RTRACE with Equisolid projection in Environmental Psychology studies

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Application of Rtrace in Environmental Psychology Laboratory

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- What is Environmental Psychology Laboratory?

- Application examples
  
  [ case 1 ] Spaciousness calculation with 3D luminance mapping
  
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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)
Application of Rtrace in Environmental Psychology Laboratory

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Light seems to affect spaciousness
Light seems to affect spaciousness

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.

CIE 2019
EFFECTS OF LIGHTING ON PERCEPTION OF SPACIOUSNESS
Hiroyuki MIYAKE et al.
DOI 10.25039/x46.2019.PO140
http://files.cie.co.at/x046_2019/x046-PO140.pdf
Spaciousness = $\log_{10} \left( \text{Arithmetic mean of } (L \text{ (cd/m}^2) \times D \text{ (mm)} \times \cos \theta) \right)$  

(to be further developed)

$L$ = luminance of each pixel : -ov

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

$\theta$ = 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
Equisolid projection

Equidistant projection

Orthographic projection

Stereographic projection

-\texttt{vth} option available

-\texttt{vta} option available

-\texttt{vts} option available

We need \texttt{THIS} !!!

\texttt{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

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)
Result

Spaciousness = \log_{10} \left( \text{Arithmetic mean of } \left( \frac{L}{\text{cd/m}^2} \times D \text{ (mm)} \times \cos \theta \right) \right) \\
(\text{to be further developed})

(luminous surfaces of fixtures are excluded from calculation)
Experiment Configuration
Experiment
Lighting scenes

Far
Dark

Close

Medium
Bright
**Produced data**

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

**Spaciousness** = \( \log_{10}(\text{Arithmetic mean of } (L \text{ (cd/m}^2) \times D \text{ (mm) } \times \text{cos}\theta)) \) \( \text{(to be further developed)} \)

- \( L = \text{luminance of each pixel} \) : -ov
- \( D = \text{distance from the observing point to the surface in that pixel} \) : -oL
- \( \theta = \text{angle between the direction to that pixel and the view axis} \) : od (normalized vector)
RTRACE OPTIONS

- ospec

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

- origin (input)
- direction (normalized)
- value (radiance)
- contribution (radiance)
- weight
- color coefficient
- effective length of ray
- first intersection distance
- local (u,v) coordinates
- point of intersection
- normal at intersection (perturbed)
- normal at intersection (unperturbed)
- surface name
- modifier name
- 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 Esr

Scalar illuminance is the quantity of light going through an infinitesimal sphere, divided by the area of the infinitesimal sphere.

**Esr** = \( \frac{|E|}{4} + \sim E \)

(18,000 points)

\[
E_s = \frac{1}{4} \int_{4\pi} L \, d\omega
\]

(1,570,792 points)
Scaler illuminance - calculated values

With Geodesic Dome
\[ y = 0.994x - 0.0132 \]
\[ R^2 = 0.997 \]

3D Luminance mapping
\[ y = 1.014x - 0.0019 \]
\[ R^2 = 0.991 \]
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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

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


Ambient Visual Information (1993)

Image: Ryuzo OHNO
Experiment about sense of security in a housing complex site

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

Image: Ryuzo OHNO
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 x 2)
much better resolution

d
direction (normalized)

v
value (radiance)

V
contribution (radiance)

w
weight

W

color coefficient

I
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
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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.

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

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


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)
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.

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**Example:**

- **Material = sky**
  - rgb = 135, 206, 235
  - \( L = 3000 \)
  - distance = infinite

- **Material = building**
  - rgb = 211, 211, 211
  - \( L = 600 \)
  - distance = 40m

- **Material = ground**
  - rgb = 88, 66, 57
  - \( L = 100 \)
  - distance = 16m

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**DIN EN 17037, 5.2 Assessment for view out**
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Thank you for your attention