Simulation of daylight by Radiance in dense urban areas

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Organized by

Architecture Department, University of the Basque Country

www.ehu.eus

Loisos + Ubbelohde, California, USA

www.coolshadow.com
Many cities have dense urban areas such as the old town.

Old Town of Donostia – San Sebastián.
Simulation of daylight by Radiance in dense urban areas

TOPIC: LIGHT WELLS

ISSUE
Darks, wet, unhealthy
Current State

Need for enhancement.

Have its dimension.

Paint everything white.

Simulation of daylight by Radiance in dense urban areas

19th Annual International Radiance Workshop
Bizkaia Aretoa Convention Center, Bilbao (Spain)

Urtza Uriarte (19-20/08/2021)
OBJECTIVE

Simulating rooms with low-light: and this requires precision.
Simulation of daylight by Radiance in dense urban areas

METHOD

- Radiance
- Sky

More accurate simulation

Reflection coefficients
- Material optical properties
- Photography
- Reflectometry-BSDF
Old Town of Donostia-San Sebastián

LIGHT WELL
Esterlines – Narrika – Enbeltran

INTERIOR
Esterlines Street 3-1°
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MEASUREMENT CAMPAIGN: FIRST ONE: DATA

- Date: 26/05/21
- Site: Light Well Esterlines Street 3-1°, Old Town of San Sebastián
- Measurement Frequency: Every hour (16.00-20.00)
- Measurement site: Roof and the first floor interior room with window to light well
- 2 luxmeters: 1 at the roof; and 1 at first floor interior (25 cm from the window and 40 cm from the wall)
- 1 camera: Sky and interior photographs, hourly
- 1 reflectometer: Optical properties with interior walls BSDF
- Sky Type: Intermediate, starting with half-overcast and turning to clear sky
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MEASUREMENT CAMPAIGN: MEASUREMENT POINTS

Roof-Sky
Photography
Light level

Window to light well

Interior – Surfaces
Light level
Photography
BSDF
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MEASUREMENT CAMPAIGN: RESULTS: LIGHT LEVEL

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MEASUREMENT CAMPAIGN: PHOTOGRAPHS: 15:00 - 26/05/2021

Lambert Projection

Hemisphere projection

SKY

INTERIOR_1st F
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MEASUREMENT CAMPAIGN: OPTICAL PROPERTIES

Reflection coefficients

Reflectometer BSDF

ρ: 0.32
ρ: 0.08
ρ: 0.83
ρ: 0.06
ρ: 0.32
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SKY DIFFERENT DISCRETIZATIONS

145 divisions  580 divisions  2305 divisions  5000 divisions

gensky
genskyvec
Hypothesis:

If the sky partition is not accurate the probability of direct radiation will be overestimated.
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SIMULATION

RESULTS: 145 DIVISIONS

145 divi.

gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 1

2-Phase Method

Parameters command *rfluxmtx*

-ab 6 -ad 1000000 -lr 10

Illuminance, lx

Max: 60 098 lx
Min: 60 019 lx
Simulation of daylight by Radiance in dense urban areas

SIMULATION

RESULTS: 2305 DIVISIONS

2305 divi.

gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 4

Max: 61 374 lx
Min: 60 917 lx

2-Phase Method

Parameters command *rfluxmtx*

-ab 6 -ad 1000000 -lr 10

Illuminance, lx

Max: 61 374 lx
Min: 60 917 lx
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SKY INTERIOR WORK PLANE

Interior

1581 sensor points.
Test with different sky partition.
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SIMULATION

RESULTS: 145 DIVISIONS

145 divi.

gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 1

2-Phase Method

Parameters command rfluxmtx

-ab 6 -ad 10000 -lr 10

Illuminance, lx

Max: 55 184 lx
Min: 0 lx
Simulation of daylight by Radiance in dense urban areas

SIMULATION

RESULTS: 2305 DIVISIONS

2305 divi.

gensky 03 21 12 +s -a 41 -o -2 -m -15
| genskyvec -m 1

Max: 56 510 lx
Min: 0 lx

2-Phase Method

Parameters command rfluxmtx
-ab 6 -ad 10000 -lr 10

Illuminance, lx
Simulation of daylight by Radiance in dense urban areas

**SIMULATION**

**RESULTS: COMPARISON**

- **ILUMINANCE, lx**

- **145 divisions**

- **2305 divisions**

21st Annual International Radiance Workshop
Bizkaia Aretoa Convention Center, Bilbao (Spain)

Urtza Uriarte (19-20/08/2021)
In this context of low-light, it would be useful to get more sky divisions, such as 2305 divisions, or more to probe whether the results will be more accurate.

5000 divisions.
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**SIMULATION PROCESS**

**STANDARD LIGHT WELL**

- 4 floors
- Sensor Grid:
  - 4 x 3 m;
  - 0.25 m between sensors
- Walls width: 0.25 m
- Window Glazing:
  - single pane;
  - specular reflection 0.08;
  - direct transmittance 0.88
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Threshold: 100 lx

Diffuse Surface 0.85

-\text{ab} 30 -\text{ad} 1000000 -\text{lr} 30 2305 \text{ divisions}
\quad 2.78 \text{ h/day}
\quad 2\text{h}47 \text{ Radiosity: } 2\text{h}53

Specular Surface

-\text{ab} 30 -\text{ad} 1000000 -\text{lr} 30 2305 \text{ divisions}
\quad 9.11 \text{ h/day}
\quad 9\text{h}07 \text{ Radiosity: } 9\text{h}12
More accurate reflection coefficients for a real WALL of a Light Well

Light Well that we are measuring; coefficients reflections from photographed front wall
The reflection coefficient of each quartering of the wall

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</table>
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SIMULATION PROCESS  LIGHT WELL REFLECTION COEFFICIENTS

DA, 1 coeficiente de 0.3

DA, 1 coeficiente de 0.5

DA, 24F x 6C coef.

DA, promedio 1 coef. 0.75

DA, 1 coeficiente de 0.85

-ab 30 -ad 10000 -lr 30
145 divisions
1h14

-ab 30 -ad 10000 -lr 30
145 divisions
2h13

-ab 30 -ad 10000 -lr 30
145 divisions
3h56

-ab 30 -ad 10000 -lr 30
145 divisions
3h58

-ab 30 -ad 10000 -lr 30
145 divisions
4h49
Defining the minimum detail of the simulation is relevant for more accurate results under low daylight level, at least:

- Sky division: 2305
- Reflection coefficients: measured BSDF of determinant surfaces
- \texttt{rfluxmtx} parameters: -ab 30 -ad 1000000 -lr 30
- Modelled surfaces: 0.25 m x 0.25 m
✓ Modelling the real Light Well, for which we have already made the first measurements.

✓ Get the calibrated simulations according with mentioned specifications
✓ Coloured luminous surfaces can create a more comfortable atmosphere.
Improving daylight *conduction* by simulating different *finishes* of surfaces or with *skylight Complex Fenestration System*
THANK YOU

GRACIAS

ESKERRIK ASKO