Evaluation of a Tangible Interface for Architectural Daylighting Analysis

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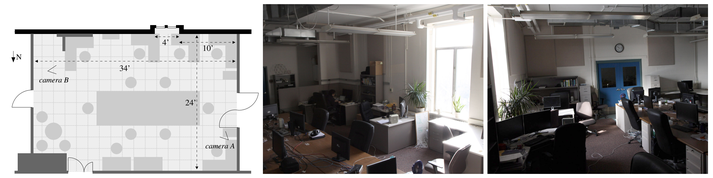
Our new TUI for architectural daylighting design allows multiple users to a) gather around a physical sketching environment and select from b) a set of wall primitives and window and material markers to c) build a rough sketch of an architectural design. A d) visualization of a daylighting simulation is projected onto these surfaces.



User study participants visited this simple open office environment as a case study for daylighting analysis. The room contains a single, tall and narrow, south-facing window that provides direct overly-intense illumination to portions of the room while leaving other areas relatively dark. Thus, occupants of the space typically turn on the overhead lights, even on sunny afternoons.

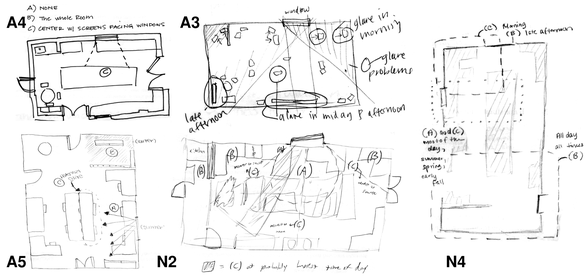
Overview

We present a study of a tangible user interface for architectural design and daylighting analysis. This tool provides an intuitive way for architects and future occupants to quickly construct physical models and then view a simulation of daylighting in the model at interactive rates. We conducted a user study of both formally-trained architects and non-architects in a set of analysis and design exercises. This study investigates the effectiveness of this interface as an educational tool, the precision and accuracy of the constructed physical models, and the overall effectiveness of the tangible interface. The four part study investigates users' intuitions about daylighting and their interaction with the tool for analysis of an existing space, for proposing renovations to the space, and for designing a totally new space with the same architectural program that better addresses the occupants' needs. These exercises revealed misconceptions in many of the participants' intuitions about daylighting and overall the participants expressed interest in this simulation tool for daylighting analysis in architectural design.

Contributions

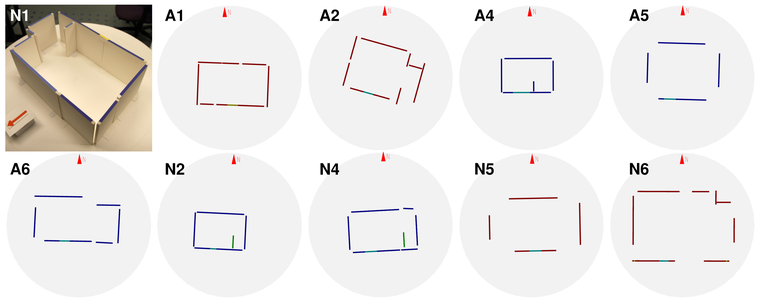
- Exploration of participants' fundamental understanding of daylighting design, overlighting, underlighting and glare.
- Quantitative analysis of the users' accuracy in using our physical sketching system to model a room they had just visited.
- Evaluation of the participants' use of our tool and their perception of quantitative and qualitative daylighting from the displayed simulations.
- Demonstration of our tangible interface as a creativity-enhancing tool for architectural daylighting design.

Sketches of a Space with Problematic Lighting



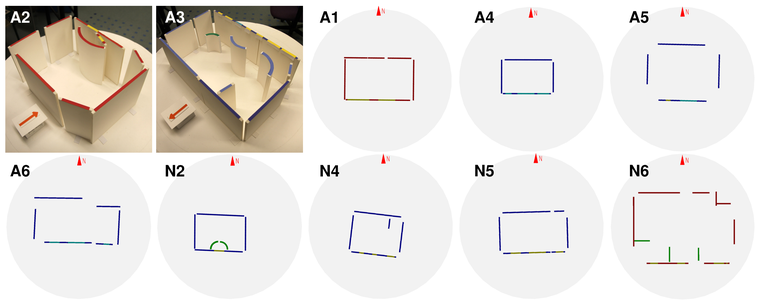
In Part 1 of the study, participants were asked to sketch the lab room and annotate this sketch with their intuition about areas with A) too much daylighting, B) too little daylighting, and C) potential for glare. The sketches demonstrate a variety of detail and accuracy in the analysis of the dynamic lighting conditions.

Models of the Example Space



A photograph of the physical geometry of the original office space constructed by one of the participants for Part 2 of the study and 2D diagrams of the geometry constructed by the other participants. Note the variety of model complexity and scale that users create to represent the same space. The red walls are 10 inches tall and the blue walls are 8 inches tall.

Renovations to the Provided Space



In Part 3 of the study participants were asked to propose a modest renovation to the geometry to improve the use of daylighting. Some users simply added windows while others attempted to reduce glare.

References

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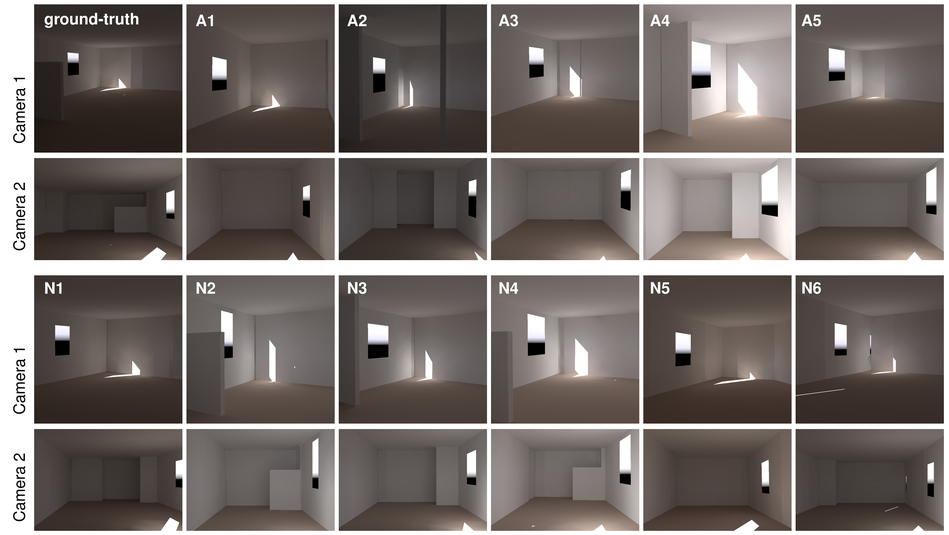
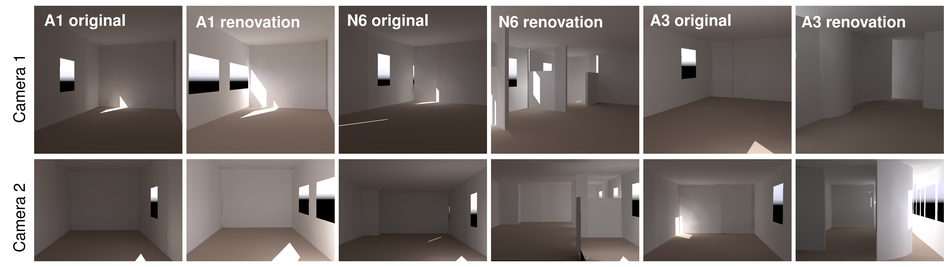
Renderings using the Architectural Daylighting Tool



Simulation results for the original room geometry constructed by the study participants. The ground-truth model was constructed with the same tangible interface using the true room dimensions. All models are constructed using the same floor, wall, and ceiling materials. All renderings in this figure are March 21st at 8:30am. The desks in the southwest corner of the room (1st and 3rd rows) experiences glare at this time. The east side of the room (2nd and 4th rows) is quite dark all year, especially in the mornings.



To address the general gloominess of the room, participants suggest adding more, taller, and/or wider windows on the southern wall. Some participants also removed the existing interior wall/partition that was deemed to be an obstruction to daylighting. While these modifications did brighten the room considerably, it will also increase the glare problems for those working at desks in the path of the light. Only a few of the participants suggested renovations that attempt to mitigate the glare problems in the space through new geometry in the model. These proposals involve the addition of partitions that diffusely redirect the harsh direct southern light for more usable daylighting.