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Computer graphics, image processing and environmental data representation — Augmented and virtual reality safety — Guidance on safe immersion, set up and usage

PROOF/ÉPREUVE

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 24, *Computer graphics, image processing and environmental data representation*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Market research assessed the requirement for standards and guidelines to help shape best practice in the application and use of augmented reality (AR) and virtual reality (VR). AR/VR technologies are continuing to evolve, this document recognizes this by addressing relevant concepts that may be applied to future and emerging technologies, and this document supplies specific examples to illustrate various categories of concern that should be considered for safe use. Although platform and other AR/VR guidelines exist, this research pointed to a need to establish formalized industry standards for best practice guidelines for the safe usage of AR/VR across a broad range of domains. Following this market research, BSI consulted with many key stakeholders in the sector and ran workshops to discuss specific AR/VR standards ideas and to assess key priorities for standards development in this area. AR/VR health and safety (H&S) was unanimously a major area of concern for stakeholders, and one they felt could hold back the growth of the sector if not addressed.

H&S is a concern for all industry sectors, but in certain areas such as the built environment, military simulation, first responder training and manufacturing and utilities, adoption of AR/VR is being hindered because H&S is not being appropriately considered. This document will provide surety to AR/VR stakeholders that the technology can be used safely across sectors and by consumers.

Safe immersion is a key area of H&S concern for stakeholders. VR, in particular, can lead to users experiencing motion sickness and disorientation, and disconnects users from their immediate surroundings, these and other effects could cause serious safety concerns in many environments. There are various factors that contribute to this, including the design and development of content, the device set-up (e.g. device not correctly positioned on the users' head), the space in which the device is used, time spent immersed, and more. What may be considered as safe is also affected by the situation (e.g. home use vs industrial use) and the sector of activity (e.g. training in a call centre vs at height on a building site). This document will take the full gamut of VR/AR use into account to provide holistic guidance for the market.

For this document, sound and haptics are less significant than visual modes and are thus considered out of scope. Despite this, it is acknowledged that, particularly in industrial settings, accurate audio fidelity may be an important training consideration.

Our understanding of AR/VR safety is still developing so this document will initially provide guidelines for organizations and consumers to consider when using the technology, and in the development of content. This document will achieve this by describing risks and considerations of AR/VR use, provide guidance to mitigate these potential issues, and finally provide AR/VR specific templates and tools for risk assessment and reporting. Noting the rapid development of AR/VR technologies, this document will be updated at appropriate moments to reflect new technological developments if and when they introduce risks not previously considered. The annex materials provide particular considerations for:

a) AR and VR distinctly;

b) enterprise and consumer usage distinctly; and

c) within particular sectors/scenarios.

This document has been developed with consideration of the needs of stakeholders belonging to two main categories. These interests are categorized as such:

1) an enterprise perspective, consisting of organisations that are implementing or managing the use of AR/VR, and therefore providing guidance to employees on safe use practices. This enterprise perspective also encompasses technology manufacturers or other service providers; and

2) a consumer perspective, informing technology manufacturers how to ensure safe use of devices by end consumers, and informing consumers of risks they should be cognizant of (e.g. how VR may impact post-use motor skills).

The reality-virtuality continuum

Milgram and Koshono first conceptualised the VC from the real environment to the virtual environment[1]. Reality, AR, AV and VR are all positioned on the VC as shown in Figure 1.

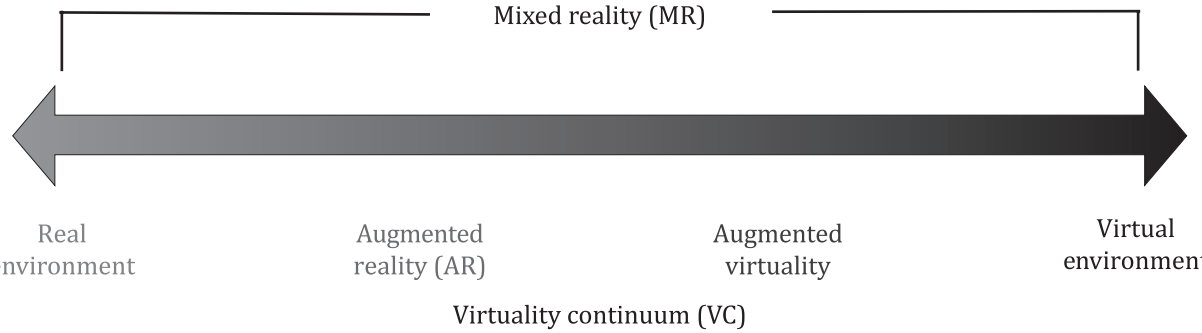


Figure 1 — Reality Virtuality (RV) Continuum (adapted from Milgram and Kishono[1])

The focus of this document is on AR and VR which are well-defined reality modes that have been in use for several decades.

Distinguishing virtual from real

In developing taxonomies for the VC, concepts of real and virtual images and objects also need to be considered. A real object has an objective existence, whereas in the VC context, a virtual object is computer-generated. Similarly, a real image has luminosity at the point where it appears to be located whereas a virtual image has no luminosity at its apparent position. These concepts are well established in optics[3].

Different aspects of distinguishing reality from virtuality are shown in Figure 2. The observer can view a real object (A) directly or indirectly via a real or virtual image. Further, a virtual object (AA) can be created by computer that can be viewed as a real image or virtual image in the case of a stereoscopic display. Modern head mounted displays may allow:

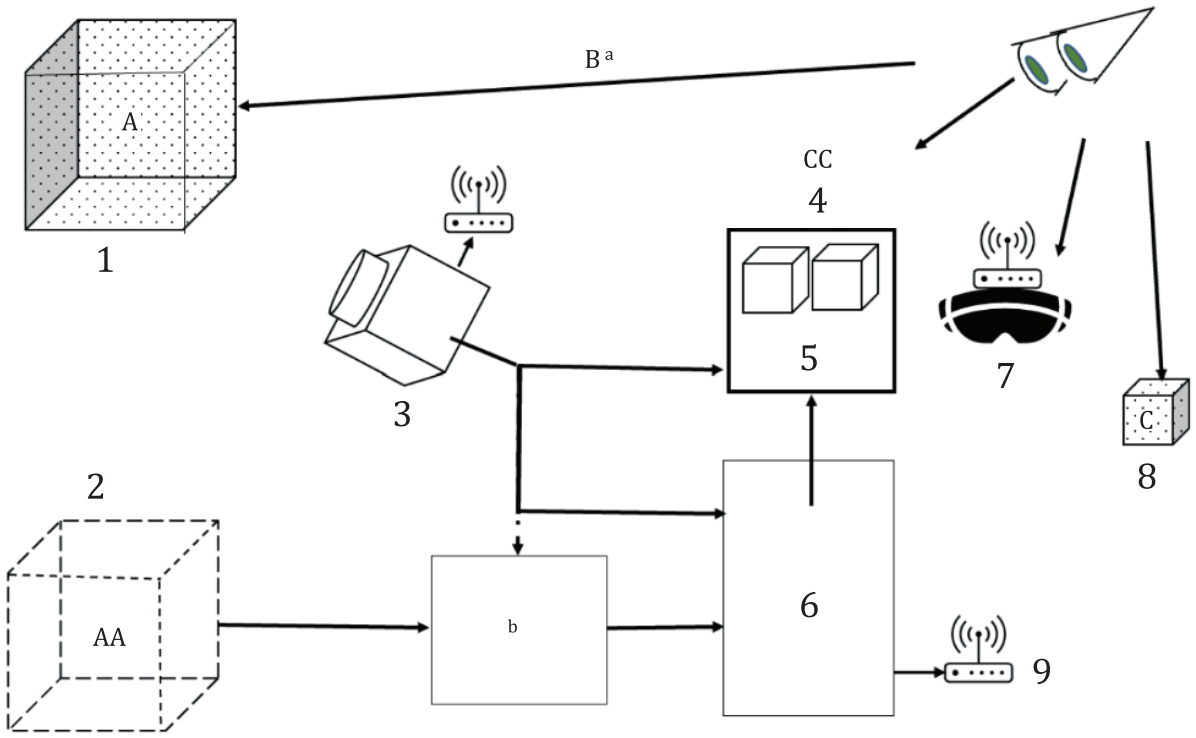
a) direct viewing of a real image of a real object;

b) indirect viewing of the same real object from a real computer synthesized image;

c) viewing of a real image from a virtual object; and

d) viewing of a virtual image simultaneously.

The HMD can access the camera and computer data via wireless technology or other similar technology.



Key

1 Real object / real image
2 Virtual objects (e.g. Created with a compute)
3 Sampling apparatus (e.g. Camera, sensor, mobile phone, etc.)
4 Non-direct viewing (synthesising display)
5 Real images
6 Computer with graphics capability
7 Head mounted display
8 Virtual Image (e.g. mirror image, holograms)
9 Wifi or Bluetooth® connection providing remote connections
a Direct viewing.
b Model: $T^2 = U^2 + V^2$ $y=mc^2$.

Figure 2 — Different aspects of distinguishing reality from virtuality adapted from Milgram and Kishono[1], and Stothard and Shiranai 2023[4]

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1 Scope

This document specifies how augmented reality (AR) and virtual reality (VR) devices are to be set up and used in the enterprise workplace in a manner that ensures health and safety (H&S) is maintained, H&S consequences are understood, and additional risks are not introduced. Within this concept of safe usage, there is particular focus on guidance around safe immersion (time) and safety in the workplace.

This document defines the concepts of AR, VR, the virtuality continuum and other associated terms such as augmented virtuality and mixed reality. This document provides guidance on:

a) setting up AR systems;

b) setting up VR systems;

c) safe usage and immersion in AR systems both in the consumer and enterprise domains;

d) safe usage and immersion in VR systems both in the consumer and enterprise domains.

This document focuses on visual aspects of AR and VR. Other modes such as haptics and olfactory are not addressed within this document.

This document covers both the hardware (the physical VR/AR head mounted displays) and areas of visual stimulus (the environments and graphics displayed in those headsets). This document does not cover all possible visual stimulus scenarios; focus is directed toward those areas that are known to have implications on safe use. This specifically includes the source vection (visual illusion of self-motion in physically stationary VR/AR users) and/or motion (physical movement of VR/AR users) and associated safe use considerations.

NOTE AR/VR have some shared safety concerns, but many are distinct to AR or VR and a consumer or enterprise environment. As such all of these are in scope, and this document is structured to account for these differences.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
augmented reality
AR
interactive experience of a real-world environment whereby the objects that reside in the real world are augmented by computer-generated perceptual information

Note 1 to entry: AR Systems are further defined in ISO/IEC 18039:2019.

[SOURCE: ISO 18038:2020, 3.2, modified — added note 1 to entry.]

3.1.2
augmented virtuality
AV
merging of real-world objects into virtual worlds.

3.1.3
consumer environment
comprising of the family and the related cultural, sociological and economic factors

Note 1 to entry: In this document, the Consumer Environment for AR/VR refers to individuals using AR/VR devices.

3.1.4
enterprise environment
people and systems are integrated into an organisation, such as a large business, classroom, or training environment

3.1.5
XR
real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables

Note 1 to entry: Within this document, XR is used as an umbrella term encapsulating AR, VR, MR and other environments

3.1.6
field of view
FOV
extent (in horizontal and vertical axis angles) of the observable world that is seen from the viewer's position

[SOURCE: ISO 23019:2022, 3.5.5]

3.1.7
mixed reality
MR
display continuum in which both real and virtual images are combined in some way and in some proportion

Note 1 to entry: Augmented reality (AR) and virtual reality (VR) are considered to be on the mixed reality continuum.

[SOURCE: ISO/IEC TR 23843:2020, 3.4]

3.1.8
real image
image which can be received on a surface

[SOURCE: ISO 10934:2020, 3.1.75.3]

3.1.9
virtuality continuum
VC
continuum of states from physical reality, through augmented reality, augmented virtuality, to wholly computer-generated virtual reality

Note 1 to entry: This is also known as the reality-virtuality continuum.

Note 2 to entry: The continuum of states is illustrated in Figure 1 below.

3.1.10
virtual image
image at an arbitrary viewpoint (3.1.4) that is generated by collecting visible photo information from real images

[SOURCE: ISO/IEC 23488:2022, 3.1.5]

3.1.11
virtual reality
VR
set of artificial conditions created by computer and dedicated electronic devices that simulate visual images and possibly other sensory information of a user's surrounding with which the user is allowed to interact

[SOURCE: ISO 9241-394:2020, 3.8]

3.1.12
visually induced motion sickness
VIMS
motion sickness-like symptoms induced by perceived motion within the visual environment, such as when watching movies and screen images of video games

Note 1 to entry: The symptoms can include dizziness, vertigo, sweating, odd feelings in the stomach, and nausea, which can progress to vomiting.

[SOURCE: ISO 9241-394:2020, 3.1]

3.2 Abbreviated terms

2D	two dimensional
3D	three dimensional
API	application programming interface
AR	augmented reality
AV	augmented virtuality
BLE	Bluetooth® [a] low energy
CGI	computer generated imagery
DOF	depth of field
FOV	field of view
GPS	global positioning system
H&S	health & safety