 2-3) ，and HTC Vive Focus.

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[14] Ratushnyi, Yevhenii. " Why You Should Give Up on PC VR and Focus on Standalone VR Apps". *Visartech Blog*, 2019, https://visartech.com/blog/advantages-of-standalone-vr-over-pc-vr/. Accessed 5 Apr 2020.

Figure 2-2 Oculus Go

Figure 2-3 Oculus Quest

The mobile headset is a branch of the standalone headset. Different from the all-in-one headset, the mobile headset is a shell with special lenses that pairs with the smartphone to provide the user with a VR experience[15] [16]. The images are displayed on the screen of the phone and the gyroscope in the smartphone is used as the sensor to track head movements. Google

[15] Bardi, Joe. "What Is Virtual Reality? VR Definition and Examples". *Marxent*, 2020, https://www.marxentlabs.com/what-is-virtual-reality/. Accessed 5 Apr 2020.

[16] Vitillo, Antony. "What Is Standalone Virtual Reality, And Why Are Enterprises Betting On It?". *Isaca.Org*, 2018, https://www.isaca.org/resources/news-and-trends/isaca-now-blog/2018/what-is-standalone-virtual-reality-and-why-are-enterprises-betting-on-it. Accessed 5 Apr 2020.

Cardboard (Figure 2-4), Google Daydream (Figure 2-5), Samsung Gear VR, etc. are this kind of headsets.

Figure 2-4 Google Cardboard

Figure 2-5 Google Daydream

2) Tethered Headset

The tethered headset works with an external device, like a robust PC or a video game console. It acts as a display while the images are generated from the graphic card of the PC[17]. For most tethered headsets, external sensors are needed to help track the user's position accurately, which enables the user to virtually walk around in the virtual environment. Some great examples are the Oculus Rift (Figure 2-6), HTC Vive (Figure 2-7)，and Sony PlayStation VR (Figure 2-8).

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[17] "Virtual & Augmented Reality Capabilities". *Neumatic*, https://www.neumatic.com/virtual-reality-augmented-reality-technologies/#TetheredVR. Accessed 5 Apr 2020.

Figure 2-6 Oculus Rift

Figure 2-7 HTC Vive

Figure 2-8 Sony PlayStation VR

3) Comparison

As a VR device, firstly the user's game experience and whether the experience can harm the user's health should be taken into consideration. Research shows that technical aspects，including mismatched motion[18], the field of view[19] and motion parallax[20] can lead the user to VR sickness. These factors that cause VR disease are closely related to the refresh rate, resolution of the display in the VR headset, and the range of the user's viewing range in the VR headset. Table 2-1 shows the parameters of some of the most popular VR headsets. From the chart, we can find that the refresh rate of the listed tethered headsets is higher than that of standalone headsets while the resolution of the display of the listed all-in-one standalone headset is higher than that of tethered headsets.

Category	Name	Release Date	Resolution of display (per eye)	Refresh rate(Hz)	Range of viewing angle	Price (On release date)
Standalone Headset	Google Daydream	10/17/2018	Depends on mobile phone	Depends on mobile phone	100°	$99.99
	Oculus Go	05/01/2018	1280 x 1440	72	100°	$199
	Oculus Quest	05/21/2019	1440 x 1600	72	100°	$399
	HTC Vive Focus	01/2018	1440 x 1600	75	110°	$599
Tethered Headset	HTC Vive	04/05/2016	1080 x 1200	90	110°	$399
	Oculus Rift	03/28/2016	1080 x 1200	90	94°	$399
	PlayStation VR	10/01/2016	960 x 1080	90	100°	$299(Controller sold separately for $99)

Table 2-1 Comparison of VR headsets

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[18] Groen, Eric L., and Jelte E. Bos. "Simulator sickness depends on frequency of the simulator motion mismatch: An observation." *Presence: Teleoperators and Virtual Environments* 17.6 (2008): 584-593.
[19] Lin, JJ-W., et al. "Effects of field of view on presence, enjoyment, memory, and simulator sickness in a virtual environment." *Proceedings ieee virtual reality 2002*. IEEE, 2002.
[20] Jinjakam, Chompoonuch, and Kazuhiko Hamamoto. "Study on parallax affect on simulator sickness in one-screen and three-screen immersive virtual environment." *Proceedings of The School of Information and Telecommunication Engineering Tokai University* 4 (2011): 34-39.

Besides, the segment of users is also a significant factor we should consider. Compared with standalone headsets, the tethered headsets have higher requirements for the external device and are more difficult for users to use, which leads to a small segment of users.

Finally, in order to better cooperate with gesture recognition, the compatibility of the development platform is also essential. Because standalone is a head-mounted device that integrates the running software with the display device, it subjects to many restrictions on the development platform. The tethered headset runs on the external device, so it has better compatibility with the device that is used to capture hand gestures.

2.3.2 Hand Gesture Capture Device

There are many types of devices that can be used to capture hand movements and recognize gestures. They can be divided into two categories based on the technology and input devices they use: wearable devices and vision-based devices.

1) Wearable device

There are two types of wearable devices: sensor-based wearable devices and glove-based devices. Sensor-based devices capture hand movements by utilizing sensors such as accelerometers, gyroscopes, and various other micro-electro-mechanical systems [21]. They capture gestures by capturing and recognizing signals of hand movements. These sensors are not limited to use on the hand but can also be used on any part of the human body that can capture the motion signals of the hand. Glove-based devices collect the rotation and position data of hand motion and send it to the computer in real-time by using multiple inertial as well

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[21] Eisenberg, Aviram. "Gesture Recognition Technology and Its Importance In VR". *Appreal-Vr.com*, https://appreal-vr.com/blog/gesture-recognition-in-virtual-reality/. Accessed 12 Apr 2020.

as magnetic tracking devices[22][23]. Apart from capturing and collecting data, glove-based devices can induce tactile feedback by using haptics technology[24][25]. The chart 2-2 shows some examples of wearable devices and the technologies they based on.

Type of device	Name	Technology
Glove-based device	DataGlove	Use 15 optic flex sensors to measure the fingers' bending degree and use the magnetic digitizer to track the wrist[26][27].
	CyberGlove III (Figure 2.3.2-1)	Use up to 22 sensors (3 flexion sensors per finger, 4 abduction sensors, and 1 palm-arch sensor) based on HyperSensor^{TM} patented technology. The precision reaches one degree[28].
	5DT Data Glove Ultra	Instrument each finger with up to 2 sensors to measure the flexure as well as 4 sensors to measure the abduction between fingers[29].
	Manus Prime One VR Glove	Use 12 sensors to measure hand orientation thumb orientation and flexion of the knuckle and top joint of each finger[30].
	Hi5 VR Glove	Use 9-DPF IMU sensors for precise hand orientation. Each wrist is instrumented with a programmable vibration sensor to give haptic feedback. The latency is less than 5ms[31].

[22] Ibid, access date 04/12/2020

[23] Yang, L. I., et al. "Gesture interaction in virtual reality." *Virtual Reality & Intelligent Hardware* 1.1 (2019): 84-112.

[24] Ibid

[25] Oscillate, John. "List of Hand Tracking Tech For VR". *Virtualrealitytimes.Com*, 2017, https://virtualrealitytimes.com/2017/02/15/list-of-hand-tracking-tech-vr/. Accessed 12 Apr 2020.

[26] Fisher, Scott S. "Telepresence master glove controller for dexterous robotic end-effectors." *Intelligent Robots and Computer Vision V*. Vol. 726. International Society for Optics and Photonics, 1987.

[27] Zimmerman, Thomas G., et al. "A hand gesture interface device." *ACM SIGCHI Bulletin* 18.4 (1986): 189-192.

[28] "Cyberglove III". *Cyberglove Systems LLC*, http://www.cyberglovesystems.com/cyberglove-iii/. Accessed 12 Apr 2020.

[29] "5DT Data Glove Ultra". *5DT*, https://5dt.com/5dt-data-glove-ultra/. Accessed 12 Apr 2020.

[30] "Manus VR. n.d. Prime One Gloves". Manus, https://manus-vr.com/prime-one-gloves/. Accessed 12 April 2020.

[31] "Home | Hi5 VR Glove". Hi5vrglove.Com, https://hi5vrglove.com/. Accessed 12 Apr 2020.

	Gesture Wrist	A wristband-type input device that combines the capacitance sensing technique with the acceleration sensor. Recognize hand gestures by capacitively measure the changes of the arm shape and measure the forearm movements by using an acceleration sensor[32].
Sensor-based device	Myo armband	Use the EMG electrodes to detect forearm's muscle activity and use the IMU to measure the user's forearm movements in three dimensions[33].

Table 2-2 Examples of wearable-based devices

2) Vision-based device

Vision-based devices capture hand movements by using various types of cameras (monocular cameras, multi-view cameras, and depth cameras) and recognize gestures by using computer vision, machine learning, and deep learning technology[34]. The cameras are used as computer vision acquisition devices and the image data are processed and analyzed by the computing system in real-time. Monocular cameras including color cameras and infrared cameras are commonly used in the early vision-based gesture interactions. Since it is hard to get the gesture information in 3D spaces, it depends more on the computer vision technologies to get higher accuracy of gesture recognition. The multi-view camera captures hands from multi positions and perspectives at the same time. These cameras construct a coordinate system, and by calculating the relative positional relationship between the captured object and each camera, the shape of the object in the 3D space can be inferred so that the gestures can be

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[32] Rekimoto, Jun. "Gesturewrist and Gesturepad: Unobtrusive wearable interaction devices." *Proceedings Fifth International Symposium on Wearable Computers*. IEEE, 2001.
[33] Visconti, P., et al. "Technical features and functionalities of Myo armband: An overview on related literature and advanced applications of myoelectric armbands mainly focused on arm prostheses." *International Journal on Smart Sensing and Intelligent Systems* 11.1 (2018): 1-25.
[34] Yang, L. I., et al. "Gesture interaction in virtual reality." *Virtual Reality & Intelligent Hardware* 1.1 (2019): 84-112.

recognized[35]. Depth camera detects objects in 3D space by using a dedicated image sensor, based on the light pulse technology. It combines the camera with the light pulse, which helps calculate the 3D information from the 2D image[36]. The table 2-3 compares some examples of the vision-based devices that can be used in VR.

Type of camera	Name	Technology
Multi-view camera	Leap Motion Controller	Use two image sensors and three inferred emitters to get the positions of 20 finger joints per hand, the palm, and the wrist[37].
	Fingo	Provide both inside-out hand tracking as well as 6DOF positional tracking for VR/AR. It can recognize 22 joints of the hand[38].
Depth camera	Kinect	Use an infrared projector together with a monochrome CMOS (complementary metal-oxide-semiconductor) sensor to detect[39].

Table 2-3 Vision-based devices

2.4 Literature Review

Warped Reality is a serious game based on the VR system, and players use their gestures rather than controllers to interact with the game. So, it is crucial to find out how to successfully develop a serious game and make it works smoothly on the VR system.

2.4.1 Serious Game Design

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[35] Ibid

[36] Busck, Jens, and Henning Heiselberg. "High accuracy 3D laser radar." *Laser Radar Technology and Applications IX*. Vol. 5412. International Society for Optics and Photonics, 2004.

[37] "World-Leading Hand Tracking: Small. Fast. Accurate.". *Ultraleap.Com*, https://www.ultraleap.com/tracking/. Accessed 12 Apr 2020.

[38] "Usens, Inc. - Products". *Usens.Com*, https://www.usens.com/technology. Accessed 12 Apr 2020.

[39] Crawford, Stephanie. "How Microsoft Kinect Works". *Howstuffworks*, https://electronics.howstuffworks.com/microsoft-kinect2.htm. Accessed 12 Apr 2020.

The serious game is a kind of game designed for a primary purpose of learning or training a skill rather than total entertainment. Serious games are becoming more critical, particularly in such areas as education, defense, science, or health. Its purpose can be various from training firefighter crews in emergencies to training a sales team, teaching mathematics, or practicing a language.

There is a methodology of designing serious by André F. S. Barbosa. It means all layers can distribute the learning contents. In the game, developers divide it into levels, and each level consists of several learning mechanisms. Players need to finish several quests in each level to get concepts that we want to provide[40]. Figure 2-9 shows the diagram of the methodology. We used this kind of methodology to support our development process.
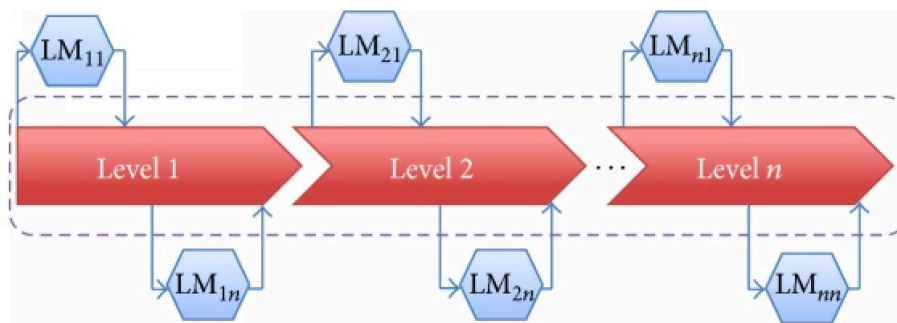
Figure 2-9 Learning mechanisms associated to each layer

2.4.2   Serious Game Analysis

1) The Dragon Cancer

The Dragon Cancer is a serious game designed for missing a little boy who had been diagnosed with a rare and aggressive form of cancer after his first birthday. Players play the game through a first-person perspective, and they can interact with characters in scenes along with making some choices. It is an exploration game, and players have an opportunity to

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[40] André F. S. Barbosa et al, "A New Methodology of Design and Development of Serious Game". *International Journal of Computer Games Technology,* vol 2014, pp. 1-8.

experience the life of that boy. The characters are modeled as polygonal 3D, so there are no facial expressions on their faces. Players could only get the story through gestures, voice acting, and ambient effects[41].

Figure 2-10 *The Dragon Cancer* screenshot

Advantages: *The Dragon Cancer* creates empathy perfectly, which is an essential purpose of serious games, through the simple way of enabling players to explore an unfamiliar environment. It means players are witnesses to how parents feel when their son dies. Through the whole gameplay process, players even feel much more painful than ever before. That is also a great story to tell players that cancer will either touch someone close to them. It is a terrible thing we will confront.

Disadvantages: The game is like a kind of art but not a pure entertainment. Players may feel sad when going through the game. There is not much fun, and all interactions in the game seem to be limited. Complex interactions are not provided because inhibiting atmosphere is what developers want to show us. To be honest, it is a great game but not suitable for all players.

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[41] Rich Stanton, "That Dragon, Cancer review- you've never played anything like it" *The Guardian.* https://www.theguardian.com/technology/2016/jan/18/that-dragon-cancer-review-youve-never-played-anything-like-it
Accessed 18 January 2016.

2.4.3   Reference Game Analysis

1)   Get Bad News

In this game, players aim for the position of disinformation and fake news tycoon. They are fake newsmakers. It will teach players how to make fake news step by step. With successfully posted fake news, players will gain more followers and credibility. We find that most of the fake news this game show is about politics, particularly some words said by President Trump. It provides us with the basic idea to build a game about how to make fake news in America. However, the question is that there is no need to teach people how to make fake news. That is not the thing we want to do. We need to help players raise awareness of the effect of fake news and make them avoid making or spreading that. It will make more sense for a serious game.
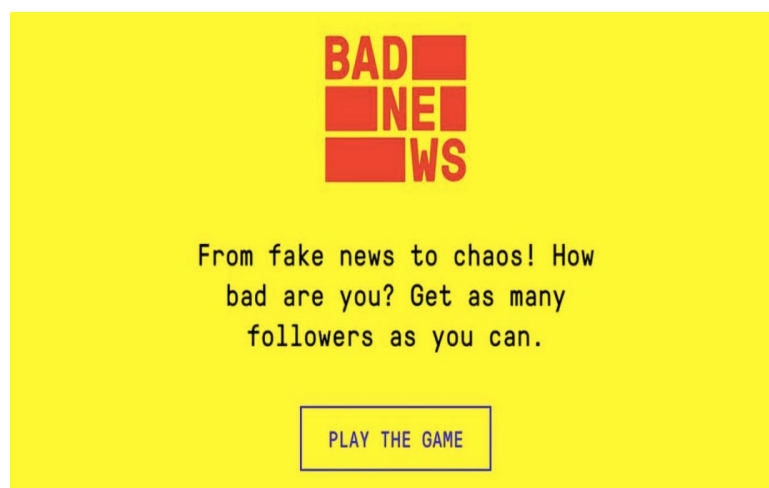
Figure 2-11 *Get Bad News* screenshot 1
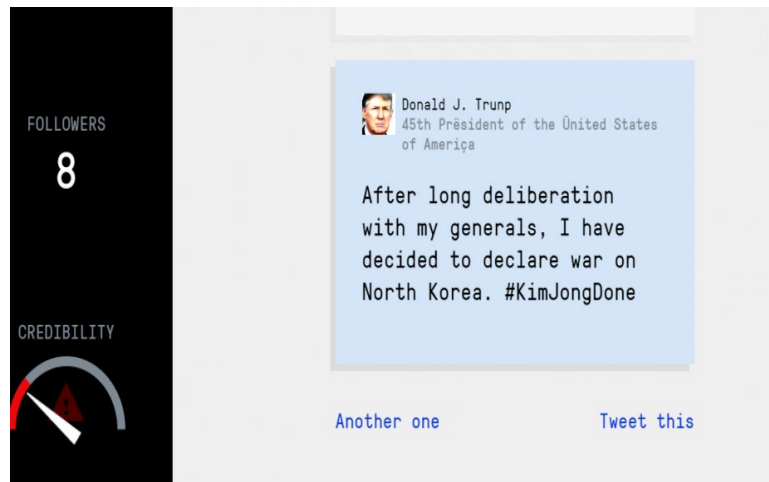
Figure 2-12 *Get Bad News* screenshot 2

2) Factitious

In *Factitious*, what players need to do is to tell the reliability of the news the game system offers. They will earn points when giving correct answers. This is a direct format to show the quantity of news with six different game levels. Each news is described in detail. It utilizes the easiest method to teach players how to tell fake news. Most news in this game is related to American politics.
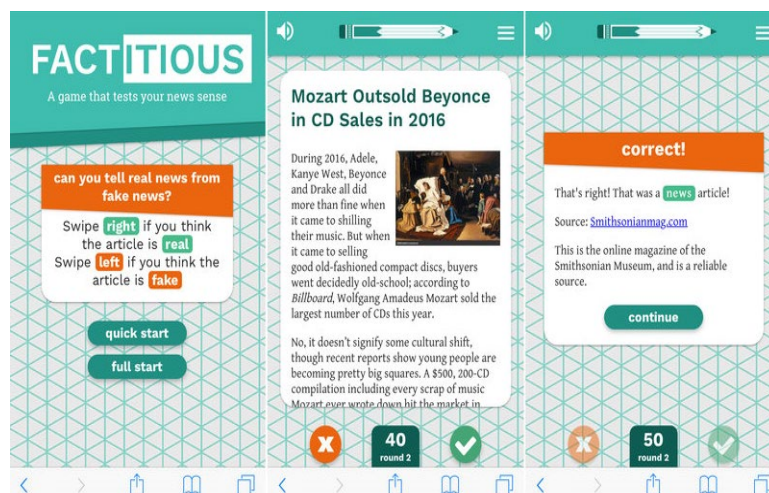
Figure 2-13 *Factitious* screenshot

Get Bad News and *Factitious* are highly representative of most games about fake news. They all based on words description rather than more interactive game mechanics, and the primary purpose is to teach players how to know the difference from fake news and real news.

However, it is still hard for us to think more about fake news. Because the lack of interactivity, we came up with an idea to develop a 3D game of fake news based on the VR system. We want to provide players the opportunity to investigate the truth behind all kinds of news and then make their own choices. It will be more convincing by using 3D settings than words description.

3) Return of the Obra Dinn

Return of the Obra Dinn is exceptional because characters and the environment are all static. Only players can move as an insurance investigator. The primary mechanism of the game is to use a magic compass showed in Figure 2-14 to make the original scenes reappear. Then players could get different stories by walking around and listening to audios. The game is combined with lots of immersive audios and static scenes. Players could hear dialogues when they trigger the reappeared scenes, and scenes in this game do not have any animations. So the story is the most important thing to attract players.
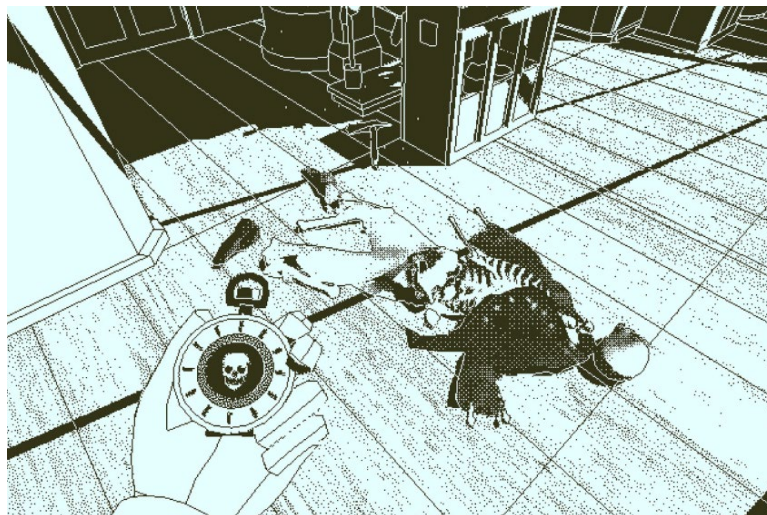
Figure 2-14 Return of the *Obra Dinn* screenshot

To some degree, we got our inspirations from *Return of the Obra Dinn*. It is a great idea to tell stories by such mechanism, and static assets could save us more time to focus on the animation. For *Warped Reality,* we want to provide players with an opportunity to investigate

the truth behind news or photos. So why not make everything back to the original position and let players walk around to see or listen to the truth by themselves?

2.4.4   Interaction Design in Games

1)   Interaction Design in Mobile Games, PC Games and Console Games

In this part, the ways of interaction are analyzed and compared for different platforms like mobile, PC and console, including the way that the character moves, triggers the skills, checks the equipment or inventory, interacts with the object in the game environment, and the way to open the menu.

For mobile and PC games, icons with specific meanings are created in the game interface. Players can click those icons to call functions or jump to other pages or interfaces. Mobile players can touch the icons, and PC players can click the icons with mouse or trigger the function of the icon by using a hotkey. As for console games, or the interactions are performed by using the controllers. Figure 2-15 shows the mobile game interface and Figure 2-16 and Figure 2-17 shows the critical guides of a PC game and a console game respectively.

Figure 2-15 Game interface of the mobile game *Last Day On Earth: Survival*

Figure 2-16 Critical guide of the PC game *PUBG*

Figure 2-17 Control scheme of the console game *Zelda*

There are two ways that the players can move the character in the game. Firstly, players can use joystick or arrow keys to control the directions that the character moves as well as faces. Joystick for mobile games can be placed according to the way that players touch the screen using fingers to make the controlling easier. For console games, the directions of movement and facing are usually controlled separately by two joysticks. The other way is that players can point the target location, which the character would move to automatically, which is used in mobile and PC games.

Skills are usually triggered by clicking specific buttons or keys. Mouse clicking is the fundamental way to trigger skills, while keys on the keyboard are also used sometimes.

To interact with entities in the environment game, players can just click the object to interact for mobile and PC games. For console games, players need to get close to the object and click some buttons to interact.

To check inventory or open menu, mobile players can click icon or swap from different directions while PC players can use a hotkey. For example, tab is always used for inventory

while ESC and backspace are always used to open the pause menu. As for console games, there is always a specific button for jumping to inventory or menu.

2) Interaction Design in VR Games

The interaction design in VR games is related to the type of VR experience. For the diorama experience, players look around the 3D scene from a third-person perspective and is not able to move. For the first-person experience, the player uses controllers to enable himself/herself to move to somewhere he/she wants in the game scene. No physical movement is needed in these two experiences. For the interactive virtual environment experience, the player walks around physically when he/she plays and is able to interact with the objects in the scene by using the controller to "touch" it.

To interact with the objects, players use controllers in original VR. The controllers are used as hands or weapons in the VR games, since their positions can be tracked during playing. Besides, players also use the controller to interact with user interface including inventory and pause menu. Take the VR game *Budget Cuts* for example, as shown in Figure 2-18, one of the controllers becomes the toolbox when the player pressing the touchpad on it and the other can select a tool from the box.

Figure 2-18 Interactive design of the toolbox in the VR game *Budget Cuts*

2.5 Humans Habits of Using Gestures

In order to find an interactive solution that meets players' habits of using gestures, we took a survey for 15 people about the way using gestures, including 9 males and 6 females. 13 of the testers are right-handed while 2 are left-handed. During the survey, the user imagines there is a virtual screen in front of them. Firstly, imagine there is a button on the screen and make action to click the button. Secondly, swap up and down to switch pages. Thirdly, imagine there is a picture on the screen and use a gesture to zoom in and out. To avoid influences of others, keep the tester take the survey alone without others present and show the testers what to do only by language without any gestures.

1) Point

When clicking a button, most people are used to forefinger. 14 persons in the survey used forefinger while only 1 person used middle finger as shown in Figure 2-19. 12 persons in the 14 persons who used forefinger only extended forefinger and kept others making a fist, as shown in Figure 2-20. One of the 14 persons extended thumb and forefinger as shown in Figure 2-21 and one showed a gesture as Figure 2-22.

Figure 2-19 Using the middle finger to point

Figure 2-20 Only extending forefinger and keep others in a fist

Figure 2-21 Extending the thumb and the forefinger
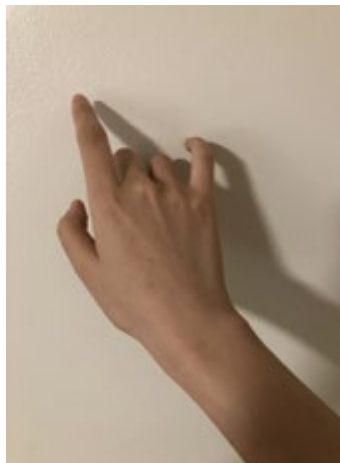
Figure 2-22 Another gesture of pointing with forefinger

2) Swap

There are basically two gestures for swapping. One is using 5 fingers to swap (Figure 2-22), which is used by 7 testers, including 6 males. Another is using only forefinger (Figure 2-23), which is used by the other 8 testers.

Figure 2-23 Using five fingers to swap

Figure 2-24 Using one finger to swap

3) Zoom in and Zoom out

For zooming in and out, there are basically four ways. Firstly, 10 testers used thumb and forefinger as shown in Figure 2-25. Secondly, 2 testers used thumb and middle finger, as shown in Figure 2-26. Thirdly, 1 tester used forefinger and middle finger as shown in Figure 2-27 and finally 2 testers used both hands as shown in Figure 2-28.
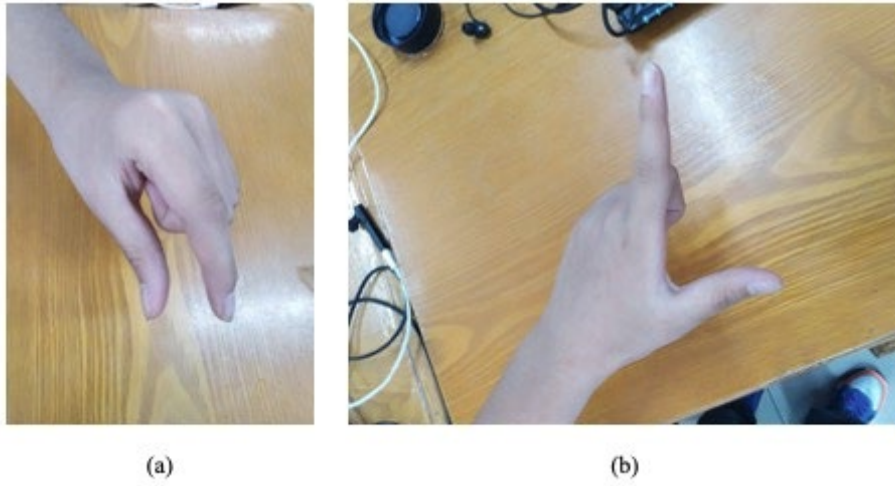
Figure 2-25 Using the thumb and the forefinger to zoom in and out (a) zoom in (b) zoom out
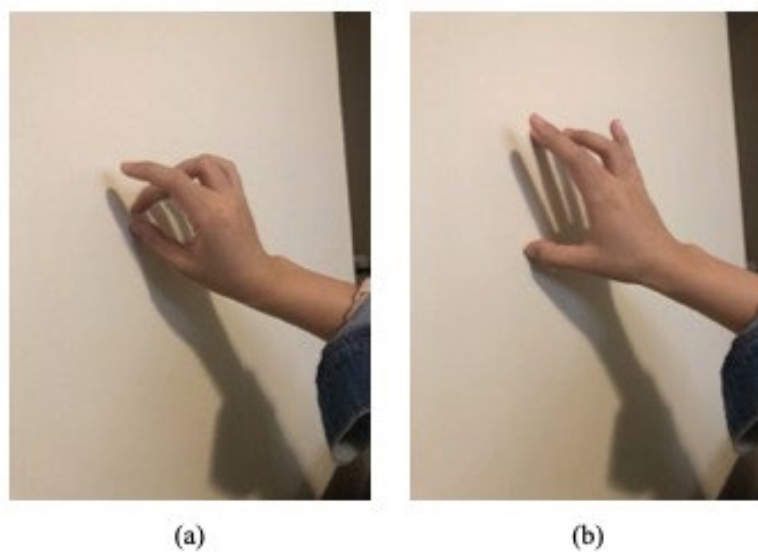
Figure 2-26 Using the thumb and the middle finger to zoom in and out (a) zoom in (b) zoom out
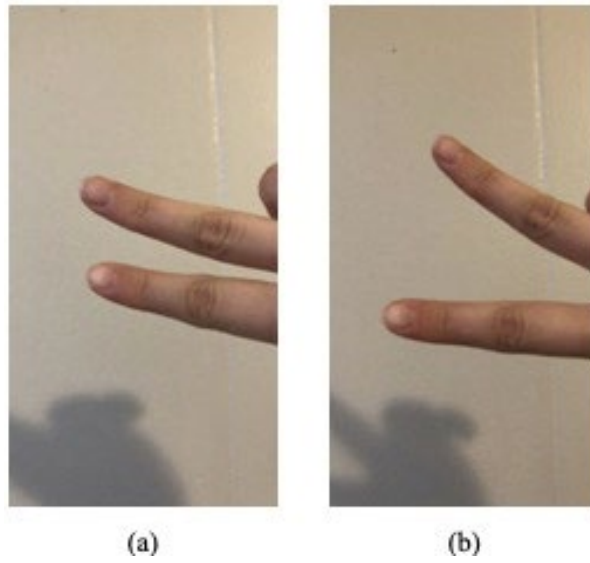
Figure 2-27 Using the forefinger and the middle finger to zoom in and out (a) zoom in (b) zoom out

Figure 2-28 Using both hands to zoom in and out

Chapter 3 Game Design

3.1 Overview

Warped Reality is a 3D serious game that is playable on the VR system. The goal is to help players raise awareness of the effect of fake news. The primary mechanics of the game is a camera mechanics. The game has one tutorial and three levels. The tutorial is meant to teach players how to use gestures to pass the game. On each level, there is an event that happened several days ago and all events are related to a senator Simon. Players need to investigate the single room in each level and then give out their judgments about the truth of the news each level represents. Level1 and level2 are based on fake news. Level3 is real. Finally, when players pass all three levels, they will get a response to show their results and tell them if they are great reporters or fake news makers.

3.2 Design Process

3.2.1 Design Iteration

In the beginning, we noticed several events in social media had harmful effects on many celebrities in both China and America. They received the number of spiteful comments based on the news. We cannot tell the truth of all kinds of bad news related to people we are familiar with. Most social media users were at the same level as us and they just saw the information that the news creators want them to see. However, these users made their comments to criticize these celebrities with thousands of malicious words. Last but not least, we found that the news showed in social media was fake. Their opponents or crazy fans made up stories and photos to attract the eyes of the public, slander the people they did not like, and even blackmail for money. We realized the activities of commenting, reposting, and spreading disinformation could even destroy one's life. Regarding this, we just came up with the idea of developing a serious game

to show this problem. Luckily, we both like taking photos to record our life. So the idea about utilizing the camera mechanism to find the truth behind the fake news just came out.

The practical designing idea did not burst into our brains suddenly. In the first stage, we decided to make a game just like the movie, *Nightcrawler*. It tells a story that a reporter keeps taking photos for emergency accidents about cars, guns, and injuries. The clearer the victims' faces are, the more he gets paid. However, he starts making up accidents, which can be fake news to fool police and citizens for the sake of increasing his reputation. Then we considered to provide players fake photos and let them make up the accident scene that matches the photo. Taking the picture is the last thing they need to do. By showing players how to make fake news by themselves, they may get an idea about the information behind some news. Nevertheless, we ignored one thing of the game's adverse effects. Not only can we teach them to realize the truth behind the fake news, but also players will know how to create fake news. They may become actual fake news makers by enjoying making up accidents in the game. That is not what we want to see. This idea was discarded.

In the second stage, learning from the game, *Get bad news,* we considered adding credibility and followers system to the game. It means players need to post much real news at the beginning to increase their credibility and followers. Then players may start post fake news to make more money. However, they need to balance the benefits, credibility, and their followers. To be honest, that is a complex system and there is a lot of work about the balance of numerical value. We might be not able to focus on our serious meaning if we decided to realize the credibility and followers' system. The idea was discarded either.

Last but not least, we made a decision on our final designing idea and the game, *Return of the Obra Dinn* helped a lot. We realized the game without any animations can make players focus more on the stories. Moreover, using time travel to rebuild the scene is a great way to let

players investigate the events that happened several days ago. That is what we concentrated on during the developing process.

3.2.2   Paper prototype

A Paper prototype can be extremely helpful during the early-stage conceptualizing — when a team needs to explore a variety of different concepts and choose the one that will be used. The paper prototype allows quickly to visualize and test various ideas[42].

Because of the intricate game system, we made several paper prototypes first to prove the mechanism could be work. It is easy to do rapid iteration for our paper prototypes, and we do not need to spend much time on them. Moreover, people feel more comfortable criticizing sketches rather than polished designs. After our advisors examined the game logic, we started the whole work to build our game. Figure 3-1, Figure 3-2, and Figure 3-3 show some pages in the prototype. See the whole paper prototype in Appendix C

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[42] Nick Babich, "The Magic of Paper Prototyping". *UX planet*, https://uxplanet.org/the-magic-of-paper-prototyping-51693eac6bc3 Accessed 1 September 2018.
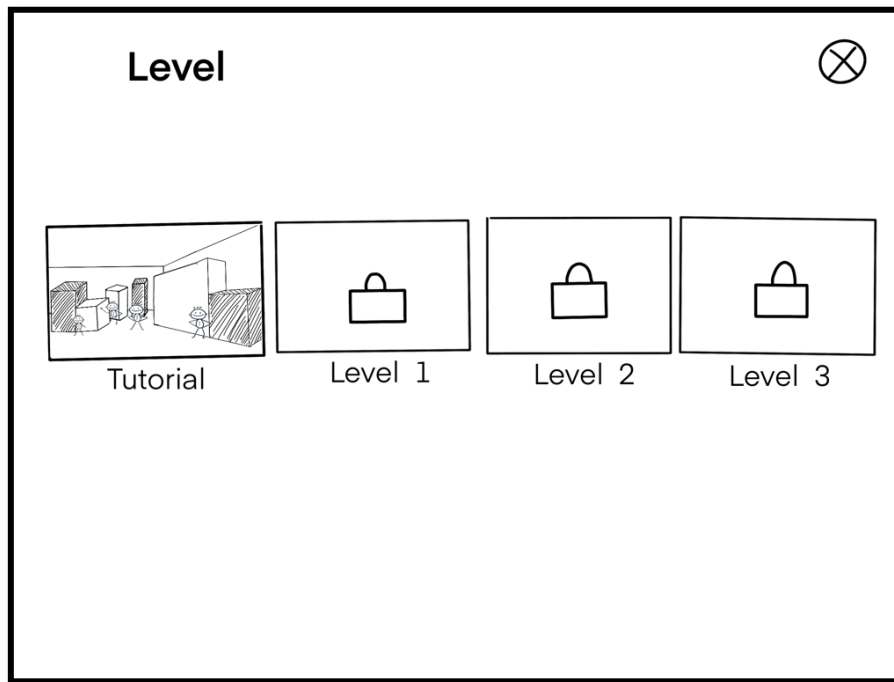
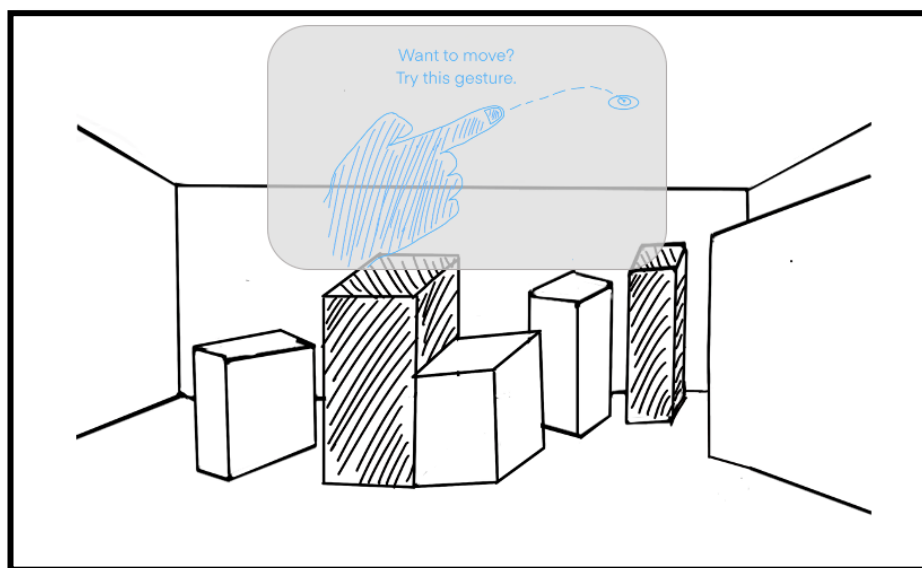Figure 3-1 Level choosing interface

Figure 3-2 *How to move* Instruction
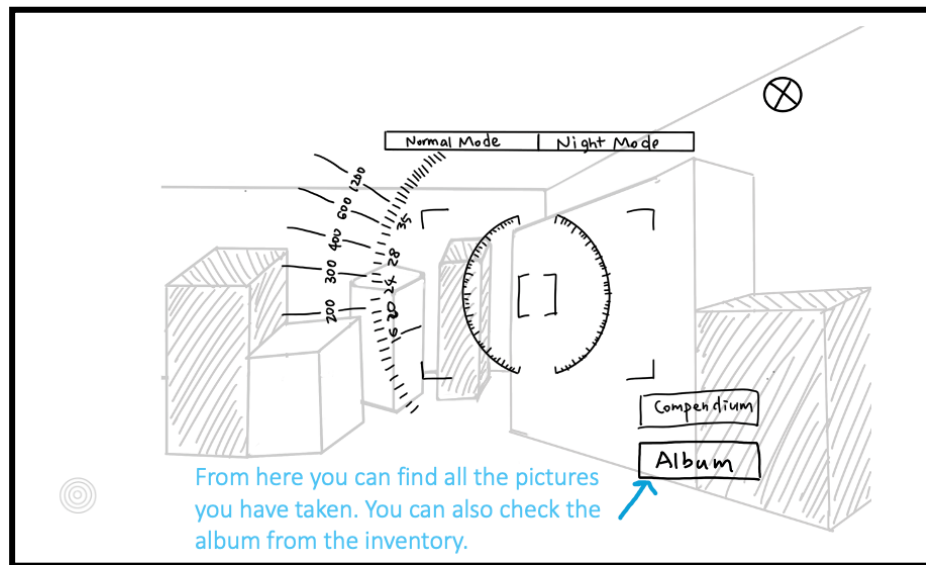
Figure 3-3 Camera interface

3.2.3 Why VR

VR allows players to gain an immersive experience in the virtual environment. They can get an intuitive feeling of being a part of the game so that they can interact with the game objects, characters, and the environment in a meaningful way. This enables players to have the same emotion as the protagonist in the game. He/She may feel that he/she is the protagonist him/herself in the story instead of controlling the protagonist at a bystander's perspective and finally can obtain better educational results. The combination of a sense of immersion and interactivity is called telepresence[43]. Jonathan Steuer defined it in his paper as "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment." [44] In the case of limited and short game time, in the VR environment, players can concentrate and enter the state of the character in the game much quicker, which also allows players to obtain educational meaning in the game efficiently

[43] Strickland, Jonathan. "How Virtual Reality Works". Howstuffworks, https://electronics.howstuffworks.com/gadgets/other-gadgets/virtual-reality.htm. Accessed 5 Apr 2020.
[44] Steuer, Jonathan. "Defining virtual reality: Dimensions determining telepresence." *Journal of Communication* 42.4 (1992): 73-93.

3.3 Game Mechanics

In this game, the primary mechanics is to take photos from the correct perspective. Players need to walk around and find the position that matches the photo we provide to them. The photo we provide consists of two main characters and some unrelated persons. We utilize a special perspective to make visual dislocation for players. So what the photo directly shows to players is different from the thing behind the photo. This is a kind of fake photo.

When players find the correct position, they still need to change to the proper perspective. To help them find the place, we provide a radar at the bottom of the screen. The closer players move to the target, the more significant effect the radar displays. Players then use the gesture of taking photos to take a photo after finding the correct position. Once the photo matches, the original scene that is the same as the photo we provide will reappear. Now players can not only get the photo's condition, they can but also investigate the whole room to see what the truth is behind this photo.

3.3.1   Storytelling

The story in this game is about a senator named Simon. In the first level, senator Simon is holding a Town Hall meeting with many citizens to talk about the regulation of guns, questions of the medical insurance, and the security of the society. After the meeting, senator Simon stands in front of the audience to answer some questions and he is surrounded by reporters. The first photo is captured when the senator stretches his arm with the words "We will make it!" and a reporter closed to the senator is scared by a cat. It looks like the senator punches that reporter since the cat is invisible from the photographer's perspective. It will attract many citizens once the photo is published with some descriptive words. How could the senator punch a citizen?

In the second level, senator Simon is in a restaurant. It seems like he is dating a woman but not his wife. Actually, lots of people know this woman because she is the daughter of the biggest Arms Dealer, Johnny, in the country. Johnny's daughter, Chris, is here to talk about cooperation, since Johnny does not want to show up. Senator Simon wants to seek financial support from Johnny to implement his policy and it would be helpful for him to win in the upcoming presidential election. It is a regular meeting. However, from the photographer's perspective, they are kissing! Senator is kissing with a woman but not his wife. That will be a scandal if the photo is published.

In the third level, senator Simon is in a hotel. This time he meets with Johnny to discuss some details for cooperation. Johnny agrees to support him, but he requires to get permission to use all ports to transport his cargo. That is a dangerous transaction because Simon knows some stuff Johnny wants to transport is illegal. Although Simon needs financial support, he will never break the law to achieve his target. He is so angry because of Johnny's unreasonable requirement. He thinks he is fooled and then he punches Johnny with all his energy. So this photo shows that Simon punches Johnny is a real photo. It is a real punch.

3.3.2   Tutorial

Since the usage of gestures in VR is rare, enable players to remember all the gestures and master the way of interacting in a brand-new game mechanism is the design goal of our tutorial. Many gestures needed to be included in the tutorial, so what is the sequence of these steps is the first problem that we should consider. Figure 3-4 shows the whole process of the tutorial. Our idea is to arrange the steps in the sequence that fixes the habits of a new player. We tested several times and found that when a new player is in a virtual room, the first thing he/she would like to do is to move and look around. Putting the moving gesture at the first step satisfied the player's willingness to walk around, as well as reminding them there is no need to

use their own feet to walk, which helps avoid physical hurts in the real world. And then, we told the player how can they get the main menu so that they can quit or pause the game anytime they want during the game. The following steps follow the sequence of game-playing, which not only teaches the gestures to the player but also let the new player know clearly about the game flow.

Different from the simple operation of pressing the button, the gesture operation requires the player to use the correct gesture. Therefore, it is crucial to make it easier and clear for players to understand what the right gesture is like. We use the animation to show the gestures instead of using static pictures, which allows the player to understand the correct movements of gestures more clearly and not only intuitively but also dramatically reduces the use of descriptive texts in the tutorial. What the player needs to do is just watching and intimating the movements of hands rather than read the text and the static pictures then try to understand what the correct gesture should be like. Besides, for some details that the player may ignore in the animation like which hand they should use to make the gesture, we still keep the text and remind the player to pay attention to so that mistakes can be avoided.

We also make efforts to help players better master these gestures. Firstly, from playtests, we found that the moving gesture is the most difficult one to master. So, we made three goals and asked players to move to these goals one by one. We help the player to master the gesture by many practices, which also avoids the situation where the player just accidentally made the correct gesture instead of grasping it. Secondly, to let players focus on learning to use the gesture, we reduced the difficulty of completing the tutorial level. We used hints to help players find the target place and remind them when they arrived at the target.
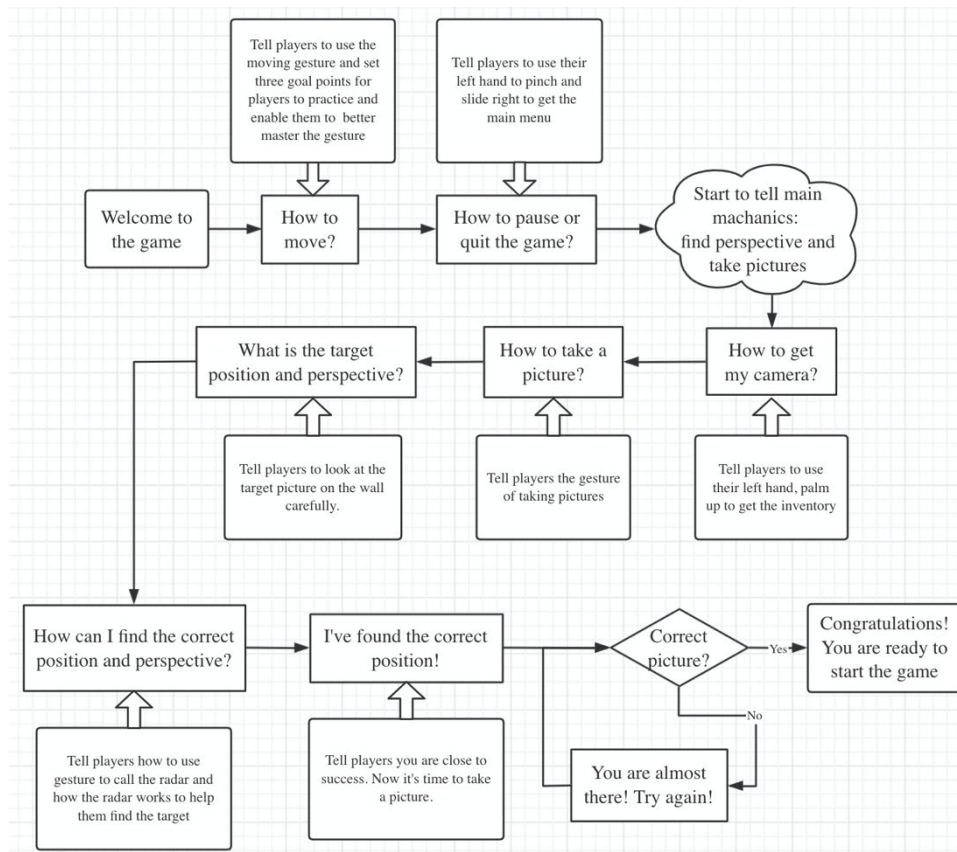
Figure 3-4 Steps of the tutorial

3.3.3 Levels

We had considered building three levels before we started. Because we thought it was not enough for us to tell a complete story that has the power to affect players. The first level could consist of an insignificant event just like a famous underage singer is smoking and the event at the last level could be highly dangerous to affect the country's politics. We want to provide players with the experience to enter into the situation gradually and it will be more immersive. However, our game is planted on the VR system and we need to limit the playing time to 30 minutes for each player because of dizziness caused by VR. No one would like to get a one-hour VR experience. We could not make the game as large as possible. After some playtests, we found the tutorial cost much time than what we had imagined since using gestures in the VR system was new stuff for most of the players. They need time to learn it and be

familiar with it. So finally, we got the idea to make it three levels and one tutorial to control the time.

3.3.4   Level Flow

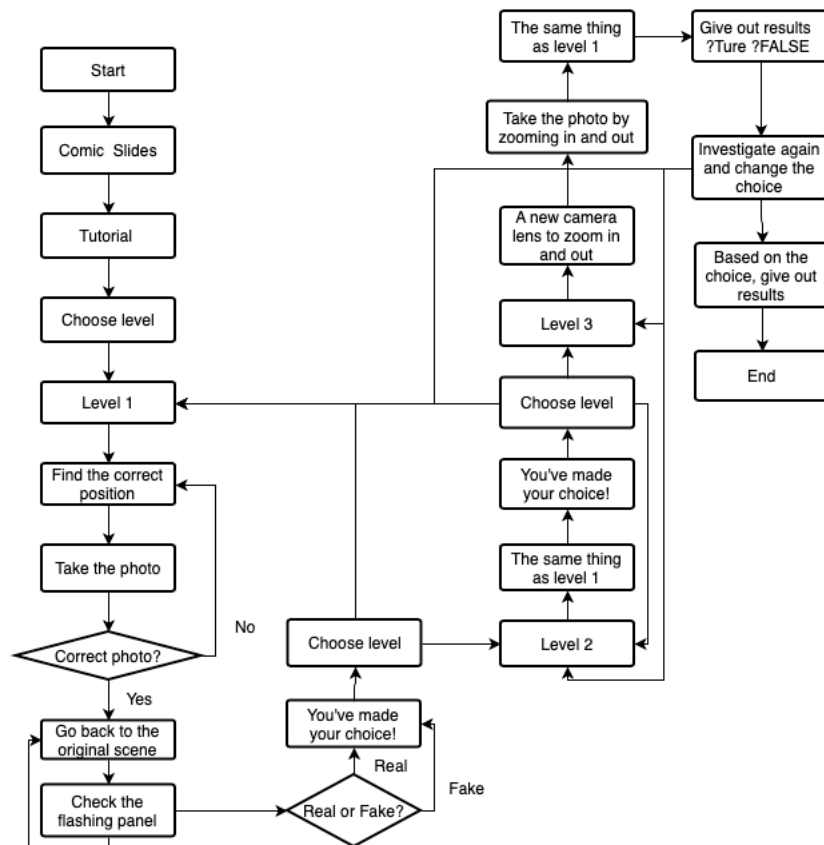Figure 3-5 shows the level flow

Figure 3-5 Level flow

3.3.5   Completion Condition

In the tutorial, players need to follow instructions step by step. Each time they do the correct thing as the instruction, they will get a "Ding-Dong" audio feedback to be reminded. One instruction is related to one completed condition. As for movement instruction, players need to move three times after seeing the instruction because we want players to be familiar

with the movement. That is the essential thing in this game. When players finish all instructions, they complete the tutorial.

In the next three levels, players need to find the correct perspective and take photos. Once they enter into the original scene that shows in the photo, they are asked to make their choice, to tell the truth of the news. There is a panel with the flashing light to show the descriptive words for the photo and players need to make their choice on this panel. Once the choice is made, they finish that level.

After they finish the tutorial and all three levels, there will be an interface to show the result players get and players can choose to enter into each of three levels again to investigate. Moreover, it is permitted to change their choice after investigating again. Then players will be given the final result. Table 3-1 shows four results players may get.

3 True, 0 False	Great! You are a responsible reporter!
2 True, 1 False	You are almost there!
1 True, 2 False	Take care of your terrible thought!
0 Ture, 3 False	Are you serious? You are a fake news maker now!

Table 3-1 Four results for players

3.4 Gestures Design

A set of gestures is designed for the game, containing gestures to interact with the game objects and gestures to interact with the game UI. All the gestures are designed following three principles:

1) Easy to learn. The gestures should be as intuitive as possible for players to understand the meaning[45]. Besides, it is essential to limit the number of gestures and make it easier for players to master and remember.

2) Easy to use. Ergonomics should be taken into consideration in gestures design. The gestures need to be easy for players to perform and will not lead to fatigue[46].

3) Avoid conflicts among gestures. Similar gestures can make players confused when playing the game, as well as increase the error rate of recognition.

In order to make it easier for players to distinguish gestures and corresponding functions, the gestures to operate with the game are mainly concentrated on the right hand, and the gestures that interact with the game UI are mainly designed on the left hand.

3.4.1 Gestures to interact with the game

Three gestures are designed to interact with the game, executing three main functions, including moving, taking pictures, and zooming in and out.

1) Moving gesture

As shown in Figure 3-6, to distinguish it from the "point" gesture, the player raises the thumb up to make a gun-like gesture and uses the index to aim at the target place he would move to.

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[45] Spillers, Frank, and Ditte Hvas Mortensen. "How to Design Gesture Interactions For Virtual And Augmented Reality". *The Interaction Design Foundation*, 2020, https://www.interaction-design.org/literature/article/how-to-design-gesture-interactions-for-virtual-and-augmented-reality. Accessed 25 Apr 2020.

[46] Tauziet, Christophe. "Designing for Hands In VR". *Medium*, 2016, https://medium.com/facebook-design/designing-for-hands-in-vr-61e6815add99. Accessed 25 Apr 2020.
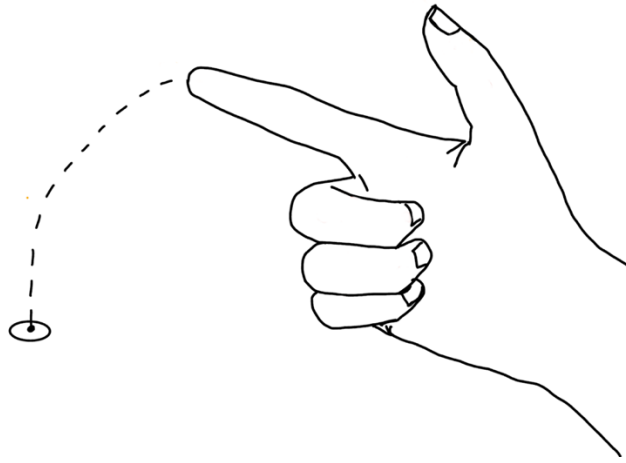
Figure 3-6 Moving gesture

2) The gesture of taking pictures

Figure 3-7 shows the gesture of taking pictures. The player uses both hands to make this gesture, with one palm facing outward and the other palm facing himself. It does not matter whether the left hand is facing outwards, the right hand is facing inwards, or the right hand is facing outwards, and the left hand is facing inwards so that the player can make the gesture comfortably and freely.
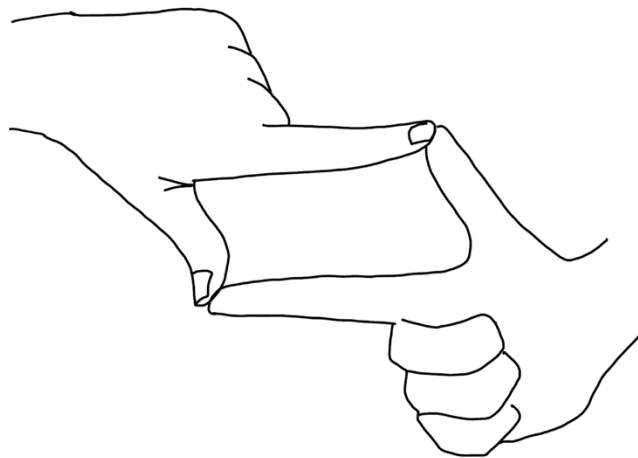

Figure 3-7 Gesture of taking pictures

3) The gesture of zooming in/out

In the zooming gesture, the player firstly pinches to call the slide bar, then slides up to zoom in and slides down to zoom out.

3.4.2   Gestures to interact with the game UI

There are three gestures to call the game UI, including the game menu and the inventory. Then, the player can quit or pause the game in the game menu and choose the tool from the inventory by clicking buttons on the game interface. All these gestures are not only designed for this game but can also be used in all the gesture-controlled VR games.

1) The gesture to call the menu

The gesture of calling the menu is designed following the players' habits of using the touch screen device. The player firstly pinches then swipe right to call the game menu. After pinching, a blue circle appears in the scene, showing that the menu is ready to be called, which avoids mistaking the player's unintentional hand movements as the command to call the menu.

2) The gesture to call the inventory

The design of gesture to call the inventory refers to the example of interface interaction that comes with the Leap Motion SDK. As shown in Figure 3-8, the player holds the hand up with the palm facing himself. The inventory displays next to the hand and follows the movements of the hand.
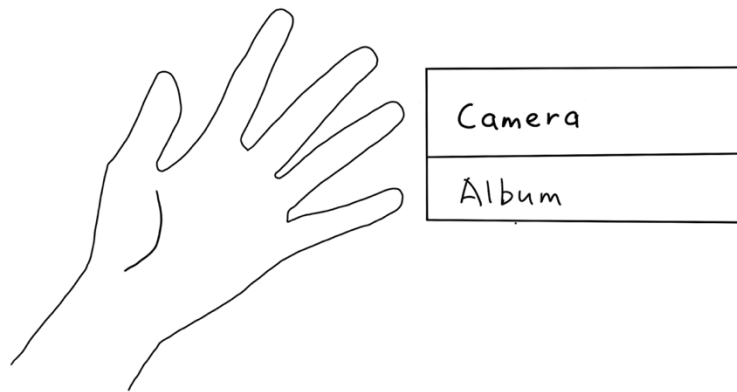
Figure 3-8 Gesture of calling the inventory

3) The gesture to call the radar

Figure 3-9 shows the gesture to call the radar. The radar is like the player's watch, so the gesture of calling the radar is the same as the hand movement of looking at the watch in real life.
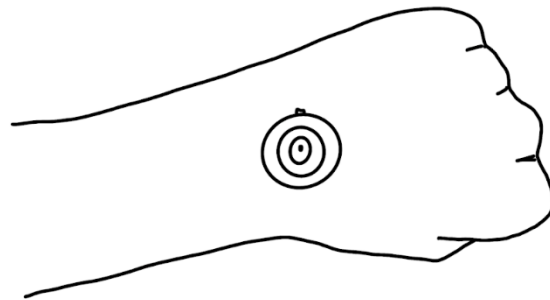

Figure 3-9 Gesture of calling the radar

Chapter 4 Game Art

Since our game is a 3D game, we need to make many 3D models as assets and some 2D pictures as user interfaces. We searched for some art styles of games. Finally, we decided to use two different art styles to form our game style. One is for the environment, and the other is for characters.

4.1 Graphics

4.1.1   User Interface

There are several user interfaces to instruct players in the game. We tried to create our art style related to the topic, Fake News. Considering it is a kind of news, we just searched for art assets about the news. The newspaper came into our minds. Besides, the primary mechanism of the game is to go back to the original scene and investigate the truth. The events happened in the past. So we thought using the vintage art style for interfaces was a great idea. Then we searched for the reference art of old newspapers. Figure 4-1 shows that. The underlying color tone is dark yellow. Finally, we created the entering interface, the level choosing interface, and the transition interface as shown in Figure 4-2, Figure 4-3, and Figure 4-4.

Figure 4-1 Old newspaper

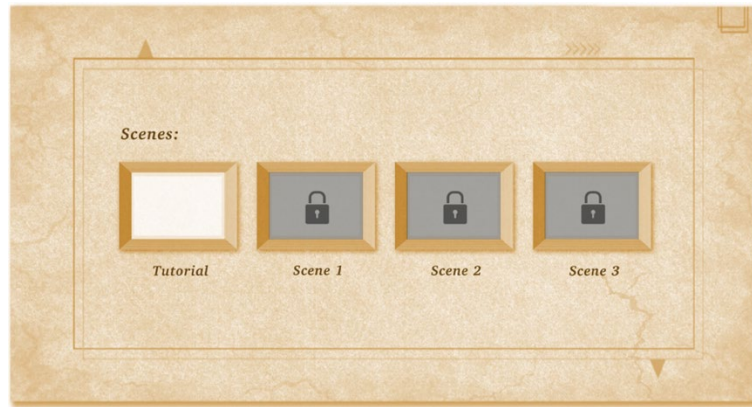Figure 4-2 Entering interface concept art

Figure 4-3 Level choosing interface

Figure 4-4 Transition interface

As for tutorial interfaces, we combined the picture of gestures and introductory words to form the instruction. Figure 4-5 shows the first draft of the moving instruction, and Figure 4-6 shows the first draft of the camera using instruction. We drew the gestures to instruct players on how to perform these gestures. With descriptive words, we had believed it would be clear for players, and they could finish the game. However, the first draft was so ambiguous that it could not pass the correct way to play the game for players.
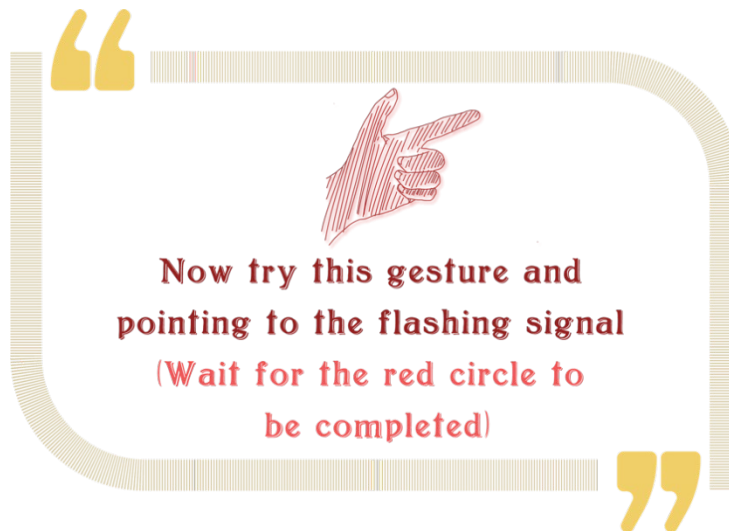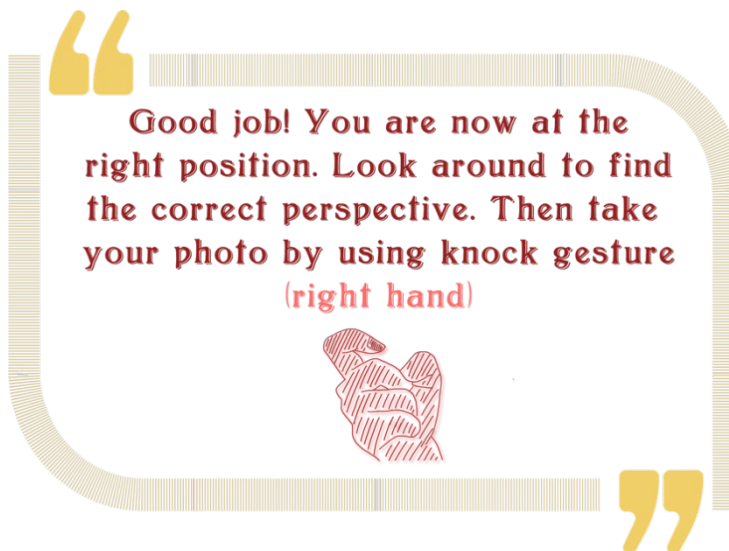
Figure 4-5 First draft of moving instruction

Figure 4-6 First draft of camera using instruction

There are several problems after our first playtest:

1) The color of instructions is not suitable for players to read. It is not clear in VR

2) The transparency of instructions is too low

3) Players always do not realize they can put their hands down after using one gesture, just like the palm gesture. If instructions do not tell them to put it down, they will not.

4) The 2D pictures send limited information. For example, although players realized they should use gun gestures to move, they did not figure out what directions they should point to. They may think they should point left with the gun gesture based on the picture rather

than point forward. Besides, the knocking gesture is not apparent either, and there were only three or four players perform this gesture successfully. The others did not realize what the gestures should be. Based on the description, they thought knock gesture is to use their fists to knock just like knocking the door. It is the question of human habits.

To summarize, problems consist of two parts. The first is the appearance, and the other is misleading information. Besides, we need lots of descriptive words because of the limitation of 2D pictures. Then to fix these problems, we decided to utilize 3D models and gif pictures in the instruction. As we can see in Figure 4-7 and Figure 4-8, the animation of 3D models shows how to perform gestures more clearly. Aimed at the problem 4) in the last paragraph, we add models of both the body and the hand so that players can directly understand they should point forward to move. We use gif pictures rather than any video formats to reduce the processing pressure of Unity.

The final version of the tutorial instructions is shown in Figure 4-9. Compared with the first draft, it is clearly displayed in the VR system. Besides, we do not need so many words to describe gestures anymore, which could provide players with better experiences.
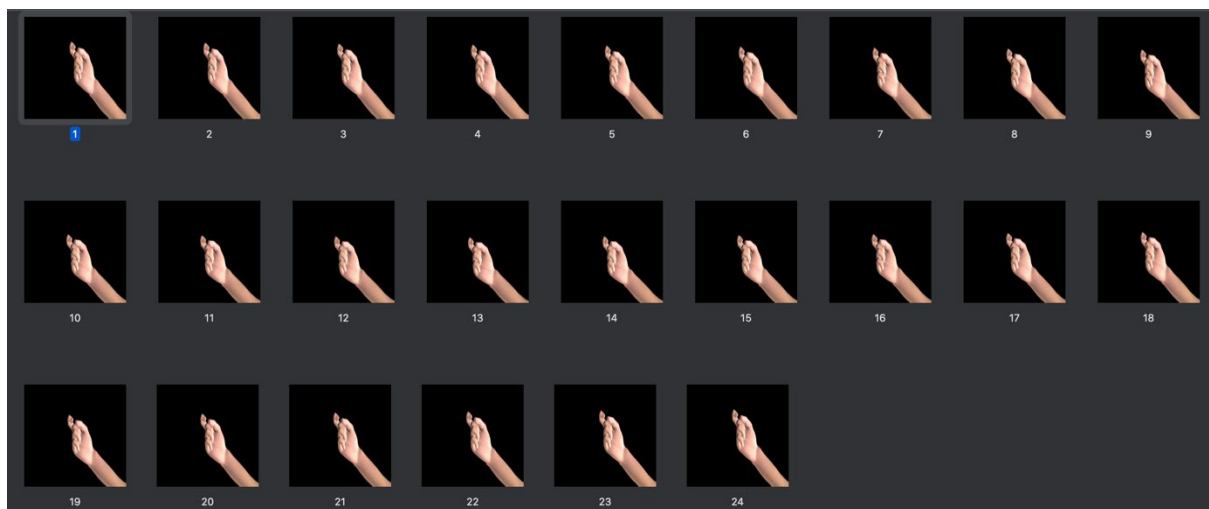

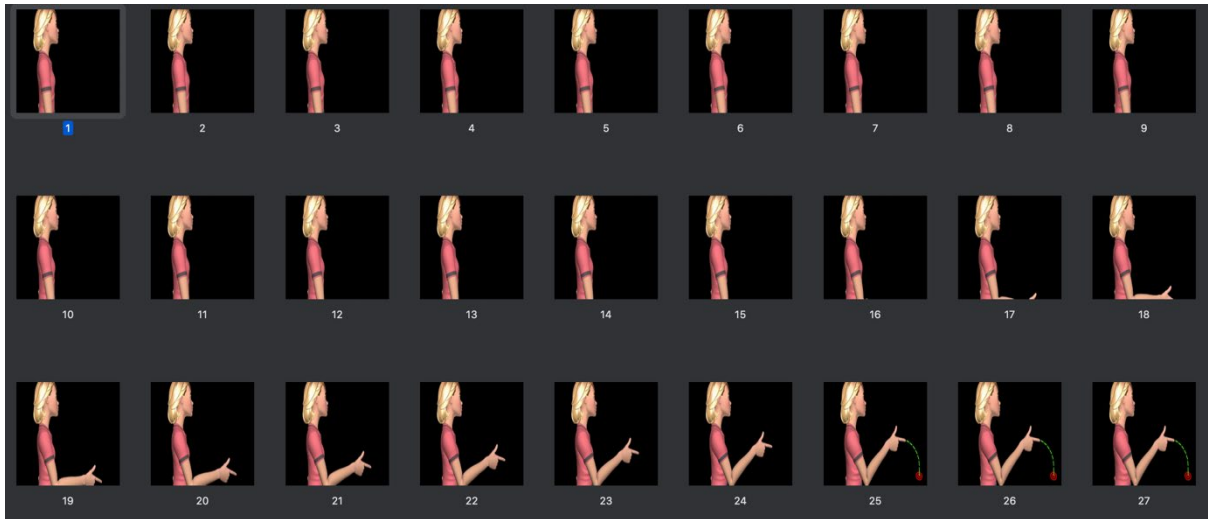Figure 4-7 Second draft of camera using instruction
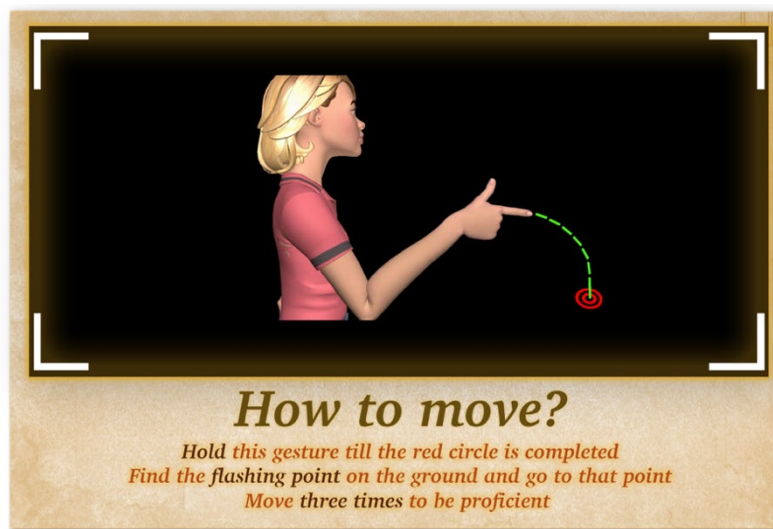
Figure 4-8 Second draft of moving instruction

Figure 4-9 One frame of moving instruction

4.1.2 Comic Slides

To introduce the background story of *Warped Reality,* including player's identity, why players need to investigate the truth, and why players could go back to the original scenes, we created the comic slides to indicate the background story at the beginning of the game. Figure 4-10, Figure 4-11, and Figure 4-12 show that. We made all graphics in Photoshop and imported them into PowerPoint. Then we added some animation effects and exported it as a video.
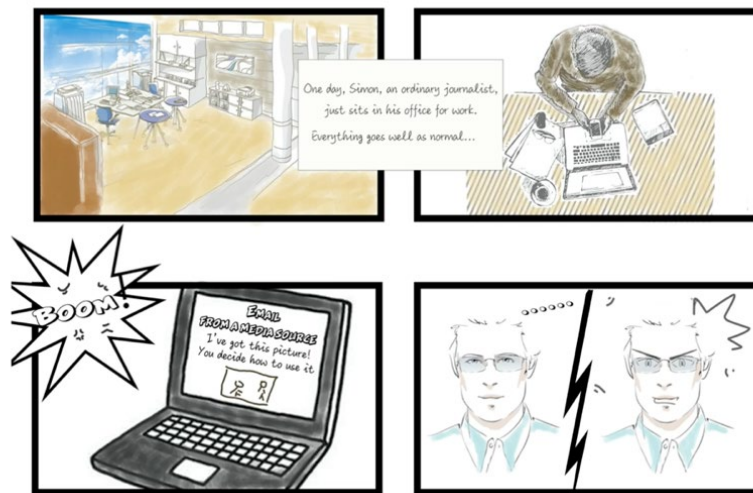
Figure 4-10 The first page of comic slides

Figure 4-11 The second page of comic slides

Figure 4-12 The second page of comic slides

4.2 3D Models

Warped Reality is a 3D game, so it consists of a quantity of 3D assets. We made assets in levels of realistic style. Three levels are all interiors scenes. The first level is a large meeting room. It consists of assets, as shown in Figure 4-13. The second is a restaurant, and the assets in it is shown in Figure 4-14. The third is two rooms in a hotel and assets in it is shown in Figure 4-15.
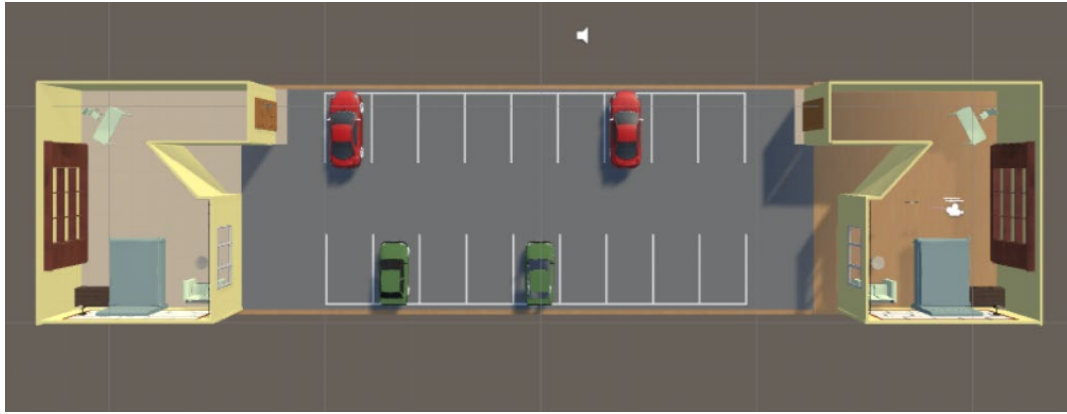

Figure 4-13 Meeting room

Figure 4-14 Restaurant

Figure 4-15 Hotel

4.2.1 Characters

The characters in this game are primary elements because we need to show players the story by characters' gestures. We did not consider making expressions of each character since we need large quantities of characters. It is hard for us to make every person with integrated details. Therefore, we decided to make low-poly characters. We searched for the game that utilizes low-poly characters. *The Dragon Cancer* is a great game that makes the use of low-poly characters. The story is shown to players by ambient sound, character's gesture, and some interactions. This game provides us with an idea of how to design low-poly characters. Figure 4-17 (a) and (b) show the concept art of the game characters.
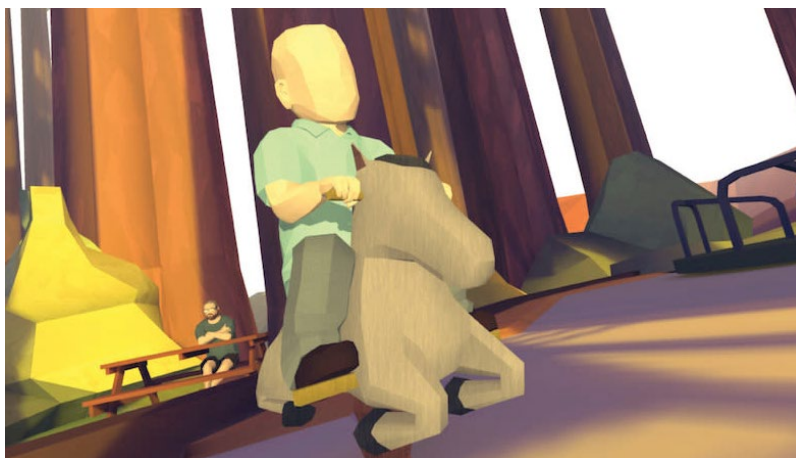

Figure 4-16 *The Dragon Cancer* screenshot

65

(a)

(b)

Figure 4-17 (a) A group of character design (b) Another group of character design

4.2.2   Environment

The environment is divided into three interiors rooms. The first is a meet room that could hold the Town Hall Meeting. We searched for the reference picture of the meeting room in the Town Hall. Figure 4-18 shows the reference art. Then we created the 3D model of the meeting room, as shown in Figure 4-19. Figure 4-20 shows the 3D model of the second level. Figure 4-21 shows the 3D model of the third level. In this level, players need to use the zoom in/out camera lens to take the photo from one window to another one that is at the opposite position. In other words, the original event at this level happened in the opposite room. That makes sense for that photo provided to players. Reporters could not stand into the room where

the parties are talking about their transaction to take the original photo. They do not want to be discovered.

Besides, based on our first playtest, we found the photo we provided was so small that they could not read some details. So, we make the photo in each as large as possible to ensure the photo cannot be an obstacle for players.

Figure 4-18 Reference meeting room

Figure 4-19 Concept meeting room design: level 1

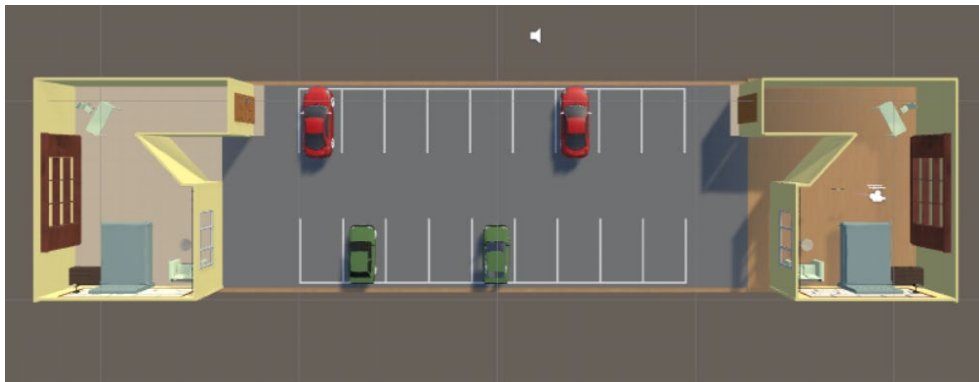Figure 4-20 Concept restaurant design: level 2

Figure 4-21 The third level design

Chapter 5 Game Technology

5.1 Hardware and Software Dependencies

The Leap Motion Controller is a device which records the hand movements. The device captures the hand movements, employing three infrared emitters and two cameras[47] [48]. Figure

[47] Dzikri, A., & Kurniawan, D. E. (2018, October). Hand Gesture Recognition for Game 3D Object Using the Leap Motion Controller with Backpropagation Method. In 2018 International Conference on Applied Engineering (ICAE) (pp. 1-5). IEEE.
[48] Chiang, T., & Fan, C. P. (2018, April). 3D depth information based 2D low-complexity hand posture and gesture recognition design for human computer interactions. In 2018 3rd International Conference on Computer and Communication Systems (ICCCS) (pp. 233-238). IEEE.

5-1 shows the internal structure of the Leap Motion Controller. The device is a 0.5x1.2x3 inches cuboid[49]. To use the device, users need to connect it to the computer by USB and then use hand movements above the device.
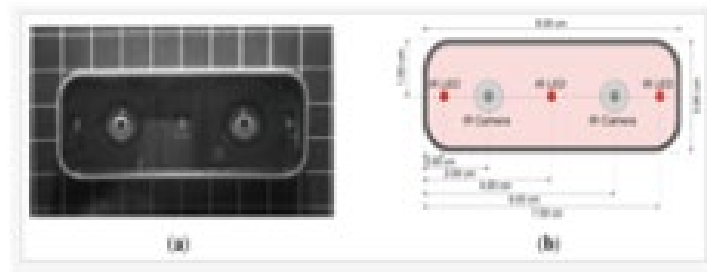

Figure 5-1 Leap Motion Controller internal structure

Leap Motion records the position of the hand with the help of the right-handed coordinate Cartesian system. The origin is at the midpoint of the device's top face. The X-axis and the Z-axis are perpendicular to each other and are parallel to the plane in which the device is placed, with the Z-axis pointing in the positive direction to the user. The Y-axis is vertically upward[50].

As shown in Figure 5-2 The data of hand movement can be read more accurate in the area that is surrounded by the spherical surface with the origin at the center of the sphere and a radius of 20 cm, the right circular conical surface with the origin as the apex. The Y-axis as the axis, the line with an angle of 15 degrees from the positive direction of the Y-axis as the generatrix[51] [52].

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[49] Ibid
[50] Dzikri, A., & Kurniawan, D. E. (2018, October). Hand Gesture Recognition for Game 3D Object Using the Leap Motion Controller with Backpropagation Method. In 2018 International Conference on Applied Engineering (ICAE) (pp. 1-5). IEEE.
[51] Ibid
[52] Naglot, D., & Kulkarni, M. (2016, August). Real time sign language recognition using the leap motion controller. In 2016 International Conference on Inventive Computation Technologies (ICICT) (Vol. 3, pp. 1-5). IEEE.
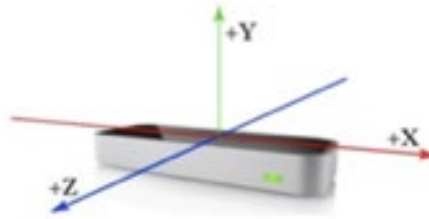
Figure 5-2 Leap Motion coordinate system

Leap Motion provides SDK to enable users to use Leap Motion Controller in VR, which allows users to use gestures instead of controllers to interact within VR[53]. As shown in Figure 5-3, the user sticks the Leap Motion Controller on the headset with the camera facing outward and connecting the cable to the USB interface of the PC. This way, the hands can be seen in the HMD and can be used to interact with the game world.

Figure 5-3 Use Leap Motion together with HTC Vive

The game is developed in Unity. Leap Motion provided several modules for this development space, such as the Core Assets, Interaction Engine, Graphic Renderer, and the Hands Module. All modules are dependent on Core Assets, according to the official development document, *Core Assets provide the foundation for VR applications with a minimal interface between Unity and the Leap Motion Controller and a collection of garbageless C#*

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[53] "Setup Guide — Leap Motion Developer". *Leap Motion Developer*, 2019, https://developer.leapmotion.com/get-started. Accessed 30 Aug 2019.

utilities[54]. With Core Assets, developers can render the Leap hands and tracking the joints in Unity. Interaction Engine provides interfaces to enable the Leap hands to physically interact with objects in our virtual space. The Graphic Renderer helps to render the graphic effects while the Hands Module is used to rig the 3D hand model with the joints.

5.2 Implementation of Gestures Recognition

Different methodologies are used to recognize static gestures and dynamic gestures. For static gestures, the key is to establish a mapping between the gesture and the relative joint positions of each finger. When the game is running, Leap Motion through Leap Hands can track the position of the joints on the player's hand in real-time. When the positions of the player's fingers joints meet the positional relationship of the stored gesture, it is registered that the player is making a specific gesture and ignites the predetermined reaction in the game. The Leap Motion Core Assets enable developers to add attachments to each joint so local coordinate systems can be attached to some joints helping measure the relative joints positions, as shown in Figure 5-4. For dynamic gestures, the movements of the hands are judged by comparing the change of the gestures in each frame picture captured by Leap Motion.

[54]"Unity Modules: Getting Started". Leapmotion.Github.Io, https://leapmotion.github.io/UnityModules/. Accessed 12 Apr 2020.
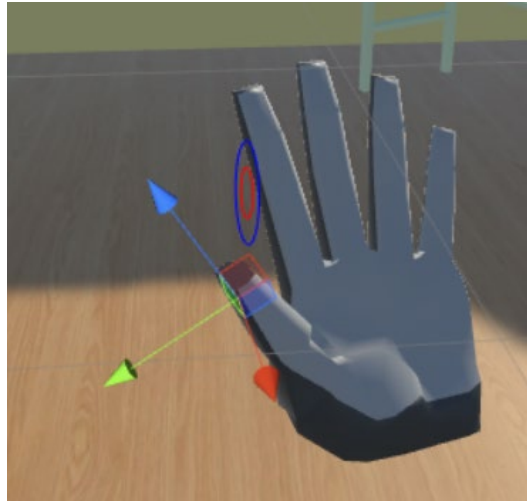
Figure 5-4 Attach coordinate system to the thumb tip joint

5.2.1 Static Gestures

1) Moving gesture

To judge the moving gesture, four constraints need to be satisfied:

a. Both the index finger and the thumb should be straight and there is an angle between the two fingers.

b. The middle finger, ring finger and the pinky finger should be bent.

c. The thumb should point to the orientation for the y-axis of the world coordinate system.

d. The index, thumb, and palm should be on the same plane.

A right-handed coordinate system is attached to each key joint, as shown in Figure 5-5. In each coordinate system, the origin is at the joint, while the orientation for the z-axis follows the direction that the part of the finger is pointing to. For the coordinate system of the palm, the orientation for the z-axis in the same direction that the palm is facing.
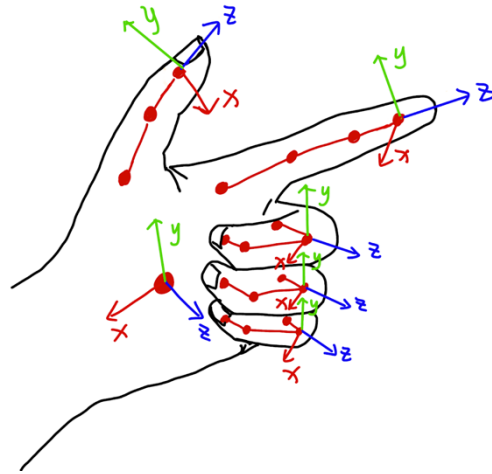
Figure 5-5 The coordinate system attached to the specific joints

With the help of the coordinate systems, the four constraints can be described as follow:

a. Use α to indicate the angle between the z-axis of the thumb joint coordinate system and the z-axis of the index finger coordinate system (Figure 5-6(a)(b)), then: $\alpha > 30^\circ$.
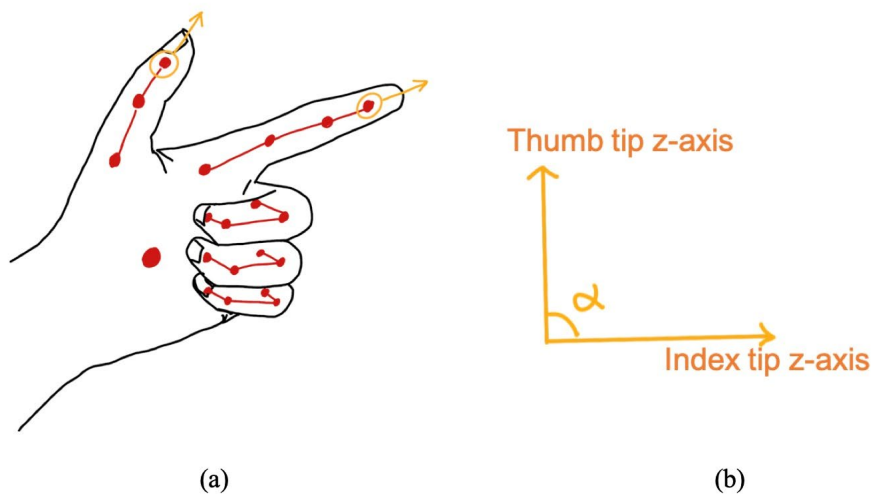

Thumb tip z-axis

α

Index tip z-axis

(a)   (b)

Figure 5-6 (a) α in 3D model (b) α in 2D space

b. Use β to indicate the angle between the z-axis of the index tip joint coordinate system and the z-axis of the middle joint coordinate system on the middle/ring/pinky finger (Figure 5-7(a)(b)), then: $\beta > 30^\circ$.
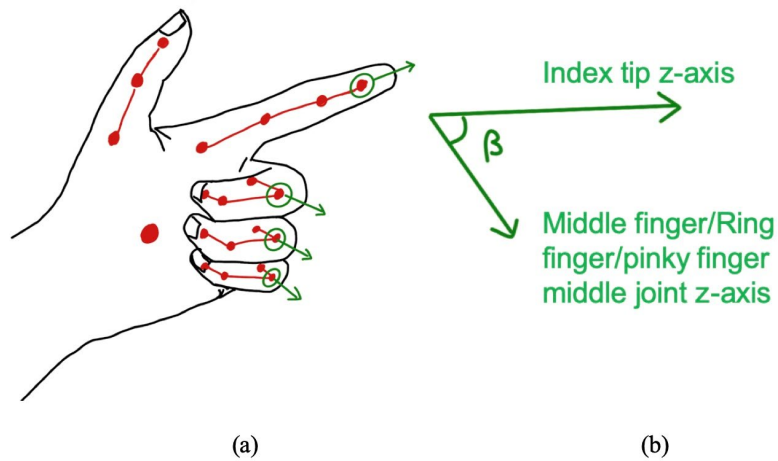
<div align="center">(a)   (b)</div>

<div align="center">Figure 5-7 (a) β in 3D model (b) β in 2D space</div>

c. Use θ to indicate the angle between the z-axis of the thumb tip joint coordinate system and the z-axis of the world coordinate system (Figure 5-8(a)(b)), then: $\theta<60^{o}$.

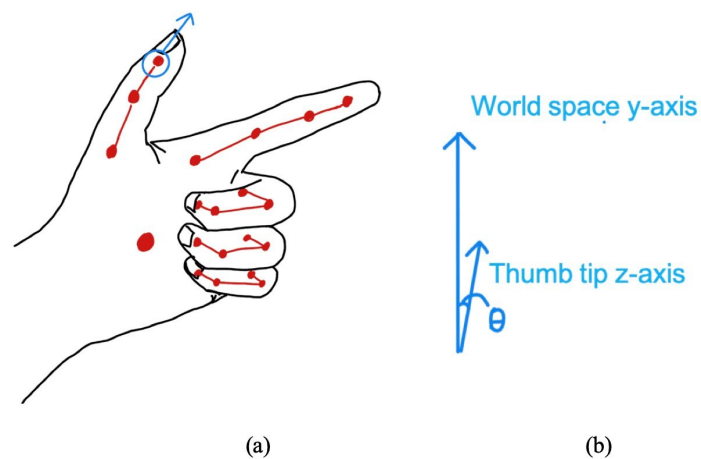<div align="center">(a)   (b)</div>

<div align="center">Figure 5-8 (a) θ in 3D model (b) θ in 2D space</div>

d. Use γ to indicate the angle between the z-axis of the thumb/index tip joint coordinate system and the z-axis of the palm coordinate system (Figure 5-9(a)(b)), then: $\gamma>70^{o}$.

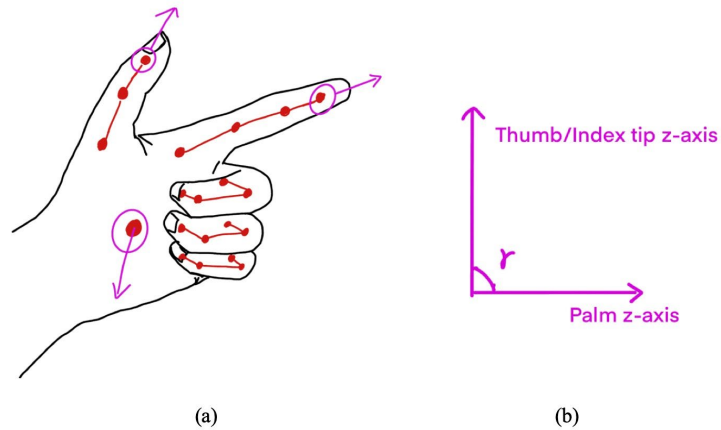Figure 5-9 (a) γ in 3D model (b) γ in 2D space

In the game, when the player's hand satisfied the constraints, it is recognized as a moving gesture and triggers the moving interaction in the game.

2) The gesture of taking pictures

The gesture of taking pictures satisfies the following five constraints:

a. There are two hands in front of the camera working together to make the gesture.

b. For either hand, the thumb and the index are in a gun-like gesture.

c. One palm is facing the main camera while the other palm is facing the opposite direction.

d. The index fingertip of the left hand is close to the thumb tip of the right hand, and the index fingertip of the right hand is close to the thumb tip of the left hand.

e. The distance between the thumb and index finger of the same hand should not be too close.

Figure 5-10 shows the coordinate systems that are attached to the key joints. With the help of the coordinate systems, the constraints (b), (c), (d) and (e) can be described as follow:
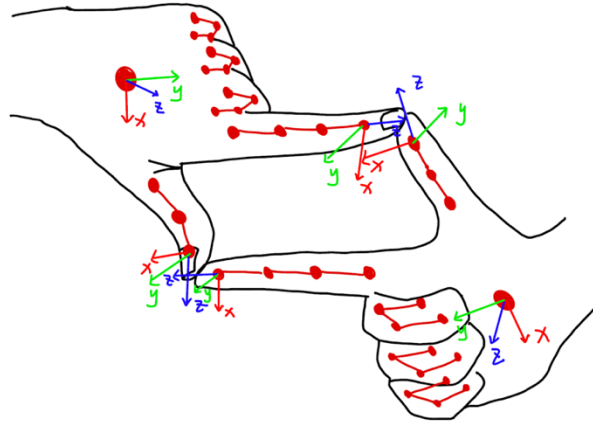

Figure 5-10 The coordinate system attached to the specific joints

b. Use α to indicate the angle between the z-axis of the thumb joint coordinate system and the z-axis of the index finger coordinate system (Figure 5-11(a)(b)), then: $\alpha > 30^o$.
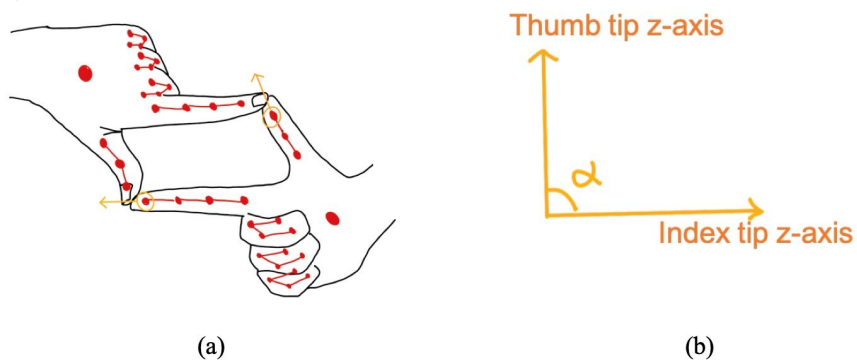

Thumb tip z-axis

Index tip z-axis

(a)   (b)

Figure 5-11 (a) α in 3D model (b) α in 2D space

c. Use β to indicate the angle between the z-axis of the palm coordinate system and the z-axis of the main camera coordinate system (Figure 5-12(a)), then: for one hand (Figure 5-12(b)), $\beta > 140^o$, while for the other hand (Figure 5-12(c)), $\beta < 40^o$.

(a)

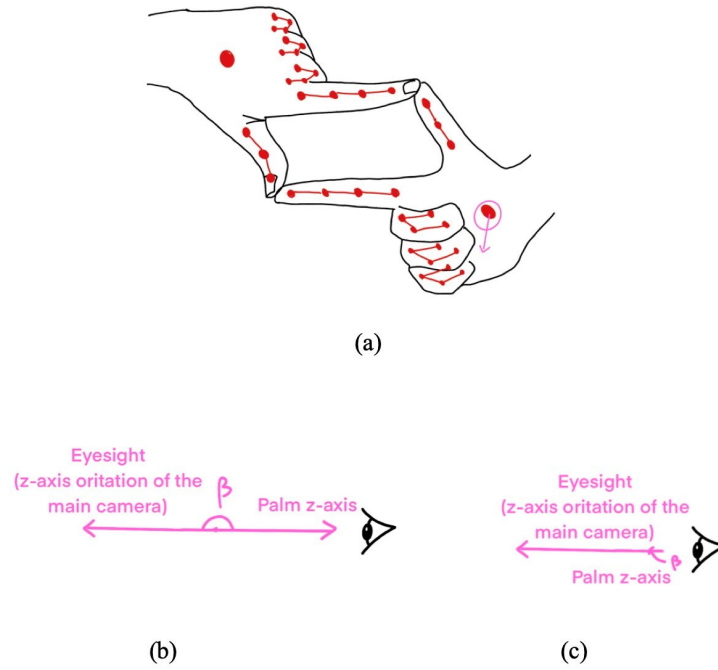(b)   (c)

Figure 5-12 (a) β in 3D model (b)(c) β in 2D space

d. Use *d1* to indicate the distance between the thumb tip of the left hand and the index fingertip of the right hand, and use *d2* to indicate the distance between the thumb tip of the right hand and the index fingertip of the left hand (Figure 5-13), then: *d1<0.1, d2<0.1.*
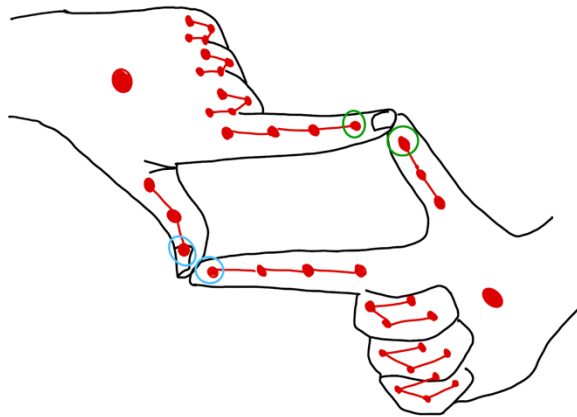

Figure 5-13 *d1, d2* in 3d space

e. Use *d3* to indicate the distance between the thumb tip and the index fingertip of the left hand, and use *d4* to indicate the distance between the thumb tip and the index fingertip of the right hand (Figure 5-14), then: *d3>1, d4>1.*
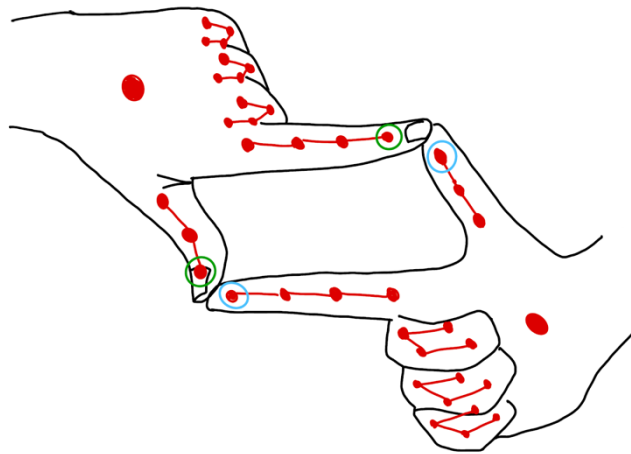
Figure 5-14 *d3, d4* in 3d space

In the camera mode of the game, when the player's hands satisfied the above constraints, a picture will be taken.

5.2.2　Dynamic gestures

1)　The gesture to zoom in/out

In the camera mode, the player pinches, and slide up and down to zoom in and out the picture. To judge the gesture, the position of the hand is called every frame. Comparing the position of the hand in the current frame picture and the position of the hand in the previous frame, when their position change in the y-axis direction in the world coordinate system exceeds the set minimum threshold, it is determined to be enlarged or reduced. When the y-axis coordinate of the current position in the world coordinate system is greater than the previous frame, it is determined to be enlarged, and conversely to be reduced.

2)　The gesture to call the game menu

The player firstly pinches then swipes right to call the menu and pinches and swipes left to hide the menu. This gesture is judged by the acceleration of the player's hand in the x-axis direction of the world coordinate system. The acceleration of the player's hand can be

obtained by calculating the change of the hand position of each frame. The *Hand* class in the Leap Motion SDK also provides a method to get the acceleration, which is designed to be called directly.

5.2.3   Conflicts solutions

Chart 5-1 shows the conflicts among the gestures and the solutions to avoid the conflicts.

Gestures	Conflict	Solutions
Movement gesture and the gesture of taking pictures	Both gestures are gun-like gestures	• For both gestures, add constraints to differentiate the palm direction. • For the gesture of taking pictures, add the number of hands as a constraint.
The gesture calling the inventory and the gesture of calling the game menu	When players put their hands up to view the inventory, the movement of the hand can be mistaken as calling the menu.	• For the gesture to call the inventory, add constraints to make sure all the fingers are stretch. • For the gesture to call the menu, add pinch gesture as a prerequisite. • For the gesture to call the menu, limit the range of hand movement on the y-axis, when exceeding the limit, it will not be recognized as the menu gesture.
The gesture calling the inventory and the gesture calling the radar	Both gestures require the player to raise his hand up in front of the camera	• For the gesture of calling the inventory, add constraints to make sure all the fingers are stretch. • For both gestures, add constraints to differentiate the palm direction.

Table 5-1 Conflicts among the gestures and the solutions

5.3 Game Development in Unity

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In a gesture-controlled game, firstly, gestures should be recognized, and secondly, corresponding functions are triggered according to the mapping between the gesture and function, as long as they correspond.

5.3.1 Move

To avoid VR sickness, teleporting is used instead of gradual movement. Figure 5-15 shows the interaction logic of moving. When the movement gesture is recognized in the game, the player finds the position they want to move, a help line is rendered in game to provide the user with feedback. After deciding the target position, the player holds the gesture for two seconds, waiting to teleport.
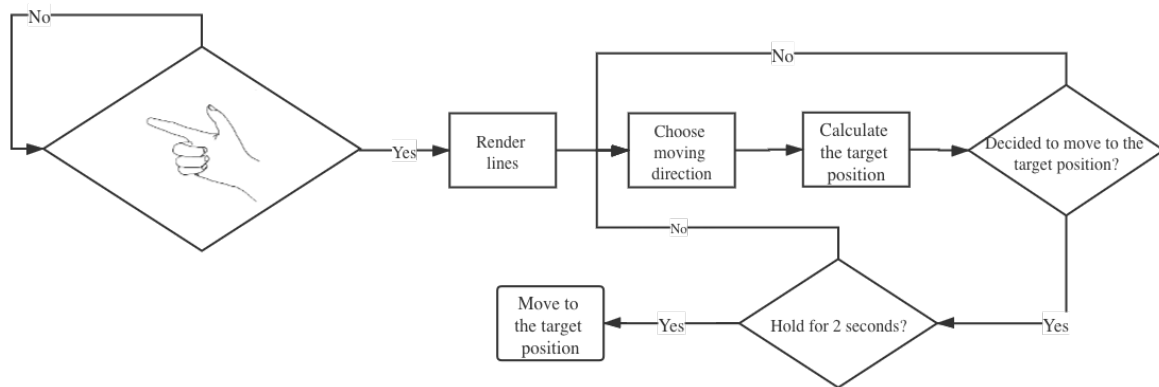

Figure 5-15 Interaction logic of moving

When the player selects the movement function, we first need to judge the validity of the moving position. In the game, we limit the maximum distance of each move. Players can only move within the defined range. Additionally, the target location is also be regarded as invalid if other game objects are lying at the target location. In the game scene, we set all game objects on a invalid movement layer, any ground area devoid of objects is placed on a valid movement layer to avoid meaningless movement.

As shown in Figure 5-16, in order to help the player to find the movement target, we set up an assisting parabola. The parabola simulates the trajectory of the parabolic motion in three-dimensional space. The original direction is determined by the player's index finger. The mass of the object and the initial velocity are pre-set to control the maximum distance of each movement better. Since the curve cannot be directly rendered in Unity, we divided the trajectory into many short straight lines rendered separately, creating the illusion of a complete curve.

Figure 5-16 Moving

5.3.2　Camera Tool

There are two camera objects set in the game scene, one is the main camera, which is used to track the player's eyes, and the other is the shooting camera, which is used as the camera tool in the game. The cameras use Unity's camera object. As shown in Figure 5-17. The shooting camera is placed in front of the main camera, we tried to simulate the way people take pictures in real life: the camera lens is in front of our eyes. There is a plane working as the display of the shooting camera in the scene.
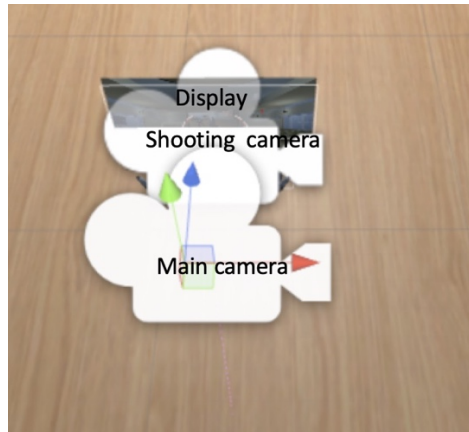
Figure 5-17 Camera objects in Unity

The pictures obtained by the shooting camera are rendered on the plane in real-time so players can keep tracking with it (Figure 5-18). When the player makes the gesture to take a picture, the picture currently rendered on the plane is saved to the file. As the player slides up and down to zoom in or zoom out, the shooting camera moves forward and backward changing the view and simulates a changing focal length.

Figure 5-18 Camera Tool

Chapter 6 Evaluation

6.1 Preparation for Testing

To evaluate the results of questions posed by this game, we organized a pre-test to make sure if players could perform gestures correctly before the final test. 20 play-testers were recruited via email from students enrolled in courses in the Interactive Media and Game Development program at WPI. The testing environment in VR was a simple room with several cubes and spheres. Players need to wear the HTC Vive and entered into the scene without any interactive interface. What they need to do is to utilize gestures following instructions. It only took each player 5 to 10 minutes to participate in the pre-experiment. This pre-test was meant to test the usability of gestures. Based on the results of testing, we polished the gestures mechanism.

After, we organized the second test for serious meaning. 12 play-testers were recruited via email from students enrolled in courses in the Interactive Media and Game Development program at WPI. Each of them has an interest in game development and virtual reality. WPI's IRB approved the test.

Play-testers volunteered thirty minutes of their time to participate in the test. They can choose time slots and only one tester was tested at a time. We supervised each test, including timekeeping, observing their behaviors, and documenting their time spent. All testers needed to wear the HTC Vive and use gestures to interact in the game. Before they started, they would be told not to move their bodies wh playing. Once the test had been done, we asked some questions about the experience and testers filled out the survey.

6.2 Data Analysis

6.2.1   Pre-test result

In the pre-test, we tested all the gestures and game mechanics to see if players are comfortable with them.

For game mechanics, as shown in Figure 6-1, 83.3% of play testers like the camera mechanism, and as shown in Figure 6-2, 75% of play testers are clear about how to operate the game after playtesting, which indicates it is easy for players to learn about the game mechanic. However, there are still problems, as shown in Figure 6-3, most people found it hard to move in the scene, and a third of people find it difficult to find the correct perspective in the game.

How do you like the camera mechanism? Please rate it.
12 responses
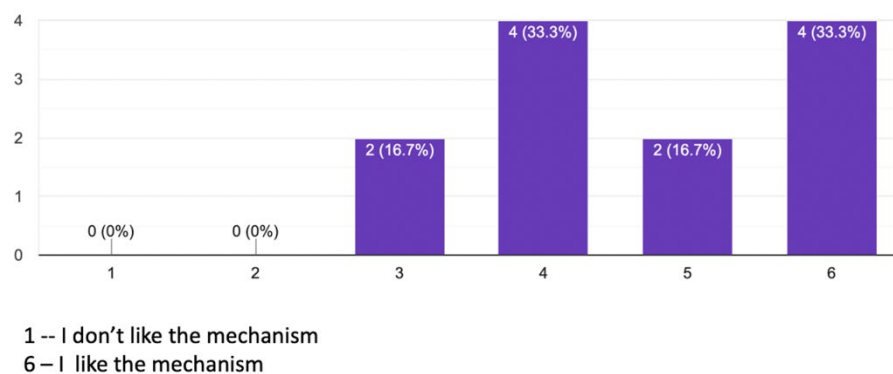
Figure 6-1 How do you like the camera mechanism?

Are you clear about how to operate in the game? Please rate it
12 responses
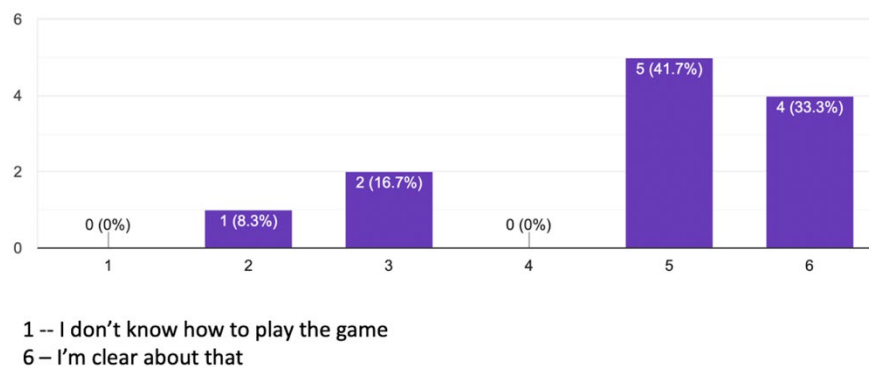
Figure 6-2 Are you clear about how to operate in the game?

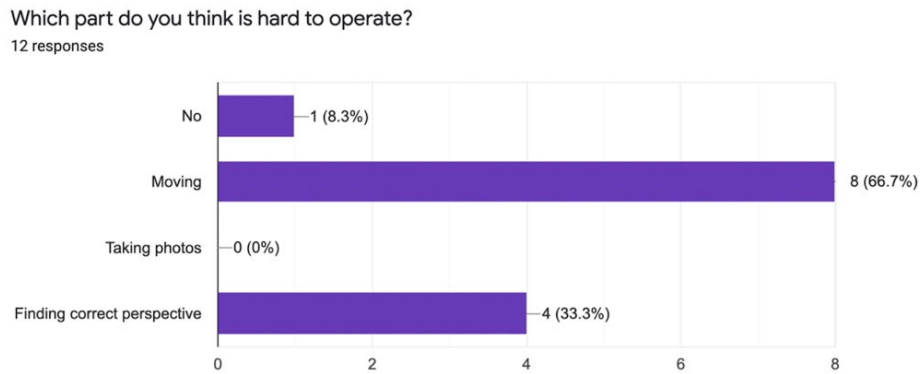Which part do you think is hard to operate?
12 responses

Figure 6-3 Which part do you think is hard to operate?

For gestures, as shown in Figure 6-4, more than 80% of players are used to using gestures to play the game, which implies that the gestures are intuitive and simple for them to master and remember in limited time. However, there are still gestures that are not recognized well by the device (Figure 6-5) and make players feel hard to perform (Figure 6-6).
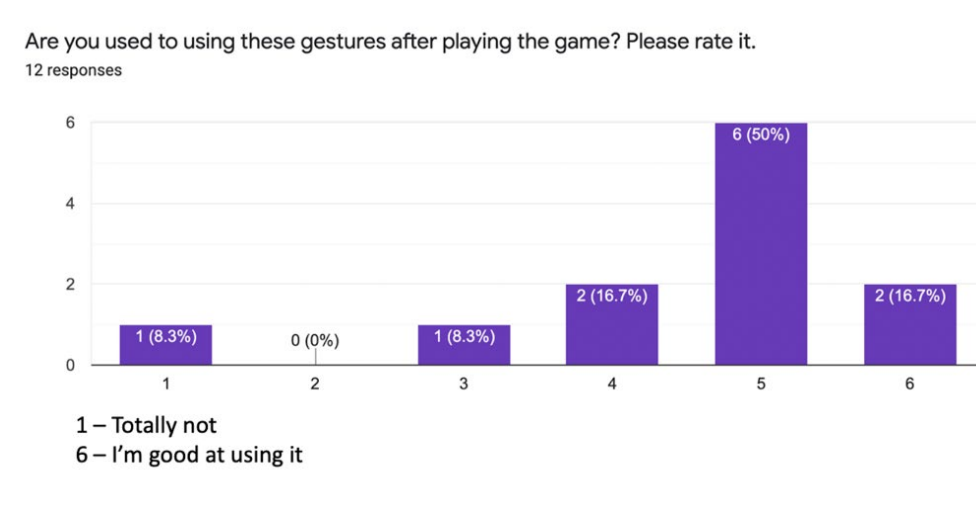

Are you used to using these gestures after playing the game? Please rate it.
12 responses

1 – Totally not
6 – I'm good at using it

Figure 6-4 Are you used to using gestures?

Which gesture do you think is not easy for you to perform?
12 responses
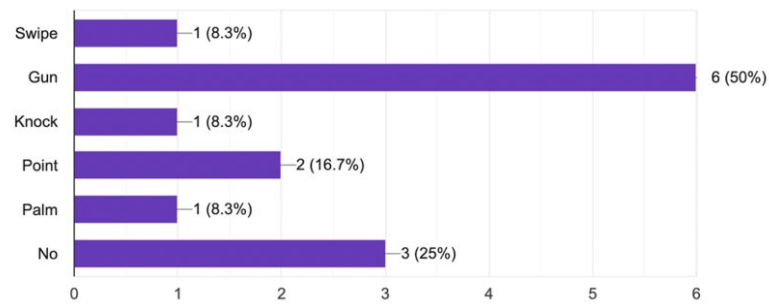
Figure 6-5 Which gesture do you think is not easy for you to perform?

Which gesture do you think the device does not recognize well?
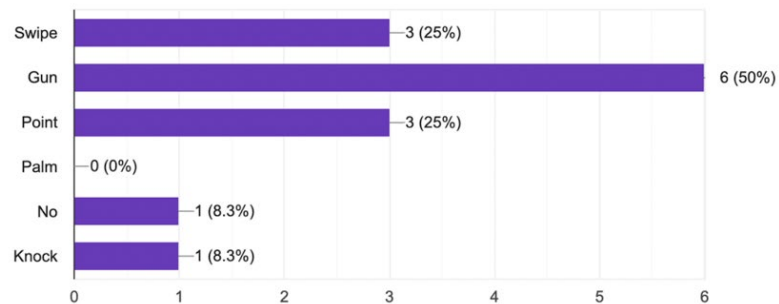12 responses

Figure 6-6 Which gesture do you think the device does not recognize well?

6.2.2   Playtest result

As for gameplay, Figure 6-7 shows that 10 people are totally clear about how to play the game and 9 people almost get that. Just 1 person is a little bit unfamiliar about the game. Actually, this man spent about 30 minutes on the first level so that he did not pass the game. Since he did not look through the instructions in the tutorial carefully, all things became hard for him. As a result, it shows that our game logic is accessible.

Are you clear about how to play the game? Please rate it

20 responses

1- I do not know how to play the game
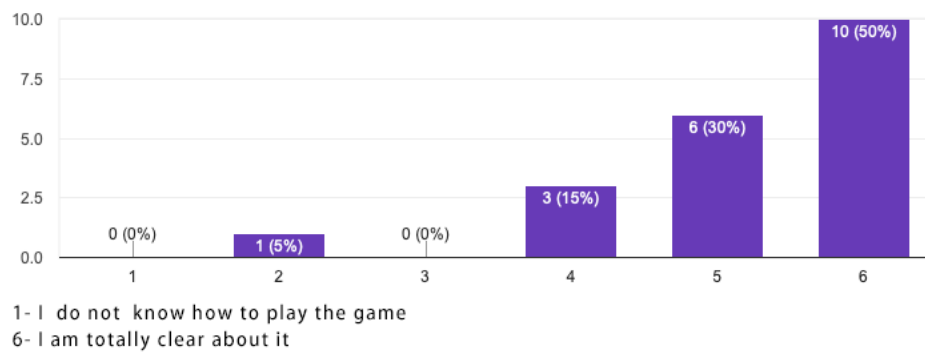6- I am totally clear about it

Figure 6-7 Are you clear about how to play the game

Based on Figure 6-8 and 6-9, we can see that it is hard for players to tell the truth only with photos since every part even share the average number as shown in Figure 6-8. When we provide descriptive words for these photos, a format just like news, to players, only 4 people are willing to consider it as fake news and most people are confused about the reliability of the news, as shown in Figure 6-9. No one thinks it is real and that is a good thing. This result matches our consumption well.

Based on photos we provided to you, do you believe they are fake or real?
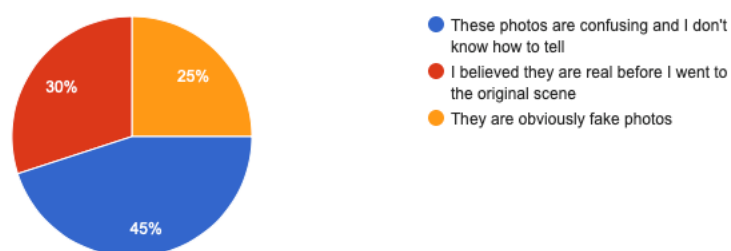
20 responses

- These photos are confusing and I don't know how to tell
- I believed they are real before I went to the original scene
- They are obviously fake photos

Figure 6-8 Do you believe they are fake or real

With descriptive words for these photos（news）, do you believe these news are fake or real?

20 responses

8

6 — 7 (35%)

5 (25%)

4 — 4 (20%)

2 — 3 (15%)

1 (5%)   0 (0%)

0

1   2   3   4   5   6

1- The news about senator is crazy. They are definitely fake news.
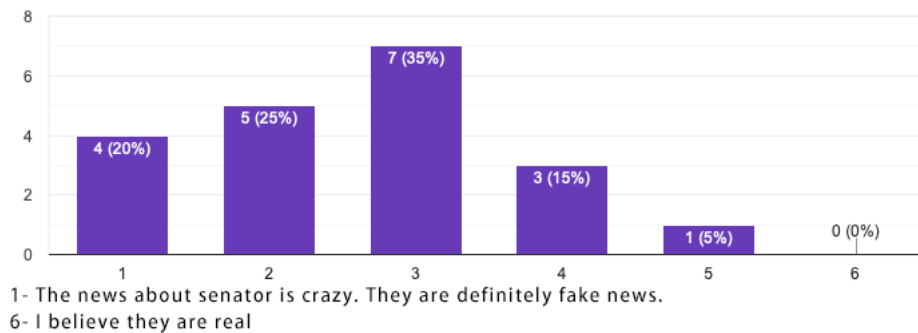6- I believe they are real

Figure 6-9 Do you believe the news is fake or real

In Figure 6-10, we can see that 10 people think it is hard to tell the truth of information and they realize they are surrounded by fake news or photos after playing the game. 9 people almost get the same idea. Actually, after playing the game, these people find that fake news can be created by a variety of methods. They find that lots of news can be fake, which they are confused about in the past.

After playing the game, do you realize we are surrounded by fake news or photos and we can be easily cheated?

20 responses

10.0

7.5

5.0 — 5 (25%)   10 (50%)

4 (20%)

2.5

1 (5%)   0 (0%)   0 (0%)

0.0

1   2   3   4   5   6

1- No, I cannot get the idea from the game
6- Yes, it is hard to tell the truth of information
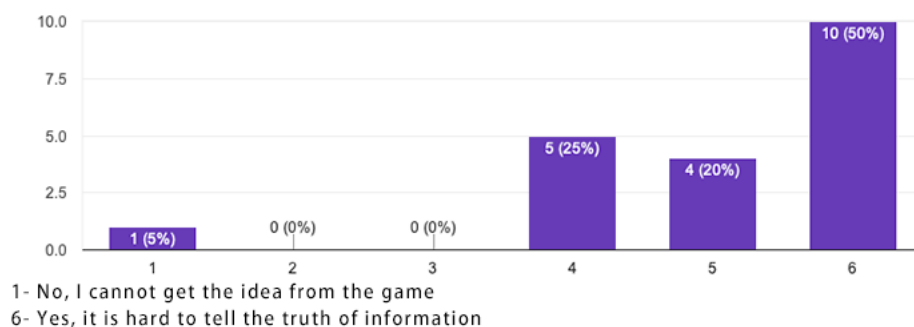
Figure 6-10 Do you realize we are surrounded by fake news or photos and we can be easily cheated

In Figure 6-11, we can see that 9 people are willing to think more before commenting or posting this kind of photo or news after playing the game. 8 people are almost willing to do that. Players said they had never played this kind of game about fake news, so they did not realize the effect of the news and photos. Now they know that every photo could cheat them

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with a simple misleading perspective and they are willing to think more before commenting or posting to avoid becoming fake newsmakers.
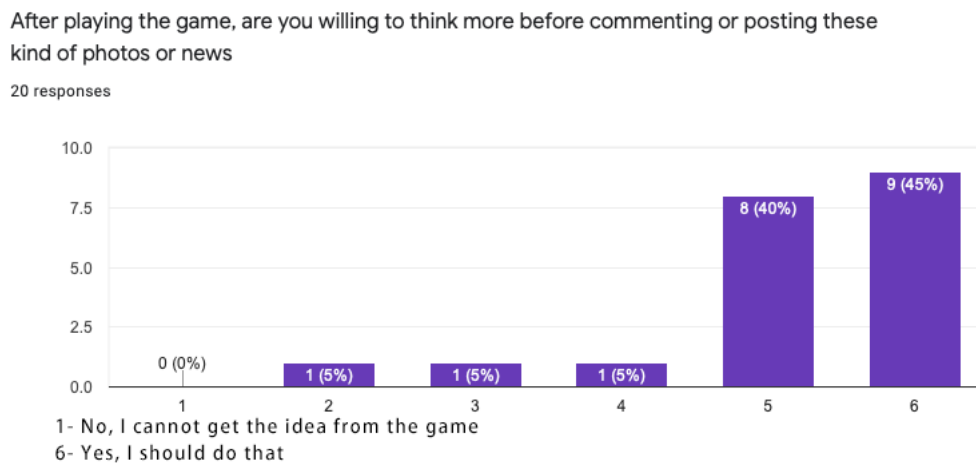

Figure 6-11 Are you willing to think more before commenting or posting this kind of photos or news

In Figure 6-12, we can see that 8 people want to find the truth behind some confusing photos and they think seeing is believing after playing the game. 8 people almost get the same idea. No one does not want to find the truth. We just provide a game idea that they can go back to the original scene to investigate by themselves and now they are interested in having the opportunity to know the truth behind some news or photos in their real life.
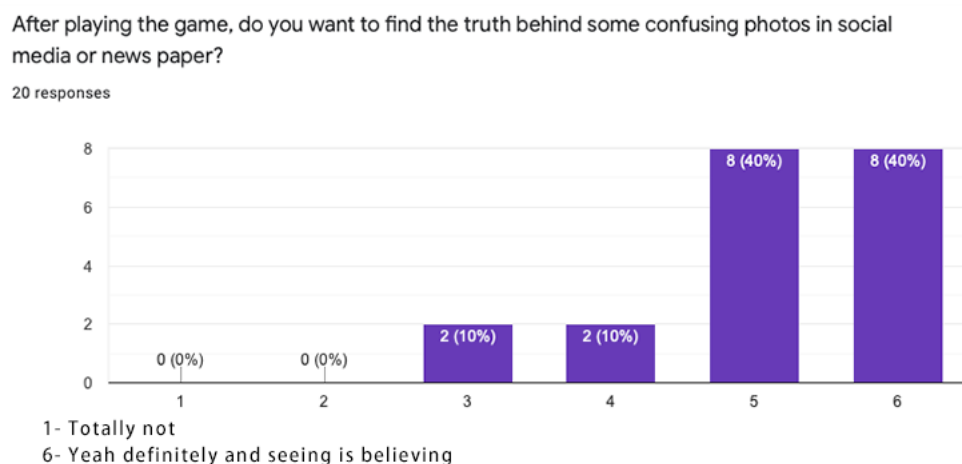
Figure 6-12 Do you want to find the truth behind some confusing photos in social media or newspaper

In Figure 6-13, we can see that 11 people realize the results for publishing this kind of fake news after playing the game. They believe fake news will hurt someone. 9 people almost get the same idea. Because we develop our story based on politics, the effect of publishing this kind of news can lead to a terrible result for society. Most players realize our intension and they can imagine the future world with published fake news.
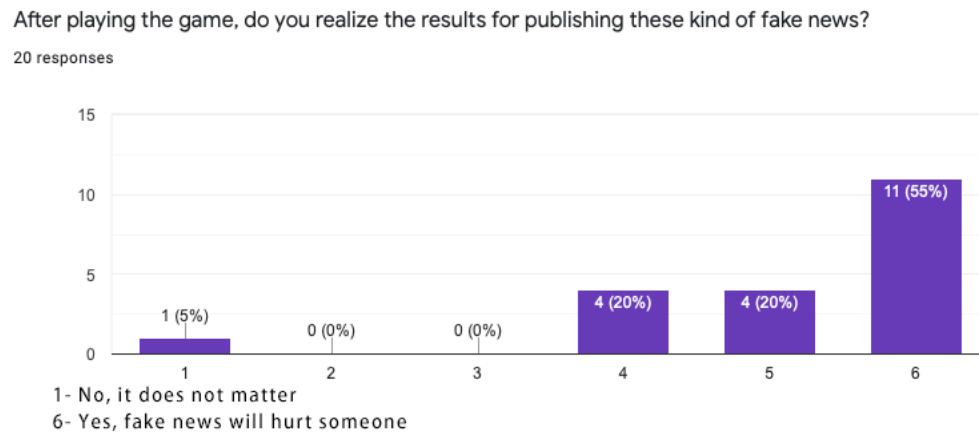

After playing the game, do you realize the results for publishing these kind of fake news?
20 responses

1- No, it does not matter
6- Yes, fake news will hurt someone

Figure 6-13 Do you realize the results for publishing this kind of fake news

For the technical part, among all the play testers who had played VR games before, as shown in Figure 6-14, more than 90% of players prefer using gestures to control the game, 62.5% of them think it is easier to learn to use the gestures to play the game rather than controllers (Figure 6-15), and 81.3% of them feel that compared with remembering all the buttons on the controllers and their corresponding functions, it is easier to remember all the gestures (Figure 6-16). For all the players including players who had tried VR games before and who had never played VR before, all of them can remember all the gestures after playing the game (Figure 6-17).

How do you like using gestures to control everything rather than controllers? Please rate it.
16 responses

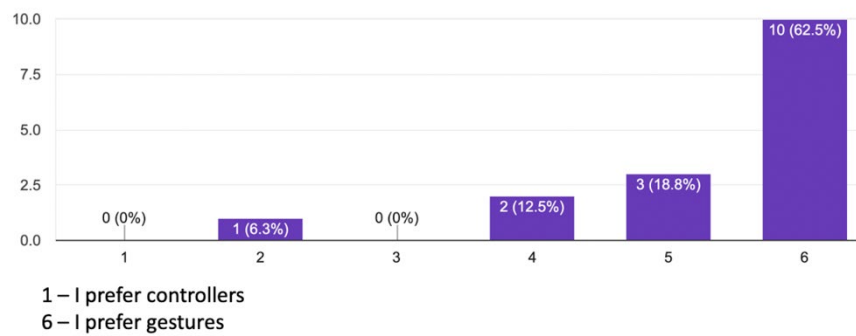1 – I prefer controllers
6 – I prefer gestures

Figure 6-14 How do you like using gestures to control everything rather than controllers?

Which one do you think is easier to learn to use, gesture control, or controller?
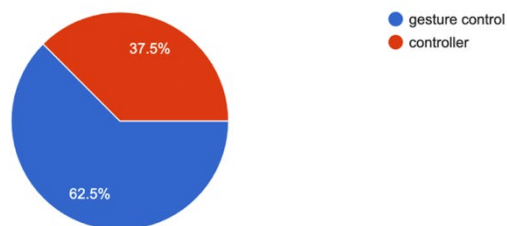16 responses

● gesture control
● controller

Figure 6-15 Which one do you think is easier to learn to use, gesture control or controller?

Do you think it is easier to remember all the gestures, or the functions corresponding to all the buttons on the controller?
16 responses

● gestures
● buttons on the controller
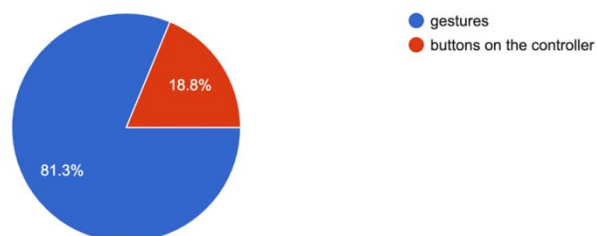
Figure 6-16 Do you think it is easier to remember all the gestures, or the functions corresponding to all the

buttons on the controller?
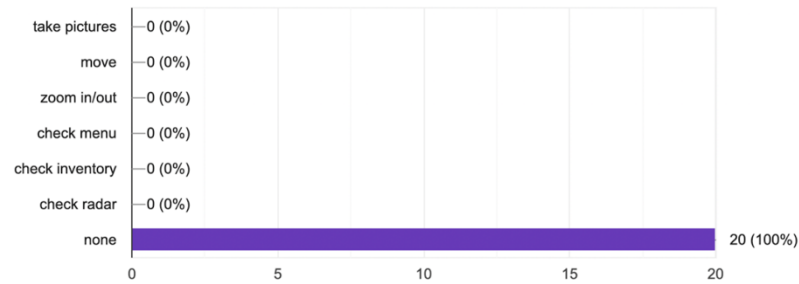
Figure 6-17 Which gesture you do not remember after playing the game?

As shown in Figure 6-18, there are still 4 people found it hard to move using gestures, but most of the players feel none of the gestures is hard for them to perform. Compared with the result of the pretest shown in Figure 6-4, in the final test, all of the players are used to using all the gestures after playing the game (Figure 6-19).

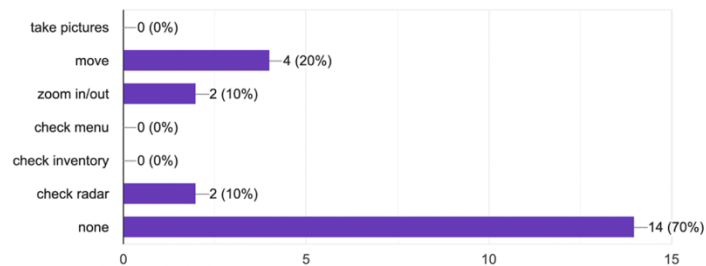Figure 6-18 Which gesture is hard to perform and make you feel tired?

92
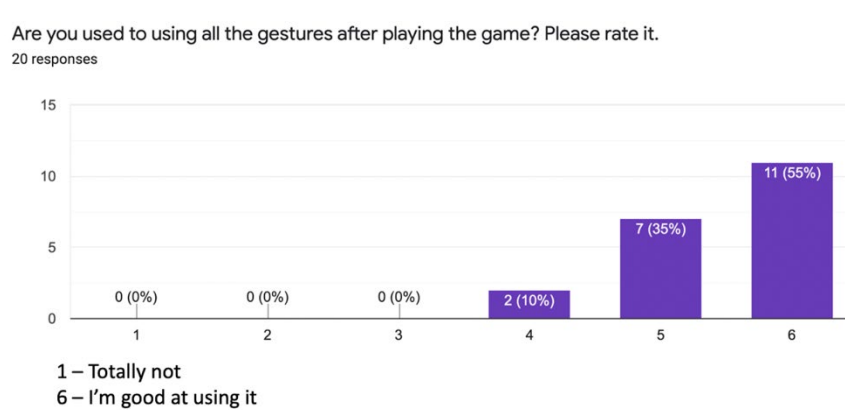
Figure 6-19 Are you used to using all the gestures?

6.3 Outcome

After playing the game, most people realize they are surrounded by fake news or photos and they can be easily cheated. They are willing to think more before commenting or posting this kind of photos or news. They want to find the truth behind some confusing photos in social media or newspaper. And these people realize the results for publishing this kind of fake news. To some degree, we realize the goal of raising the awareness of fake news.

For the technical part, we can find that compared with the controllers, most players prefer using gestures to play the game. The gestures are easier for them to master and remember in limited time, which is consistent with our goal of allowing players to pay more attention to the exploration of the game itself rather than learn to use the controller. Besides, the set of gestures are easy for players to master and remember, which meets our expectations.

Chapter 7 Post Mortem

7.1 What went right?

1) We considered making a camera in the beginning and the camera mechanism came out as the primary tool for the game.

2) We utilized the perspective to make three photos successfully and they can provide misleading information for players.

3) Gestures of static characters were designed to help tell the story for players.

4) The paper prototype established a great foundation for the developing process. Based on the game logic in the paper prototype, our development was accelerated.

5) The survey of the players' habits of using gestures has played an essential role in the design of gestures.

6) Two playtests provided great feedbacks to help polish the game.

7) Models are easy to create because of the art style.

7.2 What went wrong?

1) The original scope of the game was a little bit large and we wanted to teach players how to tell fake news. But it is hard for us to teach players within three levels and one tutorial. Moreover, there is no animation in the game, which means the difficulty of showing the story correctly just increases. In the end, we changed our goal to raise awareness of the effect of fake news. That is what we could realize.

2)   Some game features have been changed during development, such as the UI and the models' quality. Some original designs could not be implemented because of the limitation of art and tech aspects.

3) The hand tracking method of the device is not taken into account in the design of gestures. In the moving gesture, since the hand is perpendicular to the camera, the index finger joints

are blocked by the thumb, which leads to errors in recognition of the index finger and reduces the accuracy.

4) In the first playtest, we got the feedback that players spent much time on using gestures and they were so unfamiliar with this mechanism. Moreover, because of the limitation of hardware devices (HTC Vive and Leap Motion), many gestures cannot be performed as smoothly as possible. Players need to try many times to be used to using one gesture. As a result, the game time increased and to some degree, it affected the player's experience of playing.

5) There is no controller version of the game. In the playtest, for testers who have never played VR games, they are not able to compare the game experience of the gesture control and the controller control.

6) We need to balance the difficulty of passing the game and using gestures. So, the game difficulty has been decreased to the lowest level. We added some apparent models to inform players and now it is easy to find the correct perspective. However, many players wanted to challenge in the game and their experience was affected.

7) The feedbacks for player's operation are not enough. Players always missed some instructions about how to play the game because of the wrong feedback. Besides, now we only provide audio feedback to players. They need more variety of feedback, such as visual effects and haptic feelings. That will provide a better experience.

7.3 What did we learn?

1) Playtest is primary for designing a game. Sometimes the development all depends on the designer's idea, but without the user's feedback, designers cannot make the game easy to play for everyone.

2) The game logic which paper prototype shows needs to be tested to make sure any parts of the game can work well. The pre-work is necessary to avoid being stuck in the game logic.

3) The serious game is a great tool to teach players or let them understand something. But it is hard to realize the target. The background story and game mechanism play an important role in serious games.

4) The tech developer and art designer need to communicate with each other more often to update their information. Art assets must match achievable techniques and sometimes improper assets may create extra workload for technical persons.

Chapter 8 Conclusion and Future Work

The goal of this thesis project is to build a serious game to raise awareness of the effect of fake news by using gestures on the VR device. To do this, we designed the *Warped Reality* and the designing process was divided into two parts, art design and technical design. The art design consists of level design, story design, and game logic design. The technical part includes gesture design, mechanism design, and importing art assets to Unity. The primary mechanism of the game is to take photos from a different perspective. Players investigate the truth behind the photo and they need to take photos at the correct perspective to get back to the original scene.

With the assumption that players could raise the awareness of fake news during the game time, we designed two playtests to see if players are used to using gestures and get the correct serious meaning. We got the feedback about the usability of gestures from the pre-test and made some changes to gesture design. After the second playtest, all gestures were proved to be easy to learn and perform in the game. As for serious meaning, based on some questions we asked, we found that the game has the power to help raise the awareness of fake news, which proved our assumption to be true.

However, there are still problems remain to be solved in the future:

1) The story of each level could gain more details. Now we just directly show players what happened in the original scene, which means they can get the truth for a few minutes. In the future, there will be lots of hints in different places. For example, in the first level, players may get something by listening to the communication between people who sit at the back of the room or by seeing the gesture from a person wearing colorful clothes. And with better ambient sounds, players could understand the overall story easily.

2) More gaming modes and complex situations could be added. For example, we can utilize the night mode of the camera to investigate a room that does not have any lights. Besides,

the time for passing a level could be limited to 5 or 10 minutes to increase the difficulty. Players have the opportunity to choose the easy mode, medium mode, and hard mode.

3) Currently there is no haptic feedback when using gestures to play the game, especially when players touched the objects in the game, which to some extent, affects the immersive and realistic experience. In future work, the wearable device can be used together with the Leap Motion controller to provide haptic feedback.

4) The initialization and real-time update of the scene can lead to latency in the game. It is necessary to find a better solution to reduce the load of hardware and reduce the latency as much as possible without affecting the 3D effect of the scene.

5) The long-time operation will cause Leap Motion to heat up, which can affect the accuracy of recognition. Besides, when the joint is blocked, errors may occur in gesture recognition. In future work, external cameras can be used to work together with the Leap Motion controller, as well as cooperated with image processing to improve the accuracy of recognition.

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Appendix

Appendix A Questionnaire 1

1. Which part do you think is hard to operate?

   ☐ No ☐ Moving ☐ Taking photos ☐ Finding correct perspective

2. When using VR to play this game, did you feel sick? Please rate your feeling

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

   1 -- Totally not

   6 -- I can't stand it

3. How do you like using gestures to control everything rather than controllers? Please rate it.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

   1 -- I hate gestures

   6 – Gestures are very cool

4. Which gesture do you think is not easy for you to perform?

   ☐ Swipe ☐ Gun ☐ Knock ☐ Point ☐ Palm ☐ None

5. Which gesture do you think the device does not recognize well?

   ☐ Swipe ☐ Gun ☐ Knock ☐ Point ☐ Palm ☐ None

6. Are you used to using these gestures after playing the game? Please rate it.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6
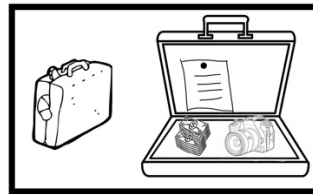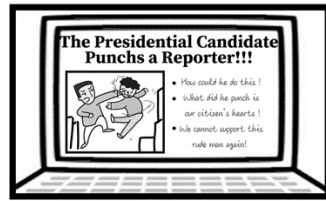
   1 -- Totally not

   6 – I'm good at using them

7. How do you like the camera mechanism? Please rate it.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

   1 -- I don't like it

   6 -- I like it

8. Are you clear about how to operate in the game? Please rate it.

□ 1 □ 2 □ 3 □ 4 □ 5 □ 6

1 -- I don't know how to play the game

6 -- I'm clear about that

9. Which part of the tutorial makes you confused?

□ Walking in the scene

□ Menu and Inventory

□ Finding correct position to take photos

□ Taking photos

□ None of above

10. Any other suggestions for the game improvement?

_____

Appendix B Questionnaire 2

Serious game part:

1. Do photos on the wall provide you with useful information?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 – No, photos are so ambiguous

6 – Yes, I can definitely get what photos want to tell me

2. Based on photos we provided to you, do you believe they are fake or real?

☐ These photos are confusing and I don't know how to tell

☐ I believed they are real before I went to the original scene

☐ They are obviously fake photos

3. With descriptive words for these photos (news), do you believe these news is fake or real?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1– The news about senator is crazy. It is definitely fake news

6– I believe it is real

4. After playing the game, do you realize we are surrounded by fake news or photos and we can be easily cheated?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 – No, I can't get this idea from the game

6 – Yes, It is hard to tell the truth of information

5. After playing the game, are you willing to think more before commenting or posting this kind of photos or news?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 – No, I can't get the idea from the game

6 – Yes, I should do that

6. After playing the game, do you want to find the truth behind some confusing photos in social media or newspaper?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 – Totally not

6 – Yeah definitely and seeing is believing

7. After playing the game, do you realize the results for publishing these kind of fake news?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 – No, it doesn't matter

6 – Yes, fake news will hurt someone

Technical part:

1. Did you feel sick when playing VR games? Please rate it.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 -- I feel sick

6 -- I don't feel sick

2. How many VR games have you tried before?

☐ 0 ☐ 1-3 ☐ 4-10 ☐ more than 10

3. How do you like using gestures to control everything rather than controllers? Please rate it.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

1 -- I prefer controllers

6 -- I prefer gestures

4. Which one do you think is easier to learn to use, gesture control, or controller?

☐ gesture control ☐ controller

5. Do you think it is easier to remember all the gestures, or the functions corresponding to all the buttons on the controller?

☐ gestures ☐ buttons on the controller

6. Which gesture you do not remember?

   ☐ take pictures

   ☐ move

   ☐ zoom in/out

   ☐ check menu

   ☐ check inventory

   ☐ check radar

   ☐ none

7. Which gesture is hard to perform and make you feel tired?

   ☐ take pictures

   ☐ move

   ☐ zoom in/out

   ☐ check menu

   ☐ check inventory

   ☐ check radar

   ☐ none

8. Are you used to using all the gestures after playing the game? Please rate it.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

   1 -- Totally not

   6 – I'm good at using all the gestures

Appendix C Tutorial for leap motion development with VR

This is the link of the tutorial:

http://yichenliclaire.com/2020/02/02/Leap-Motion-And-VR-Development-In-Unity-1/

Appendix D Paper prototype

Wrapped Reality

New Game

Continue

Setting > — left-handed / right-handed

Quit

One day, Simon, an ordinary journalist, just sits in his office for work. Everything goes well as normal…

BOOM!

BREAKING NEWS

Level ⊗

Tutorial · Level 1 · Level 2 · Level 3

XXXXXX

GO → ← press the button

Now you are in the scene where
the news happened

Want to move?
Try this gesture.

9

Great! You make it!

10

You can swipe down to view the game menu. Try it!

11

12

Setting

Quit

13

Great! You make it!

Setting

Quit

14

15

16

17

113

18

Compendium ⊗

Photo 0   Photo 1   Photo 2   Photo 3

The compendium shows the target picture. Press at the picture to look it more carefully.

19

20

Compendium

Tutorial   Level 1   Level 2   Level 3
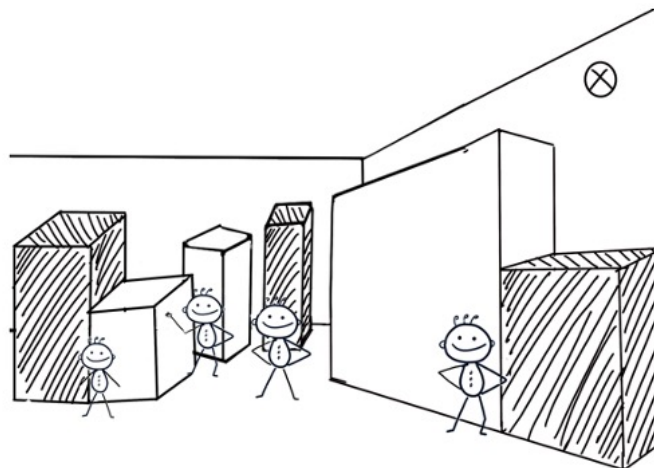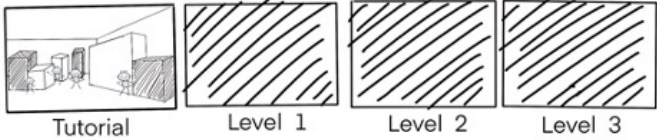
Now go back to the scene and take a picture at the same position and perspective as the target picture.

21

There are many rings in the lower left corner of your vision field. It is a radar. This radar tells you whether you are close to the correct position. The closer you are to the target, the more rings you will have on the radar.
Now it shows that you are at the correct position.

22

You can take pictures now! Find the camera in the inventory.

23

24

This is a camera.

25

From here you can find all the pictures
you have taken. You can also check the
album from the inventory.

26

Album   You haven't got any pictures now. Go back to take pictures!   ⊗
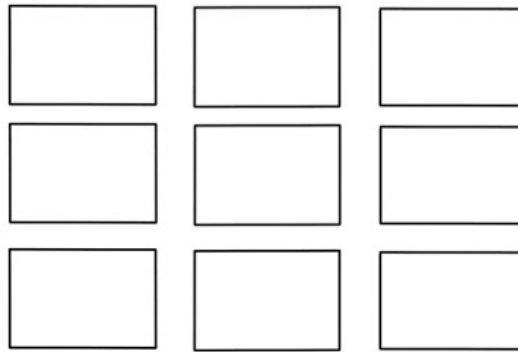
27

Now, find the perspective and try this gesture to take a picture!   ⊗

Normal Mode   Night Mode

1280 600 400 300 200

35 28

Compendium

Album
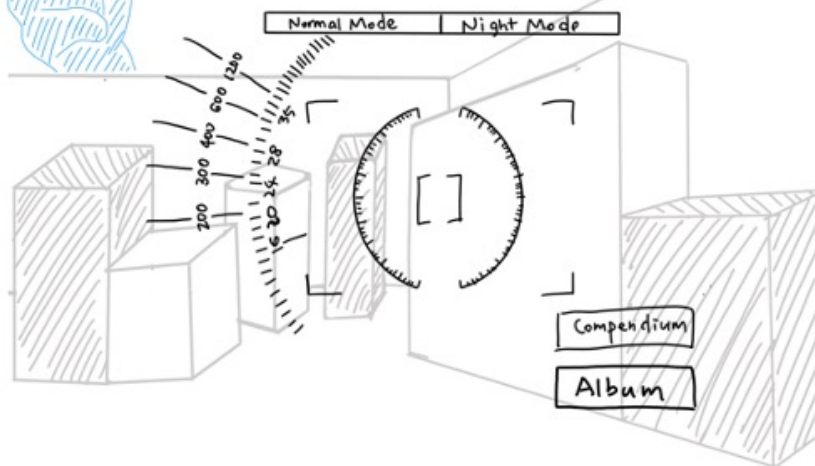
28

(BIBI) Oh no, the picture is not correct.
Find the perspective and try again!

Try Again
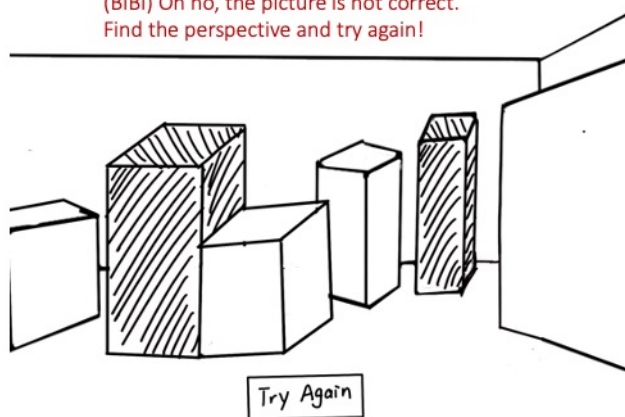
29

(Music) Good job! You get the correct picture. You are a great journalist now. Go and invest!
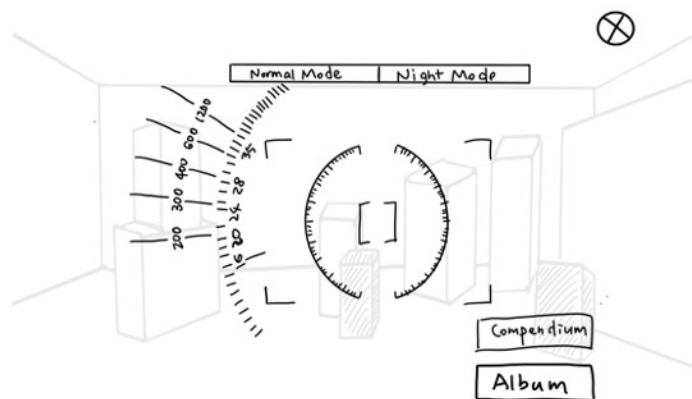
Go!

Level

| Tutorial | Level 1 | Level 2 | Level 3 |

Level

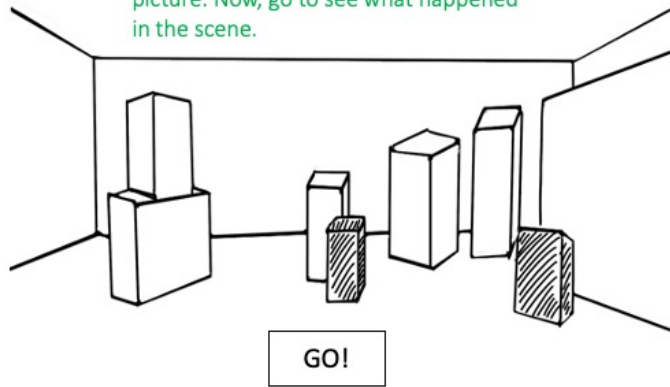| Tutorial | Level 1 | Level 2 | Level 3 |

118

Normal Mode | Night Mode

Compendium

Album

119
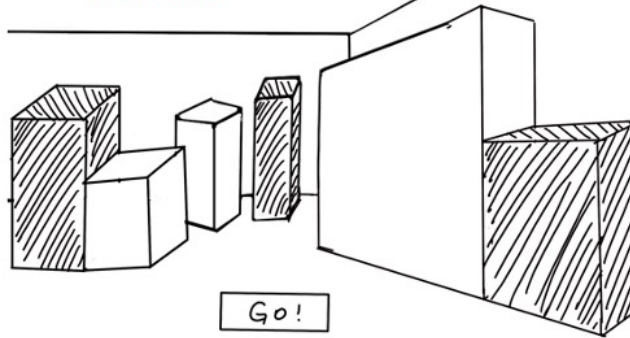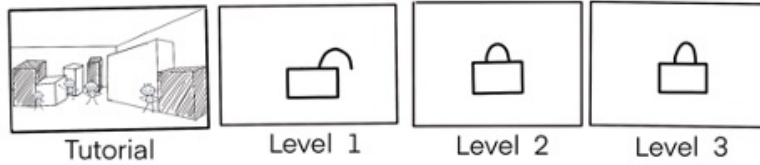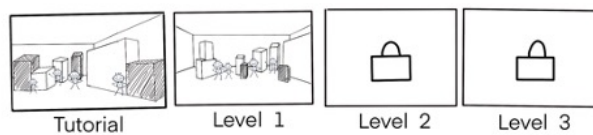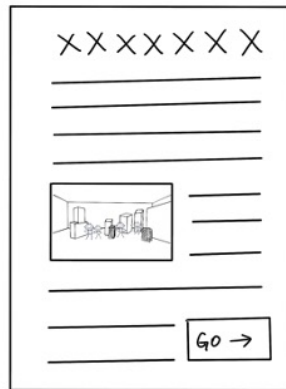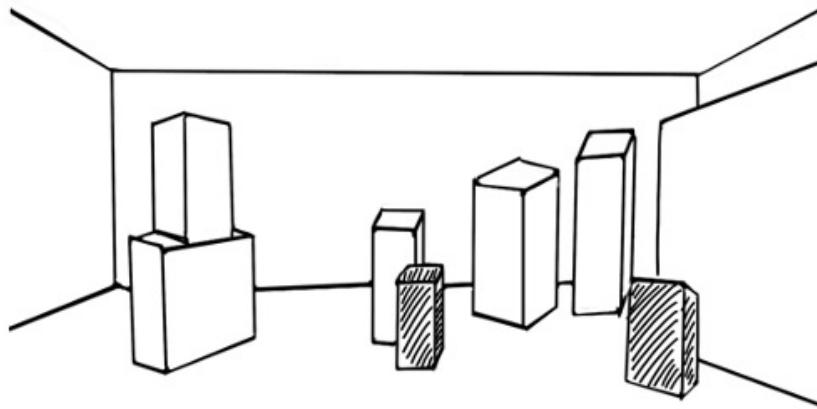
(Music) Good job! You get the correct picture. Now, go to see what happened in the scene.

GO!

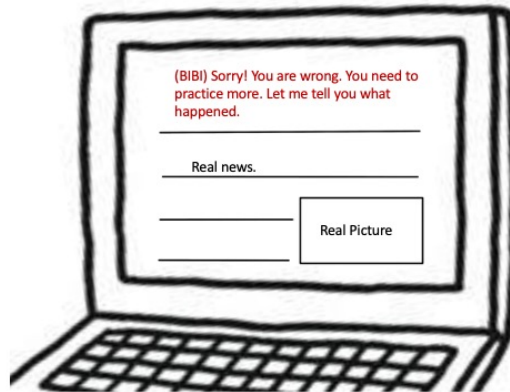Have you explored the scene?

Yes, I'm ready to answer the question.

No, I'd like to explore more.

Is this fake news?

Yes

No

(Music) Congratulations! You are a sharp journalist! Let me tell you what happened.

Real news.

Real Picture

(BIBI) Sorry! You are wrong. You need to practice more. Let me tell you what happened.

Real news.

Real Picture
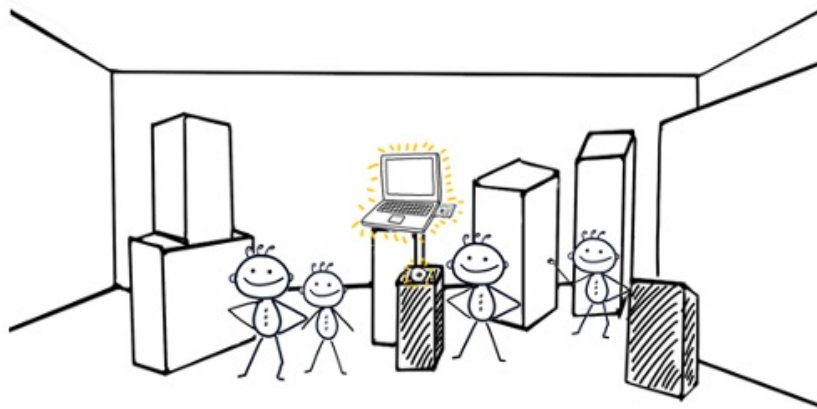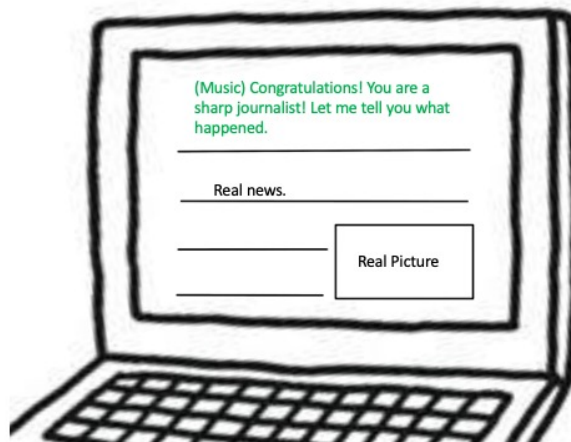
41

You've got a new camera lens now!

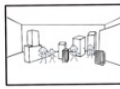Use this gesture to zoom in.
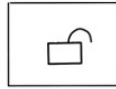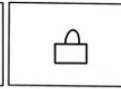
Use this gesture to zoom out.

Got it!

42

Level

Tutorial   Level 1   Level 2   Level 3

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