裸眼立体ディスプレイの光学測定法

NEC液晶テクノロジー株式会社
上原　伸一

Outline

- Background
- Fundamental Principle of Measurement Methods
- Measurements for Viewing Spaces
  - Pseudoscopy
  - 3D Crosstalk
  - 3D Moiré
  - Interocular Luminance Difference
  - …
- Summary

Background

ISO/TC 159/SC 4/WG 2 has decided that a Technical Report on 3D (stereoscopic) displays will be prepared as the first step of standardization.

ISO Standards about "Displays" have been discussed based on ergonomics.

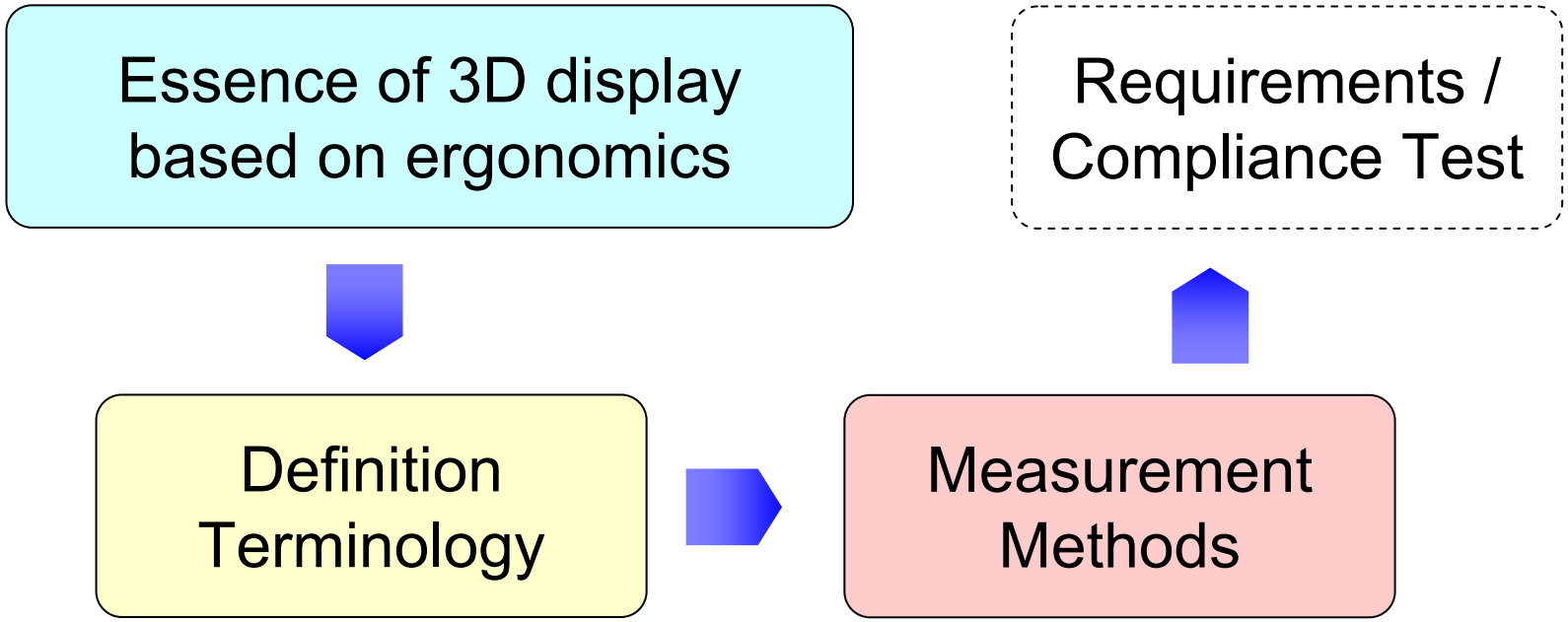
<u>Measurement methods should be based on human factors for 3D displays appropriately.</u>

Proposal of measurement methods for 3D displays

Fundamental Principle of Measurement Methods

Fundamental principle of measurement

- Measurement methods should be based on the definition of 3D display correctly.
- The definition should be based on the essence of 3D display.

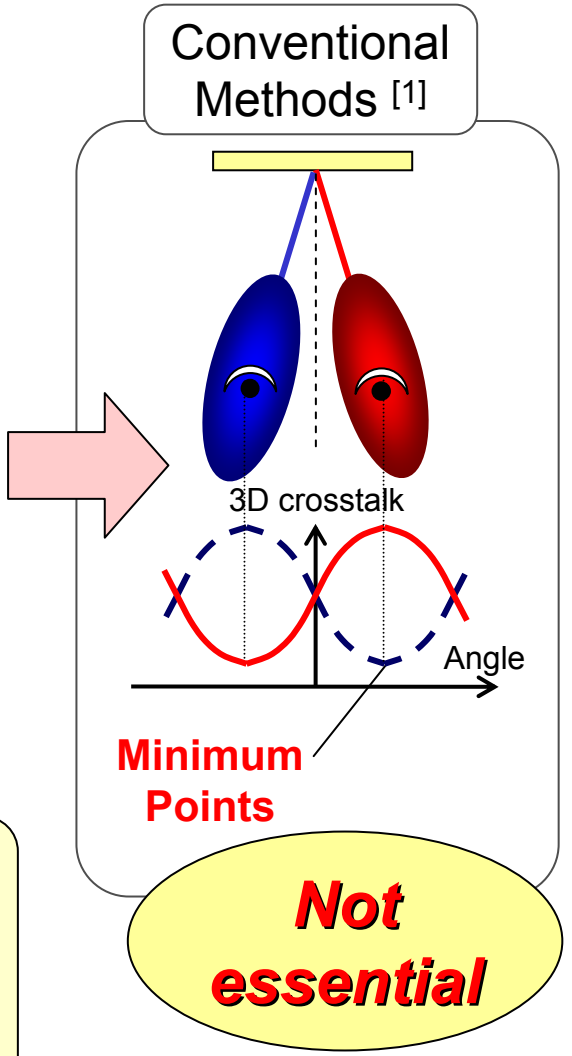


Example of definition & measurement (1)

Definition of two-view autostereoscopic display (Conventional)

A display device with a specific stereoscopic structure that divides the display pixels to two and directs the information from these two pixel groups to two different angles thus creating two views, basically one for the left and one for the right eye of the user.

In this definition, angular measurement will be carried out. However, the relation between angles and views is not clear.

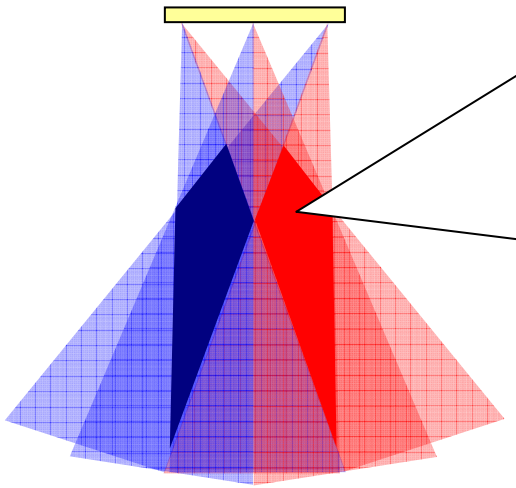


[1] Proc. of Euro Display 2007, S7-3, pp.132-135, 2007.

Example of definition & measurement (2)

Definition of two-view by Japanese Committee

A display device with a specific stereoscopic performance that emits lights to two directions with the different information respectively thus creating a left eye viewing space for viewing left images and a right eye viewing space for viewing right images.



Left eye viewing space
Right eye viewing space

Key point:

Correct measurement of "viewing spaces" that "R/L images" can be seen

- **Measurement at three locations**
- **Evaluation of the space using the proper threshold level**

Fundamental of measurements

NOT
“point”

Autostereoscopic display:
a display that can create space* where requirements for 3D viewing are fulfilled

* In this space, 3D images should be viewed without visual fatigue caused by autostereoscopic displays.

“Space certification” should be a fundamental of measurements.

Measurements for Viewing Spaces

Measurement items and objectives

	Qualified Binocular Viewing Space (QBVS)	Qualified 3D Viewing Space (QSVS)
Pseudoscopy	Pseudoscopy Free	—
3D Crosstalk	—*	Two-view: Crosstalk Free
		Multi/Integral: —*
3D Moiré	Binocular Viewing **	3D Viewing
Interocular Luminance Difference	Binocular Viewing **	3D Viewing
Interocular Chromaticity Difference	Binocular Viewing **	3D Viewing

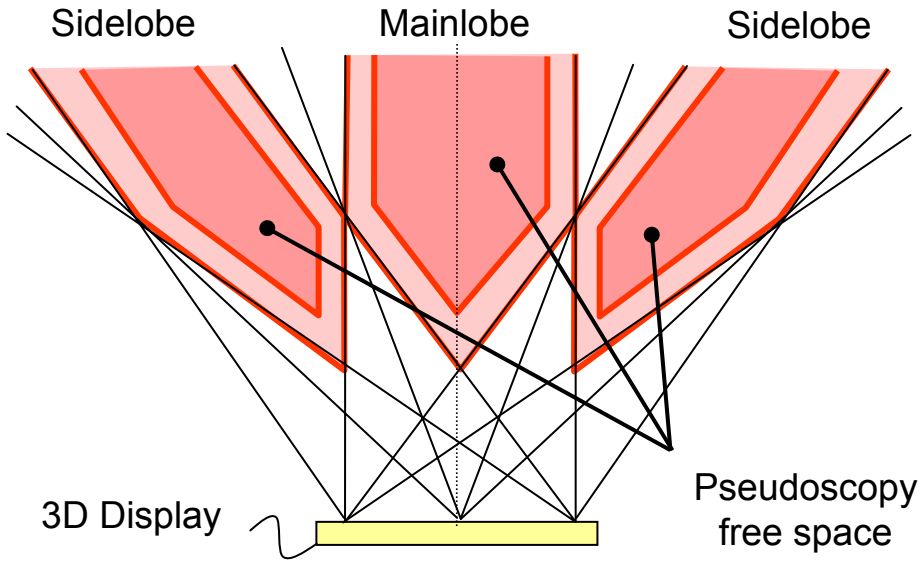
QBVS is defined as the space where users can view images with both eyes without visual fatigue caused by autostereoscopic displays.

* Other measurement methods will be applied.
** Requirement for viewing with both eyes

Pseudoscopy Free Space (1)

a) Objective

- In most autostereoscopic displays, the undesirable space where pseudoscopic images can be seen is formed.
-Pseudoscopic images are considered to be not good for viewing.
-Therefore, the pseudoscopy space should be clear.



* Pseudoscopic images are viewed near the boundary of lobes.
Therefore, first, lobe profiles should be measured.

Pseudoscopy Free Space (2)

b) Applicability:

-All autostereoscopic display technologies

c) Preparation and Set-up

-configurable measurement conditions:

- test patterns: 1 “view” white others black (for all views)

  Optional: gamut measurement

  The supplier should specify which pixels are used for measurement.

- measurement location: Three locations in horizontal (Center, R&L)

Pseudoscopy Free Space (3)

d) Procedure

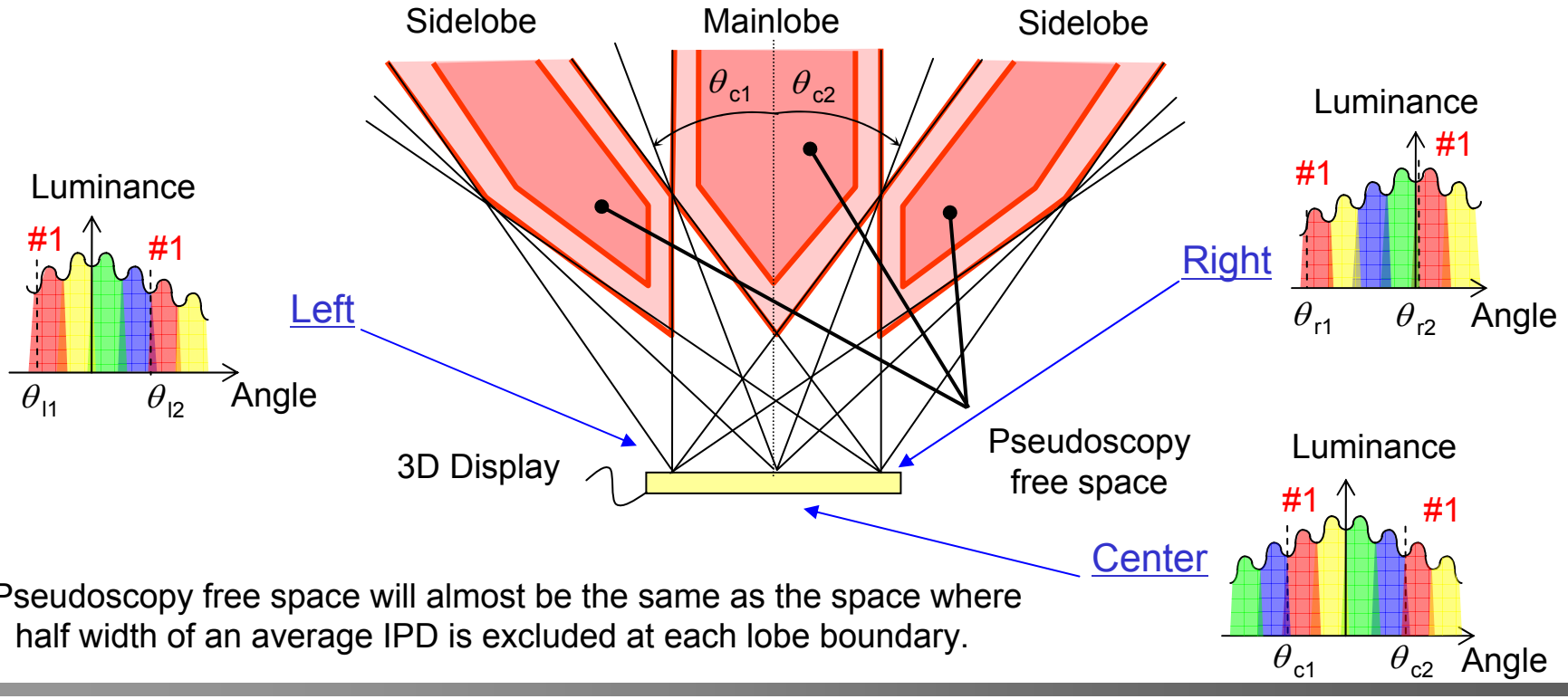
1) Luminance profiles of each view are measured at three locations (Center, R&L).

e) Analysis

1) The angular ranges of recurring views are calculated (θ_{c1}, θ_{c2}, …).

2) By using these angular ranges, each lobe is obtained.

3) Pseudoscopy free space is calculated as the space that a user with an average IPD can not see pseudoscopic image. *

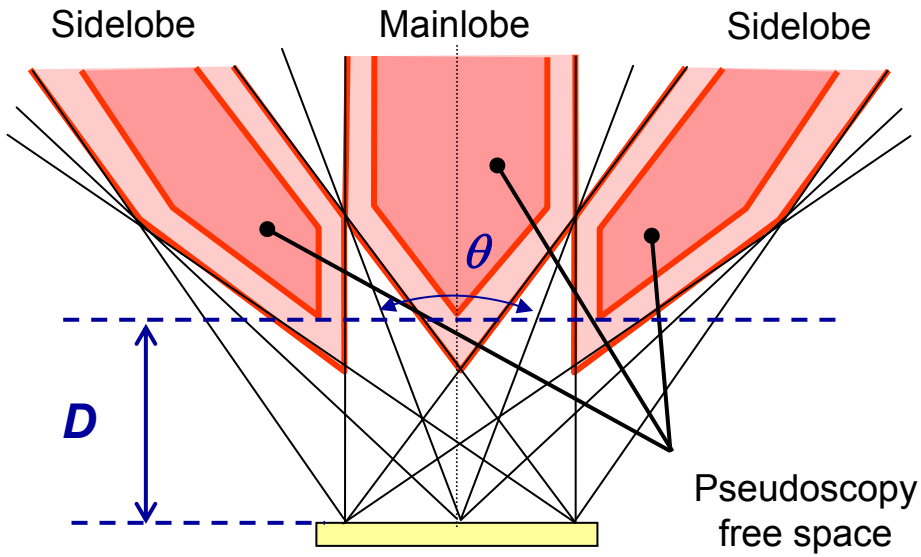


* Pseudoscopy free space will almost be the same as the space where half width of an average IPD is excluded at each lobe boundary.

Pseudoscopy Free Space (4)

f) Reporting

Report each lobe (if necessary) and the pseudoscopy free space.
The angle, distance of lobe or the space will be effective.



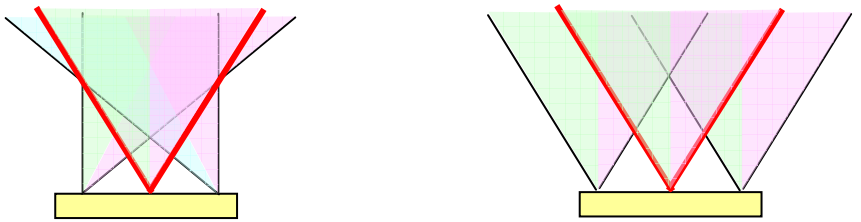
Measurement at three locations

Three locations (Center, Left and Right) are essential for certifications of lobe.

Because...

Parallax images are distributed in different angular directions in horizontal.
The directions at each location is important.

(Example)



One location measurement is NOT appropriate.
At least two locations are needed.

Minimal and essential locations are Left & Right.
In addition, Center is an important location.

Measurement at three locations

* If total screen certification is required, camera test had better be used together.

3D crosstalk free space

a) Objective

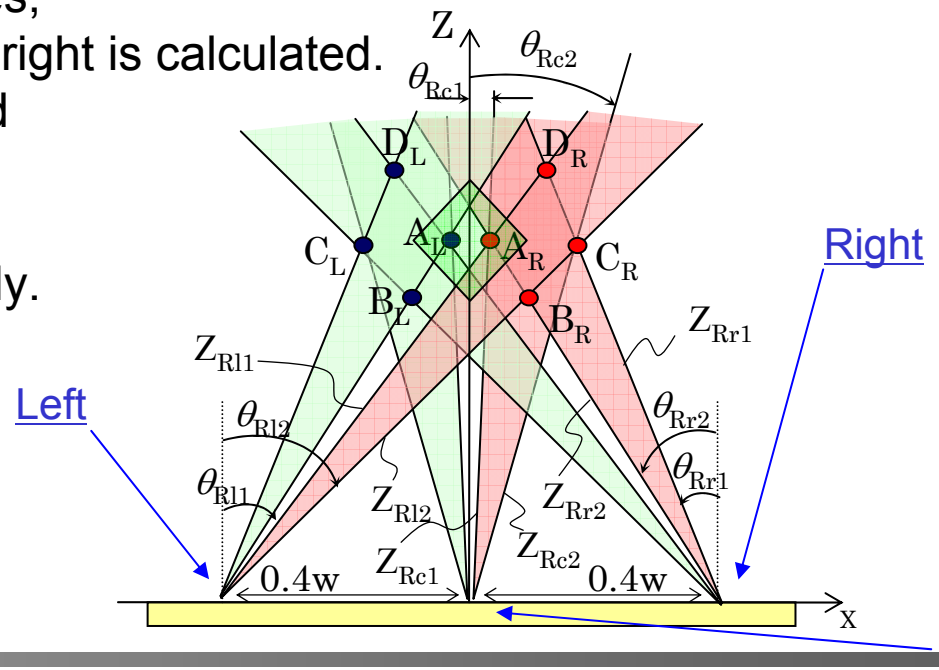
At least, in two-view autostereoscopic displays, 3D crosstalk is considered to be impact parameter, and lower 3D crosstalk level is considered to be preferable.

d) Procedure

Luminance profiles of each view are measured at three locations.

e) Analysis

1) 3D crosstalk profiles are calculated .
2) The angular ranges under a proper threshold of 3D crosstalk are calculated.
3) By using these angular ranges,
   each viewing zone for left or right is calculated.
4) 3D viewing zone is calculated
   as the zone in which a user
   with an average IPD
   can see each image correctly.



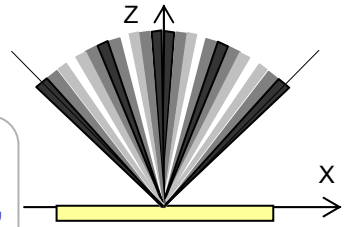
* The threshold of 3D crosstalk should be determined carefully based on human ergonomics data.

Luminance 3D moiré (1)

a) Objective

First Objective

- 3D moiré is a kind of moiré in a wide sense, in some cases its appearance is quite different from that of the moiré on ordinary 2D displays. When spatial frequency is low, luminance angular fluctuation increases, causing luminance non-uniformity on screen.



ISO9241-303: 5.4.9 Moiré effects (The moiré on 2D display)
"Moiré is a regular image superimposed of the intended image."
"They can appear as ripples, waves and intensity variations that are superimposed on the screen image."
This standard will be applied when spatial frequency is high.

Second Objective

- In order to certificate the viewing space, angular measurement should be carried out.

* In some cases, not only luminance variations, but also chromaticity variations occur. (Chromaticity 3D moiré)

Luminance 3D moiré (2)

b) Applicability

- All autostereoscopic display technologies

c) Preparation and Set-up

-configurable measurement conditions:

- test patterns: all “views” white

- measurement location: Three locations in horizontal
(at the center, the right and the left on the screen)

d) Procedure

Luminance profile in all views white is measured at three locations.

Luminance 3D moiré (3)

e) Analysis

1) On luminance profile in all white, inflection points, which are points where the curvature changes sign, are detected.

2) Luminance contrast modulation and angular differences are calculated between two neighboring inflection points. The luminance contrast modulation is

$$C_m = | L_A - L_B | / (L_A + L_B)$$

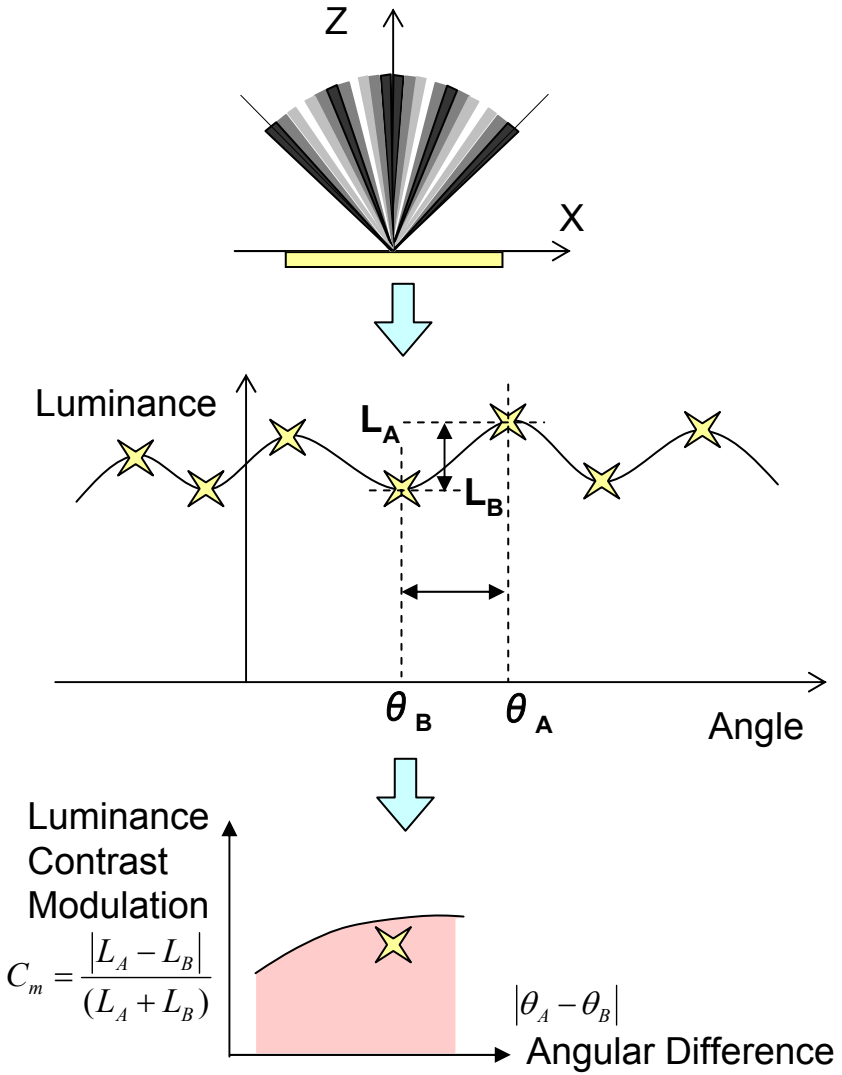
f) Reporting

Report the C_m and the angular difference.

g) Comments

The C_m should be below the curve of threshold characteristics* for 3D moiré, that certificates the space.

* The threshold should be determined carefully based on human ergonomics data.



Interocular luminance difference (1)

a) Objective

Excessive luminance difference between both eyes is considered to be undesirable for viewing.

b) Applicability

- All autostereoscopic display technologies

c) Preparation and Set-up

- configurable measurement conditions:
  - test patterns: all “views” white
- measurement location: Three locations in horizontal
  (at the center, the right and the left on the screen)
  - test illumination: dark room
  - spectral characteristics: luminance only

d) Procedure

Luminance profile in all views white is measured.

Interocular luminance difference (2)

e) Analysis

In each lobe, luminance difference between both eyes is calculated.

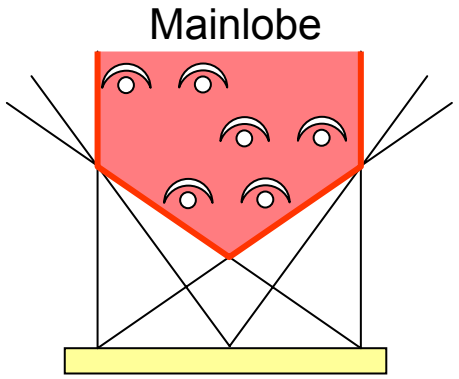
f) Reporting

Report the luminance difference (or maximum) between both eyes.

g) Comments

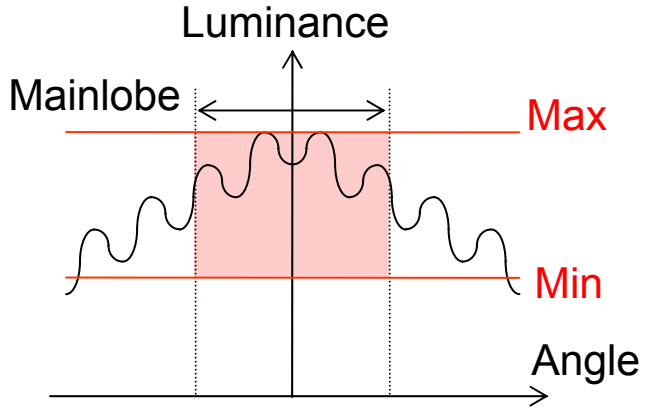
The luminance difference between both eyes should be under a proper threshold of interocular luminance difference, that certificates the space.

(a) Interocular luminance difference check



The space fulfilling the luminance requirement will be obtained.

Alternative: (b) Max/min luminance check



The luminance difference between max. and min. is checked to be under a proper threshold.

Summary

- **Metrology should be based on the essence of 3D display, definition, human ergonomics.**
- **Space certification should be fundamental of measurements for 3D display.**
- **We proposed measurement methods for QBVS and QSVS.**
  (Pseudoscopy, Interocular Luminance Difference, …)
- **Each threshold value should be determined carefully on human ergonomics.**