Optical Data for Complex Glazing and Shading:
Models, Measurements, Calculations

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NFRC Objective

• Build database for window/shading system rating (and design)
  – Window 4/5 database full of specular materials
  – Window 6 needs to expand CGDB
Summary of Approach

• Measurement and microstructural models of component materials
• Raytracing as a general method for modeling of complex systems
• Specific models (e.g. blinds and screens) for speed and reduction of database
• Leverage with international efforts
Full-Scale Measurement
Validation

A Direct Peak

B Direct Peak + Reflection

C Reflected Peak

Direct Peak

Direct Peak + Reflection

Reflected Peak
Gonio-spectro-radio-meter
Types of Directionality

specular

diffuse

shading device
Measurement of Diffuse Glazing
Different ways to measure transmittance

1. Sample, here a fritted glass with the fritted side towards the sphere
2. Standard Labsphere port plate, easy to remove
3. Part of the sphere
0. Aperture plate (not included by Labsphere) to reduce beam size
One sample - 6 results

Transmittance of white fritted glass

- Small aperture, facing sphere
- Small aperture, facing beam
- Large port, facing sphere
- Large port, facing beam
- Standard port, facing sphere
- Standard port, facing beam

Measured transmittance vs. Wavelength (nm)
Normal incidence BTDF for white fritted glass
BTDF of White vs. Clear Frit

Hemispherical transmittance 0.30 distributed over a wide range of angles

Hemispherical transmittance 0.90 distributed mostly between 0 and 5 degrees
Getting Started

• Computer, faster is better but not essential.
• TracePro® raytracing program, 10K$.
• Virtual goniometer macro package, in development at LBNL.
Outline of Raytracing Process

1. Create your sample using the solid modeling engine in TracePro or other CAD program (ACIS compatible, .SAT file format). (minutes to hours)
2. Create a “document” with the detector sphere (LBNL macro), insert your sample in the sphere. (3 minutes)
3. Set up number of rays to trace and other parameters. (2 minutes)
4. Replace 1-3 by combining them in a script containing any number of samples and trace conditions.
5. Run (hours, unattended)
Drawing your sample

- Clicking, dragging and pointing in a 3D CAD interface.
- Importing drawing from e.g. AutoCAD.
Drawing your sample with script

- Writing a text *script* with commands that draws/rotates/translates etc. your sample.

```plaintext
(define drawSlab
  (lambda (y)
    (begin

    ; insert a solid slab
      (define curBlind (insert:block blindX blindY blindZ)
      )

    ; Used to make it a solid, now apply only bottom mtrl to bottom, rest is topMaterial
      (property:apply-surface curBlind topMaterial)

    )

)
Blind Model from Script
Scripting your run(s)

- Manually setup and run in TracePro.
- Automatic setup and run with LBNL script.
  + 100% repeatability
  + String several traces together

```scheme
(define numberOfRays 1000)

; First simulation (with comments on each line)
; Create new model window to be certain of no old stuff in it
(file:new)
; now execute all the scripts
(createDetectorSphere 2000) ; 2m radius
(renameDetectorPatches)
(drawBlinds 70 11 120 1 16 12 0 solref070 solref070)
(traceAndDetect numberOfRays (string-append outputPath "A70frontBTDF.txt")
  (string-append outputPath "A70frontBRDF.txt"))
```
Segmented Detector Sphere
Virtual Goniometer
Presenting data

• Data generated is stored as ASCII text or Windows XML format (also ASCII) for maximum flexibility.

• Visualization and analysis packages are available for MATLAB® (Jacob Jonsson LBNL, Marilyne Andersen MIT), but the ASCII format should allow for maximum end-user flexibility.
Data presentation

BRDF visualization: projection on a virtual transmittance hemisphere

BRDF visualization: section views of photometric solid along azimuthal planes

BRDF visualization: Photometric Solid