The use and effect of virtual reality technology in life health and life safety

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Declaration

I hereby declare that this thesis is my own work and effort and that it has not been submitted anywhere for any award. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

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Abstract

In recent years, more and more research are using virtual technology to develop various education and training systems. Virtual reality technology has proven to be very effective in education and behavior modification. In a country with many natural disasters like Japan, disaster prevention education is also a very important issue. In addition, a lot of manpower and material resources are spent on safety education in facilities and schools every year. This research explores the role and effect of virtual reality technology using VR/AR/MR equipment in life health and life safety. At the same time, the advantages and disadvantages of VR and MR in applications were discussed, the trade-off between computing resources and reality was considered, and more effective life safety education was sought. This research proposes a human movement training system realized by VR and a life safety evacuation training system realized by MR. In Experiment 1, VR was used to induce participants to explore the virtual space and make corresponding training actions, and the participants' feedback was recorded to detect the effect of the virtual space. In Experiment 2, the spatial recognition feature of mixed reality (Hololens) was used to "burn" objects in real space to create a large-scale simulated fire field. According to data investigation, it has been confirmed that 3D holographic obstacles can be used to train 3D obstacle avoidance, and an impressive degree is effective for training. Without exceeding the device function limit, the realism is improved as much as possible. The system is designed to be used directly in any place (home or public place) to increase immersion and realism. In Experiment 3, by connecting two composite reality machines, the observer can observe and record the participant's actions in real time. If it is two devices of the same version, it can also simulate a two-person joint evacuation exercise, thereby increasing the degree of authenticity and impressiveness. In order to improve the efficiency and training effect of virtual evacuation.

Keywords: *Virtual Reality, Mixed Reality, Trade off, Hololens, Health and safety Training, Fire Simulation,*

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Chapter 1

Introduction

1.1 Background

Combined with the development of virtual reality in real life, virtual reality technology has also been widely used in the prevention of psychological trauma and psychotherapy. People are basically afraid of things. Some people will feel dizzy and trembling when standing on the roof, some people on the plane will think of a crash disaster, and people standing in a crowded room will feel throat discomfort. Under normal circumstances, experienced disaster survivors may suffer from a disease called post-traumatic stress disorder, which is sometimes very serious. For example, the crowded city roads reacted enthusiastically, and some soldiers thought of previous explosions and roadside bombs. After the attack, survivors will be very afraid to see quiet streets with strangers. If the patient wants to overcome anxiety and recover from trauma, this can be very difficult, time-consuming and very important for the patient. VR/AR/MR technology can change people's way of thinking through pre-experience and stimulate them through corresponding scenes to complete some exercises and training. Virtual technology can bring participants to the real world that is separated from reality or transformed to help them learn and recognize. Wearing a headset device allows patients to experience a new 3D world and get special senses that are usually difficult to achieve. Such as exploring the underwater world or riding a roller coaster to overcome fear in advance.

Due to the inefficiency of some relatively traditional counselor training methods and the large amount of labor and material costs, people have always placed high expectations on virtual technology in the field of life safety and health education. The common shortcomings of these traditional training methods are the lack of sensory stimulation, the lack of clear pointing meaning, and the exciting environment for cutting methods. These are the strengths of virtual technology.

1.2 Related research

In 2020, there are many VR fire simulation trainings, even appearing on the training platform steam. We often encounter fire accidents, but how to escape from fire has always been unable to attract the attention of young people. According to literature reports 【1】, there are some possible reasons why young people are not motivated to participate: traditional fire safety education is not only boring, but also a waste of manpower and material resources. The most important thing is that there is a certain degree of danger. However, with the development of VR technology, the application of VR technology to fire escape training has greatly increased the fun of disaster prevention education. All of VR/AR/MR applications are summarized, and the future development trend is prospected 【2-4】. MR can superimpose the virtual scene carrying three-dimensional information with the real world, greatly improving the intuitiveness, accuracy and real-time nature of the user's sensory world. Boeing plans 【5】 to use the infrared equipment on the drone to find overlooked fire points, thereby providing more environmental awareness and helping staff make better decisions to control fires. In a fire extinguishing program designed by Boeing, the staff can also control and analyze the holographic map made by the drone through HoloLens to assist the fire fighting work. After wearing HoloLens, this mixed reality helmet, the data obtained by the drone can be presented in the form of three-dimensional vision. The staff only need to operate the flight simulator above the map, and the drone can automatically fly to the target location. Although many devices are currently regarded as AR/VR/MR devices, in fact, according to specific definitions, many devices do not fully comply with the defined functions of AR/VR/MR 【6】. Take Google's AR/VR/MR equipment as an example. Since Hololens was used, many people have been developing it with AR equipment. However, Microsoft stated at the Developer Summit that Hololens is not an AR device, but an MR (Mixed Reality) device. The previous device Google Glass was AR glasses. And Hololens is obviously more powerful than Google Glass. Hololens as an MR device has many advantages over Google Glass, an AR device. According to Microsoft's explanation, Google Glass can only superimpose the virtual scene and the real scene. Virtual and real are not well integrated, Hololens can integrate virtual and real. For example, the picture displayed in Hololens can be pasted to the wall in the real scene. When the user turns his head, the picture does not follow the rotation, but keeps the feeling of sticking to the wall. The user will feel that the picture is on the wall. Not on the glasses. But the picture in Google Glass will always follow the glasses, and the user will only feel that the picture is on the glasses. In addition, Hololens can also allow users to interact with virtual scenes and recognize the user's gestures in real time. The user's hand can touch virtual objects, for example, the user's hand can hit a virtual ball. However, according to the definition of AR 【7】, if the AR function is fully realized, it is not simply to superimpose the virtual screen into the real scene, but the real scene must be recognized, including the three-dimensional structure and content, so that the computer can draw the virtual screen to better understand the reality. For "enhancement", for example, a navigation arrow should be displayed on the road. If the position of the road is not correctly identified, the arrow cannot be drawn well and cannot fit the road naturally. It is very suitable for various research and development. And compare. However, Google Glass is just a wearable mobile device, including a camera, display, processor, and battery. The user using Google Glass basically looks at the weather, time, information and other content displayed on the screen, and there is no real scene outside the glasses. Too much connection, in addition to Google Glass, a heavy function of voice control to take pictures and browse photos, this function can only be said to be a miniature camera worn on the eyes, not a real AR device, so it is difficult to be used Research and compare. The real AR first emphasizes the sense of presence. The content displayed by AR must be closely related to the scene. Without the scene, there will be no enhancement. Therefore, AR must try to fill the user's entire field of vision with the real scene. Observe the real scene naturally, and the design that weakens the natural light often leads to a bad experience (outdoors, except when the light is too strong). AR needs to use a light transmission design or use a wide-angle camera to shoot the scene and display it in real time. It is certainly not enough to only display the scene, it is defined as ordinary glasses or ordinary video surveillance. AR must understand the scene in real time, and understand the three-dimensional structure and content of the scene, such as knowing the location of the ground, the location of the wall, the size of the space, where is the channel, where it will collide, etc., and can correctly identify the content in the scene , Such as which are cars, which are people, which are buildings, etc. After understanding the scene, it can be enhanced. There are many enhancements, such as changing the color of the wall, displaying navigation arrows on the ground, displaying names next to items, and so on. Therefore, AR technology that does not understand the scene is not real AR. For example, randomly paste some text and tags on the video. The specific content and display position of this information will not change with the real scene. They are all set manually in advance. Fixed. VR first emphasizes the sense of immersion, a complete virtual reality experience. Since virtual scenes can be artificially designed without requiring a sense of presence, the pictures of real scenes will destroy the sense of VR immersion. Therefore, VR needs to isolate the external light from the product. The design is also to make the virtual scene occupy the entire field of vision as much as possible, to avoid the real scene picture from entering the eyes. Natural light entering the eyes is called light leakage in VR products, which is a bad indicator. A good VR experience requires the experiencer to forget the reality he is in. Entering a VR scene is like entering a dream. We can compare the VR experience to "dreaming". Google's VR platform is also called DayDream. "Dreaming" is generally not related to the actual environment the user is in. Interactivity is a very important aspect of VR, allowing participants to interact with virtual objects or even the entire virtual scene, making users feel like they are in a world with a complete experience. There are currently many VR devices without interactivity, like a substitute for a display.

Through the above analysis, the similarity between VR and AR is that both need to use computer graphics and image technology to draw virtual images, and VR requires higher fidelity of images. And all the images in VR are drawn by a computer, so the computer's image drawing performance is high, and a high-performance GPU is often required. Most of the images in AR are taken through lens transmission or cameras. The computer-drawn images in the AR program account for a relatively small proportion of information, and have low requirements for image fidelity, so the requirements for graphics rendering performance are not high. But AR needs to understand the scene. Understanding the scene is not a simple matter. It requires very complex algorithms and needs to run in real time. In this way, AR requires very high CPU computing performance. The difference between VR and AR is that VR must isolate as much of reality as possible, and AR must introduce as much reality as possible. The requirements of the two in this regard are completely opposite. VR equipment uses sponges and other materials to close the eyes and screen, so that Outside light cannot enter, and AR equipment will use high-transmittance lenses, wide-angle cameras and other components, and try to invite outside light in. VR has high requirements on GPU, but relatively low requirements on CPU, AR has high requirements on CPU, but relatively low requirements on GPU.

In terms of virtual scene rendering performance【8】, the CPU, RAM, and GPU performance of HoloLens, the target operating device of the prototype system, is much lower than that of ordinary desktop computers. AR technology can simultaneously visualize the information in the real world and the virtual world, and supplement, superimpose and merge the two kinds of information, so as to achieve a sensory experience beyond reality. Compared with VR technology, AR visualization method can realize selective information enhancement on the basis of adapting to reality and retaining reality. While observing interactive virtual information, it can also see the real world. It is not easy to cause dizziness and user experience.

VR first entered the market, and was applied to many practical scenarios after being researched and developed. And because life safety has always been the most concerned thing for people, it has been seeking solutions through various forms for many years. The application of VR quickly attracted the attention of some scholars and used it in the fields of medical health and life safety.

As people's acceptance of virtual reality continues to develop, disaster prevention drill centers in the form of VR experience halls have also been built, and VR technology has become closer to people's lives. According to reports in 2019【9-10】, several companies in China opened VR experience halls with the theme of safety education across the country. It includes a VR fire safety training system to provide experiencers with a variety of fire escape content, including fire escape scenes such as subways, campuses, homes, shopping malls, and office rooms. Experiencers only need to wear VR glasses and somatosensory equipment to see realistic scenes. Experiencers can learn in the system how to call the police, how to choose an escape route, how to use a fire extinguisher to put out the fire, and how to protect themselves. Through VR technology, the real fire scene is 100% restored in the virtual space, making people immersive, simulating the scene of the fire and various perceptions of the human body to the greatest extent, allowing the experience to deeply feel the illusion that the fire is around. The VR fire protection system will set up prompts for the entire experience process to avoid panic caused by the fire. Experiencers can deeply feel the "real" of the fire during the experience and perform corresponding operations according to the systematic prompts. In this step-by-step process, they can learn fire safety escape knowledge and master escape skills, thereby ensuring that people master the fire fighting and fire escape skills. The frequent occurrence of fires makes the country pay more attention to the dissemination and education of fire protection knowledge, but the usual publicity and education are generally less effective and difficult to attract everyone's attention. In the future, the technologicalization of fire safety education will not only be reflected in on-site rescue, but also in the awareness of prevention. We use virtual reality technology to provide a variety of safety education training and simulation training according to different fields, so that participants can more deeply feel the terrible fire and the complicated situation of disasters, thereby increasing the importance of safety education by participants.

The virtual firefighting scene has the advantage of being immersive and "real" and vivid and has a strong sense of substitution. It is very important to train participants to react correctly in the fire scene. At the same time, it is also very important for participants to feel the thrills of the disaster site without causing any harm to the participants. Let participants master the fire fighting and fire escape skills in a similar training experience. At the same time, participants can gain a sense of presence through images, voice and other forms, which is the effect of real-time feedback operations. As the types and quantities of fire fighting equipment are increasing, the on-site environment is becoming more and more complex. Therefore, VR/AR/MR technology is needed to make firefighting experience. Reduce the time cost invested in drills, improve the effectiveness of publicity and training, and break space constraints, enabling fire safety training and drills anytime and anywhere.

Japan has been developing in various areas due to disaster prevention issues. The cause is that 20.5% of the earthquakes of magnitude 6 and above that occur in the world occur in Japan, and the number of active volcanoes is occupied by 7.0% of the world【11】. Besides, in the case of an earthquake fire between large cities such as Tokyo and Kyoto, if the fire probability is 0.00048, the probability of a room being burned will be about 0.9 for a 5000-community【12】. Although efforts are being made in each area to reduce the mortality rate in Japan, disaster prevention is a life-threatening issue.

Here, the cause of emphasizing the importance of disaster prevention education is an important part of the education in which disaster prevention education lives because proper judgment at the disaster site can save lives【13】. People who should be saved often lose their lives by panic.

In 2017 Mizuno team【14】A method for automatically generating evacuation routes using virtual space is proposed. It proposes a method of automatically drawing a map, automatically identifying obstacles in front, and intelligently planning an escape route so that participants can follow the escape route. This approach is to solve the problem that participants have too much freedom in the usual fire escape training and even want to move in the VR environment. You can plan the route in advance to clear the obstacles and move. However, this approach severely limits the places to participate and increases the preliminary work. The overly blunt map performance will make it difficult for participants to immerse themselves in the virtual experience and lack realism.

In 2008 Takebe team【15】 A fire evacuation simulation was carried out for the teacher group. They first determined the school's designated route and conducted the first evacuation experiment based on the literature. As a result, everyone completed the evacuation goal within the designated time. However, in the second test, with the same personnel and school, the accidental fire site was added and the evacuation route specified in the literature was broken. As a result, all personnel failed to successfully complete the evacuation. Since various accidents may occur in the evacuation process and the scheduling of the flow of people, and under special circumstances, it may also cause panic. Therefore, it is necessary to simulate special circumstances to deal with various evacuation needs.

NTT FACILITIES Research 【16】 Improve the function of disaster simulation and reduce the overall cost by using VR/AR. They created a tsunami and fire evacuation simulator for outdoor use, so that participants can easily experience disaster simulation through the assembly of smartphones and glasses. When an experiment was conducted at an elementary school in Mitaka City, Tokyo, it proved that it has augmented reality capabilities and educational significance for disaster recognition. But there are also some shortcomings, such as the lack of display effect of the analog screen, resulting in limited picture impact. The link with real life also requires the association of participants and lacks influence.

In 2019 Itamiya team【17】 developed a simulator application that virtually fires and extinguishes the fire with AR, for cost reduction in fire extinguishing training. It needs a real fire extinguisher with virtual water spray training, but it may be more suitable for firefighters than the general public, and it was lack of impact in smoke and flame.

MR connects the real world and virtual space like AR, it can calculate and express complex screens like VR in real-time with a strong impact. 3D model reproduction in the room has evolved into an automatic processing method, and precision is increasing【18】. The great advantage of Hololens【19】 is that holograms can be expressed with high precision and the current position can be calculated using a 3D map while recognizing the surrounding space.

Hololens, which brings more realistic interactivity, is obviously more suitable for simulating fire scenes. Microsoft said【20】that compared with the previous version of the scientific research mode, this update not only opens the permission to view data such as inertial measurement, but HoloLens 2 gesture recognition and eye tracking functions can also be used simultaneously with the scientific research mode, bringing richer scientific research experiments Sense of experience. According to Microsoft official data, Hololens 2 weight balance distribution design. Compared with the appearance of the first generation, the second generation adopts a weight balance distribution design. The center of gravity of the second generation is moved backward by 58 mm, and it is widened at the rear of the device to play a protective role. At the same time, let the spine share part of the weight. This greatly improves the comfort of the second generation, and it is no longer so pressing. When wearing Hololens1, because of the light head heavy, I always worry about the device slipping when I lower my head. After adopting the weight balance distribution design, Hololens2 will be relatively stable to wear. According to the experimenter's experience, the head can be flexibly rotated up and down and left and right after being worn without burdening the neck and bridge of the nose. Although it is not much lighter than the Hololens 1, it is in the wearer's head is more balanced, and the headband design is added to distribute the weight. This balanced design makes the wearer feel very light, even if the head shakes, it is not easy to loosen. Especially in the ergonomics of the glasses body, the one-hand flip design does not need to be taken off frequently, which is extremely practical in various engineering fields. As for the Hololens2 display, let me briefly talk about a few important parameters. The resolution has been increased from 720p to 2k without affecting the picture quality, and the viewing angle range has more than doubled. There is a knob on the back of Hololens 2 for adjusting the size of the device. With this knob, it can be adjusted with the internal hinge, no matter if it is a big head or a small head, there is no need to worry. Moreover, it is equipped with a memory foam, which can be matched according to different people's head shapes. This sponge can be removed for cleaning or replacement. Hololens officially stated that the comfort level has been increased by about 3 times through this design. HoloLens 2 still uses two visible light cameras on the left and right for positioning based on structured light and supplemented by IMU. Due to the improvement of computing power, sensor accuracy and algorithm, HoloLens 2's SLAM capability is much stronger than that of the first generation, with better stability and strong continuity.

2. Experiment 1: Complete the training action through VR interest induction

The purpose of Experiment 1 is to test the participant's response to the virtual space, and through the training, to achieve VR interest induction, and guide the participant to complete a series of designated actions. The experiment is designed as a series of VR training experiences, allowing participants to explore and complete goals in the training independently. The system uses Kinect to capture the participant's movements and displays them in a virtual space synchronously through animated characters, in order to improve the participants' cognition of their movements and the fun of the experiment itself.

2.1 About interest induction

VR technology completely controls the vision, so it can make users stay away from the original feeling of the body and place their own images through imagination in the virtual space. It is important to keep the frame rate stable and higher than 60 fps, it can avoid The nausea caused by sports【21】. Because the real world has many physical rules, so in the virtual world, it should also have some physical rules to follow. The immersion of virtual reality is an experience of getting the senses of the body in a non-real physical world. It can know in our brain that this is false and unreal, and it is an experience that includes the spiritual world or part of the physical world. In the virtual world, when we create somatosensory and activate enough perception, we can enter the immersive experience. Virtual reality requires as many senses as possible to simulate. These senses include sight, hearing, touch and so on. Correctly stimulating these sensations requires sensory feedback and multi-sensory coordination based on vision. Using this, we can use interesting, animated characters and beautiful pictures to attract the attention of users, produce an immersive sense of substitution, and let users happily complete the training goals spontaneously. This sense of substitution greatly suppresses all kinds of discomfort and fear during training. Many evaluation factors for entertaining the senses. However, because the experiment focuses on the induction of interest and the completion of specific goals, the exercise experiment training. 2. Curiosity training. 3. Tension training. 4. A sense of accomplishment training. Thus, as shown by the progressive KDDI research【22】, viewers of virtual YouTuber created through motion tracking technology can perceive a sense of security, compassion and self-affirmation. Self-affirmation is an important aspect of inducing interest. In VR trainings, the use of animated characters to express the user's behavior in real time can improve the user's sense of self-identity. This recognition brings satisfaction and happiness, enhances the desire to explore, and increases the effect of interest induction. Interactive elements are essential to the virtual reality experience. It can provide participants with sufficient comfort and allow them to participate in the virtual environment naturally. If the virtual environment reacts to the participant's behavior in a natural way, the excitement and immersion of the participant will be preserved. And if the response of the virtual environment is not fast enough, the human brain will notice it quickly, and the immersion will be weakened. The response of the virtual environment to the interaction can include the way the participant moves or changes his or her viewpoint, usually through head movement. Through this information interaction, it can affect the user's behavior in real time, so it is generally considered to be very suitable for the fields of medicine and education【23】. In order to achieve a pleasant life and health education, the accuracy of VR-related simulator technology has also been improved, even reaching the medical field. Using limited resources to effectively train and educate requires VR to achieve high-precision and real-time functions in a virtual environment【24】. They believe that not only in young people, but also in studies involving the elderly, people generally believe that VR training can help improve the enthusiasm of the elderly and lead to human health【25】. In order for the human brain to accept an artificial, virtual real environment, it must not only look real, but also feel real. Wearing a head-mounted display (HMD), you can achieve realistic visual effects. HMD displays a three-dimensional environment that simulates reality. Real feelings can be achieved through handheld input devices, such as interactive motion trackers based on user actions. By stimulating people's senses in the real world, the virtual reality environment becomes more and more like the natural world. Using the hand as an input tool makes the interaction method the most intuitive and natural. It allows participants to freely use different types of gestures to interact with the virtual world. However, gesture input usually requires interactive objects to be within the reach of the user's hand in order to manipulate them. VR induction systems can usually provide effective guidance for participants. And through the data obtained by sensors, scientifically and strictly grasp the mental state of these people and the training and education procedures【26】. For mobile phones, tablets, and laptops, the carrier format and screen size are known from the very beginning of writing an application. But in a 360° VR space, the carrier form and screen size depend on the design and layout of the VR environment, which in turn is determined by the purpose of the VR application. The interface should not continue to appear within 0.5 meters of the user, because too close can make it difficult to concentrate. However, this area is suitable for triggering the gesture interaction of settings and menus. The depth of space beyond 20 meters from the user will not be perceived. Therefore, the area between 0.5 meters and 20 meters is called the golden zone. However, in view of the current screen-based VR display technology is limited, the focus of the line of sight is 2 meters, and the content is placed between 2-10 meters will make people feel the most natural and comfortable. The content shown here can be comfortably perceived. In the Internet age of today's society, communication is connected with huge invisible lines. In the field of information sociology, the connection between people and computers has been discussed, and various research results have attracted people's attention. There are individual differences in attitudes towards animated characters, but the positive influence has been shown to be positively correlated with the degree of interaction【27】. The fun of computer trainings is related to the user's intrinsic motivation. These motivations include "challenge", "curiosity", "competition", etc., which can be divided into "sensory motor skills pleasure", "visual excitement pleasure" and "challenging pleasure" 【28】.

2.2 The composition of the experimental VR training

The VR experimental environment is a PC for VR, running on Windows 10. The hardware developed using the VR gaming environment is HTC Vive Pro HMD. Its base station location tracking can reach up to 7m X 7m spatial location tracking, and HTC Vive's SteamVR locator 1.0 can support 3.5m X 3.5m spatial location tracking. Vive pro resolution: single-eye resolution 1440 x 1600, binocular resolution is 3K (2880 x 1600). If a realistic visual experience is required, the field of view must be as close to reality as possible, so it is necessary to satisfy the FOV close to the human eye and the angle of view following the head movement as much as possible. The feature of FOV is that the coverage of the eyes is different, usually the total of the two eyes can exceed 180 degrees. Since it is difficult to achieve this effect on a flat LCD screen, VR hardware mostly uses convex lenses to achieve a FOV of about 100 to 110 degrees. Although it does not reach the level of natural field of view, it is 50 to 60 degrees compared to the traditional FOV. It is a huge improvement, which directly affects the design and interaction of 3D images. In order to solve the problem of viewing the picture through the lens at a close distance, we usually need to perform a proper reverse distortion correction on the picture. The training engine is Unity 3D (v2016.2). Taking into account the saving of computing resources, some unnecessary image effects will not be added, such as the depth of view, blur effect and lens flare effect used in training development for VR, because we are also in the real world Can't see these effects. The training images are made using Photoshop and 3dsMAX. Image analysis uses opencv to achieve unification. Use Kinect for Windows in conjunction with Unity3D to simultaneously represent user movement in the 3D model.

2.2.1 Operational judgment training

First of all, the core of the action judgment training is to observe the movement of the entire body. Create an inspection training that allows participants to understand how their bodies move in a virtual environment. In order to express the user's movement in real time, the official "Kinect for Windows SDK" provided by Microsoft is used to provide the coordinates of the user's skeleton for the animated character through Kinect. As shown in Figure 1, since the presence of the user is recognized, the coordinates of the bone marrow can be seen. In this way, the participants start to move the anime characters by moving their bodies. As shown in Figure 2, the training will set a moving target in a specific safe activity space. Guide the target object to move according to the prescribed rules. In order to achieve the goal, the user's actions can be carried out to the prescribed rules. The guide target object is placed at a distance where the two hands can be released from the character, and guided from the lower right direction to the upper left direction to the lower left direction, so that the whole body can be moved to adapt to the environment.

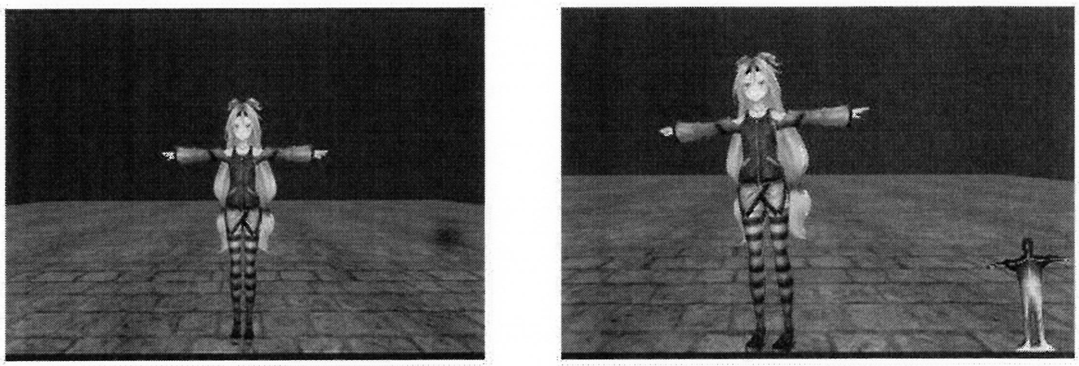


Figure 1: Project the skeleton from Kinect to the animator by "getbonestransfor"

AvatarController.cs script to animated characters

Kinect Manager.cs script to empty

use Transform GetBoneTransform and return bones[index]

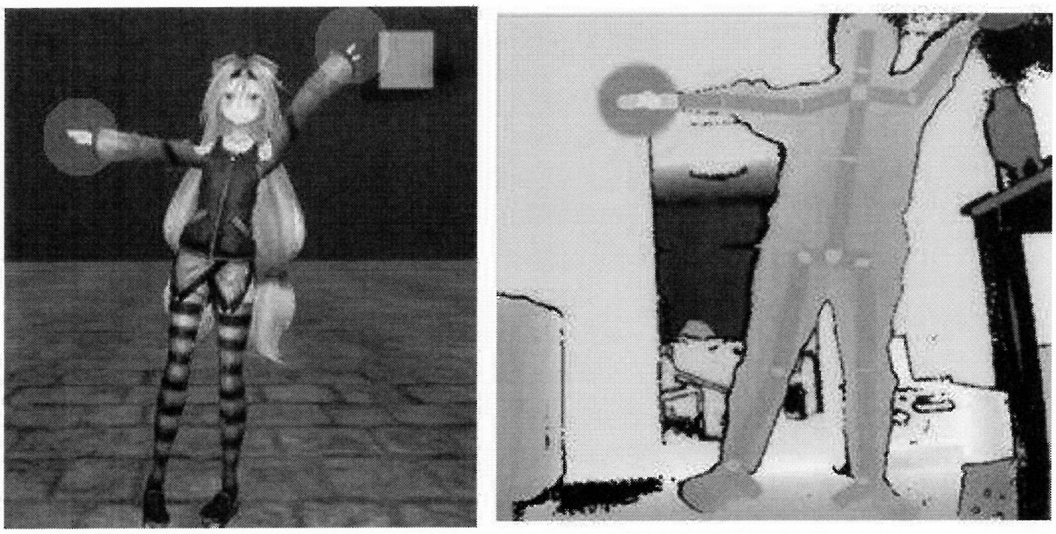


Figure 2: Reach the goal

Using this training not only allows the participants to adapt to the virtual space, but also allows us to grasp the participants' conditions in all aspects, including dizziness, pain and other discomforts in order to respond in time. The movement data obtained from a healthy college student, and the data is used as a basic sample to construct the basic model of the experiment. After that, animated characters are used in the virtual space to express the actions of the participants. It looks consistent with the movements of the participants and is trusted by the participants like a mirror. Expect the participants to imagine the cute characters in themselves. Under this influence, users can enter the virtual world from the lonely reality and be attracted by the virtual world. In the sample collection of college students, the participants showed positive reactions and even made a lot of actions that exceeded their goals. If this method is presented with better quality images, users may be able to project cute, young and healthy consciousness into their reality through imagination, and produce long-lasting effects.

2.2.2 Curiosity training

In the next training, we made a training similar to a puzzle, which can guide users to solve problems. Since this kind of puzzle training can be played without time limit, users can achieve their goals slowly, not even rushing to achieve them and observe and use the objects or parts they are interested in. This provides participants with more free time to get used to their point of view, feel the error between the virtual and the real, and then continue to explore ways to complete the training's goals. This method will make participants happy to copy the same action, such as raising the right hand to the same height repeatedly, and this meaningless and boring repetitive action usually arouses people's strong disgust in reality. But in VR trainings, these actions have interesting meanings. This puzzle training requires participants to judge according to the color blocks of different colors, and place or throw the puzzle parts of the corresponding colors at the correct angle to the position of the corresponding color blocks of the puzzle board to complete the target puzzle. If the system judges that the colliding body on the puzzle board matches the puzzle component, then the components will be bound to the puzzle board until all are completed or the training is reset. It uses Unity's own gravity physics engine, so that the throwing can be expressed very smoothly and naturally. In order to show the effect feedback of the component binding, a command to change the component color is added when the component is bound.

```
private void OnTriggerStay(Collider other)
        {
            if (place == other) //the right position
            {
                render.material = mat1; //change color

            if (!beCapture) //if leave hand here
              {
                    //There is still distance, close to the target
            if (Vector3.Distance(transform.position, place.transform.position) > 0.02f)
                {
                        rigidbody.isKinematic = true;
                transform.position = Vector3.Lerp(transform.position,
place.transform.position, Time.deltaTime * 5f);
                 transform.rotation = Quaternion.Lerp(transform.rotation,
place.transform.rotation, Time.deltaTime * 5f);
                    }
                  else //or merge now
                    {
                        Destroy(rigidbody);
                        foreach (var i in colliders) i.enabled = false;
                        render.material = mat0; //color
                        Transform clone = Instantiate(gameObject).transform;
                        clone.parent = place.transform.parent; //match
                        clone.position = place.transform.position; //position set
                        clone.rotation = place.transform.rotation;
                        Destroy(clone.GetComponent<PuzzlePiece>());
                        PuzzleFrame.shared.Inlay();
                        Destroy(gameObject);
                    }
                }
            }
        }
```

If the binding occurs successfully, the component color will be highlighted. Timely feedback similar to this situation will give participants a clear reminder of success. This feeling is a positive feedback and an indispensable part of attracting participants' mental power.

```
void Update()
        {
            //Pick up and discard
            if (m_Device.GetHairTriggerDown()) //Trigger button pressed
            {
                if (m_TriggerOther) //Hit an object
                {
                    m_InHand = m_TriggerOther;
                    m_TriggerOther = null;
                    m_FixedJoint = gameObject.AddComponent<FixedJoint>();
                    m_FixedJoint.connectedBody = m_InHand.GetComponent<Rigidbody>();
                    m_FixedJoint.breakForce = grabPower; //Shake
                    m_FixedJoint.breakTorque = grabPower; //Twist
                }
            }
            else if (m_Device.GetHairTriggerUp()) //The trigger is raised, ready to discard
            {
                if (m_InHand)
                {
                    if (m_FixedJoint)
                    {
                        m_FixedJoint.connectedBody.velocity = m_Device.velocity; //Shake
                        m_FixedJoint.connectedBody.angularVelocity = m_Device.angularVelocity; //Twist
                        m_FixedJoint.connectedBody = null;
                        Destroy(m_FixedJoint);
                    }
                    m_InHand = null;
                }
            }

            //Reset
            if (m_Device.GetPressDown(SteamVR_Controller.ButtonMask.ApplicationMenu))
            {
                UnityEngine.SceneManagement.SceneManager.LoadScene("Scene");
            }
        }
    }
```

At the same time, in order to avoid system failures caused by excessive collisions or incorrect links caused by the misrecognition of the physics engine, we consider adjusting the smoothness of the puzzle parts to a high level. Although some system failures will still occur in rare cases, it will no longer affect normality. use one-button reset can solve various special situations that occur during the puzzle process. The position and direction of the puzzle board may vary according to the participant’s position.

As shown in Figure 3, in the case of the left hand, the puzzle board appears above the user's position as the target. At the same time, in order to protect the safety of participants, we set up a bright blue safety range marking line according to the size and location of the laboratory to prohibit participants from going out of the test range and conflict in reality. It can be seen from the initial screen that the user picks up a piece of chess with his left hand, judges the color and finds the corresponding target position on the puzzle board, and then throws the puzzle. Participants are required to repeat the action four times in the same way to complete the entire piece. In the imposition puzzle, if any failure occurs, the participant needs to return to the origin and start a new round of challenge. In order to improve the visual sense and sense of balance, we added a cosmic background to make the picture more three-dimensional.

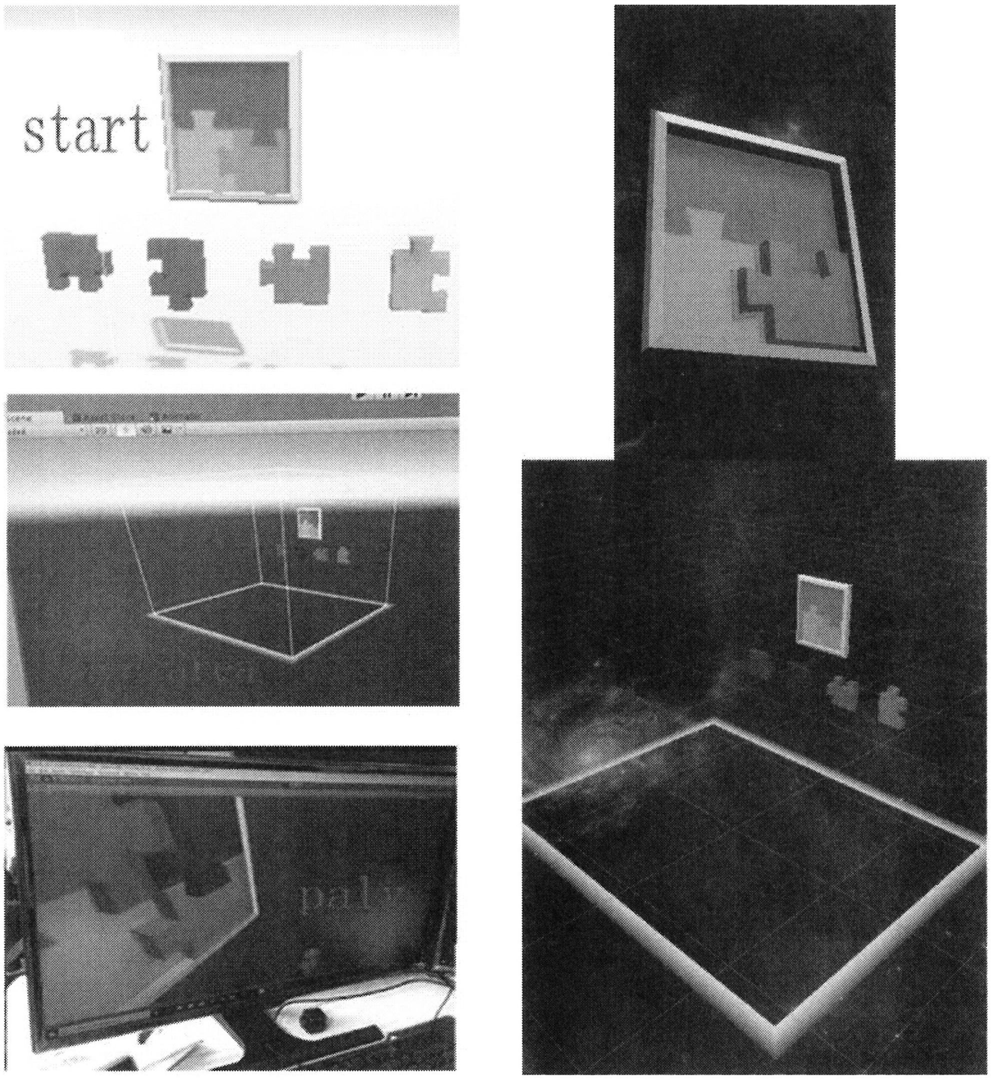


Figure3: Puzzle training Guide users to solve problems

Without time limit, users can achieve their goals slowly, not even rushing to achieve them and observe and use the objects or parts they are interested in.

2.2.3 Tension Training

The third training is a tension training. The core of this training is to bring tension to participants and train participants to maintain tension. This kind of tension that must complete the goal in a short time can quickly attract the attention of the participants, make the participants forget the time in the tension and achieve the effect of immersive experience. Here, we first create some enemies, make them fall randomly in the direction of the participants, and create tension by constantly approaching enemies at high speed. Participants must turn their bodies and make slashing actions to destroy the approaching enemies in a very limited time. The enemies appear not only in front of them, but may also appear around the participants, making the participants experience the feeling of being surrounded on all sides. This places high demands on the participant's response speed. The tension generated by this kind of pressure can allow participants to concentrate quickly, weaken other senses, and even complete some extreme actions, which has the meaning of rapid strain training.

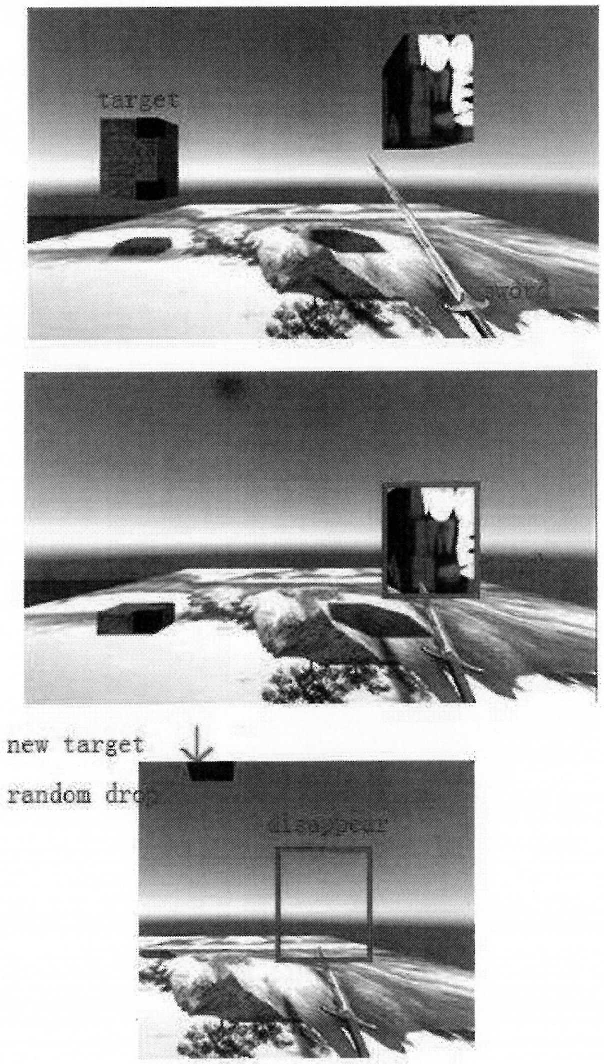


Figure 4: Tense training

As shown in Figure 4, if the target is successfully pierced before approaching, the collision body of the sword will coincide with the collision of the enemy, and the enemy is judged to be pierced and the destruction command is executed. Enemies randomly appear from new positions within the range of +-5.0f.

```
//create army
static int i = 0;
    private void OnTriggerEnter(Collider other)
    {
        if (other.gameObject.name == "dagger" || other.gameObject.name=="ground")
            {

                GameObject newcub = GameObject.Instantiate(GameObject.Find("ccub"+i));

                newcub.name = "ccub" + ++i;
                                                          //Random area
                newcub.transform.position = new Vector3(Random.Range(-5.0f, 5.0f),
                                                    Random.Range(6f, 15f),-2.3f);
                Destroy(this.gameObject);
        }
    }
```

The number of fallen enemies and the sense of distance from the user can be adjusted. These variables that put pressure on the user gradually increase, and the training becomes more exciting. It is also possible to release enemies from a designated direction. According to training needs, a large number of enemies can be preset in directions that are more difficult for participants to adapt. However, this kind of fast-reaction movement can induce participants to make excessive movements in some cases. Therefore, in order to ensure safety, a more open space and surveillance protection are required, and all users are prohibited from playing in real space in this training, and position moves.

2.2.4 Sense of Achievement Training

The fourth training is an achievement training. The core is to allow participants to go through a difficult and painful process until the user reaches a certain goal. This process of achieving success through challenges will bring a great sense of accomplishment. Here, we create a training similar to "Angry Stick". In the training, the participants will face a huge passage maze. The participants need to hold the virtual iron rod with one hand and move forward in one direction until the exit of the passage. In the process of advancing, you need to be careful not to let the iron rod in your hand collide with the frame that constitutes the passage. Once a collision occurs, you will get negative feedback and a penalty of returning to the starting point. The communication route is composed of two similar combined collision bodies. For simple performance, we use the texture of the water pipe. And set a starting point and a finishing point. The iron rod must enter from the starting point and hit the red door at the starting point at the moment of entering, turning it into green to start the training. In order to prevent the cheating of withdrawing the iron rod halfway, a transparent monitoring area is set around the path. Once the training starts, the monitoring area will be activated. If the iron rod leaves the area, the training will be declared as a failure and the starting point will turn red.

```
void OnTriggerEnter(Collider other)
    {
        var objstart = GameObject.Find("startcub");
        var objend = GameObject.Find("endcub");
    //Trigger starting point cub
        if (other.gameObject.name == "startcub")
        {
            objstart.GetComponent<Renderer>().material.color = Color.green;
        }
    //Trigger end point cub
        if (other.gameObject.name == "endcub")
        {
            if(objstart.GetComponent<Renderer>().material.color==Color.green)
            {
                objend.GetComponent<Renderer>().material.color = Color.green;
            }
        }
    //Crash obstacle game reset
            if (other.gameObject.name == "Mesh"||other.gameObject.name=="Mesh")
            {
            objstart.GetComponent<Renderer>().material.color = Color.red;
            this.transform.position =new Vector3(-13.98f, 0.19f, -6.13f);
             }
    }

```

During the training, any time it collides with the collision body on any side of the path, it also declares that the training has failed and must be restarted. Only when the starting point is in the green open state and the iron rod successfully touches the completed red door, the completion point will turn green to announce the success of the training. In this training, participants cannot withdraw halfway once they start. They must be focused and carefully observe the iron rods and paths in the 3D space to ensure that no collisions occur, and at the same time, the iron rods will not be pulled out to trigger the trigger too far. Overcoming the pain caused by observation and exercise and reaching the end, participants can feel a deep sense of accomplishment. Because of failure, you must start over. If the difficulty is too high, this conference is a training that can easily lead to abandonment. So the difficulty setting is very critical. As shown in Figure 5, when the hand-held iron rod comes into contact with the path, it is returned to the starting point. Effective paths are usually not smooth or vertical planes, and have particularly difficult parts. Here, the complexity of the pathway can control the degree of attention and sense of accomplishment. And it is expected that this kind of micro-manipulation can better improve participants' perception and cognition of virtual space.

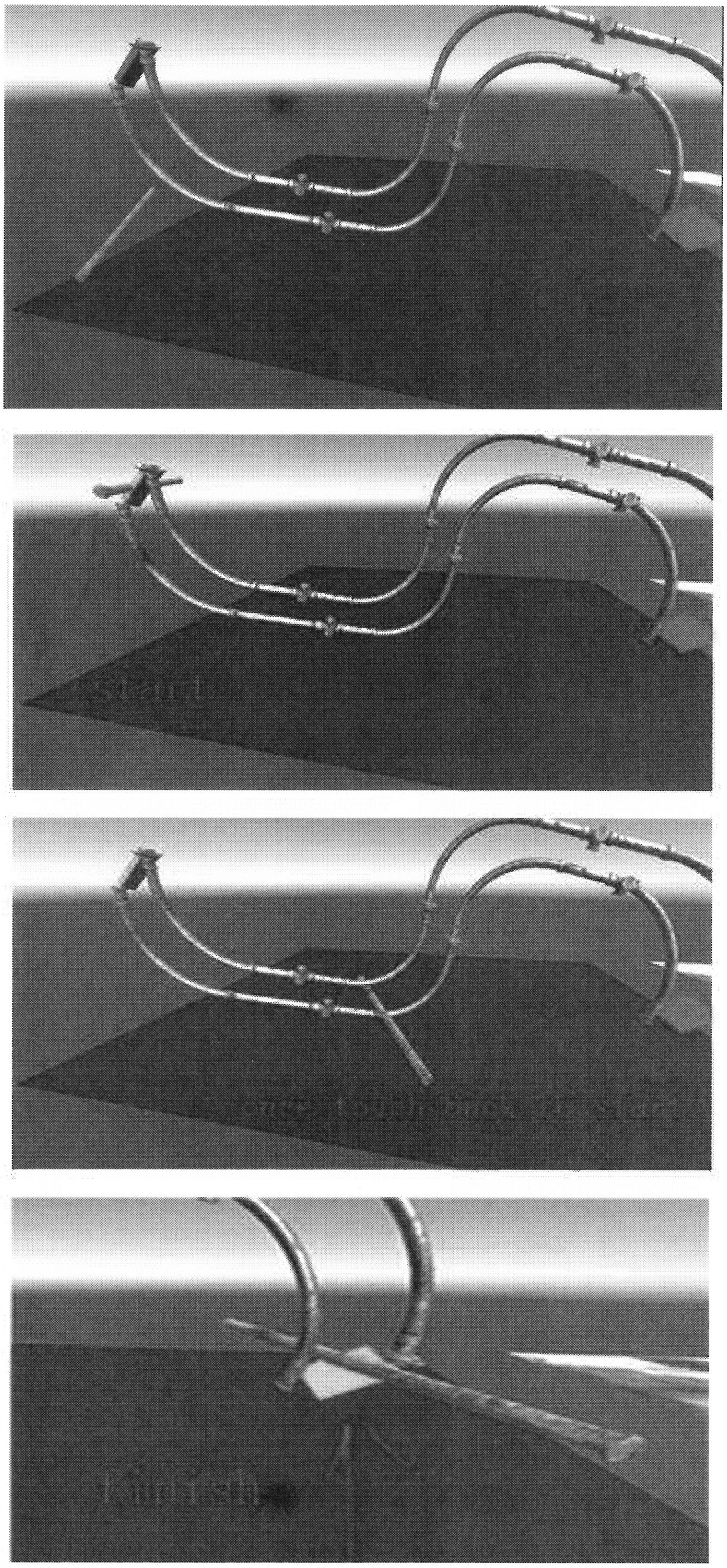


Figure 5: Achievement feeling training

A starting point and a finishing point. Prescribed area is set around the path. Once pass through the start point no stop. Failure will back to starting point and turn red.

2.3 Experimental results

As shown in Figure 6, an ordinary college student is very relaxed when raising his right hand, and is also very normal when making picking movements. And another ordinary college student with damaged right shoulder muscles was playing. Even if he raises his right hand, he will feel a certain degree of pain. In order to complete this puzzle, the college student leans slightly and raises his right hand. When he made the pick-up action, he made an abnormal excessive action. Although the college student with an arm injury spent more time completing the experiment, he still completed the goal of the training without giving up halfway. When the feedback mentioned that they were unable to raise their hands due to injuries, college students said: The VR training experience is very attractive. Desperate to finish the training, they raised their right hand, seeming to forget the pain this sense.

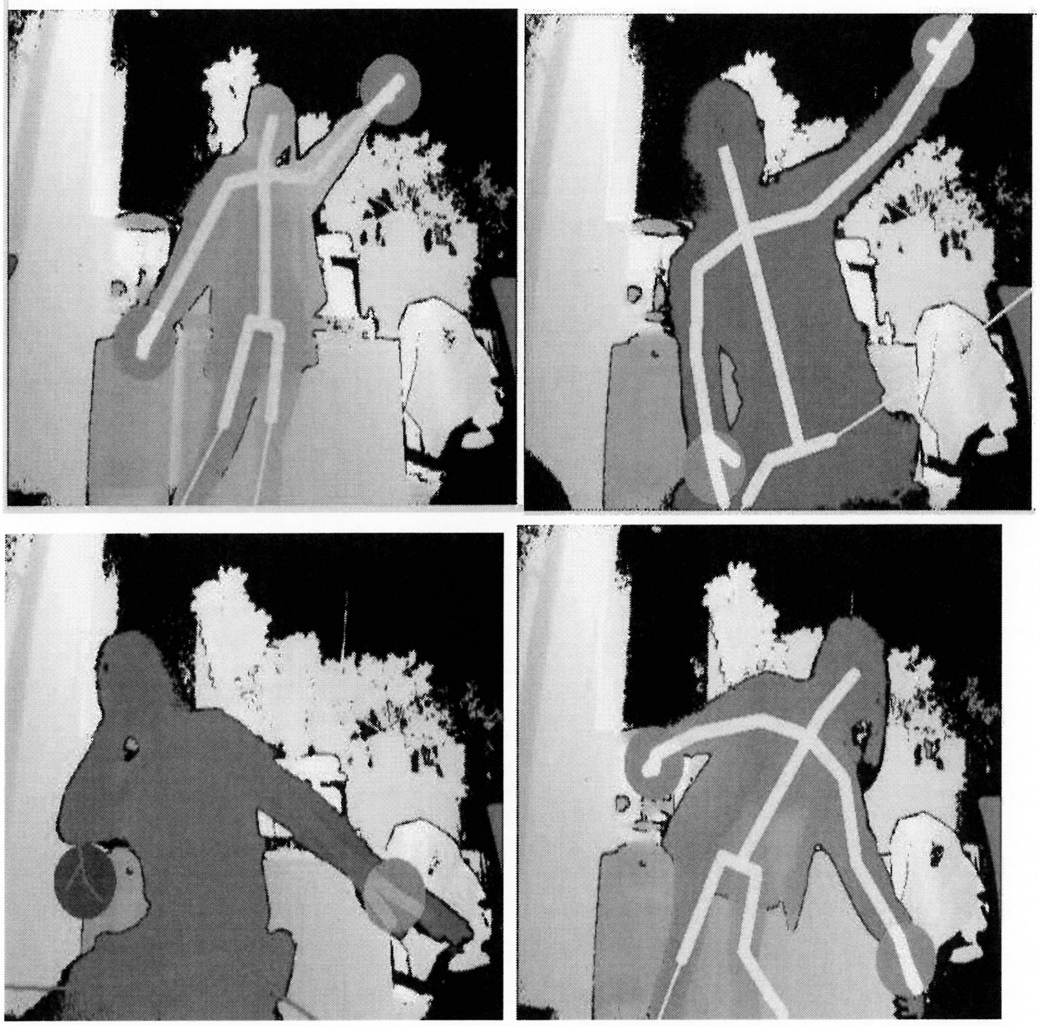


Figure 6: Puzzle training experience

Deeply attracted the interest of the participants and brought unexpected reality sense.

We observed through experiments that in the two use of VR, the participants who used VR for the second time showed a sense of familiarity with the virtual environment and were able to complete the training goal in a shorter time. Without clearly informing the participants of the training goals, although most of the participants are still serious about completing the jigsaw puzzle, some participants have a strong interest in the various parts of the training and the entire virtual space. I took some time to observe the scene behind me in the virtual space, and carefully observed the position of the hand indicated by the handle. These participants still observed the parts themselves carefully after they picked up the training parts. And made interesting explorations such as deliberately wrong splicing or trying to splice first. After being familiar with the environment, they began to try other users, and consciously tested the throwing speed and falling sensation.

As shown in Fig.7 This gravity physics engine deeply attracted the interest of the participants and brought unexpected reality sense. Participants who have been explored are often able to master the operations in the virtual world well, and in the end, they have a goal to complete smoothly and quickly.

According to psychological research on immersive experiences 【29】, people forget reality when they focus. This is called flow theory. The core is that someone can achieve smoothness only when their skills and challenges match. For example, someone forgets to sleep and eat while playing a training, and this kind of training usually encounters some challenges, and the experiencer will make judgments based on his known situation, and he has the ability to deal with these challenges. If the goal is too high, it leads to abandonment. If the goal is too simple, the experiencer will get bored and quickly abandon the challenge. The mobile experience is considered the best experience. When the current challenge matches their own abilities, the experiencer will be immersed in the current situation and forget the state of the real world. At the same time, heart flow will change the experiencer's perception of pain or real-time. The design of the training is not to passively meet the needs of the participants, but to guide the behavior of the participants through eye-catching design, so that the participants get a sense of immersion. However, too much experience will make the fresh experience unattractive.

Figure 7: Puzzle training a great help to improve the effect of education

2.4 summary

In fact, for the college students participating in the experiment, the impact of using VR for the first time can only temporarily attract his curiosity, and most of the participants quickly adapt to the virtual environment. They spent more time observing and fiddling with the pieces of the jigsaw puzzle, and even started thinking about other ways of playing besides completing the puzzle, such as throwing the pieces of the jigsaw puzzle with both hands like an acrobat. Therefore, although visual stimuli can bring short-term appeal, a design that can truly guide participants to exert their personal talents can continue to attract participants' attention and bring a better immersive experience. The immersion theory puts special emphasis on the subjective experience of participants, which provides psychological support for our life safety education. In the process of various life, health and safety education, if immersion theory can be effectively used and immersion education training can be carried out, it will be of great help to improve the effect of education and the long-term impact of participants. It can more effectively transform boring content into interesting perceptual experience, thereby guiding participants' cognition and behavior, and may also learn stress response and conditioning during emergencies. Therefore, we can boldly present the entire life safety education as "immersion training". The training process is to use virtual reality technology to give full play to all possible factors, so that the participants can achieve the best reception state, fully enjoy the stimulation and happiness brought by safety education training, and unconsciously learn a lot of emergency experience. Therefore, the use of immersion theory in life safety education to enhance participants' sense of immersion can make participants' cognitive initiative to a high level.

4 Experiment 2:Fire simulation and feedback

The purpose of Experiment 2 is to realize the basic parts of fire field construction (including escape route arrangement, escape direction guidance, fixed fire point and flame performance), and to obtain user feedback at the same time to test participants' feelings of flame in the virtual world And impressive. The experiment is designed to simulate a fire in the area where the participant is located, and requires the participant to observe the flame and avoid the flame, bend over and other necessary escape actions and reactions. Although it is expected that any room can be used in practical applications, in order to be able to use a computer to record the video recording of the participant's perspective, it is necessary to conduct a small-scale experiment within the communication distance of Hololens, and taking into account the personal safety of the participants, it is also necessary Participants are always controlled within the control of the staff to conduct the experiment. In future practical applications, terrain data and escape route data from different sites will also be added to plan evacuation routes according to the needs of the organizer. When conducting evacuation drills in this way, it is necessary to spread fire and smoke in a considerable area, and to move long distances (escape behavior) in a wide area. In the design of the escape system, we need to consider the very limited computing resources of Hololens in advance to enable it to complete a large-scale disaster prevention drill as practical as possible.

3.1The escape route design

The design of the specific escape training system is shown in Figure 8. According to the basic escape route design of the building, there are generally several possible evacuation drill routes. In actual escape, there will be emergencies such as increased fire points caused by sudden explosions, so the escape drill system It is necessary to create as many difficulties and flames as possible in the simulation to increase the difficulty and realism. However, due to the limited computing resources of Hololens, it is impossible to preset or represent all flames in a wide range of facilities at the same time. So it is necessary to save computing resources through programming. Spatial Mapping can convert scanned grids into entities, but at the same time it takes up relatively large computing resources. But if we need to keep the needed images in the old place, we need to use it. Without Spatial Mapping, we can only move objects in space, but cannot place objects or images on specific objects in the real world, such as on a chair. When we use Spatial Mapping, Hololens will first scan out the three-dimensional information of the room where we are. After scanning, we can place the object on the scanned space object. You can even control the script to display the placed object in the correct position when the program is restarted. In order to save computing resources, we do not use Spatial Mapping to convert the scanned grid into entities as much as possible, but use image recognition to convert the objects or images we need into entities in a small range. The method considered here is to eliminate the part out of the user's line of sight when designing the flame display to save computing resources. Since the system is set up indoors, participants will move slowly and it is difficult to see distances of 10 meters or more. Besides the corridors, it is difficult for people to observe very distant objects due to obstructions or flame. So we limited the number of flames in the system, and matched the user's current location in real time, only showing flames within 10 meters of the participant. In addition, although the flame occupies a lot of computing resources, a small number of flames will lead to insufficient shock, so smoke that emphasizes the atmosphere of the fire is needed. In order to save the computing resources of smoke, the system is designed to only add special smoke effects at the front coordinates of the user's perspective. At the same time, in order to increase the sense of urgency and authenticity, a timer is added to the system to calculate the time from the system and increase the smoke density over time. At the same time, in order to simulate the degree of freedom of fire escape and emphasize the authenticity, it is necessary to express the evacuation route and evacuation instructions to the participants as naturally as possible. Therefore, the design is shown in Figure 1, which is the same as in real life, and is set in each important location. Evacuation signs, so as not to compulsorily guide participants to create a sense of violation and reduce their enthusiasm. When guiding the user's evacuation behavior to the expected evacuation route, the evacuation sign is not mandatory. This increases the uncertainty in disaster drills. Unlike ordinary escape training in the past, the escape without mandatory guidance is full of challenges and exploratory significance. If a fire occurs outside the planned fire point, the user must follow the fire location Judge. This kind of random escape training is not only full of fun and attractiveness, but also can simulate emergency and dangerous situations with sudden explosions or object obstacles in the expected path, and can train sober thoughts and determination. This is in the ordinary escape training in the past. It is difficult to achieve or extremely costly.

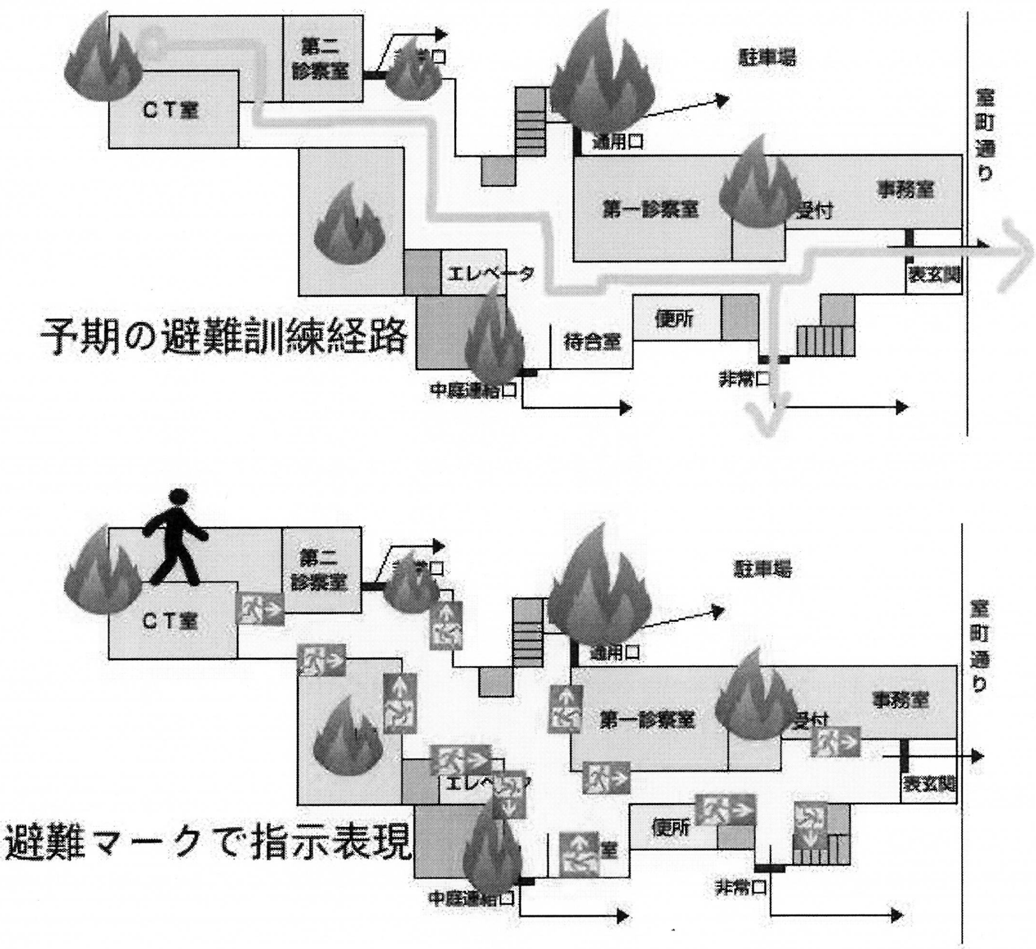


Figure 8:Evacuation drills

Random escape training to simulate emergency and dangerous situations , common way performance

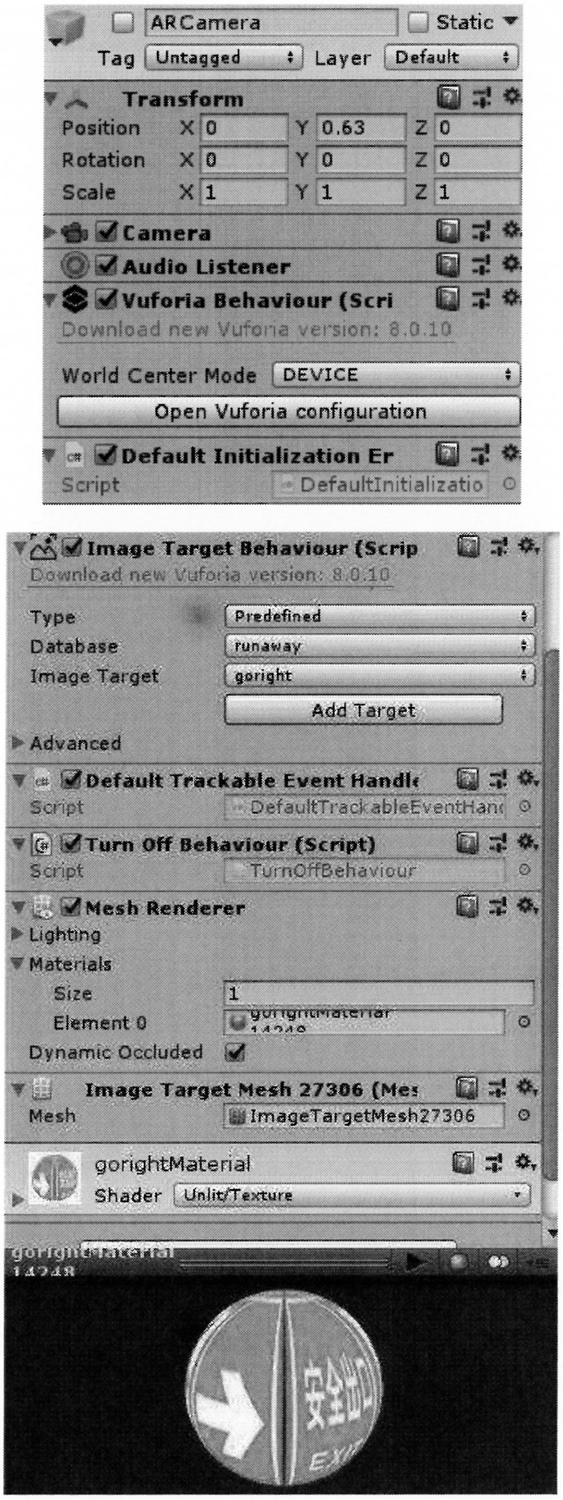


Figure 9: vuforia setting

Escape signs may be difficult to distinguish in bright flames.

Highlight and expand the display, so that participants can clearly see the direction in the flame

3.2 System design

In the development environment of this research, we use a computer with a GTX1050Ti graphics card, and run the software Unity3D (v2018.2) and VS2019 in the Windows 10 environment to complete the program design. The hardware used is a Microsoft HoloLens, and the tag recognition uses the AR development SDK Vuforia Engine 9.0. The images and models were created using Photoshop and 3ds MAX.

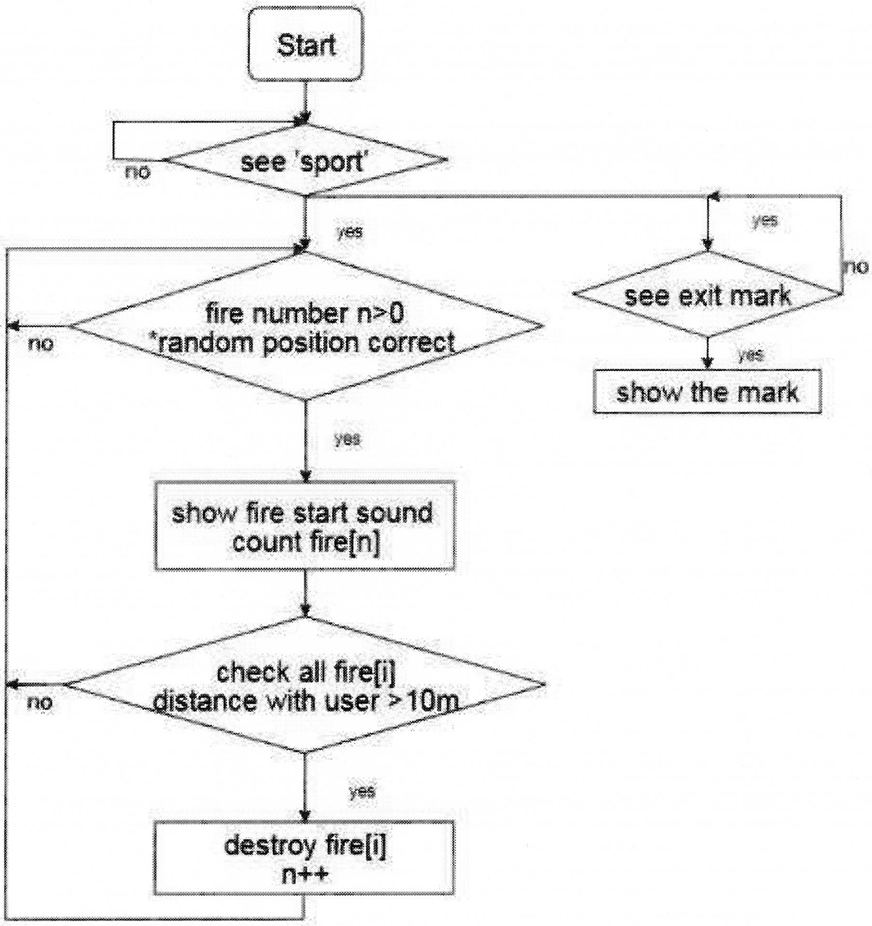


Figure10 : system design

The basic design of the program is centered on the line of sight of the participants. We first simulate the line of sight of people with invisible rays. This line is sent out from the helmet position, that is, the camera position, keeps the forward direction, and changes with the helmet position or angle. In front of the line of sight, there will be objects or floor walls that are materialized by spatial mapping. The line of sight collides with them, and we believe that the place of collision is the point of view. The first thing to make sure is that the object on the ground that caused the fire is being observed by the participants. After confirming the sight collision (observed by the participant), start the procedure. First, start the smoke program, including timers and script-controlled smoke effects. After the program starts, when an evacuation sign is recognized at any point in time, it is clearly expressed in a bright way. Regarding the control of flame special effects, there are two judgment conditions that can be ignited, one is the current number of flames "n" is set to 25 in the test, and the second is to determine the correct ignition position. If both are satisfied, the sound effect and the flame are activated at the same time, and the flame information is stored in the array. Since HoloLens does not have a GPS sensor, the distance between the position of the array element and the current camera (HoloLens device) position needs to be determined in real time so that the flame is always represented only around the user's position. When the distance between the participant and the flame exceeds 10 meters, the array element and its flame are extinguished, and the number of possible flames increases, and then the process returns to the judgment of ignition conditions. The system will continue to run until the user directly stops the software.

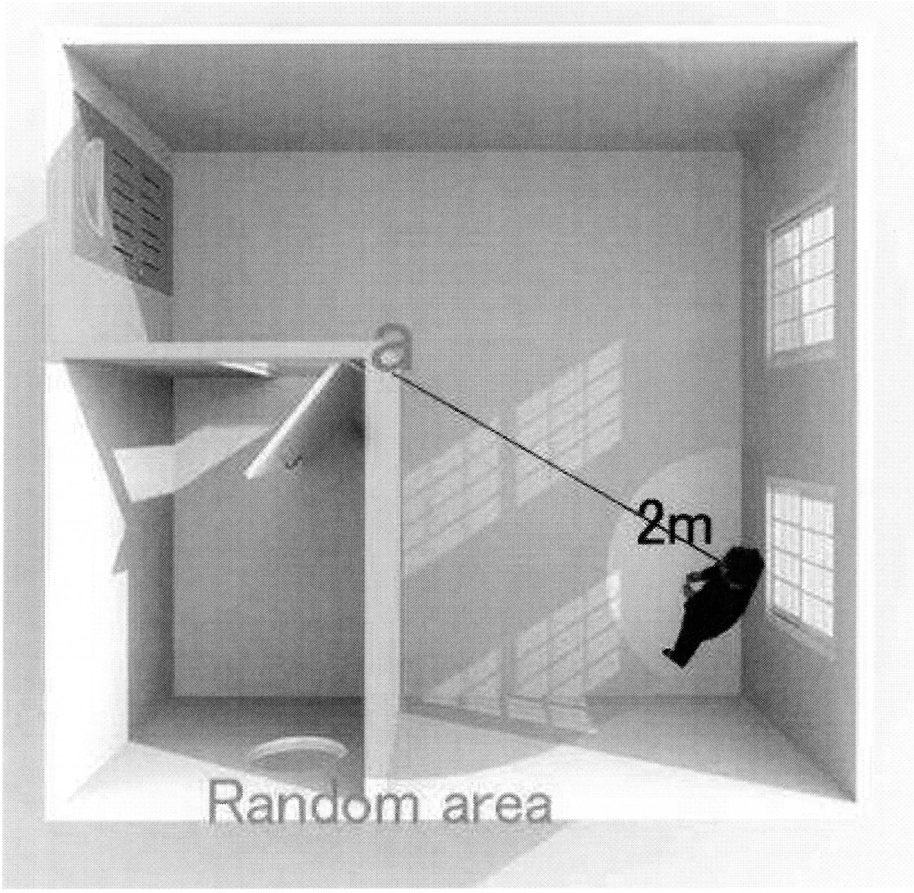
3.3 Large scene fire simulation

It is very difficult to simulate a large scene fire with limited resources. An important function of Hololens as MR is that it can recognize the user's space in real time through spatial mapping, and it becomes an obstacle. However, it is impossible to distinguish the orientation during the mapping process, that is to say, we cannot directly identify the ceiling or the ground or some other obstacles through the spatial mapping function. In the process of completing the spatial mapping, all the places that are actually spoken are transformed into obstacles with a certain amount of triangles. Although the space is materialized and completed, it is very easy for us to place the flame on these obstacles. But in the real physical world, the burning of flames must conform to the laws of physics, and it does not appear anywhere. Therefore, here we need to establish a set of identification methods so that we can light a flame in a relatively correct place. However, in this process, the coordinates we can rely on are the coordinates of the user's head, which is the coordinates of the camera in the virtual space. In addition, it is the xyz axis based on the camera.

In order not to cause a simulated fire that causes a waste of resources, we decided to set up flames only in some common fire locations. So first we need to determine the very easy to burn and non-combustible parts in an area. First of all, high ceilings and chandeliers, although they may be ignited and burned by flames, this situation is a relatively rare or severe fire later manifestation, so we exclude them. Then there are objects with slender and sharp shapes or small surface area. They are often non-flammable iron or small items, which do not have enough fire range. We also exclude this situation. The last is the wall. Although the wall is burnt in the fire scene, it is often not the surface of the wall that burns, but the burning of the root of the wall from the ground. The fire scene is more focused on furniture or areas like beds, chairs, tables, carpets, and sofas. Therefore, we summarized the position of the combustion into three characteristics:

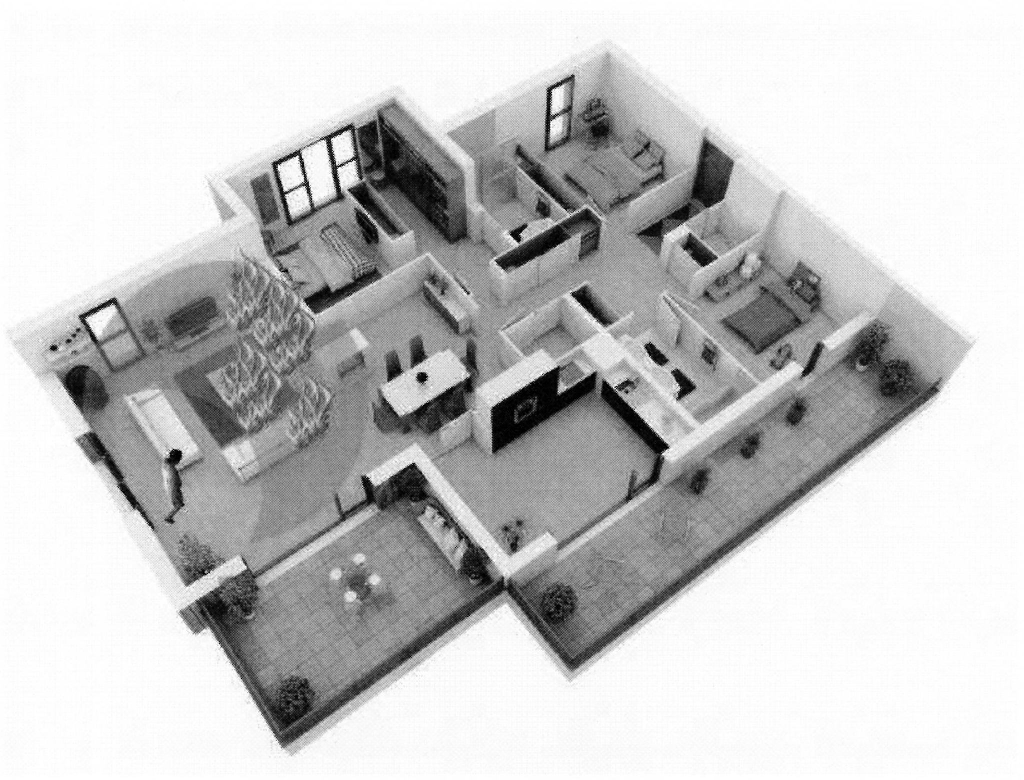
1. It has a partial horizontal plane.
2. Lower than the height of the user.
3. A certain distance away from the user but as close as possible to the user.

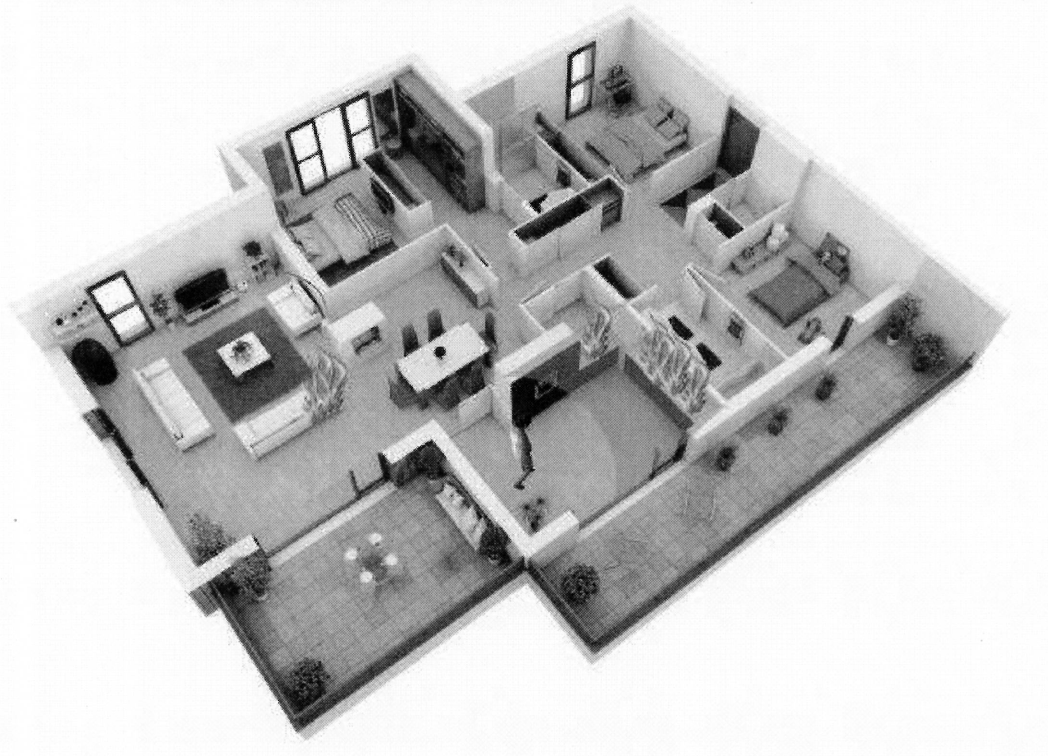
And depending on the function limitation of the device, it may not be able to display stably within the range of 1-2 meters from the device position. Finally, in order to enhance the sensory experience, the random flame position outside the designated fire point can more simulate those emergencies.



Limited computing resources, realizing a sense of presence on the fire scene

As shown in Figure 11, when the character in the figure is moving, when the ignition point is more than 10 meters away from the current helmet coordinate, the flame is destroyed and the available ignition stock is increased, which causes the user to always move in the forward direction. Flames, and there are still enough flames burning during the review, giving the user the illusion of flames everywhere in the room, which is a good simulation of a huge disaster scene. When the character in the picture walks to the bedroom, the flame in the living room has actually been destroyed. Unfortunately, there is a problem with this design. Although it leaves the kitchen, the distance between the kitchen and the bedroom does not exceed 10 meters, so even if the flame in the kitchen cannot be observed, computing resources have to be occupied.





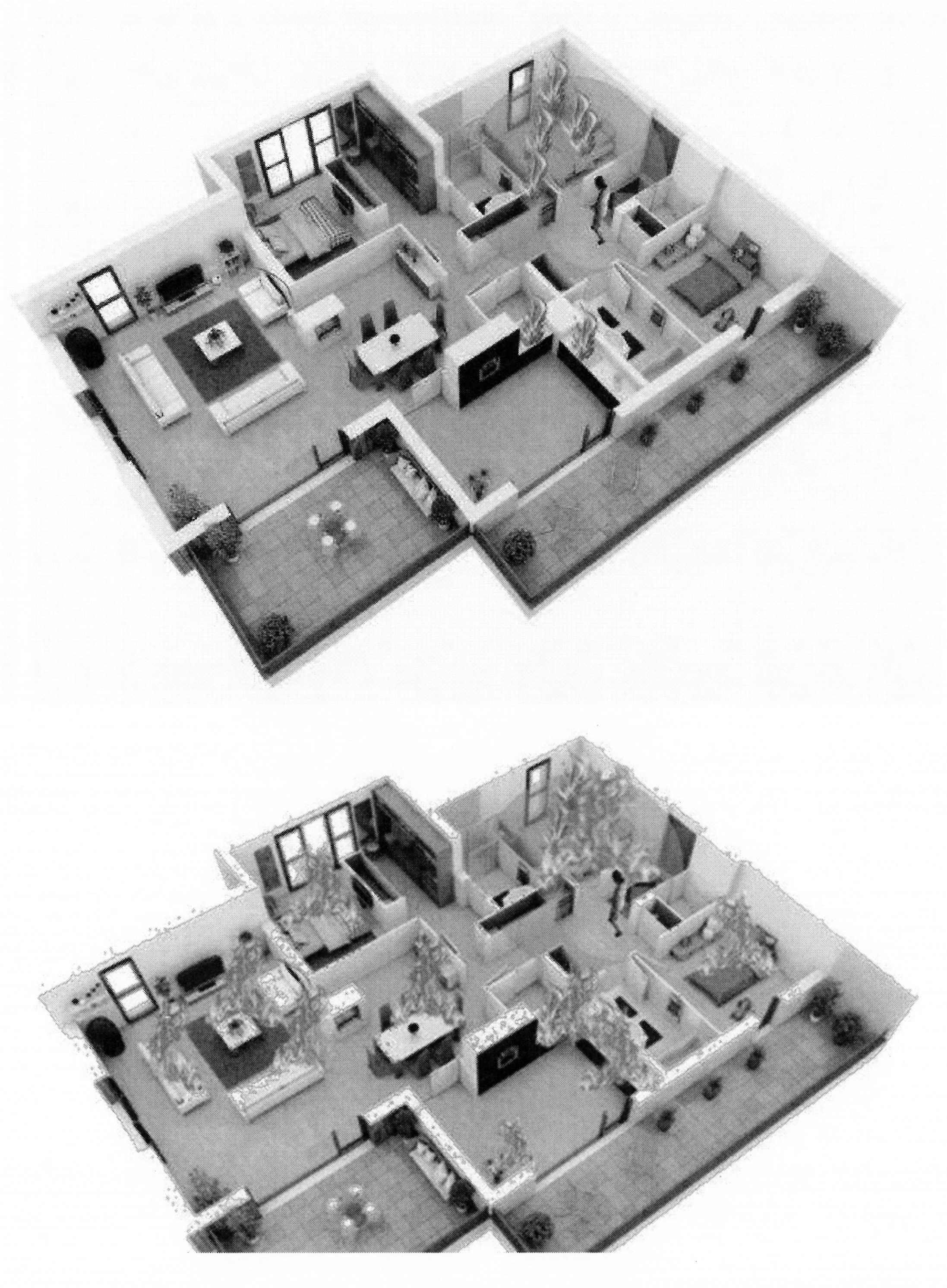


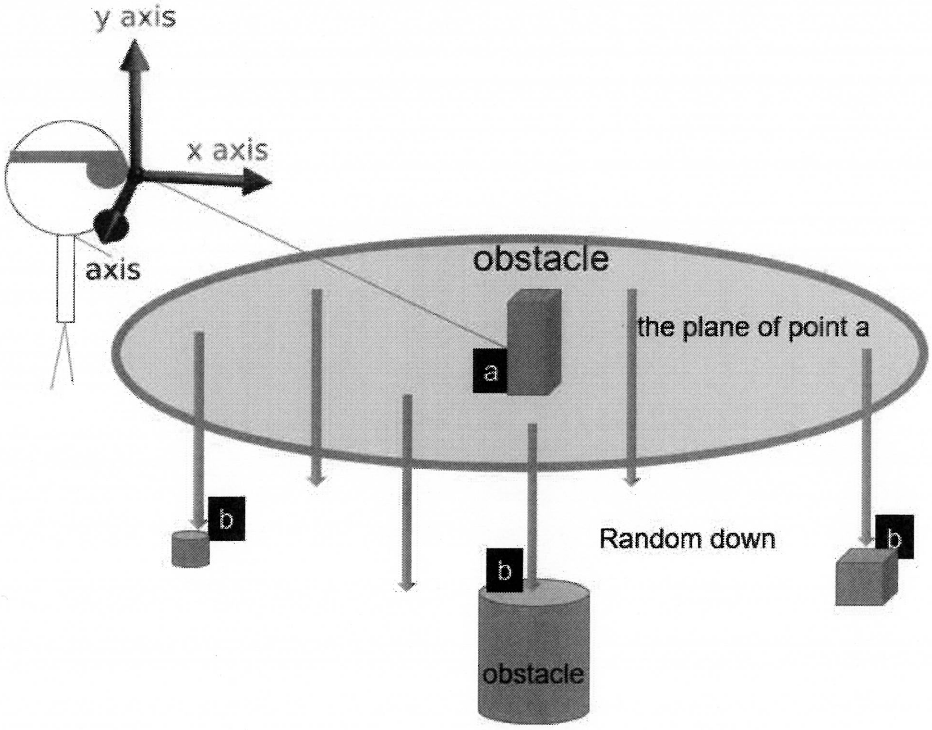
Figure 11: Fire sport2

From the perspective of the participants, there will be the illusion that the whole house is on fire, which solves the problem of large-scale evacuation training

3.4 Simulate special situations

Since in the actual disaster prevention exercise, the ignition position will be set in advance in many cases to increase the difficulty and special conditions, so the reserved space is considered in the program in order to change and optimize in possible application scenarios. For example, in some fire drills, there is command training of the on-site command team to practice the use of warning signs, or immediately rush to the first scene after hearing the broadcast, surround and block the scene, guard the affected area, keep the road unblocked, and guide the fire truck And firefighters to simulate various complex activities such as fighting and fighting. At this time, it is necessary to add some key elements to the simulation through image recognition and other methods. For example, special flame posters are attached to some special locations, and when users approach the poster, they will recognize the poster screen and ignite an explosive flame, or plan the warning zone and other interactive designs, etc., which can be optimized according to the user's needs and change. It should be noted that when setting this kind of flame, it needs to make it not disappear after being ignited, so that it has nothing to do with the flame capacity number "n".

Most of the current conventional virtual disaster drills are single-person evacuation drills. Because it uses VR to simulate the fire scene, in order to prevent collisions, multi-person simulations are not performed. However, in real life, public facilities are more prone to many fires. These fires are often due to high density of people, narrow and closed spaces, and rapid expansion of dense smoke and poisonous gas, causing people to panic and chaotic. As a result, many people who should have fled were stranded in the fire, and deaths and injuries increased. Therefore, in disaster prevention education in schools or companies, multiple evacuation drills are often required to simulate chaotic conditions. This requires the use of multiple Hololens devices to conduct joint online disaster prevention simulation exercises. Since Hololens can share and interact with multiple people, theoretically, as long as there are enough equipment, more than 50 people can participate in the same evacuation drill. But this function needs to be rewritten according to the needs of the script. The more common method is to use the Microsoft development document "HoloToolkit-Sharing-240", which can share the coordinates and screen of the host device with the host IP. Other devices run SharingService.exe from the local host to change the IPv4 address. In this way, the flame is ignited with the coordinates of the host as the center, and the indication of the exhaust mark is also expressed in its original position. In this way, it is possible to simulate the gathering of people and their judgment like a fire scene.



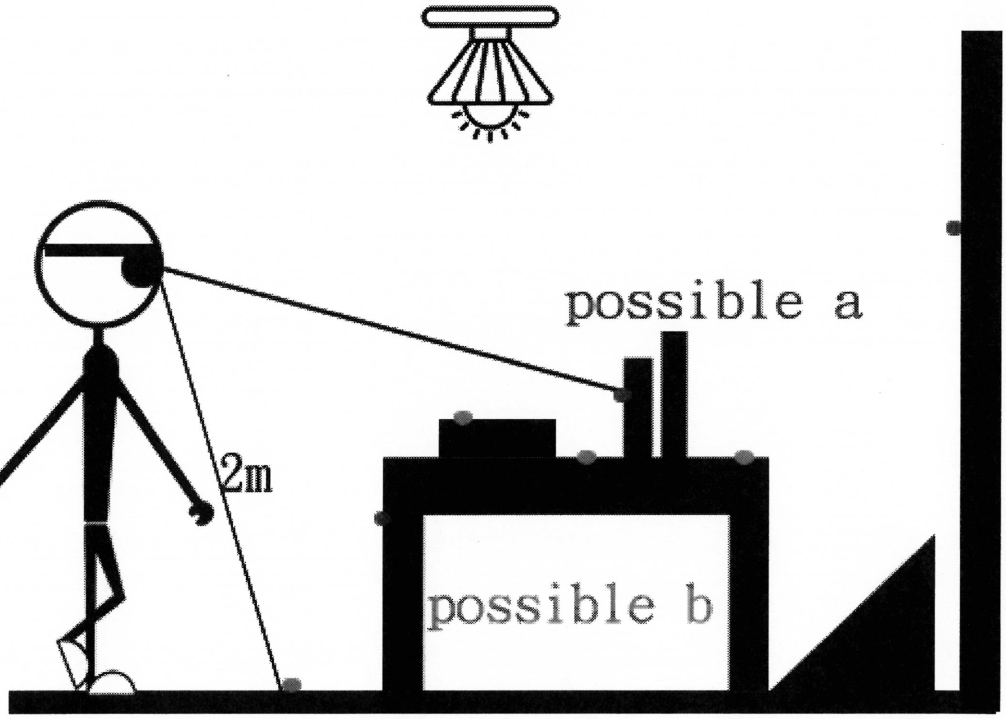


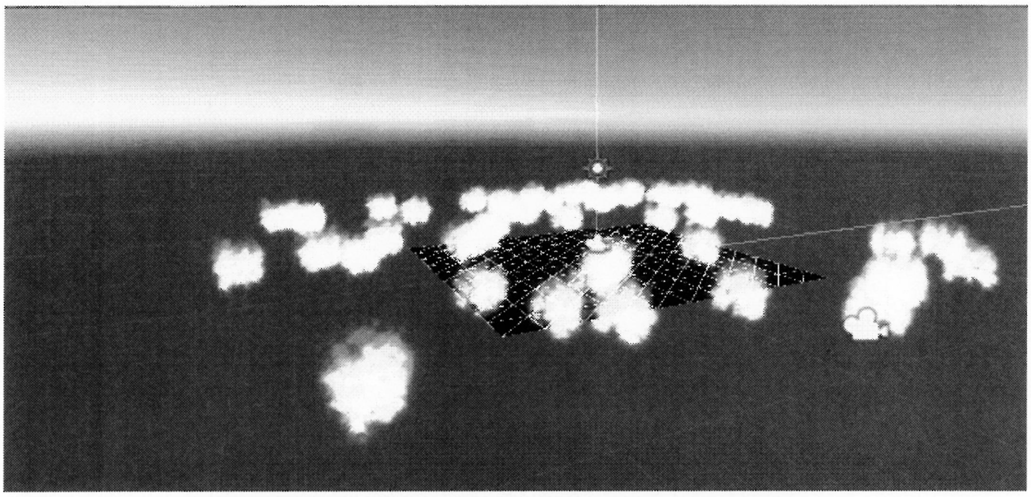
Figure 12: possible sport

a ： Focus of sight

b： Possible fire point

As shown in Figure 12, a ray from the device simulates the user's line of sight. The line of sight starts from the helmet and moves forward until it recognizes the collision with the obstacle obtained by the spatial mapping. We define the identified collision point as point "a", and then use the coordinates of point a as the center to draw a perfect circle with a radius of 6 meters. Because the space used for the simulation is usually not regular, it is impossible to pass through high plane obstacles such as walls, and the blocked range will not become a random area. With the device coordinate as the center of the circle, that is, the user's position as the center of the circle, the range within 2m around it needs to be excluded, because the range of about 1-2m from the device cannot be displayed stably. In this random area, taking the plane of point a as the starting point, randomly emit a ray perpendicular to the y axis, and the collision point between the ray and the obstacle is called point "b". Point b is the possible ignition point. At this time, it is necessary to confirm whether the location of point b is a relatively flat plane, so we need to confirm that there is no obstacle within 0.01 meters around point b, if not, it is determined that this is a correct ignition point.

As shown in Figure 13, the flames are randomly placed around the camera position. The location of the main camera will be where the participant's helmet is located. The flame script needs to check the make fire option. In the test run, the effects of fire and smoke were successfully simulated. We can adjust the camera position from the test operation interface and observe the overall effect from a distance.



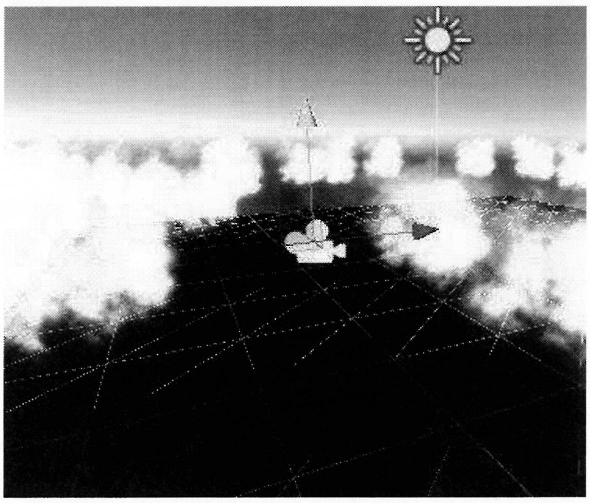


Figure 13: Fire test in PC

```
//make a fire creater
    void CreateFire()
    {
        //point down
        Ray ray = new Ray(transform.position, Vector3.down);
        RaycastHit hit;
        if (n > 0 && Physics.Raycast(ray, out hit))
        {
            //around 10 meters
            Vector3 a = new Vector3(hit.point.x + Random.Range(-10, 10), hit.point.y, hit.point.z + Random.Range(-10, 10));
            //out of 2 meters
            if (Vector3.Distance(a, hit.transform.position) > 2)
            {
                lstfire.Add(Instantiate(firpic, a + Vector3.up * 0.3f, firpic.transform.rotation));
                n--;
                //sound player
                if (fireSound != null)
                {
                    if (fireSound.isPlaying == false)
                    {
                        fireSound.volume = 0.0f; //be quite and ready for loudly
                        fireSound.Play();
                    }
                    else if(fireSound.volume < 0.5f) //loudly
                    {
                        fireSound.volume += Time.deltaTime;
                        if (fireSound.volume > 0.5f) fireSound.volume = 0.5f;
                    }
                }
            }

        }

    }
```

3.5 The fire

In order to consider the trade-off between computing resources and reality, the expression of the flame that usually takes up a lot of computing resources is an important part. To express the flame with very low computing resources, we first considered the use of texture animation, but because the flame requires high-speed motion and the complex overlap of the 3D effect, it is difficult to show the ideal effect in virtual reality. Several students who participated in the observation effect said that even if they are not in Hololens, they can feel a very obvious sense of violation in the computer display. Therefore, we consider using a unified particle system. The particle system will of course take up more computing resources, but we need a minimum of realistic experience. Even the particle system【29】 can save computing power as much as possible in terms of performance. For example, each particle has its own life value. As time goes by, the life value of the particle continues to decrease until the particle dies (the life value is 0). When one life cycle ends, another life cycle begins immediately. In order to reduce the number of particles, some particles can die faster after the initial stage. But on the whole, it still consumes a lot of computing resources. The reason is that the particle system greatly increases the number of visible polygons per frame. Each particle may require four vertices and two triangles. Based on this calculation, 2,000 visible particles in a scene will add 4,000 visible triangles. And because most particles are moving, we cannot pre-calculate the vertex buffer, so the fixed-point buffer needs to be changed every frame.

Using the particle system, the authenticity of the flame performance will be greatly improved, but the choice of materials will vary greatly according to different application scenarios. As shown in Figure 14, using a particle system with 20 continuous images as a material can express flames. However, in order to represent this range, the shape of the flame is relatively flat and is usually displayed on a computer screen, but this will cause the problem of insufficient 3D effects in HoloLens. Although flames usually occur on flat surfaces (such as the ground), they may not be suitable for use on narrow or slightly inclined objects (such as chairs). Therefore, we are looking for flame materials with a smaller range, easy to control and replace. As shown in Figure 15, smoke and flame are represented separately, and the rate is controllable, providing a more refined sense of reality. In addition, a cigarette can be mixed with a variety of flames to show the changes in its density and position over time, and match the characteristics of the flame, thereby further saving computing resources.

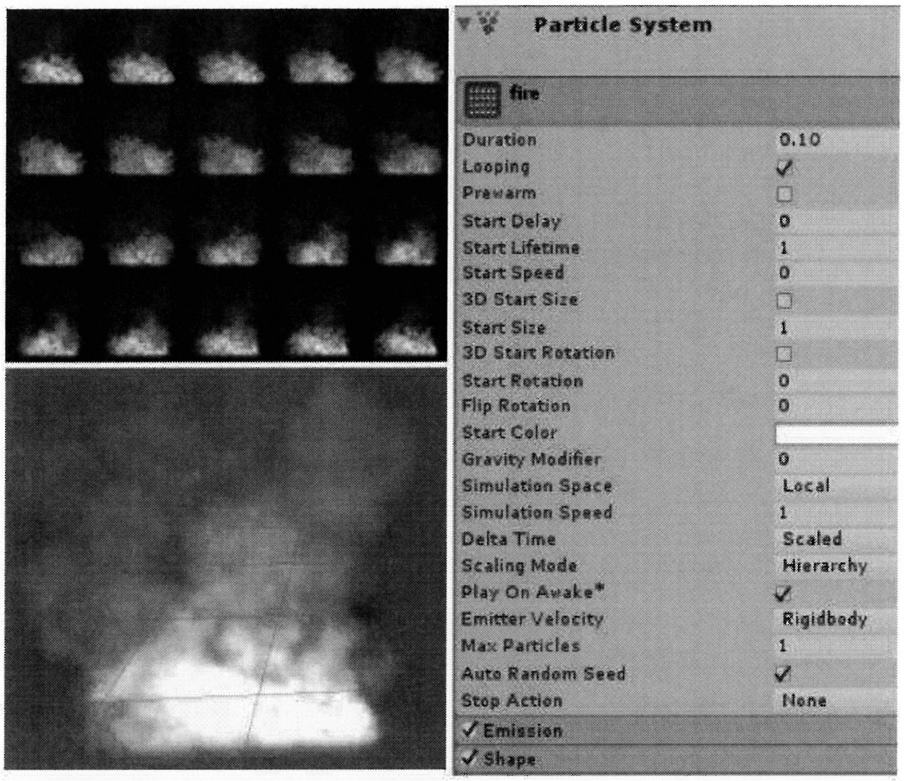


Figure 14: space fire

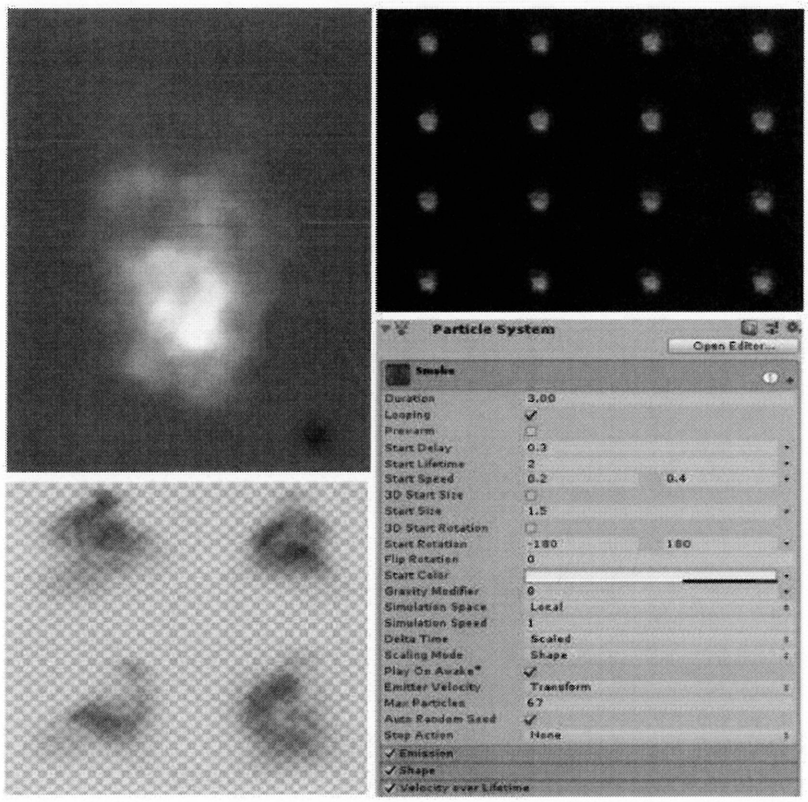
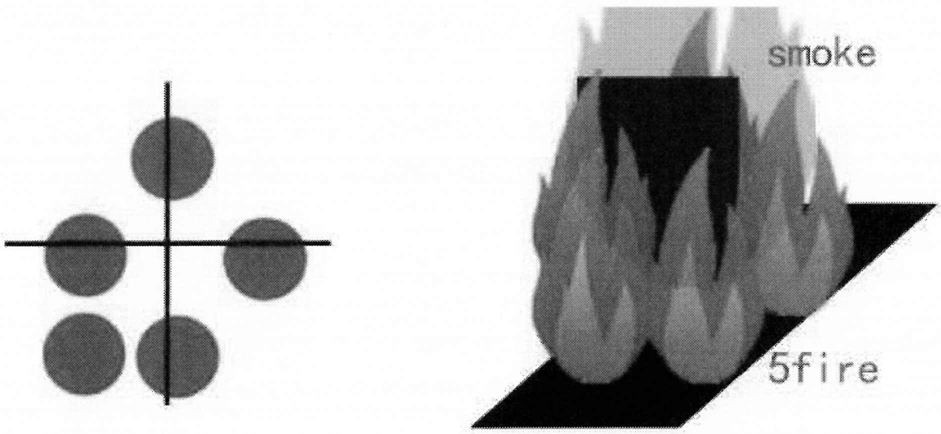


Figure15: fire and smoke sense of reality. Change with time

Although we try not to use transparent materials in the training, the effect particle system completely needs the calculation of transparent blending. According to the official explanation of unity【30】, the particle system uses the particle shader calculated by the Alpha Blended algorithm. The source pixel and target need to be first The RGB three color components of the pixel are separated. Then multiply the three color components of the source pixel by the value of Alpha, and multiply the three color components of the target pixel by the inverse value of Alpha. Then add the results according to the corresponding color components. Divide the result of each component by the maximum value of Alpha, and finally recombine the three color components into one pixel for output. Reading back pixels to GPU for blending is a very extravagant thing. It will seriously occupy system bandwidth and cause power consumption to increase. Therefore, in order to better express a more realistic flame with lower computing resources, as shown in Figure 16, the flame uses a small and delicate material, and then constrains the shape of the emission and controls the speed within 0.8 to make it its own The appearance is closer to reality. We stack five flame bodies without smoke to form a group. Then combine a special smoke effect to become a flame burning point. This not only reduces the amount of calculation, but also improves the realism in some situations, such as chairs, which can pass through the surface of elongated objects to block and adapt to those irregular objects.



Not only reduces calculation, but also improves the realism in some situations, such as chairs, which can pass through the surface of elongated objects.

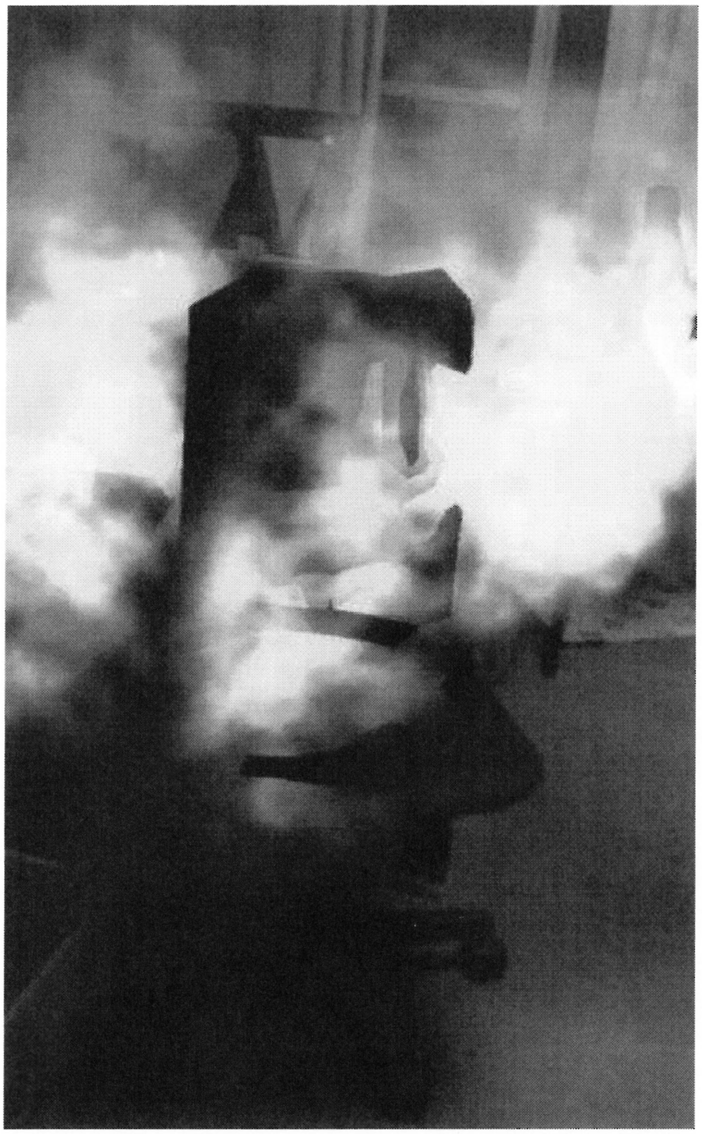


Figure 16: Fire structur

3.6 Experimental results

We conducted a usage test. Put the system into HoloLens and observe the effect, as shown in Figure 17. We can see that the desk with the computer is lit, and the flame is very realistic, and as we expected, it has reached a high degree of randomness. In some places, it naturally gathers into a large-scale flame, and is The obscured place clearly avoids obstacles, which conforms to the physical laws we usually recognize. And facing a piece of debris, it can also correctly burn in a relatively flat position as a fire point. On the whole, the expected basic functions can be realized, and it gives people a sense of sight of the fire scene and has a relatively strong impact. But at the same time we also found some problems with it. For example, due to performance issues, it usually takes more than 20 seconds to start the program. The position of the flame may happen to be not on the front side (appears on the side many times). Although the sound of a simulated fire can be heard immediately to distinguish the fire, the moment of the fire still will be stuck. We preset a lot of smoke, which looks very good on the computer screen, but it does not show up well on the HoloLens screen. The reason is probably that the camera is too close to the camera and the display cannot be stabilized.

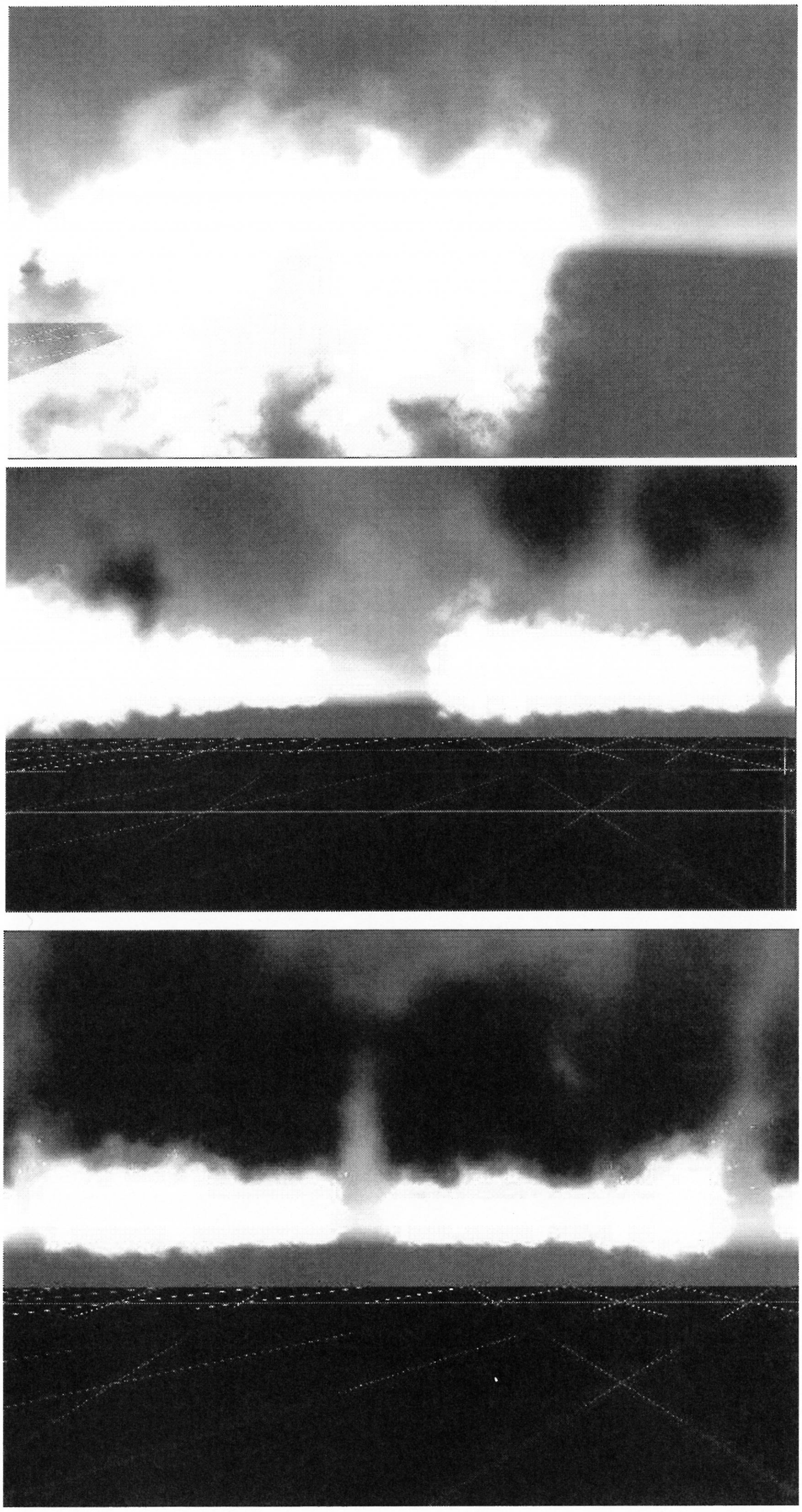


Figure 17: Experiment scene on computer

For MR fire simulation, we can "burn" things in the space where participants are in real time and experience the real fire scene. By using mixed reality, instead of imagining reality like VR, we directly simulate disaster scenarios in the real world. The lack of realism among participants has almost disappeared, and it has been realized to influence reality.

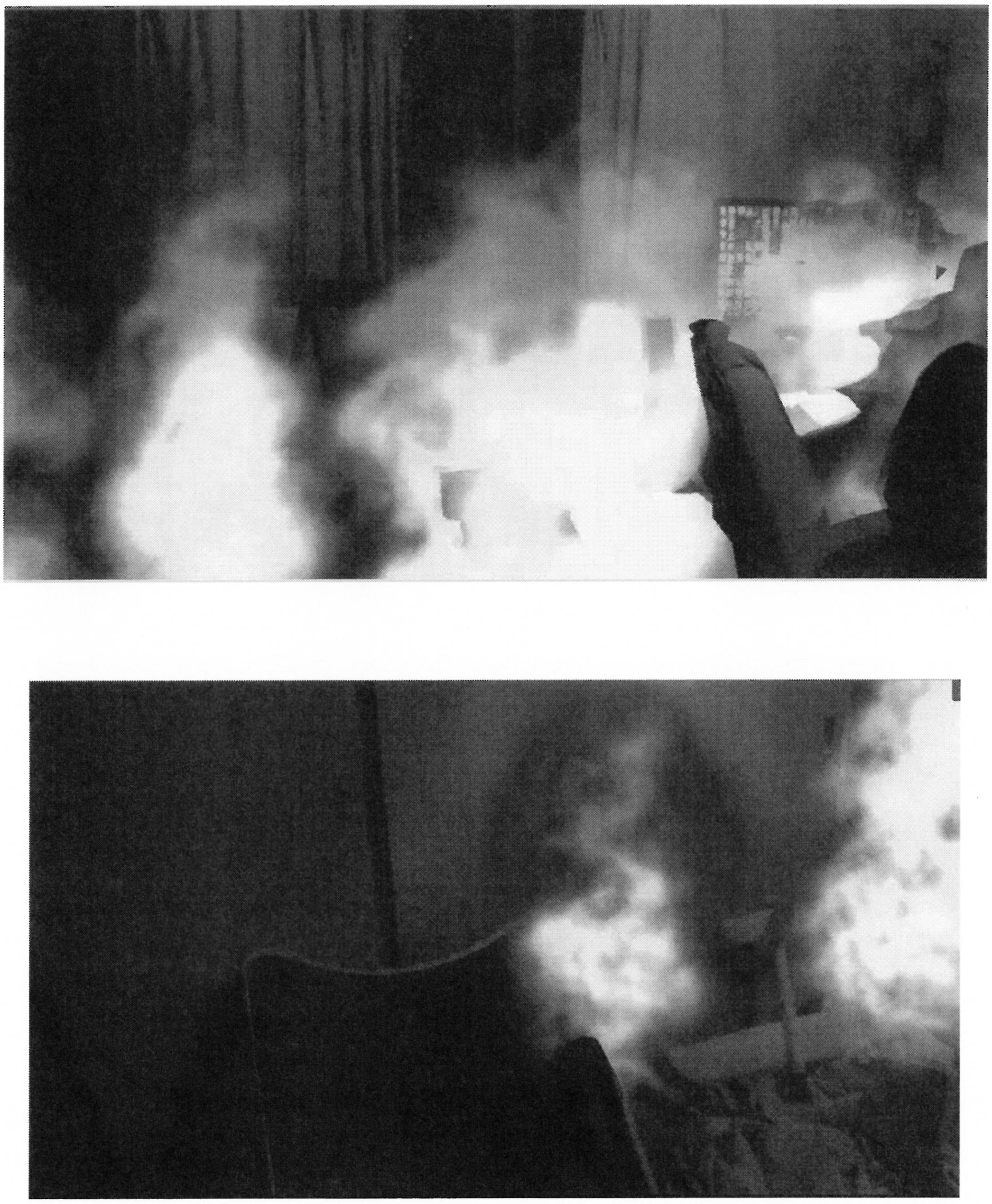


Figure 18: Experiment scene on Hololens

As shown in Figure 19, we can observe the effect of arranging five flames. When the chair is used as a fire point, the flame model can well pass through the occlusion of the back of the chair, express the flame near the link between the seat surface of the chair and the back of the chair, and burn around the range of the chair, thus obtaining a very realistic effect.

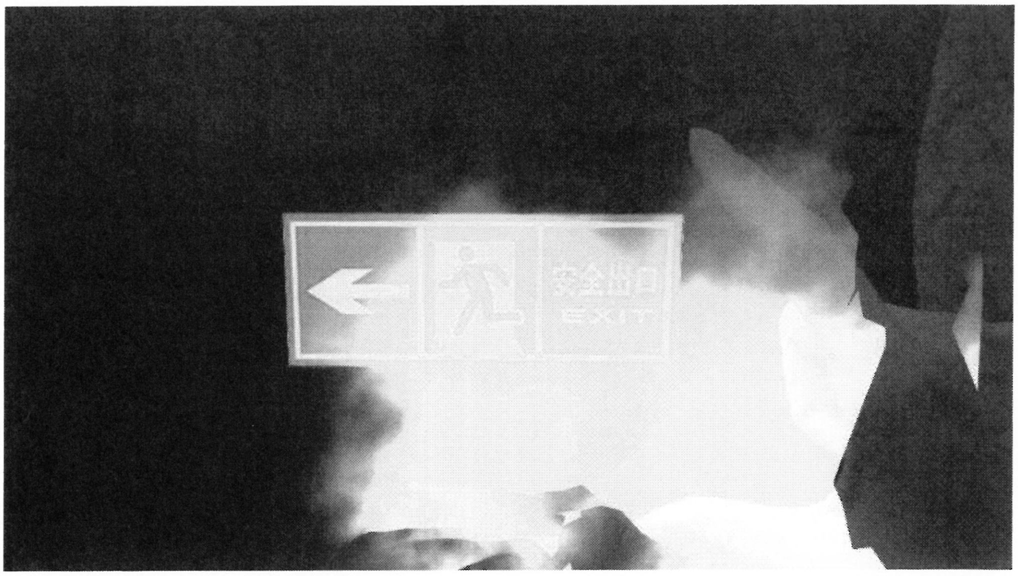


Figure 19: Evacuation mark

Figure 20 shows the evacuation signs installed on the evacuation route for weak intervention guidance. We can clearly see the escape signs and the direction they point to. This expression will attract attention through highlighting and train participants to be vigilant when they observe evacuation signs. As we expected, even in a very bright flame, the direction of the escape sign can be seen.

3.7 Participant survey

3.7.1 Survey results

A questionnaire survey of 9 subjects was used to check the results of the experiment. One of the subjects is 0-20 years old, 7 subjects are 21-40 years old, and one subject is 41-60 years old. All participants were involved in healthy participants and had no special mental or physical disabilities.

In addition to explaining the purpose of the experiment to the test subjects, the questionnaire was also interpreted as "conducting user surveys to judge the role of a part of the disaster prevention training system through MR. The main experimental function: fire scene simulator". This fire scene simulator system can allow test subjects to test wherever they are needed, without specific area restrictions.

We conducted a questionnaire survey and analyzed the extent to which reality, fear, and influence left a deep impression. In addition, the experience of the virtual reality equipment of the experimental subjects and whether they have experienced fire experience, and the influence of experimental subjects with different conditions on the gap are also considered.

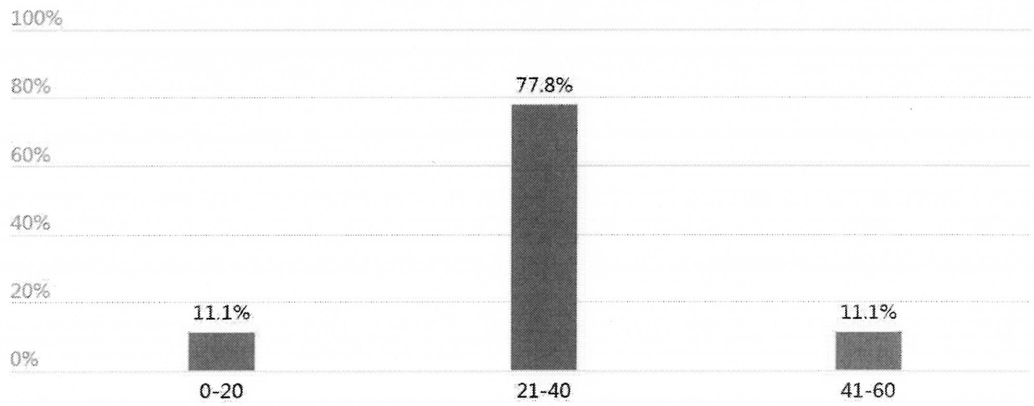


Figure 20: Age group

A total of 9 subjects were mainly from 21-40 years old.

As shown in the figure 20, one subject is 0-20 years old, seven subjects are 21-40 years old, and one subject is 41-60 years old.

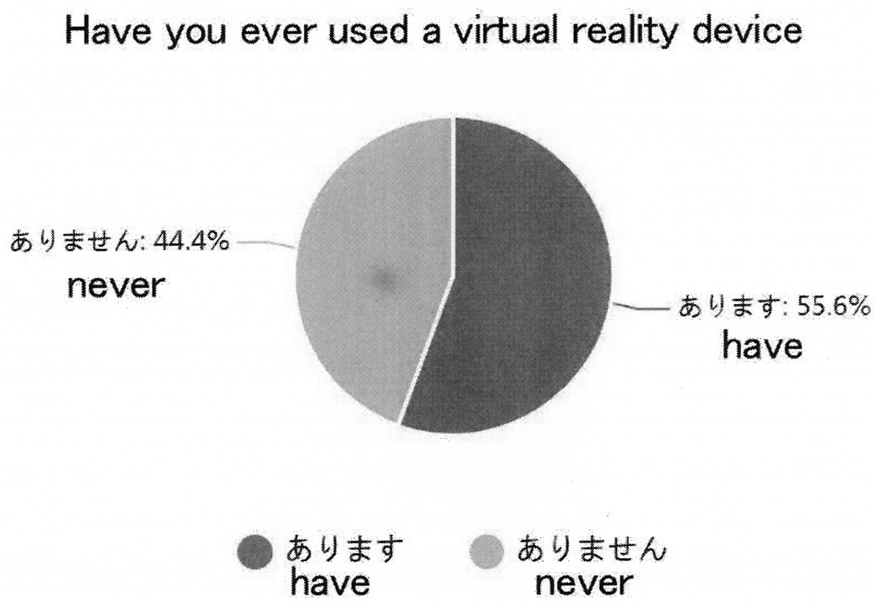


Figure 21 : virtual experience

Among the experimental subjects, slightly more people have experience in using virtual reality screen-related products than those without experience. As shown in the figure 21, five of the test subjects have experience in using virtual reality screen-related products, while the remaining four do not. Now that virtual reality equipment has not yet been fully popularized, people's acceptance of virtual space varies greatly.

Figure 22 : fire experience

Nearly half of the experimental subjects have experience of experiencing the scene of a fire.

As shown in the figure 22, 5 of the 9 subjects have never experienced a fire. On the one hand, it proves that the probability of fire happening around us is very high. On the one hand, it has a high impact on the experimental results.

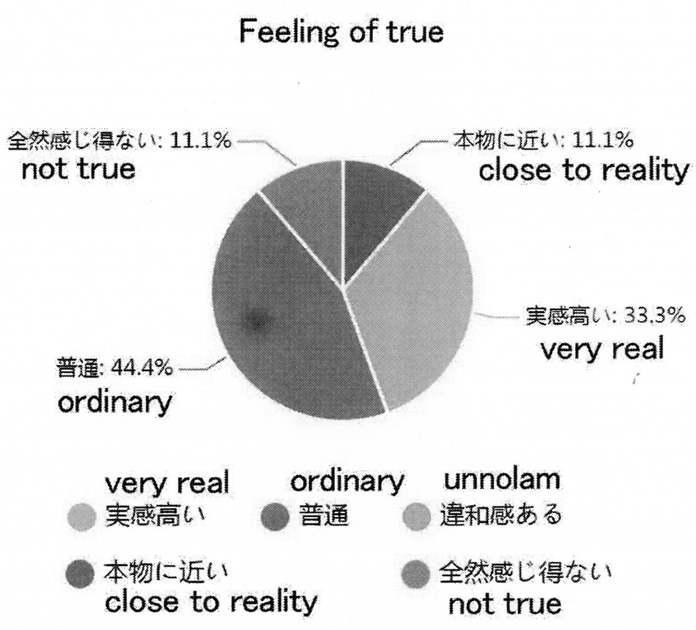


Figure 23 : feeling of true

Regarding the degree of realism of the fire simulation scene, the realism of the picture has been affirmed by most people, and more than 80% of the participants can feel the real fire scene experience. As shown in Figure 23, 1 person thinks the picture is close to reality, 3 people think it is very real, and 4 people think it is ordinary. Although there is no person who thinks that the picture is offensive, there is 1 person who thinks it is not true at all.

In this question, we have obtained relatively ideal results. Most people's recognition of realism verifies the authenticity of flame simulation. We enable participants to watch scenes that are difficult to complete in real simulations while ensuring safety. The realism of this experience goes beyond fire simulation without using virtual equipment. Authenticity is also an important factor affecting the effectiveness of safety education, and more realistic images will bring participants more correct perceptions. For safety education, the right impression is essential.

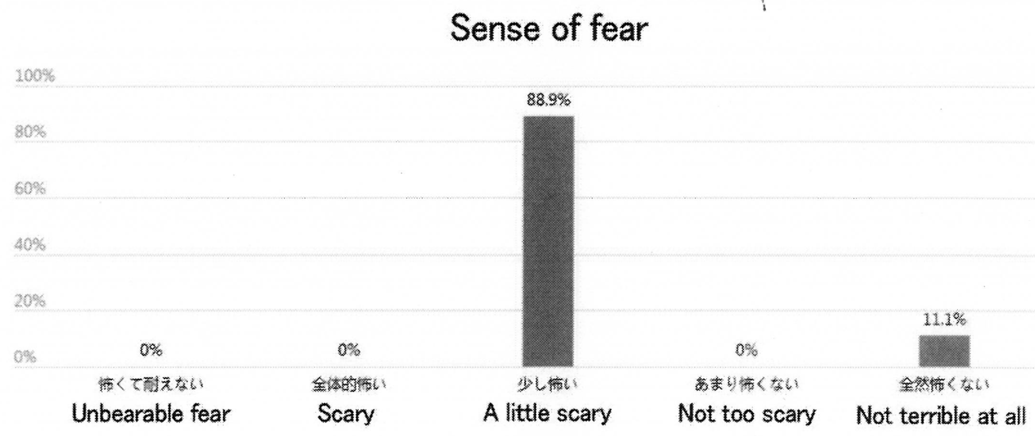


Figure 24 : feeling of fear

Regarding the terrible shock, five levels of answers were set, and the answers obtained tended to be consistent. As shown in the figure 24, except for one person who thinks it is not scary at all, the rest think it is a little scary.

The impact of the picture is related to the feeling of horror, so we hope that this feeling of fear can leave a deeper impression on the participants. But we don't want the images to be too scary, because too scary images may leave some participants with dangerous psychological trauma. Therefore, we expect that the sense of fear can reach a higher but not too high level. According to the reaction of the participants, we can further increase the sense of fear by adding more dense smoke. Most people felt the sense of fear, which proved that the necessary screen impact was achieved while saving computing resources.

This impact experience is a very important part of safety education, because in addition to technical factors, psychological factors seriously affect people's behavior in emergencies or disasters. The impact images are also a kind of psychological exercise, allowing participants who have never experienced a disaster to understand the horror of the disaster, and these fears can also improve people's attention to the disaster, thereby achieving psychological Education effect.

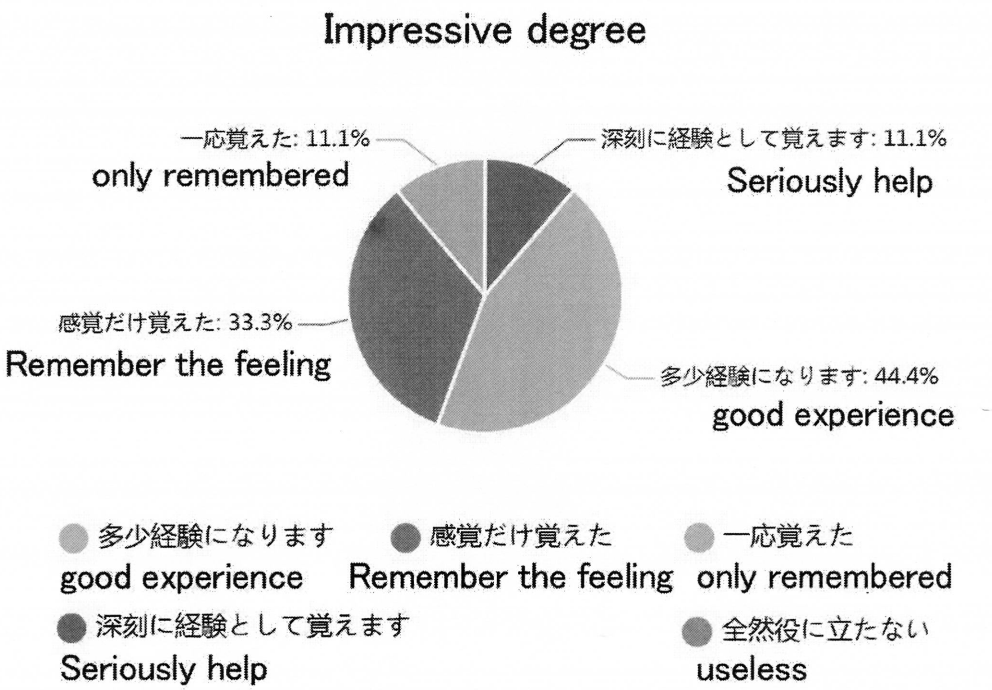


Figure 25 : Impressive degree

There is no negative answer to the question about whether it will leave a deep memory after the test and be helpful to the fire that may be experienced in the future. This verifies the effectiveness of virtual reality in safety education. As shown in Figure 25, there are 1 people who think they have deep memories, 4 people who think they will become experiences, and 3 people who only remember feelings. The remaining 1 person thinks they are not impressed, and no one thinks it is completely useless. Although the participants' experience of the virtual fire scene was short, they were deeply impressed, which is very important in terms of safety education. Obtaining a rare disaster experience in a relatively interesting way is also highly anticipated.

3.7.1 Cross analysis

We use some cross-analysis to better understand the effect of Experiment 2:

Table1： Age and feelings

	Close to real	High quality	ordinary	Discomfort	Not true
0-20		1			
21-40	1	2	3		1
41-60			1		

Among the 9 subjects, only one subject was 21-40 years old thought that the firefighting demonstration screen was not realistic, and subjects of other age groups all gave positive answers. It can be seen that the experimental subjects of different ages all expressed affirmation of the authenticity of the fire protection demonstration. Age has little effect on the realistic perception of fire simulation images.

Table2: Average of the participant sample

	Have fire experience	No fire experience
Have experience in using virtual reality screen related products	2	3
No experience in using virtual reality screen related products	2	2

As shown in Table 2, among the 9 experimental subjects, 2 have fire scene experience and experience in using virtual reality screen related products, 3 have no fire scene experience and have experience in using virtual reality screen related products, and have fire scene experience and There are 2 people who have no experience in using products related to virtual reality screens, and 2 people who have no experience in fire scenes and products related to virtual reality screens. The sample of the test subjects is very average and can reflect the test results well.

Table3: Use experience and realism

	Close to real	High quality	ordinary	Discomfort	Not true
Have virtual experience		2	3		
Never virtual experience	1	1	1		1

The effect of experimental subjects with experience in using virtual reality screen related products on the authenticity of the screen. As shown in Table 3, there are 5 experimental subjects who have experience in using virtual reality screen-related products, of which 2 think that the authenticity is very high, and 3 think that they are ordinary. All of them gave more positive and intermediate answers. There are 4 test subjects who have experience using virtual reality screen related products. Except for one who thinks the authenticity is very high and one who thinks it is ordinary, the remaining answers appear to be close to reality or not at all.

Participants who have not experienced the virtual space will have very different results due to different adaptation levels. In future experiments, we should consider whether we have experience in using virtual reality screen-related products as an influencing factor on screen authenticity. The physical adaptation exercises in Experiment 1 are necessary virtual space experience exercises. A better understanding of virtual space will help to obtain a stable educational effect. The physical adaptation exercises in Experiment 1 are the necessary virtual space experience exercises. Now that virtual devices have not yet been fully popularized, short-term training can quickly achieve virtual space cognitive effects. In future experiments, unstable samples caused by various incompatibility with virtual devices can also be avoided.

Table4: Fire experience and realism

	Close to real	High quality	ordinary	Discomfort	Not true
Have fire experience	1	1	2		
Never fire experience		2	2		1

Whether the experimental subjects have experienced the impact of fire on the authenticity of the pictures is shown in Table 4. Among all the 9 subjects, except for one subject who has never experienced a fire, they think they have no real feeling at all after using the fire simulation demonstration. In addition, among the remaining 8 test subjects, there are 4 test subjects whether they have fire experience or not. Among them, the test subjects who have experienced fire have a higher evaluation of the authenticity of the pictures. However, on the whole, whether a fire is experienced has little effect on the authenticity of the fire simulation demonstration.

In summary, we evaluate the authenticity of images with fire simulation demonstrations from three aspects: age, experience using virtual reality screen-related products and whether they have personally experienced a fire. Among them, age and whether they have personally experienced a fire affect the evaluation of the authenticity of the image Smaller, almost everyone gave positive reviews.

Whether there is experience in using virtual reality screen related products on the assessment of the authenticity of the screen deserves further attention. The purpose of the virtual fire demonstration is to let more ordinary people who have used related equipment quickly learn about the fire. The huge difference in virtual presentation evaluation is a problem worthy of attention.

In general, the current fire virtual demonstration performs well in terms of the authenticity of the picture performance.

Table5: Age and fear

	Unbearable fear	scary	A little scary	Not too scary	Not scary at all
0-20			1		
21-40			6		1
41-60			1		

The influence of age on the degree of fear of fire simulation exercises is shown in Table 5. Among the 9 subjects of different ages, except for the 21-40 years old, one of them thinks that the fire simulation exercises are not scary. The remaining 8 subjects all agreed that there was some horror. The purpose of creating an atmosphere of fear in the fire simulation exercise is not only to increase tension and realism, but also to leave a deep impression. However, if the degree of fear is too high, the effect will not be achieved, and it may even become a reactionary effect and cause fire fear.

In use, the degree of fear can be controlled from the amount of smoke and flame according to the purpose of use. For example, when conducting disaster prevention education for minors, in order to avoid adverse effects on mental health, it may be necessary to reduce fear.

Table6: Virtual experience and fear

	Unbearable fear	scary	A little scary	Not too scary	Not scary at all
Have virtual experience			4		1
Never virtual experience			4		

The effects of experiment subjects with experience in using virtual reality screen-related products on the degree of horror of the screen are shown in Table 6. Except for one subject with experience in using virtual reality screen-related products, the other eight subjects, regardless of whether they have The experience of using virtual reality screen related products all think that the fire drill screen is a bit scary.

Table7: fire experience and fear

	Unbearable fea r	scary	A little scary	Not too scary	Not scary at all
Have fire experience			3		1
Never fire experience			5		

Whether the test subjects have experienced the fire and the impact on the horror of the screen is shown in Table 7. Except for one subject who has experienced the fire, it is considered not scary at all. The remaining eight subjects, regardless of whether they have fire experience or not, think that the fire drill screen is somewhat terror.

In general, the horror level of the current fire simulation exercises is more appropriate. It can make people nervous and feel real, and they will instinctively want to escape, but they will also leave a deep impression. It helps as safety education.

Table8: age and impressive degree

	Seriously help	good experience	Remember the feeling	only remembered	Useless
0-20		1			
21-40	1	3	2	1	
41-60			1		

The impact of age on the impressive degree of fire simulation images is shown in Table 8. One experimental subject aged 0-20 considered it helpful to have a deeper memory. Among the 7 subjects aged 21-40, 1 thought it was very helpful and had a deep memory, 3 thought it was helpful to have a deeper memorization, 2 thought it remembered the feeling, and 1 thought it just had a certain memory. One subject, 41-60 years old, thought that he had remembered feelings.

The purpose of the fire simulation exercise is to let everyone experience the feeling of the fire scene, so that they can react quickly when experiencing a fire. Regardless of age, after being trained in fire simulation exercises, they can leave a certain memory. Generally speaking, age has little effect on the impressive degree of fire simulation images. This virtual safety education simulator is basically suitable for all ages.

Table9: virtual experience and impressive degree

	Seriously help	good experience	Remember the feeling	only remembered	Useless
Have virtual experience	1	2	2	0	0
Never virtual experience	0	2	1	1	0

Experimental subjects with experience in the use of virtual reality screen related products have an impressive impact on the fire simulation screen as shown in Table 9. Among the 5 experimental subjects with experience in the use of virtual reality screen related products, one thinks it is very helpful and remembers Profound, 1 thought it was helpful to have a deeper memory, and 2 thought it remembered the feeling.

Of the remaining 4 subjects who had no experience in using virtual reality screen-related products, 2 thought it was helpful to have a deeper memory, 1 thought that they remembered the feeling, and 1 thought that they only had a certain memory.

The difference here is obvious. The five test subjects who have experience in using virtual reality screen related products have a deeper memory of the fire simulation exercise screen. The five test subjects with experience in using virtual reality screen related products have slightly poorer memory of the fire simulation exercise screen.

It can be seen that when ordinary people who have no experience in using virtual reality screen-related products use fire simulation exercise images for training, the effect will be slightly worse than that of people who have experience in using virtual reality screen-related products. In this regard, we suggest that before using virtual devices as safety education, it is best to train participants similar to Experiment 1, so that participants can better grasp the feeling of virtual space.

Although whether or not the experimental subjects have experience in using virtual reality screen related products has a certain impact on the impressive extent of the fire simulation screen. But fortunately, the purpose of the fire simulation exercise is to allow everyone to experience the fire scene before the fire, and to leave an impression for quick response in the future. Even ordinary people without experience in using virtual reality screen related products will not hinder it. The level of authenticity of the fire simulation exercise images has been fully capable of achieving educational purposes.

Table10: Fire experience and impressive degree

	Seriously help	good experience	Remember the feeling	only remembered	Useless
Have fire experience	0	1	2	1	0
Never fire experience	1	3	1	0	0

Whether the test subjects have experienced fire has an impressive impact on the fire simulation screen as shown in Table 10. Among the 5 test subjects who have experienced fires, 1 thought it was helpful to have a deeper memory, and 2 thought they remembered their feelings. , 1 thinks it just has a certain memory. Among the remaining 4 subjects who had not experienced the fire, 1 thought it was very helpful and memorized deeply, 1 thought it was very helpful and memorized deeply, 2 thought it was more memorable and helpful, and 1 thought memorized the feeling .

The difference here is obvious. The four subjects who have not experienced a fire have a deeper memory of the fire simulation exercises. The five subjects who had experienced the fire had slightly worse memories of the fire simulation exercises. It can be seen that although the level of authenticity of the fire simulation exercises is not as good as that of the real fire scene, it has been fully able to achieve the purpose of education. This also explains why experimental subjects who have never actually experienced a fire often give higher ratings. It can be seen that whether the scene has experienced a fire has a certain impact on the impressive degree of the fire simulation picture. The influence from the fire experience can be felt more by the fire experienced person than by the inexperienced person, but the impact is not so impressive. The cause may be that the experienced person remembers the fire of memory and strengthens the sensation, but it may not be more impressive than the real fire. On the other hand, inexperienced people do not have such strong empathy when they experience it, but they may be quite impressive as their first experience.

In short, the purpose of the fire simulation exercise is to allow everyone to experience the simulated fire scene before possible fires in the future, and thus to train, so that ordinary people who experience the fire scene again can quickly judge the situation on the scene and remain calm. Therefore, it is particularly important to remember the state of the fire scene after training.

3.8 Summary of Experiment 2

In Experiment 2, we implemented a large-scale disaster prevention exercise with limited functions and simulated the uncertainty of the fire scene. And got a good effect feedback in the feedback of the participants. We look forward to effectively improving the effect of safety education in actual use and reducing safety risks and use costs.

But at the same time, we also found that one participant could not feel the impact of the fire simulation well, and found that the participants usually lack a sense of tension, and more participants showed curious and interesting reactions. Although this kind of feedback can prove that it can make a deep impression, as a safety education, it still lacks tension and guiding significance. In order to improve this shortcoming, we consider adding another virtual device to provide third-person observation. At the same time, use new equipment to join observers and instructors, thereby increasing the pressure on participants and verifying its effects.

5 Experiment 3: Increase observer

The purpose of Experiment 3 is to test the addition of an observer or participant and provide video feedback. In order to test the influence of observers and other participants on participants who participated in Experiment 2. According to the literature【31】, researchers have proved that objects in virtual space and objects in the real world have the same influence in 3D obstacle avoidance related experiments, and the feedback through the third-person perspective has profound Influence, can facilitate the instructor to improve the behavior of participants. Therefore, Experiment 3 expects that through the observer's central console guidance, participants can improve their awareness of safety education and better understand their performance in the virtual space. At the same time, the participation of observers can also increase the participants' nervousness and deep impression of the fire simulation, which is closer to the core essence of this research (life safety education significance) as a whole. Experiment 3 looks forward to proving that the addition of an observation control system can improve the impact of virtual fire simulation on participants. In order to achieve this goal, we first tried to rewrite the script to link the virtual device through the network link of the unity engine. Then the flame simulation is implanted into the network system to create a 3D villain to mark the location of the participants for the observer. Due to the emphasis on testing to increase the effect of observing the instructor, in Experiment 3, we only completed the simple network connection and the most basic flame simulation function.

4.1 Unity network connection test

Using the network function of the unity engine for online testing, we rewritten the online GUI script and set a green prompt scene for successful online and a red prompt scene for unsuccessful online. A virtual device acts as the host, and a computer device acts as an observer player. With this simple network manager, the flame can be observed on the network and displayed on the host and client at the same time. In this process, we must keep the devices participating in the connection always in the same WiFi environment.

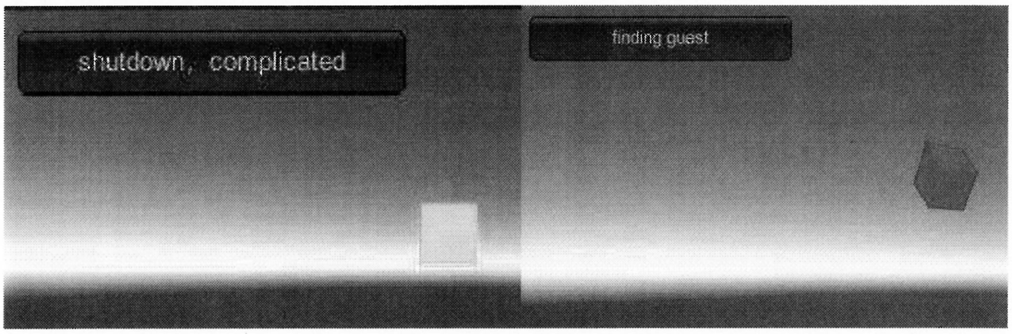


Figure 26 : network test

Among them, Hololens1 entered the program smoothly, but after various attempts, we were unable to make hololens1 and hololens2 compatible with our program at the same time, and have not been able to solve this problem. It is speculated that it is related to the new version of the network management script change. So we only use a computer to imitate a virtual device instead of a virtual device to complete the experiment. Although this does not affect the guidance effect experiment of the observing instructor, it will cause us to be unable to realize the simulation of co-escape in the current experiment.

```
void HostGUI()
    {
        if (base.isNetworkActive)
        {

if (GUI.Button(new Rect(10, 10, ButtonWidth, 30), "shutdown,complicated"))
            {
                m_NetworkDiscovery.StopBroadcast();
                base.StopHost();
            }
        }
        else if (m_NetworkDiscovery)
        {
            if (m_NetworkDiscovery.running == false)
            {
if (GUI.Button(new Rect(10, 10, ButtonWidth, 30), "finding guest"))
                {
                    m_NetworkDiscovery.Initialize();
                    m_NetworkDiscovery.StartAsServer();
                    base.StartHost();
                }
            }
        }
```

4.2 Clone and server

The basic idea of interconnection in the network is data sharing. The first is to put the flame, and calculate and complete the flame placement based on the host's camera. In order for the online device to observe the flame at the correct position, we first need to abstract the flame effect into a simple prefab and give it a network identity. Then use the network incubation script to guide the flame to the correct position. Since this experiment only involves placing and destroying and does not involve mobile interaction, there is no need for the callback of interactive information for the time being, so the script is not used, and only the information is retained in the recommended network manager Interactive. However, if more information is needed later, the interaction can also be realized through callback related scripts. It should be noted that the representative prefab cloned on the server must be put into the simple network manager's array to complete the establishment of the network identity during the clone.

```
public void CmdSpawn(Vector3 positon, Quaternion rotation)
    {
        GameObject clone= Instantiate(prefab);
        clone.transform.position = positon;
        clone.transform.rotation = rotation;
        NetworkServer.Spawn(clone);
    }
```

4.3 Observer client experiment

We use 3D villains to show the current location and orientation of the participants. First, mark the fixed online position as the origin, and wait for the movement and behavior of participants as shown in Figure 27. The observer can observe the position of the 3D villain on the operation interface in real time, and observe the position of the participant in the virtual first person. The observer can observe whether the participant is trying to avoid the danger, and can also try to guide the participant to move away from the danger. Observers can observe the behavior of participants from different perspectives.

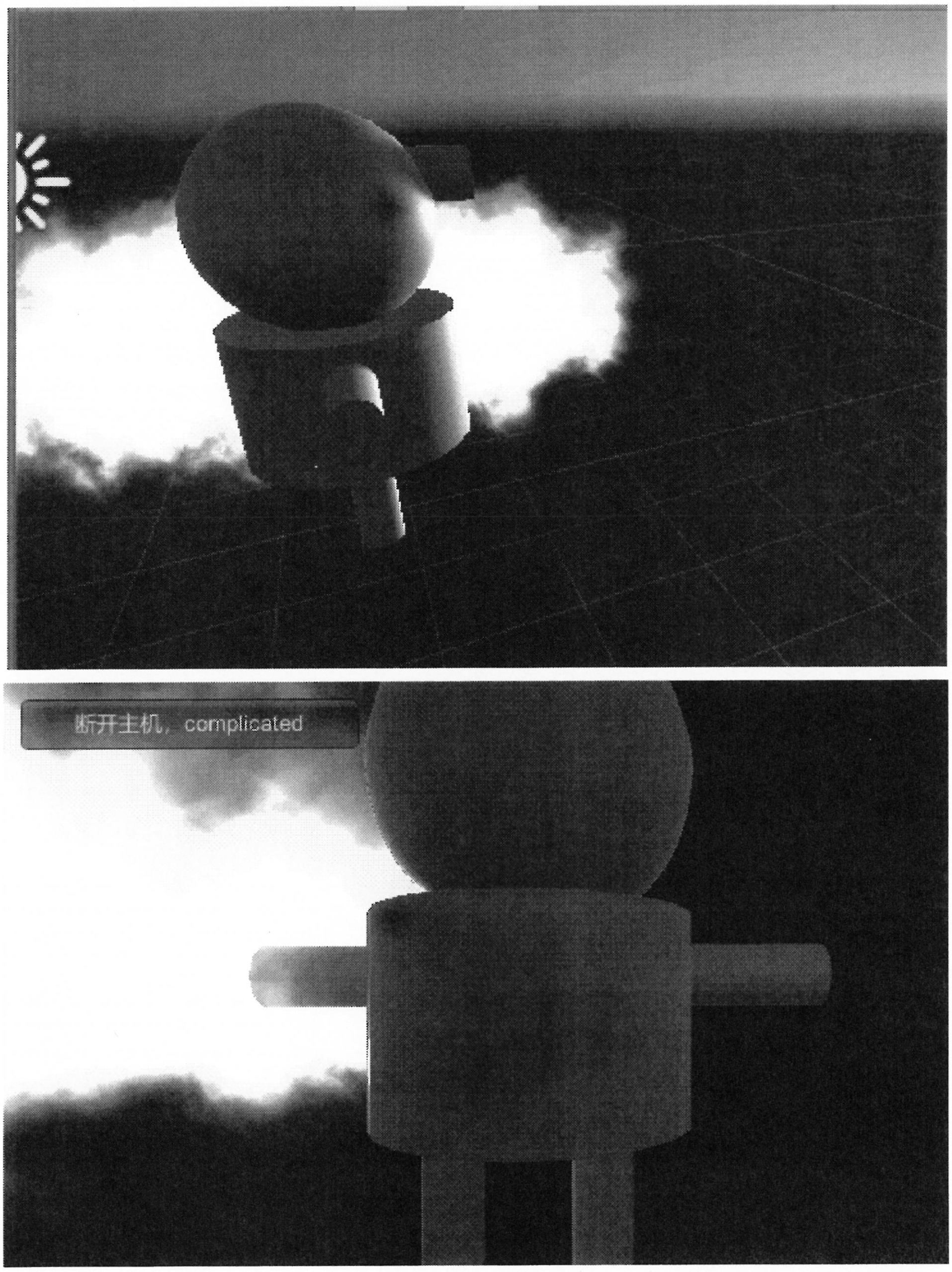
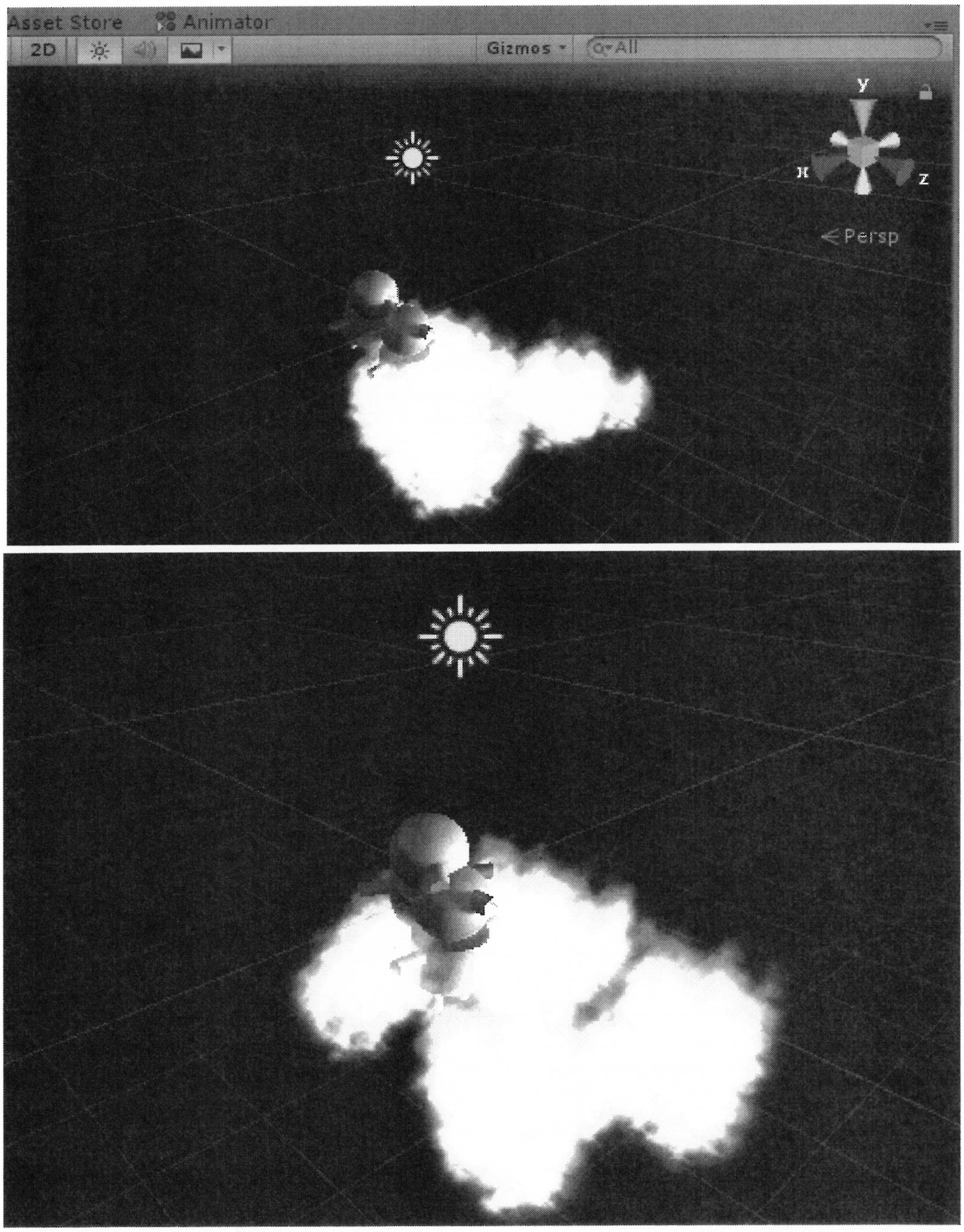


Figure 27: 3D villain

As shown in Figure 28, the participant's online position is in the middle of a flame. At this time, the observer can see the participant's position and orientation. The observer wants to guide the participant to move to the periphery of the flame. Since the observer can observe all terrain and flame positions from a third-person perspective, the observer can see the position of the participant in real time and give correct guidance during the movement of the participant.

In the experiment, the observer showed a more nervous reaction and actively guided the participants out of the danger zone.



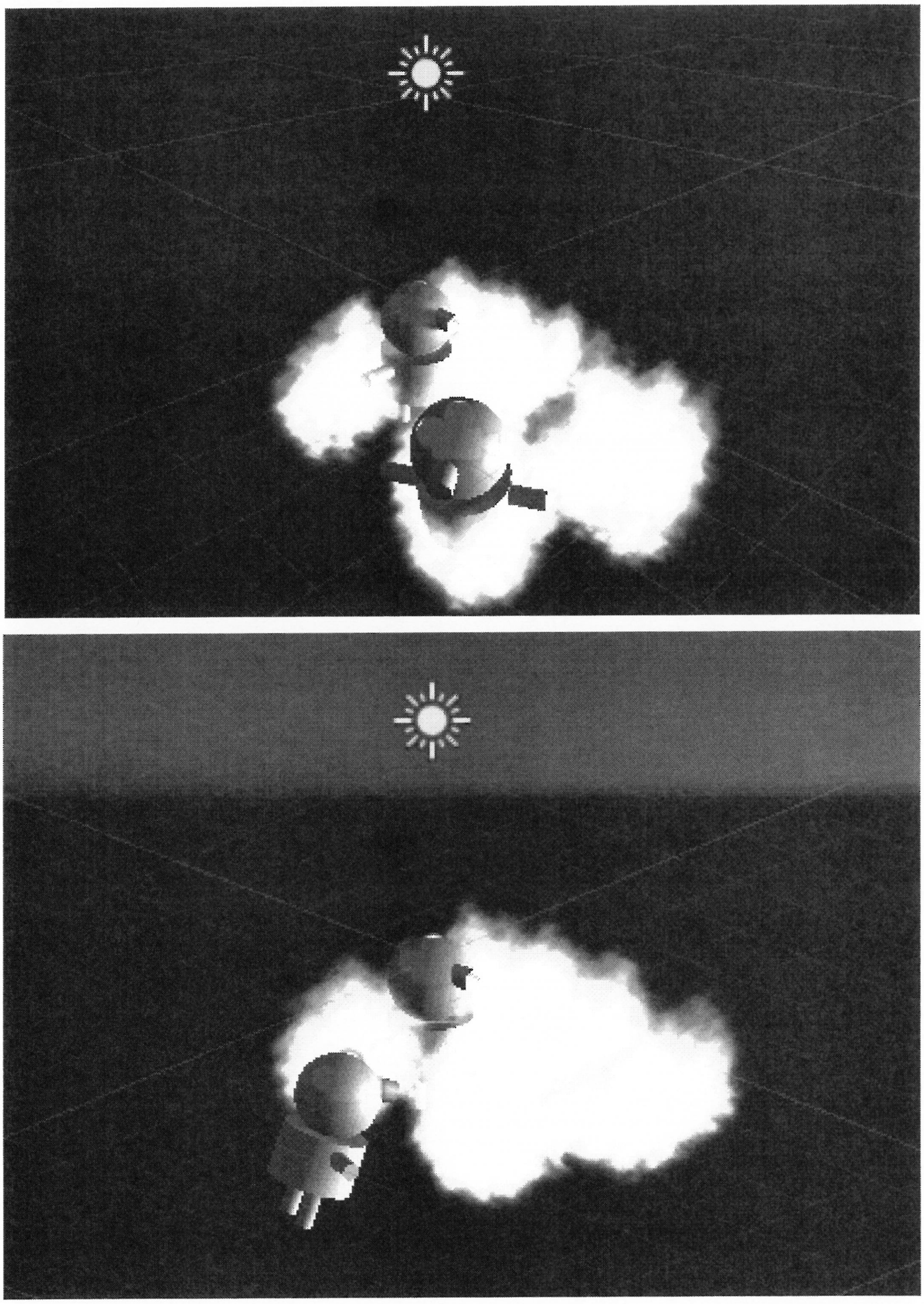
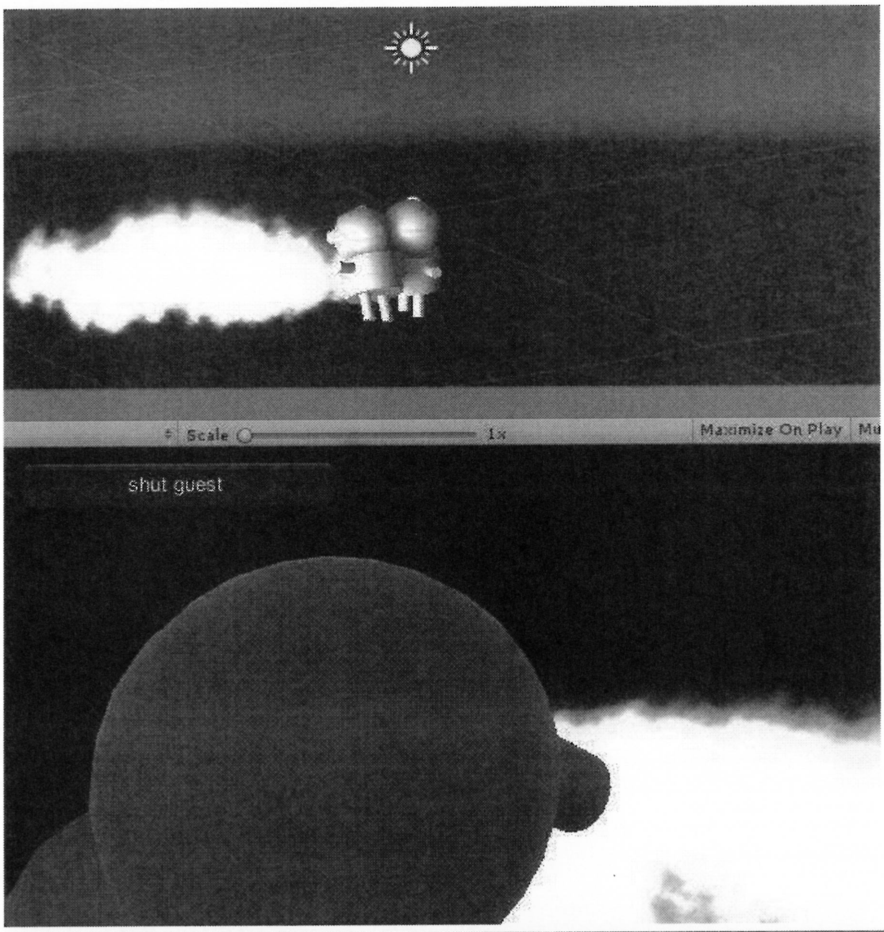
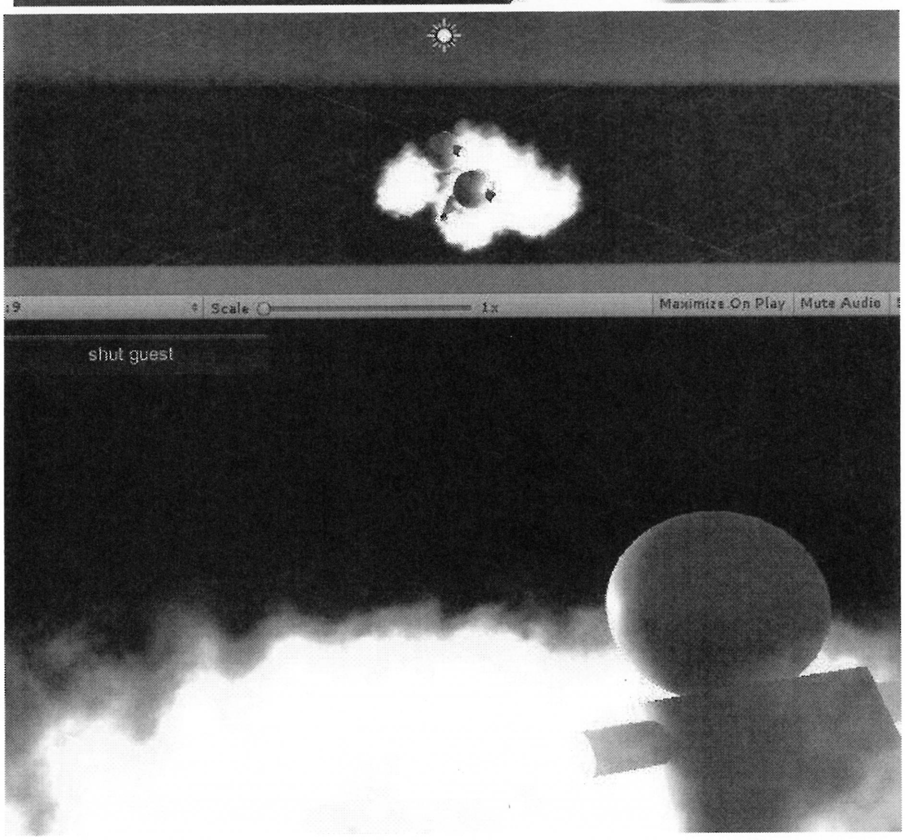


Figure 28 : Participants move

As shown in Figure 29, in the observer's interface, it is not only possible to observe the scene situation in a 360-degree third-person perspective on the operation interface. It is also possible to observe participant status immersive through the virtual second-person perspective. This helps the observers have a deep understanding of the participants' conditions while directing. At the same time, this second-person observation can also be fed back to participants when needed.


Scale
1x
Maximize On Play
shut guest


Scale
1x
Maximize On Play
Mute Audio
shut guest

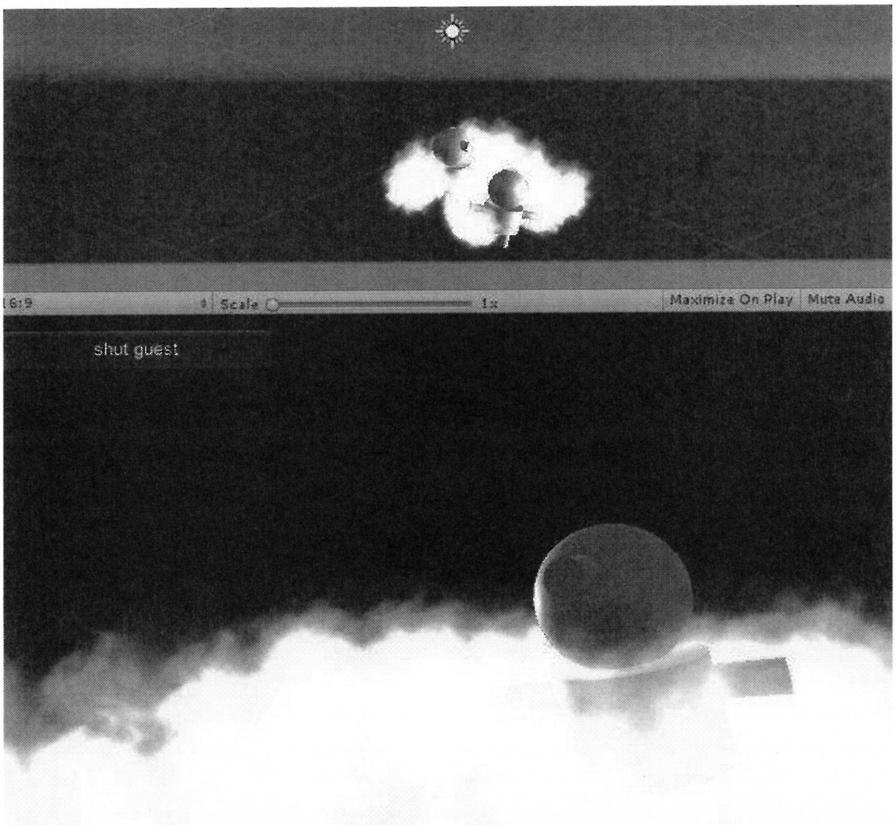


Figure 29 : Virtual second person perspective

4.4 Summary of results

We let participants who participated in Experiment 2 participate in the observer and observed experiments. When observing the participant in the flame, the observer showed nervous feedback and actively guided the participant out of danger. On the part of the participants, although the quality of the flame display was lower than that of Experiment 2, due to the presence of the observer and the observation of self-behavior, the performance was more nervous and serious than before. They have made more spontaneous and positive behaviors as observers. Participants performed as we expected, paying more attention to safety education, and said that the experiment left a deeper impression on them.

6 Conclusions and Future Directions

In order for the virtual space technology to be better developed in the field of life safety education, we have verified through Experiment 1 that the interest guidance through virtual reality technology is that meaningless behavior becomes meaningful in virtual reality. It will have a greater impact on the body and mind of the participants. In Experiment 2, we combined virtual space with reality to vividly display the virtual fire scene in the real world where participants are. It is verified that the virtual fire simulation using Hololens is feasible, and it is meaningful and effective as life safety education. In Experiment 3, we used the network link under the same wifi to provide a second-person view and a third-person view for fire simulation. And compared the behavior of the participants in Experiment 2 as observers or participants in Experiment 3. It is verified that the participation of observers and participant feedback can effectively improve their participation enthusiasm and depth of impression, thereby increasing the importance of life safety as a whole. The results of this experiment are in line with our purpose of enhancing the effectiveness of life safety education. We also look forward to using multiple Hololens1 or other devices to change the experimental method to achieve better results.

In the future, with the development of 5G communication technology and the improvement of equipment performance, collective disaster prevention drills can be carried out not only indoors but also anywhere, and user expressions and evacuation routes can be collected in the database to achieve better life safety Educational effect. In addition, we look forward to developing a technology that can enhance the sense of realism by adjusting the temperature through a sensor-equipped odor generator and sensor system.

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Appendices

1 .particle system description

Find the Renderer column in the Inspector panel of the particle emitter, and then drag the flame material to Material. Find Texture Sheet Animation in the Inspector window of the particle emitter, and set the X and Y options of Tiles to split the image into several parts. The Time Mode setting allows particles to be emitted, and the corresponding pictures are displayed over time. In order to constrain the emission shape, find the Shape column in the Inspector panel and set the Angle to about 15, so that the scattering angle is converged. Then set Radius to about 0. Control the existence time and speed of particles, and find the main settings of the Particle system. Checking Prewarm will make the particle system run at full state at the beginning of the game, instead of launching from less to more. Set Start Lifetime and Start Speed to 1 respectively. In this way, the launch range and distance are controlled. Set Simulation Space to world. In this way, when the flame moves, the fired flame will stay in the previous position. Set Simulation Speed, and set the flame burning speed to about 0.8. Find the Size over Life time column and set the Curve of Size to display from presence to absence. Flame color gradient can be achieved by setting Color over lifetime.

2 .Bind two objects directly without writing a script separately

Solution 1: Put object A into object B, and object A as the child of object B. In this way, object B is taken as the parent object, so that no matter where the object B moves, the distance between it and A remains the same.

Solution 2: Import the script SmoothFollow.cs that comes with unity to follow the object. You can set the distance and height of the two by yourself.

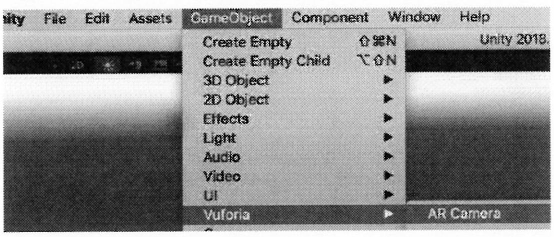
3 .Control patch

Sometimes we need some control patches to turn on or turn off the script. In the article, there will be a disconnection problem after the network connection. So add a patch to turn off the network identity, and detect it every time it is turned on to avoid errors.

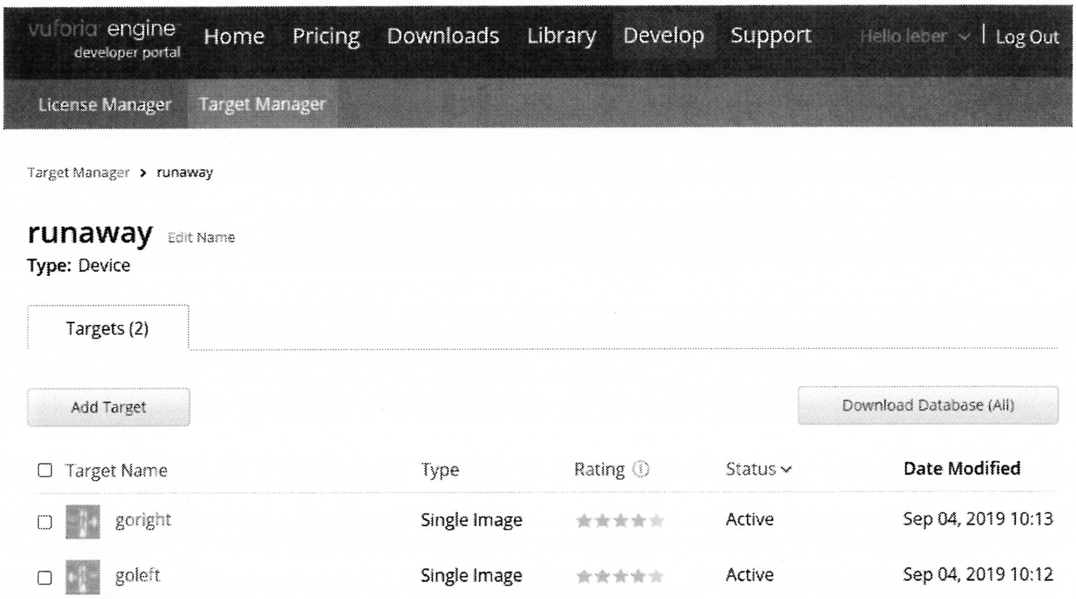
```
GameObject.Find("ObjectName").GetComponent<scriptName>().enabled = true;
GameObject.Find("ObjectName").GetComponent<scriptName>().enabled = false;
```

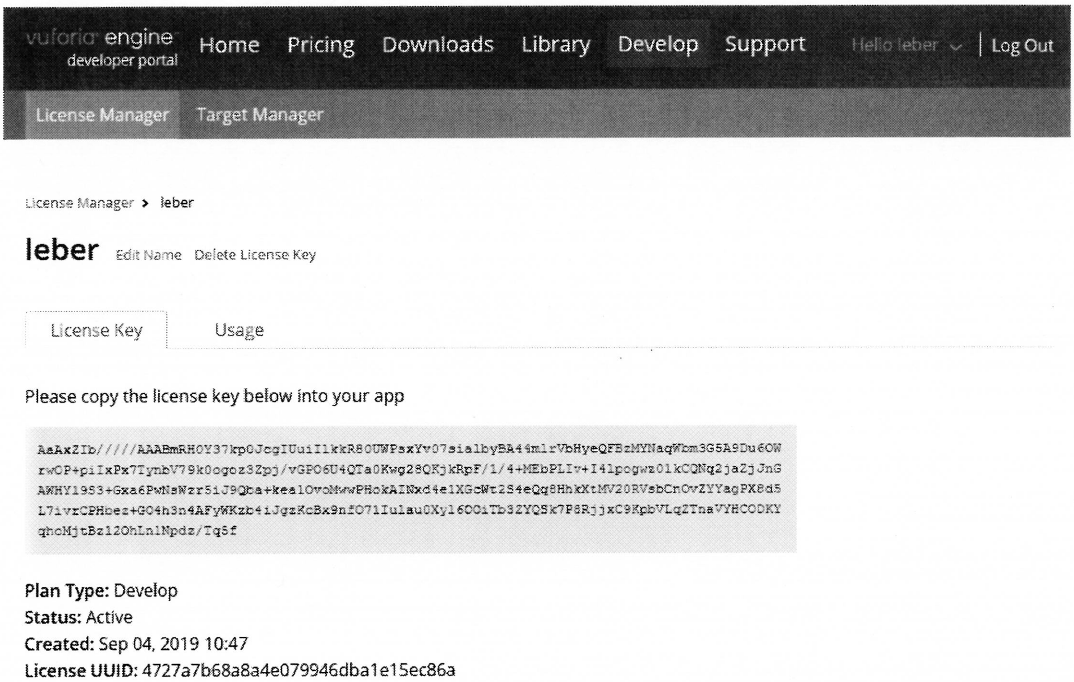
4 .Vuforia description

The recognition accuracy of escape signs is not high, so vuforia can complete the required functions. First use the Unity installation package to install Vufoia. Before using Vuforia, we must activate Vuforia in the project and check the Vuforia Augmented Reality option in the playersetting. At this time, you can create a vuforia ARCamera in the gameobject.



Use the official website to register https://developer.vuforia.com/, enter the management interface to upload the picture of the identified object. And copy the license key to unity, the location is in the app license key in the Open Vuforia Configuration option of ARCamera.





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2. Xingrun Shen, Kazuyoshi Yoshino, Shanjun Zhang, "Fire Simulation And Disaster Prevention Education System By Mixed Reality" International Journal of Research in Engineering and Science (IJRES) www.ijres.org Volume 8 Issue 9, PP. 38-45 , 2020.

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