TECHNICAL REPORT

ISO/TR 9241-380

First edition
2022-06

Ergonomics of human-system interaction —

Part 380: Survey result of HMD (Head-Mounted Displays) characteristics related to human-system interaction

Reference number
ISO/TR 9241-380:2022(E)

Documents
Document Sharing Hub
© ISO 2022

Full document details: ISO TR 09241-380-2022

COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub

Full document details: ISO TR 09241-380-2022

Contents

Page

Foreword ... **v**
Introduction ... **vi**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **1**
4 Head-mounted displays (HMDs) ... **2**
5 Categories of HMDs ... **3**
5.1 General ... 3
5.2 Categorized by virtual image ... 5
5.2.1 VR type ... 5
5.2.2 AR type ... 5
5.2.3 MR type ... 5
5.3 Categorized by virtual image formation ... 6
5.3.1 Imaging display and optics ... 6
5.3.2 Scanning type ... 6
5.3.3 Light field fype ... 6
5.3.4 Holographic display with waveguide type ... 7
5.4 Categorized by ocularity ... 8
5.4.1 Binocular ... 8
5.4.2 Biocular ... 9
5.4.3 Monocular ... 9
5.5 Categorized by physical configuration ... 9
5.5.1 Eyeglasses type ... 9
5.5.2 Placed on eyeglasses ... 9
5.5.3 Frame plus optical device ... 10
5.5.4 Goggles ... 10
5.5.5 Smart phone with box ... 10
5.5.6 Helmet mounted ... 11
5.6 Categorized by system configuration ... 11
5.6.1 Wireless HMD (standalone) ... 11
5.6.2 Smart phone with special optics ... 12
5.6.3 Wired HMD ... 12
5.7 Categorized by physical input devices for HMD system ... 12
5.7.1 HMD System without external physical input devices ... 12
5.7.2 HMD System with external physical input devices ... 12
6 HMD human-system interaction characteristics ... **13**
6.1 Optical characteristics ... 13
6.1.1 General ... 13
6.1.2 Distance between eyes ... 18
6.1.3 Distortion and aberration ... 18
6.1.4 Inter-Ocular optical properties ... 21
6.1.5 For AR/MR ... 26
6.1.6 For AR ... 29
6.1.7 For AR, video see-through properties ... 30
6.1.8 For light field display ... 30
6.2 HMD system-related characteristics ... 31
6.2.1 Time delay of HMD system (latency) ... 31
6.2.2 Degree of freedom ... 32
6.3 Other characteristics of HMD ... 33
6.3.1 Physical properties ... 33
6.3.2 Alignment ... 34
6.4 Physical conditions of a viewer ... 34

© ISO 2022 – All rights reserved

AVA Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

6.4.1 Age ... 34
6.4.2 Habituation ... 35
6.4.3 Preference ... 35
6.4.4 Duration ... 35
6.4.5 Posture of a user ... 35
6.5 Presence and immersion ... 35

7 Visual induced motion sickness (VIMS) ... 35
7.1 General ... 35
7.2 SSQ ... 35
7.3 VIMS related factors ... 36

8 Consideration ... 36

Annex A (informative) **Visual Fatigue and Discomfort ... 37**

Bibliography ... 39

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 ISO documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

A list of all parts in the ISO 9241 series can be found on the ISO website.

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.

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

Introduction

The evolution of electronic devices has led to the growing popularity of head-mounted displays (HMDs) for direct human–machine interaction. Although ISO 9241-303 and ISO 305 addressed HMDs as 'virtual displays', the information in these documents was limited to devices available at the time, and the evolution of HMDs requires new parameters to cover the interactions between the user and the HMD itself. To provide the latest information to suppliers, users, and anyone who interacts with HMDs, it is important to establish which HMD characteristics need to be considered.

Unlike a conventional display, a viewer wears an HMD to see the displayed images. In most cases, when images are shown on a conventional display, there is a certain distance between the viewer and display. However, as stated, a viewer of an HMD wears it, usually on their head. Obviously, such viewing conditions affect the viewer in certain ways, by not only the optical characteristics (which are the main concerns for conventional displays) but also other physical characteristics such as weight. Therefore, discussing the ergonomic considerations of HMDs requires a systematic approach by considering several aspects simultaneously, which is the aim of this document.

NOTE The International Electrotechnical Commission (IEC) also works on the standardization of HMDs (the IEC calls them 'eyewear displays'). At the time of publication, the following IEC standards are available and are being developed:

IEC TR 63145-1-1: 2018: *Eyewear display - Part 1-1: Generic introduction*

IEC 63145-20-10:2019: *Eyewear display - Part 20-10: Fundamental measurement methods - Optical properties*

IEC 63145-20-20:2019: *Eyewear display - Part 20-20: Fundamental measurement methods - Image quality*

IEC 63145-22-10:2020: *Eyewear display - Part 22-10: Specific measurement methods for AR type - Optical properties*

© ISO 2022 – All rights reserved
Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

Ergonomics of human-system interaction —

Part 380: Survey result of HMD (Head-Mounted Displays) characteristics related to human-system interaction

1 Scope

This document provides information based on a study of the characteristics of head-mounted displays (HMDs) regarding the ergonomics of human–system interaction. Although this document covers the broad range of ergonomics issues that arise, it specifically provides more-detailed information about the visual aspects of the interaction, and it provides information that could form the basis for future possible standards related to HMDs.

NOTE It is preferable to take systematic approach to consider characteristics of HMD, since HMD affects a viewer not only by visual aspects, but also by some other physical aspects.

2 Normative references

There are no normative references in this document.

3 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
head-mounted display
HMD
electronic device that shows information on one or more displays attached to the head of a human

3.2
virtual reality
VR
artificial environment presented by a computer

Note 1 to entry: See Figure 1.

Note 2 to entry: Including telepresence and interaction with and reaction from the virtual environment.

[SOURCE: ISO/IEC TR 18121:2015, 3.6]

3.3
mixed reality
MR
physical and digital (virtual) objects co-exist and interact in real time

Note 1 to entry: See Figure 1.

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

3.4
augmented reality
AR
reality that has virtually added information

Note 1 to entry: See Figure 1.

Note 2 to entry: AR is used in ISO 9241-910 with no definition.

Note 3 to entry: AR is used in ISO/IEC TR 18120:2016 with no definition.

Note 4 to entry: AR is used in ISO 19154:2017 with no definition.

Note 5 to entry: AR is used in ISO/IEC TR 19566-1:2017 with no definition.

3.5
reality
world or the state of things as they exist

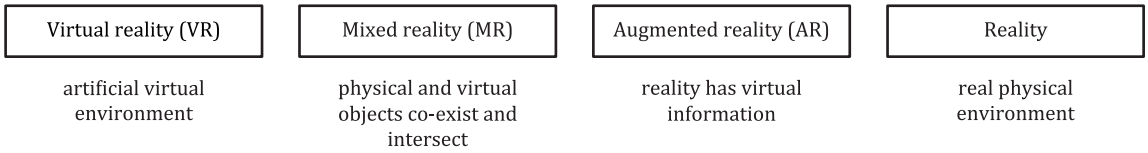


Figure 1 — VR, MR, AR, Reality

Note 1 to entry: See Figure 1.

3.6
exit pupil
vertical/horizontal dimension of the QVS (qualified viewing space)

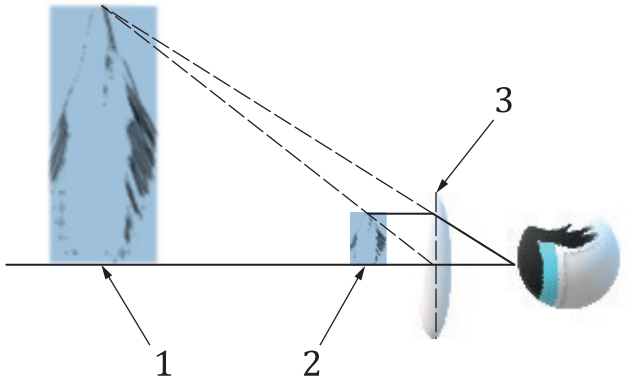
[SOURCE: ISO 9241-302]

4 Head-mounted displays (HMDs)

An HMD is an electronic display device that provides visual information by using one or more displays that are placed on a human head and secured by elastic straps or earpieces or integrated in a helmet (see Figure 2). An HMD shows information by using virtual images rather than real ones (see Figure 3). Most HMDs consist of one or more electronic displays and proper optics that treat the images on the display or displays so that they can be seen by one or more human eyes. In some cases, there is no physical display, only optics (see Figure 4). Because of these considerable differences from conventional displays, numerous characteristics need to be considered regarding human–system interaction. This document explores those characteristics and point out new ways of evaluating HMDs regarding their users (viewers).

Figure 2 — Example of a head-mounted display

© ISO 2022 – All rights reserved
Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022



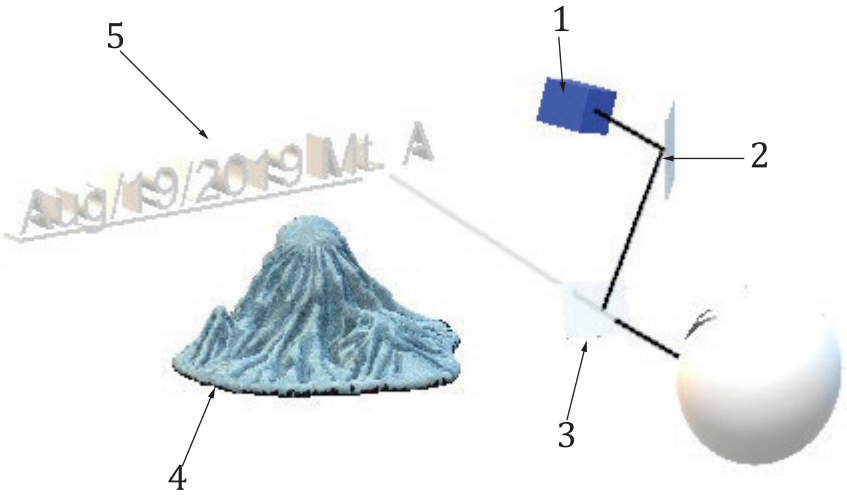
Key

1 virtual image

2 real image on a display

3 convex lens

Figure 3 — Example of a virtual image



Key

1 laser source

2 mirror array

3 half mirror

4 real object

5 virtual image (projected image)

Figure 4 — Example of a direct scanning HMD

5 Categories of HMDs

5.1 General

There are several ways to categorize HMDs, such as by the type of images that the device shows, how the device forms a virtual image, ocularity, and physical configuration (Figure 5)

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

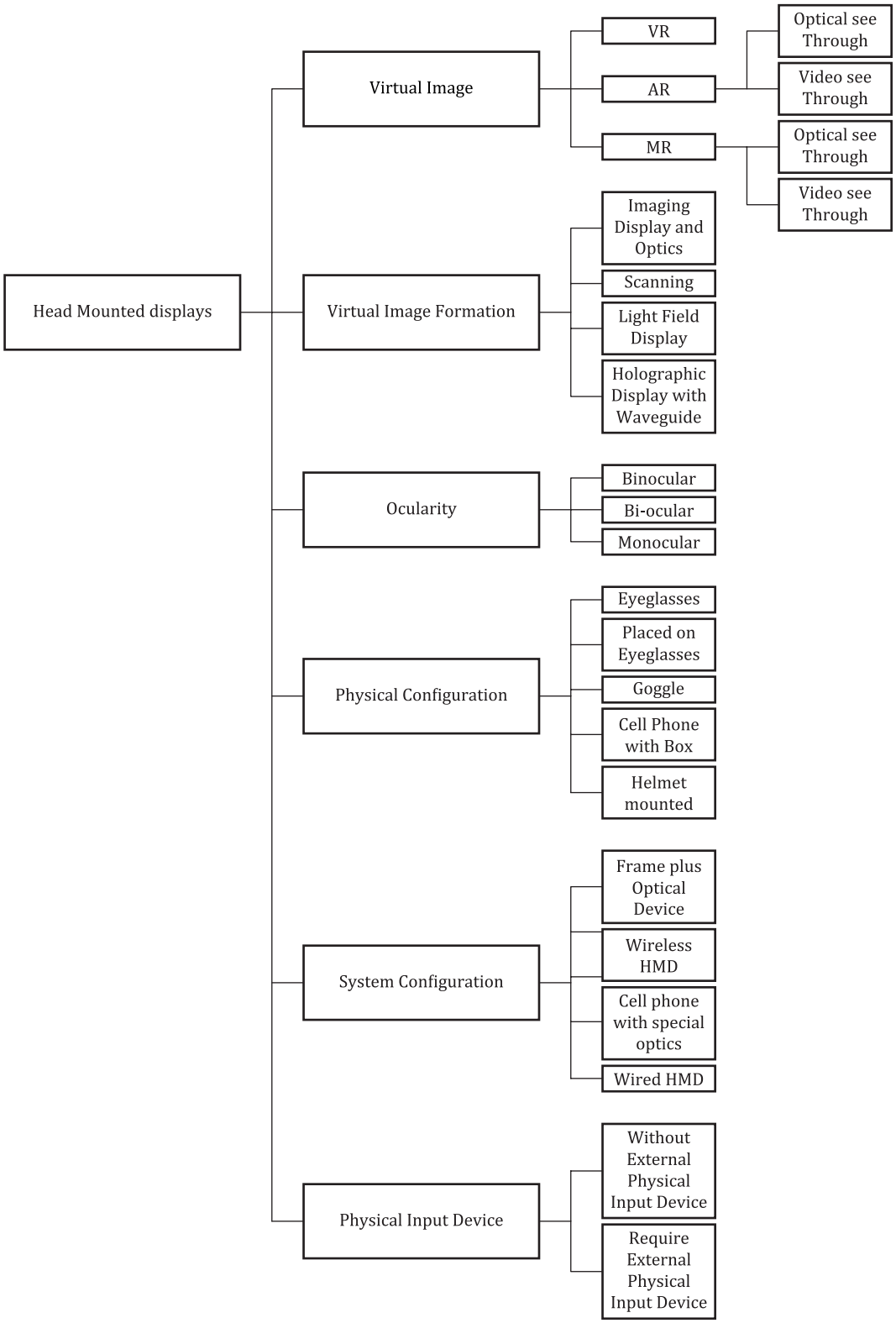


Figure 5 — Example of categorizing HMDs

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

5.2 Categorized by virtual image

5.2.1 VR type

The VR type of HMD displays only computer-generated images (virtual images). The HMD covers the viewer's eyes completely, meaning that they can see nothing except the displayed images (see Figure 6).

Figure 6 — Example of a VR HMD

5.2.2 AR type

The AR type of HMD presents images of the real surrounding environment by using either transparent optics (see-through AR type) or electro-optical devices, such as a video camera (video-see-through type), and it shows computer-generated images (virtual images) by using certain electro-optical devices (see Figure 7).

Figure 7 — Example of an AR type HMD

5.2.3 MR type

The MR type of HMD presents mainly computer-generated images and imposes real images (outside scenery) by means of either video see-through or see-through optics (see Figure 8).

Figure 8 — Example of an MR type

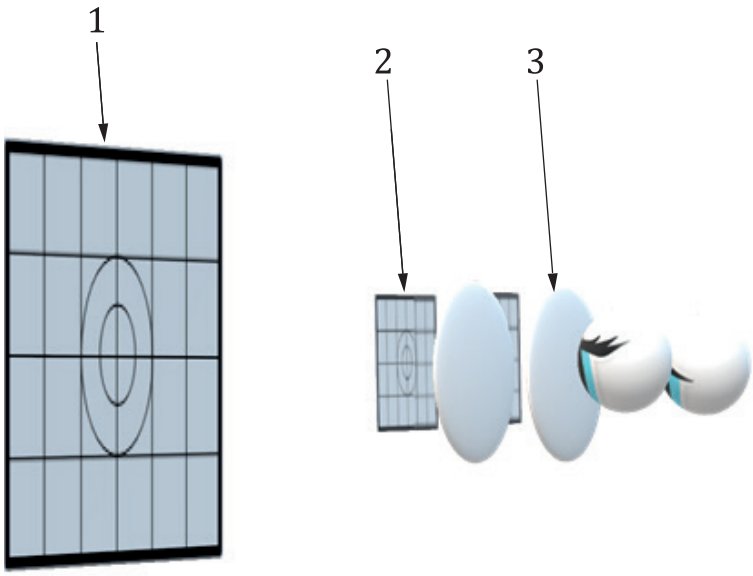
© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022

5.3 Categorized by virtual image formation

5.3.1 Imaging display and optics

This type of HMD shows virtual images by both showing them on displays and forming them by using optics (see Figure 9).



Key

1 virtual image

2 displays with real image

3 convex lenses

Figure 9 — Example of an image forming type

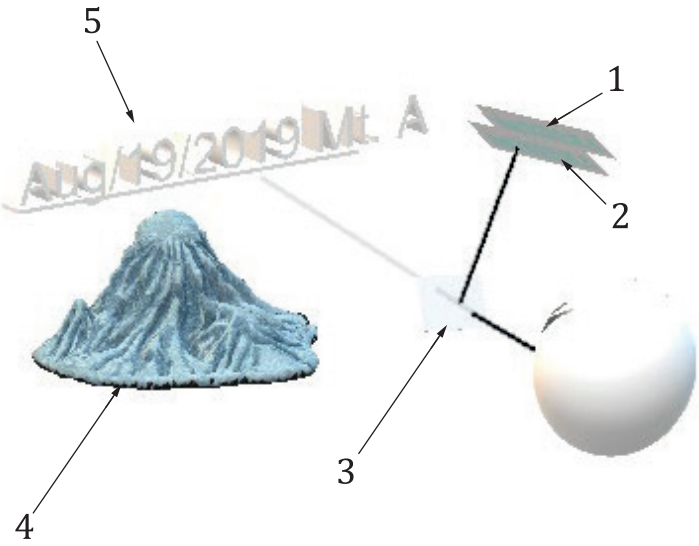
5.3.2 Scanning type

This type of HMD does not form images by any means; rather, it uses light rays to scan the human retina via certain optics (see Figure 4).

5.3.3 Light field fype

The light-field approach involves providing a near-eye display by using certain optics, such as those based on micro-lenses (see Figure 10).

© ISO 2022 – All rights reserved
Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022



Key

1 LCD
2 micro lens array
3 half mirror
4 real object
5 virtual image (projected image)

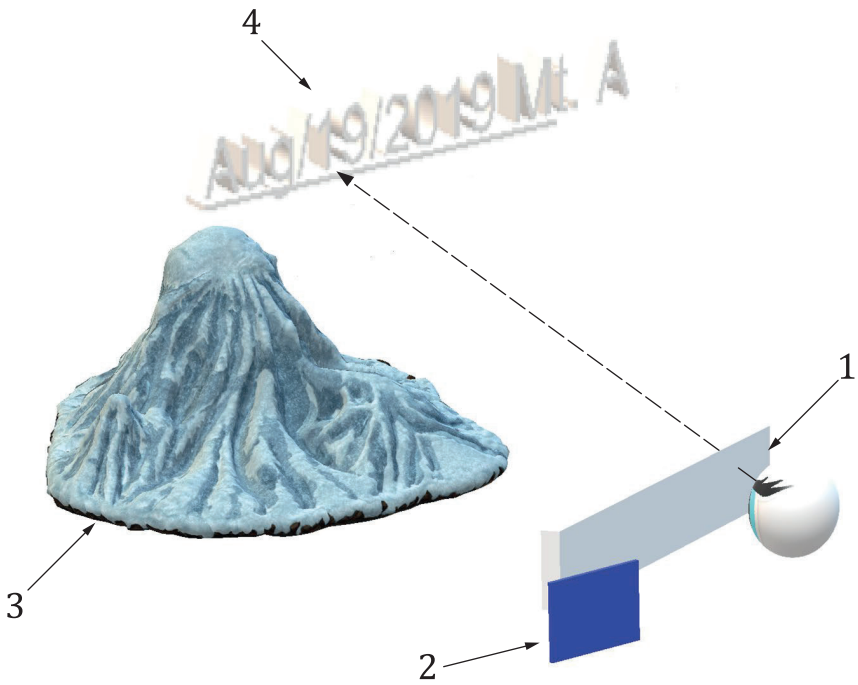
Figure 10 — Example of a light field display

5.3.4 Holographic display with waveguide type

holographic with waveguide to provide near-eye display by using certain optics, such as micro lens-based optics (See Figure 11).

© ISO 2022 – All rights reserved

Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022



Key

1 light guiding element

2 LCD

3 real object

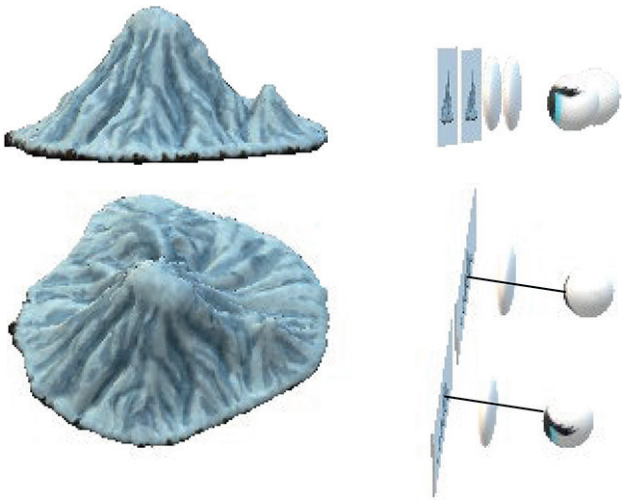
4 virtual image (projected image)

Figure 11 — Example of a holographic with waveguide display

5.4 Categorized by ocularity

5.4.1 Binocular

The binocular type of HMD shows independent images on each imaging device by using stereo separation and stereo convergence (see Figure 12).



NOTE Two separate images are seen using two separate displays and lenses.

Figure 12 — Example of a binocular display

© ISO 2022 – All rights reserved
Documents
Document Sharing Hub
Full document details: ISO TR 09241-380-2022