Radiance Related Activities at LBNL

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Goals

1. Enable accurate annual assessments of innovative daylighting technologies
2. Enable users of all abilities to simulate complex fenestration with Radiance
Outline

Part 1: Overview of Radiance related activities at LBNL

Part 2: Applying new Radiance tools to perform an annual assessments of complex fenestration systems
Radiance Related Activities At LBNL

- Optical Measurements
- Window6 BSDF integration
- COMFEN - Radiance Integration
- Building Controls Virtual Test Bed (BCVTB)
- Increased Support of Radiance Community
Measurements of Optically Complex Fenestration Layers

- Measured ~200 devices!
- Working on a way to make data available (some kind of robust database).

pab-opto goniophotometer
Window6

• Includes non-specular window components
• Writes a BSDF file for glazing + shading
• Working to include MGF data for mkillum renderings.
Window 6

- Venetian Blind
- Homogeneous Diffusing Shade
- Woven Shade
- Frit
- BSDF import
COMFEN

- Commercial Fenestration Design Tool for conceptual/preliminary design
- For architects, engineers, building industry professionals
- Provides comparative results between façade design options and their impact on the perimeter zone
- Multiple glazing and shading options on each façade.
- EnergyPlus simulation engine
- **Not** whole building analysis.
Define a glazing system for a window (glass + gas components).
Include shades, blinds, drapes, external shading devices, etc.
Assign glazing systems to windows in model.

Drag a glazing system onto each window.

<table>
<thead>
<tr>
<th>Name</th>
<th>TVS</th>
<th>SHGC</th>
<th>U-Factor</th>
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<td>1.78</td>
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</table>
COMFEN Annual Energy Results

[Graphical representation of energy use intensity, peak energy use, and CO2 emissions for various scenarios.]

- Energy Use Intensity:
  - Heating, Cooling, Fan, Lighting

- Peak Energy Use:
  - Gas, Elect.

- CO2 Emissions:
  - Gas, Elect.

- Facade:
  - Window Annual Total Solar Gain (per total floor area)
  - Window Peak Solar Gain (per total floor area)
Monthly Zone Results

Energy-use + Peak

Facade-energy (load)
Solar Gain

Facade Gain

Window Gain
Radiance Integration with COMFEN

• Clean & Easy Radiance integration for modeling complex fenestration using BSDF.

• Stage One - static renderings using mkillum l+ option with BSDF file (October 2010)

• Stage Two - more realistic renderings using mkillum l- option and using detailed geometry incorporated in BSDF file.

• Stage Three - Annual Daylight Calculations with Radiance?
Radiance Integration with COMFEN
Building Controls Virtual Test Bed (BCVTB)

• allows users to easily connect simulation programs & share data between programs.

• provides an opportunity to simulate interaction between building systems

• gives the ability to test control semantics
BCVTB is

- Based on Ptolemy framework
- Actor-oriented framework for concurrent simulation
- UC Berkeley EECS department
- Java
- Has a graphical user interface - Vergil
- Open Source
BCVTB GUI

This model illustrates the implementation of an EnergyPlus model that communicates with Ptolemy II through BSD sockets. Input into EnergyPlus is a signal for an EMS actuator of a shading device.

Output simulation time and wall clock time. This is for illustration purposes only and not needed by the above model.

Author: Michael Wetter
Support Radiance User Community

• We’re working to secure funding for a new website.

• We want to host Radiance Workshop in 2011
Website Wish List

- Organized process for pre-release testing. (volunteers for platform testing needed!)
- Anonymous CVS access (via mirror or git)
- Organized library of tutorials, references and documentation.
- Material repository with some sort of trusted user rating system.
- Improved browsing and searching of the mailing list (forum with subscription)?
- Anything else?
Annual Assessment of
Optically Complex
Fenestration
Applying new Radiance BSDF tools
Open Plan Office Space

- The space is extra deep for testing daylight redirection systems.
- The fenestration consists of upper daylight windows and lower view windows.
Fenestration Systems

Daylight Glazing 67% VLT

View Glazing 30% VLT

Reference 1 Venetian Blinds
Reference 2 Clear Glazing
Test Case Optical Light Shelf
View Matrices

- Illuminance sensor points for daylight sufficiency
- Luminance renderings for visual comfort
Illuminance View Matrix

Zone 1

Zone 2

Zone 3
Illuminance View Matrix

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<thead>
<tr>
<th>rtcontrib settings</th>
<th>Value</th>
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<td>-ds</td>
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Computation Time:
1.25 CPU*Hours
(1) 2.66 GHz Processor
Rendered View Matrix

View 1

View 2

View 3
Rendered View Matrix

<table>
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<tbody>
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</tr>
<tr>
<td>-ds</td>
<td>0.06</td>
</tr>
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Computation Time:
- 4013 CPU*Hours
- (64) 2.66 GHz Processor
- 62 Hours (wall time)
Daylight Matrix

Reinhart MF:4 sky
(2305 divisions)

No External Obstructions

Computation Time:
1.25 CPU*Hours
S Matrix

- Sky vectors were pre-computed and zipped to reduce repetitive generation of the same sky vectors.
  
gendaylit [options] | genskyvec -m 4 | gzip > m_d_t.svec.gz

- gensky was used when gendaylit failed (assumed a static sun and sky efficacy).

- Computation time: 1.0 CPU hours
T-Matrix (BTDF)

- Generated a BTDF using radiance genklemsamp and rtcontrib.
Prelude Calculation Times

- V Matrix: 1.25 hours for Illuminance
  62 hours for a Rendering
- D Matrix: 1 hour
- T matrix: 1 hour with genBSDF
  0.05 hours with Window6
- S matrix: 1 hour

Now we can start our annual simulations!
Annual Runs

- dctimestep for illuminance zones
  - Illuminances processed for UDI, CDA and lighting energy use.
  - computation takes 2.5 hours

- dctimestep for rendered views
  - Images analyzed for DGI
  - computation takes 12.5 hours (smaller images would speed this up)
BCVTB Model for Annual Daylight Simulation
Why Use BCVTB?

BCVTB is not necessary for annual simulations with Radiance.

We used BCVTB because of our future needs:

- Ability to easily incorporate control algorithms when we simulate dynamic systems
- Ability to add Energy Plus to the model to simulate HVAC energ.
- Ability to connect manufacturer’s control hardware to test systems without the need to reveal proprietary algorithms
Useful Daylight Illuminance

Useful Daylight Illuminance
Washington

- Zone 1
- Zone 2
- Zone 3

Ref 1 | Ref 2 | Test 1
--- | --- | ---
0% | 40% | 60%
Daylight Glare Index

Visual Discomfort
Washington
Percent of Hours DGI>22

Ref 1  Ref 2  Test 1

View 1  View 2  View 3
Annual Daylight Glare Index Plots
Washington

View 1
Reference Case 1: Venetian Blinds

View 1
Reference Case 2: Clear Glass

View 1
Test Case 1: Passive Optical Light Shelf

View 2
Reference Case 1: Venetian Blinds

View 2
Reference Case 2: Clear Glass

View 2
Test Case 1: Passive Optical Light Shelf

View 3
Reference Case 1: Venetian Blinds

View 3
Reference Case 2: Clear Glass

View 3
Test Case 1: Passive Optical Light Shelf

Daylight Glare Index [DGI]
Who Would Do This?

• Manufacturers
  • Test products in a prototype stage
  • Test products in various climates
  • Test control algorithms for motorized products.

• Lighting Consultants
  • Simulate performance of various systems for a specific project
  • Evaluate design of custom shading systems
What do users need to do this?

- **Illuminance only - relatively fast:**
  
  a desktop computer

  half a day (for computation - not including model prep.)

- **Renderings - slower:**

  Could be sped up by using lower resolution images and reduced rendering parameters. Could still be done with a desktop computer but would need to run overnight. A small cluster doesn’t hurt though.
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More Info:

Window 6
http://windows.lbl.gov/software/window/6

High performance commercial building facades
http://lowenergyfacades.lbl.gov

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