IEC TS 63033-1

Edition 1.0 2017-05

TECHNICAL SPECIFICATION

colour inside

Car multimedia systems and equipment – Drive monitoring system
Part 1: General

IEC TS 63033-1:2017-05(en)

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Part 1: General

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.160.99; 43.040.15 ISBN 978-2-8322-4282-7

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Part 1: General

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IEC TS 63033-1, which is a technical specification, has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
100/2819/DTS	100/2877/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63033 series, published under the general title *Car multimedia systems and equipment*, can be found on the IEC website.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

The drive monitoring system is a camera-based visual system enabling the car user to record and view in real time the surrounding visual image of their vehicle from anywhere within a 360° surround view perspective. The purpose of this document is to specify the model for generating the desired surrounding visual image of the drive monitoring system. Typically, the drive monitoring system is defined by the audio-visual monitoring system requirements of the car multimedia system and equipment.

To ensure the correct positioning of the car in relation to its surroundings, the rear-view monitor for parking assistance, the blind spot monitor for displaying views of the blind spots, and the bird’s-eye view monitor are used. Each drive monitoring system provides a different viewpoint to the car's driver. It’s a heavy burden for a car driver to switch between these systems and quickly recognize the multiple fields of view. In addition, the fields of view are limited to these camera systems which cannot freely change the eye point depending on the driving situation. As a result, the usage cases for these types of systems are limited to singular functions such as parking assistance. Furthermore, on commercial vehicles such as trucks, buses and other special vehicles, ranging from construction to agricultural machinery, the usage cases for these systems is even more limited. In these vehicle types, there might exist situations in which no one is available to assist the driver in properly ensuring the car's correct and safe position.

To resolve these problems, the drive monitoring system provides the driver with the optimal surround view image as constructed by the model explained in this document. It provides the optimal viewpoint of the vehicle and its surroundings to the driver for ensuring the car’s good positioning in various driving situations (parking, turning, high traffic situations, etc.). This is not only true for passenger cars, but good positioning can also be quickly ensured for commercial vehicles and other special vehicles as well.

Part 1 specifies the model for generating the surrounding visual image of the drive monitoring system. Part 2 specifies the information sets that are provided by the drive monitoring system, which include recording methods for that information and the actual visual images. Part 3 specifies the measurement methods of surrounding visual images for the drive monitoring system.

CAR MULTIMEDIA SYSTEMS AND EQUIPMENT – DRIVE MONITORING SYSTEM

Part 1: General

1 Scope

This document specifies the model for generating the surrounding visual image of the drive monitoring system.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

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 Terms and definitions

3.1.1
car
any kind of powered wheeled vehicle

3.2 Abbreviated terms

3D	three dimensional
camera ECU	camera electronic control unit
CAN	controller area network
GUI	graphical user interface

4 System model

4.1 General

The system model of the drive monitoring system is described in Figure 1. Cameras, which are mounted on the outside the car, capture the visual image of the environment outside the car. The visual images are projected onto a virtual 3D projection surface that is then displayed as a composite image onto the monitor. The images displayed can be rendered from any viewpoint within the 3D projection surface, thus enabling the optimal viewing perspective onto the display based on the scenario. The number of cameras required on vehicles other than passenger cars may be more than four depending on the size and shape of the car. This model defines a drive monitoring system with four cameras as typical for most car type applications. The number of cameras used in generating each composite image may change depending on the viewpoint. The mounting positions and angles for the four cameras should be calibrated as per the method described in 4.2 and 4.3.

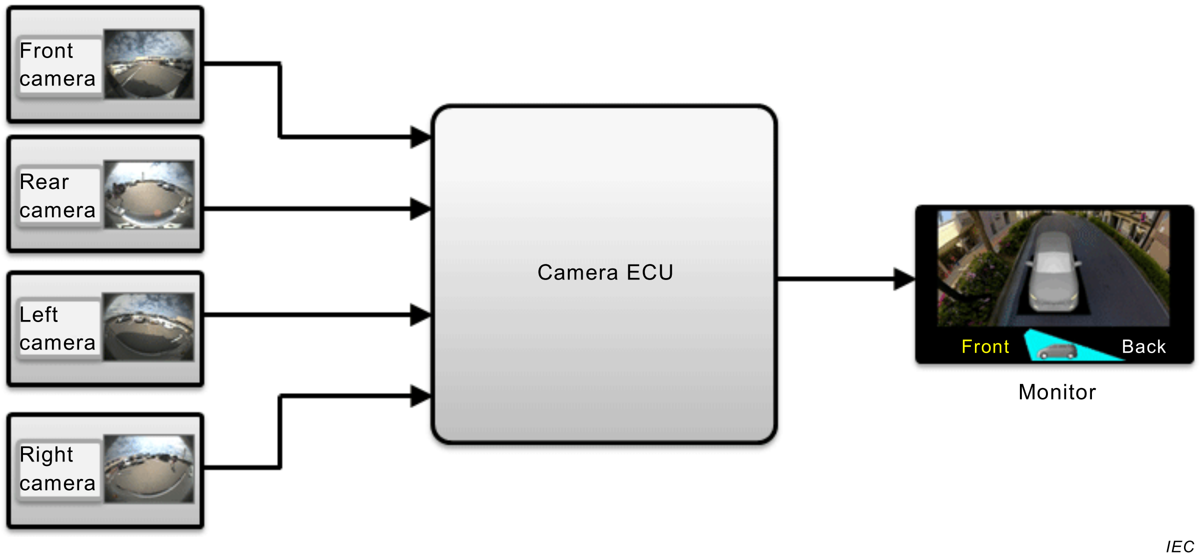

Figure 1 – System model for the drive monitoring system

4.2 Number of cameras and camera field of view

The horizontal angle of view of the camera is described in Figure 2. Overlapping areas and blind spots on the horizontal field of view change depending on the number of cameras and the horizontal positioning – viewing angle of the cameras. Overlapping areas between adjacent cameras should be wide for better composite views. The number of cameras and the horizontal angle of view of the camera should be determined such to ensure there are no blind spots. In regards to the vertical angle of view, the tilt angle of the front and rear cameras (ψ_{Front}, ψ_{Rear}) is described in Figure 3. The blind spot of the vertical field of view will change depending on the vertical and the tilt angle (ψ) of the camera. The vertical angle of view of the camera and the tilt angle (ψ) should be decided such to ensure that no blind spots are generated. The details are described in Annex A.

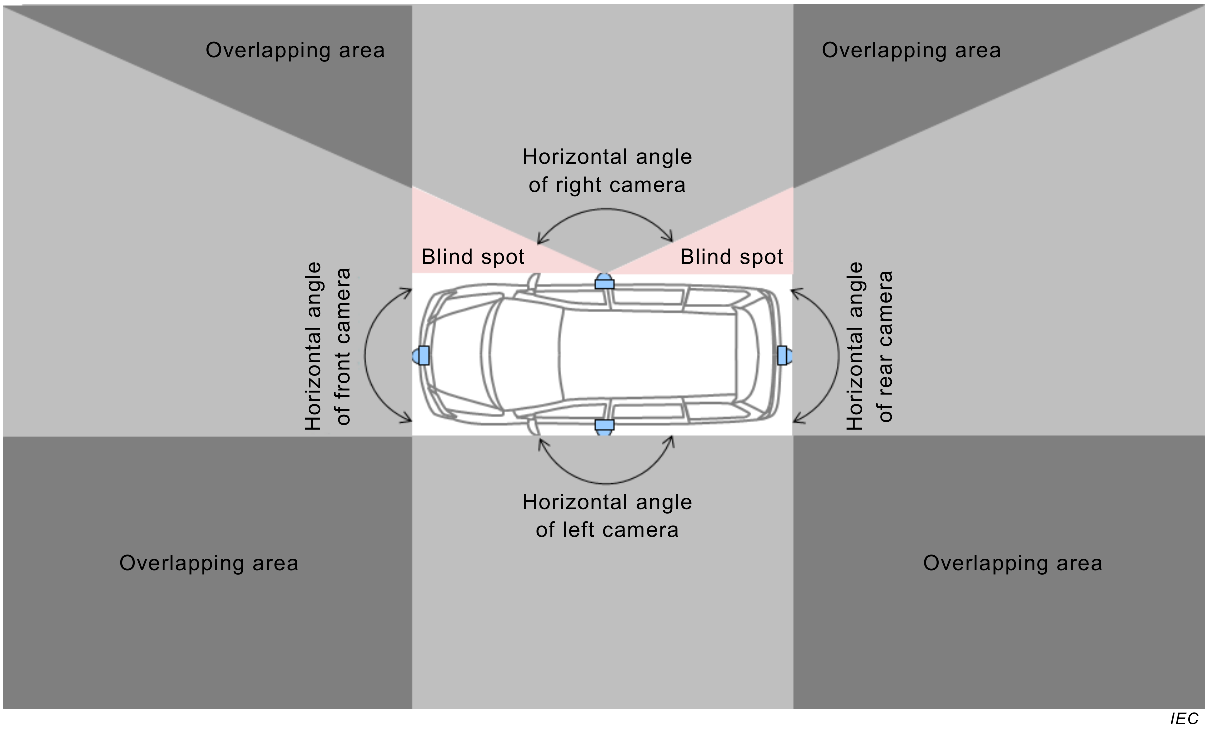

Figure 2 – Horizontal angle of view of the camera

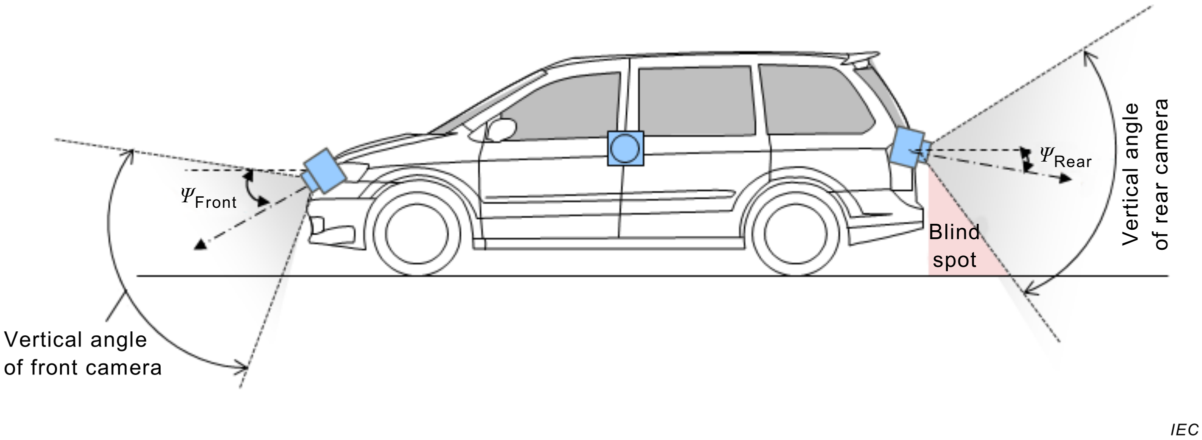

Figure 3 – Vertical angles of view of the camera

4.3 Method for projecting visual image to 3D projection surface

Following the right-handed coordinate system, the length of the car is the Y_{car} axis, the width direction of the car is X_{car} axis and the vertical direction is the Z_{car} axis. The vehicle's cameras capture and generate a video image that is projected onto a virtual projection surface, with the road surface being at $Z_v = 0$ (refer Figure 5). This virtual projection surface is then projected onto a 3D projection surface as further described in Figure 4 and Figure 5. The 3D projection surface that should be used is described in Figure 4. Projecting the camera generated image onto a 3D projection surface is described in Figure 5. The 3D projection surface should be a 3D sphere whose polygon model is similar to a polyhedron. One point of the projection image (P_V coordinate of the 3D projection surface), is converted to one point (P_C coordinate of the camera coordinate system) based on the optics origin of the car's cameras. This coordinate conversion is defined as:

$$P_C = M_{V \to C} \times P_V$$

Where $M_{V \to C}$ is the coordinate conversion matrix to the car coordinate system, fixed by the camera mounted position and the angle for the car coordinates. Incident vector V_i when the car's camera photographs the subject at position P_C is defined as:

$$V_i = -\frac{P_C}{|P_C|}$$

The coordinates of the car's camera image that records the subject of incident vector V_i can be calculated by the internal parameter of the car's camera. Projecting the car's cameras' captured composite image onto a 3D projection surface is realized by arranging the pixels of four cameras with the relations mentioned above.

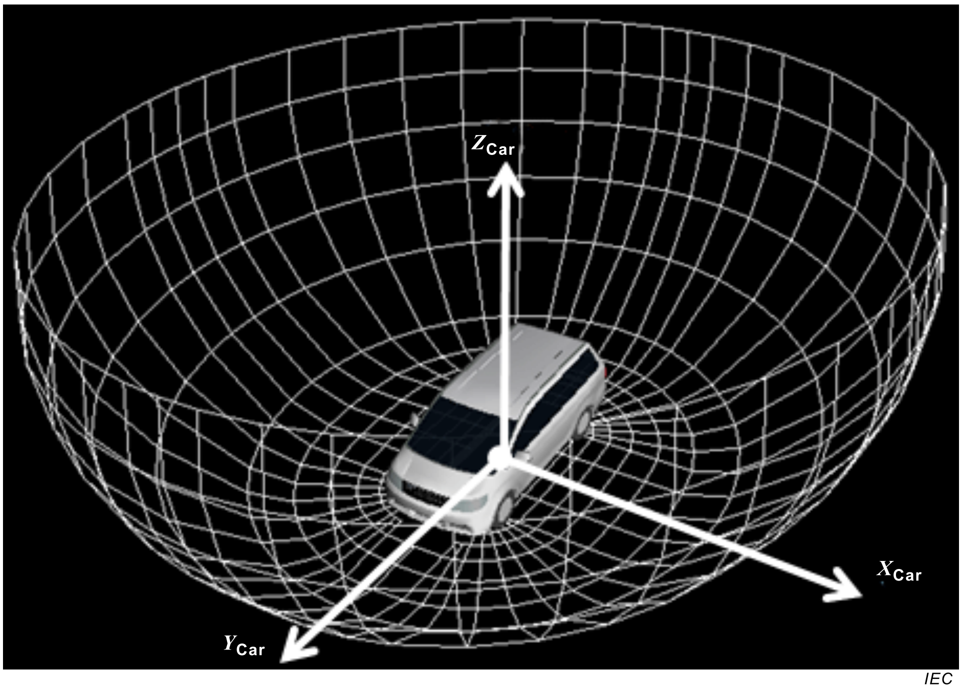

Figure 4 – 3D projection surface

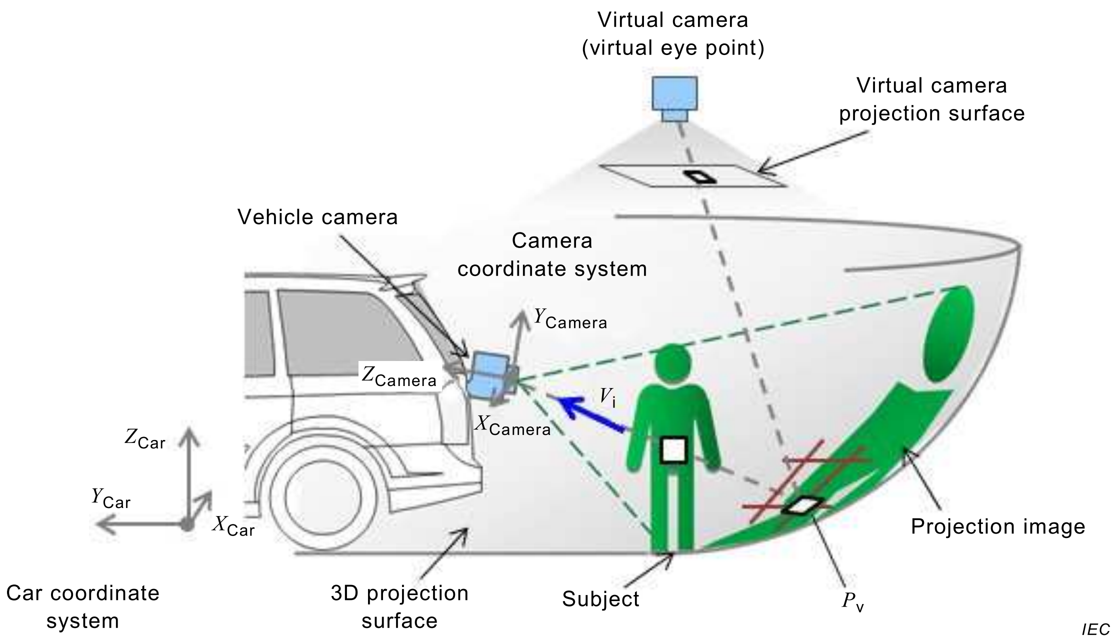

Figure 5 – Projecting to 3D projection surface

4.4 Visualizing the projection image at free eye point

The virtual eye point is the ability to change viewing perspective anywhere within the 3D projection. The polygon model constituting the 3D projection surface is visualized from any virtual eye point. Visualizing the polygon model uses 3D computer graphics technology. The texture image is the car's camera image updated at a video rate. The wrap around view image is composed by performing the polygon rendering, which associates the image coordinate of the car's cameras with the polygon vertex as texture coordinates.

4.5 Free eye point capability

The virtual eye (sometimes referred to as ‘free eye’) point parameters of direction and field of view of the virtual camera are freely changeable during polygon rendering. The free eye point is fully changeable to any viewing perspective within the 3D projection surface. Positioning of the virtual eye point is accomplished by changing the virtual camera parameter in relation to the car's surroundings and the driving situation. Thus, the real-time rendering of the video image, tied between individual eye points, is capable of smoothly changing by the continuous changing of these virtual camera parameters.

5 Camera configuration

5.1 Camera

The lens of the camera should be isotropic and have a rotary symmetric distortion characteristic in an optional axis. The details are described in Annex B.

5.2 Lens distortion data

Lens distortion data should be input during calibration. Lens distortion data should be arranged as the coordinate data of the height of real image corresponding to the incidence angle value, in ascending order. The type of lens distortion data incorporates both rotationally symmetric lenses and non-rotationally symmetric lenses.

5.2.1 Distortion data of rotationally symmetric lens

Distortion data of rotationally symmetric lenses is described in Figure 6. It is composed of the angles of incidence (a_1 and a_2) between the optical axis's centre and their distances (d_1 and d_2) from the centre. The distortion data format of a rotationally symmetric lens is described in Figure 7.

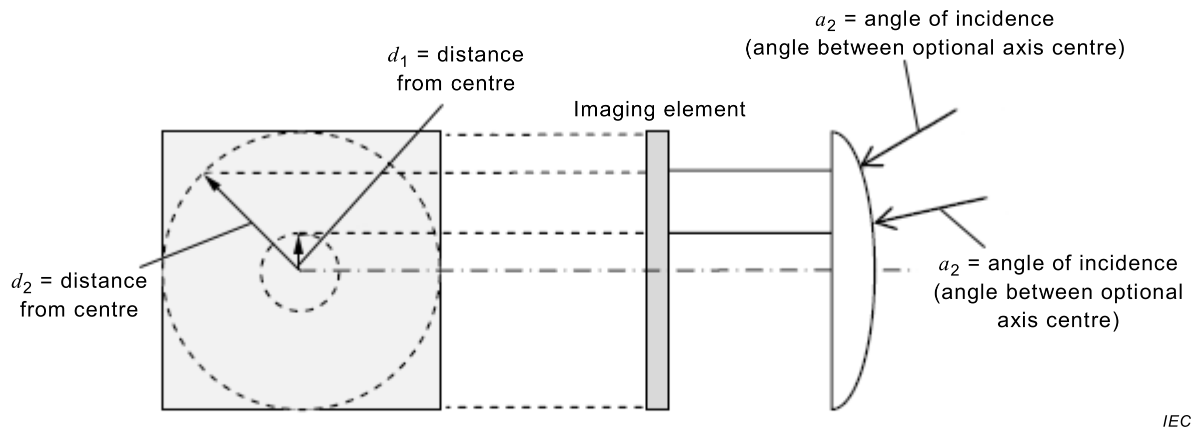

Figure 6 – Distortion data of a rotationally symmetric lens

File identifier	: [#]
Camera element size	: [Width, Height]
Camera element dot pitch	: [Dot pitch X, Dot pitch Y]
Number of array data	: [n]
Array definition	: [Angle of incidence, Height of real image]
	(unit: degree) (unit: mm)
	[a_0 , :]
	[a_1 , :]
	[a_2 , :]
	[: , :]
	[: , :]
	[: , :]
	[: , :]
	[a_{n-2} , :]
	[a_{n-1} , :]

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Figure 7 – Distortion data format of a rotationally symmetric lens

5.2.2 Distortion data of non-rotationally symmetric lens

Distortion data of non-rotationally symmetric lens types is described in Figure 8. It is composed of an angle of incidence (pan angle and tilt angle) and the location (x,y) on the imaging element. The distortion data format of a non-rotationally symmetric lens is described in Figure 9.

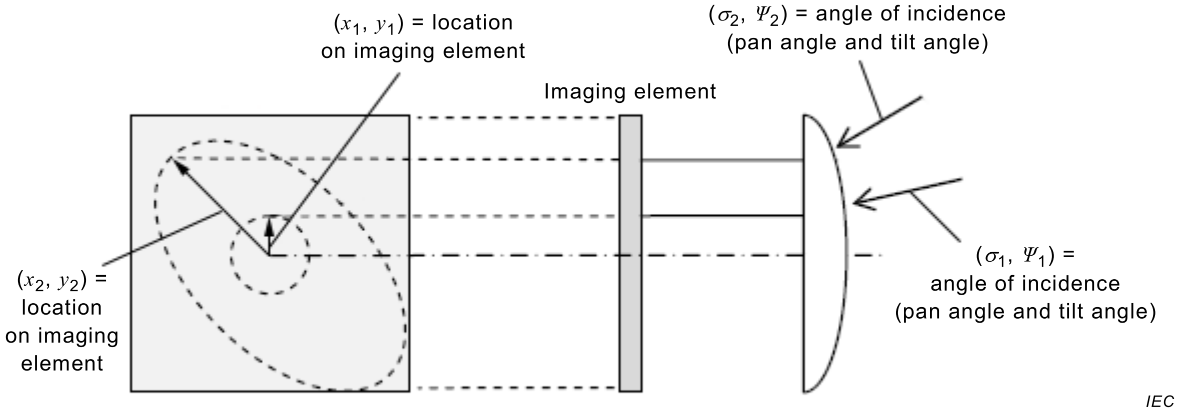

Figure 8 – Distortion data of a non-rotationally symmetric lens

File identifier	: [#]			
Camera element size	: [Width, Height]			
Camera element dot pitch	: [Dot pitch X, Dot pitch Y]			
Number of array data (lines, rows)	: [n, m]			
Array definition	: [Pan angle of incidence, (unit: degree)	Tilt angle of incidence, (unit: degree)	Real image x coordinate, (unit: mm)	Real image y coordinate] (unit: mm)
	[p,t$_{(0,0)}$	, :	, :	, :]
	[p,t$_{(0,1)}$	, :	, :	, :]
	[p,t$_{(0,2)}$	, :	, :	, :]
	[:	, :	, :	, :]
	[:	, :	, :	, :]
	[p,t$_{(0,m-1)}$	, :	, :	, :]
	[p,t$_{(1,0)}$	, :	, :	, :]
	[:	, :	, :	, :]
	[:	, :	, :	, :]
	[:	, :	, :	, :]
	[:	, :	, :	, :]
	[p,t$_{(n-2,m-1)}$	, :	, :	, :]
	[p,t$_{(n-1,0)}$	, :	, :	, :]
	[:	, :	, :	, :]
	[:	, :	, :	, :]
	[p,t$_{(n-1,m-2)}$	, :	, :	, :]
	[p,t$_{(n-1,m-1)}$	, :	, :	, :]

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Figure 9 – Distortion data format of a non-rotationally symmetric lens

5.3 Optical axis shift data

Optical axis shift data should be used at calibration. Optical axis shift includes optical axis shift of camera, shift by AD or DA conversion and shift from ideal capture image. The optical axis shift adjusts the amount of shift from the central coordinates using the captured image's width and height as an input. Optical shift data that should be matched on the texture coordinate is described in Figure 10. The format of optical shift data is described in Figure 11.

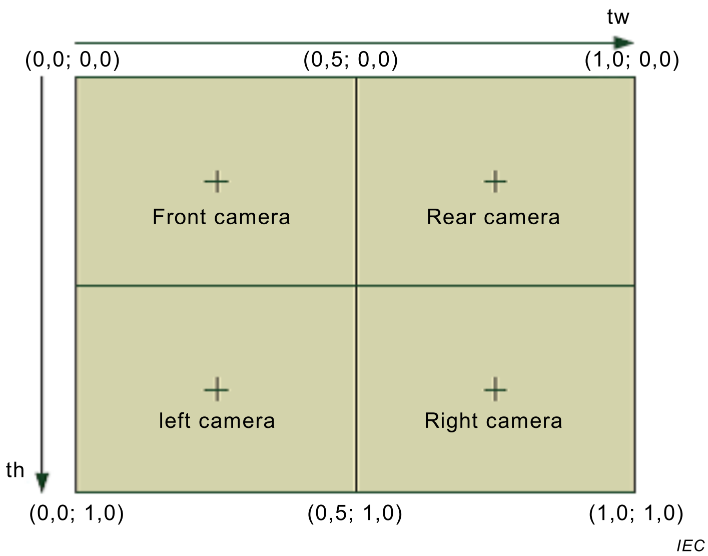

Figure 10 – Texture normalization coordinate at the centre of each optical axis

File identifier	: [#]				
Front camera	: [(Texture normalization tw coordinate at each camera optical axis center),	(Texture normalization th coordinate at each camera optical axis center),	(Pixel expansion rate at horizontal direction),	(Pixel expansion rate at vertical direction)	]
Rear camera	: [	,	,	,	]
Left camera	: [	,	,	,	]
Right camera	: [	,	,	,	]

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Figure 11 – The format of optical shift data

6 Rendering

6.1 General

The composite view data should be designed by the camera ECU manufacturer beforehand. In real time, the composite view is rendered using the camera parameter generated in Annex C based on the pre-designed composite view data. For every composite view data, the following data and parameters should be set:

– 3D projection surface data,

– capture spec data,

– conversion of eye point parameter,

– virtual 3D image car model data,

– guide line and bitmap data,

– layout data and layer setting data.

6.2 Composite view data

6.2.1 3D projection surface data

3D projection surface examples are described in Figure 12. They should be designed depending on the car's size, the car's shape and the virtual eye point in every composite view data.

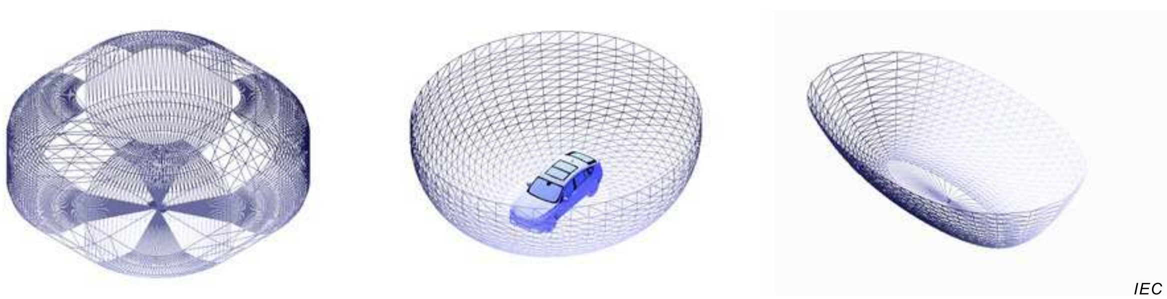

Figure 12 – 3D projection surface data

6.2.2 Capture size

Capture size indicates an effective pixel size of each camera and should be determined based on the resolution of the cameras used. The capture specification data format is described in Figure 13.

File identifier	: [#]
Camera format	: [(Color space)]
Front camera	: [(Effective horizontal pixel size) x (Effective vertical pixel size)]
Rear camera	: [ ]
Left camera	: [ ]
Right camera	: [ ]

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Figure 13 – Capture specification data format

6.2.3 Conversion of eye point parameter

The virtual eye point should be fixed in every composite view depending on camera angle, position and scaling. The position of the point of view, the direction of view and the scope of view, are interpolated before and after changing. Therefore, the driver can instantly recognize from what position he is viewing his care and quickly respond, if necessary, to ensure the correct position. The camera angle in the conversion of eye point is described in Figure 14. Camera position/scaling in conversion of eye point is described in Figure 15.

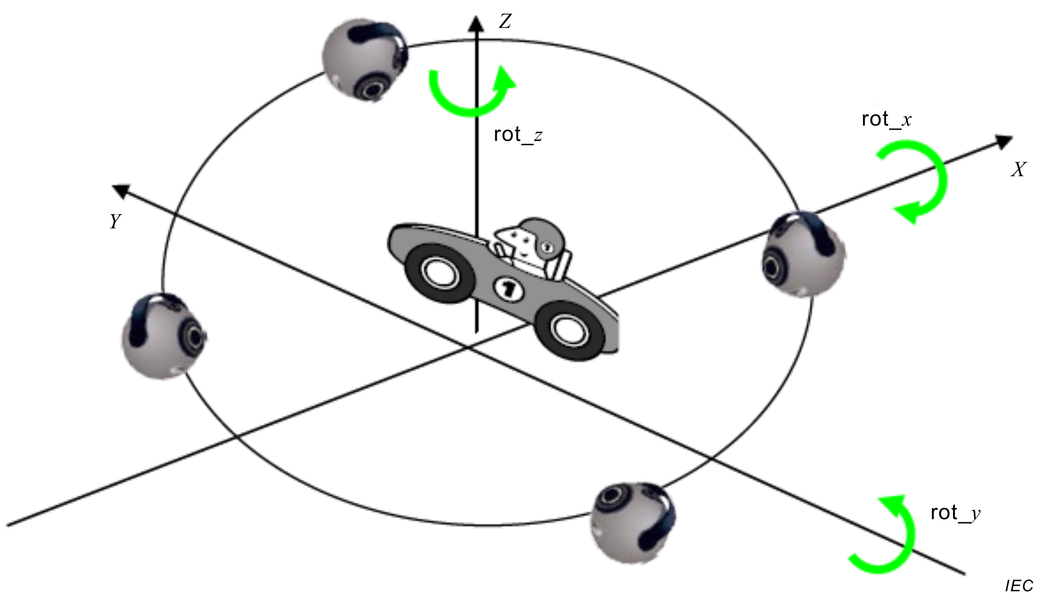

Figure 14 – Camera angle in conversion of eye point

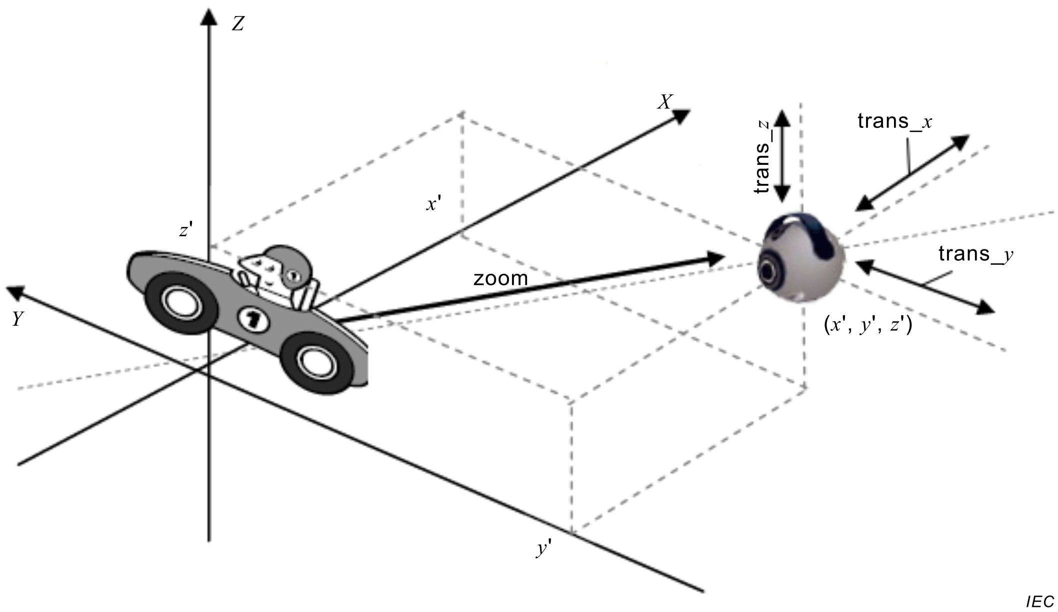

Figure 15 – Camera position/scaling in conversion of eye point

6.2.4 Virtual 3D image car model data

Virtual 3D image car model data should be designed with real dimensions based on the circumscription quadrangle of the camera's mounting position fixed in Annex A. The transmittance of virtual 3D image car model data should be set in every composite view data. Virtual 3D image car model at original dimensions is shown in Figure 16. Virtual 3D image car model at real dimensions is shown in Figure 17.

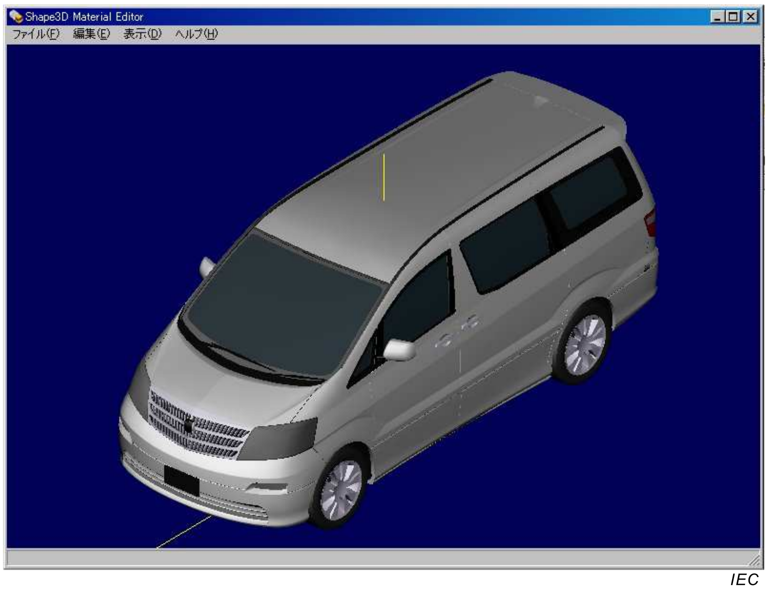

Figure 16 – Virtual 3D image car model at original dimension

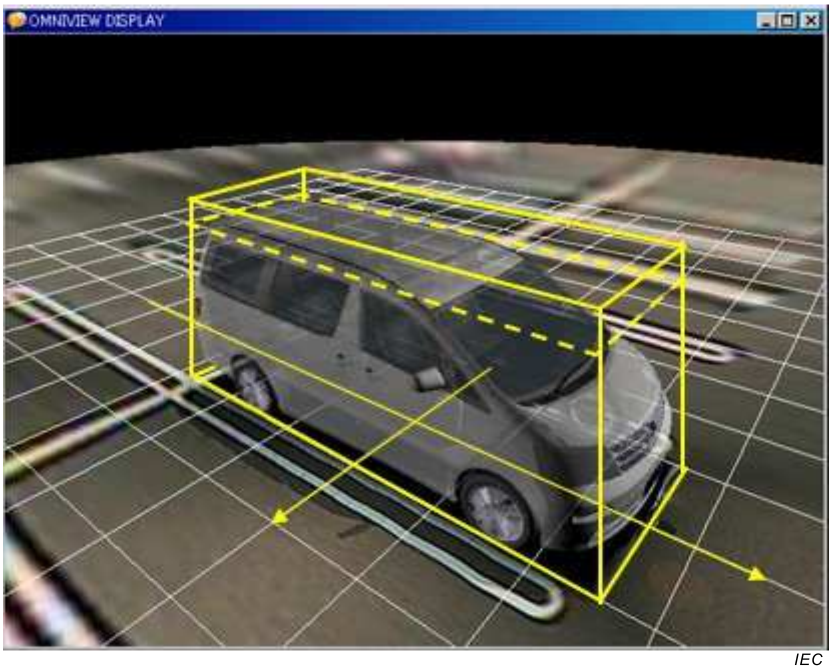

Figure 17 – Virtual 3D image car model at real dimension

6.2.5 Guide line and bitmap data

An example of guide lines for outlining the position of the car and bitmap for highlighting the virtual eye point is shown in Figure 18. The guide line and bitmap data should be added for GUI improvement.

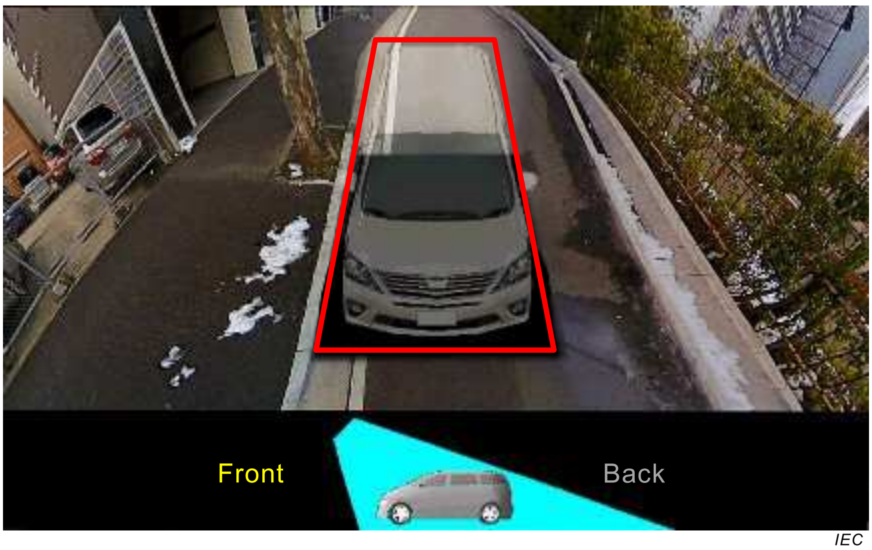

Figure 18 – Guide line and bitmap data

6.2.6 Layout data and layer setting data

Layout data and layer setting data should be designed in every composite view data. Layout data should be defined by the camera image coordinate system (described in Figure 19), screen coordinate system (described in Figure 20) and object coordinate system (described in Figure 21). The camera image coordinate system deals with an actual camera image. Its size is the input size of an actual camera image. The screen coordinate system deals with an object on an actual screen and can layout two or more objects in the screen. The object coordinate system deals with separate objects respectively in the coordinate system. The relation of layout data and layer setting data is described in Figure 22.

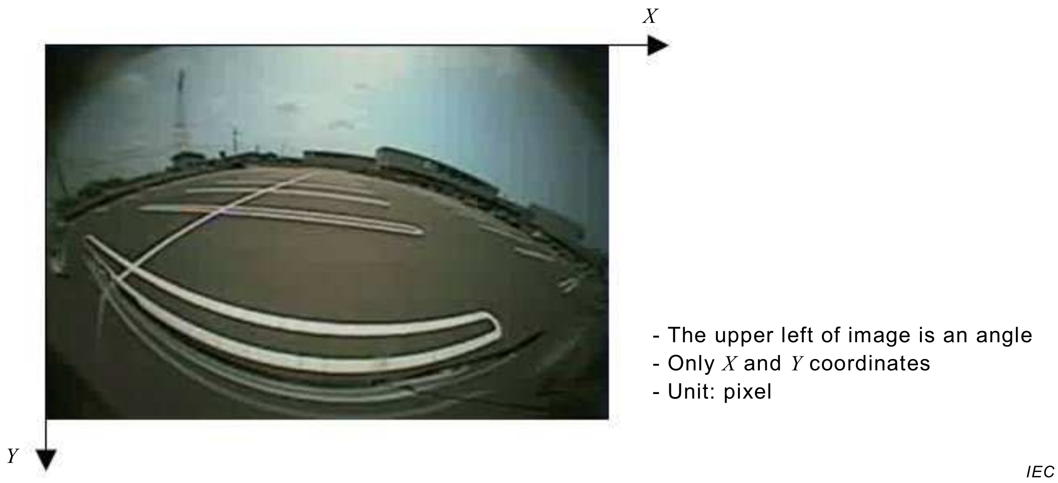

Figure 19 – Camera image coordinate system

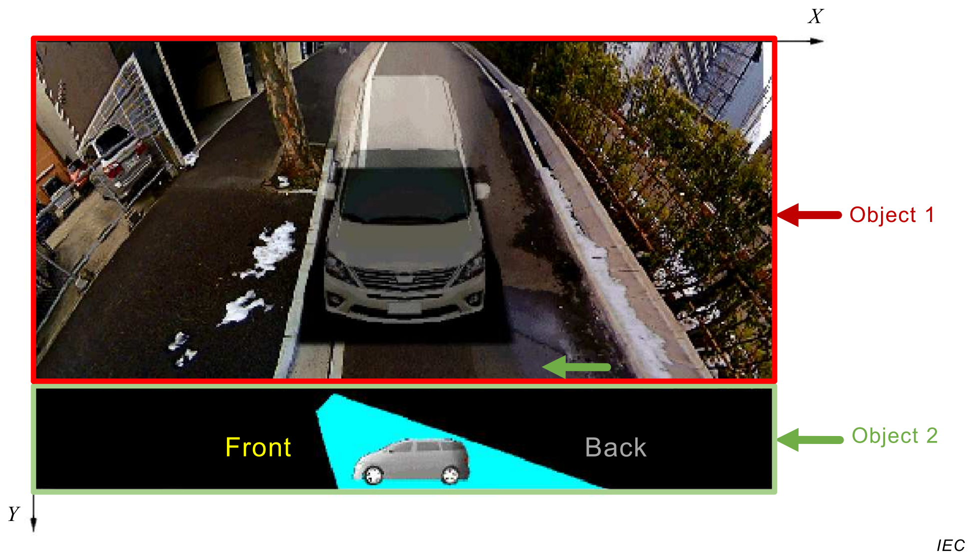

Figure 20 – Screen coordinate system

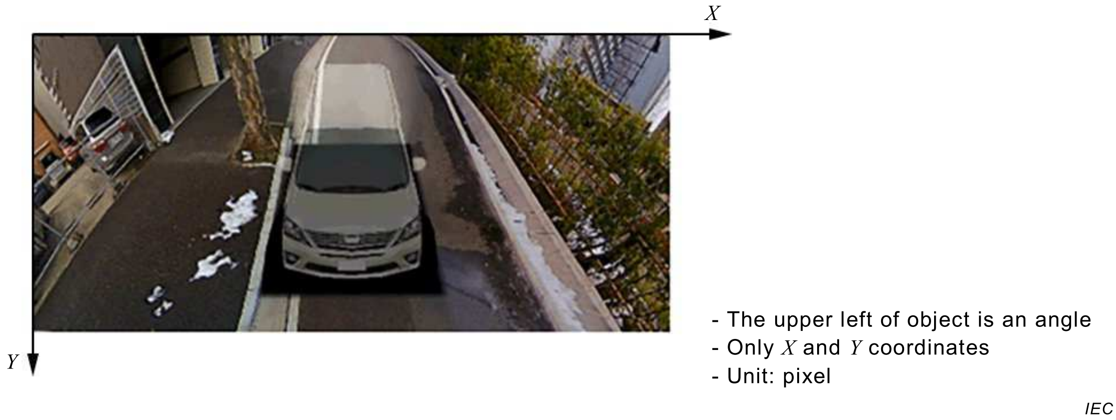

Figure 21 – Object coordinate system

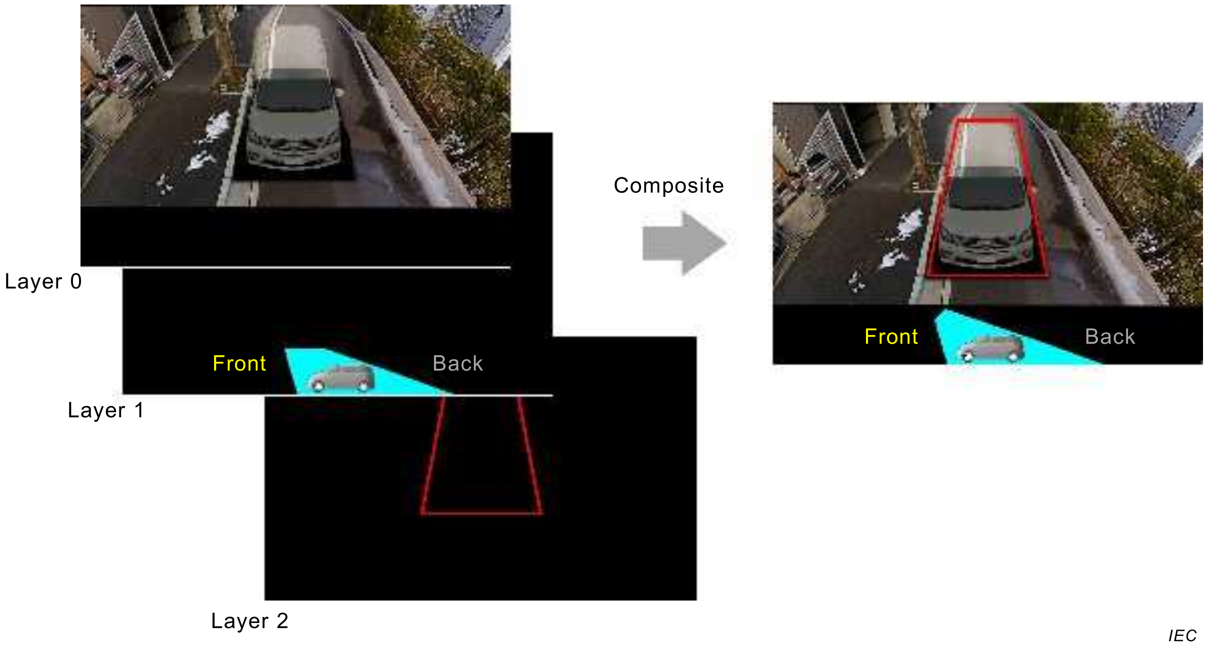

Figure 22 – Layout data and layer setting data

Annex A
(informative)

Camera mounting to the car

A.1 Camera mounting position

Each camera should be mounted on the outside edge of the car to avoid the body of car shutting out the camera views. The front and rear facing cameras should be aligned as near to the left to right centre line as possible. The left and right side cameras should be aligned as near to the front to rear centre line as possible.

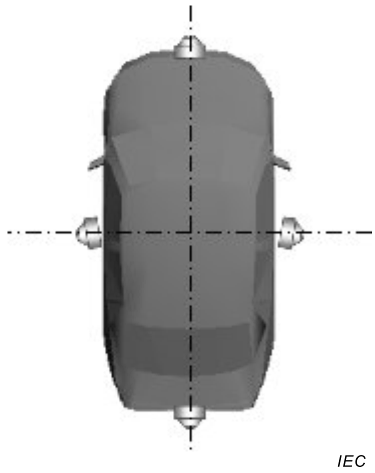

Figure A.1 – Camera mounting position

A.2 Camera mounting height

Each camera should be mounted at a height of more than 60% of the height of the car's body. The four cameras should be mounted at the same height to prevent a disparity in the position of the subject in the composite view at the border area between the cameras. Increasing the height gap between the cameras also increases the parallax between the cameras. The camera mounting height should be adjusted to decrease the parallax between the cameras as much as possible. The mounting height of the four cameras is shown in Figure A.2.

Figure A.2 – Camera mounting height

A.3 Camera mounting angle

The mounting angle of each camera should be adjusted so that the angle for each camera (x, y, z angular position), shall be set such that the combined 360° composite image can be achieved relative to the road surface. Once the mounting angle of each camera is set, it should then be fixed in the calibration process (see Annex C). The mounting angles of the four cameras are shown in Figure A.3.

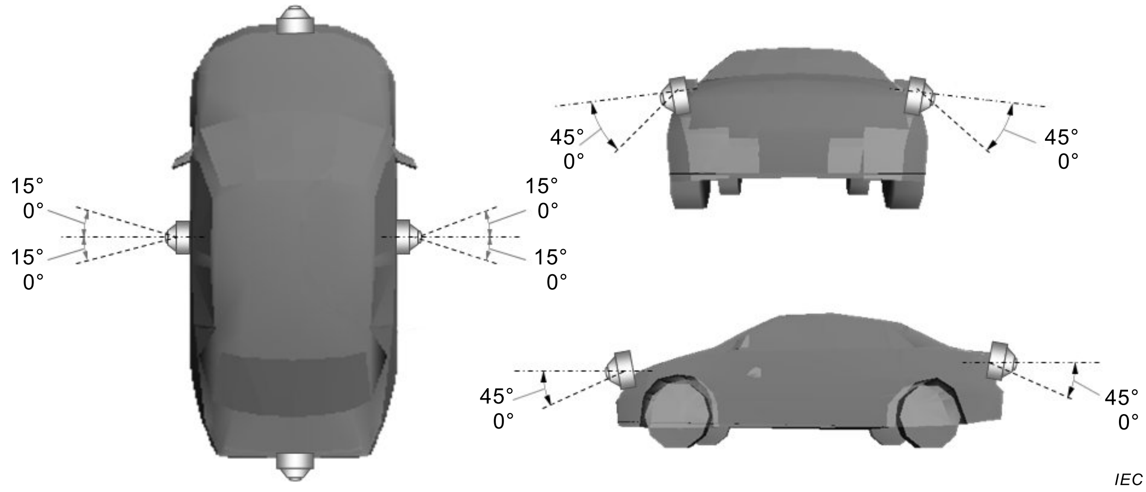

Figure A.3 – Camera mounting angle

Annex B
(informative)

Camera field of view

The horizontal view angle of the camera should be more than 180°. The vertical view angle of the camera should be more than 130°.

Annex C
(informative)

Camera calibration

Camera calibration is shown in Figure C.1. The mounting positions and angles for the four cameras should be calculated by using lens distortion data and optical axis shift data of the car coordinate system. In real use cases, mounting positions and angles for the four cameras should be adjusted for optimizing the composite views.

- Mounting position: x, y, z at optical centre (mm)
- Mounting angle: tilt angle ψ, rot angle φ, pan angle θ at optical axis direction (angles measured in degrees)

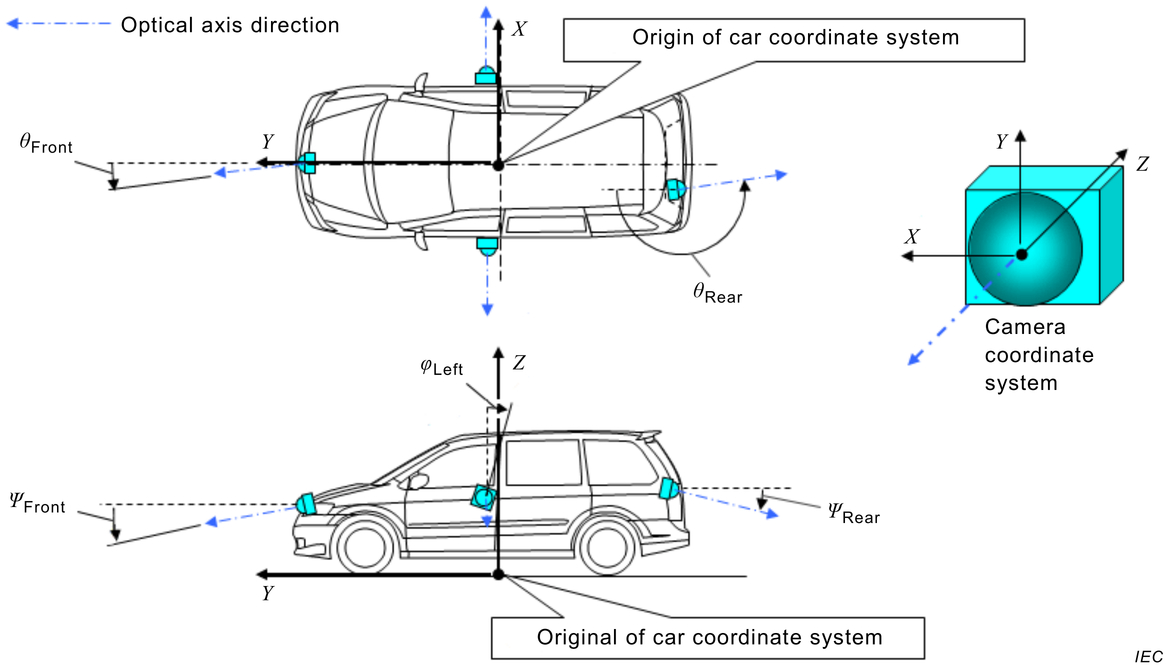

Figure C.1 – Camera calibration

Annex D
(informative)

Display

D.1 Display specification data

Display specification data should be fixed in every composite view. Display specification data should be determined depending on the resolution of the camera.

D.2 Composite view change mode

Composite view change mode should be fixed beforehand. The trigger of the composite view change should be designed by:

– user operation,

– CAN information.

Annex E
(informative)

Time behaviour

E.1 Start-up time

It needs to be ensured that the manufacturer of the camera ECU provides information of the start-up time of the system. The start-up time means the time from power-on ignition to the composite view being displayed on the monitor. The start-up time should be within 10 s.

E.2 Frame rate

It needs to be ensured that the manufacturer of the camera ECU provides information of the frame rate of the system. The frame rate should be more than 30 fps.

E.3 Latency

The camera ECU should have a sufficiently short latency in order to render the image nearly at the same time. The latency should be lower than 100 ms.

Bibliography

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