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SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Multimedia Quality of Service and performance – Generic
and user-related aspects

Influencing factors on quality of experience for virtual reality services

Recommendation ITU-T G.1035

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Recommendation ITU-T G.1035

Influencing factors on quality of experience for virtual reality services

Summary

Recommendation ITU-T G.1035 classifies virtual reality (VR) services and identifies the key quality of experience (QoE) factors of VR.

History

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Influencing factors on quality of experience for virtual reality services

1 Scope

This Recommendation categorizes and summarizes the factors affecting the user-perceived experience of a virtual reality (VR) service, with the intention of helping to identify the methodologies for assessing VR quality. VR quality of experience (QoE) assessment methodologies are left for further study. Since VR technologies are still evolving, this Recommendation mainly addresses omnidirectional video services, while leaving others, e.g., point-cloud or volumetric video types, for further study.

VR is a new type of media which is different from traditional video and audio. It generates realistic images, sounds and other sensations that replicate a real environment and simulate a user's physical presence in this environment by enabling the user to interact with this space and any objects depicted therein using specialized display screens or projectors and other devices. These multisensory experiences, which can include sight, hearing and, less commonly, touch and smell, are well coordinated and synchronized through the user's interaction and feedback. A person using VR equipment is typically able to "look around" the artificial world, move about within it and interact with features or items that are depicted on a screen or in goggles as in the real world.

In order to understand whether QoE or user-perceived performance of the VR service is good enough or not, benchmarking is critical. Benchmarking aims to measure user-perceived performance or QoE in the VR environment. Compared with traditional video and audio, the multisensory experience in VR imposes a new set of requirements for QoE assessment. The challenge is to characterize VR's real-life immersive video, spatial audio and interactivity. Prior to being able to benchmark the QoE, it is important to address the requirements and basic factors that are relevant for assessing the VR quality for different VR services.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 frame rate [b-ITU-T H.262]: The rate at which frames are output from the decoding process.

3.1.2 quality of experience (QoE) [b-ITU-T P.10]: The degree of delight or annoyance of the user of an application or service.

3.1.3 QoE influencing factors [b-ITU-T P.10]: Include the type and characteristics of the application or service, context of use, the user's expectations with respect to the application or service

and their fulfilment, the user's cultural background, socio-economic issues, psychological profiles, emotional state of the user, and other factors whose number will likely expand with further research.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 cybersickness or simulator sickness: A physiological condition arising when exposed to a virtual reality environment.

NOTE – Definition based on combined information in [b-Kennedy] and [b-Stanney].

3.2.2 degree of freedom (DoF): Represents the ways an object can move within a space, which is a key element in helping create an immersive environment for a user.

3.2.3 immersion: A psychological state characterized by perceiving oneself to be enveloped by, included in and interacting with an environment that provides a continuous stream of stimuli and experiences.

NOTE – Definition based on [b-Witmer].

3.2.4 motion-to-photon latency: The time it takes between the user moving their head and this motion being reflected on the screen of the head-mounted display (HMD).

NOTE – Definition based on [b-Brandenburg].

3.2.5 presence: The subjective experience of being in one place or environment, when one is physically situated in another place or environment.

NOTE – Definition based on [b-Witmer].

3.2.6 refresh rate: The frequency at which a display updates its image, expressed in hertz.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2D	Two Dimensional
3D	Three Dimensional
AR	Augmented Reality
DoF	Degree of Freedom
FoV	Field of View
GPU	Graphic Processing Unit
HD	High Definition
HMD	Head-Mounted Display
HRTF	Head-Related Transfer Function
MPEG	Moving Picture Experts Group
MR	Mixed Reality
PPD	Pixel Per Degree
PPI	Pixel Per Inch
SSQ	Simulator Sickness Questionnaire
UHD	Ultra High Definition
VR	Virtual Reality

VoD Video on Demand
VVC Versatile Video Coding

5 Conventions

Within the scope of this Recommendation, a person interacting with a VR head-mounted display (HMD) is referred to as a user, viewer or player, all with equivalent inference.

6 Virtual reality overview

Virtual reality (VR) is a technology that uses game engines (e.g., Unity) to create artificial environments that enable people to interact in six degrees of freedom (DoF). VR generates realistic images, sounds and other sensations that emulate a real environment or create a synthetic one. VR services aim to provide users with high levels of immersion and presence wherein users may feel detached from their physical, real-world surroundings. This is different from augmented reality (AR) or mixed reality (MR), which enhance user experiences by adding virtual components such as digital images, graphics or sensations as a new layer of interaction with the real world.

6.1 Devices

A VR display device is usually a typical head-mounted display (HMD) with two goggle-size miniature screens – one per eye. These displays focus and reshape the picture for each eye and can create a stereoscopic three-dimensional (3D) image by angling the two dimensional (2D) images to mimic how human eyes see the world.

To achieve an immersive experience, head tracking or eye tracking are used in HMDs to create the correct camera angle and perspective so as to attain a natural viewing experience. In addition, tracking may include capturing of the movements of any other body parts.

Depending on the VR service and DoF permitted for the users, audio hardware needs to take into account headphone or loudspeaker audio reproduction. The headphones may be standalone or integrated into the HMD, both of which allow open and closed acoustic design. When using standalone headphones, additional hardware such as a soundcard or wireless technology may also be involved.

6.2 Content

There are two types of content to consider when constructing a virtual environment for the VR experience.

The first consideration is synthetic, which is completely invented from geometric primitives and simulated physics. This is common in VR games and VR social services. Synthetic representations of individuals, called avatars, enable users to interact and can provide a level of anonymity in some contexts.

The second consideration is captured using 360° cameras. For example, 360°/omnidirectional images and videos are captured to allow users to explore the scene in $360^\circ \times 180^\circ$ from a given viewpoint in a VR system, which could be seen as an extension of traditional video streaming applications.

6.3 Platform

When using online VR applications, VR contents are stored in servers, streamed by requests and rendered locally in user's devices. Local rendering requires high-performance terminal devices to provide an acceptable user experience.

Cloud VR [b-GSMA AR/VR] is a new cloud computing technology, where VR content is stored and rendered in the server. Therefore, video and audio outputs are coded, compressed and transmitted to