Education on energy efficient lighting technologies

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Abstract -This paper presents the development of a complete educational structure using advance media technology and facilitating distance-learning techniques, addressing the use of energy efficient lighting in buildings. This result represents the main deliverable of the Synthlight project "Creation of a European Educational Infrastructure on the energy efficient lighting technologies, assisted by 3D synthetic environment", part funded by the European Commission SAVE Program under contract 4.1031/Z/01-123/2001 coordinated by the National and Kapodistrian University of Athens.

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1 Introduction

In the future, to successfully prepare professionals, new forms of experiences should be created and used, such as Virtual Reality. Information infrastructures will provide channels for delivering such technology learning experiences just in time, anyplace and on demand. The specific targets of Synthlight educational structure are the following:

1.To collect, combine and translate the existing technical data, scientific knowledge, industrial and research developments on the characteristics of the energy efficient artificial lighting technologies applied to buildings into an educational package, using synthetic environments (VRML, stereo images etc.)

2.To develop a European Lighting Education Infrastructure (ELEI) which will be offered via a Distance Learning Module. The ELEI will provide channels for delivering technology-intensive learning experiences in anyplace and on-demand. A certification scheme that will be awarded by the participants will be created.

3.To exploit new technologies offered by manufacture today such as Head Mounted Displays (HMD) or Stereo Projectors in the education process and provide the building designers, engineers and operators all the necessary technical and scientific information on the appropriate design, evaluation, selection and implementation of energy efficient lighting techniques for buildings.

4.To offer the building professional all necessary technical and economic information to asses the real potential for energy conservation of the various existing lighting conservation techniques as applied to buildings as well as the associated limitations and restrictions. Thus to assist designers and building professionals to define appropriately energy conservation priorities.

5.To change the conventional education process especially in the lighting field by using extensive "visual" information. The improvements that can be achieved are the following:

- Increased learner motivation.
- Advanced topics mastered
- Trainees acting as experts do

2 Development of the Educational Material

The new training material that was developed consists of a handbook, supplemented by advanced multimedia technologies such as VRML, stereoscopic images and videos and JAVA applets as well as a set of exercises based on the contents

of the handbook. All the developed material can be found on Synthlight WEB site located at the following address:
http://www.learn.londonmet.ac.uk/packages/synthlight/index.html

A) The Handbook
The handbook that was created covers the existing technical data, scientific knowledge, industrial developments, as well as the more recent research development on lighting and the characteristics of the energy efficient lighting technologies applied to building. The handbook is divided in 5 chapters:
Chapter1: Fundamentals (Introduction, photometry, colour, the visual system)
Chapter 2: Daylight (Introduction, Daylight and climate, sense of time, sources, daylight factor, uniformity, site scale design strategies, plan organisation, windows, glazing, outdoor reflected light, Innovative daylight systems, artificial skies)
Chapter 3: Artificial Lighting (Introduction, light sources, luminaries, lighting design, important design criteria, cost)
Chapter 4: Integrating artificial lighting and daylighting (Introduction, lighting control, control strategies, daylighting control strategies, how daylighting control works).
Chapter 5: Case studies (3 case studies carried out by the partners are presented)

B) The visual material
Synthetic environments have great educational potential, especially in learning domains where the acquisition of spatial knowledge is both essential and difficult to teach. One of Synthlight's principal targets was to change the conventional education process especially in the lighting field by using extensive "visual" information. Therefore various types of visual material have been created to help understanding better the topics mentioned in the handbook and thus make the education process more interesting. The following types of visual material have been used:

Stereoscopic Images: A stereoscopic image is created from two sets of pictures, taken from slightly different perspectives. The information is encoded in interlaced format using the right software.

Fig.1 Stereoscopic image

Stereoscopic videos: For a camcorder to view and record in stereoscopic 3-D, it is necessary for the camera to have a "second eye" view of the scene to be recorded. In order to shoot a stereo video, a standard video camera attachment (Nu View adapter), which can encode the stereo information on the cassette, is used. The adapter encodes in different lines pictures from two views separated about 6.5 cm. The NuView adapter uses a proprietary, patent pending process that allows two distinct views (left and right eyes) to enter the single lens of a camcorder, in order to provide a true stereoscopic 3D image to be displayed and/or recorded.

Fig2. Nu View adapter

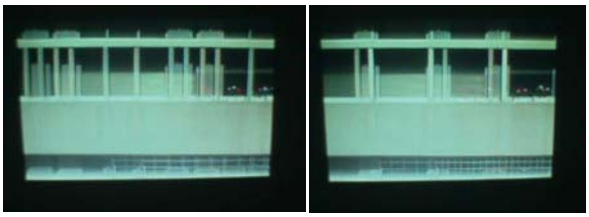

Fig 3.Example of pictures taken with Nu-view

To get the 3D effect, the user will need special shutter goggles. Shutter goggles are small LCD panels mounted in a spectacle frame. When activated by a voltage, they will change from being transparent to being opaque. A controller switches the two panels alternatively, blocking out the left eye while allowing the right one to view the screen, and vice versa. The controller is also plugged between the graphics card of the computer and its monitor. It synchronizes the shutter rate to the refresh rate of the monitor. By setting the screen to interlaced mode and delivering images in an appropriate format, the eye is tricked into believing that the scene has a depth, and the distances between objects can be judged.

Fig. 4: Shutter goggles

Conventional 2D images: are presented as an alternative to interlaced stereoscopic ones for those who don't have the hardware to display 3D images.

Conventional Videos

Panoramas: A panorama could be defined as a picture or series of pictures representing a continuous scene. It displays a segment of a panoramic image, reprojecting the image to have conventional perspective.

VRML: VRML is an abbreviation for Virtual Reality Modeling Language. It's a scene description language that describes the geometry and behaviour of a 3D scene or "world".

Fig.5: VRML

The hardware and software used to develop Synthlight visual material is described in the following table.

	Hardware	Software
Stereo images	Camera, tripod	3D maker
Stereo video	Camcorder, Nu View 3D adapter, A capture card	Capturing software: PixelView Station v.5.19-9xTV/FM
Panorama	Camera, tripod	A stitching software (i.e. Ulead COOL 360), A viewing software: PTVJ_EX (Pano Tools), JAVA
VRML		ViZ software, Open VRML or Cosmoplayer, JAVA
Viewing stereo images	Head Mounted Displays or Wired 3D glasses, NKUA has used i-Art's Eye 3D Premium package, TX4000 Emitter and VGA Dongle from i-Art, CRT monitor, a good graphics card	Eye 3D Driver and Activator

Table 1: Hardware and software used to produce and view Synthlight visual material

C) Exercises

In order to test the knowledge on the contents of the handbook, 15 multiple-choice questions to each of the four main chapters of the SynthLight handbook, excluding the case studies were

designed. To each of the questions, a choice of four possible answers is displayed, one of which is correct.

3 Synthlight European Educational Infrastructure

A European Lighting Education Infrastructure (ELEI) has been created based on the new educational material that was described in the previous paragraph. The ELEI provides information on lighting and the integration of efficient lighting techniques into buildings, using synthetic environments and enhances building professionals to learn across barriers of distance and time. The ELEI can be used as:

- **A database**, which allows people, by using "visualization" tools, to expand their perceptions so that they recognize underlying relationships that should otherwise be swamped in a sea of numbers.
- **A Distance Learning Module**. This infrastructure that has been created and is available on Synthlight web site will provide channels for delivering lighting technology–intensive learning experiences just in time, anyplace and on-demand

More specifically Synthlight educational structure consist of:

a) A permanent **WEB- SITE** that contains all the developed educational material (**http://www.learn.londonmet.ac.uk/packages/synthlight/index.html**). All content can be viewed with any modern web browser on any platform. The site has the same look and functionality on MS Windows and LINUX systems, as well as on an Apple Macintosh computers

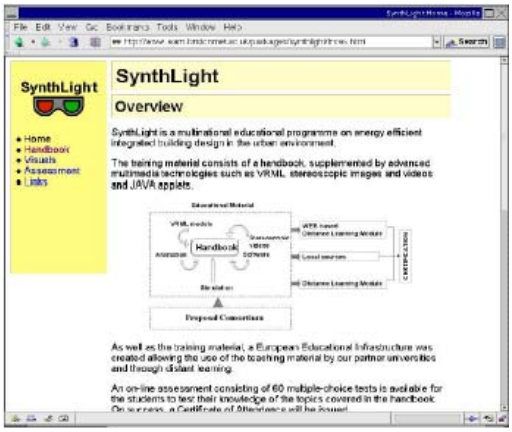

Fig. 6 Synthlight web page

b) **The handbook on Lighting**. Each chapter of the handbook can be downloaded or printed.

c) **The visual material.** For each "visual information" a short description is given and there is a reference of the corresponding paragraph of the handbook. A legend beside each visual indicates the type of the visual information (stereo video, image, VRML etc.) and there is a thumbnail 2D image depicting the visual information for those who do not have the necessary equipment for viewing stereo images/ videos.

d) **Links**. On Synthlight web page the user can find several links regarding lighting, lighting industry, Institutions, software, resources etc for further reference and information.

e) **An on line assessment** with multiple choice questions covering the contents of the handbook. A student passes the test if he/ she answers more than **80%** of the questions correctly

f) **A Certification scheme**: A Certificate of Attendance is attributed via e-mail to the students who manage to pass the on-line test. The process of marking and sending out the Certificates is automated with some software that was specifically developed for this purpose.

This infrastructure is "running" on a WEB server (URL address previously mentioned) or can be used (via CD's) directly from low-end PC's. It is of a permanent nature and will be continuously updated and improved.

The Distant Learning Module (DLE) operation is presented on the following graph:

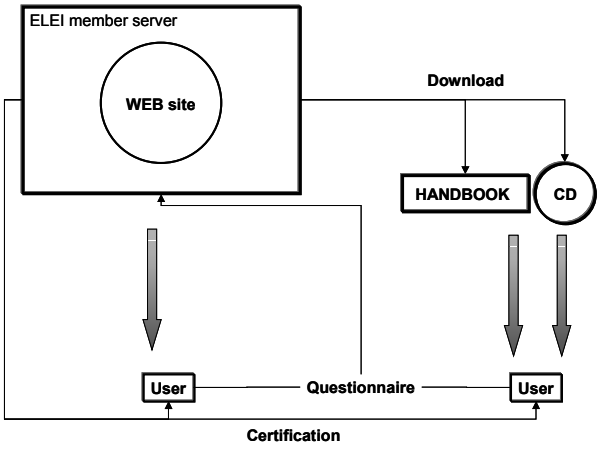

Fig.7: Structure of the Distant Learning Module

The effectiveness of the developed educational material was evaluated by classified experts and students during four pilot seminars, communication via e-mail and test courses that were organized by

the participants of the project at four Universities: a) Department of Applied Physics, National and Kapodistrian University of Athens and the Department of Architecture, University of Thessaly, Greece, b) Department of Architecture, London Metropolitan University, UK c) Lichtakademie, Bartenbach Lichtlabor, Austria, d) Lyon Architectural School, France. In general the outcomes from the evaluation process verify that Synthlight educational infrastructure has achieved its goal in creating a web based distance learning module, giving free access to all the above mentioned information via the Internet to anyone having access to a computer, the Internet, and having motivation to succeed in a "virtual" classroom. Furthermore, Synthlight distance learning module allows students to participate from anywhere in the world, anytime and on demand. It offers maximum flexibility and it is student cantered.

Furthermore, the use of Synthetic environments in the education process was evaluated. Synthetic environments, like VRML, are immerssive and interactive, increasing learner motivation and facilitating understating of advance topics. In theory, it easy to create 3D synthetic worlds with the proper luminance distribution. There are many tools today capable to render accurately 3D scenes. In practice there are some problems:

- Rendering time can be enormous depending on the scene complexity
- The vividness of a synthetic picture relies on small specularities, disturbances and generally speaking with a certain degree of randomness. Although a procedure like Monte Carlo method can produce the above effects these are transferred quite difficult to a VRML scene.
- As humans we need a large field of view in order to achieve immersive experience. This can only be done with projectors, which in turn have high cost.
- Viewing of a 3D scene using 3D goggles can be frustrating after some time because of the flickering of the image.

The overall educational package is addressed to the following target groups:

1. Building professionals and lighting experts (e.g. Building Designers and engineers, Building Physicists, Building managers etc.)
2. The staff and students of Universities and Higher degree schools.
3. Students seeking the basic instructional skills for entry-level positions in industries.

4 Conclusion

This paper presents the development of a European Educational Infrastructure on energy efficient lighting technologies using synthetic environments and other advanced media technologies. Synthlight learning structure is offered to professionals who are in need of continuous education and students seeking the basic instructional skills for entry-level positions in industries but it can also be used as a wayfinding tool and database by building professionals, providing information on how to implement lighting improvement projects as well as references for more specific information. The fact that the course and all the information is available over the Internet free of charge to everybody is the strongest advantage of Synthlight ELEI and it is considered to be a refreshingly new approach to the trend of proprietarising and charging for knowledge and education.

The results of Synthlight project could be applied in the future also in other domains. Potential future applications of the results of SynthLight project include:

- Marketing tools: interactive adaptive displays can be used to demonstrate the use of different lighting fixtures, daylighting systems, shadings, finishes on a building or for walkthroughs.
- Communication tools: The use of 3D synthetic environments and increased use of computers in general could lead to several shifts in communication skills: crossing distance and language barriers between the architect and client or for the education of architects
- Evaluation/ Modelling tools: Improved visualization through the use of VR in architectural practice will clearly help to overcome the limits to "believability" related mainly to display techniques and power requirements
- Modelling/ Design tools: Virtual representation of environments (VR) could revolutionise the process of design, not only because of it's potential value as a communication and visualisation tool, but because it offers a "trial run" in designing lighting schemes.

References

[1] A. Tsangrassoulis, A. Synnefa, M. Santamouris, D. N. Asimakopoulos, Synthlight Final Report, Athens 2004.

[2] Synthlight web page, **http://www.learn.londonmet.ac.uk/packages/synthlight/index.html**

[3] Hedberg, J. and Alexander, S., Virtual reality in education: Defining researchable issues, *Educational Media Internationa*l, Vol.31, 1994, pp. 214-220.

[4] Dion Hoe-Lian Goh, Yin-Leng Theng, Yin Ming, Eng-Kai Suen, Ee-Peng Lim, An Interactive Learning Environment for a Dynamic Educational Digital Library, *Proceedings of WSEAS Multiconference : Information Systems, Decision Support Systems, Internet Computing,* Salzburg, Austria, February 2004.

[5] Chun-yu Chen, Wei-shuo Lo, An Agent e-Learning System for Interactive and Collaborative Communication, *Proceedings of WSEAS Multiconference: Information Systems, Decision Support Systems, Internet Computing,* Salzburg, Austria, February 2004.