IDEA-l, a prototype of a natural lighting design tool for the early stages of the design process

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ABSTRACT

This paper discusses IDEA-l, a new natural-lighting design tool, currently under development, that is meant to offer the architect/designer a digital equivalent for scale models, artificial sky simulators and heliodons. The program is part of the IDEA+ research project at K.U.L. This project, under guidance of Prof. H. Neuckermans, aims at developing a new integrated design environment for architects. The paper starts with a discussion of lighting as a design issue. Next the specifications for the new tool are given. The paper ends with a brief development status.

1 INTRODUCTION

It is an almost impossible task to describe the importance of light for architectural design in all its facets: it has an impact on a building's functionality, energy balance, appearance and atmosphere; it influences one's comfort, mood and health; the effectiveness of a lighting design depends on fields ranging from physics to human psychology. With this in mind, one would expect to find the design of lighting systems intricately interwoven with the overall architectural design process. However, this image hardly corresponds with reality.

2 CURRENT DESIGN PRACTICE

All too often do architects/designers base early design decisions upon their intuition or upon truisms, such as "Light shelves improve energy efficiency". It is then the task of the lighting expert to optimise the options dating back to the conceptual design phase (de Wilde et al. 1999). This approach can hardly be called ideal: since early design decisions tend to have the greatest impact (Lechner 1991), unfortunate ones are also the hardest to correct.

It would be a great improvement if all decisions in the design process could be informed ones. What we therefore need is a means to predict the impact and consequences of design alternatives. We need a way to make the experts' knowledge available to the designers at an early stage.

3 DESIGN TOOLS AND TESTS

When we look at the tools that are currently available for lighting design, we can distinguish between different categories, corresponding to different aspects of lighting: artificial lighting, sunlight, skylight[1] an integrated approaches.

3.1 **Artificial lighting**

Over the past few years most lighting equipment manufacturers have developed their own software, which is often freely available to designers. Some even provide computing services over the internet[2]. Although they all have their particular possibilities and user interface, they typically contain a database of the manufacturer's luminaires and a simple tool to design a layout of luminaires, compute the corresponding illuminance values and draw up the bill of quantities.

3.2 **Sunlight**

Traditionally sunshining and the control of insolation can be tested manually and graphically by means of a few different kinds of projections on sunpath diagrams, or by using a heliodon to test scale models. Since the same tests can fairly easily be implemented in computer programmes, an increasing number of CAD-packages offer simple solar tests. With them sunpath diagrams, shadowing and solar envelope can be determined.

3.3 **Skylight**

As opposed to the previous two, there are not too many applications that treat skylight as a separate feature. There are, however, several traditional manual and graphical computation methods, such as the Waldram diagram and the BRE protractors. They produce an estimate of the daylight factor.

3.4 **Integrated approaches**

As pointed out in the introduction, there is more to lighting than illuminance levels alone. Many research teams have therefore acknowledged that lighting design is a matter that calls for a more integrated approach. Consequently a number of energy simulation programmes have been developed. Examples include Adeline, which makes use of Radiance and Superlite to link lighting design to energy savings, DOE-2, which can perform hourly energy simulations and estimate utility bills, and ESP-r, which covers energy and mass flows and environmental control systems within the built environment.

3.5 **Actual design practice**

Most of the above-mentioned tools do not meet the goal of helping the architect/designer during conceptual design. The artificial lighting applications offered by luminaire manufacturers are very easy to use, but generally irrelevant to the first design stages. The daylight tables, diagrams and protractors prove too cumbersome to use compared to the given output. Building scale models and testing them with artificial skies, endoscopes and heliodons is overly labour-intensive and costly. In general the integrated simulation software, while excellently suited for later design stages, requires a level of expertise that is too high and data that is far more detailed than is available during conceptual design. The solar testing software is probably the most interesting for the early design stages: it combines ease-of-use to practical and relevant output.

This brief overview of the available tools shows that there is a clear lack of design tests and tools that are suited for the conceptual design stage. This has been recognised by a number of research teams around the world, which has led to applications such as Energy 10 (NREL), PowerDOE (DOE2), BDA (LBNL), Leso-DIAL (Paule 1997) and ILSA (de Groot 1999). These form a huge step in the right direction, but have yet to find their way to every-day practice.

4 KNOWLEDGE TRANSFER

Our main objective is a tool that facilitates the transfer of knowledge from lighting experts to architects/designers. Two main strategies to accomplish this can be distinguished:

1. Performing simulations on simplified models;

2. Presenting the knowledge in the form of a rule base that comes to a conclusion solely on the basis of the model's characteristics.

In our opinion the second approach is the less realistic one. Given the highly complex nature of the matter, it is unlikely that the quality of a lighting design can be directly derived from the description of the model alone. Since one design decision automatically influences several others, we believe overall performances will be strongly determined by second-order effects that cannot be captured in rules.

Of course, the second approach includes the risk of basing decisions upon inaccurate data. Since we are dealing with incomplete designs, we are forced to work with simplified models. It is, in other words, possible that the simulation will not be representative for the actual design. However, accurate illuminance levels and daylight factors are not what the architect is looking for in an early design phase. Qualitative statements are of far greater importance to him than quantitative ones.

Nevertheless, a prerequisite for this approach is the thorough study of these simplified models, in order to isolate the design question at hand. Where this proves impossible, the user should be warned of possible implications for other aspects (e.g. increased heat gains from large glass surfaces can imply higher cooling loads in summer).

5 IDEA-l

IDEA-l, currently under development at K.U.Leuven, is a new tool that is conceived to fill the discussed void in the architect's toolbox. It is part of the larger IDEA+ project, which aims at providing a new Integrated Design Environment for Architectural design (Hendricx et al. 1999). We will now have a closer look at its specifications.

5.1 **Target user group**

Our target group consists of architects in general, i.e. people with feeling for the problem of manipulating light, but without any special technical expertise in that field. We should therefore try to keep the threshold low and make sure that the required knowledge is minimal without jeopardizing the scientific value of the results.

5.2 **Functionality**

What we need is a cost-efficient and practical design tool that proves useful at the beginning of the design process. It should therefore not only be a design test, but a Decision Support System (DSS), helping the architect/designer during the most decisive of design stages. It should not merely return the daylight factor, but help the user to interpret the results, identify weaknesses, offer insights into the influences of the different design parameters and stimulate the comparison of different alternatives. Next to computing illuminance levels and daylight factors, the tool will allow the user to test daylight autonomy[3], his design's suitability for visual tasks and visual comfort. In addition the aesthetic quality of the design can be verified with a semi-realistic rendering.

The objective of the proposed tool is not to render the in-depth lighting design study as performed by lighting specialists redundant, but rather to complement it with an earlier and less elaborate step at a point in time where major changes to the design are still possible.

Artificial lighting is rarely part of the conceptual design stage. We have therefore focused our attention on daylighting — both sunlight and skylight.

5.3 **Dealing with raw data**

Typical of any design process is the absence of detailed data in the early stages: the architect cannot be bothered with reflection factors, colour spectra or sky distribution functions. He's still exploring concepts, and material choices are far from precise.

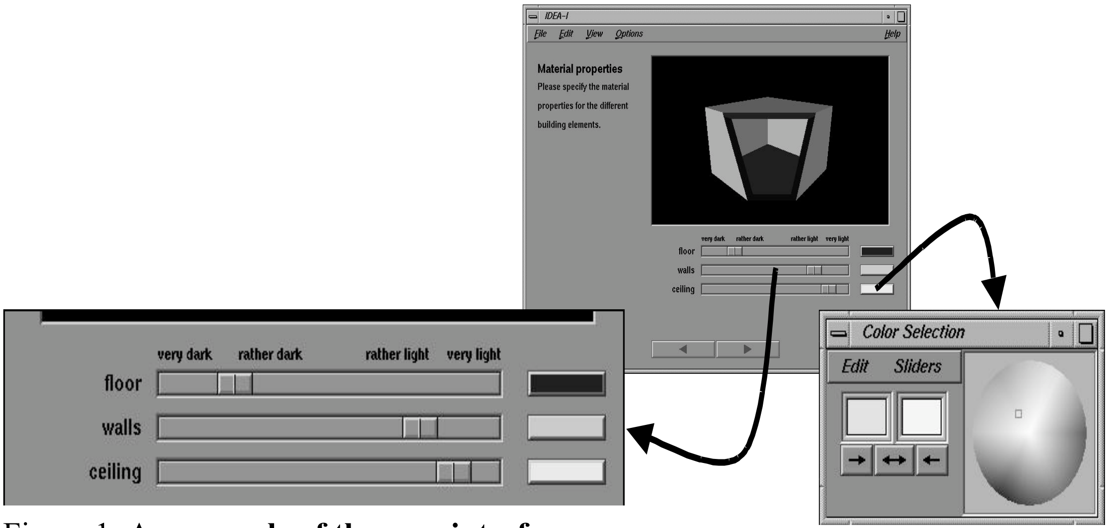

Figure 1: **An example of the user interface**

This should be taken into account when developing the tool. Data input should reflect the designer's way of thinking. It should therefore be intuitive rather than numerical: numeric values should be hidden from the user and be replaced with verbal descriptions. For instance, when assigning reflection factors the user should get a range of choice going from "very dark" to "very light", which the application can then translate to appropriate numeric values (figure 1). Similarly, if the sole purpose of a realistic rendering tool is for the user to be able to judge the light effects of a certain window and space composition, we shouldn't bother him with entering detailed material descriptions and fine-tuning texture maps, but instead offer him a visual colour picker, and the choice from a small library of the predominant building materials.

5.4 **Full interactivity**

For our program to be a design tool, it needs to be fully interactive. This means that the user should be able to go swiftly back and forth between his CAD package and the new tool. Ideally both programs should use one and the same digital model, so that every change made in one is reflected in the other. Alternatively, both programs can be made to communicate so that their digital models can be checked for inconsistencies.

The main goal of the IDEA+ project is to develop an integrated environment where all design applications, whether modeller, DSS or design test, all use a single database, uniting all their data. Since this is still largely a plan for the future, IDEA-l will allow input from data files in a handful of recognised file formats, and contain a simple geometric modelling module.

It is often argued that abstract, box-like models suffice to explore design options. However, we believe that the architect/designer will be more inclined to use the lighting tool when it allows him to experiment on his own design, rather than on an abstract box. Moreover, it is our experience that it is often the extraordinary cases, which cannot be described with a simple abstraction, that call for a helping hand.

5.5 **Low threshold**

If the new tool is to have any chance of being used by architects, we need to keep the threshold as low as possible. If the tool does not provide a sufficient amount of useful information with a minimum of hassle, architects simply will not use it (Degelman 1998).

Different aspects here include the necessary learning period, the ease-of-use and the amount of work the user has to put in before obtaining any results. The former two are closely related to the user interface. The latter is a matter of how well the tool is integrated into the software environment the architect works in.

5.5.1 *User interface*

One aspect of the user interface that has already been touched upon is the way in which the user is asked for input. As mentioned above, this should be intuitive rather than numerical. As for the general structure of the interface, it should reflect the most appropriate way of guiding the user through the process of entering data, running tests and interpreting the output. We propose that it follow the example of the many "wizards" popping up in today's software world, programs that guide the user through the different steps of a procedure, only allowing him to take a single step forwards or backwards, thus guaranteeing a structured approach. The interface should also encourage self-learning: through extensive use of "tool tips" and a glossary, the user can be stimulated into mastering the terminology and perhaps part of the science behind lighting design.

5.5.2 *Integration into the existing software environment.*

If what we want is a cost-effective solution, we need to minimise the amount of "manual labour" that can in any way be avoided or automated. Thus, one feature that needs special attention is the input of data. More specifically, we need to avoid the trap of developing yet another separate application, with yet another file format, for which the user needs to build yet another digital model. This again illustrates the need for an integrated design environment as described under section 0.

6 DEVELOPMENT STATUS AND PLANS FOR THE FUTURE

So far the underlying structure has been developed, i.e. a graphical kernel and a simplified data structure kernel have been implemented and are used in the development of new packages in our research project.

Currently at the beginning of 2000 our efforts are focused on the development of a geometrical modeller and the proposed lighting tool, of which first prototypes are expected in the summer of 2000. Both will be fully interactive and complementary to each other. Special attention goes to platform-independency:

development of the tools happens simultaneously on Windows NT and IRIX, in order to achieve a rigorous separation between platform-independent functionality and the mere platform-dependent user interface, and to study the possibilities of cross-platform data sharing.

Following work will include the implementation of the database, the implementation of its interfaces with both tools and eventually with existing CAD packages, and the further elaboration of both tools. Key issues will include the transfer of data between different levels of scale and between different levels of detail, consistency checks in simultaneous collaborative design, the adaptability and expandability of the database, and the organisation of data in design views.

7 CONCLUSION

We have presented a new design tool for natural lighting that is currently under development at K.U.Leuven, specifically devised for use by architects in the early stages of the design process. This tool is meant to fill a void in the architects' toolbox by offering a quick estimate of the impact of their design choices on the aesthetic, energetic and functional quality of their projects. With it, architects will be able to get a grip on every-day daylighting problems for which, until today, they have had to rely on their intuition. Though we have a long way to go, we feel confident that this is a first step in the right direction.

8 NOTES

[1] We use the terminology as proposed by the CEC. Sunlight corresponds to direct solar radiation, skylight to diffuse sky radiation.
[2] Ledalite's online calculator: http://www.ledalite.com/cfm/calc.cfm
[3] Daylight autonomy: percentage of the working year that artificial lighting can be omitted.

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