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A Study on Applying Proxemics to Camera Position in VR Animation <Help Us!>

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Abstract

With the development of science and technology, virtual reality (VR) has become increasingly popular, being widely used in various fields such as aviation, education, medical science, culture, art, and entertainment. This technology with great potential has changed the way of human-computer interaction and the way people live and entertain. In the field of animation, virtual reality also brings a new viewing form and immersive experience. The paper demonstrates the production of VR animation <Help Us!> and then discusses camera's position in VR animation. Where to place the VR camera to bring a comfortable viewing experience. The paper, with the proxemics as its theoretical framework, proposes the hypothesis about the camera position. Then the hypothesis is verified by a series of experiments in animation <Help Us!> to discuss the correlation between camera position and proxemics theory.

Keywords: *Animation, Virtual Reality, Game Engine, Proxemics, Camera Position*

1. Introduction

Looking back at the history of movies, from silent movies to sound movies, from black-and-white movies to color movies, there is an increasing richness of expression and expressive dimensions. Since the release of Avatar in 2009, 3D movies have been introduced into our lives. A two-dimensional picture on a flat screen no longer seems to satisfy the demand for cinema; audiences expect a three-dimensional movie world for better immersive experience[1]. Various types of theaters with special effects have appeared in individuals' lives, such as IMAX cinema, 4D cinema with muti-function seat, 5D cinema with tactile and olfactory stimulation, 360-degree panoramic cinema. The direction of hardware development is to make it easier for the audience to immerse themselves in the movie scene through a wider range of vision coverage and more diverse sensory stimulation. The continuous emergence of new theaters in various forms reflects the different demands of the new era for cinemas and the new demands on projection and production techniques[2]. After more than 10 years of development, 3D and 4D cinemas and movies are becoming increasingly popular, and a variety of theaters with special effect also emerge, but their stereoscopic performance is extremely limited. Whether it be a 3D movie or a circular-screen movie, the stereoscopic vision is not perfect enough. However, the advent

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of VR has made a huge breakthrough in the visual experience[3].

With the advancement of technology, VR technology has been re-noticed as an emerging buzzword and has also created a new wave of gaming, animation, film technology and experiences. A new VR section was introduced into the 2017 Cannes Film Festival, bringing new forms of viewing, with various film and game companies starting to develop new VR-based films and games [4]. Although it is not yet mature enough, the tremendous immersion that VR bring is unmatched by any other technology that exists today, and is something that no one can resist. In the future, audiences will be able to enter the virtual world to live, experience, learn, play and watch movies just as they do in the real world[5]. The VR world brings a tremendous amount of realistic experience that is unattainable in theaters such as 3D cinema, circular cinema and other theaters, which reflects the great potential of VR technology. In this particular social context, it is undeniable that VR is bound to be the future of film and animation, Therefore, researches into VR-related technologies are clearly valuable and meaningful. A wide range of issues related to VR animation are worth exploring; for instance, individuals may be curious about how to use VR technology to create new forms of animations, or how to improve audiences' viewing experiences.

More researchers tend to delve in VR due to the rapid development and the widespread of the technology. The current researches on VR animation mainly focus on the analysis of VR animation, including its narrative mode, performance techniques, sightline design and other related items[6]. However, there is still a big gap in the research about the virtual space and camera in VR animation, which is a very important part of VR animation production process. In this paper, the VR animation <Help Us!> is used as an example to explore the problem of where the camera should be placed to provide the most comfortable viewing experience for audiences. In order to reach a conclusion, the theoretical investigation of proxemics is firstly conducted based on the theory of proxemics in <The Hidden Dimension> written by Edward T. Hall. Then, the most comfortable viewing distance in VR animation will be inferred with the support of relevant studies on proxemics in virtual space. To further verify this conclusion, one of the scenes in the VR animation <Help Us!> is used as an experimental object, and 100 people participate in the experiment and complete questionnaires. Finally, by analyzing the results of this experiment, the conclusions of this paper are finally drawn.

There are various ways to make VR animation. and at present, there are roughly two ways to make a 3D VR animation[7]. One is to build an animation scene in 3D software to get 360-degree image sequences by rendering, and then synthesize the image sequence into a 360-degree VR animation. The other way is to build an animation scene in the game engine, and use the real-time rendering function to generate the final VR animation[8]. In this paper, by taking the example of the VR animation <Help Us!>, which is created in the second way mentioned above, camera position problem will be discussed. This animation is built in the game engine Unity and the final animation is rendered in real time. The animation <Help Us!> uses the VIVE VR hardware device produced by HTC, and the virtual camera used in the animation scene construction process is the CameraRig that comes from the Unity SteamVR asset.

2. Proxemics

In the book <The Hidden Dimension> written by Edward T. Hall, he defines proxemics as a term for interrelated observations and theories of man's use of space. According to Edward's description, distance between people could be divided into four categories: intimate distance, personal distance, social distance, and public distance[9].

Intimate distance (0 to 45 centimeters) is the distance at which intense feelings are expressed: tenderness, comfort, love, and also strong anger. Personal distance (0.45 to 1.30 meters) is the conversation distance between close friends and family for instance the distance between people at the family dinner table. Social distance (1.30 to 3.75 meters) is the distance for ordinary conversation among friends, acquaintances, neighbors, co-workers. Public distance (greater than 3.75 meters) is defined as the distance used in more formal situations, around public figures or in teaching situations with one-way communication or when someone wants to hear or see an event but does not wish to become involved[10].

For strangers, intimate distance can be perceived as intrusiveness. Most people will react with suspicion and hostility if their space is invaded by someone they are not familiar with. In many cultures, it would be considered bad taste to maintain an intimate distance in public. Personal distance, which is normally at arm’s length, refers to distance between friends and acquaintances rather than between lovers and family members. Personal distance preserves individuals’ privacy, but it does not necessarily suggest exclusion. Social distance, which is little more formal than personal distance, is usually a distance that should be kept when there are more than three individuals in cases like impersonal business or social gatherings for friendly interaction. However, public distance, which is formal and rather detached, is not conducive for people to express themselves in larger spaces. Therefore, in order to achieve clear communications, speakers have to use exaggerated gestures and louder voice[11].

2.1 Proxemics in Movies

Scenes in movies can be categorized into following types: medium shot, close-up shot, and long shot. In movies, proxemics patterns are also related to the shots and their distance ranges. The intimate distance can be likened to the close and extreme close shot ranges. The personal distance is approximately a medium close range. The social distances correspond to the medium and full shot ranges, and the public distances are roughly within the long and extreme long shot ranges.

In general, the greater the distance between the camera and the subject is, the more emotionally neutral audiences can remain. Conversely, the closer audiences are to the character, the more emotionally invested they are. The medium shot is almost the closest thing to the way humans observe their surroundings. Usually, the distance between the camera and the subject is between 1.52 and 3.04 meters to produce a medium shot. This kind of shot is like what you are seeing when you're talking with the other person in the same room. It is similar to everyday viewing; therefore, a medium shot will make the viewer feel rather comfortable[12]. A close-up of a character will make audiences feel close to the character. It will Connect the audience to the character and make the audience care about or identify with the character's issues. If the character is a villain, close-ups can evoke an emotional revulsion in audiences; because a threatening character may be regarded as an invader to audiences’ spaces [13].

It can be seen that the proxemic theory is not only the theories of man's use of space in real life, but also exists in movies. Different shooting distances or different shots are used to mobilize the subtle emotions of people due to spatial distance.

2.2 Proxemics in Virtual Reality

According to the proxemic patterns, it can be seen that the distance between people varies based on the degrees of intimacy. In other words, there is personal space around people. Personal space (PS), a flexible safety zone maintained around the body during walking, is used by the locomotor control system to navigate safely around obstructions[14]. The personal space maintained around the body during obstacle circumvention is asymmetrical in social environment, and it affects the distance that people keep with others. The research shows that the concept of PS is also applicable to VR scenarios, and the overall shape and side asymmetry of the personal space are maintained in the virtual environment [15]. As what is shown in the figure 1 below, personal space is usually oval in shape, with the front area of a person having about twice as much space as the back and sides[16].

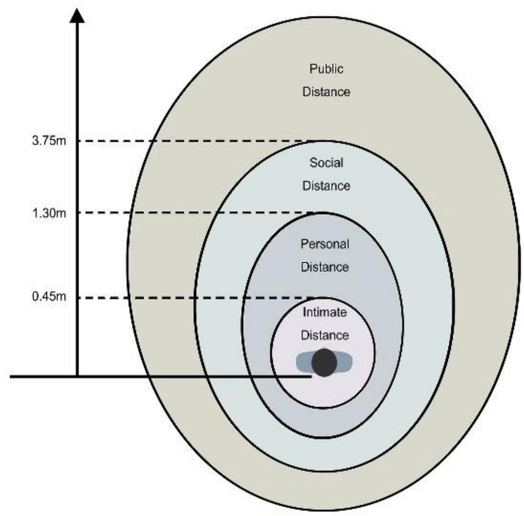

Figure 1. Definition of the personal space in virtual space.

Since in the virtual space, human movement also follows such a rule. In the process of experiencing VR movies or VR animations, the audience will keep a certain distance from the virtual characters due to the existence of personal space around themselves. Then in the virtual space, there must be a most comfortable distance between audiences and virtual characters. This comfortable distance varies because of individual sensory differences, but this comfortable distance interval should have some relationship with the proxemic distance interval. In VR animation made by game engines, the position of the camera is where the audiences' line of sight is located. In other words, in this kind of VR animation, the camera also exists an optimal viewing distance. Audiences are most comfortable when watching animation at this distance range, and this most comfortable viewing distance is relevant to the proxemics theory.

3. VR Animation <Help Us!>

VR animation, an animation supported by VR technology, is a kind of content that allows people to enter a virtual space to experience stereoscopic images[17]. A key feature of VR animation is that viewers can experience VR contents at their own will in a 360° virtual space[18]. The key elements in experiencing virtual reality are a virtual world, immersion, interactivity, and imagination[19].

<Help Us!> is a short VR animation made in the game engine Unity without interactive experience. The audience can sit on a chair and use the VIVE device produced by HTC to watch the animation, experiencing the immersive experience of a virtual world. In the process of creating this animation, various problems were encountered, and one of the most confusing ones is where the camera should be placed in Unity. Although in the VR environment, the position of the camera is not completely fixed, it will change according to the position of the headset worn by the audience. However, when the audience is watching the animation on his chair, the change in the position of the headset is very limited. In other words, the distance is more determined by the director. When building the scene, at what distance is the audience most comfortable watching it?

3.1 Apparatus

This VR animation is based on HTC VIVE device. The computer configuration is as following: processor is Intel(R) Core(TM) i7-6700 CPU @3.40GHz; the memory is 16.0GB; the graphics card is NVIDIA GeForce GTX 1060 6GB; the motherboard is PRIME Z270-A (Rev 1.xx). The motion capture technology is used for the animation part to reduce the production time, and the software used for this animation includes Unity, Maya, Zbrush, Photoshop.

3.2 Production Content

The VR animation presented here is the final work presented through an internship project based on an English story book, which tells the story of a puppy called "Bonbon" (Figure 1). One day Bonbon helps his mother to send a lunchbox to his father who is working in a donut shop. On the way to the donut shop, he meets a little duck who cannot find her mother. Bonbon uses the footprints left behind to help the little duck find her mother. After hearing the story, Bonbon's father is so touched that he decides to hold a donut party and invites the whole family of the duck to come.

This is an original English fairy tale which is designed for early childhood English education. This animation serves as a supplementary video for the accompanying textbook. As the target audience of the animation is children, the style of the whole animation is bright and warm.

Figure 2. VR short animation <Help Us!>.

3.3 Production Steps

The main-production stages of VR animation, including the modeling, rigging and animating, are similar to traditional 3D animation. Character modeling uses Zbrush to sculpt the approximate shape and then do re-topology with Maya. However, the humanIK system, which is used in the rigging part in Maya, provides no facial expressions. In addition, several blendshapes for the characters need to be made after body rigging. The characters' animation part is completed with the help of motion capture equipment, which reduces the time needed for the entire production process.

After the modelling and animating sections are finished, the files need to be imported into Unity. The export and import process is done by FBX format. The type of the animation is set to legacy and make it play automatically, as it is showed in Figure 3.

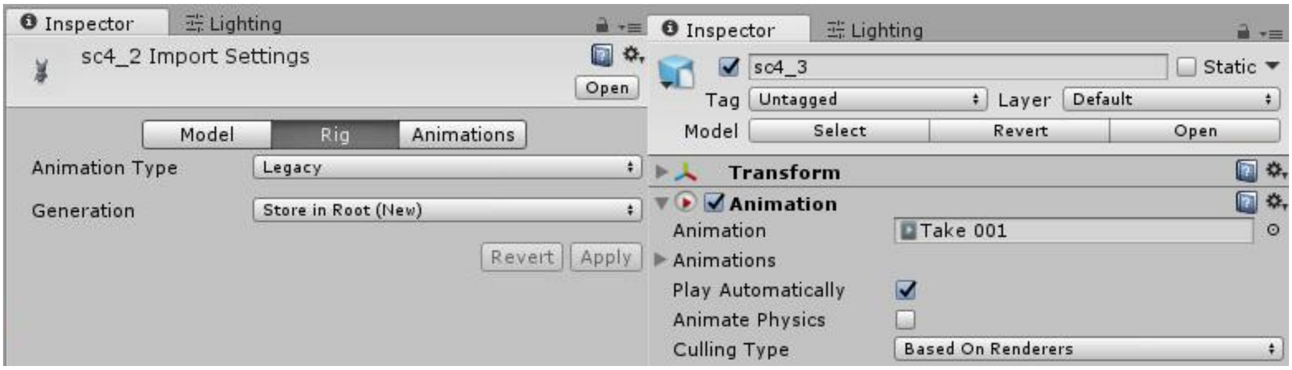

Figure 3. Animation file settings in unity.

After the files are imported successfully, the next step is to build the scene. There are a total of six scenes in this animation. Each scene is built with an independent scene file and needs to import all requiring background modellings, character animation files, the steam VR camera and sound files. All six scenes need to be connected after they have been built. The connection is like the method of making the game level in Unity. The game will automatically move to the next level after the goal is reached. As what is shown in Figure 4, a simple script is created to define a scene playback time. Each scene will switch to the next scene when it reaches the expected time. Finally, the animation was built and finished after using the lighting system, and it will play automatically after pressing the play button. Unlike the video format of a traditional movie, the game engine-based animation ultimately generates an exe file.

3.4 Camera of <Help Us!>

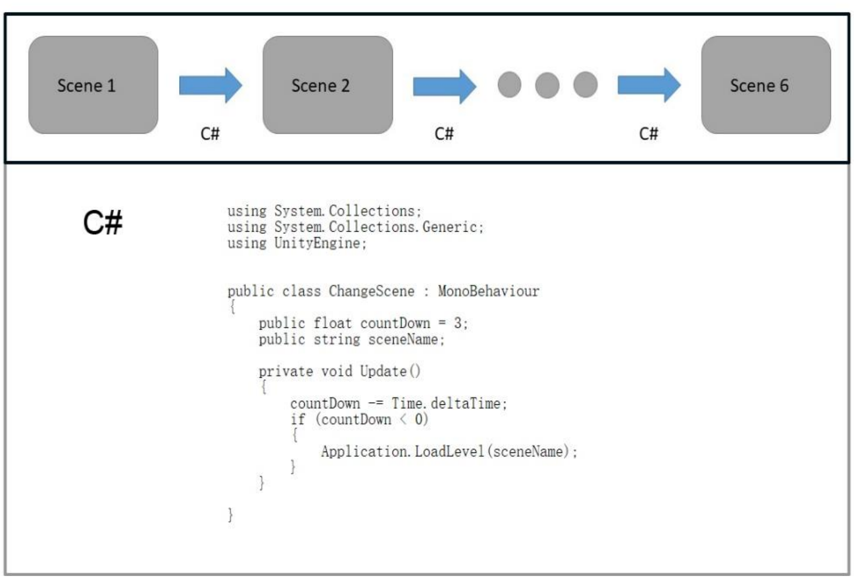

Figure 4 .The VR animation scenes are connected by script.

The hardware required for viewing the animation is the HTC VIVE. Firstly, due to the HTC VIVE's own nature, it tracks the position of the head display; therefore, the position of the camera in the animation camera will move due to the movement of the audience. In VR films, the scales of scenes and characters are usually kept in line with real sites in order to provide a greater sense of immersion for the audience. In this animation, the main character, Bonbon, is about one meter tall and the mother is about 1.5 meters tall. The best way for the audience to view the film is to sit on a fixed chair (Figure 5).

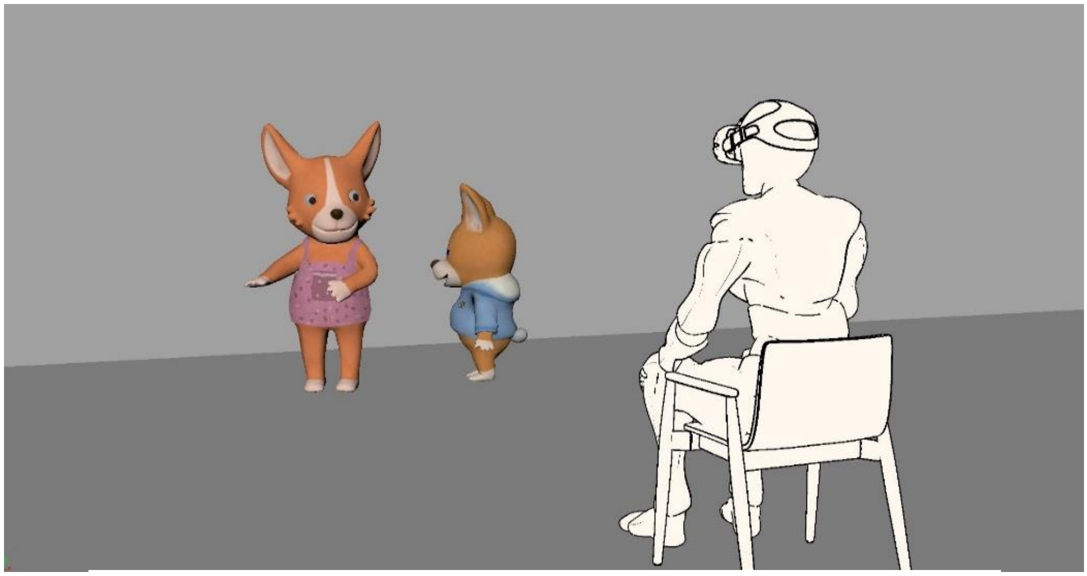

Figure 5. The audience watching VR animation.

As mentioned above, there is a personal space around the audience itself, so in the virtual space the audience will maintain a certain distance from the virtual character. And the position of the human eye in the virtual space is the location of the camera. To ensure the position of the camera, here are two questions taken into consideration: how far should the camera be kept from the character in the VR animation? What kind of distance is the best viewing distance in VR animation?

Hall's proxemic theory contains four types of distance: intimate distance, personal distance, social distance and public distance. According to the definition, the distance between people is determined by the degree of intimacy. The definition of intimate distance above is the distance within which intense feelings are expressed, and the relationship between the character and the audiences do not belong to this category. Personal distance is suitable for close friends or family members to conduct communications. However, the distance between virtual characters and audiences is not within the range in terms of their relationship. Social distance is the distance for ordinary conversation among friends, acquaintances, neighbors, co-workers. Public distance is defined as the distance used in more formal situations–around public figures or in teaching situations with one-way communication or when someone wants to hear or see an event but does not wish to become involved. From these definitions, it can be assumed that the distance between audiences and the character may be in the range of social distance (1.30 to 3.75 meters) or public distance (greater than 3.75meters). In order to verify this conclusion, experiments will be conducted to test whether this conjecture is correct.

4. Experiment on Camera Position

4.1 Experiment Process

It is speculated that that the optimal viewing distance for VR animation is within the range of social distance (1.3-3.75m) or public distance (greater than 3.75m). In order to verify whether this hypothesis is correct or not, the following experiment is designed.

In order to get the best viewing distance for audiences when they were watching VR animation, a scene was selected from the animation <Help Us!>. Among four scenes in this animation, the scene of Bonbon and his mother staying at home was selected as the virtual environment for the experiment. After the scene was constructed, 100 volunteers were recruited to participate in the experiment. During the experiment, volunteers were required to wear the headset and sit on a chair to watch the animation scene. They could use the teleporting function in the scene to move around until they found the most comfortable viewing distance. The distance between the volunteer's headset and the character would be determined and recorded by a script in Unity. In order to make HTC VIVE Pro be used smoothly, the computer configuration is used as following: the processor is Intel(R) Core(TM) i7-7700 CPU @3.60GHz; the memory is 16.0GB; the graphics card is NVIDIA GeForce GTX 1050 Ti; the motherboard is 8298(KBC Version 06.21).

The animation used for experiment was looped to give the volunteers enough time to find their personal best viewing positions. This is an indoor scene, and considering that the virtual walls may affect the experiment results, we removed the walls of the room to expand the virtual space for the experiment. Since there were two characters in this animation scene, we chose the center points of Bonbon and his mom as the marker points, and made sure the height of the marker points is the same with the height of the volunteers' eyes. The optimal viewing distance was then obtained by measuring the distance between the volunteers 's headset and the marker point.

For this experiment, we recruited a total of 100 volunteers, including 41 males and 59 females. The age of the volunteers ranged from 8 to 44 years old, with an average age of 24. In the 100 volunteers, 24 people were using the VR for the first time, and 76 people had experienced VR movies or games before. The vast majority of the volunteers came from Dongseo University, and their age group ranged from 19 to 30 years old. These youngsters are more receptive to new things, and they have stronger learning ability. Therefore, although some of them were first users of the VR technology, they could quickly adapt to the virtual environment. In addition, according to other related studies, males will have a stronger negative reaction to the frontal invasions of personal space than females[20]. Considering the situation, it has to be ensured that there is no huge gap between the number of two genders.

Before the experiment, the volunteers were firstly informed of the general procedure, then put on the headset and sat on a chair in the middle of the room to watch the animation. They should move their positions in the virtual space through the VIVE controller to find the best viewing point. After the experiment, the volunteers will fill out a simple questionnaire, and the experiment time for each volunteer was about 2-5 minutes.

4.2 Experiment Results

After the experiment, the data from 100 volunteers were obtained. The most comfortable viewing distance of the volunteers in different age groups are shown in the table below. As can be seen from the results data, the viewing distance of the 100 people involved in the experiment ranges from 1.50 to 10.41 meters, with an average distance of 4.08 meters.

Table 1. Experiment Results on the Most Comfortable Viewing Distance

	Age	No	Avg（m）
Male	0-9	1	4.48
	10-19	3	3.30
	20-29	30	3.84
	30-39	5	5.36
	40-49	2	5.16

Female	10-19	9	3.66
	20-29	45	4.25
	30-39	4	3.70
	40-49	1	2.46

The distribution of the data can be clearly seen by making a graph (Figure 6) of the experimental data of 100 participants, with the nearest distance being 1.50 meters and the farthest being 10.41 meters. And comparing these data with the four distance ranges of proxemics, it can be seen that all the data of this experiment are distributed in social distance and public distance. The data in public distance account for 55%, and the data in social distance account for 45%. Before the experiment, the prediction of the most comfortable viewing distance belongs to social distance and public distance, which is basically consistent with the experiment results.

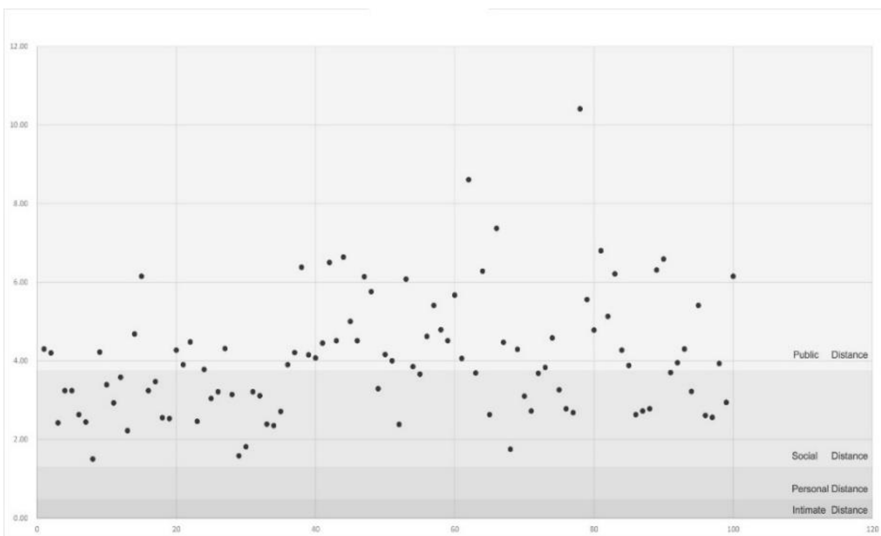

Figure 6. Data distribution of the most comfortable viewing distance.

Based on the results of this experiment, some adjustments can be made to the camera position in the VR animation <Help Us!>. In the scenes of this animation, the camera can be placed in a range of about 2 meters to 7 meters from the character. Therefore, audiences can have a relatively ideal experience while watching the animation.

5. Conclusion

According to the experimental results above, it can be seen that in the VR environment, the relevant theories of proxemics still invariably affect human senses, and affect the distance between the participants and the virtual agents. The above experiment shows that the most comfortable distance between the camera and the virtual character in the VR animation <Help Us!> is basically distributed in the social distance, public distance range. According to existing researches on personal space, when a single virtual agent approaches, participants choose to be at larger distances to angry virtual agents than to happy virtual agents[21], and an increasing amount of interaction partners also increases the distance kept between participants and virtual agents[22]. Therefore, this distance range may also be related to the number and emotion of virtual characters, the atmosphere of the entire virtual environment, and the age or cultural differences of the audience. The influences of these factors on the VR animation camera position are not discussed in this paper. However, it is undeniable that proxemics theory does affect the distance of the camera in VR animations.

When designing a VR animation based on a game engine, the director can set the position of the camera based on this conclusion, so that the audiences can watch the animation at a comfortable distance. Reduce the discomfort caused by the position of the camera, and help the audience to better focus on the VR animation.

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