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Brief Introduction to VR Session 2: Good VR Experience Elements



iLab

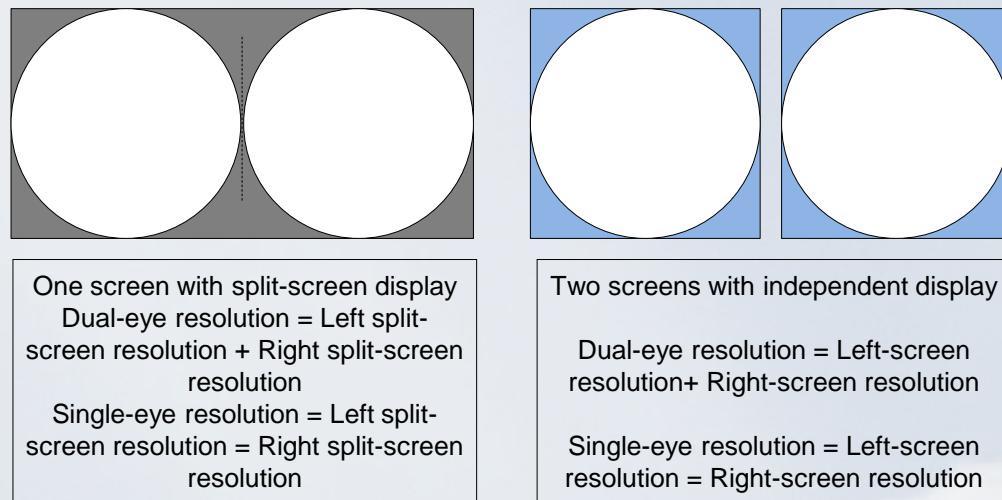
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Why cannot we get clear pictures after inserting a 2K mobile phone in to a VR HMD? Why cannot we clearly see a face in 4K live VR broadcasting? Maybe you can find the answers in this report. This report describes the factors affecting VR experience from the perspective of five senses of people.

1. 4K HMD and 8K 360° Video Provide Good Visual Experience

1.1 Why does a 2K HMD offer a poorer viewing experience than a 2K mobile phone?

Generally, the resolution of a VR HMD indicates the dual-eye resolution. For example, the dual-eye resolution of a 2K VR HMD is 2K, that is, the resolution sum of the left and right screens. However, some VR HMDs use two independent screens to respectively project images to both eyes. So the single-eye resolution is often used as the parameter of VR HMD to highlight the difference of the screen structure.



Currently, 2K VR HMD is the mainstream. A mobile VR HMD needs to have a 2K phone inserted, so the single-eye resolution is only 1K. Provided that the distance between the screen and human pupils is about 5 to 10 cm, after optical magnification of lens, the imaging will appear in front of human eyes at 25 to 50 cm. When viewing a 2K video within a half meter, you may see pixels, not to mention 1K video!

The pixels detected by human eyes in one degree (pixel per degree, PPD) decide the viewing definition. The greater PPD brings the clearer image, but the threshold of human-distinguishable pixels is around 60 PPD. Another hardware parameter field of view (FoV) of VR HMD indicates the angle of view in VR. Generally, the FoV in the horizontal direction of HMD is provided in product parameters, which should exceed 90 degrees.

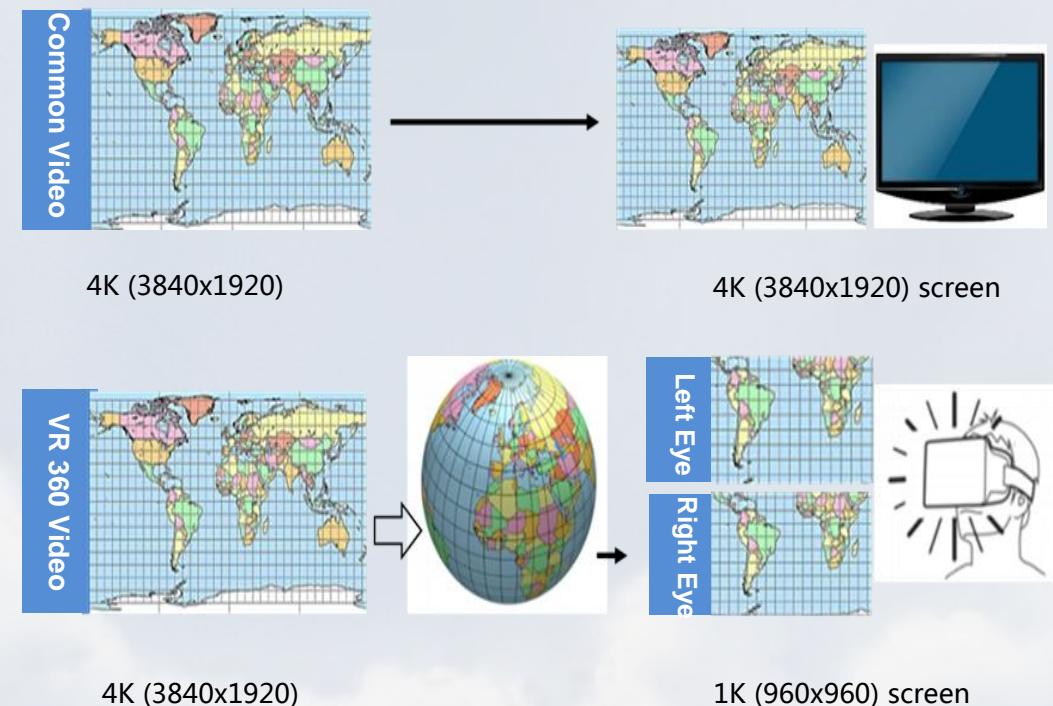
Taking a Samsung Gear VR equipped with a Samsung S7 2K (2560x1440) phone as an example, its FoV parameter is about 100 degrees and single-eye resolution is 1K (1280x1440), so its PPD = $1280/100 = 12.8$, which is much lower than 60. This is another reason why the images are clear on a 2K phone but not on a 2K VR HMD.

The resolution of VR HMD or phone screen must reach 4K to provide good VR experience.

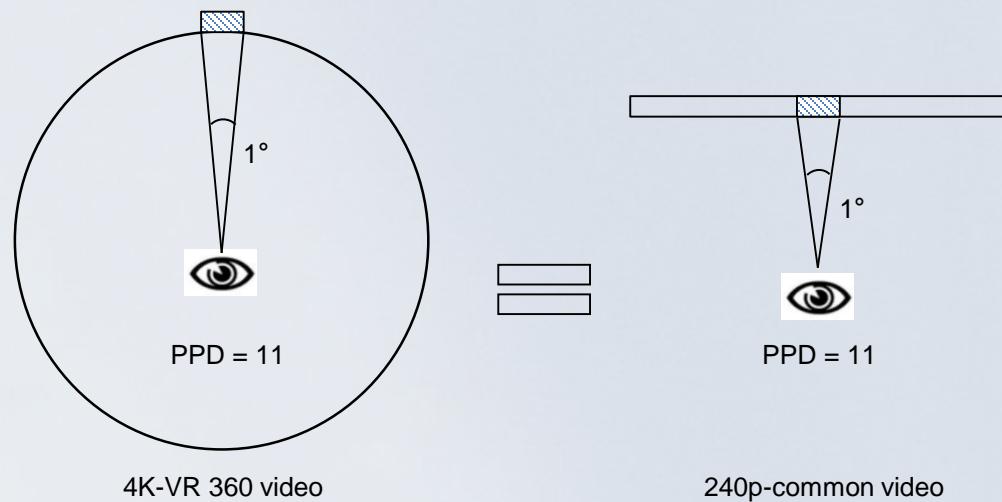
VR HMD Resolution (Dual-eye/ Phone Resolution)	Single-eye Resolution	Experience Effect (Definition)	Current Situation
2K	1K	Poor	Mainstream
4K	2K	Fair	Few products
8K	4K	Good	Few products

1.2 Why does the 4K VR 360 video offer a poor experience?

The playing principles are as follows: 4K (3840x1920) VR 360 video projects the image to the sphere area, which is equivalent to looking outside from the sphere center. The user can only see a part of sphere within his FOV scope. Actually, the resolution projected to each eye is about 960x960. Therefore, the viewing experience of 4K VR 360 video is poorer than that of common 4K video.



From the perspective of PPD, the horizontal direction of its PPD is about 11 ($3840/360 = 10.67$), while the PPD of common 240p video is about 11. In other words, the resolution of 4K VR 360 video only equals to common 240p video.



According to *Whitepaper on the VR-Oriented Bearer Network Requirement* released by Huawei iLab, 4K VR 360 video is at the preparing stage, and 8K VR 360 video is at the beginning stage, which can provide viewing effect equivalent to 480p common television.

1.3 Relationship between VR 360 video and VR HMD

Do we need an 8K (7680x3840) VR HMD to view an 8K VR 360 video? The answer is no.

The horizontal PPD of an 8K VR 360 video is $7680/360 = 21.33$. Based on the requirement of 90-degree FoV, the horizontal pixels of single eye are $21.33 \times 90 = 1920$, and the single-eye resolution of the screen needs to be 1920x1920. Therefore, a 4K VR HMD is suitable for viewing an 8K VR 360 video. (For a mobile VR HMD, a 4K mobile phone is required.)

VR 360 Video	Equivalent Viewing Experience to Common Television	Single-eye Resolution	VR HMD Resolution (dual-eye/Phone Resolution)
4K VR	240p	1K (960x960)	2K (1920x960)
8K VR	SD 480p	2K (1920x1920)	4K (3840x1920)
12K VR	HD 2K	4K (3840x3840)	8K (7680x3840)
24K VR	Ultra HD 4K	8K (7680x7680)	16K (15360x7680)

* Equivalent viewing experience of common televisions is estimated based on PPD.

In addition to the VR HMD hardware and video content, the video coding and compression modes also affect viewing experience of VR 360 video.

2. Other Elements Affecting VR Experience

2.1 Spatial audio effect enables vivid audio experience

Sound in the VR should reflect the direction and distance to generate spatial audio effect. Especially in narrative VR videos, whose images are not that important, the sound is the essential tool to attract audience's attention.

By combining with movie content, Dolby Atmos (ATMOS) solution can accurately control multiple speakers to present various dynamic audio effects from near to far and from top to bottom. However, ATMOS can only restore voice direction but not distance.

Google provides a spatial audio effect solution to this problem. It uses multiple virtual speakers to enclose the user, then calculates the output of each speaker according to spatial gesture of the user's head, and finally synthesizes into 2 channels of audio signals, which can be received by a headset. Google makes the spatial audio effect solution open-source and provides Unity and Unreal engines with the plug-in of the solution.



Dolby Atmos



Google VR spatial audio effect

2.2 Smell, touch and taste feedback

Smell, touch and taste also affect immersive experience of VR. Touch sense includes human skin's perception of heat, force, vibration, slide and surface textures. Common devices include force feedback gloves. Smell and taste feedback is under continuous research. It is likely to bring a video with real smell in the future.

With the promotion of VR standard by industry organizations, each VR experience element would be refined and quantified to evaluate VR experience quality and improve user experience. In addition, the network also affects VR experience. What kind of network is required to support good VR experience? Pay attention to the next session.