LIGHTSOLVE - A FULL-YEAR GOAL-BASED TOOL FOR DAYLIGHTING PERFORMANCE EVALUATION

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ABSTRACT

Lightsolve is an innovative tool that offers architects and lighting engineers a goal-based simulation platform for daylighting performance evaluation in early stages of building design. Users can import their own 3D model and define their own design goals for a comprehensive spectrum of daylighting performance perspectives regarding task illumination, visual comfort, overheating risks, health effects and visual interest of a space. The tool provides key information to the designer that is easy and intuitive to grasp thanks to a combination of unique, visual and interactive graphical display formats. Available visualization options include photo-realistic renderings, full-year temporal performance representation as color maps, and spatial performance distribution through false-color renderings. Both model orientation and localization can be user-defined, and weather data (e.g. TMY) can be used to get climate-specific results. Accuracy is ensured by the usage of the ubiquitous and extensively validated Radiance simulation tool.

INTRODUCTION

Designing spaces that are able to balance the many aspects of daylighting performance (workplane illuminance, visual comfort, overheating risks, visual interest, etc) over a whole year is a real challenge, yet a problem faced every day by building designers. A simulation framework for climate-based daylighting design support has been developed over the past few years, named Lightsolve, meant to address guidance at the early stages of the design process [1-3]. The adopted approach for this framework is to express performance from the perspective of user-defined goals fulfillment and with a strong emphasis on temporal dynamics and on displaying performance visually [2].

LIGHTSOLVE FOR DAYLIGHTING PERFORMANCE EVALUATION

The various research efforts have now been gathered into a new software platform for interactive, comprehensive daylighting analysis, available to architects and lighting designers and compatible with most 3D modeling softwares. The new embodiment for Lightsolve includes a Radiance calculation engine combined with an interactive user interface to visualize temporal and spatial 'distribution' of performance simultaneously. Annual performance is analyzed statistically over user-defined time intervals [4] (rather than time-steps directly derived from a TMY weather file) and is based on the validated ASRC-CIE sky model [5].

Daylighting performance is assessed from various perspectives based on metrics previously developed or under development and adapted for that purpose: Acceptable Illuminance Extent [2] for task (typically workplane) or surface (e.g. wall) illuminance, Daylight Glare Probability [6] for visual comfort – possibly extended to whole perimeters of interest [2], Solar Gains Surplus or Scarcity [2] for overheating risks and seasonal gains management, non-visual lighting effects [7,8] for health impacts (direct effects such as alertness and/or

circadian effects such as phase-shifting e.g. [9]), and perceptual daylight effects regarding contrast or variability [8,10].

These different types of performance metrics can be simultaneously visualized over time and over space on the Lightsolve interface, both in absolute terms using a linear color scale, and from a goal-based perspective using a triangular color scale [2].

LIGHTSOLVE OUTPUTS – ANALYSIS EXAMPLE

The Lightsolve interface and visualization framework (see Fig. 1) offers a very powerful support to reveal multi-faceted performance thanks to its time-based focus combined with a simultaneous visualization of renderings.

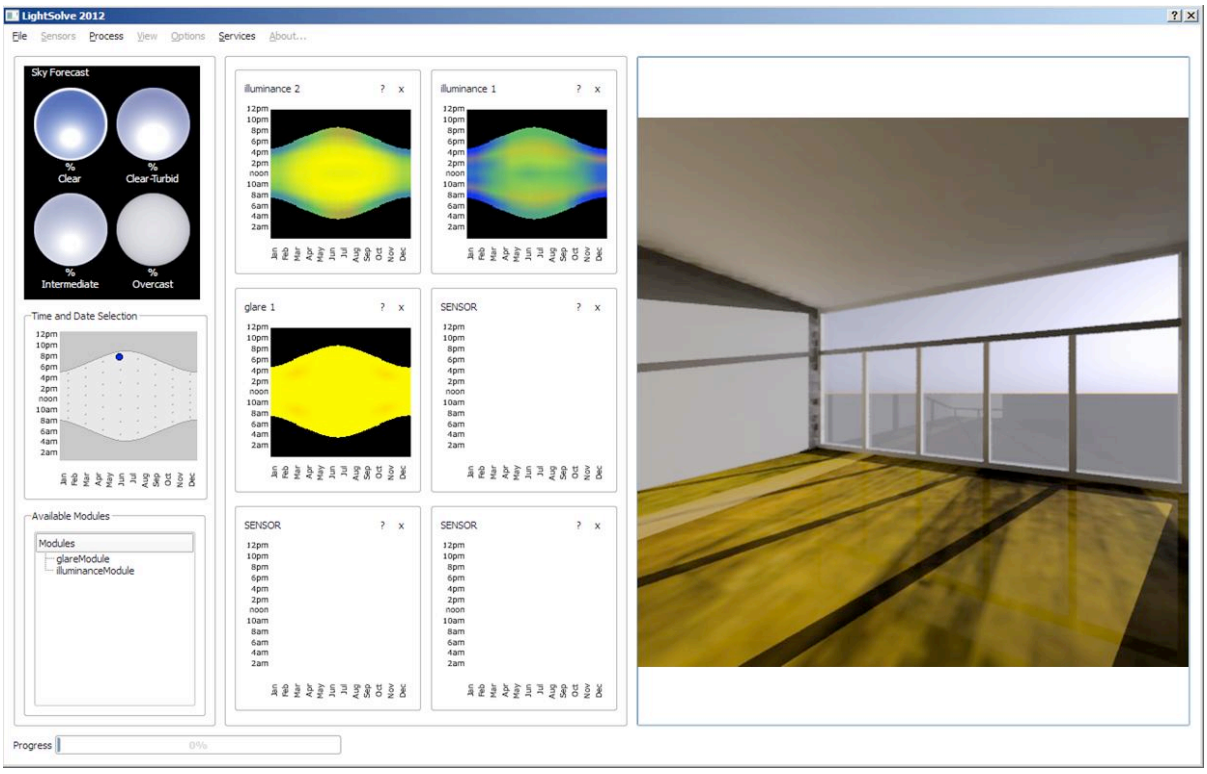

Figure 1: Lightsolve interface with a 3D model of a West-facing room, located at 41 degrees North (latitude). A real-time rendering is shown on the right.

As soon as a 3D model is uploaded in Lightsolve, the user can define his/her own design goals for each of the performance perspectives (metrics) of interest to the project. Then, the processing of the full-year analysis can be launched. It takes less than 1 minute to get results for all metrics. In Fig. 2 such results and their visualizations are depicted for a 3D model of a simple West-facing room.

There are two ways to visualize performance. Either using an absolute scale (most straightforward approach), where the respective metric's average value is displayed over a user-defined perimeter of interest, such as workplane illuminance [lux] in the example shown in Fig. 2a. Or using a goal-based scale, like in Fig. 2b, where what is represented is how closely prescribed goals are met. For both scales, two representations appear side-by-side on the Lightsolve interface to fully reveal annual, seasonal and daily performance over both time and space: a time-varied representation in the form of a temporal map (left) over which a cursor (cross in Fig. 2 left) can be moved to select a given moment over the year; and a rendering (right) associated to that specific moment, where the spatial distribution of the respective metric's values can be visualized in false-color on the user-defined sensors (areas

of interest). The type of sky (clear, clear-turbid, intermediate or overcast, see [4]) can be selected for visualization, while weather conditions are accounted for according to the selected weather data file.

The resulting "double combination" of absolute vs. goal-based and time-based vs. spatial visualization, further discussed in [8], makes the performance analysis particularly interactive and intuitive to the user.

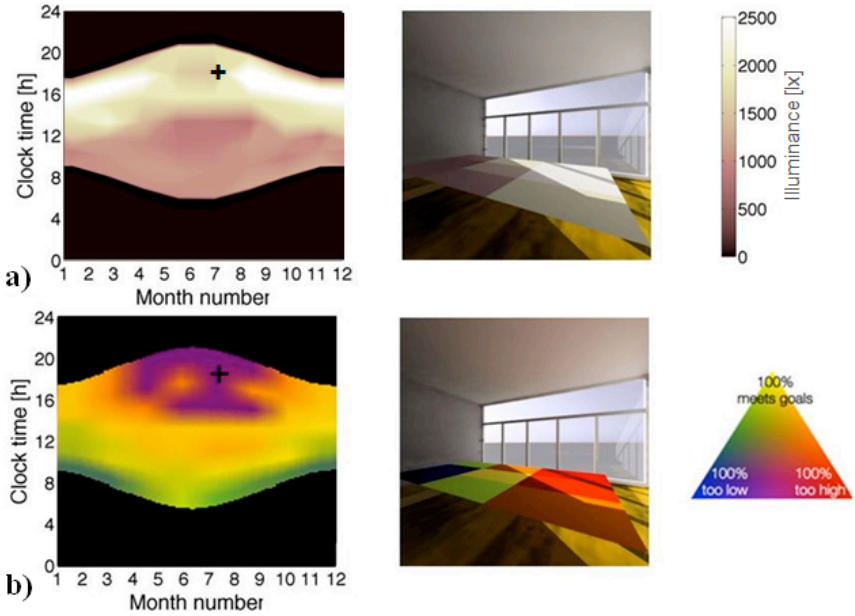

Figure 2: Time-based illuminance analysis (left) with associated rendering at given moment (right and cursor) on an absolute (a) and goal-based scale (b). Performances are evaluated on the visible sensor plane defined by the user (area of interest).

CONCLUSION

Lightsolve offers a set of innovative simulation resources that makes it a unique design support tool for comprehensive yet reactive and intuitive daylighting performance analysis. Such a tool could enable a desirable shift in schematic stage design practice and offer a more holistic approach to daylighting analysis by embedding its many aspects into a unique, interactive simulation framework.

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