



New Technologies and Experience Report of the All Online VR Era



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iLab

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According to *Who Will Lead VR Industry into the Online Era* released by Huawei iLab, VR 360° panoramic video has been available for mature

commercial use. Are there any other VR technologies? How will they affect the VR industry development?



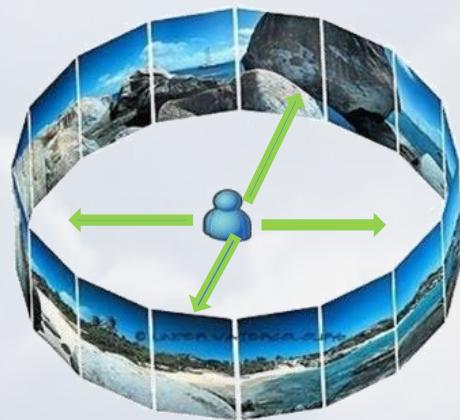
1. Key Technologies of VR

Things develop gradually in a long process. There is no exception to VR. With the industry development, various technologies are applied in various periods and scenarios to achieve different effects.

(1) 360° panoramic video: the first booming online VR technology

For details about the technology, see *Who Will Lead VR Industry into the Online Era* released by Huawei iLab.

- **Technology introduction:** A camera is set at the center for 360° shooting and the panoramic images from each direction are stitched together. Users can have a fixed observation location and select a view angle with head as the center to change corresponding images.
- **Application cases:** entertainment videos & live events

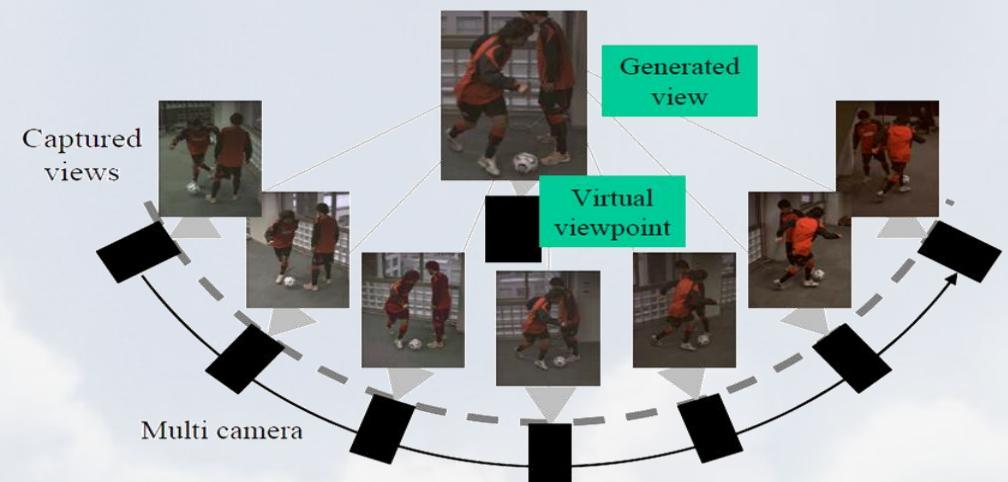
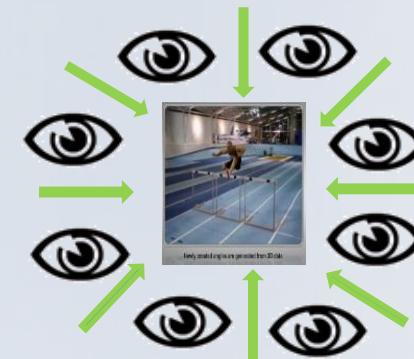


- **Commercial maturity:** The terminal hardware is already available and can be supported by some high-end mobile terminals. The technology is compatible with current technologies and can use existing coding and transmission technologies. In addition, flexible interaction modes guarantee corresponding modes of HMD and traditional terminals. At the early stage of VR development, networks required by traditional common 4K videos can meet the requirement of 360° videos. Of course, the increasingly high requirement for VR experience imposes even higher bandwidth requirements.
- **Commercialization date:** Online commercial contents exist already

(2) Free viewpoint video technology: Weak interactive VR technology is unavailable for commercial use yet.

- **Technology introduction:** free-dimensional shooting+modeling computation with multiple cameras arranged at a certain angle. Obtain a "virtual angle" from angles between cameras through modeling computation of the shooting, and get a better view effect through the free change of observation points at different locations.
- **Application cases:** live events
- **Commercial maturity:** Smooth angle switching requires extremely high computing performance and large data amount, as well as a fast modeling computation among over 100 pieces of viewpoint information. There is no standard and mature commercial system. MPEG is still discussing the requirements and specifications. Currently, only replay technologies have conducted shooting experiments on NBA games. Online VR has not yet been put into commercial uses.
- **Commercialization date:** at least 5 years later

Free-dimensional TV for shooting



(3) Computer graphics simulation technology: single-user interactive VR technology

- **Technology introduction:** A virtual entity is rendered through real-time computation of computer graphics.
- **Commercial maturity:** Large computation workload poses high requirements on the CPU and GPU performance. The technology is locally applied up till now. Oculus and HTC demand high-performance hosts and use professional graphics card such as GTX970/1070. The technology cannot be supported by mobile terminals (phones/pads). The cloud rendering technology that

promotes the online process of computer graphics is immature for commercial use and the performance cannot fully meet requirements. Nvidia's commercial cloud rendering technology optimizes the latency of cloud games to be less than 80 ms but there is still a long way to reach the 20 ms latency required by E2E VR.

- **Application cases:** games, simulation, remote medical care, and remote education
- **Commercialization date:** 4-5 years later



(4) Light field technology: light field rendering, the future VR technology

- **Technology introduction:** It is the ultimate technology that solves the conflicts of traditional flat screen vergence adjustment. It records 4-dimensional light field information and projects the information onto retina, recording the optical strength and angle of light from each point. The information volume is much greater than traditional 2D videos. It can be too real to be distinguished: Through the light field, views of objects are so real that people can hardly find

any difference between the real and the virtual, thereby fundamentally solving the vergence adjustment conflicts.

- **Application cases:** entertainment videos, live events, games, simulation, remote medical care, remote education, and apartment viewing
- **Commercial maturity:** Currently, the technology is still in the stage of academic pre-research and experiment. MPEG has no date for standard discussion yet.
- **Commercialization date:** at least 10 years later

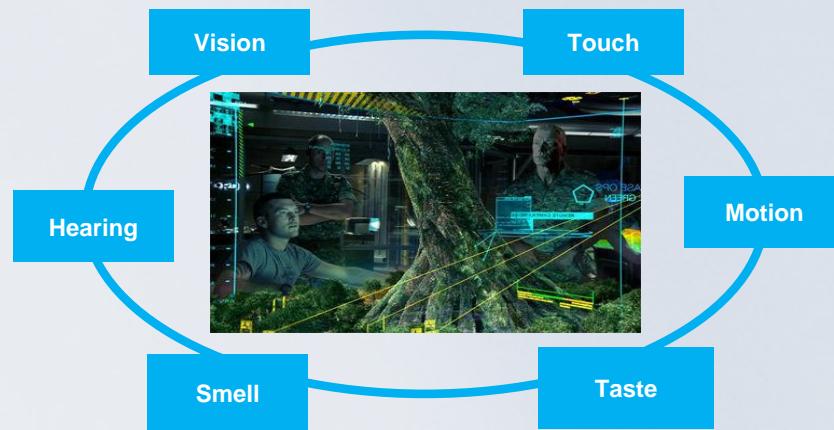




2. VR Experiencing Issues, Impact on Networks, and Improvement Measures

VR application brings technology transformation and brand-new experience. MPEG regards VR as a new media type that is different from traditional audio/video media and that has multi-senses. Apart from

common vision and hearing senses, there are many other senses, such as touch, motion, taste, and smell that bring immersive experience to users and enable users to interact with the virtual world.



Standard organizations such as MPEG think that VR experience quality is vital to the success of VR industry. In May 2016, in the conference of major standard organizations of digital multimedia industry, all experts agreed that the top priority of VR development was to improve the quality of VR experience and that the establishment of evaluation standards would be the key point of success.

MPEG will focus on VR technology in the next few years. It has set up a specialized workgroup to comprehensively discuss the application needs, related single-point technologies (audio and video processing and compression), and system solutions (data and file format, interaction information processing and protocol, transmission system and protocol).

However, current VR experience is not so satisfying mainly because the image quality is poor and will cause eye fatigue and dizziness. It is different from traditional video experience from the following aspects:

- Full-view experience of VR imposes higher requirements on images than traditional videos and common screens.
- VR experience needs external tools, such as a helmet. Watching video with a helmet makes viewers feel closer to the objects on the screen. If the video quality is neither particularly good nor extremely poor, viewers will subconsciously make efforts to watch the video, consequently affecting user experience.

Huawei iLab has made in-depth analysis on the issues that affect the VR video experience. The following lists four main issues and corresponding measures:

1) Quality issue of visual information

- **Issue description:** Low image quality causes visual fatigue and discomfort.
- **Industry's approaches:** content optimization of 360° videos. In recent years, the focus is to improve the field of view (FOV) resolution and image quality.
- **Impact on networks:** Requirement on image quality leads to increasing demands for bandwidth (> 100 Mbit/s).

(2) Motion-to-photons latency issue

- **Issue description:** The mainstream viewpoint is that the latency cannot exceed 20 ms. Otherwise, a sense of dizziness will be caused.
- **Industry's approaches:** The terminal hardware issue is resolved to improve the local E2E software and hardware performance. Currently leading VR terminal vendors, such as Oculus and HTC Vive, have started from the sensor tracing element, display technology, and GPU to decrease the local motion-to-photons latency to 20 ms.

• Impact on networks:

- Visual and motion packets are synchronized on local terminals (weak interactive VR). There is no requirement on network latency but massive bandwidth demands may arouse (5 Gbit/s).
- Vision and motion packets are synchronized after being transmitted through the network (strong interaction VR): latency < 8 ms.

(3) Motion-sensing conflict

- **Issue description:** If any motion feedback output is missing, the mismatch between physical motions and eye views of virtual information will result in dizziness.
- **Industry's approaches:** Increase the multi-sensing output of terminals and provide the convergence capability of feedback from vision, hearing, feeling and physical movements, thereby promoting the evolution towards interaction-VR of CG.

- **Impact on networks:** Vision and motion packets are synchronized after being transmitted through the network (strong interaction VR): latency < 8 ms.

(4) Visual vergence-accommodation conflict

- **Issue description:** The issue is also known as focusing conflict and is presented on display terminals that utilize binocular parallax. The focus of eyes stays on the screen because there is no in-depth information from the screen light. Dizziness is caused because the eye focus does not match the visual depth of the view field.

- **Industry's approaches:** future new technologies. Light field recording and projecting technologies can record and restore the strength and angle of the light transmitted from three-dimensional space, thereby matching the human visual vergence with eye focus.

- **Impact on networks:** Four-dimensional light field information brings explosive growth of requirements on bandwidth.

According to *Who Will Lead VR Industry into the Online Era* released by Huawei iLab, VR 360° panoramic video technology has been available online for

commercial use. However, it may take long for VR games and other applications to evolve from local to online.



- From Goldman Sachs's VR reports, VR game will firstly get popular as a local game application among PC game users.
- VR game imposes high requirements on terminal performance, thereby its popularization will not be as fast as that of 360° videos.
- The cloud rendering technology that promotes the online process of VR games is not mature for commercial use since its performance cannot fully meet the requirements.
- Nvidia's commercial cloud rendering technology enables a latency of less than 80 ms for cloud games. However, there is a long way to go for a 20 ms latency required by E2E VR.

Huawei iLab is keeping track of and analyzing VR technologies, such as CG cloud rendering. Huawei iLab is also doing research into VR experience evaluation standard to accelerate VR industry's online process. At present, iLab has concluded the framework design of the industry's first VR evaluation system, covering various VR technologies, weak and strong interaction VR applications, and highlighting the features of VR technology applied in new media. The modeling of the technology is from the following perspectives:

- Media rendering quality: information quality in a virtual environment, involving image quality, resolution and frame rate.

- Immersion: the degree of users' surrounding by information in a virtual environment.
- Freedom level: How free are the users when they are interacting with each other in a virtual environment?
- Sense of involvement: the concentration that users keep on the virtual environment.

- Interaction: How natural is the interaction among users in a virtual environment?
- Physiological comfortableness: Virtual environment generates a sense of dizziness and fatigue, thereby affecting users' physiological comfortableness.

