Modeling and Rendering with AGI 32

ABS 731 Lighting Design & Technology

Spring 2006
What is AGI 32?

- AGI32 is used to predict the photometric performance of selected luminaires or daylight penetration in a simulated environment.
- The environments that can be considered range from simple to complex (i.e. a small room to a multi-level auditorium).
Calculation Techniques or Modes

**Direct**

- A simplified calculation technique used when reflected light need not be considered in the results.
- Lends itself particularly well to exterior lighting applications and warehouses with low reflectance surfaces.
- Uses considerably less computation time.

Arch. Ernst Holzapfel, Italy.
Calculation Techniques or Modes

- **Full**
  - Required in all other cases and is capable of predicting the interaction of light with reflective surfaces in any environment.
  - Required for rendered results.
  - *Must* be used for daylighting.

Arch. Ernst Holzapfel, Italy.
What Can You Calculate?

- Capable of a number of lighting specific computations aside from the basic incident illuminance (fc/lux) on any real or imaginary surface.
- Can also compute pavement luminance for roadway and tunnel applications per IESNA-RP-8-2000 and RP-22-2004,
- Glare Rating,
- Unified Glare Rating (CIE metrics for discomfort glare evaluation), and
- Daylight Factor for use with LEED specifications of usable daylight penetration.
Importing & Exporting Files …

- Can read from DXF (Drawing Exchange Format) or DWG (AutoCAD native format) files.
- Some information can be exported to DXF format. This is primarily used to send numeric results back to CAD for presentation with other project documents.
Photometry from Industry

- Photometric databases of IES format information are included with the software and are constantly maintained with updates available from the AGI32 website.

- Photometric data accessed in this way is guaranteed to function with AGI32 and is most easily searched and browsed for relevant products to suit your application.

- AGI32 will also read any photometric file in IESNA-LM-63-1995 format or newer that you may already have on your computer system.
Similarities

- The program is very similar to any CAD program.
- It is completely graphical … much like constructing a working drawing in CAD.
- 3-dimensional Cartesian coordinate system consisting of X, Y and Z axis.
- English or Metric units.
- Infinite drawing area; common zoom, pan functions.
Menus

- File-Open, File-Exit, File-Import and other commands are available from the File menu.
- The more operation specific menus ADD and MODIFY contain commands designed to Add or Modify entities in the drawing.
- The VIEW menu contains commands that operate on what you see on the screen.
- The CALCULATE menu provides calculation parameters and commands.
Menus

- DAYLIGHTING menu provides access to daylighting capabilities.
- The RAYTRACING menu contains settings and commands to initiate and view post-process ray tracing images.
- The TOOLS menu contains commands that can be considered Tools providing peripheral functions or adjusting some parameters of program operation.
# Setting Up A Project

<table>
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<tr>
<th>Example project</th>
<th>Desired results</th>
<th>Relevant commands</th>
<th>Calculation points</th>
<th>Render</th>
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<tr>
<td>Softball or area lighting</td>
<td>Numeric point x point, statistics, schedules, export to DXF</td>
<td>Direct with Autocalc (optional)</td>
<td>None or Buildings for shadow only</td>
<td>Polygon</td>
</tr>
<tr>
<td>Commercial interior</td>
<td>Numeric point x point, statistics, schedules, export to DXF</td>
<td>Full</td>
<td>Yes: Room and Objects</td>
<td>Automatic placement</td>
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<tr>
<td>Commercial interior with visualization</td>
<td>Same as above plus rendering, cannot export rendering to CAD</td>
<td>Full</td>
<td>Yes: Room and Objects</td>
<td>Automatic placement</td>
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<tr>
<td>Exterior with visualization</td>
<td>Same as above</td>
<td>Full</td>
<td>Buildings, Objects for ground</td>
<td>Polygon, 2pt, 3pt or automatic placement</td>
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<tr>
<td>Daylighting</td>
<td>Same as above</td>
<td>Full</td>
<td>Exterior or Interior model</td>
<td>Any</td>
</tr>
<tr>
<td>Roadway</td>
<td>Numeric, IES or CIE luminance computations</td>
<td>Direct</td>
<td>No (automatic for luminance calcs)</td>
<td>Roadway Luminance</td>
</tr>
<tr>
<td>Roadway with reflective geometry (tunnel)</td>
<td>Numeric, IES or CIE luminance computations</td>
<td>Full</td>
<td>Room and Object, tag as Roadway contributor and roadway surface in advanced edit</td>
<td>Roadway Luminance</td>
</tr>
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</table>
Interior Project - Steps for Success

- Step 1 - Open AGI32 and set the program in Full Calculation Mode.
- Step 2 - If a CAD background is available, use the File-Import command to bring in the drawing background from CAD generated DXF or DWG file.
- Step 3 - Define the luminaire photometrics to be used in the application using the LumAdd-Define command.
  - Take special care to define the proper Render Mode symbol for the luminaire. If the luminaire comes from a photometric database delivered with AGI32, the manufacturer may have already matched a custom symbol with this photometric file.
Step 4 - Create the 3-dimensional space required in the application. For simple applications this step may involve creating a single room shape using the Room command.

- For more complicated spaces, it may involve multiple Room shapes and a variety of Objects in combination. Three-dimensional CAD models can also be imported ranging from objects to complete architectural spaces.
Step 5 - Locate the luminaires as desired from the Luminaire toolbar.

Step 6 - Click on the Render button on the Main toolbar and AGI32 will advance to render mode displaying a wireframe mesh of the model.

Step 7 - Click on the Calculate button to watch the progressive *radiosity* calculation process. The process can be halted at anytime, however, the solution is complete only when the computation has reached a Convergence of 0.01.
Interior Project - Steps for Success

- Step 8 - Investigate the model using the standard view and Interactive command buttons from the toolbar.
- Step 9 - Return to AGI32’s Normal mode for any modifications to luminaire positions, quantities or definitions.
- Step 10 - You can iterate back and forth in Render mode and Normal mode as often as you like. Experiment with the Pseudocolor mode using the Display Properties command for a nice method of evaluating luminance or illuminance quantities.
- Step 11 - Within the AGI32 Normal mode, select the Add-Calculation Points-Automatic Placement command. Then select any surfaces within the dialog where calculation points are desired. On exit from the dialog, AGI32 will automatically place the calculation points.
Interior Project - Steps for Success

- Step 12 - Compute the project again from Normal mode or Render mode. Computations are slightly faster from Normal mode as the software does not have to intermittently refresh.

- Step 13 - The output options for an interior application are similar to those available in the previously discussed exterior application with a few additions for renderings.
  
  13.a For simple printed output of point by point results you can repeat Steps 9-12 as presented for exteriors.

  13.b For more complete printed output including rendered views, the Optional Steps in the exterior application move the focus to the Page Builder section.

  13.c Single views can also be exported to JPG or BMP format & complete 3-D virtual worlds can be exported in VRML format.
To Make Models More Realistic

- **Add texture maps** – AGI32 contains a library of bitmapped textures (materials) that can be applied to any reflective surface. You can also add your own bitmap textures to the library easily.

- **Ray-tracing** – If you select a single view or a series of viewpoints in render mode, AGI32 is able to run a post-radiosity process ray-trace to consider specular reflections and create very hard shadow lines in your renderings.

- **Color Bleeding** – The degree of color bleeding can be controlled within AGI32 to make the rendered image appear closer to that interpreted by the human visual system.
Daylight Analysis

- Consider the effect of sun, sky and ground as a light source in the environment.
- Emulate these conditions:
  - Clear
  - Partly Cloudy
  - Overcast
  - 15 other general sky conditions described by the CIE.
Daylight Analysis – Types of Studies

**Daylighting**

- Allows you to calculate the daylight contribution for one particular moment in time (e.g. Friday, November 29, 2002 at 9:35 AM) with one sky condition.

- You can consider the effect of electric lighting, as well.
Daylight Analysis – Types of Studies

Daylight Study

- Allows you to set up *multiple instances* of daylight application to the environment.
  - You can analyze several times within one day and/or several dates per your specifications.
  - Multiple sky conditions may be specified as well as the application of electric lighting.
  - The images created within the daylight study are saved and can be viewed and shared with the Daylight Study Viewer.
Daylighting Calculations

Step 1 - Direct light (electric and daylight)
Step 2 - Subdivide surfaces
Step 3 - Indirect Daylight
Step 4 - Windows and Openings to Interior surfaces
Step 5 - Indirect exchange between Interior surfaces

Virtual Ground
- Virtual ground plane
- 18% reflectance
- Non-obstructive

Exterior Daylight surfaces
- 30 - Single sided, Daylight
- 31 - Double sided, Daylight
- 32 - Single sided, direct flux only, Daylight
- 33 - Double sided, direct flux only, Daylight

Windows (transparent)
- 20 - Transition Window, Transparent
- Transparency from 0 - 100%
- Can be tinted
- Pre-defined windows available
- Consider Fresnel reflections

Windows (diffuse)
- 21 - Transition Window, diffuse
- Transmittance from 0 - 100%
- Can be tinted

Openings
- 22 - Transition Opening
- 100% transparency
- Transmits white light only
- No reflection

Lambertian

AGI32 Version 1.7 Daylighting
Radiosity

- Radiosity is a *global illumination technique* used to process interior and exterior environments where luminaires and surfaces are defined.

- Global illumination describes the *interaction* between objects, rooms and/or buildings with the light sources (including daylighting and windows/openings) and each other.

- In AGI32, each surface on every entity is broken up into smaller pieces, called *patches*.

For a good overview of radiosity: [http://www.siggraph.org/education/materials/HyperGraph/radiosity/overview_1.htm](http://www.siggraph.org/education/materials/HyperGraph/radiosity/overview_1.htm) & parts 2, 3, 4 that are linked after part 1.
Radiosity

- Each patch is divided into additional pieces, called *elements*. Patches emit light, elements receive light.
- Each patch reacts with the other elements that are visible to it by reflecting light towards them.
- The process of distributing the light between surfaces is known as a *step*. 
Radiosity Solutions

- **Direct** - Sunlight and electric light is emitted to all elements visible to them. Sunlight is transmitted directly into interiors only through Daylight Windows and Openings.

- **Adaptive Subdivision** - If adaptive subdivision is enabled (for non-daylight and/or daylight surfaces), the adaptive subdivision for both daylight and electric light is processed at this time.
Indirect Daylight - Radiosity (exterior) - The Sky Dome, Virtual ground plane and any other exterior surfaces proceed through radiosity calculations until the specified Convergence value is reached. Direct light from the Sky Dome and interreflected light from other surfaces is collected on the external surface of the Daylight Windows and Openings.
Radiosity Solutions

- Transition - The Daylight Windows and Openings serve as Transition zones to bring the external interreflected component inside as a *virtual luminaire*. The photometric distribution of each window (based on the direction and intensity of the luminances calculated in the exterior radiosity solution) is computed.
Indirect Interior - Radiosity (interior) - The Radiosity solution is computed for the interior environment, with the Windows and Daylight Openings acting as luminaires. The calculations are processed, as described above, until the specified Convergence value is achieved.

**Note:** Light hitting the interior of daylight windows and openings is not emitted to the exterior, it is absorbed.
Ray Tracing Overview

- Is a global illumination based rendering method.
- It traces rays of light from the eye back through the image plane into the scene. Then the rays are tested against *all objects in the scene* to determine if they intersect any objects.
- If the ray misses all objects, then that pixel is shaded the background color.
- Ray tracing handles shadows, *multiple specular reflections*, and texture mapping in a very easy straightforward manner.
- In ray tracing, a ray of light is traced in a *backwards* direction. That is, we start from the eye or camera and trace the ray through a pixel in the image plane into the scene and determine what it hits.

For a good overview of ray tracing:
http://www.siggraph.org/education/materials/HyperGraph/raytrace/rtrace0.htm
Surface Types

- To consider the effect of daylighting in exteriors as well as interiors, surfaces imported into or created within AGI32 must be assigned *appropriate surface types* (and attributes) specifically for daylighting analysis.

- Exterior surfaces considered in daylighting computations are handled differently, and separately, from other surfaces.
Surface Types - Examples

- **Daylight Exterior Single Sided**
  - Receives and reflects Direct and Indirect Daylighting Surfaces are single sided - surface normal must face out.

- **Daylight Exterior Double Sided**
  - Receives and reflects Direct and Indirect Daylighting.
  - Surfaces are double sided.

- Many other daylight and non daylight surfaces.
As humans, we often perceive the luminance of an interior space to be similar to that outdoors as we look out the window from within. Truthfully, it is generally several orders of magnitude different.

While the human eye can adapt by changing the aperture of the pupil, AGI32 must attempt to render a scene while restricted to a limited exposure setting (similar to the F-stop on a camera lens).
This results in an image that is similar to what one might see with a digital camera attempting to correctly expose both interior and exterior in one image: If the interior exposure is “normal”, the exterior is overexposed.

Similarly, if the exterior is correctly exposed, the interior is usually dramatically underexposed.
Exposure settings to handle the interior vs. exterior exposure settings.

- **Non-Daylight** - The average Luminance of all non-daylight surfaces is calculated. The average Luminance value is divided by 18% reflectance to determine the average Illuminance value.

- **Daylight** - The average Luminance of all exterior daylight surfaces is calculated. The average Luminance value is divided by 18% reflectance to determine the average Illuminance value. Exposure is set to properly display this average value.
Exposure settings to handle the interior vs. exterior exposure settings.

- If the average reflectance of the current environment differs greatly from the assumed 18% value, the image may appear under or over exposed.
- Exposure modification may need to be applied to properly display the image.
Run “Instant Gratification in Help Files!

- 45 minute overview and setup
- Setup a room with one or two daylight openings. Bring results to class next week!
- Keep it simple but get a “feel” for the program (and please start *using* it so I can continue to justify getting it donated for us).
Sources

- AGI32 Software and help files.
- AGI32 tutorials.
- AGI32 website: http://www.agi32.com
- Note: you can download the entire manual in “pdf” format or use the help system with the software – all of the manual is there!
  http://www.cs.unc.edu/~rademach/xroads-RT/RTarticle.html