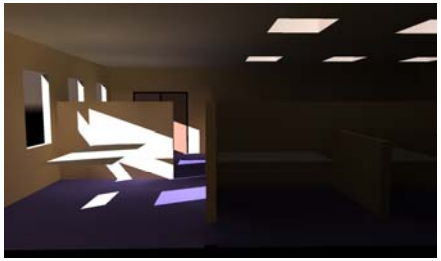

Interactive Selection of Optimal Fenestration Materials for Architectural Design

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ABSTRACT

We present a method for the optimization of advanced fenestration materials in architectural design. Prismatic and laser cut window panels can be used to redirect intense illumination from the sun; however, the transmissive properties of these materials and the complexity of natural daylight result in non-intuitive interactions with the built environment.

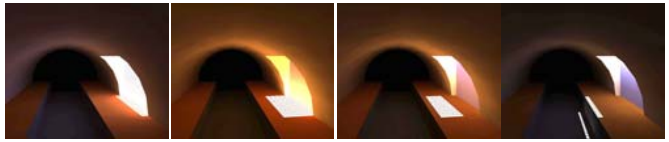
We simulate the direct and indirect illumination from the sun and sky throughout each day for different months of the year. Having accurate quantitative and qualitative data about the natural lighting allows the designer to make adjustments to the design that reduce the need for supplemental electric lighting. The user can interactively explore the high-dimensional configuration space to select optimal materials.

Our system is appropriate for use in schematic design: an early stage of the architectural design process where scale, appearance, and adjacencies of an evolving design are explored and critiqued through frequent meetings between the architect and client. We demonstrate our system on several models inspired by field observations and the designs of architecture students we have consulted during the development of this project.

Keywords: Global illumination, radiosity, architectural daylight design, shadow volumes.

Sunlight penetrates the louvres of this architectural studio project in an unanticipated way, causing discomfort. An interactive daylight rendering system could have predicted this problem, allowing the designer to optimize the orientation of the louvres.

The depth of direct beam light penetration in a model is easily ascertained with the physical *heliodon*. The heliodon table rotates along many dimensions relative to a fixed light source (the sun), facilitating design exploration.



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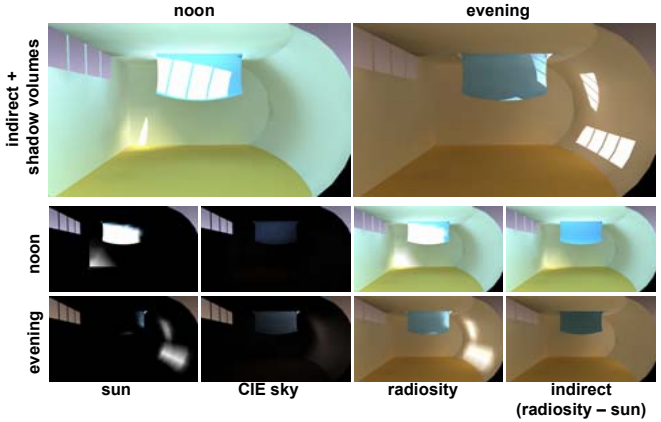
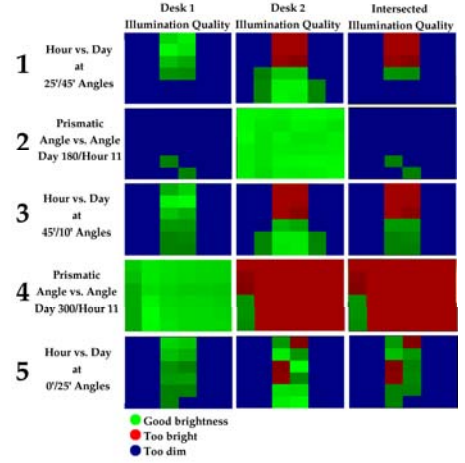
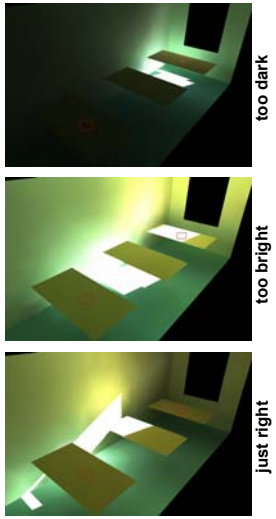
HYBRID RADIOSITY / SHADOW VOLUMES



In designing the interesting curved geometry for the living space in this residential design, the architect redirects the strong overhead noon sunshine from a set of skylights with a curved diffuse blue deflector but allows the warmer late afternoon sun to penetrate deep into the room and wash over the far wall.

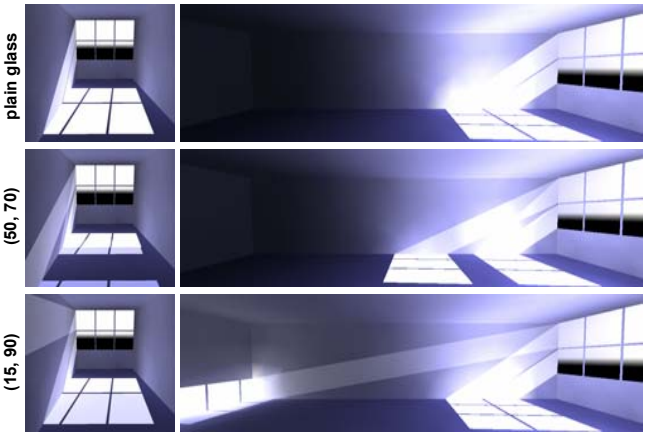
HUMAN-GUIDED OPTIMIZATION

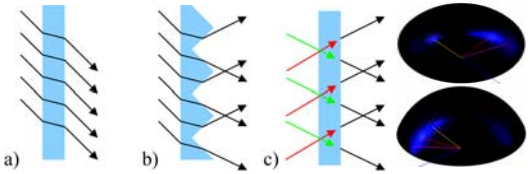




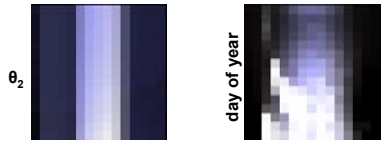
A simple office scene with a single southern-facing window. Fenestration material is optimized to maximize *daylight autonomy,* the percent of time when the natural illumination at both desks (marked with red squares) is appropriate for reading.

ADVANCED FENESTRATION BTDF





In a flat pane of glass, light rays are refracted, but exit parallel to the input rays. Light rays that pass through a prismatic panel are refracted differently and exit in two different directions due to the microfaceting. We can reverse engineer the directions of two "fake suns" allowing us to render the specular refraction in real time.



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