Applying Daylighting Simulation in Architectural Studio Education

Jinyeu Tsou, Benny Chow, Selina Lam

Introduction

Computer generated simulation results are not necessarily valid design solutions. In some cases, unscientific "simulation" applications have misled designers to believe the "illusion" rendered by the system. This paper presents two case studies to highlight the pedagogy of architectural daylighting simulation. Both are located in Hong Kong's high-density urban context.

Hong Kong is a small city, covering 1,097 square km with a population of 6.8 million[1]. Mountains and hills dominate the topography, and more than 70% of the land is reserved for country parks. Property constraints encourage dense, high-rise construction and building on steep slopes. This creates a complex environment for daylighting design. Although the Buildings Ordinance specifies minimum standards for natural light and ventilation, residents have complained about the deterioration of their lighting condition in recent years. Challenged by the constraints imposed by Hong Kong's physical environment, there is a need for students and professionals to explore computer simulation to integrate daylighting strategy into architectural and urban design.

Natural Lighting Simulation for Architectural Studio Education

Natural lighting has always played an important role in architecture, to highlight form, to create a particular ambience, and to provide occupants with visual comfort and functional illumination[2]. Recently, there has been a revival of interest in daylighting for energy efficiency[3,4]. It is not easy for students to master the concepts and develop their own comprehensive understanding. In studio, their focus should be on qualitative aspects and synthesis, rather than quantitative analysis. Thus, this project adopted the paradigm of problem-based learning.

Environmentally friendly design in Hong Kong is challenged not only by its high-density urban context, but also by its hot humid sub-tropical climate. Since controlling the reception of solar radiation is essential for sustainable building design, this project focused on the relationship of natural lighting to solar control.

Although a common goal of computer visualization is to render photorealistic images[5], we must carefully consider the validity of the image on the screen. It requires experience to differentiate a convincing illusion from an accurate prediction. Impressive images are not sufficient to provide the scientific evidence required for environmental design, but pure numerical analysis is inappropriate for architectural design. Scientific visualization techniques, such as iso-illuminance maps, offer good graphic representations of numerical analysis. Based on such considerations, the project used Radiance simulation software from LBL. The system calculates illumination from physically valid lighting photometry and daylighting parameters[6].

Case Study 1: Place for A Sensitive Heart

This was a third-year collaborative exercise focusing on the design of a group of residential blocks. The site planning stage focused on building orientation, with a particular emphasis on inter-block shading. The challenge was to collaborate with several other designers to propose an integrated solution for the ensemble, while also pursuing one's own design merit.

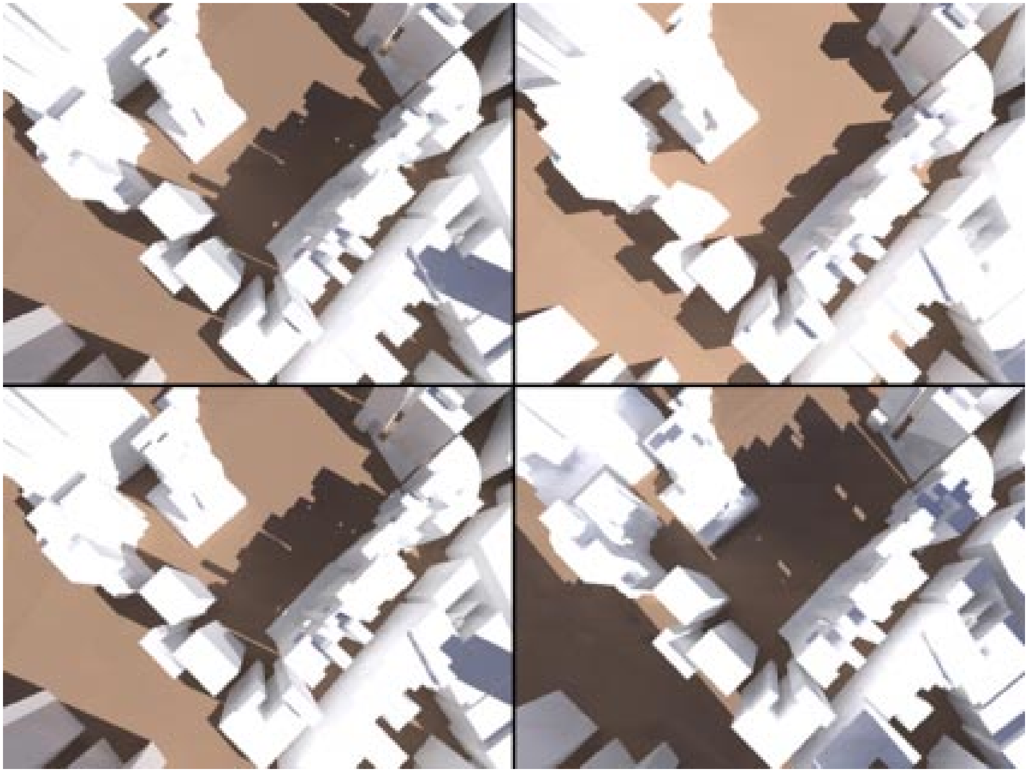

Figure 1:
Inter-block shading analysis.

The research team created a digital site model from a 1:1000 GIS map to facilitate students' collaborative design activities. Tutorial sessions guided the students to insert their own digital building models into the base model.

A dedicated server allowed students to observe the group progress and to conduct "negotiations" to optimize the overall result. The computer rendered the inter-block shading for the entire grouping. Design options were compiled as a series of web pages that served as a logbook for the exchange of ideas. Figure 1 shows a series of analyses for one of the group designs.

Case Study 2: Shading Analysis for Façade Design Options

This was a graduate-level exercise to apply shading devices to the sky lobby of a residential block. The goals were to solve the over-heating problem caused by the high summer sun, and to assess how the shading would affect the interior illumination. Students used Radiance in their design analysis. In the proposal illustrated in Figure 2, the student designed a double deck lift lobby in order to provide deep natural light penetration and increase the daylight factor for the inner area.

Discussion

The students provided positive feedback regarding the effectiveness and efficiency of simulation in lighting design. We draw attention to the following:

1. Although simulation can reveal design shortcomings, knowledge of natural lighting learned in environmental technology courses is necessary for design improvement.
2. Due to previous experience with general-purpose rendering software, students tend to provide too much detail in their simulation models.
3. Sufficient technical support, tutorials, and design examples are vital.
4. Non-technical studio teachers have difficulty understanding the simulation process, and the "black box" aspect causes mis-expectations in both teachers and students.
5. Validation of simulation results could be crucial for students to limit their problem domain. Errors in the simulation process may tip the results

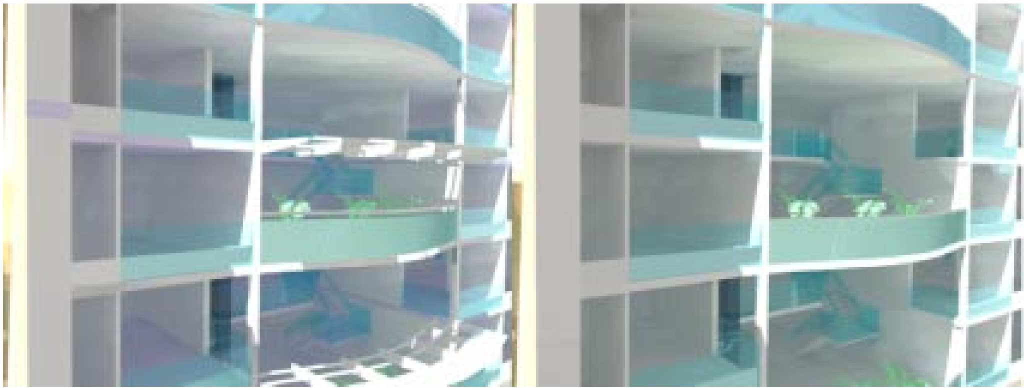

Figure 2: Shading analysis of the double deck lobby of a proposed residential block.

unrealistically either for or against a design strategy. Knowledgeable guidance is essential for accurate simulation.

6 It is difficult for students to "zoom out" from a design detail after they "zoom in" with scientific simulation. Studio instructors sometimes have difficulty redirecting students' focus to solving other design problems.

The digital site model created from the GIS data was effective as a collaborative platform. It is difficult to give scientific evidence as to how far students could improve their design using this computational approach on a collaborative project. However, the system definitely provided a dedicated common ground for students to carry out the "negotiation process".

References

1 **Hong Kong 1998**. Information Services Department of HKSAR, 1999.

2 N. Baker, A. Fanchiotti and K. Steemers. **Daylighting in Architecture: a European Reference Book**. James & James (Sinence Publishers) Ltd., London UK, 1993.

3 H. J. Bryan. "**Daylighting**." ASHRAE Journal, p. 26, Feb. 1990.

4 Victor Olgyay. **Design with Climate: Bioclimatic Approach to Architectural Regionalism**. Van Nostrand Reinhold, 1992.

5 Greg W. Larson. **Rendering with Radiance: the art and science of lighting visualization**. Morgan Kaufmann Publishers, 1997.

6 R. Compagnon. "**The Radiance simulation software in the architecture teaching context.**" Proceeding of the 2nd Florence International conference for Teachers of Architecture. Firenze, 1997.

Jinyeu Tsou, Benny Chow, Selina Lam
Department of Architecture, The Chinese University of Hong Kong
jinyeutsou@cuhk.edu.hk, kaming@cuhk.edu.hk, selinalam@cuhk.edu.hk