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INTERNATIONAL STANDARD

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3D display devices –
Part 1-2: Generic – Terminology and letter symbols

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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FOREWORD

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IEC 62629-1-2 has been prepared by IEC technical committee 110: Electronic displays. It is an International Standard.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) added new terms related to holographic display and light field display;
b) added new terms on the performance specifications used in other IEC 62629 series documents;
c) added Annex C to explain the depth perception in 3D displays in more detail.

The text of this International Standard is based on the following documents:

Draft	Report on voting
110/1287/CDV	110/1330/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

In this standard, the following print types are used:

- *Terms defined within Clause 3: in italics type.*

A list of all the parts in the IEC 62629 series, under the general title *3D display devices*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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3D DISPLAY DEVICES –

Part 1-2: Generic – Terminology and letter symbols

1 Scope

This part of IEC 62629 provides a list of the terminologies that are frequently used in describing 3D display technologies in the IEC 62629 series. Terms for various 3D display technologies on stereoscopic, autostereoscopic, volumetric, and holographic displays are included.

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 terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 General terms

3.1.1
3D display
display device giving depth perception with physiological depth cues

Note 1 to entry: Physiological depth cues include accommodation, convergence, binocular parallax, and motion parallax. The 3D display provides users with all or some of the physiological depth cues so that they can perceive depth. Physiological depth cues should be distinguished from pictorial depth cues which can also be provided by the usual 2D displays. Pictorial depth cues are features in an image that give a hint of the depth. Examples of pictorial depth cues are texture gradient, shadow, occlusion, and vanishing lines. See Annex C.

3.1.2
stereoscopic display
3D display providing binocular parallax

Note 1 to entry: See *autostereoscopic display* (3.1.3). For classification of the 3D displays, see Annex B.

3.1.3
autostereoscopic display
stereoscopic display that requires no viewing aids

Note 1 to entry: See *stereoscopic display* (3.1.2). For classification of the 3D displays, see Annex B.

3.1.4
two-view display
two-view autostereoscopic display
autostereoscopic display providing one stereoscopic view

Note 1 to entry: See *multi-view display* (3.1.5).

3.1.5
multi-view display
multi-view autostereoscopic display
autostereoscopic display providing multiple stereoscopic views

Note 1 to entry: See *two-view display* (3.1.4).

3.1.6
integral imaging display
integral imaging autostereoscopic display
light field display
autostereoscopic display that reproduces ray space

Note 1 to entry: Depending on the light field or ray space that the display reproduces, the display may not be an autostereoscopic display. For example, if the reproduced light field allows the user to recognize information only at a pre-defined authorized condition, then the display is a secure display, not an autostereoscopic display. But in the IEC 62629 series, the light field is limited to the one corresponding to the 3D images such that the display reproducing the light field is an autostereoscopic display.

Note 2 to entry: If the angular range of the light field reconstruction does not cover the two eyes of the user, the display is a monocular 3D display, not an autostereoscopic display. However, in the IEC 62629 series, the light field display is limited to the autostereoscopic display.

Note 3 to entry: An integral imaging display is the same as a light field display. Sometimes, though, it could refer to a subset of the light field display which uses an array of lenslets or pinholes for the reproduction of light field. See Annex E.

3.1.7
voxel
volume pixel which can be addressed to control its light intensity

Note 1 to entry: Voxel includes not only the physical element that emits or reflects light but also the optical image point to which light from the display converges or diverges from.

3.1.8
volumetric display
autostereoscopic display which forms a set of voxels distributed in space

3.1.9
stereoscopic image
pair of images with parallax shown on a stereoscopic display

Note 1 to entry: Stereoscopic images are made by capturing images of an object from slightly different positions and are used as output of a stereoscopic display. See Annex A.

3.1.10
stereoscopic view
pair of sights provided by a stereoscopic display, which induce stereopsis

Note 1 to entry: Stereoscopic view is generally not the same as stereoscopic image. In some cases, more than a single monocular image is projected on the retina of an eye by crosstalk. See Annex A.

3.1.11
monocular image
one part of a stereoscopic image

Note 1 to entry: See A.2.2 and Figure A.3.

3.1.12
monocular view
one part of a stereoscopic view

Note 1 to entry: See A.2.2 and Figure A.3.

3.1.13
designed viewing distance
viewing distance recommended by the manufacturer of the 3D display

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-22-1 [3][1].

3.1.14
lobe
space wherein one or multiple stereoscopic images are projected in correct angular order by an autostereoscopic display

Note 1 to entry: See Annex D.

3.1.15
ray space
light field
spatial and angular distribution of light rays

Note 1 to entry: Distribution of the light rays in a space can be described by a plenoptic function, also called light field, which represents intensity as a 7D function of spatial position (3D), direction (2D), wavelength (1D), and polarization (1D) of the rays. The 7D plenoptic function can be reduced to a 4D ray space which only represents the ray angular direction (2D) and the spatial position (2D) intercepting a plane. Although the light field originally means the plenoptic function, it is also frequently used in its reduced meaning of ray space. In this document, the ray space and the light field have the same meaning, representing 4D distribution of the light rays.

3.1.16
holographic display
autostereoscopic display that generates continuous wavefront converging to each point of a 3D image in space by light diffraction

Note 1 to entry: In its broad meaning, holographic display does not require continuity of the wavefront.

Note 2 to entry: For a detailed explanation, see IEC TR 62629-41-1 [4].

Note 3 to entry: If the angular range of the wavefront generation does not cover the two eyes of the user, then the display is a monocular 3D display, not an autostereoscopic display. However, in the IEC 62629 series, the holographic display is limited to the autostereoscopic display.

3.1.17
holographic stereogram display
autostereoscopic display that provides discrete stereoscopic views by light diffraction

Note 1 to entry: A full parallax holographic stereogram display generates a discrete wavefront converging to each point of a 3D image and can be considered as the holographic display in its broad meaning.

Note 2 to entry: For a detailed explanation, see IEC TR 62629-41-1 [4].

3.1.18
complex amplitude
complex value representing amplitude and phase of the light wave

Note 1 to entry: For a detailed explanation, see IEC TR 62629-41-1 [4]..

3.1.19
wavefront
locus of spatial points that share the same phase of the light wave

Note 1 to entry: For a detailed explanation, see IEC TR 62629-41-1 [4]..

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1 Numbers in square brackets refer to the Bibliography.

3.1.20
aerial display
display that forms a real image in mid-air by use of an incoherent light source display and a passive optical component to converge diverging light from the light source display

Note 1 to entry: For a detailed explanation, see IECTR 62629-51-1 [5].

3.2 Terms related to components

3.2.1
active glasses, pl.
glasses whose left and right lenses alternate their optical characteristics, by synchronizing with displayed sequential images on a stereoscopic display (e.g., synchronizing with TV fields, TV frame, etc.) to separate the displayed images into left and right monocular views

Note 1 to entry: Usually left and right images are displayed alternately on a screen. When a left image is displayed, the left lens of the active glasses is turned on to transmit the image and the right lens is turned off to cut off the image. The lenses do not need a function for focusing light.

3.2.2
passive glasses, pl.
glasses whose left and right lenses have complementary but fixed optical characteristics to separate displayed images on a stereoscopic display into left and right monocular views

Note 1 to entry: Usually left and right images are displayed on a screen with spatial or temporal multiplexing. In the spatial multiplexing, spatially divided left and right images are displayed at the same time on a screen; each divided segment in the screen emits polarized light to display the images, and the left and right segments have orthogonal polarization. The left lens of the passive glasses has a polarization to pass the emitted light of the left images and to cut off that of the right images, while the right lens passes the right images and cuts off the left images. In the temporal multiplexing, left and right images are displayed sequentially on a screen with alternating orthographic polarizations. The left lens of the passive glasses has a polarization to pass the emitted light of the left image frames to cut off that of the right image frames, while the right lens does the opposite.

3.2.3
polarized glasses, pl.
passive glasses equipped with two polarizers whose polarization properties are opposite to each other

Note 1 to entry: See *linearly polarized glasses* (3.2.4) and *circularly polarized glasses* (3.2.5).

3.2.4
linearly polarized glasses, pl.
passive glasses equipped with two linear polarizers whose polarizing directions are orthogonal to each other

Note 1 to entry: See *polarized glasses* (3.2.3) and *circularly polarized glasses* (3.2.5).

3.2.5
circularly polarized glasses, pl.
passive glasses equipped with two circular polarizers whose rotational directions of circular polarization are orthogonal to each other

Note 1 to entry: See *polarized glasses* (3.2.3) and *linearly polarized glasses* (3.2.4).

3.2.6
patterned retarder
array of two kinds of optical phase retarders arranged alternatively in a plane

3.2.7
parallax barrier
barrier with an array of slits for providing one or multiple stereoscopic views

3.2.8
lenticular lens
lenticular sheet
set of semi-cylindrical lenses that are arranged side by side in a plane

3.2.9
fly-eye lens
set of lenslets that are arranged in a plane

3.2.10
spatial light modulator
device that spatially modulates the complex amplitude of light

Note 1 to entry: Depending on the modulation type, the usual spatial light modulators can be classified into amplitude-only and phase-only spatial light modulators.

3.3 Terms related to performance specifications

3.3.1
interocular chromatic difference
difference in chromaticity between left and right monocular views

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-12-1 [2].

3.3.2
interocular contrast difference
difference in contrast between left and right monocular views

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-12-1 [2].

3.3.3
interocular luminance difference
difference in luminance between left and right monocular views

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-12-1 [2].

3.3.4
interocular crosstalk
luminance leakage into the observed monocular view of an eye from the monocular image for the other eye

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-12-1 [2].

3.3.5
3D crosstalk
luminance leakage into an observed monocular view from other monocular images that are not designed to be seen at the observing position

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-22-1 [3].

3.3.6
ghost
image artefact that the observer perceives due to the incomplete image separation of the left and right views

Note 1 to entry: For a detailed measurement procedure, see IEC 62629-13-1 [6].

Annex A
(informative)

Definition guidelines for terms which include "image", "view" or "vision"

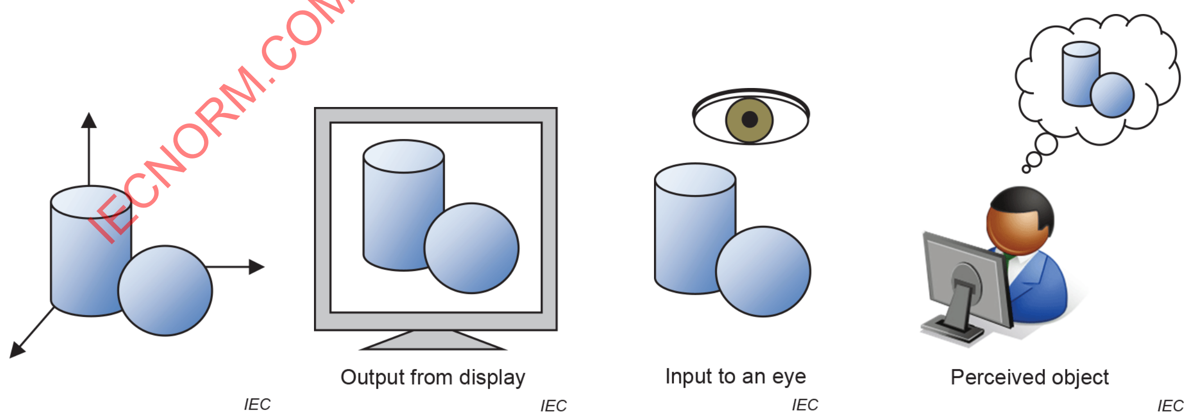
A.1 General

The terminology in Clause 3 avoids the definition of such short words as "image," "view" or "vision" (even though those words are used in many terms in Clause 3), because defining them explicitly ends up confusing readers, as these words have multiple meanings in daily usage. Instead, a brief description on how a term which includes one of these words is defined is presented here to relieve readers' confusion by indicating the reason why the short word causes trouble.

A.2 Definition guidelines

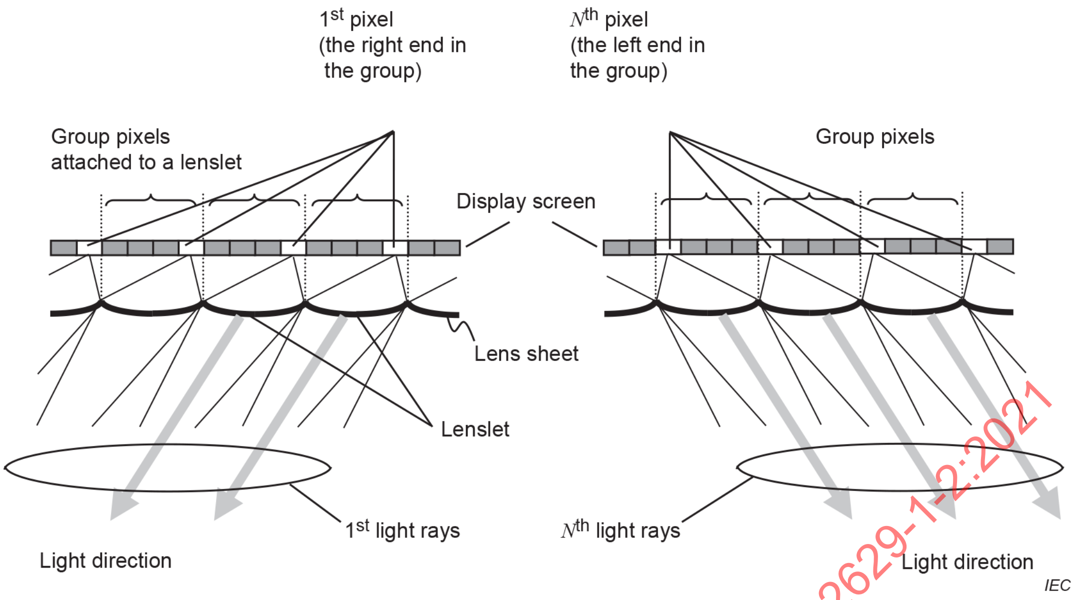
A.2.1 Stereoscopic image and stereoscopic view

"Image" and "view" are treated as an output from the display device and an input to a human eye, respectively. However, "image" is allowed to have another meaning of perceived object in the brain as an exception because "image" is also treated as a product of "vision", which means the brain's information processing of the optical input to the eyes (see Figure A.1). Multi-view autostereoscopic displays make use of "group pixels," a sequence of pixels that is periodically arranged on the horizontal line of the display screen to control the emission of light rays (see Figure A.2). Each i^{th} pixel in the "group pixels" emits a light ray in the specified direction and thus all of the i^{th} pixels have the same light direction. An "image" is composed of a group of light rays in the same specified direction and therefore any two of the "images" derive from different light sources. This means that "images" are mutually independent. On the other hand, a human eye generally receives a plurality of "images" because it has no filter that selects a specified "image" and thus neighboring "views" are supposed to include the same "image". This means that "views" are not mutually independent. Readers' confusion can come from unawareness of the difference between "image" and "view," or readers can confuse what is presented to people with what is observed by people.



(a) Object **(b) Image** **(c) View** **d) Image (perceived)**

Figure A.1 – Difference between "image" and "view"



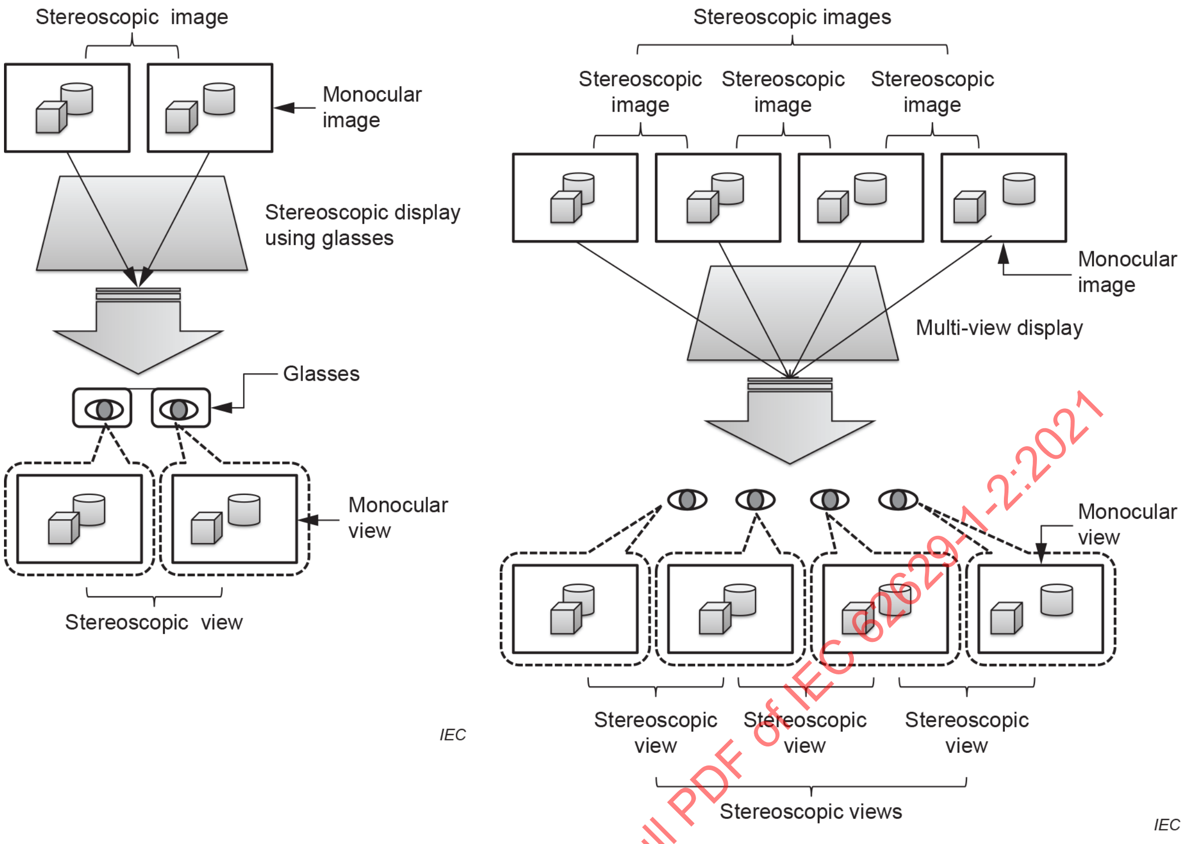
(a) **Test image** Im_1 (b) **Test image** Im_N

Figure A.2 – Structure of multi-view display[2]

A.2.2 Convention in using the plural form of stereoscopic image and stereoscopic view

In this document, "stereoscopic image" and "stereoscopic view" mean a pair of "images" and "views" as shown in Figure A.3. Therefore, "stereoscopic image" and "stereoscopic view" include two "monocular images" and "monocular views", respectively. The stereoscopic display using glasses and the two-view display present a single "stereoscopic view" in this sense. The multi-view display presents a collection of "stereoscopic views".

2 Taken from IEC 62629-22-1.



(a) Stereoscopic display using glasses **(b) Multi-view display**

Figure A.3 – Stereoscopic images and stereoscopic views

A.2.3 View and vision

"Vision" is treated as the brain's information processing of the optical input to the eyes in order to generate an "image" in the brain; "vision" therefore has a higher-level meaning unlike "view" which means an input to a human eye or simple seeing. "View" can be considered as a primary sense whereas "vision" is a secondary sense in that it needs the fusion of visual information received by both eyes. Readers may not notice that there is a big difference between "view" and "vision."

A.2.4 Imaging and vision

"Imaging" means the optical function of the display so that people can perceive an object in the brain by observing the image of the object. "Imaging" is, therefore, different from "vision" which is a secondary sense of human beings. Also note that "imaging" is different from "image", which is an output from the display. Readers may not understand those differences.

Annex B
(informative)

Classification of 3D display types

B.1 General

The display types described in the IEC 62629 series are classified as in Clause B.2.

B.2 Classification

B.2.1 3D display

The following classification is applied in the IEC 62629 series (see Figure B.1). The measurement methods of a stereoscopic display using glasses and autostereoscopic displays of two-view, multi-view, integral imaging, volumetric, and holographic display types are currently under consideration in the IEC 62629 series:

a) stereoscopic display;
b) monocular 3D display; and
c) other 3D displays.

B.2.2 Stereoscopic display

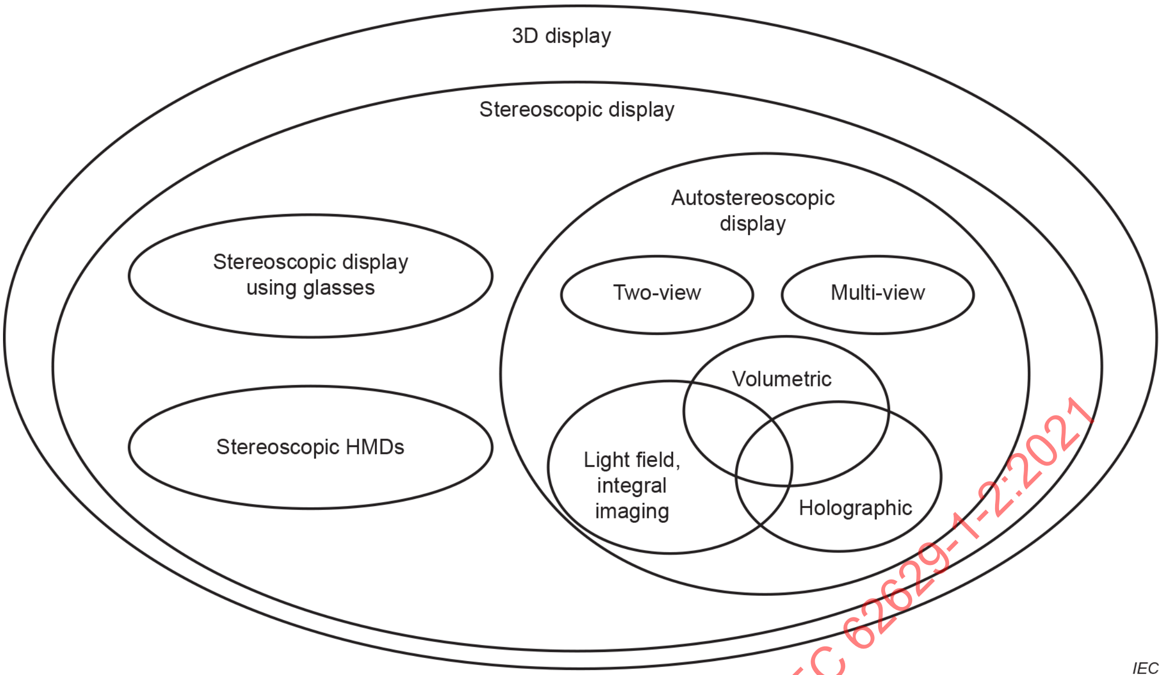
A stereoscopic display is classified as follows:

a) stereoscopic display using glasses;
b) stereoscopic HMD;
c) autostereoscopic display; and
d) other stereoscopic displays.

B.2.3 Autostereoscopic display

An autostereoscopic display is classified as follows:

a) two-view (autostereoscopic) display;
b) multi-view (autostereoscopic) display;
c) light field (autostereoscopic) display;
d) integral imaging (autostereoscopic) display;
e) volumetric display;
f) holographic display; and
g) other autostereoscopic displays.



NOTE Most 3D displays provide binocular parallax and hence they can be classified into stereoscopic displays. In principle, however, there can be 3D displays that do not provide binocular parallax. A monocular 3D display that gives depth perception by providing accommodation depth cue to a single eye is one example. Therefore, strictly speaking, a stereoscopic display is a subset of a 3D display. Volumetric display, light field display, and holographic display have intersections depending on their properties. Some full-parallax light field displays and full-parallax holographic displays can be considered as a volumetric display if they reproduce ray space or wavefront with sufficiently high angular density. Holographic stereogram is a subset of the holographic display but it can also be considered as a light field display. Therefore, it is hard to define a clear boundary among the volumetric, light field, and holographic displays.

Figure B.1 – Classification of 3D displays

Annex C
(informative)

Relation between depth perception and 3D display

C.1 General

The relation between depth perception and the 3D display is explained in Clause C.2, Clause C.3, and Clause C.4.

C.2 Depth perception by binocular parallax when viewing a 3D display

Binocular parallax, or the difference between projections of the world onto the retinas of the two eyes is one of the strong depth cues of humans. Stereoscopic displays provide users with binocular parallax to induce depth perception. When a user watches a stereoscopic display, the user's eyes fixate at certain left and right image points (I_L and I_R) which correspond to each other (see Figure C.1). The two eyes also rotate inward to form the retinal images of the fixated corresponding image points at the optic axes of the eyes. When the disparity between the fixated corresponding left and right image points (I_L and I_R) is not zero, the retinal images (A_L' and A_R') of any physical point on the 3D display screen (A) are formed at different retinal positions in the two eyes with respect to their optic axes. This difference makes the user perceive that the fixated image point is located at a different depth from the 3D display screen, inducing the depth perception.

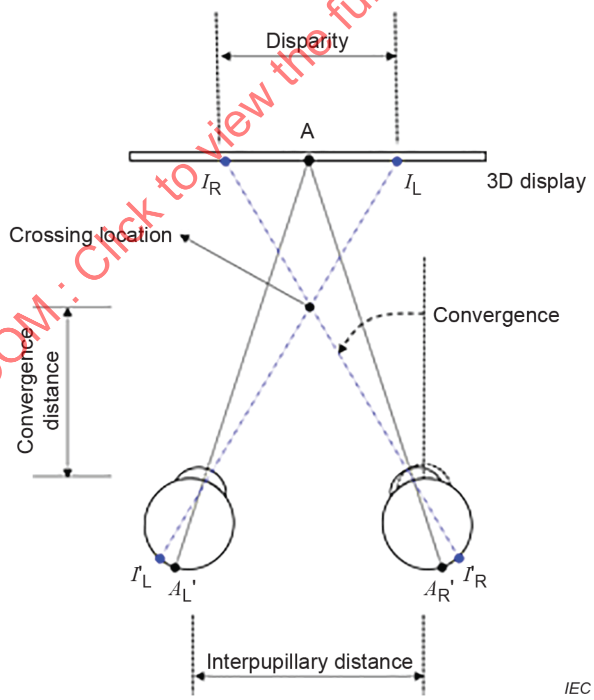


Figure C.1 – Depth perception by convergence when viewing a 3D display

C.3 Convergence accommodation conflict when viewing a 3D display

When a user watches a 3D display, the eyes not only rotate inward (convergence) such that their optic axes form a crossing location as explained in Clause C.2, but also change their optical power. The process by which the eye increases or decreases the optical power by controlling the focal length of the eye lens to form a clear optical image on the retina is called accommodation. In an ideal case, both the convergence distance (the distance from the eye to the crossing location) and the accommodation distance (the distance from the eye to the plane where the eye focuses) are the same and they coincide with the actual object distance (see Figure C.2). Due to many possible causes, however, the accommodation distance can deviate from the convergence distance, and this is called vergence accommodation conflict (VAC) or accommodation convergence conflict. Some 3D displays can also cause VAC. In most cases where the VAC happens with such 3D displays, the accommodation is fixed to the 3D display screen distance while the convergence distance is controlled by the disparity in the stereoscopic views. With the VAC, the depth cue from the vergence response is not consistent with that from the accommodation response. This VAC is generally considered as a non-desirable phenomenon which brings side effects in 3D display viewing experiences. The side effects are usually reduced when one of the vergence and accommodation depth cues is negligible. For example, when the 3D image is displayed at a far distance from the eye, or when the user's age is high and the eye focus control capability decreases, the accommodation depth cue is much weaker than the vergence depth cue, usually resulting in fewer side effects of the VAC.

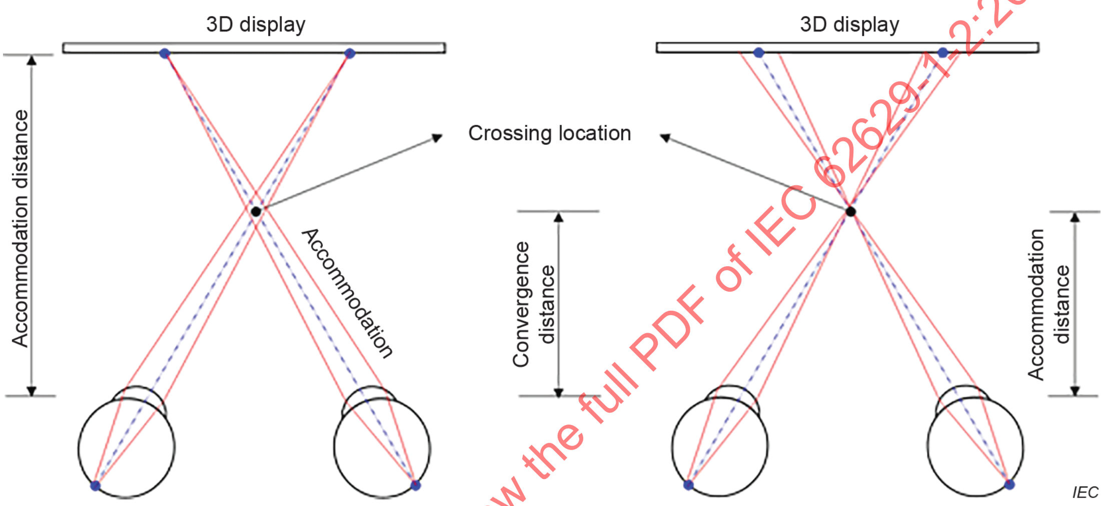


Figure C.2 – Vergence-accommodation conflict

C.4 Horizontal-parallax-only and full-parallax 3D display

In natural viewing conditions of an actual 3D object, slightly different image projections of the 3D object are captured at different eye positions. This difference in the image projections is called parallax (see Figure C.3). The horizontal parallax and vertical parallax refer to the parallax in horizontally and vertically separated eye positions, respectively. In 3D display viewing conditions, the parallax observed in the views is often limited in terms of its range, continuity, and directivity. The terms horizontal-parallax-only 3D display and full-parallax 3D display, indicate the parallax directivity that the 3D display provides. A horizontal-parallax-only 3D display presents proper parallax in horizontally separated views but not in vertically separated views. By contrast, a full-parallax 3D display presents proper parallax both in horizontally and vertically separated views.

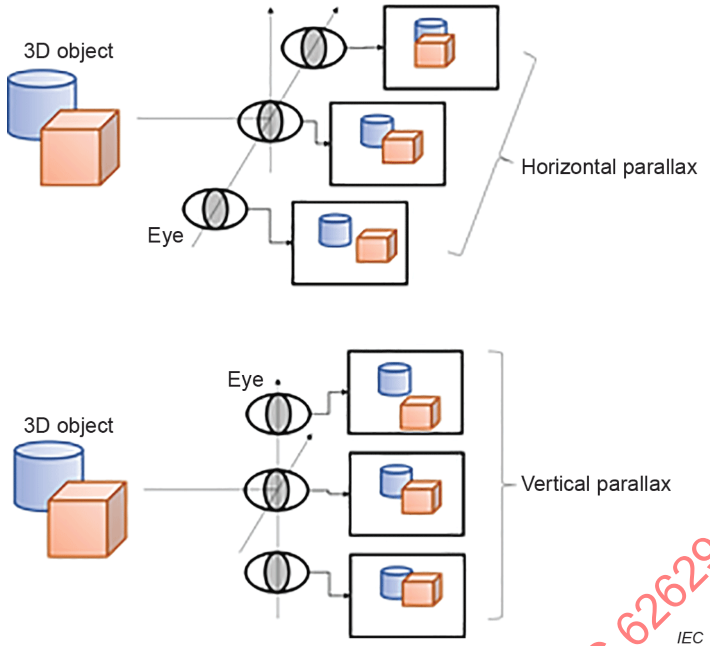
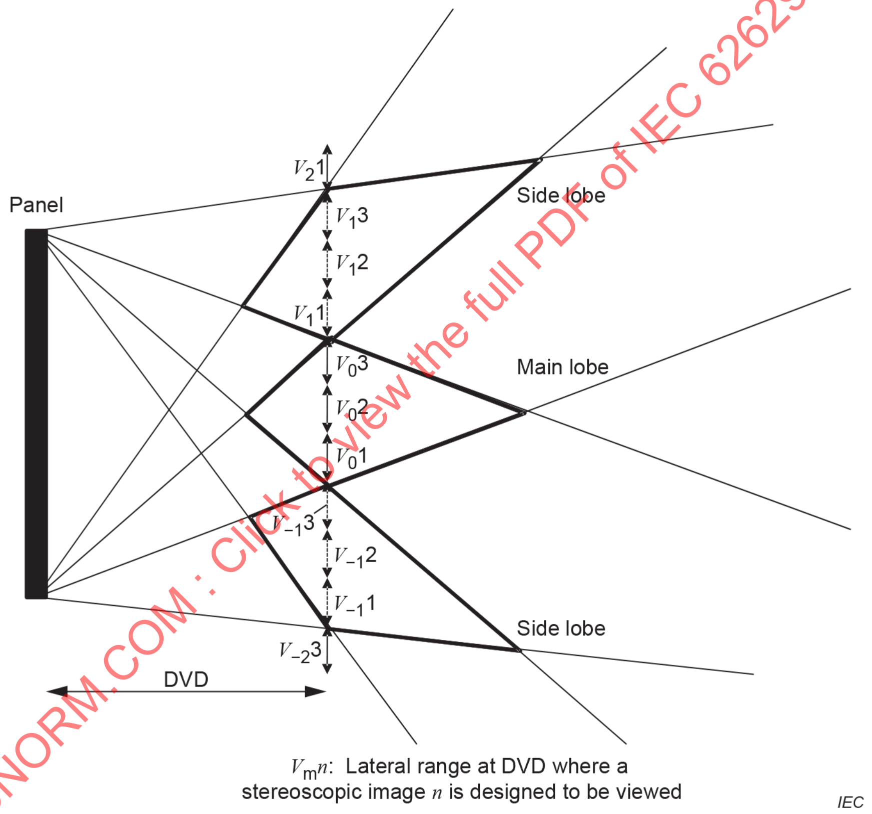


Figure C.3 – Horizontal and vertical parallax

Annex D
(informative)

Lobe

In multi-view displays treated in this document, a sequence of N pixels is repeatedly allocated in a horizontal direction on the screen. In an ideal condition, every light ray from the k^{th} pixel in the sequence passes through the viewpoint at the designed position and every light ray from the $(k + 1)^{th}$ pixel through the neighbouring viewpoint whose position is also designed, where k is from 1 to N-1 and N is larger than 2 (see Figure A.1). In consequence, a sequence of N viewpoints is repeatedly allocated in a horizontal direction in front of the screen and, therefore, intersections of light rays from the screen form an area that includes each sequence of N viewpoints (see Figure D.1). All the areas are called "lobe" and the area right in front of the screen and the other areas are usually called "main lobe" and "side lobe", respectively. If the left and right eyes are located in a lobe, stereopsis is induced, and if they are located in two consecutive lobes respectively, pseudostereopsis is induced.



NOTE In IEC 62629-22-1 [3], the angular range of a lobe is measured.

Figure D.1 – Lobe of autostereoscopic display