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INTERNATIONAL STANDARD

colour inside

3D display devices –
Part 62-11: Measurement methods for virtual-image type – Optical

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

Draft	Report on voting
110/1459/FDIS	110/1473/RVD

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.

A list of all parts in the IEC 62629 series, published 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- withdrawn,
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- amended.

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3D DISPLAY DEVICES –

Part 62-11: Measurement methods for virtual-image type – Optical

1 Scope

This part of IEC 62629 specifies the standard measuring conditions and measurement methods for determining the optical properties of the image created by 3D display devices and virtual-image optics such as head-up displays. The virtual image refers to an image in which the 3D visual information is superimposed with the outside world. Eye-wear type displays are however beyond the scope of this document.

NOTE The meaning of a virtual image in optics is in general an image formed when the outgoing rays from a point on an object always diverge. With regard to display application, a virtual image can be interpreted according to a real viewing case. When an image is viewed, even though there is no physical display (monitor, TV, screen), in front of a person's eyes, it is called virtual image.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendment-s) applies.

IEC 62629-1-2, *3D display devices – Part 1-2: Generic – Terminology and letter symbols*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62629-1-2 and the following 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

3.1.1
virtual image distance
distance from the centre between both eyes to the centre of a virtual image

Note 1 to entry: The eye-centre corresponds to the point where the half of the binocular spacing is located.

3.1.2
field of view
angle subtending the area of the virtual image as observed from the centre between both eyes

3.1.3
eye-box
<3D display devices – virtual-image type> three-dimensional space within which the users place both their eyes and properly see the entire virtual image

3.1.4
look down angle
angle in a downward direction between the normal line and viewing direction from which the virtual image is viewed at the centre between both eyes

Note 1 to entry: The normal line represents a line forming a vertical angle of 90° from the centre of the eye to the virtual image plane.

3.1.5
look over angle
angle in a sideway direction between the normal line and viewing direction from which the virtual image is viewed at the centre between both eyes

3.2 Abbreviated terms

CCD charge-coupled device

CMOS complementary metal-oxide semiconductor

FOV field of view

HUD head-up display

IPD inter pupil distance

LMD light measuring device

4 Measurement systems

4.1 Measuring device

A spot LMD or an imaging LMD such as a 2D imaging colorimeter should be applied for measuring light and colour properties, for example luminance value, chromaticity coordinates, etc. The specification of the LMD applied should be described in the report as in the example given in Table 1.

NOTE If a 3D display has the characteristics of multi-view, which is explained in IEC 62629-22-1 [1][1], the aperture size of 2 mm to 5 mm is suggested and is not larger than 6 mm.

Table 1 – Example of reported specification of an imaging LMD

Image sensor type	CCD, CMOS
Resolution	1 380 × 1 030, 2 448 × 2 050,
Luminance range	0,05 cd/m^2 to 100 000 cd/m^2
Repeatability	ΔL (luminance) < 0,1 % $\Delta x, y$ (chromaticity coordinate) < 0,001
Measuring accuracy	ΔL < 3 % (for Standard Illuminant A) $\Delta x, y$ < 0,002 (for Standard Illuminant A)

The geometric property of the 3D virtual image can be estimated using the imaging LMD (multiple imaging LMDs or one imaging LMD with movement). Annex A shows a comparison of measurement items between the conventional 3D display and the virtual-image type 3D display.

1 Numbers in square brackets refer to the Bibliography.

4.2 Measuring setup

4.2.1 Eye-box and virtual image plane

The geometric relationship between an eye-box and a virtual image plane is shown in Figure 1.

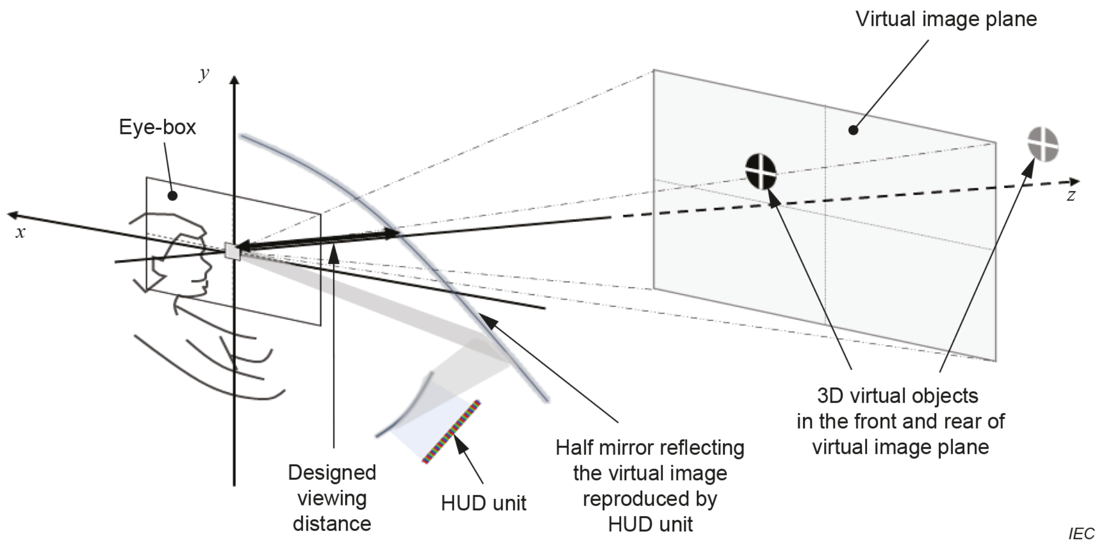

Figure 1 – Geometric relationship between an eye-box and a virtual-image plane

If users' eyes are placed in the eye-box, it is assumed that the users can view the entire virtual image without moving their head or making any other adjustment. The eye-box position can be specified by a supplier since this is varied by the application. The designed viewing distance shown in Figure 1 is the distance between the centre of the eye-box and the position on the half mirror, which should be suggested by the supplier. For the measurement, the designed viewing distance should be applied as the measuring distance.

If the eye-box location information is not provided by the supplier, this can be determined according to the method presented in 4.2.2. The measuring devices of the imaging LMD should be set up within the eye-box position. When the same left and right images without parallax are input, the plane on which the image is displayed is referred to as the virtual image plane. A 3D virtual object can be presented in the front or the back of the virtual image plane. A 3D coordinate system of xyz indicated in Figure 1 is defined in order to figure out the positions of the 3D virtual object and the virtual image plane from the eye-box of the users. The centre of the eye-box is defined as the zero position (xyz = 0).

NOTE If the supplier does not provide the eye-box position, this can be estimated by checking the geometric location where observers can view the entire virtual image plane. In general, the eye-box location is defined by the manufacturer according to the application. For example, it is determined by considering the distance from the windshield or combiner to the driver for automotive application, and the distance from the user to the half mirror for the exhibition application.

4.2.2 Determination of the eye-box

If the eye-box position is not provided by the supplier, the following method can be applied to determine the eye-box:

NOTE H1 to H9 and V1 to V7 in Figure 2 indicate examples of the position of the imaging LMD to determine the eye-box.

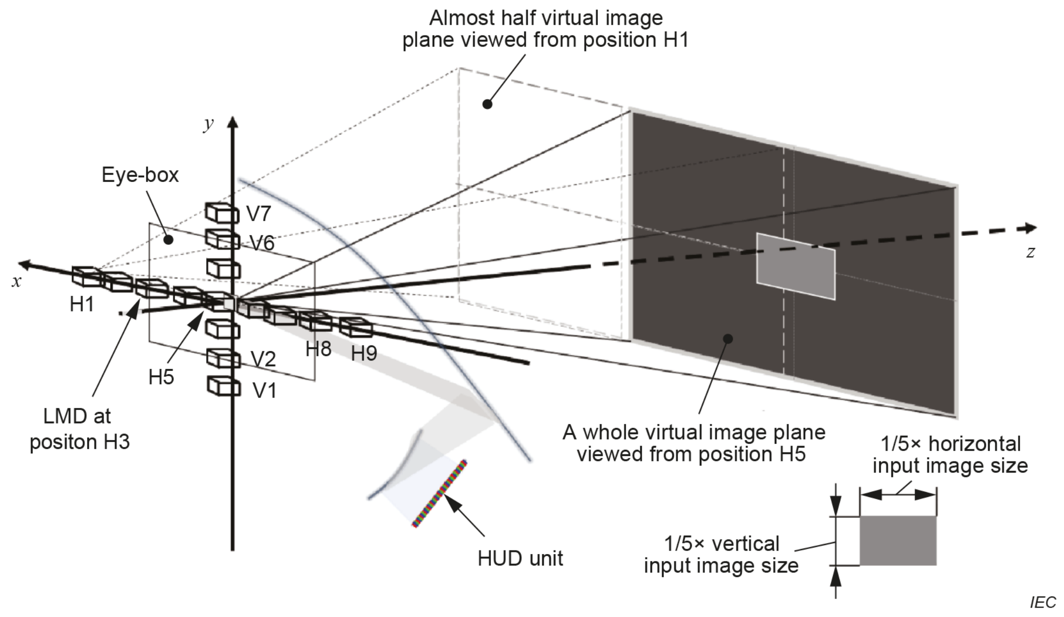

Figure 2 – Configuration for determination of the eye-box

a) a full grey input image (e.g. RGB = 50) with a white outline and a centre grey square (1 / 5 input image size in the horizontal and vertical position, e.g. RGB = 200) can be used as shown in Figure 2;

b) an imaging LMD is located at the designed viewing distance (z = 0) and should be directed to the centre point of the input image;

c) the virtual image of full grey input is captured, and the luminance of the centre grey square is measured by moving the imaging LMD in an increment of 5 mm from left to right;

NOTE 1 When the experimenter visually observes the virtual image (in Figure 2) at the designed viewing distance, the left border of the target virtual image starts to be viewed. The LMD is placed at position H1.

d) find the maximum luminance value from those measured while moving the imaging LMD, and calculate the percentage of the maximum luminance value at all imaging LMD locations;

e) the leftmost and rightmost positions, at which the full grey image with the white outline is acquired and the percentage of the maximum luminance value is greater than 50 %, are determined in the x-axis (for instance, almost half of the virtual image plane and 40 % of the percentage of the maximum luminance value are only acquired by the imaging LMD at the H1 position);

NOTE 2 The percentage of the maximum luminance value applied to find the eye-box boundary can be selected as 50 % or something else, but the value will be recorded in the report.

f) for example, the leftmost and rightmost horizontal positions to be determined are H3 and H8 in Figure 2;

NOTE 3 The left eye and right eye are located at the leftmost and rightmost positions determined through the procedures (a) to (e). Both eyes are free to be located inside the leftmost and rightmost positions.

g) the horizontal centre (x = 0) is found from the middle position of H3 and H8;

h) the virtual image of full grey input is captured and the luminance of the centre grey square is measured by moving the imaging LMD in an increment of 5 mm from the bottom through the horizontal centre (x = 0) to the top;

i) find the maximum luminance value from those measured while moving the imaging LMD, and calculate the percentage of the maximum luminance value at all imaging LMD locations;

j) the bottommost and topmost positions, at which the full grey image with the white outline is acquired and the percentage of the maximum luminance value is greater than 50 %, are determined in the y-axis;

k) for example, the bottommost and topmost vertical positions to be determined are V2 and V6 in Figure 2;

l) the vertical centre (y = 0) is found from the middle position of V2 and V6; and

m) the zero position (xyz = 0) is finally determined.

4.2.3 Measuring configuration for geometric property

Figure 3 illustrates the configuration of three imaging LMDs and the test pattern displayed on the virtual-image plane in the three-dimensional xyz−coordinate system for evaluating geometric characteristics of the virtual projected image.

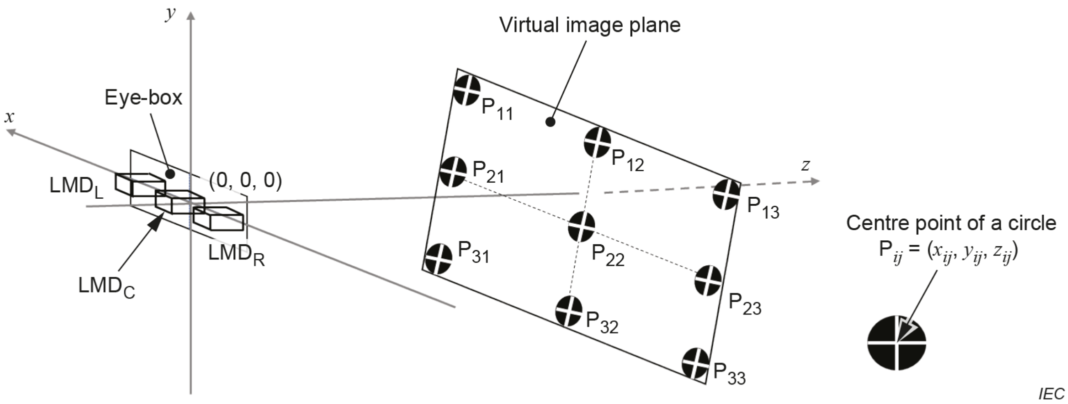

Figure 3 – Measuring setup for geometric property

The measurement items for assessing the virtual image geometry relative to a user's eyes are the look down/over angle, virtual image distance, and field of view. To ensure that projections are properly aligned, geometric distortion is also measured. The centre of the eye-box is defined to be the origin (x = 0, y = 0 and z = 0) at which the centre imaging LMD (LMD_C) is placed. The gap between the left (LMD_L) and right (LMD_R) imaging LMDs is assumed to be the same as the inter pupil distance (IPD) of a user. The average IPD of 60 mm or 65 mm can be used for this gap. The IPDs are selected to reflect mean values among both male and female examinees found in previous research [2]. The distance between the $LMD_{L(R)}$ and LMD_C is the half of the distance between the LMD_L and LMD_R. If one imaging LMD instead of three imaging LMDs is applied, the measurement can be conducted by moving the imaging LMD. The measuring point for each of the nine black circles in the test pattern is named P_{ij} (i and j = 1, 2, 3). P_{ij} can be expressed as $(x_{ij},\ y_{ij},\ z_{ij})$ in the xyz-coordinate system.

The 3D virtual image/object to be evaluated can be located on the virtual image plane or in the front/rear of the virtual image plane (Figure 1). If the 3D virtual image/object is placed on the virtual image plane, there is no parallax. On the other hand, if the 3D virtual image/object to be evaluated is located in the front or rear of the virtual image plane, there is negative or positive parallax.

Annex B describes the principle of the geometric-property measurement method applied for this document and comparisons with other measurement methods. Annex C provides the geometric calibration process for the imaging LMD. The required calibration level should satisfy the following condition.

The rotation matrix R in the calibration result of three imaging LMDs (LMD_L, LMD_C and LMD_R) in Figure 3 should be $R_L = R_C = R_R$ in theory. For the practical case, if $R_L \neq R_C \neq R_R$, there is then nonzero for the difference in the vertical pixel index of $\left|n_{ij}^{L} - n_{ij}^{R}\right|$ between the captured images by LMD_L and LMD_R where the n is vertical pixel index of the captured image of the test pattern ij. To obtain reliable results, the value of $\left|n_{ij}^{L} - n_{ij}^{R}\right|$ should be less than 1 %, that is, the difference in the vertical pixel index between the captured images by LMD_L and LMD_R should