Abstracts

Daylighting Case Studies

Daylighting in Museums - Case Studies
Matt Franks, ARUP Lighting (USA)

Lighting is one of the most important components in the design of museums. It is critical to provide appropriate light levels and color rendering so that works appear in the best possible manner. Museum designers must also be conscious of conservation issues to avoid damaging artwork from exposure to too much light. Daylight is being utilized in new museums because of its fuller spectrum and color rendering qualities, and the improved visual connection to the surroundings. Daylight must be carefully controlled because of its high light levels and extreme variability. This presentation will discuss several museum projects where daylighting is an integral component, and how Radiance was used to help ensure that daylighting helped provide an improved visual environment while keeping within conservation goals.

Experiences with Radiance in Daylighting Design, Part II
Zack Rogers (AEC, USA)

This talk will present some of the Radiance modeling Architectural Energy Corporation has done in support of our Daylighting Design Consulting work, focusing on the various ways we have used Radiance to guide the design process. Radiance has proved to be extremely effective in analyzing and visualizing daylighting designs, allowing numerous daylighting design alternatives to be explored beforehand, informing and guiding the daylighting design decisions of a project. The types of daylighting design projects that will be highlighted vary widely and include schools, laboratories, offices, museums, atriums, and various other types of spaces. The focus of the presentation will be on newer work that has occurred since the Berkeley Radiance conference.

Radiance in Practice: a Consultant's Perspective
Mark Shewfelt(Enermodal, Canada)

This presentation outlines the challenges and rewards of using Radiance to simulate natural and electric lighting in a consulting (i.e. time-critical) environment. Obstacles such as learning curve, modeling, workflow, and analysis will be discussed. Comparisons will be made to other lighting simulation packages and their associated benefits and drawbacks. Various examples and case studies will be presented.

Using Radiance for Integrated Daylight Design: Stantec Case Studies
Max Richter (Stantec Architecture, Canada)

Stantec is multi-disciplinary design firm that has been using Radiance as part of our integrated design approach to projects for two years. The project types on which we have explored daylight simulation include offices, laboratories, hospitals, atriums and classrooms. We have used Radiance in two lighting simulation packages and these experiences will be used to highlight the challenge and potential of integrating Radiance-based daylighting design into our project workflow.

The Weidt Group – Daylighting Design using Radiance
Vinay Ghatti and Autif Sayyed (The Weidt Group, USA)

Daylighting has always been an integral component of The Weidt Group's energy and sustainable design assistance, which it has been providing to architects and engineers for nearly three decades. Our holistic design approach involves optimizing both daylighting and energy performance to achieve sustainable goals. Our tools of daylighting and sun penetration analysis have evolved over time- from physical models to present day computer simulations. Some of the programs we have used are Lumen Micro, Lumen Designer, Lightscape, DOE-2, custom-made spreadsheet calculations and Radiance. The addition of Radiance to our palette of available tools has enabled us to do more detailed and accurate daylighting analyses. Our daylighting analyses vary according to the projects' design goals. While a swimming pool project might require high quality renderings to analyze glare and reflections, other projects like offices and educational facilities might require illuminance analysis on the work-plane to optimize window design. Radiance is also used for solving glare problems in existing buildings. Our custom spreadsheet tools are used more effectively for sun-penetration analysis and during design charrettes, where time is critical. A majority of the work at The Weidt Group is focused on whole building energy analysis using the hourly energy simulation program DOE-2. Similar to DOE-2 modeling, we have developed a custom spreadsheet-based interface for Radiance simulations as well. The interface is used for running parametric options in Radiance. We have also developed similar spreadsheet-based tools for analyzing sun-penetration and daylight factor for simple geometries. Our continuing research helps us constantly update these tools with new features. As we continue to explore daylighting in architecture, Radiance not only offers us cutting edge tools to expand the realms of simulation, but helps us achieve our sustainability goals.

Radiance Validation Studies

Development and validation of a Radiance model for a translucent panel
Christoph Reinhart (National Research Council, Canada)

This study describes the development and validation of a Radiance model for a translucent panel. Using goniophotometer combined with integrating sphere measurements, optical properties of the panel were derived and converted into a Radiance model using the trans and transdata material types. The Radiance model was validated in a full scale test room with a facade featuring the translucent panel material. Over 120,000 desktop and ceiling illuminances under 24,000 sky conditions were measured and compared to simulation results using the Perez sky model and a Radiance-based daylight coefficient approach. Overall mean bias errors (MBE) below 9% and root mean square errors (RMSE) below 19% demonstrate that translucent materials can be modeled in Radiance with an even higher accuracy than was demonstrated in earlier validation studies for the plastic, metal, and glass material types. Further analysis of results suggests that the accuracy of around ±20% currently reached by dynamic Radiance/Perez/daylight coefficient calculations for many material types is sufficient for practical design considerations. A procedure is described showing how goniophotometer and integrating sphere measurements can be used to accurately model arbitrary translucent materials in Radiance using transdata function files.

Simulation Quality Web Site?
Michael Donn (Victoria University, New Zealand)

In early 2005, the CIE produced a set of standardized Test Cases To Assess The Accuracy Of Lighting Computer Programs (CIE TC.3.33 Final Technical Report - April 7, 2005). These test cases promise to do the same thing for lighting performance simulation that the BESTEST do for building energy performance simulation. This presentation explores how these tests might form the basis of a suite of building performance quality assurance measures. The CIE tests consist of a set of 'analytical solutions' to simple lighting situations in 'test cells' plus a set of carefully measured data from a similar small test cell like room. The Quality Assurance role these tests play at present is in the continued diagnosis and careful design of software: as new versions are released they can be re-run against these benchmarks to ensure that adding feature x has not caused a problem in another part of the program. The issue of Quality Assurance addressed by this paper is focused squarely on the user of software. It focuses therefore on the question of how to provide assurance to the general practitioner that the predictions of their software are a dependable prediction of performance in reality. The paper suggest that the tests might need to be supplemented with data on ease of use and ease of modeling and speed of understanding. It also notes that comparative costs of software and the expertise to run the programs would need to be updated. An on-line web based system is posited as the likely outcome of this exercise. The proposal is to build a system that is like a lot of the web, self limiting. A system where the users maintain and develop the standards – police any mis-use and contribute their own tests.

Dynamic Daylight Simulations

Lighting considerations in integrated building simulation: a review of the ESP-r to Radiance link
Iain MacDonald (University of Strathclyde, Scotland)

Daylight availability and its use to offset artificial lighting in buildings can have profound effects on the indoor environment and energy usage patterns in buildings. To appreciate these effects two open source tools have been integrated: Radiance and ESP-r. This work has been undertaken over the last decade and has seen several contributions from MSc student projects to major European research projects (e.g. Daylight Europe, Image). To set the scene current capabilities are reviewed, this will be followed with an analysis of where lighting simulation capabilities can be advanced/improved to enable future use of these powerful tools. These areas include the use of daylight coefficients, glare assessment, solar irradiation and realistic values for surface properties.

A file format for dynamic daylight simulations (DDS)
Christoph Reinhart (National Research Council, Canada)

This paper has two objectives. To define a standard daylight coefficient format that is independent of building location and scene orientation, and to present an overall file format for dynamic daylight simulations (DDS) that organizes daylight coefficient sets for different sensors in a building. The DDS file format is meant to serve as:

- a standalone file format to calculate annual illuminance/luminance profiles in a building,
- a common format for inter-program data exchange (e.g. for integrated thermal/lighting simulations), and
- a potential new building property block for complex building models such as Industry Foundation Classes (IFCs).

Radiance's New Rtcontrib Program
Greg Ward (Anyhere, USA)

Flexible as it is, radiance is already an integrated quantity and does not tell us everything we might want to know, such as how light traverses an optical system. Until now, such calculations could not be performed by Radiance's core engine due to this basic formulation. With the 3.7 release, we have added the capability of reporting contribution coefficients during ray traversal, permitting general ray-tracing evaluations. However, this new -oTW option to rtrace may produce gigabytes of data, so we have also introduced a program for integrating and managing this information, called rtcontrib. Rtcontrib controls rtrace and tallies ray contributions in a flexible fashion, permitting efficient calculation of daylight coefficients, optical transmission, and other quantities produced as images or collections of floating point coefficients. During this talk, the author will describe rtcontrib's basic operation and demonstrate a daylight coefficient calculation using electrochromic glazings as one example of its use.

Making use of the new Dynamic Daylight Simulation (DDS) file format
Denis Bourgeois (National Research Council, Canada)

The recently-proposed Dynamic Daylight Simulation file format (DDS) aims at standardizing daylight coefficient output from lighting simulation software, such as Radiance. This revision provides an opportunity to reexamine how daylight coefficients are effectively used within a simulation context, either for estimating annual daylight autonomy profiles, mapping luminance distributions for glare assessments, or predicting total energy savings from automated daylighting controls via integrated thermal/lighting simulation. A new module is proposed to read in DDS files, and fold the daylight coefficients at run-time with the all-weather Perez sky model and annual weather data. This DDS module can be accessed directly at run-time by whole-building energy simulation programs such as ESP-r or, for the typical Radiance user, in a 'standalone' way from the command line to produce, for instance, annual daylight autonomy profiles. Additional module functionality includes its expandability, e.g. boundless number of sensor points and daylight sources, making the module as useful for visualization purposes as for integrated thermal/lighting simulations. The presentation concludes on how the module is used within ESP-r along with SHOCC; another simulation module which considers occupant-related use of personal controls in thermal/lighting simulation.

User Interfaces, and CAD Links

An Integrated Development Environment for Radiance
Andrew Marsh (Square One, UK)

An increasing number of ECOTECT users are utilizing Radiance in quite complex ways as part of their preliminary design analysis. The export functions in ECOTECT support a reasonable range of Radiance's capabilities, making the generation of basic scene files and analytical images relatively simple even for novice users. However, as the aspirations of these users build, there was need for the development of a more sophisticated version of the free Radiance Control Panel that originally came with ECOTECT. This new version takes an integrated development environment (IDE) approach, linking a syntax-highlighted editor with project management, interactive help, user-defined code templates and image analysis features. It uses a series of wizards to guide users through some of the more complex analysis functions and features a range of support tools such as a preliminary visual materials editor, batch run processing and a panorama generator. It also includes an attempt at another version of winmage for Windows to make some of the image analysis functions a little more obvious to designers.

3D luminaire geometry with Relux Vision
Siegbert Debatin (Relux Informatik AG, Switzerland)

The luminaire manufacturers show increasing interest in 3D luminaire geometry. They do not only want to distribute their photometrics but also 3D geometry, which enables the light planner to create high quality visualizations. Most luminaire file formats define some sort of geometry. Very restricted in shape it is sometimes only luminous geometry. Only the IES format has the possibility to add high end geometry as a link to a MGF file. But this feature is very rarely used. The members of Relux now have started to assign 3D geometry files to their luminaires. The models may have various articulations and they also have proper materials. Through Relux Vision they can be exported to Radiance.

Radiance Extensions and Developments

The Radzilla Project
Carsten Bauer

Being open source, Radiance also is interesting for gaining experience in software development itself. The Radzilla project exploits this in various ways in an evolutionary manner. At first, a central topic consisted out of porting the rendering programs to C++, rearranging the code, and -moderately- introducing object orientation. Apart from that, new features have been added, and externally developed modules have been integrated. Many of the new features aim at optimizing classic Radiance for complex visualization tasks in architecture, art or design without compromising the accuracy in general. In the actual stage the focus of activity has moved to the periphery, and work concentrates now on getting acquainted with further software tools by setting up a more user friendly environment for visualization production and linking Radzilla with other 3D programs or libraries (e.g. OpenGL). The presentation will provide an overview of the structure and the newly added features of the current release, and also give some insight into the work going on 'behind the scenes'.

Teaching Radiance

Using Radiance in Teaching 1990 to 2005
Michael Donn (Victoria University, New Zealand)

A Masters student at Victoria University, Robert Amor. now a computer scientist at Auckland University, visited LBNL during a trip overseas in 1990. He brought back with him material of interest to his Masters which formed the foundation of his work on general models of data exchange between building performance analysis computer tools. He also brought back a tape of a new lighting program. At the time the architecture year three students were building 3D models in their elective 'Computer Applications' class. Rendering was with Autoshade and its Renderman shaders. Rendering was a last minute extra for most students. As early as 1991, the capable students were encouraged to experiment with this alternative 'renderer' called Radiance. Today at the Victoria School Radiance analysis is routinely used in 2nd year Building Science introductory lighting Classes; in 3rd and 4th year Architecture and Building Science lighting classes; and in 3rd year rendering classes. This presentation uses students' own comments to illustrate the impact of front end usability tools since those early experiments.

New Design Approaches using Radiance

Latest results with image based lighting
Santiago Torres (University of Tokyo, Japan)

The results of a pilot study about the effect of daylight on visual discomfort are presented. Digital images were used to capture the exterior environment and later included in a Radiance simulation. The results allowed the calculation of visual discomfort indexes which were then compared to survey data. This study demonstrates the capabilities of image based lighting for numerically accurate simulations.

Detailed characterization of daylighting under a roof, a dormer and a vertical window: Final results of an exhaustive simulation project using Radiance
Marie-Claude Dubois (Laval University, Canada), Kjeld Johnsen (BRE, Denmark), Karl Grau

This paper will present the final results of an exhaustive simulation project achieved at the Danish Building Research Institute and Laval University School of Architecture between 2002 and 2005. The aim of the Radiance simulations was to fully characterize daylighting in a room alternately fitted with a roof, a dormer and a vertical window. The evaluation of daylighting conditions in this room was based on the computation of a large set of performance indicators and on a subjective evaluation of the scale of shadow in the renderings. The performance indicators considered were: the daylight glare index, the luminance ratios, the luminance difference index, the vertical-to-horizontal illuminance, the absolute luminances, the horizontal illuminance, the size, location and intensity of sunlight patches and the cylindrical illuminance. This paper will show that it is possible to fully characterize daylighting by a careful examination of these indicators for a large number of times and skies, and that this process can be used as a methodology for the evaluation of daylight quality in any architectural project.

Radiance Artwork

Virtual Light Projection
Rob Shakespeare (USA)

A preliminary study where several directions of illumination are captured in a Radiance scene and then projected onto a performer, more closely tying the actor's lighting with the content of a rear projected image of the scene.

Software Demos

Sensor Placement Optimization Tool (SPOT)
Zack Rogers (AEC, USA)

Public Interest Energy Research (PIER) provided funding to develop the Sensor Placement Optimization Tool, SPOT, software program to solve a lighting industry-wide gap between the design intent of these types of systems and the actual implementation. SPOT is a software package intended to assist designers in establishing the correct photosensor placement relative to the proposed daylighting and electric lighting design and to analyze and verify overall design performance. SPOT also provides useful annual daylight analysis as well as electric lighting analysis of the given space. SPOT consists of an Excel interface on top of a largely invisible Radiance calculation engine. The presentation will introduce users to SPOT and provide a demonstration of its implementation, focusing on the use of Radiance as a calculation engine.