USING "HIGH DYNAMIC RANGE PHOTOGRAPHY" AS A DESIGN TOOL

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ABSTRACT

Using "High Dynamic Range Photography" (HDR) as a design tool in order to reduce a buildings carbon footprint was investigated in a second year design studio. Inexpensive digital cameras and free software that show the luminosity values of surfaces in buildings has made High Dynamic Range Photography a valuable tool for analyzing lighting in existing buildings. Daylighting of buildings has been shown to reduce the amount of energy that buildings require, thus reducing the carbon footprint of the building. It is therefore important for architects to understand how to properly use daylight in a building. This paper explores how to use High Dynamic Range photography in physical models as a teaching tool for beginning level students in an Architectural design studio. The use of High Dynamic Range Photography helps students to better understand how light enters buildings and how to design with daylight.

1. INTRODUCTION

The advantages of daylighting a building have been well documented as both saving energy and raising occupant satisfaction. Building designers and Architects should therefore understand how to design a building to use daylight if they want to effectively reduce energy use and increase the user's delight with the building. As a faculty member of a university whose department wants to adopt the 2010 initiative, I wanted to increase the understanding of the students in designing with daylight and develop a way for them to evaluate their designs without using expensive equipment or a method that would be too complicated for the students to replicate when they are away from school.

2. DESIGNING WITH DAYLIGHT

Daylighting a building should use the available light from the sky in order to illuminate the interior space to an appropriate level for the tasks performed. Great daylight design should not have a consistent level of light throughout the space instead, it should provide a variety of levels to make the space more dynamic and exciting while also achieving light levels that are appropriate for the tasks that will be performed in the space. Alvar Aalto's library at Mount Angel in St. Benedict, Oregon is a good example of how to use different light levels for diverse spaces that require distinctive levels of light. If one compares this to the library that Aalto designed 35 years before Mount Angel at Viipuri, Finland (now in Russia), she will find that the Mount Angel library is more dynamic because the daylight level at the stacks is different than the levels for the reading areas. The Viipuri library, on the other hand, has an almost consistent light level throughout the stacks and reading tables.

3. DAYLIGHT MODELS FOR DESIGN

Architecture students have the skill set to build models for design. Introducing daylighting models to the students is easy and valuable since it does not require the students to learn a whole new skill set, such as learning a new computer program. Daylighting models are an excellent way to study the way daylight will light a building before it is built and also make it easy to make design changes early on in the whole process. The difficulty for students is that the typical results from a daylighting model is not visual enough, since the results are usually numbers tested at a limited number of

points in the model. The other disadvantage of traditional testing in daylighting models is the cost of light meters and their limited use when daylighting is not being tested.

4. HIGH DYNAMIC RANGE PHOTOGRAPHY

Most students have digital cameras or can readily obtain one. By simply adjusting the exposure of the camera and taking a series of pictures, a student can use free software to create High Dynamic Range Photographs (HDR). These HDR photos can be used to visually assess how well their building designs utilize daylight.

4.1 What Is High Dynamic Range Photography?

High Dynamic Range photography allows for a greater range of luminance between light and dark areas of a photograph than normal digital imaging techniques. HDR can accurately characterize the wide range of intensity levels found in actual scenes. Inexpensive digital camera sensors are attaining progressively higher resolutions. These cameras can capture a great dynamic range, but not in a single photo. Varying the shutter speed can change how much light the camera can capture by a factor of 50,000 or more. High dynamic range imaging utilizes this characteristic by creating images composed of multiple exposures, which can far surpass the dynamic range of a single exposure and also give somewhat accurate luminance levels in a scene.

Fig. 7: HDR Photograph of Daylight Model

4.2 Software for creating HDR photographs

To learn more about High Dynamic photography, and to create your own HDR image, the best place to start is the website WebHDR. (4) This site teaches the basic concepts of HDR and also allows users to upload photos to create their own HDR photographs without downloading any software. The software that I used in the architecture studio was "Photosphere," developed by Greg Ward the author of "Radiance." Photosphere runs on OSX for Macintosh only. Other software is available for alternative platforms and is listed in detail at the WebHDR website.

5. ANALYZING DAYLIGHT WITH HDR

Photosphere and other HDR software uses the header file from the jpeg image the camera produces to determine the exposure of an image. The header contains information on the ISO film speed, aperture and exposure. After the software combines the exposure bracketed images it can determine the luminance distribution of the scene with good accuracy. (2) Photosphere will also create a false color luminance map of the scene, which illustrates to the students how well their intentions for the daylight levels were met within their daylighting models.

6. HDR IN DAYLIGHT MODELS

The students in my studio were asked to build daylighting models that would be both dynamic and have sufficient light levels using only the light from the sky. The space they were modeling was part of a larger building that would house a "Legerdemain Academy." The students were in the middle of the second year of a five-year architecture program at California Polytechnic State University, San Luis Obispo. They have not had any courses on daylighting, so I gave them a brief description of what the model should look like and the packet "BUILDING DAYLIGHTING MODELS," Daylighting Lab Seattle, University of Washington Department of Architecture. The rest was designed using their intuition of how light will enter the building through the openings that they designed into their building.

TABLE 1: EXPOSURE OF FIGURES

	Shutter	Aperture
Fig.1	+2EV- 1/3.4	f/2.8
Fig. 2	+1EV- 1/8.8	f/2.8
Fig. 3	Metered- 1/18.8	f/2.8
Fig. 4	-1EV- 1/40.7	f/2.8
Fig. 5	-2EV- 1/77	f/2.8

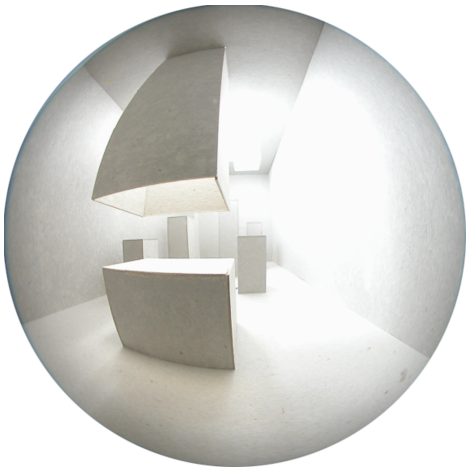

Fig. 1: +2EV

Fig. 2: +1EV

Fig. 3: Metered Exposure

Fig. 4: -1EV

Fig. 5: -2EV

The completed models where tested by photographing them using a Nikon E5000 digital camera with a fisheye lens attachment. Five photos were taken using the auto-bracketing setting on the camera. (Figures 1 through 5, See table 1.) If an auto-bracketing setting is not available on your camera the exposure levels can be changed manually around the auto exposure level. A minimum of three photos should be taken: one over exposed, one with normal exposure and one underexposed. More than three photos may yield more accurate results. The five photos were then combined into one HDR photograph using the software Photosphere. After the HDR photograph was created, Photosphere was able to display a luminance map with false colors. (Figure 6.)

7. DESIGN EXAMPLE

The student in this example was designing a small theater for the performance of "slight of hand" card tricks. His design intention was to use daylighting to illuminate a table top that the trick was to be performed upon, while also using daylight to have a lesser degree of ambient light throughout the rest of the space. His theater was in an urban environment, so he chose to daylight from above using a solid light tunnel to illuminate the tabletop and to use translucent "stalactites" to provide the ambient light. He was somewhat successful with his daylighting scheme (Fig. 6) with the tabletop receiving relatively more light than the surrounding areas. His translucent "stalactites" did illuminate the upper wall to a greater extent than the tabletop, which may draw the audience's attention away from the performer. Also, the daylight factor at the tabletop was roughly calculated to be about 1%, which may be too dark for the audience to see the performance. The students were able to discuss ways to improve the amount of light falling on the tabletop in more advanced ways than previous classes did when they did not have such a visual method of light levels in a model. Traditional methods of measuring light levels in a daylighting model might not have captured the higher luminance levels at the upper wall if the sensors were placed only at the working plane

8. CONCLUSION

By using High Dynamic Range photography in daylight models, students were able to visually test their designs against their intentions. Since the students did not have to learn a new skill set, and inexpensive digital cameras combined with free software were available to them, the students may be more likely to use this method in the future. Even though this was the students' first exposure to daylighting and building daylight models, they seemed to have a better understanding of what daylighting can and cannot do in a building by using HDR photography and free software. Hopefully, they will be able to use this method as they go out into the profession and develop it further.

9. ACKNOWLEDGMENTS

I wish to thank the students of my second year design studio who built the daylight models and participated in this experiment.

10. REFERENCES

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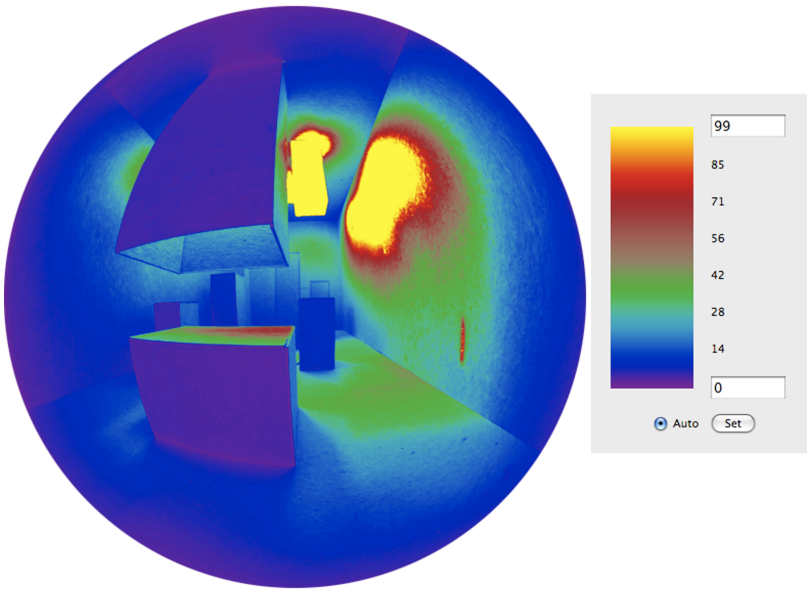

Fig. 6: HDR Photograph showing luminance map as false colors.