The Creative Eye: A Tactile and Digital Process of Imagining and Building Lights in Architecture

Claude MH Demers
Laval University

INTRODUCTION

The future of architecture greatly depends upon the ability for architects to understand and integrate scientific knowledge in the act of design. Whereas some aspects have been relegated to specialists, the integration of light in buildings should be more importantly linked to the architect's basic knowledge in the creation of spatial ambiences. Technology has introduced an important number of variables that contribute to the complexity of the act of design. These variables have however expanded the possibilities offered to architects; they enabled the exploration of new typologies of space and light as building science has allowed new assembling techniques and structures. The introduction of electrical lighting and the rapid developments of science have reorganized, sometimes even confined the architect's act of designing light in buildings. The importance for architects to take advantage of the present technological era offering more convivial access to computer simulation is indisputable. However, the tendency to rely mainly upon the calculated and simulated results has, in fact, recently produced a dependence upon the machine. The following sections explore aspects of a design methodology developed since 1993 [Demers, 1997] that has already been tested by students in studios as well as in professional research projects on daylighting integration to architecture (figure 5).

THE EYE OF THE ARCHITECT : a library of images relating matter, shape, time and light

A library of digital photographs has the potential to revive past memories of lighting experiences in the design activity. Research [Demers 2006] has demonstrated the potential of the image to generate quantitative and qualitative data as well as offering a basis for interactively add images one to another in a series of digital experiences [Demers, 1999]. The camera has a privileged relationship with reality that tends to create a belief of its strong capacity to report, identify and document functions. The representation is not always objective since the operator may alter a photograph in such a way that it transforms reality into other interpretations. Prendeville [1996] notes that the pictorial perception of space and the instantaneous and simultaneous perception of objects that occur in photography do not happen in everyday reality. He argues that familiarity with the camera has however encouraged an unconscious instrumental attitude to perception. In its habitual exploitation, the camera functions as a means of appropriation, and thus has perhaps reinforced a seemingly ingrained assumption that the world is arrayed, ready composed and itemised.

Figure 1 : Copper Baptistry at Norwich Cathedral, UK.

A photograph of the baptistery of Norwich Cathedral (figure 1) is showing a record of lighting patterns on a concave surface of copper located in a space with a high ceiling and surrounded by middle reflectance stone materials. The subtle unevenness of the surface of the material is revealing an impressionist vision of the cathedral, providing valuable information for future reference. Classifications of such images

[Demers, 2006] are now available for architects interested to organize photographs in relation to contrast and image brightness. In the context of architecture, photography becomes partly a scientific basis, partly a recording of lighting patterns. Interestingly, a photograph may promise reality, truth, and scientific precision, but it also belongs to the art as it often holds magic and mystery, contributing to inspire architects in the creative process. The eye of the architect therefore becomes more intimately linked to a certain reality of lighting composition as it is rigorously trained.

THE CREATIVE EYE :manipulation of materials generating complex reflections of light

The exploration of the visual capacity of multimedia technology to suggest and generate different lighting ambiences through computer manipulations such as collage, scaling, and duplication is actively developing. Editing a digital image with the computer facilitates and accelerates the process of alteration and transformation. Initial images may originate from a real environment but, for a more abstract and systematic classification, the use of a physical model produces more accurate results. A library of images may constitute a starting point to initiate the design process to avoid any physical modeling. An initial library consisting of basic photographs that initially inspire the architect, allowing them to sketch spaces with existing images of light could constitute a premise to the actual building of physical scale models. Whereas initial images constitute a basic resource for space creation, the combination of images generates numerous design possibilities. Inspired from the library of images, the manipulation of materials under certain

lighting and spatial configurations adds a further level of complexity and realism to the concretization of new design explorations. Most tactile manipulations constitute much more adaptable experiences and are still quicker to accomplish than any other type of simulation with a computerised tool. For many architects, liberation from the machine is also an important source of imagination and encourages unexpected discoveries that can accurately complex modeling of lighting effects. In further developments of design, computerised simulations may be of a higher relevance, especially when the creative act is converging towards a more determined set of solutions.

The research demonstrates the importance and interest for architects to integrate computer simulation in the design process in relation to the use of more conventional design tools such as physical models, drawings and a recently developed technique of image analysis that allow a more intuitive access to the science of light. The rapid and complex development of the architectural project during the design stage normally requires intricate computerized calculations [Novitski, 1990]. Physical modeling however, allows qualitative and quantitative analysis of space, whatever the level of complexity involved [Robbins, 1986]. Previous research has shown the possibility to combine computerized image analysis with the experimental method [Demers, 2000]. The combined utilization of physical modeling and computerized image and experimental approaches of design with images. It provides a simplified design tool of analysis for early design stages as well as for further development of a project. Inspired by the lighting reflections captured on the baptistery of an English cathedral (figure1), the creative eye of the architect remains in search of deformations and further experimententations in stimulating but rather complex to simulate environments. Figure 2 shows a sheet of copper, folded and crumpled, as part of studies undertaken under real sky conditions. This simple setting presents highly complex variables that would probably discourage any computer simulation adept : the presence of water and ice, the numerous folds in the copper sheet, the variability of the sun angle and the color of the sunlight all add the the quality of the light. Assesment of images promises an even more interesting of images as it will add layers of understanding to such experiments. analysis promotes the complementary tactile

The image can initially provide a framework for suggesting ambiences, or more realistically, propose an accurate visual representation of a space to build. The design methodology suggests two complementary approaches to the utilization of images in lighting design:

- The interaction approach based on the simultaneous use of the video and physical models.
- The typological approach based on a library of images.

The first utilization of the image is closely linked to the artistic creative process with all meanings inferred, within a spatial framework not so defined. The second, more

realistic approach, provides immediate design solutions, and originally needs lighting representations of real spaces or physical models. The library of images acts as a beginning of the design process, allowing a more formal and realistic approach. Maholy-Nagy had foreseen the interdependence of the two approaches when he suggested that composition and construction are aspects of the same problem. He argues that composition constitutes the highest level of intellectual evaluation of elements in their relationships between each other, whereas construction must ideally be pre-determined at every point of its technical and intellectual relations. Construction therefore demands an increased quantity of knowledge, especially technically, which should not necessarily imply the non-existence of any intuitive inspiration [Moholy-Nagy, 1932]. In architecture, composition needs to preserve its constructive realism to remain in the realm of the possible. The first approach therefore refers to the inspiration stage of a composition which remains rather suggestive, while the second proposes a context of acute, more constructive realism. These two aspects are complementary, but necessitate different methodological and technical operations. Lessard [1988] maintains that the linear continuity of events in a logical sequence is no longer an appropriate model for describing relationships with the world and culture. He mentions that nowadays, the adequate expression of this relationship is throughout the arrangement and combination of elements in space. The medium of

Figure 2 : Copper folded in melting ice, Quebec City.

photography, because of its technical possibilities, becomes part of an interactive process of retouching and photomontage. The acts of cutting or juxtaposing, which consist in the careful arrangement of photographs, become a more advanced art form than the early glued photographic compositions of the Dadaists [Maholy-Nagy, 1967].

MATTER IN SPATIAL CONTEXT :
Tactile explorations with materials ad light

The complex reflections of light on a highly reflecting and uneven material, requires basic physical model simulation to obtain more rapidly the qualitative and qualitative analysis. This research has shown the use of images as a tool for light analysis and composition. There are presently new techniques for movie making that involve sequences of images or even drawings that could be combined to create a moving sequence. The concept of creating a moving sequence from transformed images and original drawings produces a virtual space and enables the expression of the translation of an observer in space. This form of composition could contribute to an assessment of the visual aspects involved in transitions between spaces. Another interesting aspect of the video is the possibility to establish, for instance, a moving sequence of a sun pattern throughout the day. Reflections on water (figure 2) or the movement of a curtain under shadows of light are not always frozen as in photography but are much more alive through the use of the video. The moving image has this possibility to render the kinetic of light in space. The possibility to create a moving sequence between different images that blend one into the other through the use of a specially designed software of image processing can create an impression of translation in space. The process of the moving image is still involving much time and even though it appears as an interesting tool for architectural representations, it will perhaps need extensive developments to ensure its valuable use in daily architectural practice. The more simple aspect of the image which simply uses fixed image is a more abstract approach, but it is presently more suitable for an assessment of light at the initial design stages. It is however

limited to an abstraction of reality, even more importantly than for the moving image.

TRAINING THE EYE :
Analysing light in its spatial context

An image, when properly exposed, is “a direct record of the amounts of light to which each area has been exposed” [Evans, 1959]. The image therefore constitutes the basis of the following method of acquiring lighting data in architecture. Digital photography has been the subject of important developments and improvements during the past decade, offering support for recording lighting patterns in space and making it an ideal tool for research and practice. Integrated pose-meters, are now more versatile and offer more precision in the calculation of the right exposure of the subject in the view field of the camera. New digital cameras integrate a multi-reading pose-meter that grants more precision and flexibility in the evaluation of the correct exposure of photographs. As the eye adapts to different lighting levels, the pose-meter of the camera needs to consider the same adjustment in relation to different lighting conditions. Whereas many scenes can be obtained from automatic exposures, images obtained in backlighting offer the most critical conditions as the photographer need to select the right exposure and even work with manual controls.

The interpretations of images enable explorations of space and light. It is assumed that architects are familiar with the limitations offered by bi-dimensional representations and therefore would not be mislead by a lack of realism in the use of collage techniques but rather more stimulated to explore new ambiences. Architects also have the possibility to inquire more specifically on further developments of a design by using more sophisticated evaluation techniques or simple physical models (figure 3). The introduction of a physical model generally responds more appropriately to a complex problem and verifies the hypothesis offered by the interaction between images. The extensive use of computer space generation contributes to an exploration of numerous design alternatives within a limited period of time, contributing to train creatively the eye of the architect.

Figure 3 : Copper as a vertical reflector of light in a wooden physical model.

Most qualitative aspects of light are not measurable, but this research introduces the use of contrast as a global integrator. Contrast has the advantage to relate to quantitative aspects of light since it can be measured. It also relates to qualitative aspects because it constitutes an essential component of the perceptual description of an ambience. Contrast has always been an important descriptor of the quality of photographic images. It also appears that contrast is the most versatile variable that can establish a common basis for the qualitative and quantitative comparison between design solutions. The conventional calculation of contrast consists in the comparison between luminances of an object and its background. This approach is rather limiting for the evaluation of an entire space, and therefore, this research has explored other means to evaluate contrast on an entire image. The lighting pattern obtained from the brightness separation of the pixel units of the image offers a morphological assessment of light in space. The number of levels in the pattern and the distance between the curves are indicative of contrast. The research proposes two physical descriptors of the lighting pattern: the gradation of light and the compactness of the pattern. These descriptors add a quantifiable aspect to the interpretation of the morphology of the pattern. The histogram of analysis for the brightness distribution of the pixels of the image also provides additional quantitative information that is relevant for the classification of spaces. The statistical data are used in the comparison between images. The standard deviation and the interquartile range are particularly significant in the overall evaluation of contrast as they are indicative of the variance between highest and lowest brightness values.

Contrast and the lighting pattern.

The notion of contrast as a global integrator of qualitative and quantitative variables of light [Demers, 1997] is an innovative aspect of this research and relates more directly to space perception and aesthetic than illumination levels and spatial organisation. Figure 4a shows the contrast analysis of a digital image obtained from physical modeling (figure 3). Contrast is responsible for qualitative aspects of visual perception. Five brightness levels are shown on the image: 100% (white), 75%, 50%, 25% and 0% (black). Such digital manipulations have been correlated with photocell measurements [Demers, 1997]. The image is also related to lighting levels, a measure well understood by lighting experts (figure 5) and results can easily be communicated to architects. Advanced interpretations are also possible and offer great opportunities for lighting researchers [Schiler, 2000].

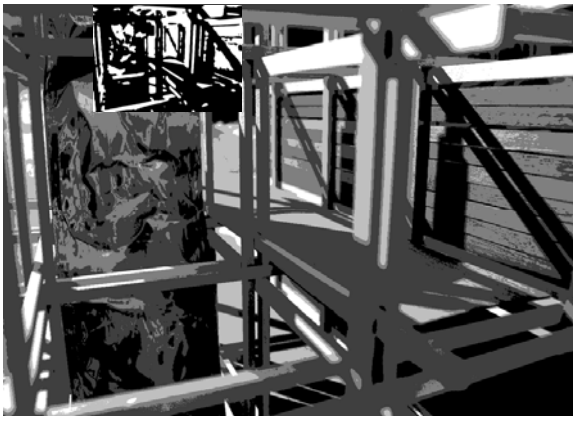

Figure 4. Quantitative and qualitative analysis of digital images of lighting environments.(a) (left) The lighting pattern, revealed through grey level separation. (b) (right) Location of high brightness areas from a two greylevel separation.

Brightness and the lighting pattern.

Hopkinson [1969] acknowledges the phototropic nature of the eye, which accounts for our being attracted or even sometimes diverted by sources of light of a high brightness in the visual field. The location of bright patterns on the digital image allows the establishing of the physical relation between space and light, essential to the perception of the visual environment. The quantification of this variable is established by applying the Adobe Photoshop “stamp” filter (figure 4b) on a grey scale digital image (figure 4a) by using mid-scales of clear/dark and uniformity settings of the software of image analysis. Other settings could be applied, but it was found that where the extremes of these scales were chosen, the resulting images were either too bold or too precise to produce any conclusive analysis. It is important to apply the same settings to each image to ensure correspondence of the results of analysis. The filter ensures that only the brightest areas of the images are highlighted and boldly represented in black and white. The dominant brightness of the image is appearing on the image of figure 5a towards the top of the

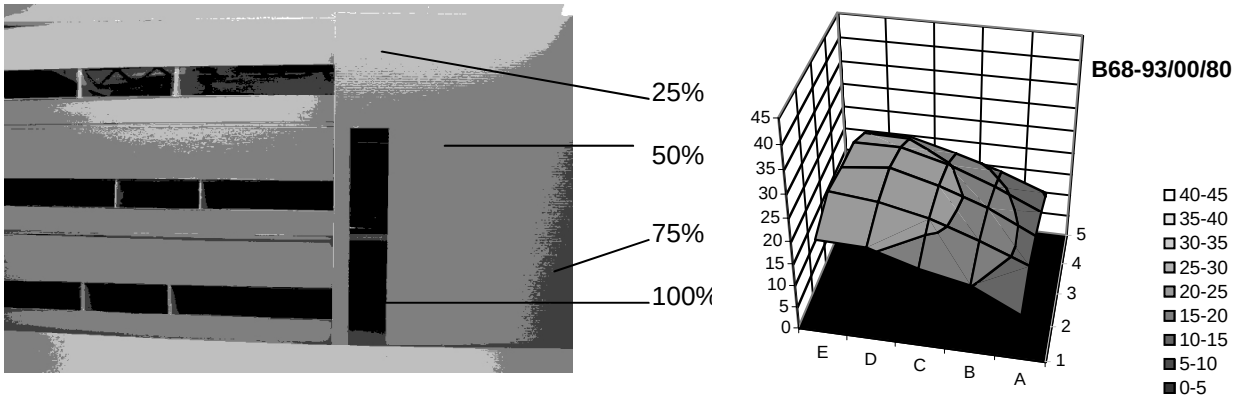

Figure 5 : Combined methods of lighting analysis. From the Daylighting studies for the Vandry Pavilion, Université Laval, Canada. (a) (left) Digital image analysis showing brightness locations. (b) (right) Experimental data from photometrical modeling.

image. High brightness zones are related to potential sources of glare, important for visual comfort and responsible for the quality of light.

CONCLUSION

The architect, in opposition to the artist, has to be conscious about quantitative aspects of light to achieve the desired result in the constructed project. There is therefore the need to include quantitative as well as qualitative aspects of light in architecture. The new technological developments that have introduced the liberation of the façade from constructive matters and opacity has recently deprived architects of a theory of light. This liberation of space from the load-bearing structure is responsible for the new complexity involved with light. The introduction of many new design possibilities have created a state of ineffectiveness in the elaboration of lighting concepts because of the rupture with tradition and intuition.

This research therefore proposes an original means of assessing light that enables architects to develop a more global approach to the luminous environment, and in some respect incites them to enquire more about its quantitative aspects. The methodology favors a convivial relation between the architect and light by introducing a technique that develops an intuitive thinking and a visual approach to light. It also explores the possibilities of using the image as a design tool. The image is an abstraction of reality, but its realistic and convincing character propels the design activities to higher levels of interpretation. The image constitutes a stimulating design tool because of its capacity to represent the immaterial qualities of light. There are however certain limits to the validity of the photographic representation, but they can easily be abstracted by most architects at the early design stage. An advantage of using images is to obtain quantitative and qualitative assessments of light in space. Quantitatively, the image represents more than its usual attributes. The familiarity with the design tool eventually encourages a more global comprehension of the luminous environment. The architect will progressively gain more confidence about the visualization of light and ultimately become less dependant on the tool as the *sum of acquired knowledge* increases. In that respect, the pedagogic significance of the method cannot be underestimated.

REFERENCES

DEMERS, C., (2006), « Assessing light in architecture: A numerical procedure for a qualitative and quantitative analysis", Proceedings of the Italian Lighting Association (AIDI), Commission Internationale de l'Éclairage (CIE), Venezia, 9-10 October 2006.

DEMERS, C., (2000), « Light and the digital image : a proposed framework for design and analysis » dans Architecture City Environment, Proceedings of PLEA 2000, July 2000, Cambridge, United Kingdom. Editors : Koen Steemers and Simos Yannas. James and James Science Publishers, London, 2000.

DEMERS, C., (1999), « The Power of Images » Proceedings of the EDRA (Environmental Design and Research Association), Orlando, Florida, 2-6 June.

DEMERS, Claude, (1998), « Qualities of light and space: contrast as a global integrator » in First CIE (Commission Internationale de l'Éclairage) Symposium on Lighting Quality, Ottawa, Canada, 9-10 May 1998.

DEMERS, Claude M.H., (1997), The Sanctuary of Art: images in the assessment and design of light in architecture, PhD thesis, University of Cambridge, The Martin Centre for architectural and urban studies, Department of architecture, Emmanuel College, England.

EVANS, Ralph M., (1959), Eye, film, and camera in color photography, New York, John Wiley and Sons, Inc.

FLYNN, John E., Clyde HENDRICK, Terry SPENCER, and Osyp MARTYNIUK, (1979),"A guide to methodology procedures for measuring subjective impressions in lighting" Research report of the Illuminating Engineering Research Institute, Project 92, in Journal of IES, January, pp. 95-110.

HOPKINSON, R.G., (1969), Lighting and Seeing, William Heinemann, Medical Books Limited, London.

Le CORBUSIER, (1923), Towards a new architecture, translated by Frederick Etchells, London, Butterworh Architecture, reprinted in 1989.

LESSARD, Denis, (1993),"The manipulated Photograph" in Thirteen essays on photography, Canadian Museum of Contemporary Photography, Ottawa, pp. 79-93.

MOHOLY-NAGY, Laszlo, (1967), Painting, Photography, Film, translated by Janet Seligman, The MIT Press, Cambridge, Massachusetts.

MOHOLY-NAGY, Laszlo, (1932), The new vision: from material to architecture, translated by Daphne M. Hoffman, Brewer, Warren & Putnam Inc., New York.

NOVITSKI, B. J., (1993), "Energy Design Software: a new generation of programs helps architects create energy efficient building designs" in Architecture, June.

PRENDEVILLE, Brendan, (1996), "Night Geography" in Night Watch: Nocturnal photographs of Cambridge and the Fens, by Ian Wiblin, Kettle's Yard, Cambridge.

ROBBINS, Claude L., (1986), Daylighting: design and analysis, New York, Van Nostrand Reinhold

SCHILER, Marc, (2000), "Towards a definition of glare: can qualitative issues be quantified?", 2nd EAAE-ARCC Conference on Architectural Research, July 4-8, 2000, Paris, France.

Architectural lighting design is a field within architecture, interior design and electrical engineering that is concerned with the design of lighting systems, including natural light, electric light, or both, to serve human needs. The design process takes account of: the kind of human activity for which lighting is to be provided. the amount of light required. the color of the light as it may affect the views of particular objects and the environment as a whole.