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# Status and development direction of Virtual Reality Video technology

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# 가상현실 영상 기술의 현황과 발전방향 연구

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Abstract Virtual reality technology is a new practical technology developed in the 20th century. In recent years, the related industry is rapidly developing due to the continuous development and improvement of virtual reality (VR) technology, and various image contents that are realistic through the use of virtual reality technology provide users with a better visual experience. In addition, it has excellent characteristics in terms of interaction and imagination, so a bright prospect can be expected in the field of video content production. This paper introduced the types of display of VR video, technology, and how users view VR video at the current stage. In addition, the difference in resolution between the past VR equipment and the current equipment was compared and analyzed, and the reason why the resolution affects the VR image was explored. Among the future development of VR video, we will present some development directions and provide convenience to people.

Key Words : Virtual Reality, Virtual Reality Video, Panoramic Video, PPD, Standalone VR Headsets

요 약 가상현실 기술은 20 세기에 개발 된 새로운 실용적인 기술이다. 최근에는 가상현실(VR) 기술의 지속적인 발전과 개선으로 관련 산업이 빠르게 발전하고 있으며, 가상현실 기술의 활용으로 실감나는 다양한 영상콘텐츠는 사용자에게 더 나은 시각적 경험을 제공하고 있다. 또한 상호 작용 및 상상력 측면에서 뛰어난 특성을 가지고 있어 영상콘텐츠 제작 분야에서 밝은 전망을 기대할 수 있다. 본 논문은 현 단계에서 VR 비디오의 디스플레이의 종류, 기술, 그리고 사용자가 VR 비디오를 보는 방법을 소개하였다. 더불어 과거 VR 장비와 현재 장비의 해상도 차이를 비교 분석하고 해상도가 VR 영상에 영향을 미치는 이유를 탐구하였다. 미래 VR 영상 발전 중에서 몇개 발전 방향을 제출하고 사람들에게 생활 편의를 제공할 것이다.

주제어 : 가상현실, VR 영상, 파노라마 비디오, PPD, 독립형 VR 헤드셋

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## 1. Introduction

The so-called virtual reality, as the name implies, is the combination of virtual and reality. Theoretically speaking, virtual reality technology (VR) is a computer simulation system that can create and experience a virtual world. It uses a computer to generate a simulation environment and immerse users in the environment. Today, virtual reality technology has entered education, entertainment, military, medical, and other fields closely related to people's production and life. Compared with traditional video, VR video has the advantages of multiple viewing angles and strong interactivity, providing users with a brand-new visual experience, which has great application value and commercial potential. With the continuous updating of VR equipment, the problem of picture clarity that people have criticized before has also been solved. This article will start with the analysis of the types of VR videos at this stage, what are the conditions that affect the clarity of VR videos, and where they can be improved.

## 2. Research on Virtual Reality Video

VR video refers to panoramic video, such as horizontal 360°×vertical 360° panoramic video, horizontal 180°×vertical 180° panoramic video, etc. Users can use VR glasses and other virtual reality devices to watch panoramic videos and get an immersive visual experience. VR video provides a visual experience of the first person perspective. The user fixes the viewing position, supports head rotation, and rotates the head as the center to select the direction of the viewing angle and watch the picture in the corresponding direction. To watch VR videos, you need a virtual reality headset, that is HMD. HMD is a kind of use of head-mounted display to close people's vision and hearing from the outside world, and guide users to have a feeling of being in a virtual environment. In 2018, HTC, Oculus, and other companies have successively launched standalone VR headsets, which directly changed the pattern of the VR market. The standalone VR headsets quickly occupied the market by virtue of its advantages of no locator, no cables, and relatively low price. The emergence of standalone VR headsets makes it more convenient to watch vr videos, no cumbersome cables are needed, and you can watch them anytime, anywhere.

### 2.1 3DoF VR Video

3DoF (DoF : degree of freedom) video, that panoramic video, This is to provide users with a full-angle visual experience in three rotating dimensions. Means that the user can freely watch the program material in any direction (yaw, pitch and roll). A typical application scenario is a user sitting in a chair watching VR video content through HMD. As shown in Fig. 1

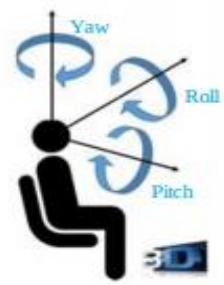


Fig. 1. Schematic diagram of 3dof VR video

### 2.2 3DoF+ VR Video

3DoF+ means that the user can freely watch the program material in any direction (yaw, pitch, and roll), while the user's head can perform a certain translational movement. A typical example is sitting on a chair to watch the scene, allowing the head to move up and down,

left and right, and back and forth in a small range within a certain range. As shown in Fig. 2.

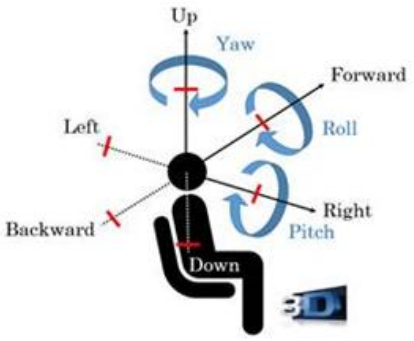


Fig. 2. Schematic diagram of 3DoF+ VR video

## 2.3 6DoF VR Video

6DoF means that users can freely watch program materials at any position and in any direction in the physical space. User movement can be captured by sensors or input controllers, while supporting user spatial displacement and head posture changes. A typical application scenario is that users move around freely and watch VR video content through HMD at the same time. If the six degrees of freedom are recorded with a light field camera (matrix composed of multiple cameras), then the traffic has skyrocketed (it is also a huge challenge for multi-angle video compression), and the range of movement for free viewing is limited. As shown in Fig. 3

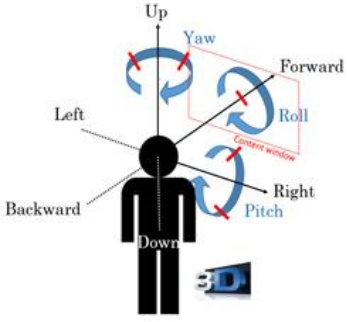


Fig. 3. Schematic diagram of 6DoF VR video

## 2.4 Typical process of watching VR videos

When watching a VR video, the user first wear VR glasses or HMD. Run the VR video application on the VR device and initialize the Sensor devices such as gyroscopes in VR glasses or HMD. The user interacts with the VR video application in real time through input devices such as the VR handle controller. When the user's VR glasses or HMD position moves, Among them, sensor devices such as gyroscopes detect the movement state of the head in real time, and transfer its parameters to the processing module of the VR video application software. After the processing module obtains the parameters of the user's head motion state, the VR video application software immediately calculates the user's viewing angle and re-renders a new frame of image to pass to the VR glasses or HMD, and the user can watch in real time.

# 3. VR Video Resolution

In a general way, we think that the higher the resolution of the video, the clearer the video will look, which is what we usually call 1080p, 4k, 8k and other concepts. But the 4K of VR panoramic video is different from ordinary 4K. 4K means that the resolution of the video image is 3840×2160. When 4K TV is playing 4K video, 3840×2160 pixels are displayed on the screen. When the VR device is playing 4K panoramic video, it only displays the part of the field of view on the screen. It will cause us to see not all the displayed resolutions. It is precisely because of this that the video production team clearly provides 4K ultra-high-definition video, but it still doesn't seem to be clear enough.

## 3.1 PPD(The gold standard of definition)

Everyone knows that the higher the resolution of an image, the more pixels it contains, the

clearer the image will look. The main units describing resolution are: DPI (dots per inch), LPI (line per inch), PPI (pixels per inch) and PPD (pixels per degree). PPI (pixel per inch) means the number of pixels per inch. Generally speaking, when the ppi value is 300, the effect of the retina screen can be achieved at the normal observation distance of the human eye (about 30 cm). But in the VR field, the unit of ppi is no longer suitable, so PPD (pixel per degree) pixels per degree are introduced, that is, how many pixels there are in each radian. Through calculation, we can convert the previous 300PPI to PPD—at a viewing distance of 30cm, the horizontal degree occupied by the mobile phone screen in the user's field of view is about 10 degrees 300PPI = 60PPD. What everyone agrees for a long time is that an image that reaches 60 PPD can be regarded as a retinal resolution. But this condition is very harsh. In fact, when watching a dynamic video, as long as it reaches about 30PPD, the human eye will not notice the pixel particles.

### 3.1.1 PPD of VR device

For VR devices, we generally directly say that the screen is a few K screens. But it should be noted that this represents the resolution seen by both eyes. For example, a 4k VR screen is 4k for both eyes, and if one eye is divided by 2, it is 2k. The following is a brief list of the monocular screen sizes and true ratios of some mainstream VR devices currently on the market. As shown in Table 1.

Table 1. Mainstream VR device information

| | Resolution Per Eye | Hz | Field of View |
|---|---|---|---|
| PS VR | 960*1080 | 120 | 100 |
| HTC VIVE | 1080*1200 | 90 | 110 |
| Oculus Rift | 1080*1200 | 90 | 110 |
| Valve Index | 1440*1660 | 144 | 130 |
| Oculus Quest2 | 1832*1920 | 90 | 110 |
| Oculus Rift S | 1280*1440 | 80 | 110 |
| PIMAX 8K | 3840*2160 | 120 | 200 |
| HP Reverb G2 | 2160*2160 | 90 | 114 |

In the earliest stage, the three major VR glasses (PSVR, Rift, Vive) generally used a resolution of 2k. At this resolution, there will be a more obvious screen door effect. Many users' experience of "screen door effect" of VR glasses has actually stayed in this period, but today, with the blessing of 4K screens, the screen door effect no longer exists. After knowing the resolution of the glasses, we also need to understand another value: FOV (Field of view). For example, a certain VR device has a 100-degree FOV, that is to say, the user can see a 100-degree angle of view at the same time when using it. Combining the two, it is not difficult to get a sharpness index PPD for VR glasses. For a VR glasses with 4K 100 degree FOV for both eyes, its PPD = 2K/100 = 20. This 20PPD is actually smaller than the 30PPD we mentioned above, which is not noticeable when watching the video.

### 3.1.2 PPD of VR Video

When we watch a VR video, the clarity partly has something to do with the hardware conditions of the VR device. The other part is related to the content of the VR video itself. To calculate the PPD of the video content, we need to know how the VR video is played. Let's take one of the most common 2D 360-degree 4K VR videos as an example. In the official play, this picture will be stretched and tiled onto a sphere. We can see that the 4k pixel long side of the source video is completely drawn to 360 degrees. As shown in Fig. 4.

Fig. 4. Schematic diagram of VR video playback

Then in this case, the horizontal PPD of this video is equal to 4K/360 = 11 PPD. It can be seen that for a 4k 360−degree video, its equivalent PPD is only 11. That is, each field of view has only 11 pixels, which is far lower than the 30PPD standard, and even lower than the 20PPD screen resolution accuracy of a 4K screen. So, when we watch a 4K resolution VR video on a 4KVR glasses, the video resolution is lower than the resolution accuracy of the screen. So, what size video should be put on a 4K screen in order to make full use of the screen resolution. In fact, using the concept of PPD, it can be easily reversed. The 4K screen is 20PPD, so only by putting 20PPD video on it can the screen resolution be fully utilized. A 20PPD 360−degree video requires 20x360=7200 horizontal pixels. So about 8K video is needed to make full use of the resolution of the 4K screen. Of course, the above is for 360−degree VR videos. For a 180−degree VR video, the 4K resolution has reached the level of 22PPD (4K/180), so it has been able to make full use of the resolution of the 4K screen VR glasses.

## 4. Development trend

In the past two years, with the launch of the current standalone VR headsets, the development of the VR market has been promoted. Compared to previous VR devices, the appearance of the integrated machine, saving the cumbersome connection, every time you play, you have to install the space positioning system, the most important thing, no longer need a high−performance computer, save a lot Inconvenience, people have enthusiasm to invest. And it is convenient to carry, and you can open the game anytime, anywhere. It is because of this, let VR add new confidence in the future development.

### 4.1 VR short video

In recent years, the rise of short video headed by TikTok , Kwai, etc has become the most popular video software today. To stand out from the many creators, you are very popular, VR video is a good choice. Even now, many short video platforms can not really realize stereo VR effects, but the unique effect of VR video will be impressed. Through creative shooting techniques, the scenery, characters and plots can be displayed through VR video, and become a wonderful artwork. It is undeniable that VR short video potential propagation power can get more recognition in the future.

### 4.2 VR live broadcast

As the 5G era, 4K / 8K VR live broadcast, such as the immersion viewing of the scene, real−time transmission, HD presentation. It can be said that VR live is the best partner to experience 5G technology, and it is also the quality option of brand promotion. Under the current market environment, the live broadcast industry is prevailed, and VR live broadcast can also become a big breakthrough in live broadcast, which can adapt, exhibition, competition, and real show and other core needs. Especially in the sports events, you can make the audience to experience the feeling of the stadium, such as the normal people who are not exposed to the F1 racing, alpine skiing and other stimulating sports. VR live broadcast is already the next foreseeable Blue Sea market, grasp the trolement of the times, is the best time to carry out VR live broadcasts and enter the best time in this field.

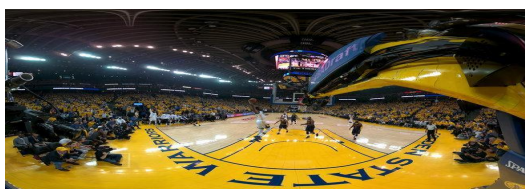

Fig. 5. VR live broadcast of basketball games

## 5. Conclusion

Through the research and discovery of this article, it is difficult to achieve a perfect immersive feeling due to the limitation of the device at this stage. But with the continuous innovation and continuous development of various technologies, VR video will also continue to change, with higher resolution, wider field of view, and more efficient encoding rate. The continuous advancement of network bandwidth will also have further development in real-time transmission, providing more feasibility for VR video. I hope that in the future VR market, VR video technology can be applied to more fields, enriching the business and applications of VR video technology, and providing people with more convenience in life. For example, in education, VR video technology can be introduced, so that students can experience the feeling of classroom at home. In the next research, I would like to study the aspect of VR video interaction, which can further improve the application of VR video.

## REFERENCES

[1] Z. J. Dong & D. Z. Zhang & C. Huang & H. J Liu(2017). Technology of virtual reality videoprocessing and streaming. *Telecommunications Science, 2017, 33(8),* 45-52.
DOI : 10.11959/J.ISSN.1000-0801.2017244

[2] X. Q. Guo. et al.' (2020). 5G High-tech Video—VR Video Technology White Paper. Beijing

[3] S. Yoganathana & D. A. Finch & E. Parkin & J. Pollard (2018). 360° virtual reality video for the acquisition of knot tying skills: A randomised controlled trial. International Journal of Surgery, *2018, Volume 54, Part A,* 24-27.
DOI : 10.1016/j.ijsu.2018.04.002

[4] Y. M. Zhou & L. Tian & C. Zhu & X. Jin & Y. Sun (2020). Video Coding Optimization for Virtual Reality 360-Degree Source. *IEEE Journal of Selected Topics in Signal Processing, Volume: 14, Issue: 1, Jan. 2020,* 118 - 129
DOI : 10.1109/JSTSP.2019.2957952

[5] B. G. Kang & S. H. Ryu & W. B. Lee. (2017). Development of an Interactive Virtual Reality Service based on 360 degree VR Image. *Journal of Digital Convergence. 15(11).* 463-470.

[6] K. S. Han (2019). The Effect of Presence and Interactivity of Digital Signage Using 3D Virtual Reality on Brand Experience and Attitude *Journal of Digital Convergence. 17(4).* 299-307

[7] B. Zhang & J. Z. Zhao & S. Yang & Y. Zhang & J. Wang & Z. S. Fei (2017). Subjective and objective quality assessment of panoramic videos in virtual reality environments. *2017 IEEE International Conference on Multimedia & Expo Workshops (ICMEW), July 2017,* 10-14
DOI : 10.1109/ICMEW.2017.8026226

[8] Z. M. Guo & Y. X. Ban & X. Lan. (2017). Architecture and Key Technologies of Virtual Reality Video Transmission and Streaming. *ZTE TECHNOLOGY JOURNAL 2017, 23(6),* 19-23.
DOI : 10.3969/j.issn.1009-6868.2017.06.005

[9] Tencent Research Institute (2020). Tencent Research Institute Industry Observation: What about short videos in the future? Tencent.
https://www.tisi.org/13504

[10] China Academy of Information and Communications Technology & Huawei Technologies Co. Ltd & BOE Technology Group Co., Ltd. (2021). Virtual (augmented) reality white paper. Beijing

[11] S. J. Han & S. U. Kim & K. C. Koo & K. J. Lee & M. S. Cho (2017). Effects of Virtual Reality Images on Body Stability : Focused on Hand Stability. *Journal of Digital Convergence.15(8).* 391-400

[12] G. M. Yu (2020). The video industry in the 5G era: development trends and overall impact. *China Academic Journal Electronic Publishing House. Aug 2020,* 39-41
DOI : 10.15997/j.cnki.qnjz.2020.22.012

[13] I. H. Cho & Y. K. Yoon & M. S. Jung (2018). A Study on Entertainment Video Game Content Industry using Virtual Reality Technology. *Korea Entertainment Industry Association 12(2).* 1-13

[14] Armir Bujari & Claudio E. Palazzi & Dilan Perale (2019).Addressing bandwidth demand in full-immersive virtual reality. *Proceedings of the 5th EAI International Conference on Smart Objects and Technologies for Social. September 2019,* 13-18
DOI : 10.1145/3342428.3342670

[15] Diana Andone & Mark Frydenberg(2019). Creating Virtual Reality in a Business and Technology Educational Context. *Augmented Reality and Virtual Reality* 147-159.
DOI : 10.1007/978-3-030-06246-0_11

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