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DAYLIGHT AND ENERGY IN THE EARLY PHASE OF ARCHITECTURAL DESIGN PROCESS

A design assistance method using designer's intents

MOHAMED-ANIS GALLAS,[1,2] DIDIER BUR[1,3] and GILLES HALIN[1,2]
1. MAP-CRAI, Centre de Recherche en Architecture et Ingénierie, Nancy, France, {gallas, bur, halin}@crai.archi.fr
2. Université Nancy, Nancy, France
3. Ecole Nationale Supérieure d'Architecture de Nancy, Nancy, France

Abstract. The integration of daylighting from the beginning of the design process can help designers to create buildings that respect their environment benefit from the solar gain thus giving an answer to illumination and energy needs (Bodart et al, 2002). This paper proposes a declarative assistance method/tool designed for the early design phase. This method assists the designer in integrating the daylight and its energetic impact from the beginning of the architectural design process by means of intents. The intents are related to the daylight, energy and spatial configuration aspects of the architectural project. The method translates the designer's intents into potential solutions. They are the first formal representation of the architect's intents that could be customized and altered during the next architectural design phases.

Keywords. Daylight; energy; early design phase; design support; intents

1. Introduction

The environmental awareness urges the designer to integrate the daylight and its energetic impact into the early phases of the architectural design process. "*Decisions taken rapidly in the early stages of design can have a large impact on the performance of the finished building.*" (Gratia et al, 2001). Several design assistance methods propose to help the designer to realize a better

integration of the daylight and the energetic impact in different phases of the design process. They mostly involve in-depth knowledge without a real integration method and are designed to evaluate the performance of architectural shapes under criteria in relation with daylight and energetic features. This type of method/tool is characterized by the lack of elements that can support the design process during its first steps. The reason is that these engineer's methods/tools are developed to answer needs that are different from the architect's ones. A new generation of prototypical methods propose to assist the architect by integrating architectural knowledge in early design phases. Among these methods, the declarative modelling one uses the intents as a main data to establish a real dialogue between the method and the designer. It uses the designer's intents to propose potential solutions.
Our research subscribes to this way and defines a method that must:

- Integrate the daylight and its energetic impact
- Be adapted to the starting phase of the architectural design process
- Allow a real dialogue with the designer

The first part of this paper presents two types of methods integrating the daylight and the energetic aspects. We present the process, the different actor's (person and system) tasks, the manipulated data types and if they answer to our expectations. In the second part, we present the process and the different phases of our assistance method integrating the daylight and its energetic impact by the use of the designer intents.

2. Design assistance methods

Different design methods are developed to assist the designer on the different tasks during the architectural design process. These methods focus on particular domains of the architectural project as the daylight, the energy or acoustics. They take part in the architectural design process by different ways and at different phases. The evaluation of an array of methods allows the identification of two major method classes, the decision support method and the design assistance method.

2.1. DECISION SUPPORT METHODS

This class of methods is designed for engineers and used to realize quantitative evaluations of architectural project features like the energetic, acoustic or daylighting behaviour. They participate during the last phases of the architectural design process where the evaluations results make sense to validate some designer choices or strategies (Figure1). Among these methods the models ones (the modular climate chamber[1], the Heliodon[2], the Scanning Sky Simulator[3]), the simplified calculation methods (LUMcalcul) and the simulation software (Dialux®, Ecotect®, ArchiWizard®).

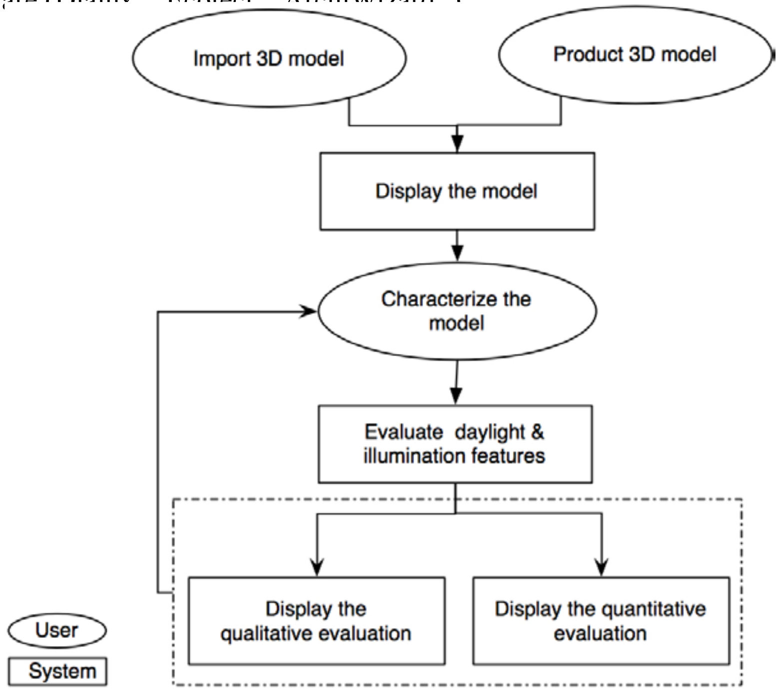

Figure 1.The process of standard support decision method

Dialux® import 3D models of architectural projects from standard CAD systems to test different illumination strategies and evaluate their daylighting or artificial lighting behaviour. These models must be formalized and characterized to make the simulation possible. The user must define the project features, i.e. the orientation, the surfaces characteristics, the light sources. The simulation results concern the quantitative evaluation as the photometrical values (daylight Factor, Luminance, etc.) and the qualitative ones (photorealistic representation of the generated daylighting effects).

The decision support methods can hardly be used during the early phases of the architectural design process because the designer is not able to define the different features characterizing the project. Indeed, Lawson (Lawson, 2006) defines the "moving activity" characterizing the starting phases of the design process where the project is still on the drawing board. The "moving activity" integrates the designer intents generation and transformation to propose potential solutions. But, these support decision methods are not able to support this design activity.

2.2. ASSISTANCE DESIGN METHODS

Different research groups in architectural domain propose a new generation of assistance design methods linking the popular three-dimensional CAD modeller (Rhinoceros®, Sketchup®) with advanced daylight simulation tool (Radiance, Daysim). It makes possible the evaluation and the validation of a large number of designs variant at the early stages of the design process. They produce a quick feedback integrated on the project development. The DIVA (Lagios et al, 2010) workflow integrates on Rhinoceros® single and multiple evaluation of the daylight behaviour of schematic design configuration. Light-Solve (Andersen et al, 2008) is a plugin for Sketchup® used to analyse and to visualise the daylighting effects from different viewpoints of the project and under various sky conditions.

Another type of methods integrates some architectural knowledge to assist the design process. They use the declarative modelling method using designer's intents to generate potential solutions. The intents represent the architect's choices or the design constraints concerning a particular aspect of the project creation. They are described using architectural terms (Lassance, 1999). This method is used in different architectural assistance method designed to create real dialogue between the designer and the method. Three actors (system, person) are participating in the declarative modelling process: the "user", the "interface" and the "system". The declarative process is organized in three phases; the "describing", the "generating" and "assessing" phases (Figure2).

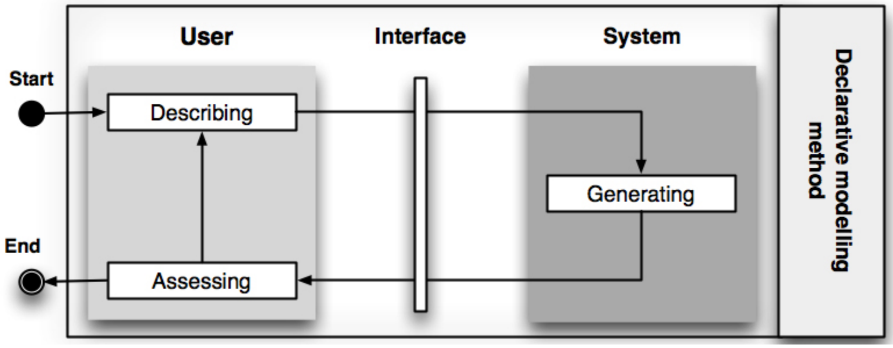

Figure 2.The declarative modelling process

On the "describing" phase, the "user" describes his intents using an architectural language in relation with a particular aspect of the architectural project, like the daylight atmospheres for instance. During the generation phase, the "system" translates the designer's intents into geometrical constraints to generate solutions. The "user" participates also in the "assessing" phase during which he evaluates the generated results. Following that, he can select solutions that are corresponding to his intents.

This method is used to assist different tasks of the architectural design project. With the WordsEye (www.wordseye.com) project the user gives the description of a desired 3D model, expressed in a natural language. A very important database is used to translate the sentences in a set of constraints and generate 3D models (Figure3).

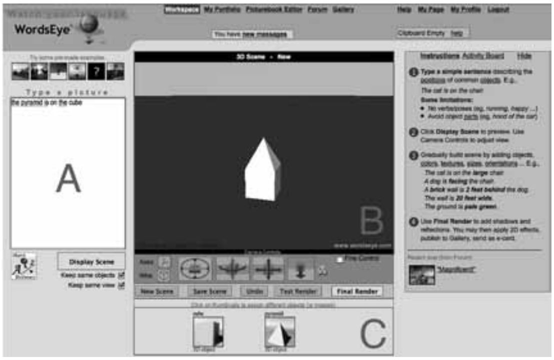

Figure 3.WordsEye modelling process, (A) describe the scene, (B) show the 3D scene, (C) show the 3D scene components.

Fauche (2000) proposes a declarative method integrating the designer intents related to sunlight, visibility and urban regulation. It uses an architectural knowledge base that translates the described intents into constraints to make the generation of potential solutions possible. The method proposes potential geometrical configuration of sunscreens or building shape generating the described intents (Figure 4 and 5).

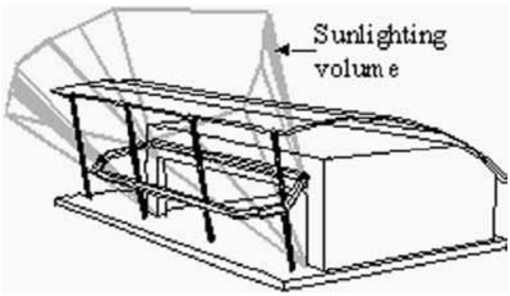

Figure 4.*Proposed solution to the daylight intent "The front of the project must be sunlit in the middle of the day in winter".*

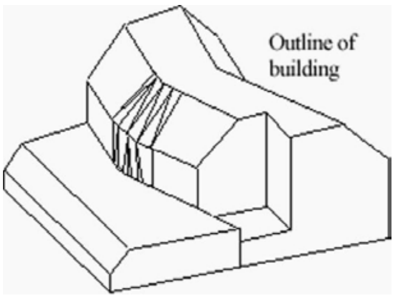

Figure 5.*Proposed solution to the urban and visibility intent "The building must be included in the maximal volume of the site".*

Leso-Dial (Paule and Scartezzini, 1997) is a declarative tool allowing the designer to describe a spatial configuration using an architectural language, to evaluate the daylighting results. An expert diagnosis allows architect to point out the possible weak points of their design (Figure 6).

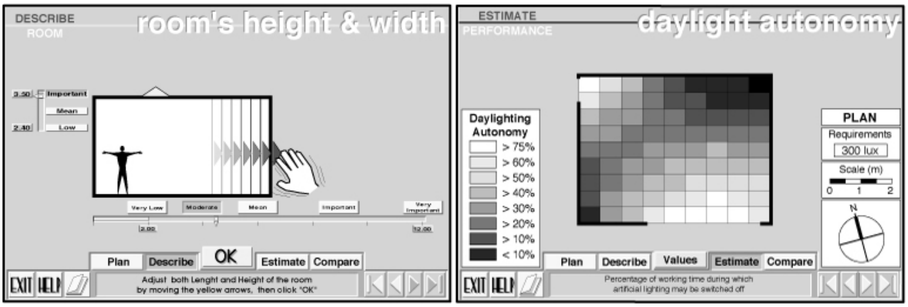

Figure 6.Examples of graphic input and output on Leso-Dial

3. Proposed design support method integrating daylight and its energetic impact

We propose a declarative design support method using the architect's intents to generate potential solutions. The intents are the representation of the daylighting effects or atmospheres that the architect would like to create. The main feature of this method, that makes it different from the other assistance methods, is the integration of architectural knowledge linked to the daylight, spatial and energetic domain of the project. This knowledge will be used as a reference to translate the designer intents into potential solutions. The solutions are a formal representation of the architect's intents. The method allows the evaluation of the energetic behaviour of the proposed solutions that constitutes another selection criterion.

3.1. THE METHOD PROCESS

In our declarative modelling method six actors are participating in the process; the "designer", the "interface" and four different "systems". Two external "systems" participate in the method process, which are the "simulation system" and the "C.A.Drafting system". Every actor realizes different tasks, which are successively organized to constitute the method process. First, the "interface" presents different intents imported from the "intents database". Then, the "designer" chooses intents that the "generating system" will integrate to generate potential solutions. After that, the "Simulation system" evaluates the qualitative and the quantitative features and the energetic impact of the proposed solutions. The “interface” presents the evaluation results. The “designer” assesses the results and selects the solution(s) that is (are) corresponding to its intents (Figure 7).

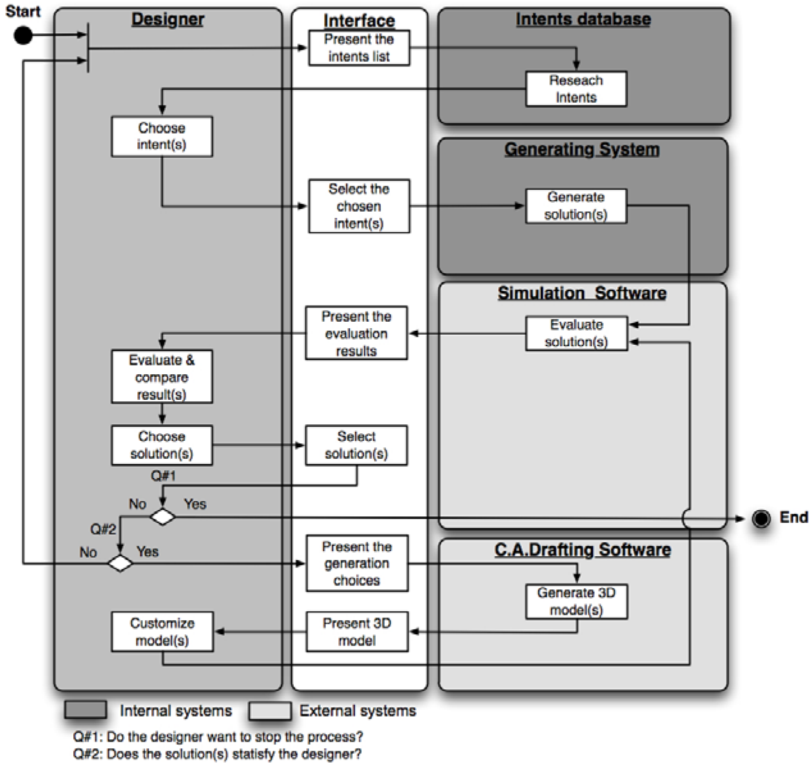

Figure 7.The proposed method process

Finally, the designer can choose to stop or to continue the process. If he chooses to continue, two cases are proposed:

- If he is satisfied with the generation results, he can generate 3D model(s) that will be further customized and evaluated.
- If he is not satisfied with the generation results, the “designer” can restart the whole process and select other intents

3.2. THE INPUT DATA TYPE

The main data used in the proposed method is the designer’s intents. Faucher (2000) defines them as “*a conceptual expression of constraints having an influence on the project*”. They are described using an architectural language and characterized using the concept of indices introduced by Mudri (1996) who proposes an evaluation method of the daylight and energetic behaviour of project sketches. The indices could have a symbolic value that represents an aesthetic quality or a numerical value as dimension, reflexion factor (Marin, 2008). We use these indices to structure an intents database that participates in the system process (Figure 8).

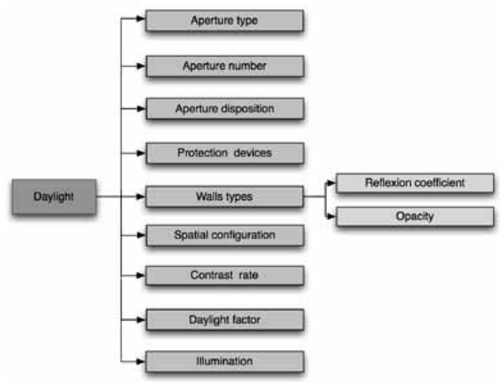

Figure 8.The list of indices characterizing the daylight intents

The intents are graphically represented by expressive icons that create a real dialogue between the designer and the system. (Figure 9)

Figure 9.Graphical representation of the daylight intent "Sunspots" (www.audience.cerma.archi.fr)

3.3. THE OUTPUT DATA TYPE

The proposed method considers the architectural project as a set of spatial units because of its complexity. A spatial unit is defined as the smaller part of the project. So, the generated solutions will be presented as a spatial unit creating a particular daylight effect or atmosphere. These cases include all the features of the architectural project. The objective of such a method consists in assisting the architect to take into account daylight effects and its energetic impact through the manipulation and the transformation of these formal cases (Figure 10).

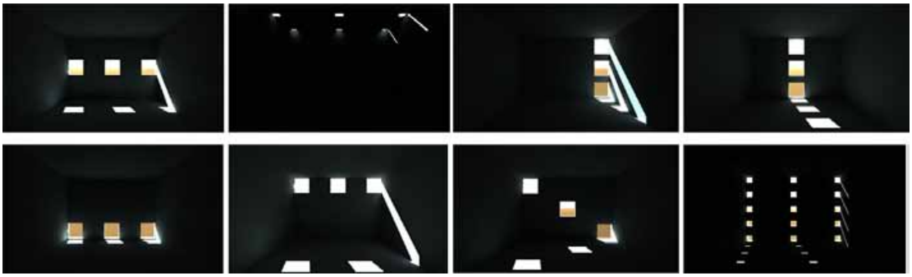

Figure 10.Examples of generated solutions

The evaluation of the energetic behaviour of the proposed solutions helps the designer to integrate this aspect in his architectural design process. The different aspects influencing the energetic impact will be evaluated by the use of indices. These indices were identified and selected because they are influencing the energetic behaviour of the architectural project.

4. Conclusion

This paper presents the first part of our research work. It proposes a declarative method to assist the designer during the early phases of the architectural design process. The only data used is the designer's intents related to the daylight atmosphere. The designer intents are characterized through the use of the concept of indices. The method generates potential solutions that are the formal representation of the designer intent's. An evaluation system is integrated to help the architect to make possible the interaction between the design choices and their energetic impact. The different input and output data are graphically represented to create a dialogue between the method and the user.

During the next step of our research, we will try to detail the different parts of the proposed method as the structure of the intents database and the generating process to develop a prototype. The objective is to evaluate the participation of this method in the architectural design process and its ability to help the architect to integrate the daylight and its energetic impact on the design process.

Endnotes

1. The Modular Climate Chamber consists of light elements and insulating modules of 120 cm2 which allow the construction of different simple or multiple volumes, interconnected or not, for diverse studies regarding the indoor environment. The chamber is equipped with a double-flux air conditioning unit of 1000 m^3/h that allows heating, cooling and air humidification.
2. The Heliodon is used to examine how direct sunlight interacts with an architect's building design.
3. The scanning Sky Simulator developed at LESO-PB, used as a basis for several other sky simulators, allows accurate reproduction of the luminance distributions of every type of sky. It can be used for diffuse light measurements within building scale models for any time of a year and any location and is thus a precious tool for the testing of innovative architectural solutions and daylighting systems.

Acknowledgements

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