EvalDRC: a new, versatile frontend for climate-based daylight assessment with Contribution Photon Mapping

CC Envelopes and Solar Energy
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Overview

EvalDRC is a scripted frontend for simulating and assessing the annual performance of Daylight Redirecting Components (DRCs)

General Features

• Visual evaluation as HDR rendering
• Numerical evaluation as illuminance plots
• Postprocessing with Daylight Metrics (sDA/ASE)
• Supports analytical and climate based sky models

Special Features

• Supports Contribution Photon Map a./o. classic BSDF data models
• TrueSun coefficients for accurate solar contribution
• Enhanced monthly Daylight Metrics (msDA / MSE)
## Process Flow

**Input**
- scene geometry
- material properties
- location & timeframe
- weather data
- sensor point grid
- calculation parameters
- metrics thresholds

**Processing**
- EvalDRC
  - timeframe setting
  - sky & sun configuration
  - photon map generation
  - coefficient calculation
  - coefficient superposition
  - metrics calculation
- RADIANCE
  - gensky, gendaylight
  - mkpmap (new)
  - rcontrib

**Output**
- HDR images
- illuminance plots
- daylight metrics
  - sDA & msDA
  - ASE & MSE
Coefficient Generation

Sky: Standard Sky Discretization with Patches (Tregenza)
Coefficient Generation

Sun: separate solar coefficients calculated with 0.5° sun sources

Solar contribution coefficients

Superposition of sky patch coefficients plus one solar coefficient
Sky/Sun Model Comparison

Standard: sun luminance distributed among neighbouring sky patches

EvalDRC: sky patches + separate accurate 0.5° sun sources
Various Strategies for the Solar Contribution

3 Phase Method / Reinhart subdiv. of Tregenza patches

DAYSIM (64 pos.)

5 Phase Method (Solar Vector)

EvalDRC
Deviation between sun positions on consecutive days is much less than between the hourly timestamps of the usual metrics time schedule (5d working week, 10h per day). Sunpath for one day can be utilized for 1 or 2 days before and after it with negligible accuracy loss for the final metrics results. (Max. deviation from the true sun positions is approx. 1 °)
sDA / ASE Daylight Metrics

spatial Daylight Autonomy: sDA $\geq 300, 50$

1: Time
I > 300 lx for T > 50% of office hours

2: Space
A > 55 %: acceptable

A > 75 %: preferred
Monthly Daylight Metrics

The monthly metrics are calculated analogously to the annual counterparts.

E.g., for a grid with N points, the msDA for month m is:

\[ msDA_m = \frac{\sum_{j=1}^{N} S(j, m)}{N} \quad \text{with} \quad S(j, m) = \begin{cases} 1 : s_{j,m} \geq \tau t_m \\ 0 : s_{j,m} < \tau t_m \end{cases}, \]

\( s_{j,m} = \) occurrence count of exceeding the sDA illuminance threshold at point \( j \) for month \( m \)

\( t_m = \) timestamp count for month \( m \)

There is no simple relationship between monthly and annual metrics. Especially, the annual value is *not* the average of the monthly values. (Cf. [1])
The sDA definition demands the consideration of sun shading for timestamps with sunlight exposure on the workplane. (Default definition: more than 2% of grid points receive more than 1000 lux direct sunlight).

Current implementation in EvalDRC:

1) perform 2 annual simulation runs, one for a scene with, and one for the scene without sun shade geometry

2) EvalDRC then performs a dynamic combination of the 2 result sets acc. to the specified thresholds
DRC Evaluation methods

**Contribution Photon Map**
Provide accurate geometry and material model of DRC system

**BSDF Data Representations**
Provide (more or less) abstract 'representative' models of DRC systems with attached BSDF data sets
Application Example: Daylight Optimization Study

Classroom (Studio) at the Dept. of Architecture, Lucerne University

View towards south facing facade

Abstract facade model

Strategy: Reduce WWR to reduce solar gain, compensate with DRC (microstructured film). Cf. [2]

Sample of holographic film, BSDF measured at CC EASE goniophotometer lab
Daylight Metrics Results

bar diagrams (left): annual sDA/ASE,
graphs (right): monthly msDA / MSE
Daylight Metrics Results

Comparison of monthly msDA and MSE

![Graph showing the comparison of monthly msDA and MSE.](image)
Application Example: Daylight Course at IYTE (İzmir)

Learning goals

- Daylight redirection strategies / DRC types
- Geometry model aspects (level of detail, etc.)
- Material models (diffuse, diffuse+specular, full BSDF, ...)
- Software based simulation techniques and limitations (Radiosity, Raytracing, Photon Mapping, ...)
- Daylight assessment (metrics, visualizations for confirmation/cross-checking)

Study Project

Development of a daylight strategy with self-modeled DRC elements for a classroom with south facing facade.
3D Models built in Relux
Final evaluation with EvalDRC
Discussion and analysis of simulation results
Conclusion & Outlook

Conclusion

- EvalDRC is a powerful, flexible and convenient framework for the performance assessment of DRCs
- Support for both Contribution Photon Mapping and/or BSDF data makes it applicable for a wide variety of DRC systems
- Monthly daylight metrics provide a better means for understanding DRC system performance compared to the coarser annual averages

Tentative Outlook

- Going public? (Funding ... ?)
- Using EvalDRC together with field-of view based glare evaluation tools
- Connection to thermal simulation tools
- Enhanced calculation methods for dynamic sunshade models
Thank you for your attention!

Our website: http://www.hslu.ch/ccease

References / Suggested further reading:


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