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# Confronting architectural design practices and parametric design potentialities

## *A discussion for the description of lighting design intentions*

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**Abstract.** *In several cases, lighting qualities are the first design intentions expressed by architects to describe the designed spaces. The emergence of parametric design models can aid the designer to shape a building while taking complex lighting constraints into account. By setting up a link between drawings of lighting design intentions in architectural design practice and lighting simulation in computer-aided design, we could allow architects to exploit the potential of parametric design approach. The confrontation of design process studies performed and the needs of parametric models shows a common ground to fill the gap. Using the visual thinking approach we study how the light features that can be used both by the architects and by the parametric models. The blur and contrast features can be used to highlight the lighting intentions. This work leads to a formal description of designer's intentions: the digital intention, which could be used for other physical phenomena.*

**Keywords:** *design process, natural lighting, intention expression, CAD*

## Lighting representation in the design process

During the architectural design process, architects have always used light in various kinds of representations with different tools. In addition, since the 1980s, parametric design has entered the architecture design field with increasing developments in the past ten years (Kolarevic, 2005). As design methods and the complexity of the buildings to be designed evolve simultaneously, confronting traditional ways of representing light with new ways of performing numerical light simulations is crucial to enhance collaborative design methods and design tools. The aim of the following discussion between existing design processes in offices and experimental tools developed by research, is to efficiently describe lighting effects that facilitate the exchange of data between designers and computers.

### *Lighting in architecture design*

In the traditional architectural representations, the light is symbolized by the 45° rays in order to show the volumes of the building with the shadows casted by the building. Parameters such as latitude, aspect of the building or environment are not considered in the design of the solar rays. At the beginning of the 20<sup>th</sup> century a real change in architectural representation creates a rupture with the established codes. Simona Talenti says that the start of the 20<sup>th</sup> century marked a great evolution because of the change in focus of representation

(Talenti, 2000). The aim was no longer only to show architecture but also to understand the relationship of the building with its surroundings.

Furthermore, the representation of light, like others parameters of atmosphere, reveals architecture by referring to our different personal experiences (Millet, 1996). An architect who is willing to reveal his architecture should therefore give a representation full of sensitivity and emotions. In this case, the representation of light becomes an expression of architectural intention to qualify the projected spaces. Moreover, since the economic crisis at the end on the 20<sup>th</sup> century, the awareness about energy consumption in buildings leads to a careful consideration of energy issues.

Whatever the intention of the lighting representations: code of representation, lighting atmosphere or energetic aspect, the architects need to represent the light during the design process. They use various ways to represent light, each way describing a specific characteristic of the designed light, e.g. draw a light ray, sketch a shading device principle, identify areas more or less lighted, reference others building with photography, add memories of their own experience, etc. Nowadays the light is described itself because it became an architectural element of the building.

### *Parametric design and lighting*

The parametric design has come into the architecture design field with increasing developments in the past ten years (Kolarevic & Malkawi, 2005). The performance-based design has led to the performative design, so the shape of the building and the performance of the building are strongly and tightly linked: the shape and materials of the building giving the performance in performance-based design, and the performance of the building giving the shape and the materials in performative design. This parametric design approach has proven to be useful in a collaborative lighting design context with a light-based parametric design approach (Tourre & Miguët, 2010) based on the performative design concept (Oxman, 2008).

### *Difficulties in expressing lighting intention*

Actually, there is still a gap remaining during the collaborative design process concerning the expression of the lighting intention. The existing tools lack a good integration into the architectural design process, forbidding to optimize efficiently the discussion between the architects and the others design actors, mainly the engineers. At some point these tools could even bring a cleavage in the design team, which have dramatic consequences that are seen only once the building is achieved.

This gap still exists maybe because there is a major problem in the description of the light: we do not see the light; we only see objects illuminated by the light. Although the description of light is difficult, it can be done using text, this solution could be quite descriptive but the problem is that the representation of the light from the texts depends on our interpretation (Mondada, 2000). A mockup is usually used to shape the building but also to show lighting effects. Graphics can also be used to describe the light. They seem to be more adapted to describe a visual phenomenon.

### *Link between tools and intentions*

The question is about the link that could be created between the ambience design intention and the tools provided by the parametric design community. How a new tool could be integrated into the architectural design process? Knowing that the elements available at this step of the design process are the intentions of designer and his first sketches.

Describing a lighting phenomenon in a graphic way raises a choice between two positions. First, the light can be described intuitively, that is to say the way we perceive our environ-

ment. Therefore we only describe the lighted objects and we have to deduce the lighting effect that has lighted the objects. So the problem is that we have no physical description of the light. Second, the light can be described by adding artificial elements into the scene in order to describe precisely the physical phenomenon, that is to say we are allowed to see the light. The problem in this case is that this description is not based on perception and therefore is not intuitive for designer.

More precisely, we address the problem of finding the key features that could be used by an architect to describe a lighting intention. This problem is related to the collaborative feature of the design process as a good comprehension of the intentions of the architect inside the design team is critical, and also to a user-centered design issue as we address the design of a Human-Computer Interface (HCI) of an architectural design tool in this framework.

### *Collaborative design*

A study in the German architect's office *Behnisch Architekten* (Drozd, 2010) noted that architects could collaborate with a climate-engineering firm whose aim is to anticipate the perception of the users in the building. It supposes that all the actors of the designing process take an interest in sharing skills and strive to understand the representations produced by each other. This way of designing atmosphere seems to be scarce while the traditional way separates the actors of the project.

The most achieved buildings are done when architects and engineers have started a real collaborative work during the early stage of the conceptual design. This work allows to produce dramatic effects, which are created by the light inside or outside the building. This is for us a great motivation to try to enhance collaboration as we think the collaborative design is the key point of the design process.

## **A visual thinking approach to efficiently express light**

We propose to describe graphically the light features, sensible or technical, that an architect could define during the design process. We choose this solution because architects and engineers largely use graphics. We have to add the right feature at the right place with the right representation in order to fulfill our goal.

We assume that the exchanges about light will be favored by enhanced light graphics: the *Digital Intention* (fig. 1). This is the description of a lighting intention on which we add special features describing the physical phenomenon, as light direction or others. Thanks to a parametric design method, as an inverse lighting model, the digital intention could be processed in order to give a feedback to the architect directly onto his intention.

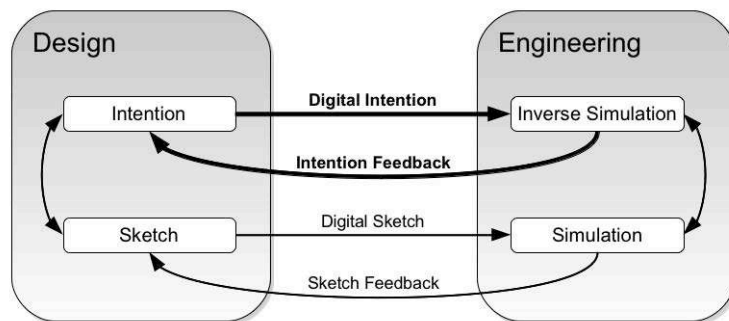


Figure 1. In the design process, the sketch is a way to exchange information; the digital intention starts an exchange at a different level

### *The light description*

By confronting studies about design process and possibilities of parametric models, we address the differences between both in order find a common ground for the light description. In others words, we define the correspondence between elements related to the design intentions and elements related to building physical values. The analysis of these critical elements poses the problem of transposing graphically and then technically the elements related both to the perception of the space and the light, and to the intention. The first issue is the way to describe the lighting effects:

- Ambience references (pictures, existing buildings): It is difficult to understand which remarkable feature the architect wants to show in a particular reference. The perception of building is global as we see the whole project (Péneau & Joanne, 1998).
- Ambience sketch: This is the most abstract of the intention expression and maybe the less usable in our case.
- Shape sketch: this scheme is a research tool for the architects allowing them to find a spatial configuration, but it focus on the building shape and not lighting effects.
- Shape and perceived phenomenon sketch: This is a good starting point as we have the shape and the lighting effects described.
- Shape and physical phenomenon sketch: This could be better or worse than the preceding sketch because a bad knowledge of the phenomenon often leads to unrealistic physical behavior. Mostly for direct sunlight.
- Physical device sketch: As the preceding one, mostly for direct sunlight.

### *The visual thinking approach*

One way to handle this problem is to use the visual thinking approach (Ware, 2008) in order to give some clues to the designer during the lighting intention expression. Following these clues, the designer gives the computer a way to interpret his intention in order to formalize it in terms of physical values or spatial relationships.

The visual thinking is used by visual designer to draw smart graphics that are easily understood by the users. Therefore we propose to use this approach to express the intention in order to communicate it and allowing the intention to be understood by the other actors of the project. An example of visual thinking is a map of the sea with color for the temperature, shapes for the streams and the size for the speed. When the size is too small, we only see a line and therefore only the stream without the direction.

The graphical expression of an idea allows to have an immediate feedback of the idea and to have an external point of view on the idea that is imagined (Lebahar, 1983). Our method is to apply this approach to the materialized intentions with graphics and then to think with these intentions.

### *Lighting features*

Lighting features can be used to describe graphically and formally a lighting intention. It means the intention can be enhanced by being described through a HCI, in order to be shown in alternatives way using the concept of active vision from the visual thinking approach, and that some features of the intentions are usable by the computer. This intention description is a basis to communicate ideas more efficiently than the intention sketch, as the ideas can be display in several ways. By multiplying the means to express an idea, the intention is understandable by people with different culture, knowledge or sensibilities. In order to have the intention usable by a computer, the elements describing the intention are linked to some precise physical elements into the numerical building mock-up. These elements can be used as input data in a parametric design framework, e.g. an inverse lighting model or a constraint solver.

Applying the active vision technique, the studied key feature has to pop-out from the global lighting intention. This popping effect can be achieved with graphic techniques as blur, color, movement, group, shape, etc. (Ware, 2008). The problem is to interpret the graphic technique and the associated lighting feature and to differentiate the features (fig. 2).

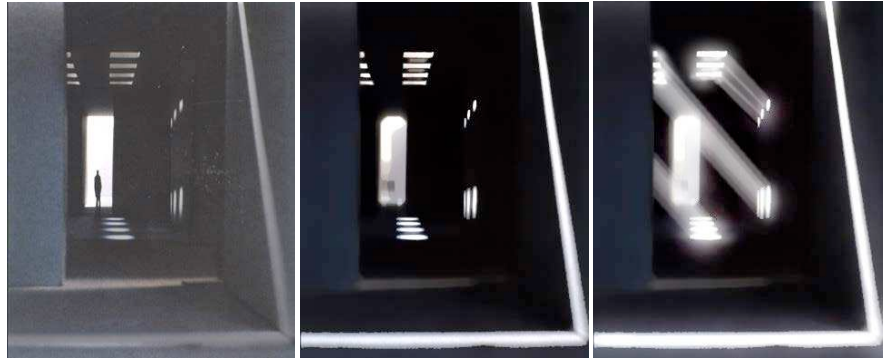


Figure 2. A mock-up picture (left) using the saturation, blur (middle) and adding direction clues (right) to pop-out lighting effects

## Discussion

It is difficult to use the lighting intentions as guidelines all along the design process, and some design tools are intended to solve this problem. Our approach is to project the lighting intentions into the 3D scene in order to follow the evolution of the architectural project, and eventually to detect the distance between the original intentions and the on going project, putting forwards the lighting effects following the idea *form follows light*. A suitable lighting intention representation can enable to set up a link between architects practice and parametric design tools, allowing the architects to deal with complex lighting constraints.

We delineate the existing gap in lighting design by studying practice and tools, and show the potential common ground filling the gap. This common ground is found by proposing key features to represent lighting intentions using visual thinking.

The interpretation of a picture by a computer remains very analytic, as the computer vision techniques allows computing the shapes or the colors into a picture, but it still lacks technique to define the atmosphere that is underlying into a picture. Maybe the aggregation technique of *Gist of a scene* (Torralba *et al.*, 2003) can be helpful to solve this problem.

Moreover, we are aware that we have not explored the full range of the possible representation of lighting, and that we can further perform some studies about photorealistic, non-photorealistic or abstract rendering, and we have to go deeper into the scientific visualization techniques.

## Conclusion

We propose to use the visual thinking approach to express a lighting intention with a graphic representation that can be processed by a parametric design model. An example of a description of a lighting intention is based on blur and contrast and can embed metadata related to physical lighting values that are hidden behind graphics, as lighting direction. This digital lighting intention establishes a direct link between the designer's mind and hand, and

the parametric design models, and therefore allows tackling complex lighting design constraints related to user comfort or energy consumption.

Our approach can be seen as formal method to describe a lighting intention. This method could be used to set up a semantic description of the user's intentions related to other physical phenomena or abstract concepts. This contribution remains a proposition, as designers has not tested it in real situation. This approach needs to be completed as some other lighting effects could be studied. So our work represents a starting point, not only to facilitate communication between a human and a computer *via* a human-computer interface, but more generally to facilitate collaborative design and the use of CAD tools outside the field of architectural design.

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