Space, Light, Spirit:

Using Computers as a Spatial Visualization and Design Exploration Medium

Tina Sarawgi
The University of North Carolina at Greensboro, USA

The constant advances in the use of computers to simulate light over the past few decades, has led computer-aided rendering to become increasingly photorealistic. However, the rendering is still processor-intensive and time-consuming, difficult to generate in real time. Design students need to be well versed in the depiction of the effects of light in an environment, crucial to spatial visualization. With increasing computing power, advanced algorithms and increased realism, the central pedagogical issue in their use is not what computers can do for us today, but what and how we can make them do what we do better. We have to be careful in not getting seduced by the advancing technology but use it innovatively to build students into better designers. This paper discusses a project demonstrating the apparent potential of computers for spatial visualization and design exploration of light and space, in their present stage.
The project shows a departure from the traditional methods of using computers or of teaching lighting in a design school. Computers are used by students to especially create flashy imagery. On the other hand, lighting is explained in clinical terms without exploration of its experiential qualities. This exercise helped the students to develop a better understanding of the physics of light from the method most familiar and expected of students – visual. The project deems it more important to have a quick means to produce an overview of the implication of the design choices than to provide precise information regarding a hypothetical final solution. Hence, after creating the lighting in the space based on the desired experiential qualities, the illumination can be conveyed to a lighting expert for detailed quantitative computations. The project results are shown and outcomes discussed.

Keywords: *visualization, light, space, digital technology, pedagogy.*

Introduction

In design institutions, students are asked to be observant of their surroundings and visualize their observation through different media available to them. It is widely accepted that only through thorough observation and visualization followed by design application can one develop into a competent thinker and designer. The consideration of the prevalent quantity and quality of light in an environment is crucial in making spatial visualization possible. Hence, instilling the importance of observing and depicting light correctly is the first step towards enabling the design students to acquire an understanding of the surrounding built environment. This needs to be followed with emphasis on learning by doing, therefore teaching students to 'make' not 'learn' light and 'design' not 'select' light. Due to their dynamic and interactive interface, computer-aided lighting simulation tools have the potential in being a part of the iterative exploratory process required to study the inherent properties of light in relation to other elements of design, and in expressing its experiential qualities.

Although the use of computers to visualize light in space is over twenty years old, this issue has been mainly considered from the viewpoint of being photorealistic than as a design exploratory medium. The radiosity and raytracing methods, developed primarily for architectural rendering, have been around since the 1980s (Rea, 2000). However, the application of these methods is still not in a stage where they encourage iterative design explorations in real time. This paper discusses a project undertaken in the upper level design studio in an interior architecture curriculum over the past few years. The project is based on observation, visualization and experimentation with the experiential qualities of light in a chosen environment. In spite of current limitations, the project demonstrates the promise of computers in not only spatial visualization but also as a design exploration medium regarding lighting in an environment, bringing forth the ability of the computers to capture the genius loci of a place.

The use of computers in lighting

Light is the most basic element for perceiving a space. Our perceived experience of architecture is primarily a sensual event involving movement and change over time. Visualization that includes movement and time sequence allows the designer to make better judgments about space and time, as well as to see the effects of light, color, texture, reflectivity, and contrast (Kalisperis, 1994). Architecture and interior design school curriculums are centered on the studio, a physical and intellectual place where ideas are transformed into physical form through development of models and/ or drawings. Holistic in nature and explorative in spirit, the curriculum engages a wide range of ideas, tools and techniques; hence a multiplicity of approaches is important to be employed with them. Traditional media cannot adequately represent the effects of movement and time in terms of light and motion. Using computers in design responds to the recognized need to adopt different tools and techniques enabling easy exploration of light and motion.

A review of related literature relevant to computer-aided lighting simulation reveals that earlier studies primarily investigate the use of computers to perform quantitative and qualitative lighting analysis of a space. Previous works are based on comparative evaluation of different software programs (Bryan and Autif, 2002; Ashmore and Richens, 2001; Roy, 2000; Ubbelohde and Humann, 1998) or contrasting different lighting techniques such as physical scale models, computer models and full-scale mockups (Wu et al., 2000; Erwine and Heschong, 2002) or analytical application of lighting in a studio or seminar course (Tsou et al., 2000; Stannard, 1998; Messadi, 1998). The potential of computers in defining the spirit of the place and hence act as a design inspiring medium has been not explored fully yet.

Humans have a subjective vision, much different from the faithful reproductions of a scene by a modern camera. What we see when confronted with a new scene depends as much on our goals and expectations as it does on the rays of light that bombard our eyes (Healy and Enns, 2002). Recognizing the above, the aim of this project is not how well a product can render light photorealistically or otherwise since there will always be better solutions or new and improved products that will come into the market. The project instead focuses on embracing lighting simulation technologies for what they are, not for what they are on their way to becoming (Fontein, 1997). Consistent with this attitude, the students were challenged to use computers not as a tool to apply lighting to design and automate lighting computations, but by revealing how light amplifies a space and becomes an architectural element. Student works from a design assignment in an upper level design studio are presented to illustrate this pedagogy.

The space, light, spirit project

The Interior Architecture Department at the University of North Carolina at Greensboro presently offers a lighting lecture course to the 3rd/4th year and graduate students. The course exposes the students to develop an understanding of the uses and control of daylight and electric light in a traditional lecture class setting. This project sought to make the process of lighting design less clinical and more experiential in nature, evolving the lighting element of the program from a lecture course in lighting to the integration of light as an essential component of space.

This paper discusses the project undertaken in an upper level interior architecture design studio where instead of being an afterthought, light was regarded from the beginning as a material and experiential entity. Emphasis was placed on experimentation with light in relation to other elements of design; seeking to make light in a space perceptible to the mind or imagination. In contrast to a programmatically driven studio, the pedagogic approach for this project was to investigate and use light and shadow as primary design materials, with the goal of visualizing dramatic spaces through the manipulation of both daylight and electric light. The programmatic functions of the selected spaces were secondary to the goal of designing with light. In most cases, daylight was the primary light source for these designs, optimizing this source as an effective tool for creating dynamic spaces (Stannard, 1998). A 4 weeks long project was introduced where the students were required to explore light as an important contributor towards creating the specific nature of a place. The students brought in their varied experiences of light, capturing the one that was most appealing to them through a written essay. The students then constructed physical models of the space to represent its lighting quality and understand the scale of the space. This was followed by visualization and exploration of the lighting qualities in the space using computer-aided lighting simulation tools by trying alternate proportion, aperture, color, and texture configurations. The changing nature of light and shadow throughout the day and/or under different electric lighting conditions was further observed and depicted dynamically in animation sequences. The use of a combination of radiosity and raytracing based rendering techniques were employed for design idea generation and verification in investigating the interplay between light and space.

The objective of the studio was to go beyond the formula-based lighting solutions by emphasizing the use of light as a design material. As a dynamic source, daylight with electric light offers the designer an opportunity to explore the variety of architectural experiences that its constant motion brings to a space (Stannard, 1998).

The written exercise was helpful in articulating the visual qualities of the space since it was an abstract yet creative way to evoke the emotional impact of the space. Some of the excerpts from student writings are as follows:

„The light flutters creating exciting rhythms of shadows on the floor evoking the spirit to move inside her. At his moment she closes her eyes feeling secure, yet free and alive by the moving light and breath of fresh air, and visualizes herself dancing joyfully.“

„Suddenly she feels the suns rays warming her back. She turns her head to see where the light is coming from and is struck by its intensity. She slowly opens her eyes again and gasps! Light is pouring into the room in the image of a cross. She falls to her knees and cries. Her heart is filled with peace and hope as the room fills with warmth and light.“

„The warmth of the light radiates throughout the entire space…. a feeling of serenity among the wonders of the mysterious space…“

The images of the physical model, the computer model and the spatial variations from selected projects are shown in Figures 1, 2 and 3. The animation movies depicting light and motion in the space can be viewed at http://www.uncg.edu/~t_sarawg/ecaade2004.html.

Discussion of project results

The project reveals the usefulness and promise of the digital media as an experiential medium introducing the role of light in shaping space and inspiring design. It was found that the computer tools advanced the student understanding of the nuances of light and in experiencing the environment generated by it beyond what non-digital medium alone

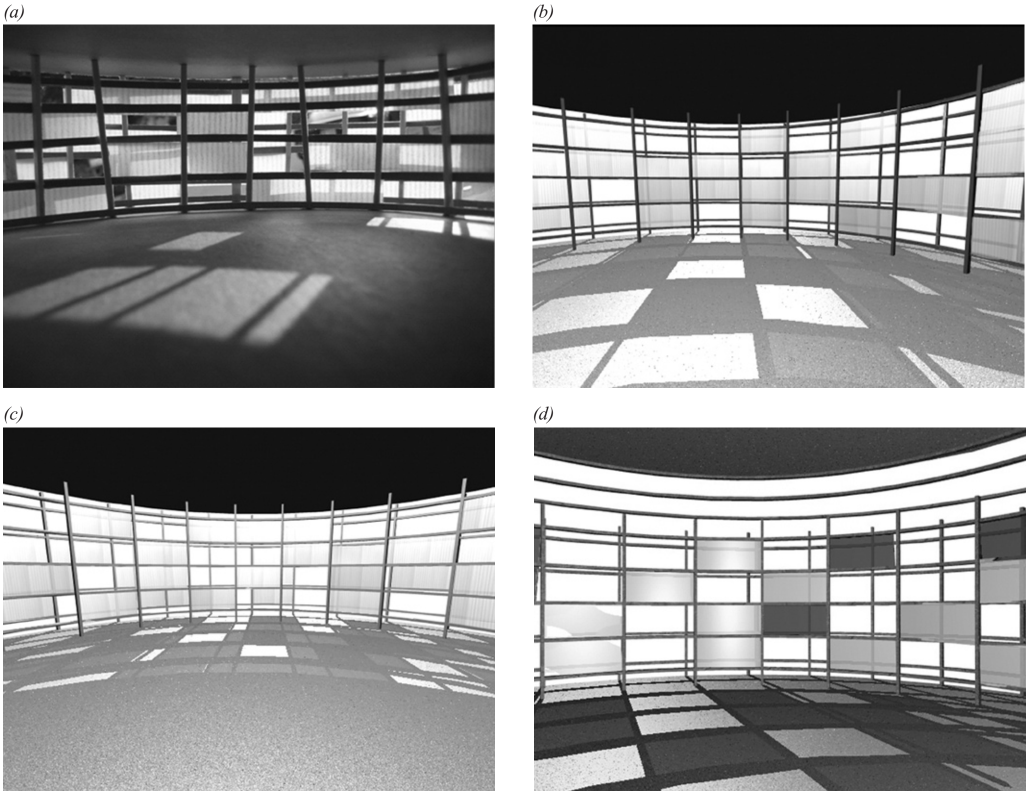


Figure 1a, 1b, 1c and 1d. Project inspired by the Church at Bolivia by Jae Cha. Physical model image (top left), computer model image (top right), spatial variation 1: change of material of the supports from timber to steel (bottom left), and spatial variation 2: introduction of clerestory windows (bottom right).

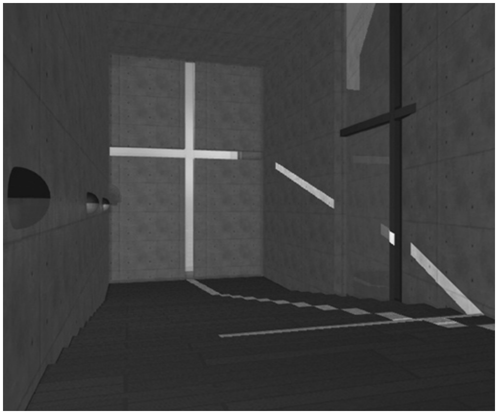
could accomplish. In spite of the inherent limitations of the computer-aided lighting simulation tools and the restrictive two-dimensional interface of desktop computers, their interactive and fairly immersive qualities coupled with animation capabilities were found to be adequate to analyze the light qualities and experience the spirit of the place. This is unlike the two-dimensional images generated from the traditional medium, which do not allow a comparable viewing flexibility or dynamic and interactive interface offered by the computers.

On the completion of the project, the students were required to reflect on the results of the project providing an overview of the impact of the various media on their understanding of the interactions of light and space. They were asked to discuss the possibilities and limitations of their project outcome using digital media. Also, given a choice, which media would they prefer to visualize and graphically present light and space for their project and why. Some of the responses of the students are quoted below:

"It (the digital model) strengthened my understanding of light and space because I could get in the

(a)

(b)



(c)

(d)

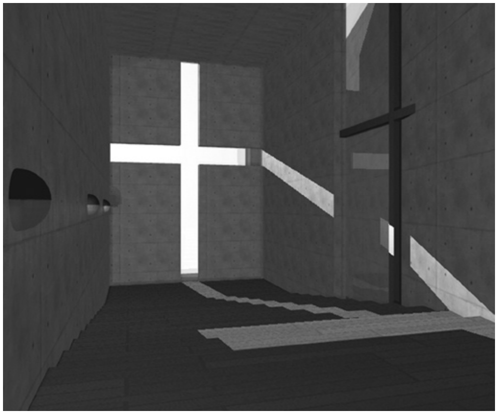


Figure 2a, 2b, 2c and 2d. Project inspired by the Church of the Light by Tadao Ando. Physical model image (top left), computer model image (top right), spatial variation 1: introduction of light slits on the side wall (bottom left), and spatial variation 2: increase in the aperture size of the central cross (bottom right).

space and visualize it and see how light reacts to changes in the space."

"The digital model was important because I could begin to alter things faster to see how the light reacted to that environment."

"The digital model allowed greater understanding of light change over time. The ability to change time/ direction of sun, color of light and materials were particularly helpful in the process."

"Sun positions and location choices were very helpful."

Overall most students felt that the digital media strengthened their interpretation of light and space. Students less familiar with the software tool were somewhat disillusioned by the digital media results in the beginning. They found the physical model simulation more intuitive. Nevertheless, they used digital media to further spatial explorations by trying out alternate lighting configurations. It was observed that adequate software tutorials are important for the students to learn the software basics to enable them to achieve the desired lighting experience in the space. Some students struggled during the reflection phase of the project because similar spatial views were not set up to compare and contrast the results.

Many students also felt that the written essay at the beginning of the exercise was helpful in exploring the lighting quality in an abstract yet creative fashion before objectively verifying it through the physical and the computer model. It helped the students to design light rather than simply depict the nature of the light in the chosen space.

The learning by doing technique through the use of computers was found to be more successful than clinical explanation of light and lighting technology in a traditional lecture format class that inspire little interest from the students and are soon forgotten. However, the students who had taken the lighting lecture class before had a better grasp of the software tools in hand, and hence explored them more comprehensively, proving that both teaching methods are complementary to one another. The project results are significant for a design curriculum where a theoretical explanation of the technical aspects of lighting and visualization are considered to be enough to understand and appreciate its experiential and place-making qualities.

Concluding remarks

The computer graphics community has continuously strived to improve the techniques to accurately render the lighting effects since the past few decades. Through global illumination algorithms, exceptional photorealistic results can be achieved of both daylighting and electric lighting. However, the rendering is still processor-intensive and time-consuming, difficult to generate in real time required for its effective use in the design process.

This project demonstrated the apparent potential of computers in their present stage. With increasing computing power, advanced algorithms and increased realism, the central pedagogical issue in their use is not what computers can do for us today, but what and how we can make them do what we do better (Simon, 1986). We have to be careful in not getting seduced by the advancing technology but use it innovatively to build students into better designers.

The project shows a departure from the traditional methods of using computers or of teaching lighting in a design school. Computers are used to especially create flashy imagery. On the other hand, lighting is explained in clinical terms ignoring the exploration of its experiential qualities. Detailed lighting computations consume time and energy in the design process often leading to a compromise in the design solution. This exercise helped the students to develop a better understanding of the physics of light from the method most familiar and expected of students – visual. It is much more important to have a quick means to produce an overview of the implication of the design choices than to give precise information regarding a hypothetical final solution. The designer can then easily and quickly solve the day-to-day problems while only complex lighting strategies or systems remain the specialist's concern (Ubbelohde and Humann, 1998). Hence, after creating the lighting in the space based on the desired experiential qualities, the illumination can be conveyed to a lighting expert for detailed quantitative computations.

The use of computers in this project made the students aware and appreciative of the importance of the consideration of light as essential to visualization and shaping a space rather than a system technology to be applied for the proper functioning of a building at the end of the design process. Hence computers were considered from the view of their capability to inspire design through light, movement and time simulation, and iterative testing procedures contributing immensely to the comprehension and appreciation of the built environment.

Future work could involve students working on an actual project in a design studio where they use the method cited in this project to address the design of a conventional building type. Currently the only lighting simulation tools available to designers are based upon direct methods where a designer begins with a geometric model, positions the lights, assigns their colors and intensity distributions, and finally computes a solution. Light Pen, a working prototype that lets designers sketch directly on surfaces in a 3D model with light is a tool that may be relevant for future work on this project (Jung, Gross and Do, 2003). Given that we usually begin with a notion of the final appearance, this tool will allow the user to create a target image by 'painting' their desired light effects and have the algorithm work backwards to

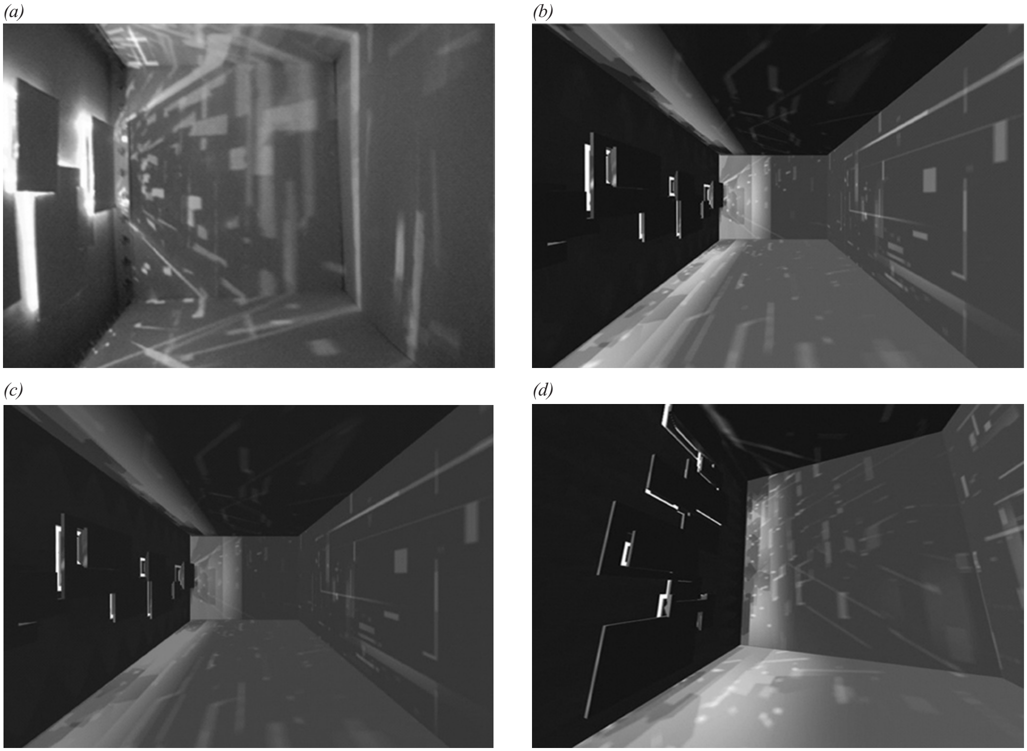


Figure 3a, 3b, 3c and 3d. Project 3 inspired by the Morimoto Restaurant by Karim Rashid Physical model image (top left), computer model image (top right), spatial variation 1: change in color of the lights (bottom left), and spatial variation 2: change in spatial volume (bottom right).

develop light in the space. This method can prove to be more intuitive, less time-taking, and hence more ideal for design exploration regarding lighting in an environment.

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