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Multimedia application for teaching the basics of lighting in physics classes

A. Pigiaki([1]), D. Zevgolis([1]) and H. D. Kambezidis([2])

([1]) *Department of Graphic Arts and Multimedia, Hellenic Open University - Patras, Greece*
([2]) *Atmospheric Research Team, Institute of Environmental Research and Sustainable Development, National Observatory of Athens - Athens, Greece*

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Summary. — The creation of a simple or an interactive multimedia (MM) system can improve the presentation of a project and, in the case of the study of lighting, it can facilitate the appropriate decision-making processing, bringing a new dimension to science teaching and learning (Jackson 2008). This paper gives a case study of the effects of lighting in a residence in Athens. A simple MM presentation via a 3D model with animation has been prepared. The case study reveals: (i) the appropriateness of the MM presentation in a lighting design, (ii) the appropriateness of the MM presentation in teaching lighting in physics classes.

PACS 01.50.-i – Educational aids.
PACS 01.50.F- – Audio and visual aids.

1. – Introduction

Physics and modern computing have been always closely linked (Percus *et al.* 2005). MM applications via 3D models can be used in order to perform simulation of physics problems (Verma 2006) while, in the field of lighting, they can provide direct experience in the computer modeling of physical systems (Koonin 1998). CAD systems that have expanded in the 3D design, photorealism, animation, and the creation of environments of virtual reality, have begun to become part of the process of the study of lighting and of the architectural design (Sanders 1996).

The presentations with the use of simple or interactive MM can be exceptionally impressive and interesting for the spectator because of the 1D, 2D, 3D, or even multiD media and the interactive environment (Papakonstandinou 2004). The presentation of photorealistic depictions of the lighting conditions can provide reliable information on the distribution of natural lighting and the design options of artificial lighting (Dietrich 2006). However, the 3D animation of moving through space constitutes the most impressive element of the MM for architecture and lighting, since it contributes to the more efficient simulation of building, light, and textures (Vaughan 2001).

2. – MM applications in teaching

In the recent years, the use of computers has become a standard part of undergraduate and graduate education in physics (Kinzel & Reents 1997). Computer use helps students simulate natural processes and understand systems, at a level previously possible only in a research environment (Landau *et al.* 2004). 3D models and MM applications are expected to gain significant value as a means of improving teaching lighting, as, in this field, depiction is the most important element of study (Vaughan 2001).

The use of MM applications is observed in sectors, such as architecture and applied engineering (Boardman 2002). In the field of architecture, the use of MM is constantly increasing, since it can improve the presentation a project, and, in the case of the study of lighting, it can facilitate the appropriate decision-making, concerning design (Vaughan 2001). In architectural applications, the MM of indirect access (off line), are mainly used so as to provide the possibility of video projection or animation of 3D photorealistic models, while a better organization and presentation of the subject is achieved (Papakonstandinou 2004).

Photorealism helps create safer estimations for the final image of a space, to effectively compare alternative proposals, to determine the precise natural dimensions, and mainly to transform information into picture. Although no program can accurately reproduce the visual experience created to a person when he/she is inside a building or an open space (Kontorigas 2006), it can give a first impression on how the space appears under specific lighting conditions. Apart from the complicated specialized programs, many types of software function in CAD bases, in order to be with more compatible with architectural design systems (Tripidakis 2008).

In the case of teaching the principles of lighting in physics classes, very little has been done. Therefore, this application can be considered a triggering situation.

3. – Case study

A study in an existing residence was conducted for the presentation of the effects of lighting through MM applications, with a simulation of the interior and the exterior space in a 3D digital model, in which the conditions for natural and artificial lighting were realistically attributed. In specific, changes of depended variables concerning natural light such as luminance and color were observed following the changes of independed variables of light, such as orientation, season, and position of the sun during the day. The effects of manipulations of the depended variables concerning artificial lighting such as luminance, color, and location of the lighting source in the interior and the exterior space of the house, were studied as well. Through this example, the basics of teaching how the principles of lighting can be applied to a working case are presented. For this reason, spaces were photographed under conditions of natural and artificial lighting and photographs were used as backgrounds for the subsequent planning.

The tasks that took place were:

1. Modeling
2. Mapping of textures
3. Applying of lighting
4. Creation of 3D depictions

TABLE I. – *Illuminance measurements at the location of the case study.*

Month	Year	Hour	Minute	Total horizontal illuminance (lux)
4	2008	9	45	61859
4	2008	10	0	65990
4	2008	10	15	71082
4	2008	10	45	81006

5. Creation of animation
6. Creation of video

For the digital study of lighting, the following software was used:

– Modeling: AutoCAD Architecture 2008

– Photorealism-Animation: 3ds Max 2009

– Image Processing: Adobe Photoshop 7.0.1

– Video: Adobe Premier CS3

With regard to the artificial lighting:

1. An effort for rendering the existing facilities of artificial lighting was made.
2. Alternative options of lighting with the use of warm and cold lights were presented.
3. Observations on the already existing installations were made.

For rendering the effects of natural lighting:

1. Values of the intensity of daylight from respective measurements at the National Observatory of Athens (NOA) were used (table I) for the particular day and time at which the photographs were taken (29/4/2008, 9:45 - 10:45 local time).
2. Images of simulation of the daylighting in the building were created for all the seasons of the year using the respective midpoints (table II).
3. The change in light intensity during 24 hours was simulated by creating animation of lighting in an external elevation of the building.

For the presentation of the effects of lighting, photorealistic illustrations and animations were created in the space, which, after proper processing, constituted a complete video of browsing around the space, enriched with sound and titles that could be used as a basic element for the creation of an MM presentation for the study of lighting of the residence.

Table II. – *Mean seasonal levels at Athens (Kambezidis 2008).*

Season	Mean seasonal illuminance level (lux)
Winter	24310
Spring	45630
Summer	52270
Autumn	36940

From the whole study, conclusions were drawn with regard to

– the appropriateness of openings, and

– the choice of the colors of the sources and the horizontal and vertical surfaces.

Moreover,

– a first impression for the adequacy of the natural and the artificial lighting of interior was given,

– examples of alternative options of lighting, coloring, and furnishing were presented for the documentation of the role of digital technology in the study of lighting.

4. – Conclusions

This study proved that MM applications, with the use of 3D photorealistic depictions and animation, can be used as educational tools in teaching lighting in physics and architectural classes.

The design and the study of lighting via 3D digital models and the presentation of the results via MM applications present a number of disadvantages but also advantages, which should be taken into consideration by the architect or the physics student. The demands for hardware and software, the time-consuming procedures of learning the programs and the restrictions on the accuracy of the final product, can constitute a suspending factor for their use. On the other hand, the increasing demands of the job market, in combination with the potential of reducing the working hours, the production of more controlled and also realistic pictures during the phases of design and presentation of the architectural messages in a more complete way, justify the use of MM applications in the field of architectural lighting.

The student or the architect cannot rely only on the results of the digital models, since the study of lighting constitutes a complicated stage of the process of designing, but, through them, it can have an important first impression of the building, so as to better evaluate the results of designing and make the best possible choices. It is obvious that examples of lighting applications in architecture are helpful tools in physics classes concerning the teaching of lighting. The use of MM is expected to prevail during the coming years in education for the teaching of the study of lighting and, therefore, it is expected that the role of interactive MM will be significantly developed, since, in this way, more realistic, but also more impressive representations of the proposed composition can be provided.

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