

RTRACE with Equisolid projection

in

Environmental Psychology studies

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Thanks to :
Chikako OHKI
Toshihide OKAMOTO

Tokyo University of Science - Nozomu YOSHIZAWA Lab.

Application of Rtrace in Environmental Psychology Laboratory

Table of Contents

- What is Environmental Psychology Laboratory ?

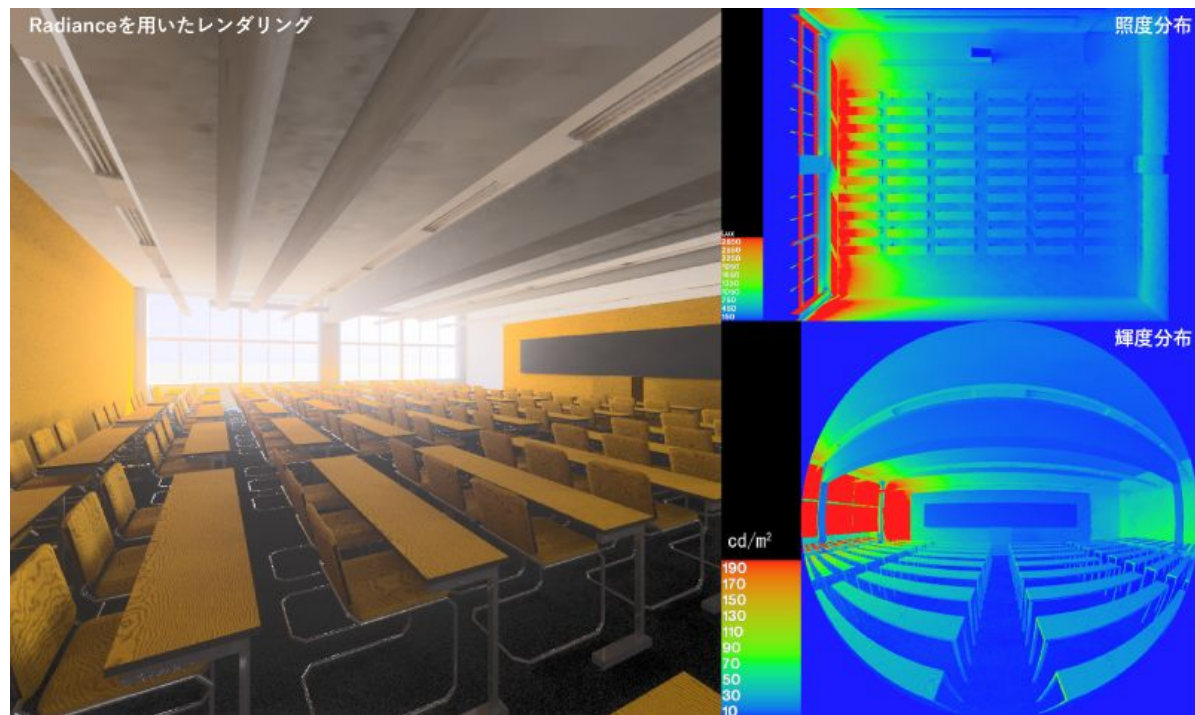
- Application examples

 - [case 1] Spaciousness calculation with 3D luminance mapping

 - [case 2] Ambient visual information for Sense of Safety from Crime

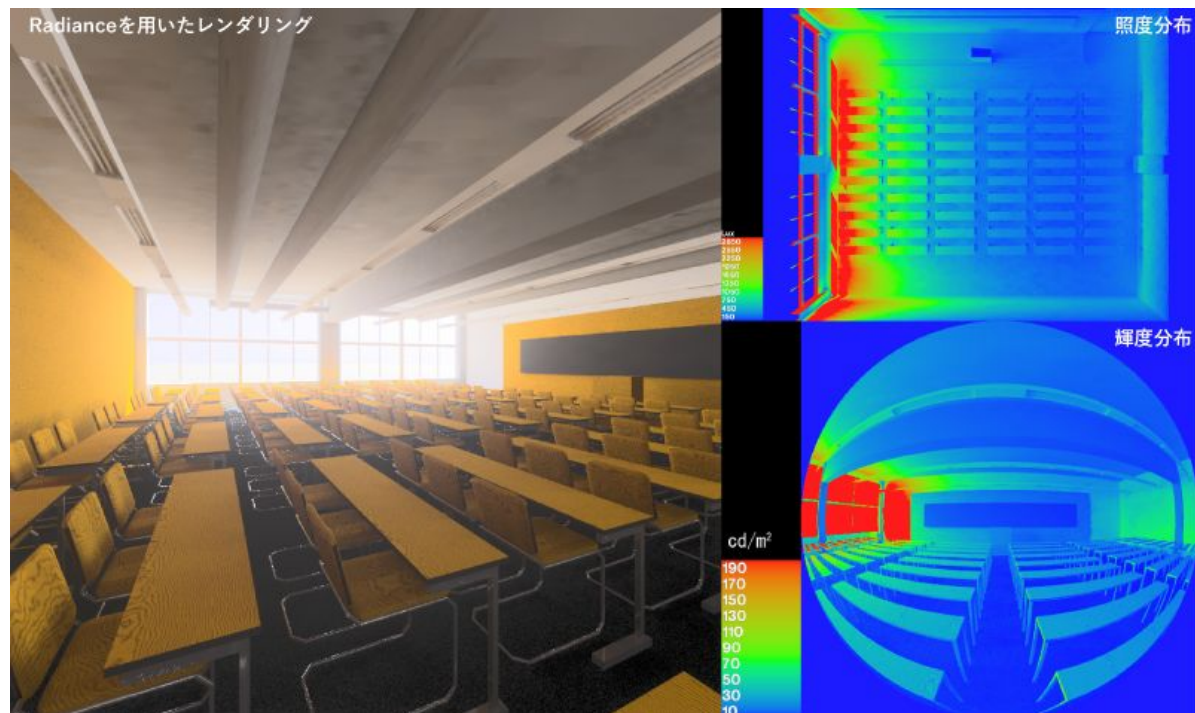
 - [case 3] View Out from a window through Sun Shading Devices

Radiance is



for simulation !

Radiance is
not only



for simulation !

RTRACE + Equisolid projection
can be used for **researches**



Spaciousness

Image : scjohnson.com



Sense of security

(Ambient Visual Information)

Image : Ryuzo OHNO



Quality of View Out

Image : DIN EN 17037:2019-03

Environmental Psychology
(finding a model how people perceive space)

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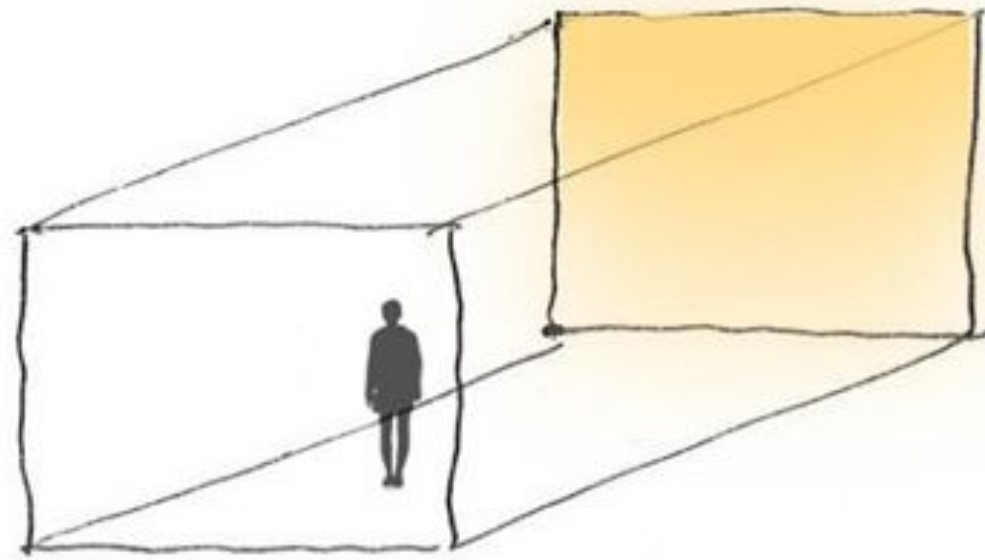
- [case 2] Ambient visual information for Sense of Safety from Crime

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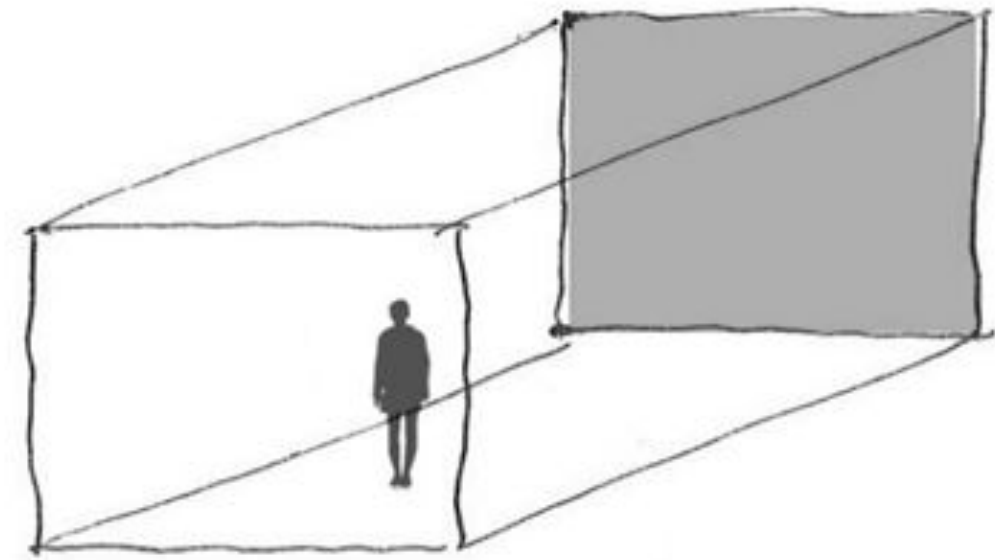
Light seems to affect spaciousness



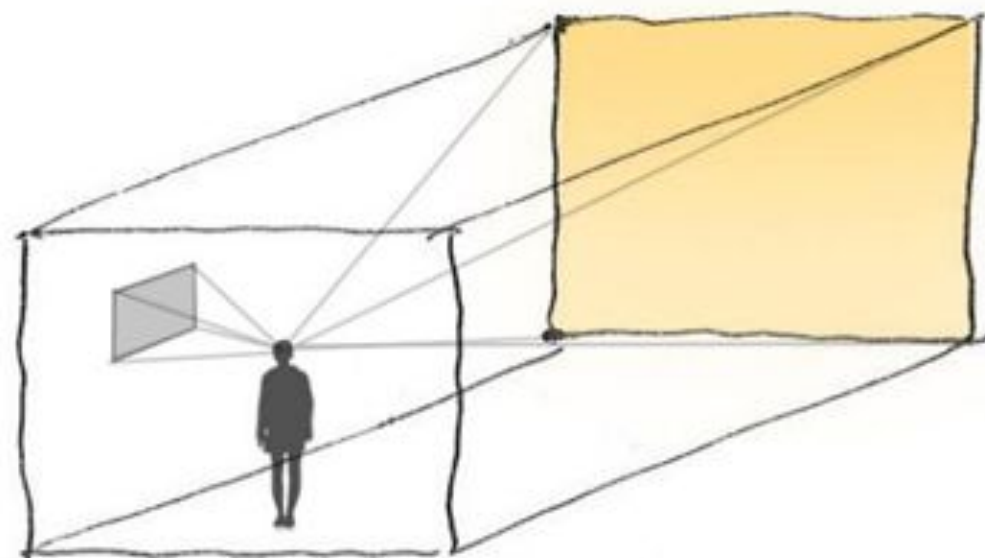
Light seems to affect spaciousness



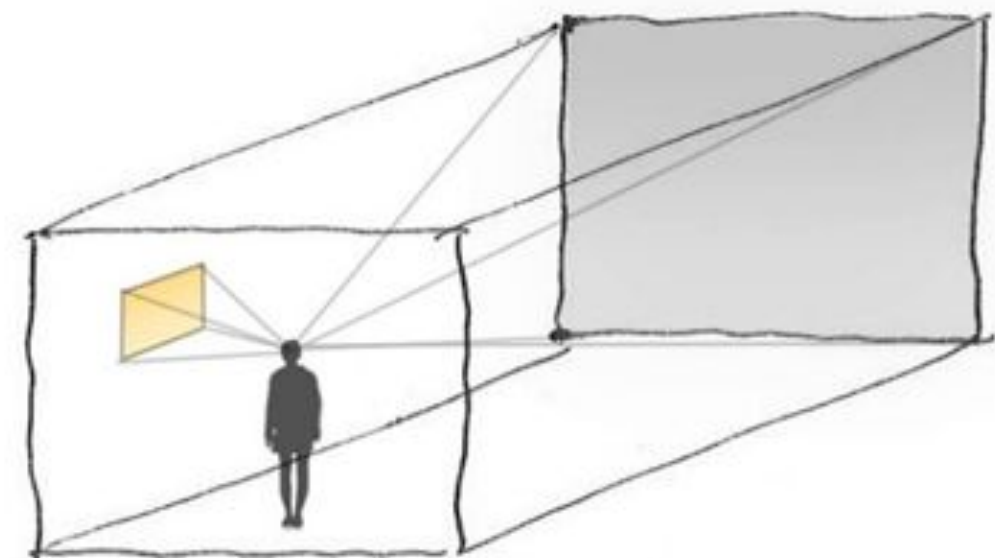
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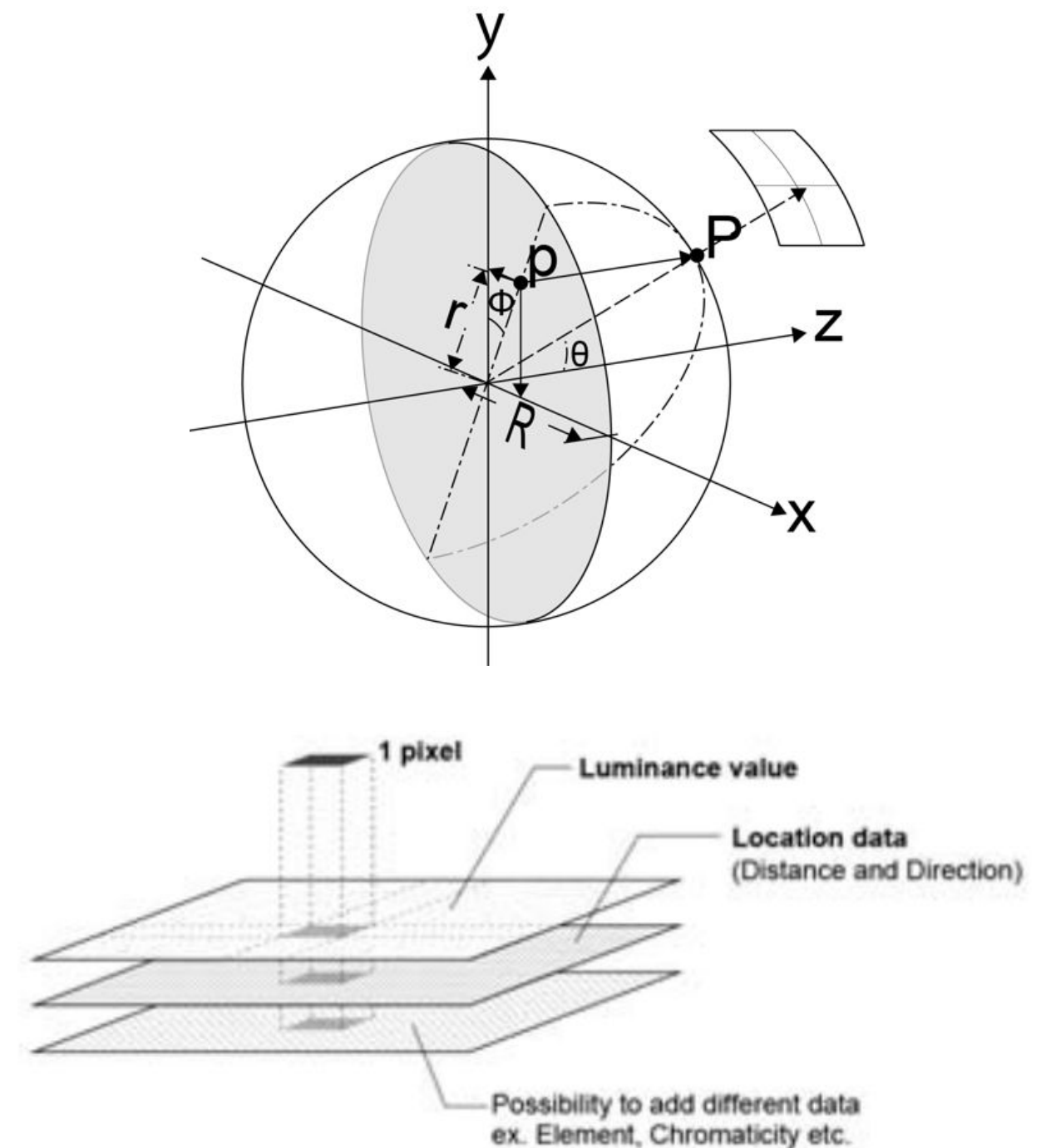
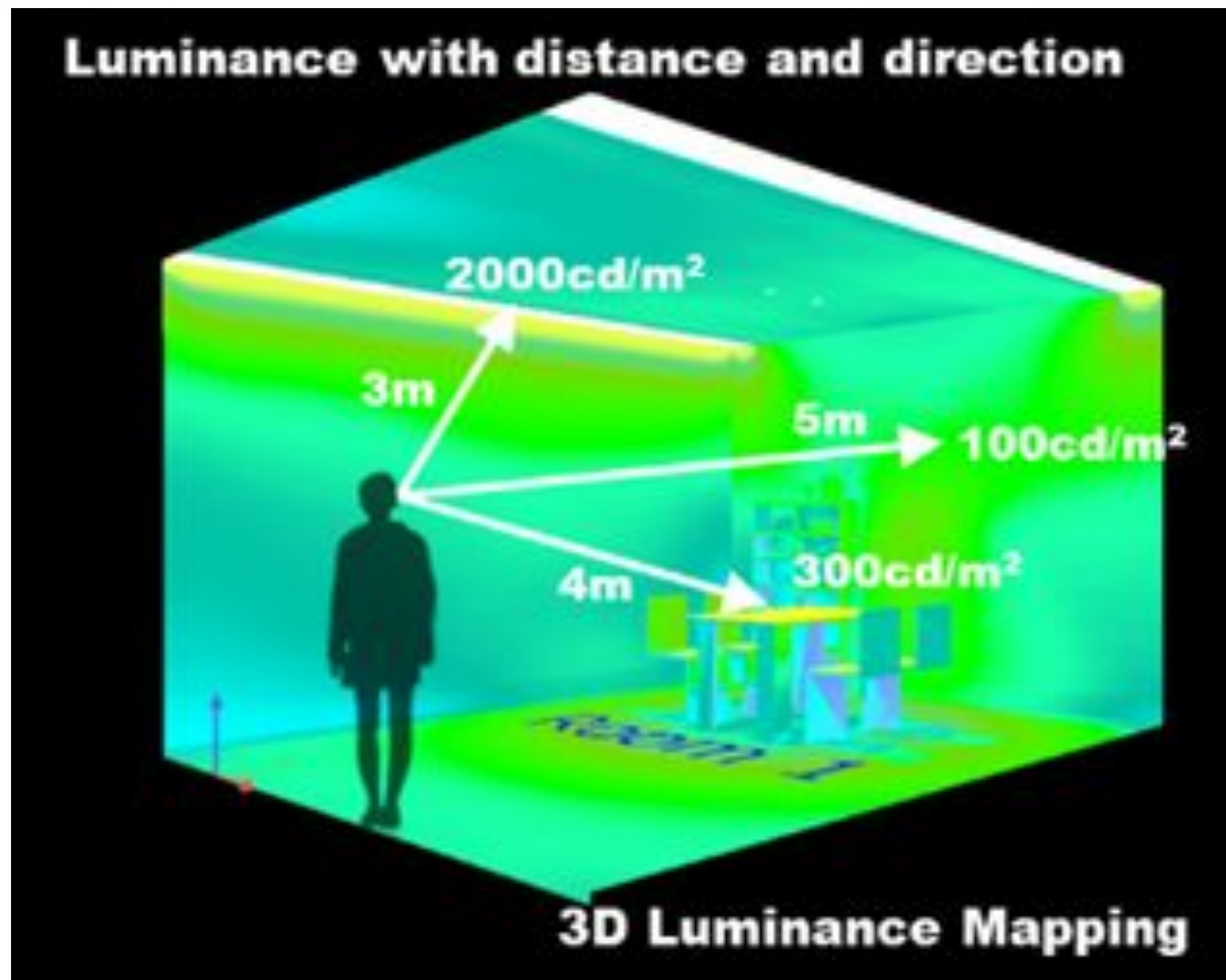
1. The brighter the space is, the more spaciousness is perceived.



>



2. The farther the light is localised from the observer, the more spaciousness is perceived.



Spaciousness = $\text{Log}_{10} (\text{Arithmetic mean of } (L_{(\text{cd/m}^2)} \times D_{(\text{mm})} \times \cos\theta))$ *(to be further developed)*

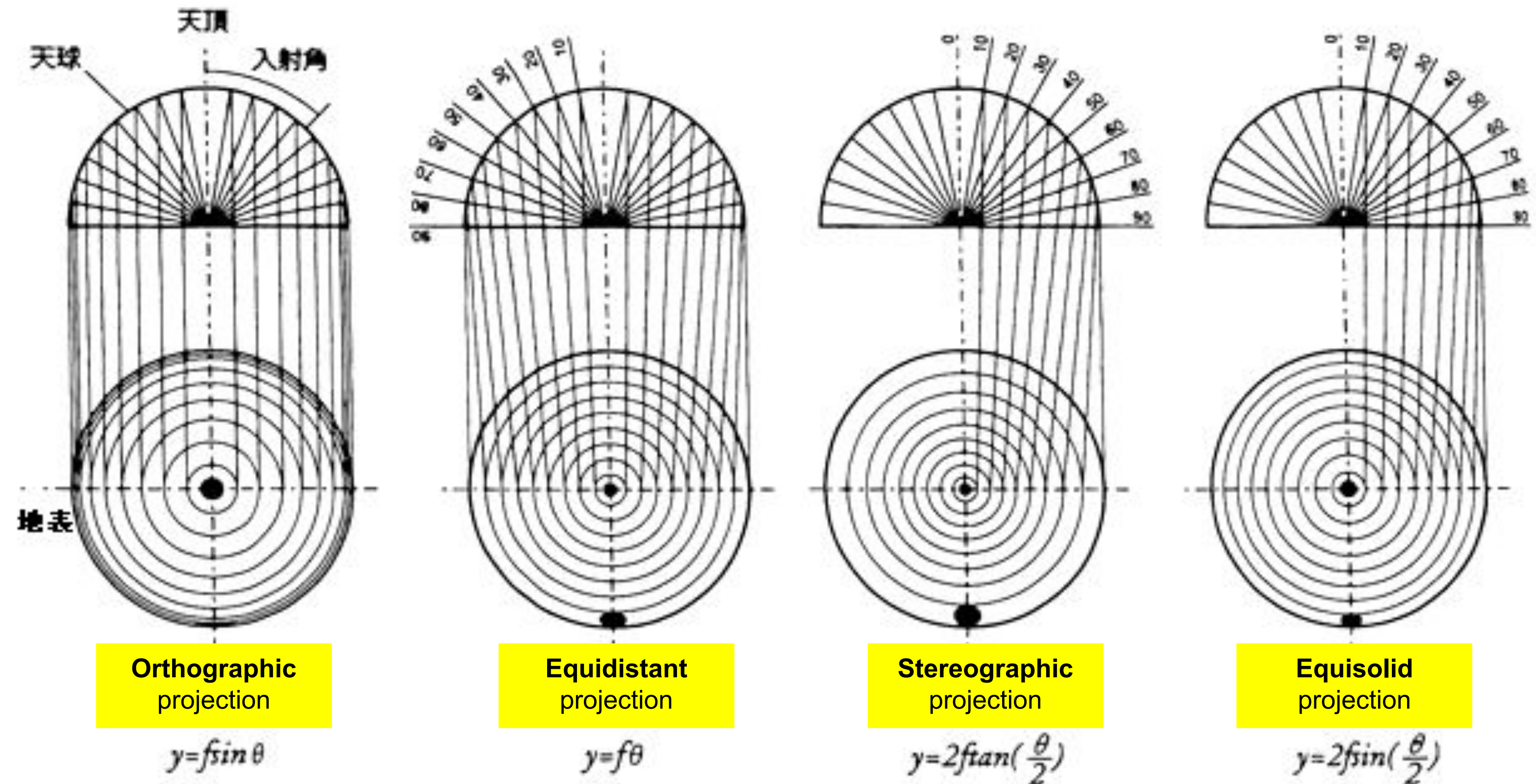
L = luminance of each pixel : **-oV**

D = distance from the observing point to the surface in that pixel : **-oL**

θ = angle between the direction to that pixel and the view axis : **od (normalised vector)**

`cnt 512 512 | rcalc -f equisolid.cal -e "XD=512;YD=512" |`

`rtrace -ab 6 -af p.amp -odvL -x 512 -y 512 -fa model.oct > case.csv`



-vth option
available

-vta option
available

-vts option
available

**We need
THIS !!!**

```
cnt 512 512 | rcalc -f equisolid.cal -e "XD=512;YD=512 |  
rtrace -ab 6 -af p.amp -odvL -x 512 -y 512 -fa model.oct > case.csv
```

Equisolid projection

```
{ Parameters defined externally:
  XD : horizontal picture dimension (pixels)
  YD : vertical picture dimension (pixels)

{ Direction of the current pixel (angles in radians) }
a=-$1+(YD/2);
b=$2-(XD/2);
aa=a/sqrt(a^2);

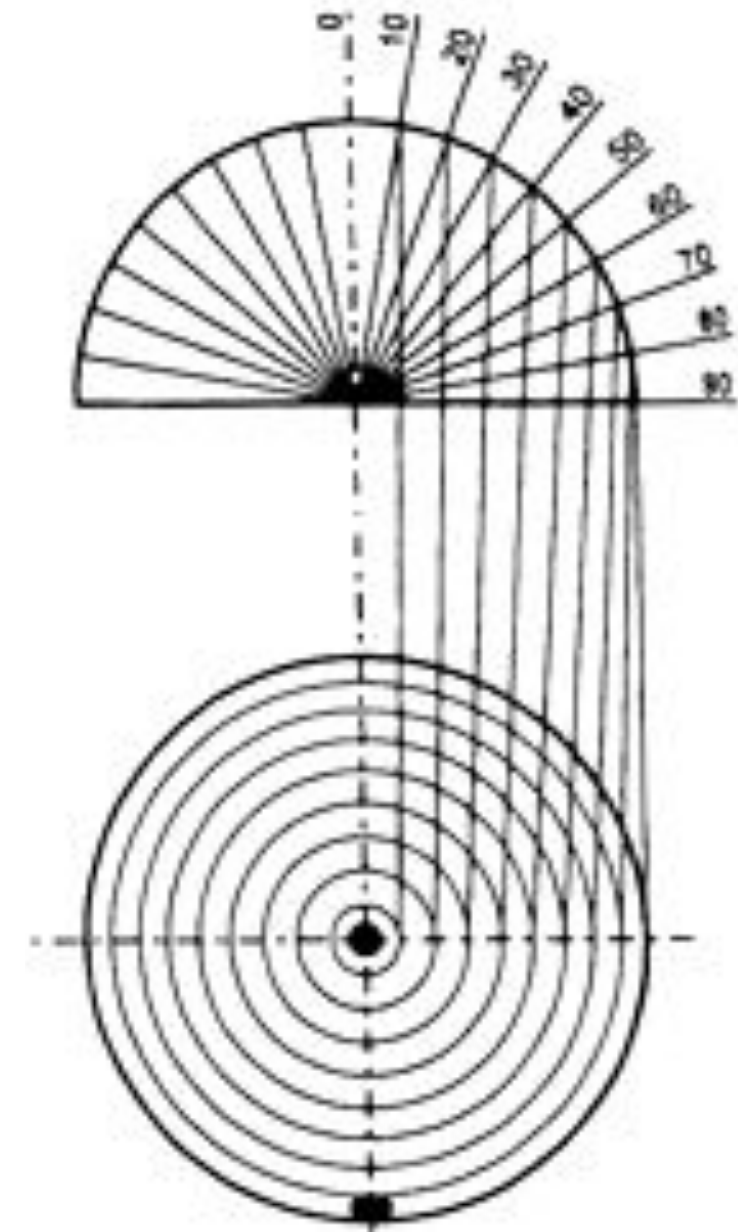
r=sqrt(a^2+b^2);

si=r/(sqrt(2)*(YD/2));
sita=2*asin(si);
sitaa=aa*sita;
fai=atan(b/a);

x=cos(sitaa);
y=-sin(sitaa)*sin(fai);
z=sin(sitaa)*cos(fai);

{ Output line to rtrace }
$1=3180;$2=0;$3=1500;
$4=x;$5=y;$6=z;
```

Referenced and modified from
Cylindrical projection by Axel Jacobs



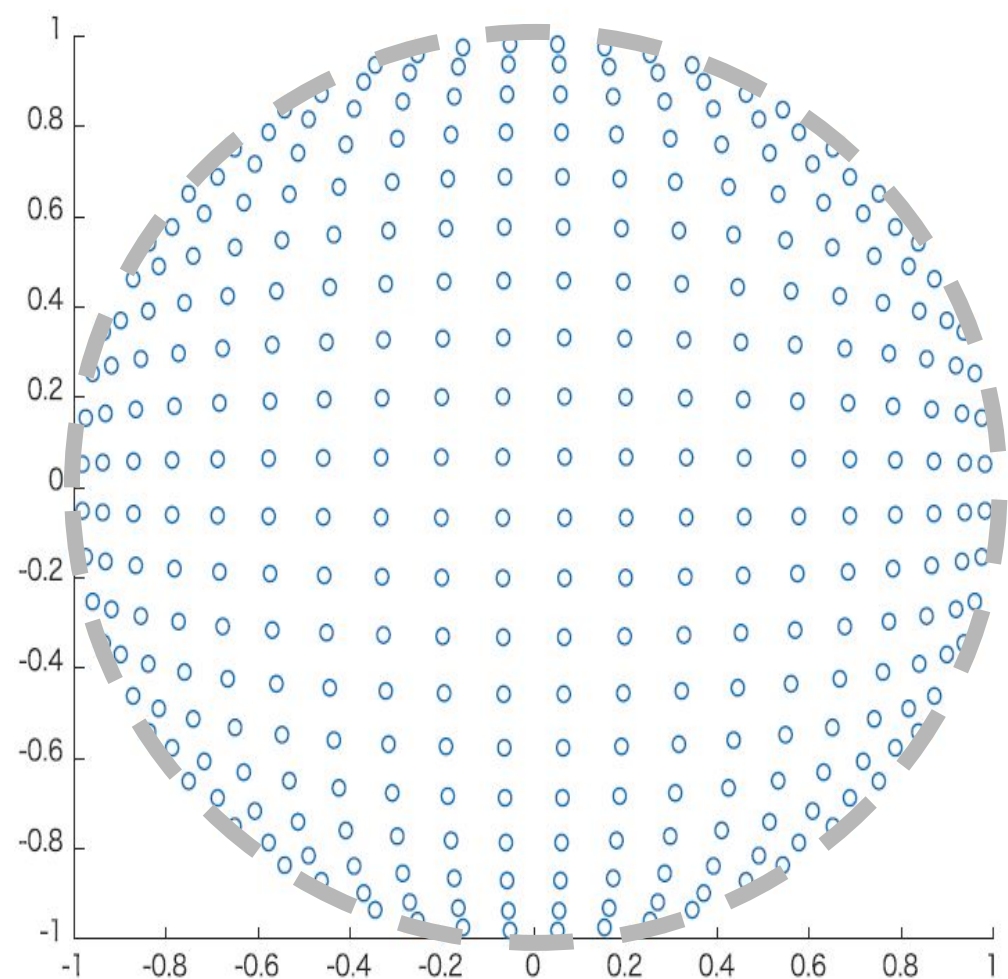
**Equisolid
projection**

$$y = 2f \sin\left(\frac{\theta}{2}\right)$$

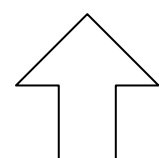
**We need
THIS !!!**

```
cnt 512 512 | rcalc -f equisolid.cal -e "XD=512;YD=512" |  
rtrace -ab 6 -af p.amp -odvL -x 512 -y 512 -fa model.oct > case.csv
```

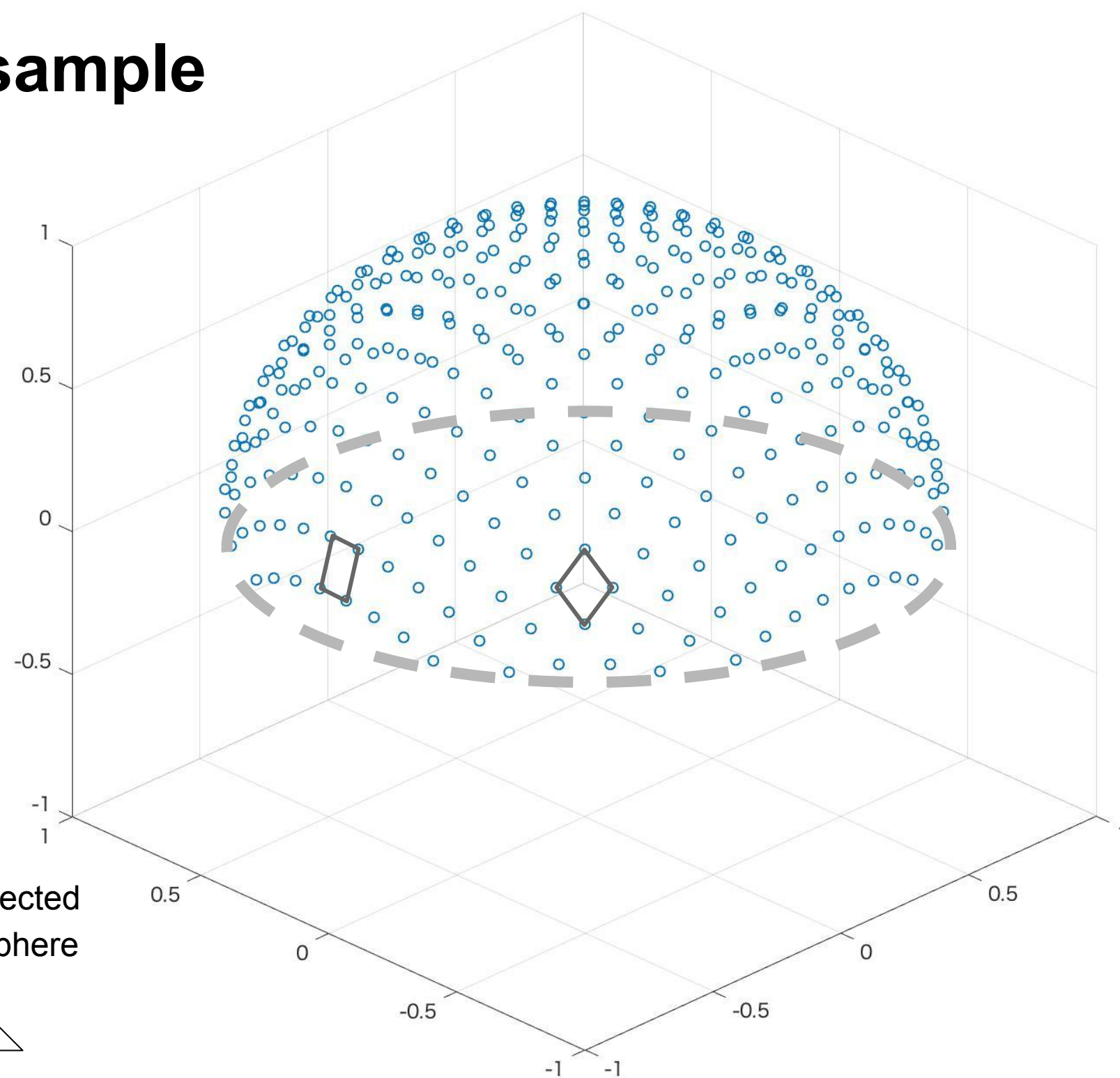
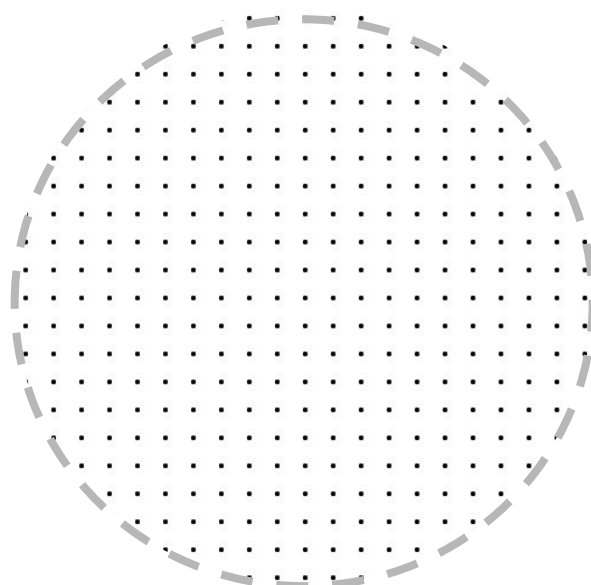

RTRACE points projection sample



Dots projected
to hemisphere



Square grid dots
on a plane



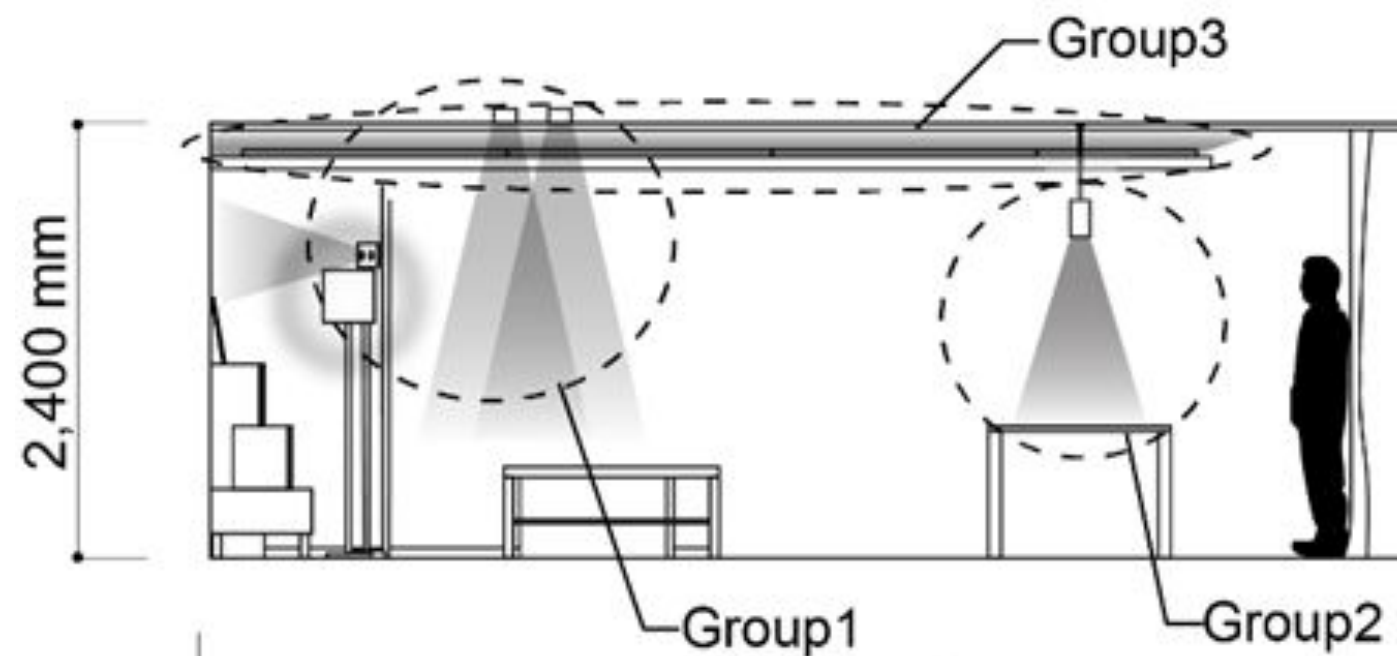
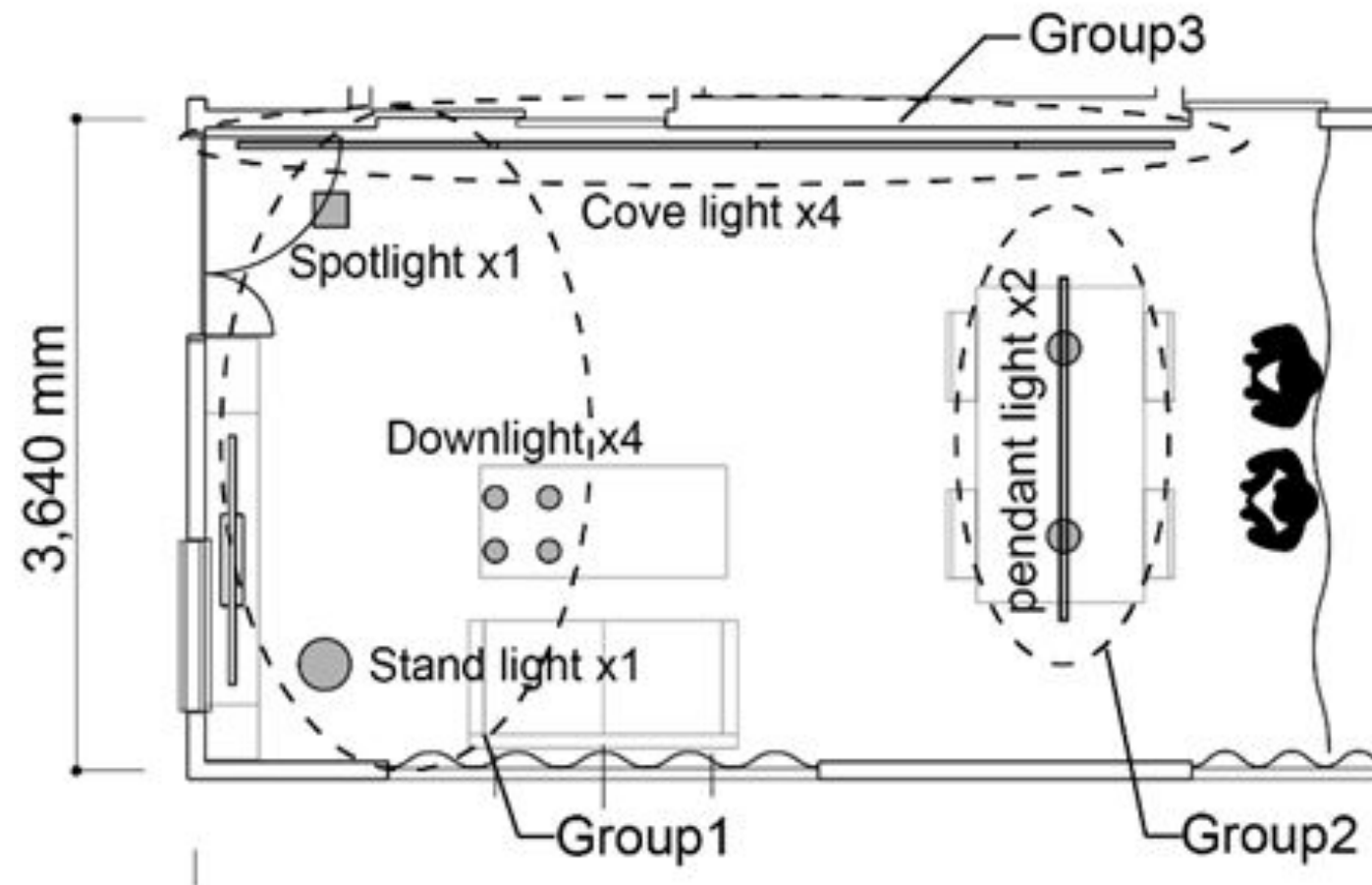
Visualization of RTRACE points

Square grid dots projected to hemisphere

(diameter 21 px = 344 dots in this example)

(in the research, diameter 512 px = 205,884 pixels are projected)

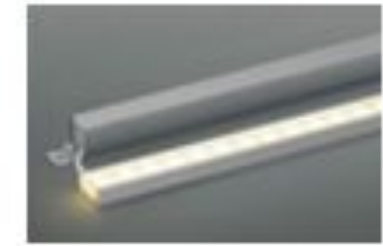
Experiment Configuration



Group 2: Near side
Pendant lights
Koizumi AP40784L



Group 3: Continuous
Ceiling indirect light
AP40784L



Group 1: Far side
Downlight Koizumi AD40308L Stand light IKEA 102.865.68, unknown



Experiment

Lighting scenes

Far

Close

Medium

Dark



Bright



Produced data

Pixel number	Distance to the pixel			Normalized direction vector (x,y,z)		Luminance of the pixel
94408	0.871	0.305	0.385	1166	61.4	
94409	0.873	0.299	0.385	1186	58.2	
94410	0.875	0.294	0.385	1207	52.3	
94411	0.876	0.289	0.385	1229	46.0	
94412	0.878	0.284	0.385	2335	3.2	
94413	0.880	0.278	0.386	2334	3.2	
94414	0.881	0.273	0.386	2333	3.2	
94415	0.883	0.268	0.386	2332	3.2	
94416	0.884	0.263	0.386	2331	3.1	

↑
same as cosθ

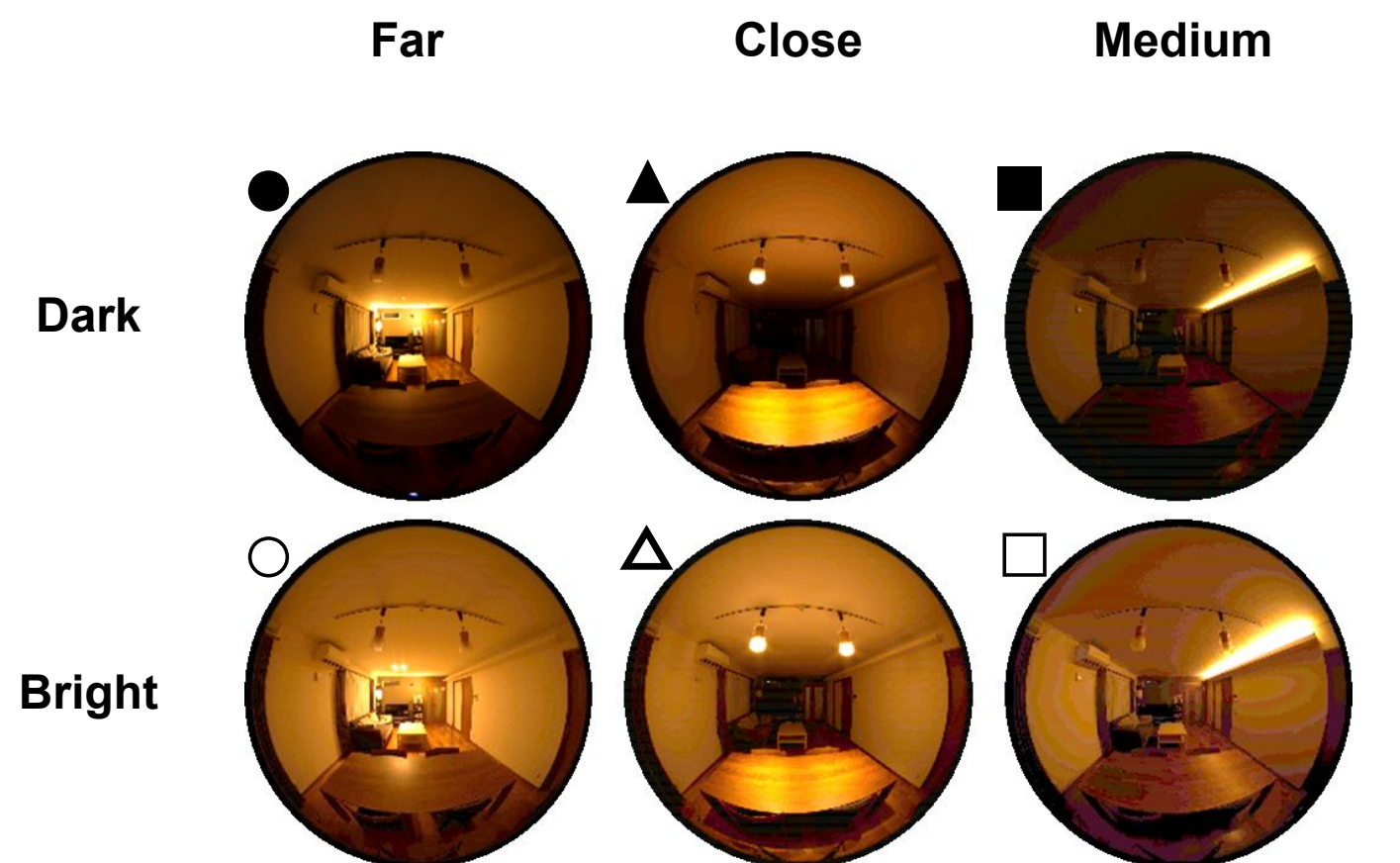
Spaciousness = **Log₁₀** (Arithmetic mean of (**L** (cd/m²) **x** **D** (mm) **x** **cosθ**)) *(to be further developed)*

L = luminance of each pixel : -o**v**

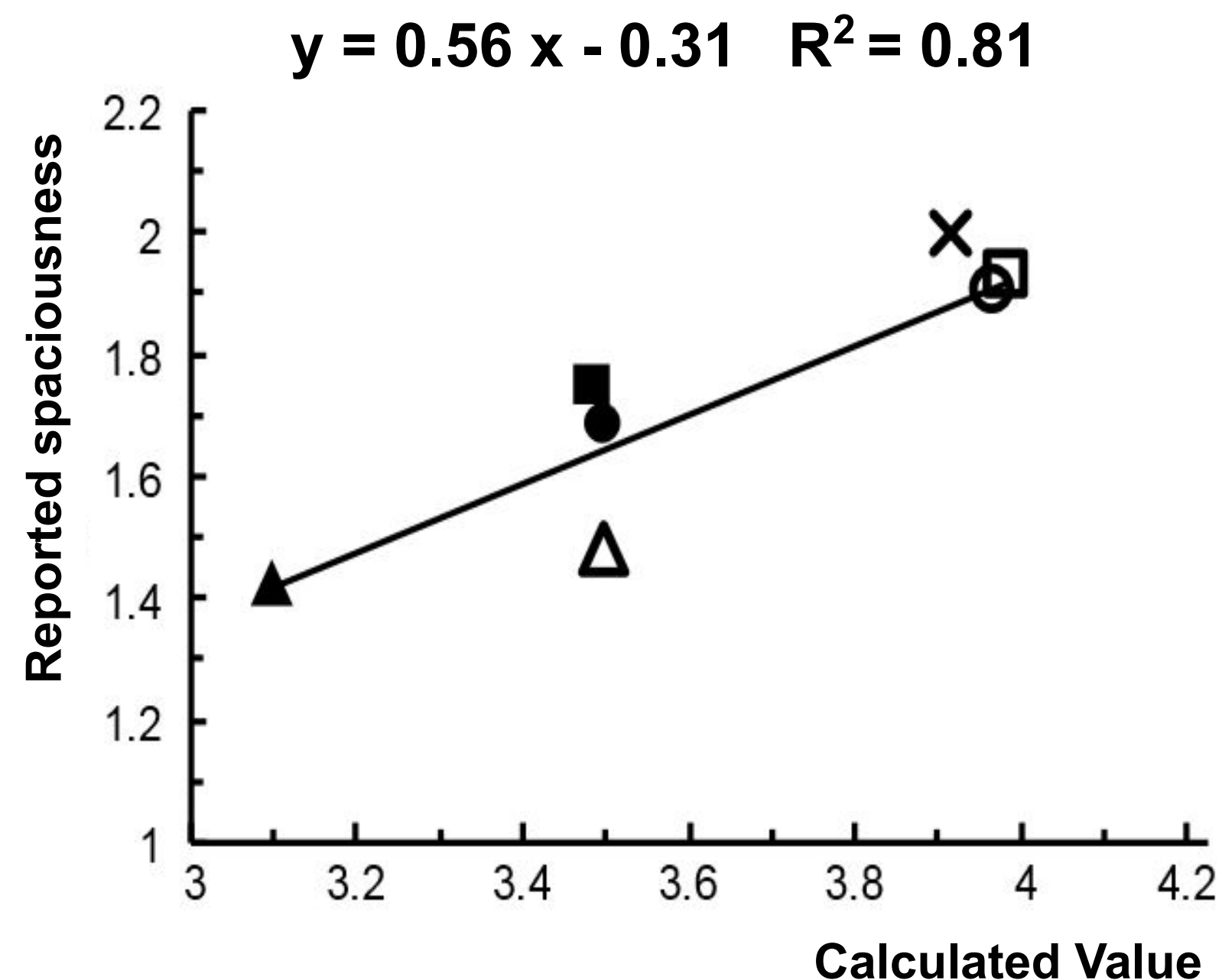
D = distance from the observing point to the surface in that pixel : -o**L**

θ = angle between the direction to that pixel and the view axis : o**d** (normalised vector)

Result



× is the base lighting scene for magnitude estimation comparison



$$\text{Spaciousness} = \text{Log}_{10} (\text{Arithmetic mean of } (L_{(\text{cd/m}^2)} \times D_{(\text{mm})} \times \cos\theta)) \quad (\text{to be further developed})$$

(luminous surfaces of fixtures are excluded from calculation)

RTRACE OPTIONS

-ospec

Produce output fields according to *spec*. Characters are interpreted as follows:

o

origin (input)

d

direction (normalized)

v

value (radiance)

V

contribution (radiance)

w

weight

W

color coefficient

l

effective length of ray

L

first intersection distance

c

local (u,v) coordinates

p

point of intersection

n

normal at intersection (perturbed)

N

normal at intersection (unperturbed)

s

surface name

m

modifier name

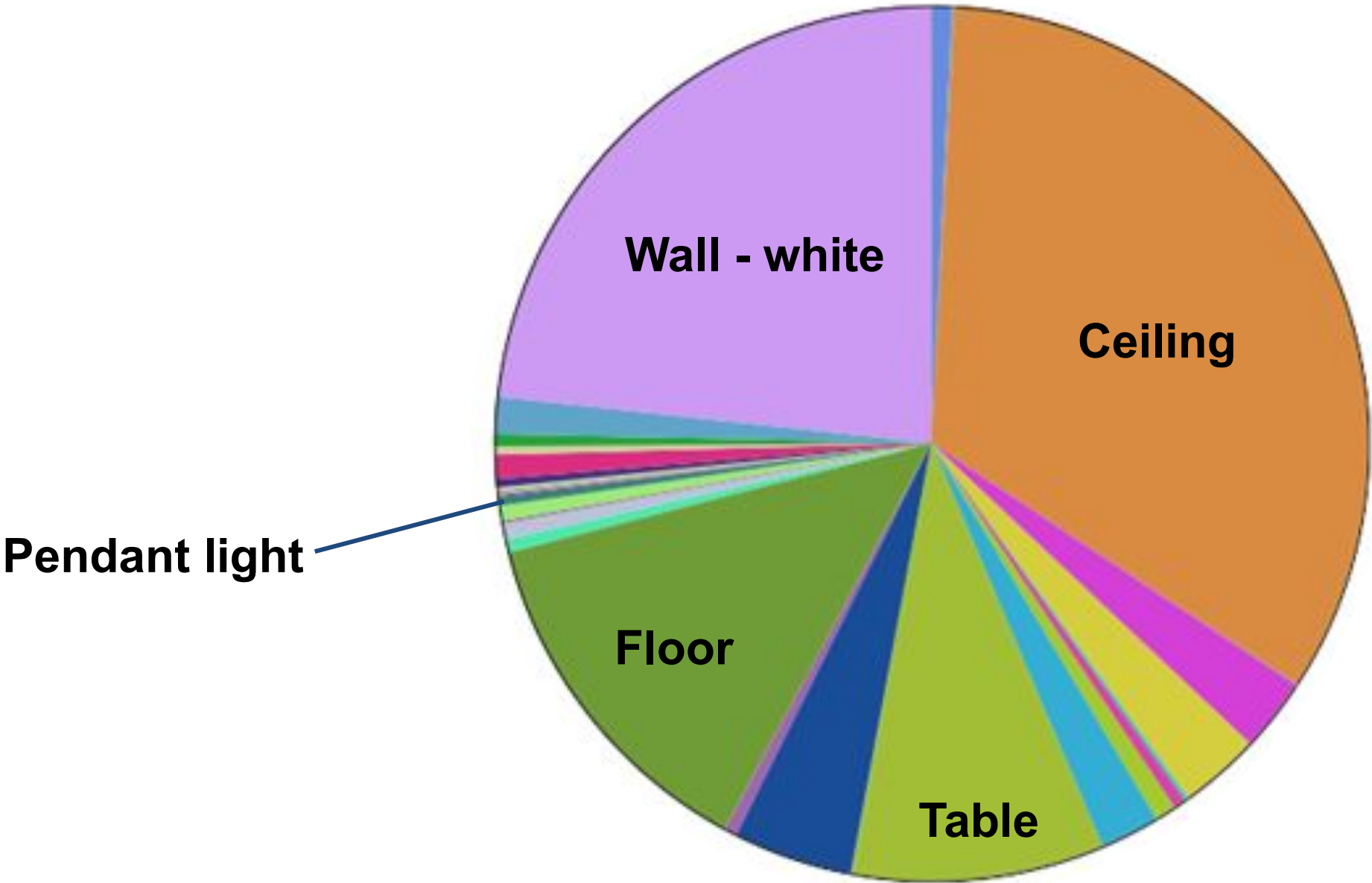
M

material name

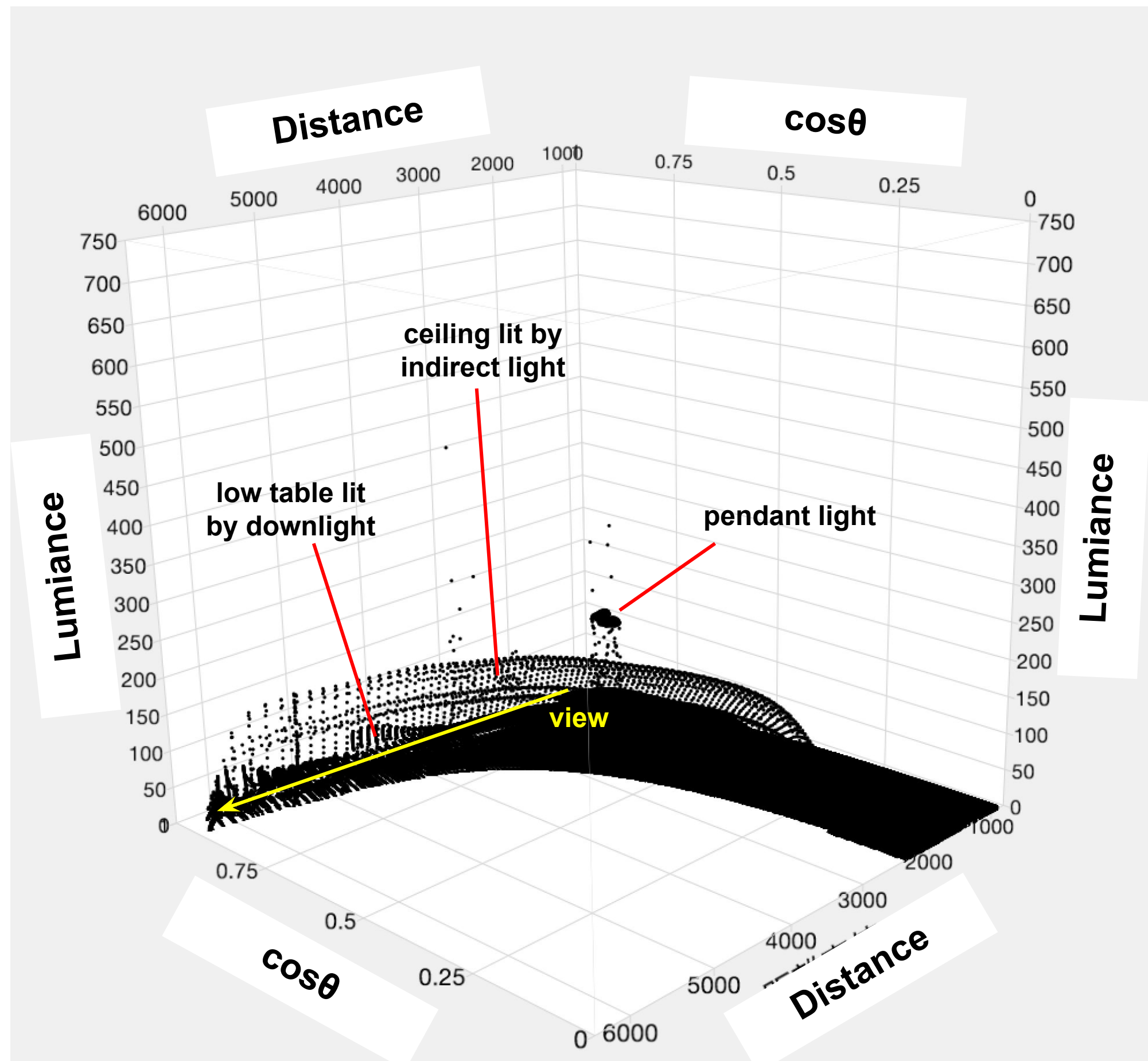
~

tilde (end of trace marker)

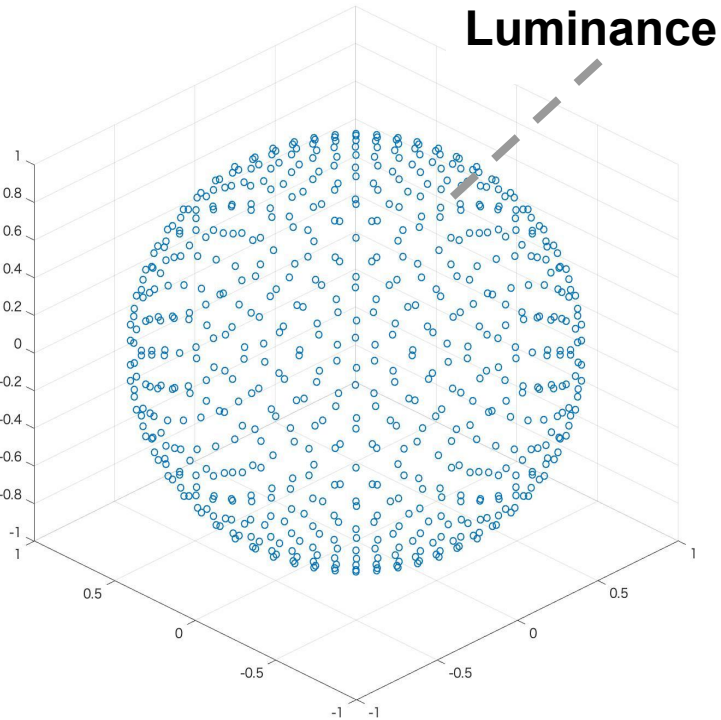
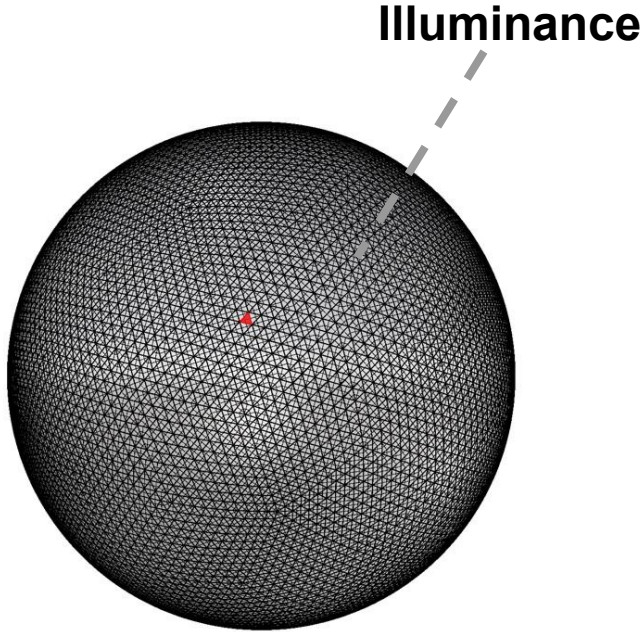
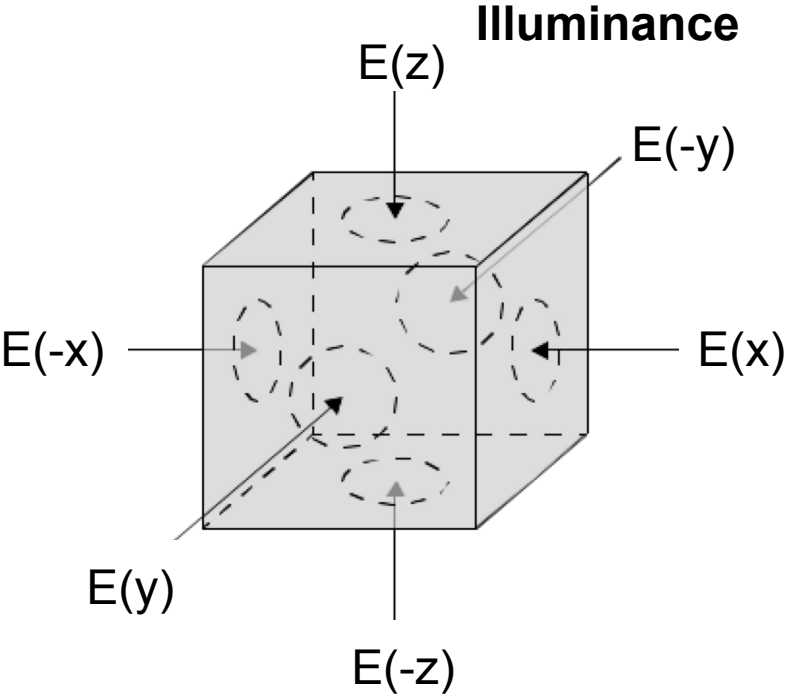
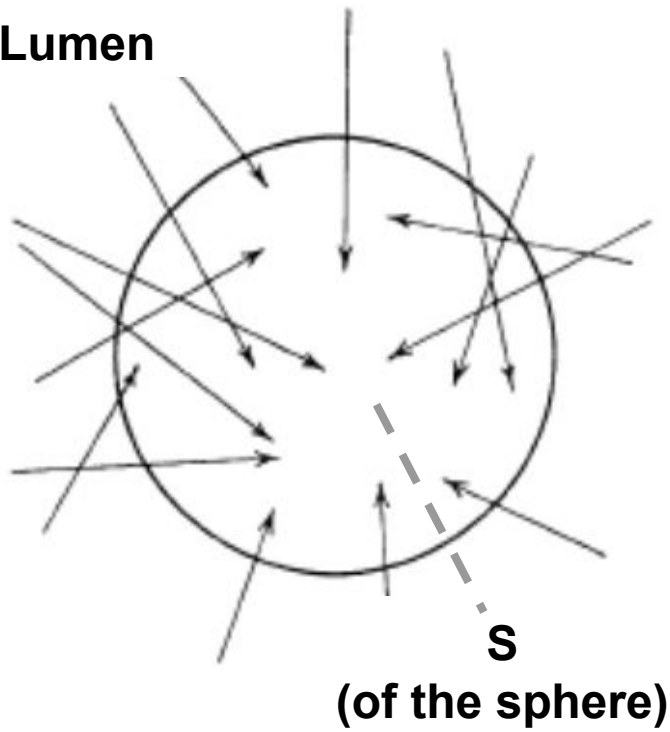
Ratio of each surface type (material name)



3D Scattering Graph of Luminance, Distance and Direction



Scaler illuminance



Definition
Scaler Illuminance

Calculation. 1
Cubic Illuminance
for practical use

Calculation. 2
Average illuminance of
geodesic dome surfaces

Calculation. 3
Average of effect of
luminance to E_s

Quantity of Light
going through infinitesimal sphere
the area of the infinitesimal sphere

Vector component /4
+Symmetric component
E_s = |E|/4 + ~E

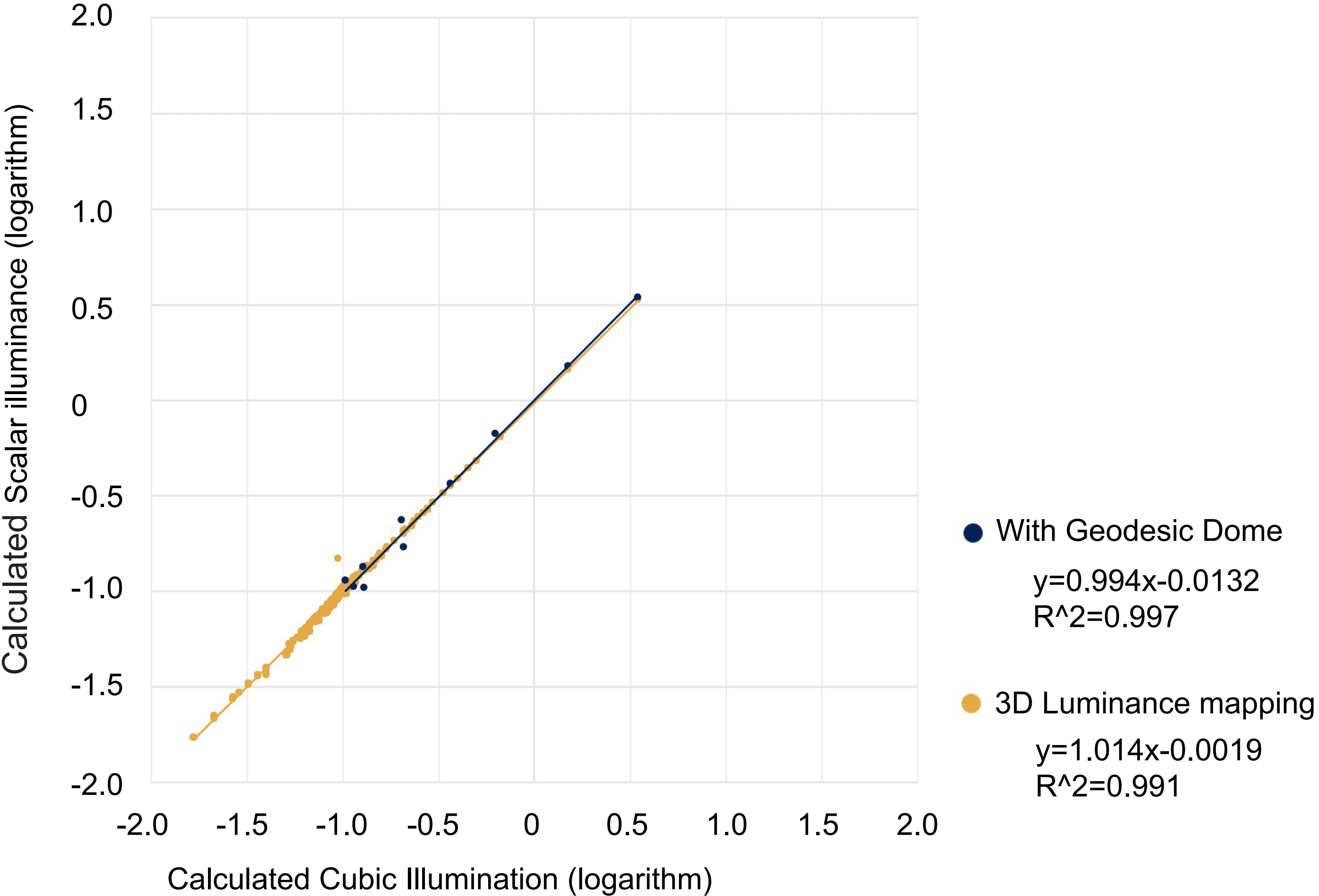
$$\frac{1}{n} \sum_{i=1}^n E_i$$

(18,000 points)

$$E_s = \frac{1}{4} \int_{4\pi} L d\omega$$

(1,570,792 points)

Scaler illuminance - calculated values



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CONCEPT OF AMBIENT VISION AND DESCRIPTION METHOD OF AMBIENT VISUAL INFORMATION

A study on description method of ambient visual information and its application (Part 1)

Ryuzo OHNO

[Journal of Archit. Plann. Environ. Engng, AIJ, No.451, Sep., 1993](#)

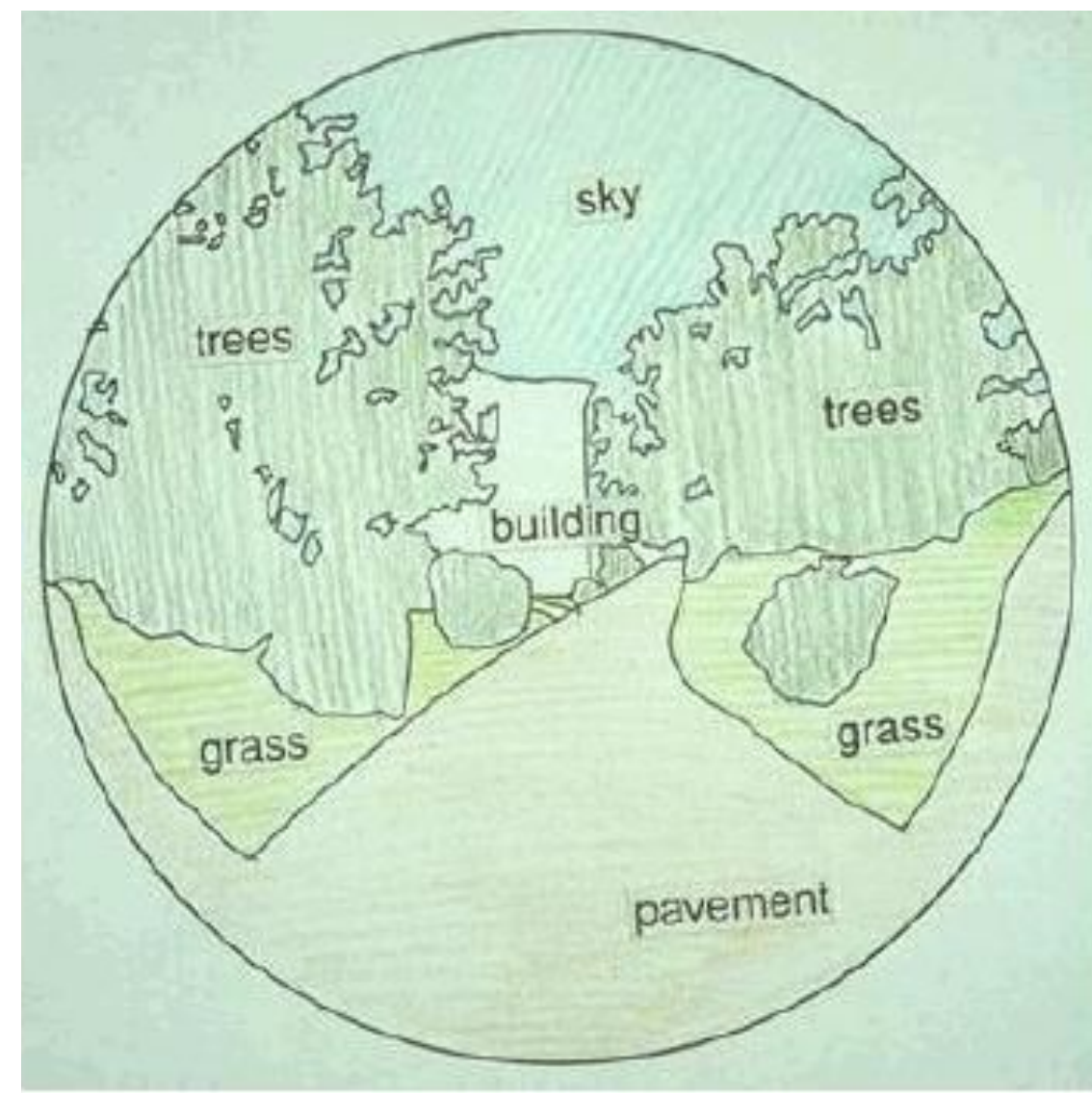
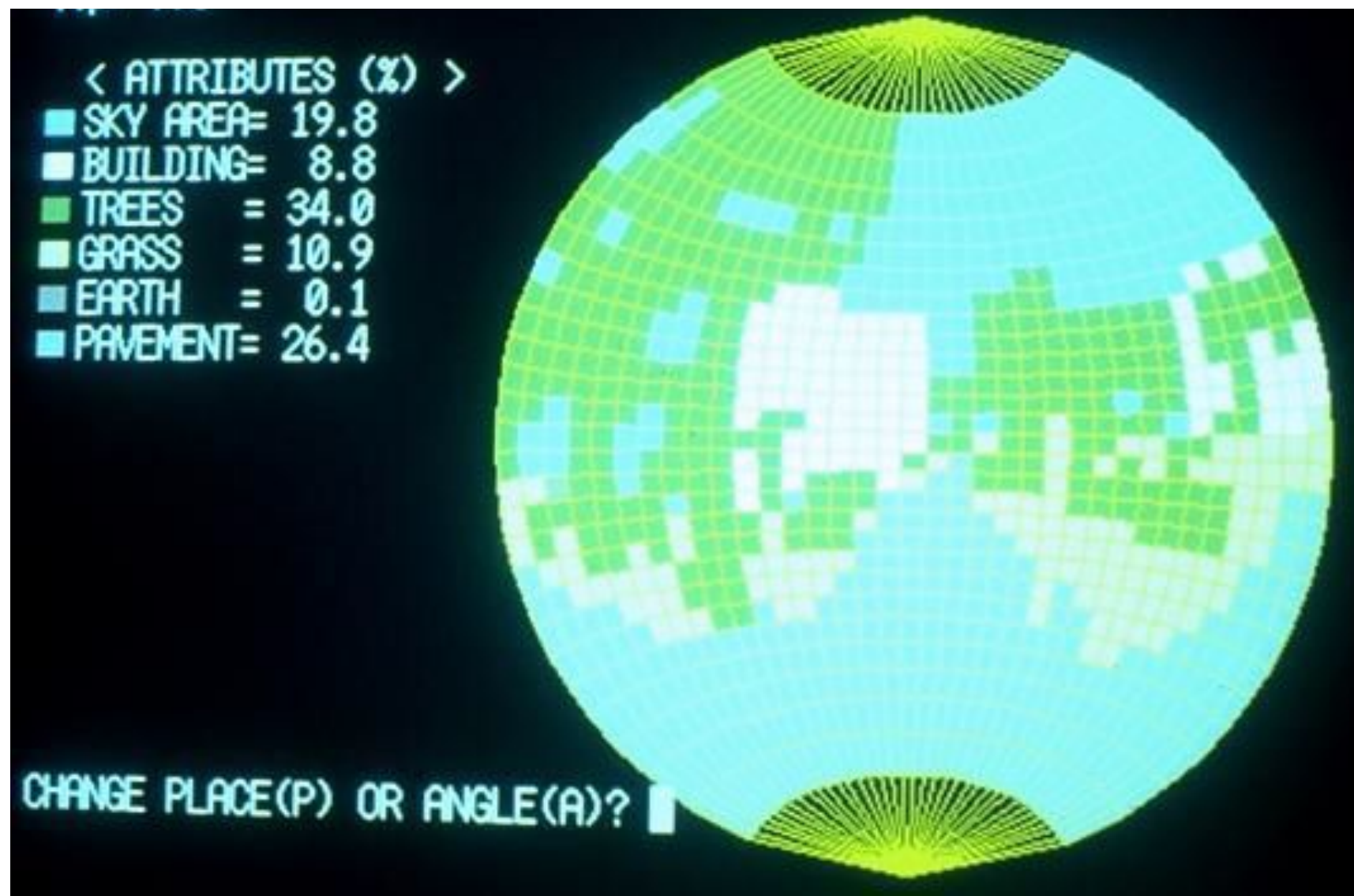
THE AMOUNT OF VISUAL RADIATION AND THE SENSE OF SAFETY FROM CRIME

A study of the site planning of multi – family housing
considering the residents' mutual visual interactions (Part 1)

Ryuzo OHNO, Miki KONDO

[Journal of Archit. Plann. Environ. Engng, AIJ, No.467, Jan., 1995](#)

Ambient Visual Information (1993)

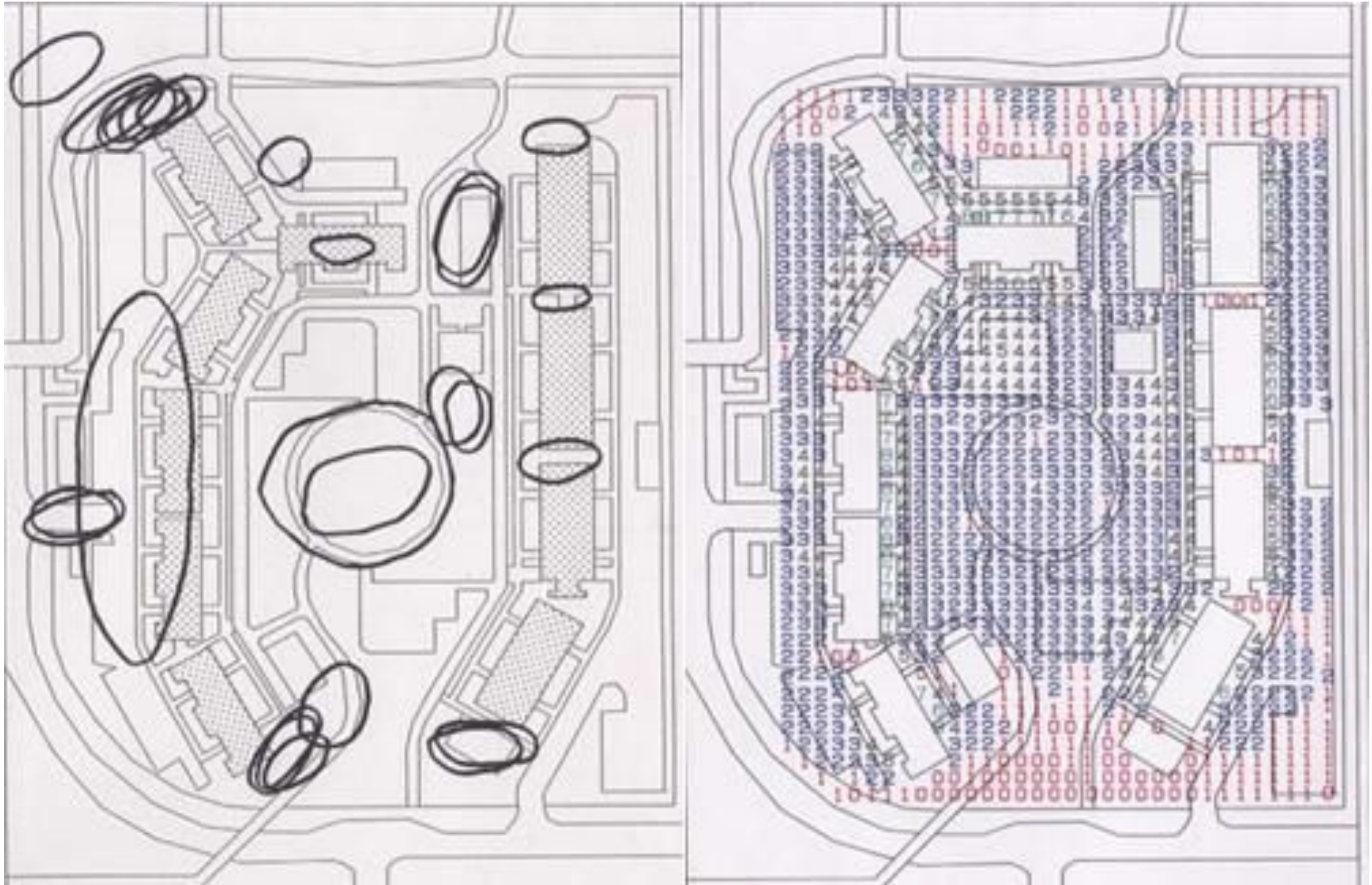


Experiment about sense of security in a housing complex site



**The ratio of wall with window in the
view from each point**

Ambient visual information mapping



**Reported area where residents
feel unsecured**

**The ratio level of wall with window
in the view from each point**

with RTRACE



Only 1,944 pixels
(Horizontal 72 x Vertical 27)



411,772 pixels or more
(512 x 512 x $\pi/4 \times 2$)

much better resolution

o	origin (input)
d	direction (normalized)
v	value (radiance)
V	contribution (radiance)
w	weight
W	color coefficient
l	effective length of ray
L	first intersection distance
c	local (u,v) coordinates
p	point of intersection
n	normal at intersection (perturbed)
N	normal at intersection (unperturbed)
s	surface name
m	modifier name
M	material name
~	tilde (end of trace marker)

different information can be deployed

Application of Rtrace in Environmental Psychology Laboratory

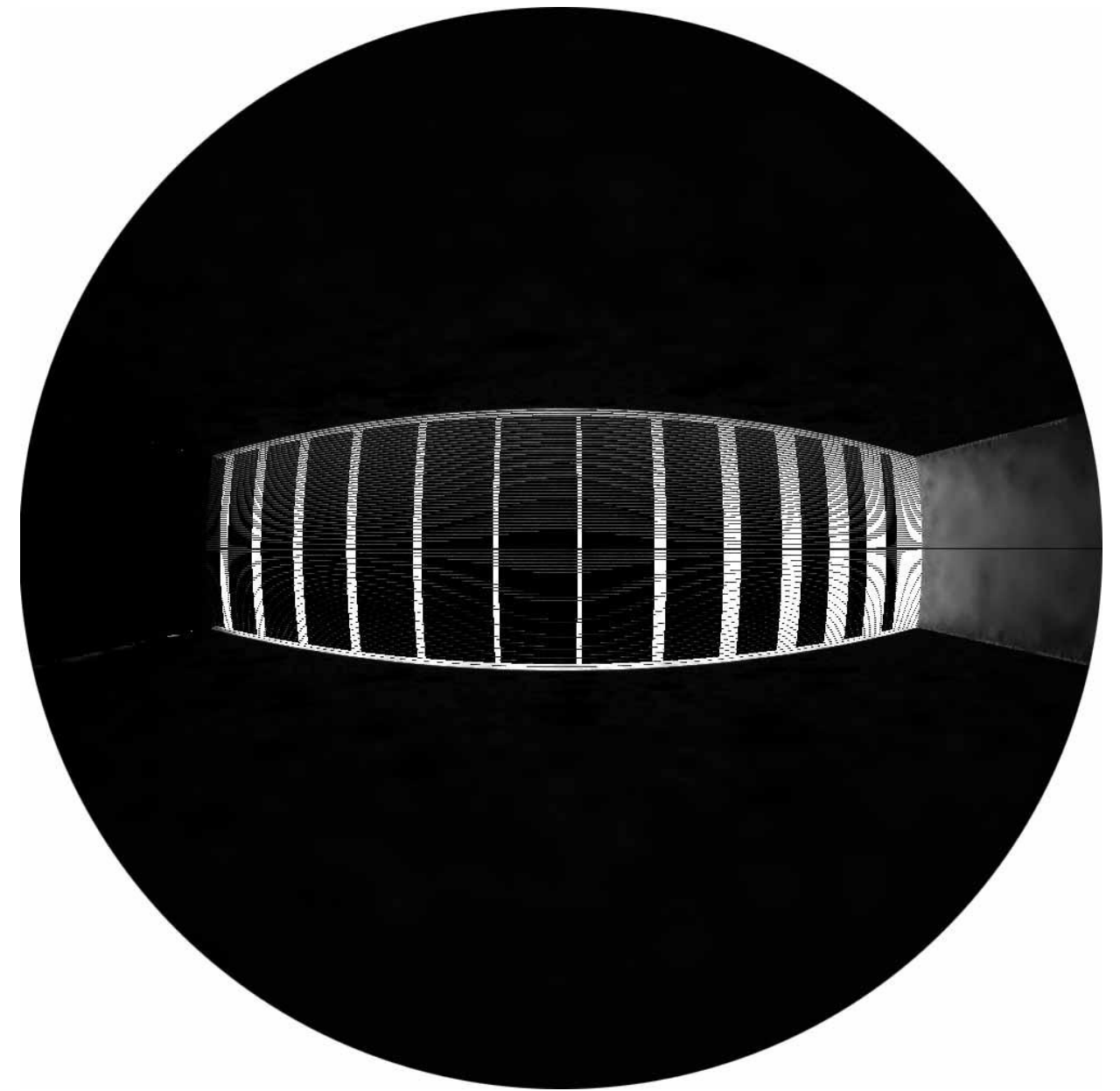
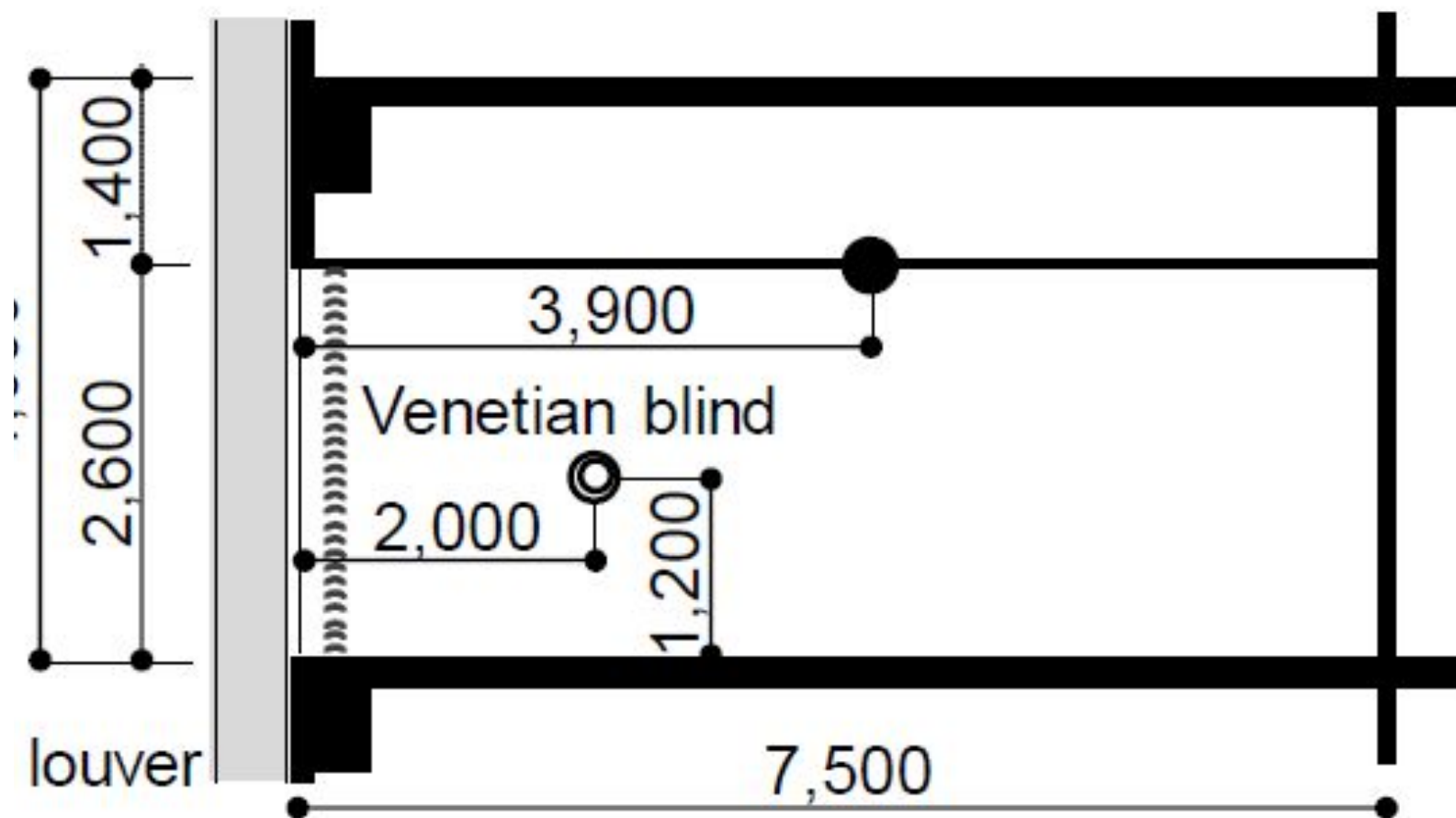
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FAÇADE DESIGN OPTIMIZATION BASED ON ENERGY USAGE, GLARE, AND VIEW USING RADIANCE AND NEWHASP

Ohki, C., Okamoto, T., Tadaki, J., Ohga, H., Yoshizawa, N.

[CIE x046:2019 Proceedings of the 29th CIE SESSION / DOI 10.25039/x46.2019.PO145](#)



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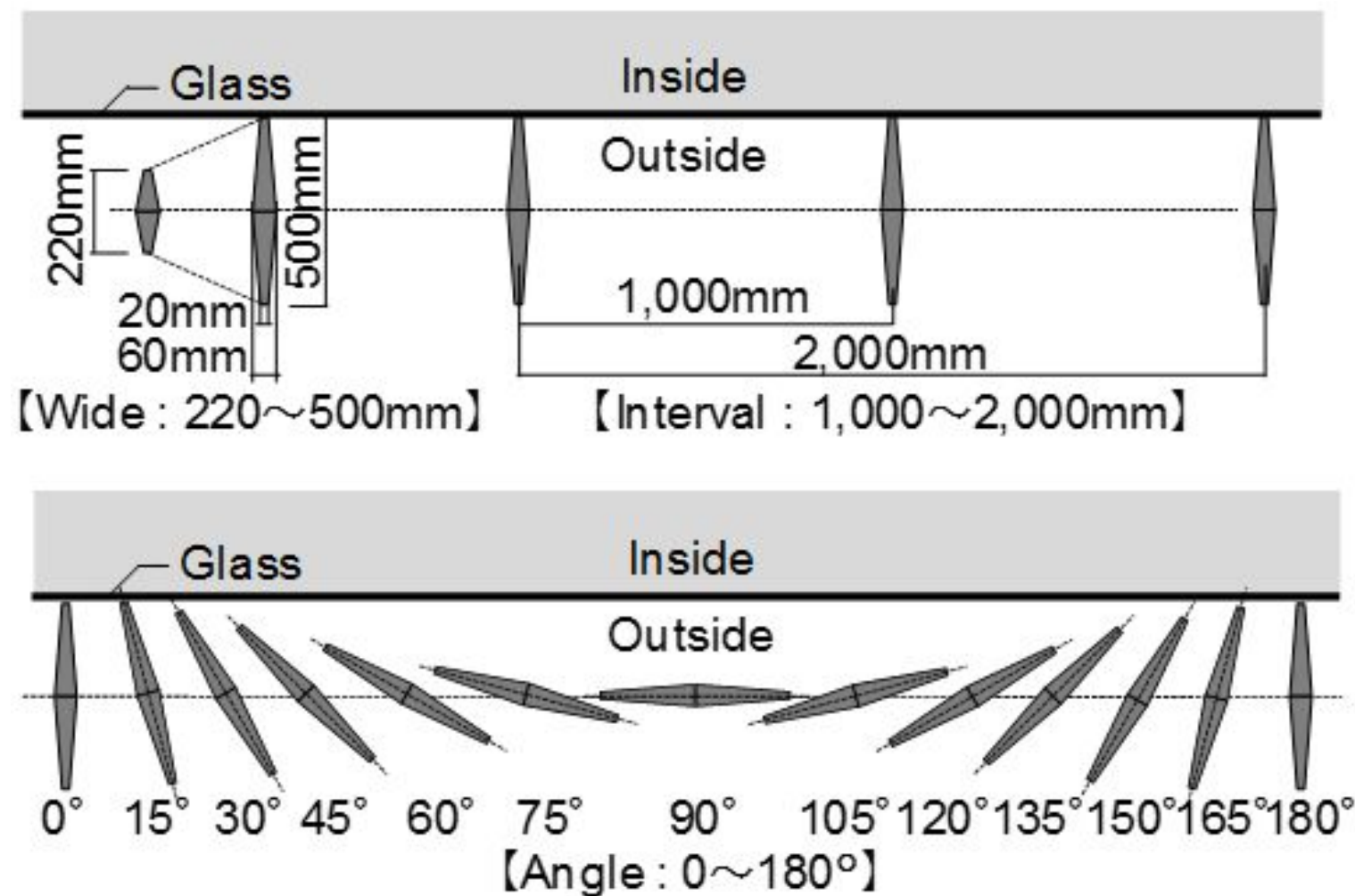


Fig.8 Detail of vertical louver

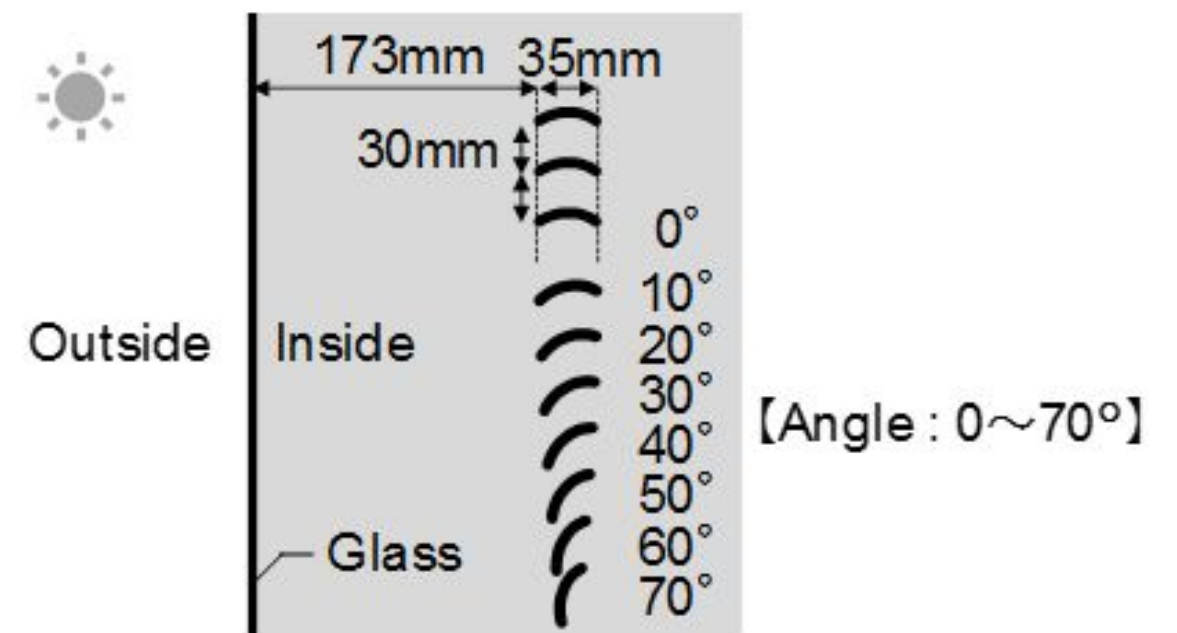
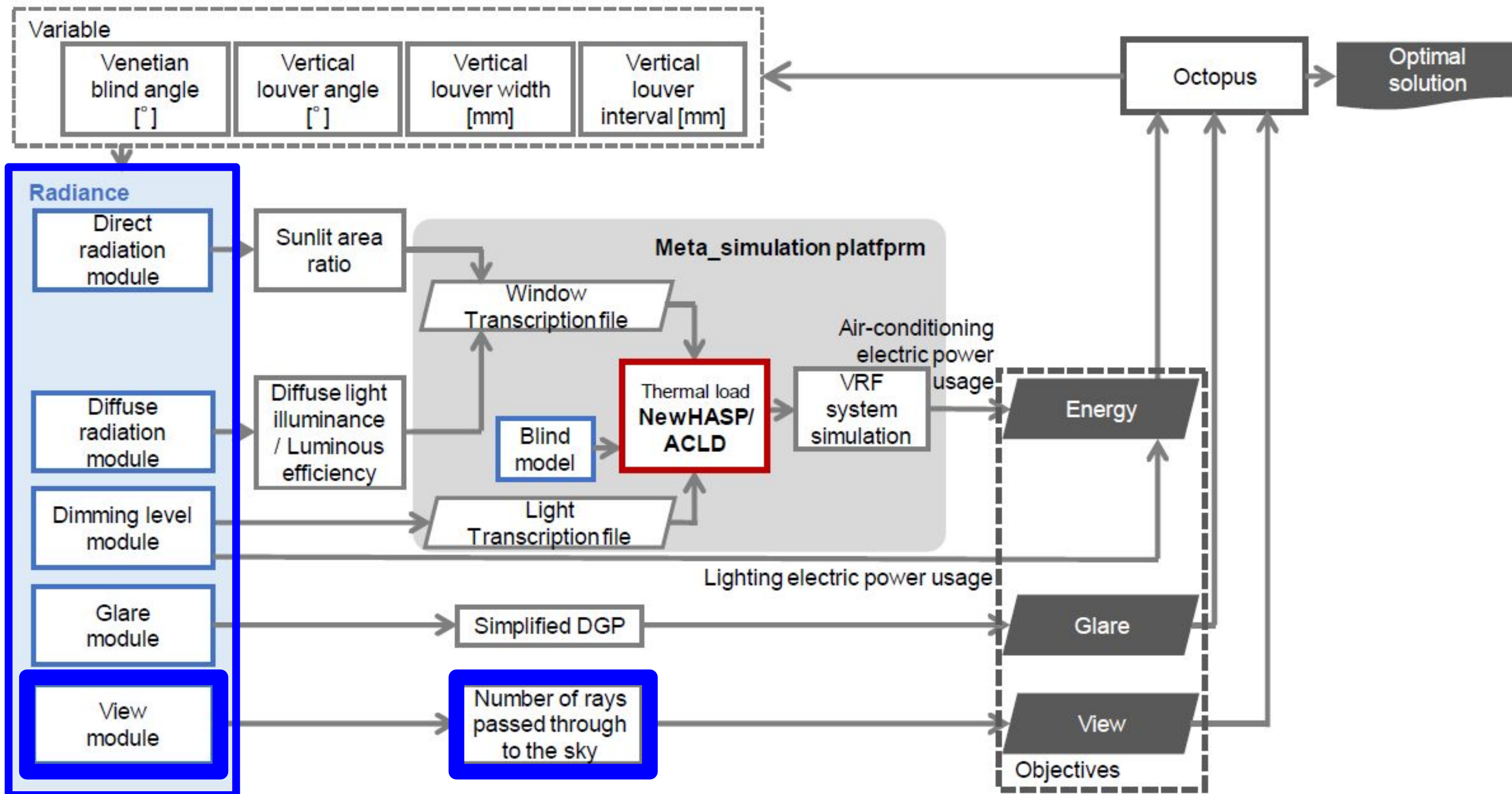
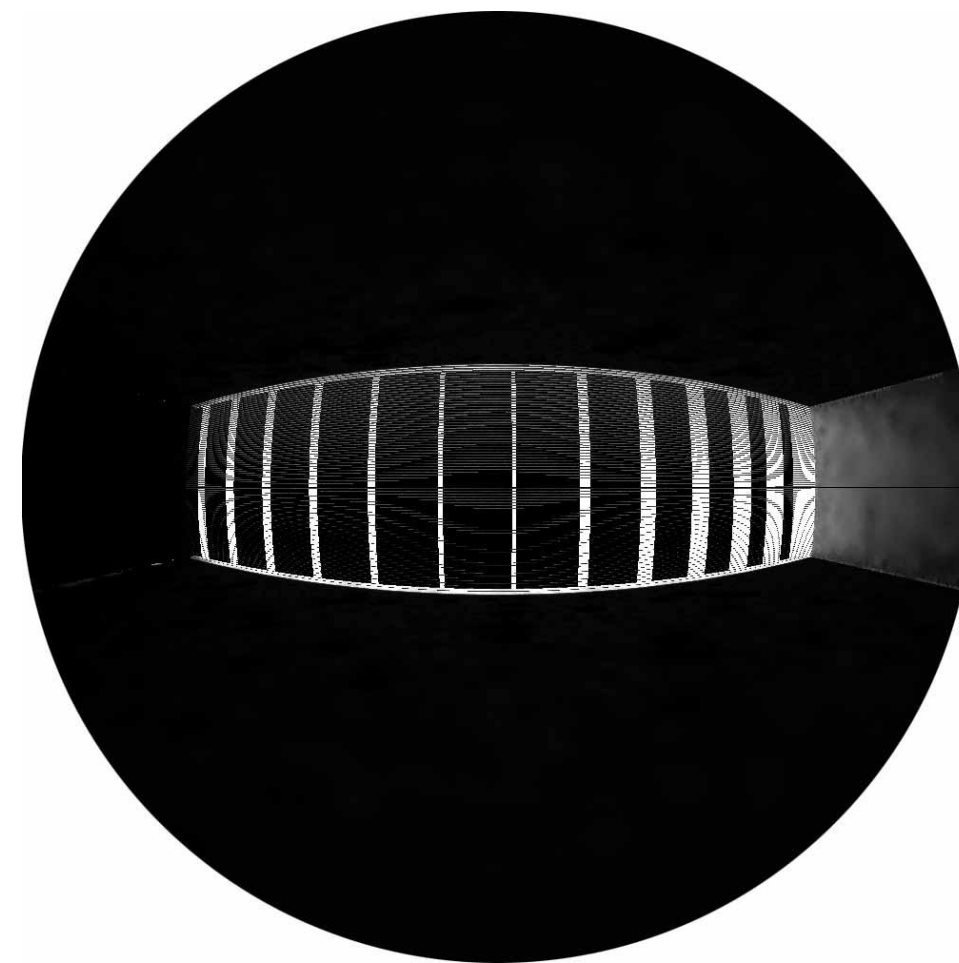
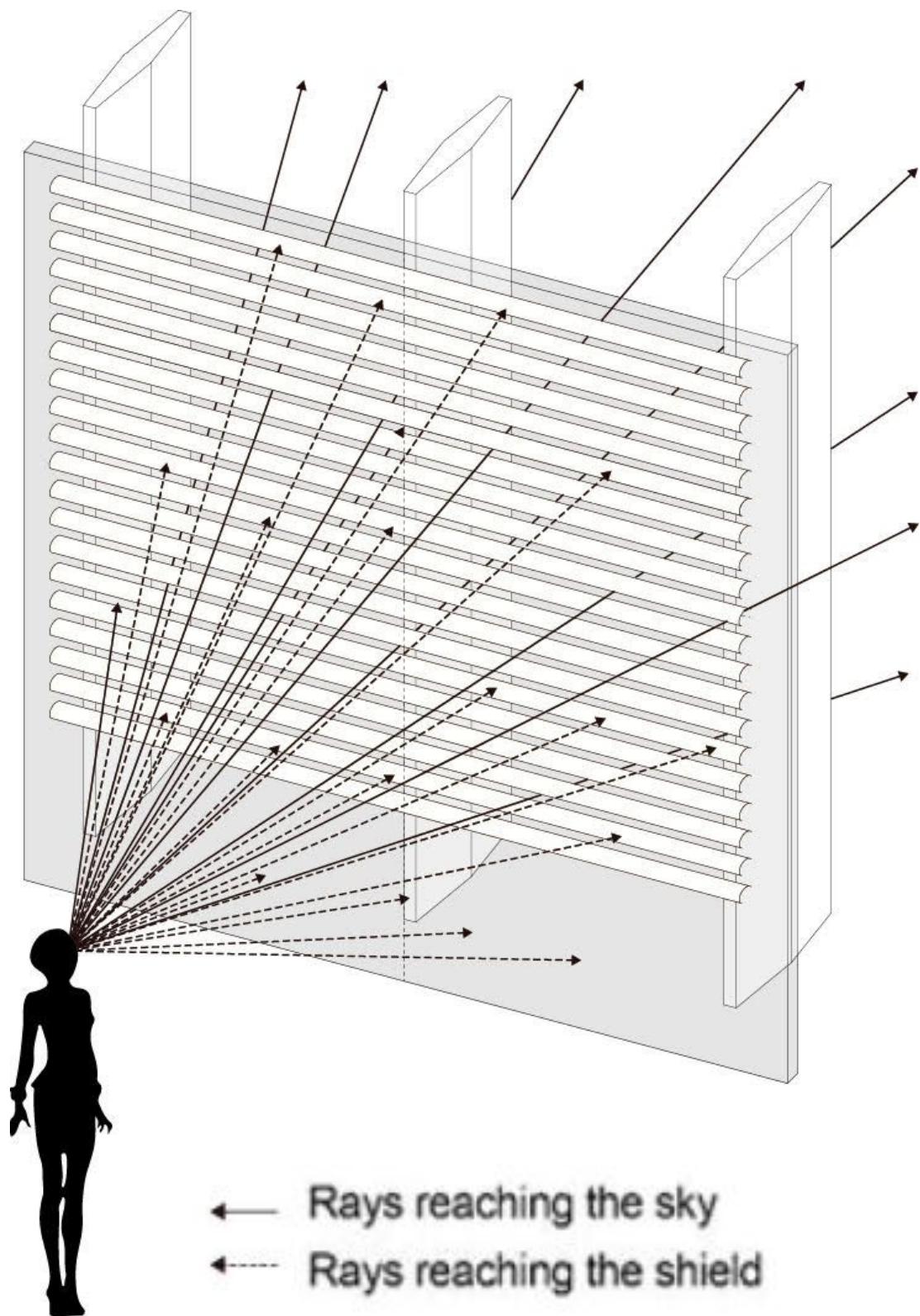


Fig.9 Detail of Venetian blind



$$V = \frac{N}{\pi R^2}$$

v View ratio (%)
 N Number of pixels with elements of sky
 R Radius on projection drawings (pixels)

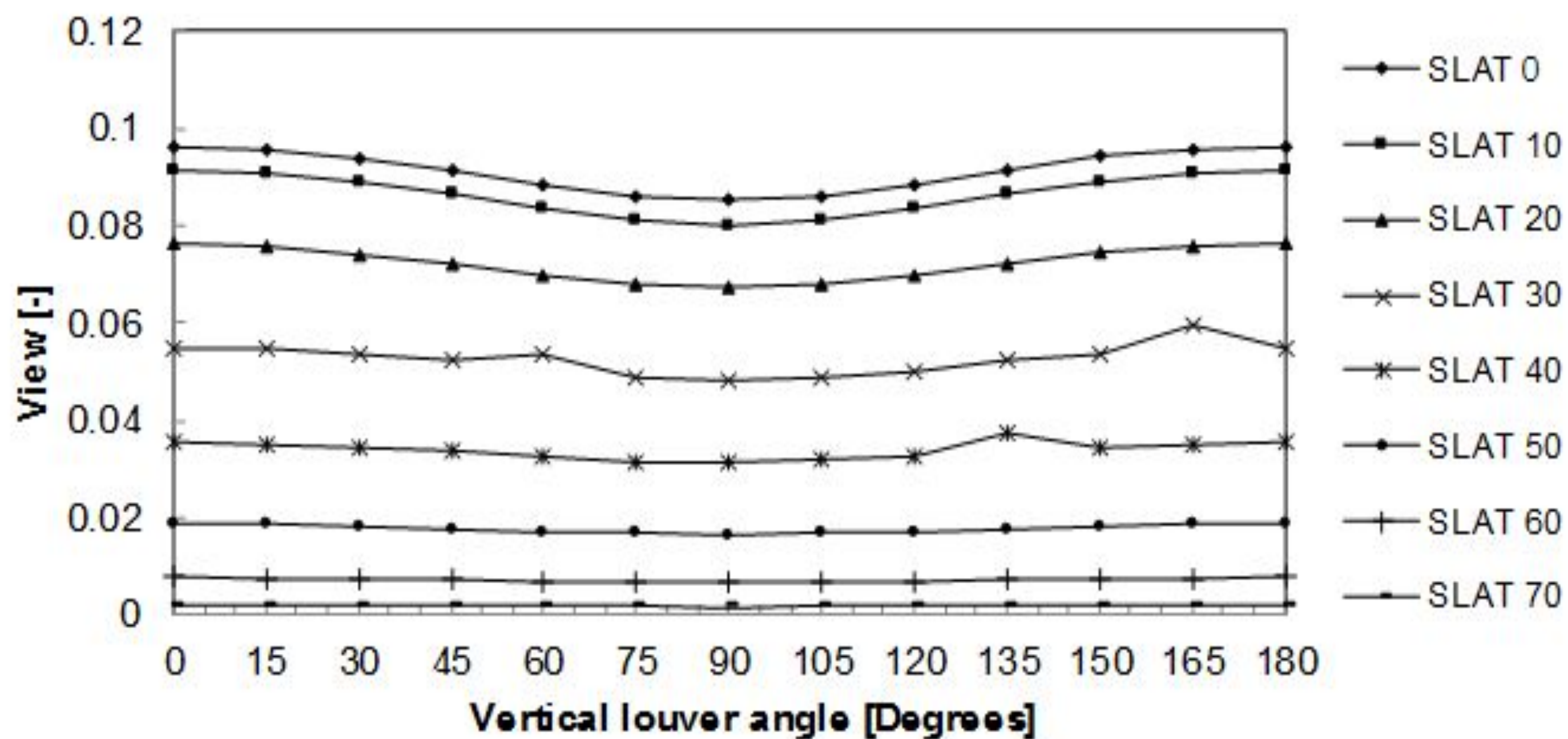


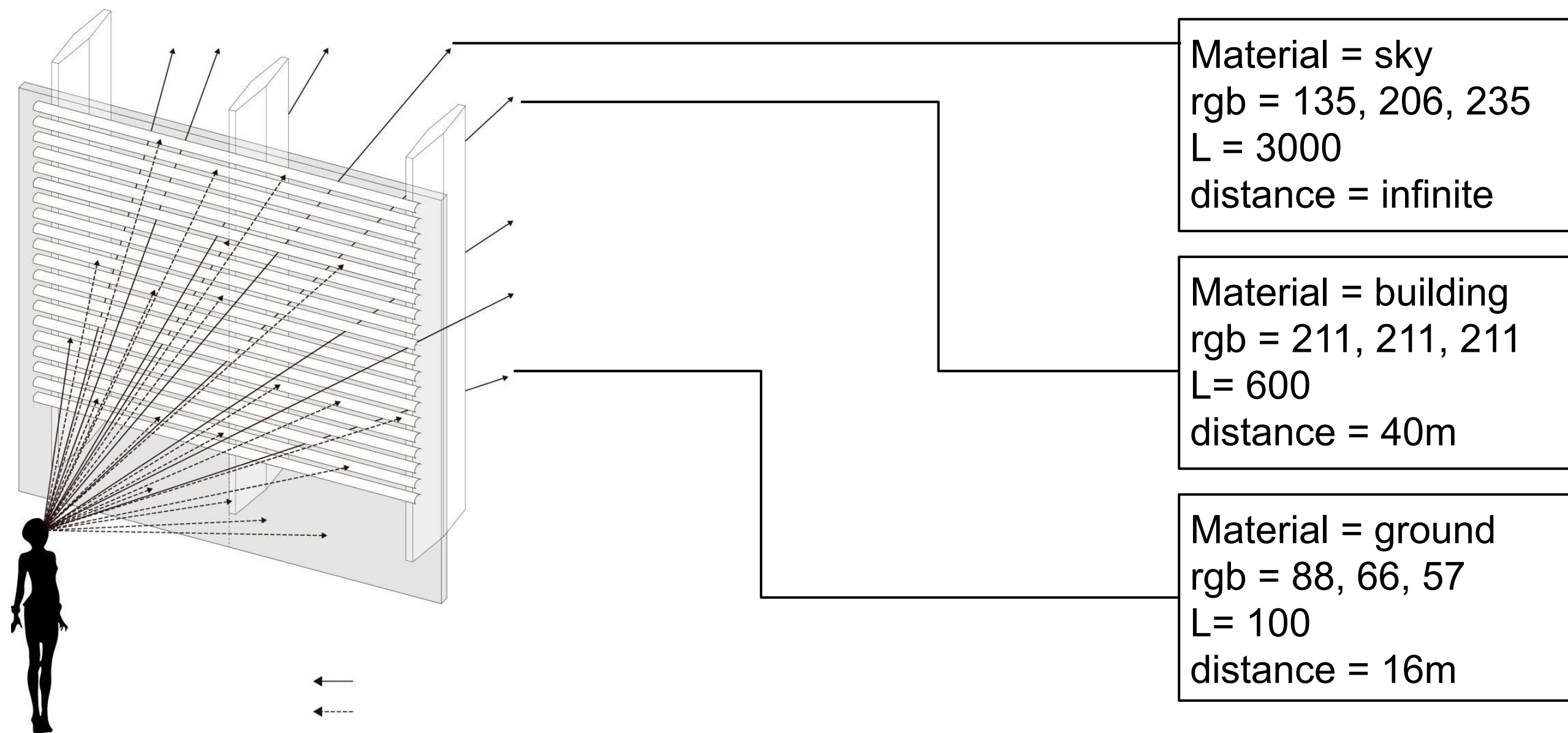
R=500

Louver angle
 : 105°

Slat width
 : 30mm

Appearance from the observation point





From any specific reference point (Q), the view quality depends on:

- the size of the daylight opening(s);
- the width of the view (horizontal sight angle);
- the outside distance of view;
- the number of layers;
- the quality of the environmental information of the view.

DIN EN 17037,
5.2 Assessment for view out

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