INTERACTIVE VIRTUAL MODEL OF BUILDING MANAGEMENT CONTROL: THE LIGHTING SYSTEM

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ABSTRACT

A virtual model to support decision-making in the planning of construction maintenance was developed. It gives the capacity to transmit, visually and interactively, information related to the physical behaviour of materials of the components of a building, defined as a function of the time variable. The model helps to identify needs related to the lighting equipment of a building, namely, the cost involved in lamp replacement and control of stock, warnings of the need for periodic inspections and minimization of times when broken bulbs are left in place.

INTRODUCTION

Virtual Reality (VR) is a technology that allows users to explore and manipulate, in real time, computer-generated 3D interactive environment. This technology offers advantages such as: representational fidelity with a high degree of realism caused by the rendering capacity for objects; the ability to look at objects from different viewpoints, and the ability to pick up, examine and modify components within the virtual world; the feeling of presence or immersion, as a consequence of the realism of the images and a high degree of interaction. It makes the VR environment motivating and engaging by giving the users the possibility to be part of the world, and by allowing them to focus entirely on the task in hand.

VR is also seen today as an integrating technology, with great potential for communication between project participants, and most recently, as a tool for the support of decision-making, made possible by the integration of specific computer applications in the virtual model (Khanzode, Fisher and Reed, 2007).

The main aim of a research project, which is now in progress at the Department of Civil Engineering of the Technical University of Lisbon, is to develop virtual models as tools to support decision-making in the planning of construction management and maintenance (Sampaio and Gomes, 2008). The virtual models give the capacity to transmit, visually and interactively, information related to the physical behaviour of materials, components of given infrastructures, defined as a function of the time variable.

In this context, the research project presents the development of a VR application, involving knowledge of the physical aspects of materials, particularly those which have a short-term function. This knowledge includes their use and environmental factors, and the application integrates these items into digital spatial representations. In this way, the indisputable advantage of the ease of interpretation and perception of space provided by the visualization of 3D models, and of the technical content underlying the real characteristics of the observed elements are brought together. The interactive application allows decisions to be made on conception options in the definition of plans for maintenance and management.

Until now, several elements have been studied and implemented in the same virtual application. The present model includes exterior closure of walls and façades; now in progress is the implementation of the floor element. The characteristics of different surfaces materials have been implemented as have some strategies of maintenance and rehabilitation for these construction elements of a building. The goal is to generate a model that can analyse, from a management perspective, the most important components of the building, a model which must be interactive.

THE VIRTUAL LIGHTING PROTOTYPE

The first component of the virtual prototype concerns the management of lamps in a lighting system. In addition, the analysis of solutions for substitution and inherent cost are predicted, the results being obtained interactively and shown in the virtual environment itself. A first study was made and reported in (Sampaio, Ferreira and Rosário, 2009). Further developments are described in this paper.

Effective integration of advanced visualization capacities is incorporated into the interactive simulation system. The present project integrates a VR system and a computer application implemented in Visual Basic (VB) language. The scholarship holders involved, in this work, are 5th year students of Civil Engineering, who had, therefore, to learn advanced software of geometric modelling and visualization and to explore the capacities of a RV technology system, the EON Studio (EON, 2009). They had to devise a research bibliography regarding lamp devices usually applied in a building and they also had to develop their programming skills in order to be able to successfully integrate the elements needed in the creation of a virtual lighting system.

The characteristics of different types of bulbs were collated in order to create a database. An adequate database structure had to be implemented, integrating different types of information, needed to create an efficient and accurate virtual model. The VR model links the 3D objects of the model to this database. The database concerns the lighting system management within a collaborative virtual environment and the respective technical data associated with each component of the model is an integral part of the application, allowing the consultation of required data at any point in time.

The database

The visualization of information related to lamps requires an understanding of the essential characteristics of those elements and of the planning strategy of lighting system maintenance. The lighting VR model must support the following essential aspects:

- The system must include a database containing the characteristics of bulb types, with wattage and the corresponding compatibility. These data are important parameters in the drawing up of management schemes. The data base must also include an image of each type of bulb (Figure 1);

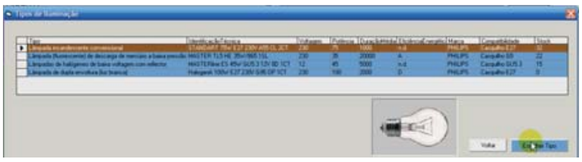
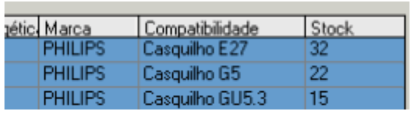


Figure 1. Details of the database of the model.

- A lamp is a replaceable component in a building. As the light source has a discrete lifestyle the VR system must incorporate the control of bulb stock (Figure 2). The model must include alerts for periodic local inspections of the actual state of each bulb in the building. After inspection, there is an automatic process in which, the compatibility of the socket of each broken bulb can be checked on the database, the element replaced, the installation date and the lighting stock updated;

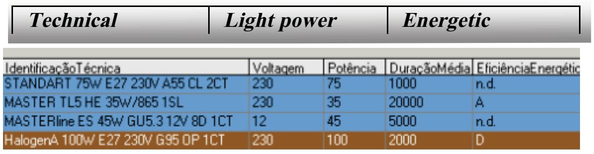
Company | *Compatibility* | *Stock*



Marca	Compatibilidade	Stock
PHILIPS	Casquilho E27	32
PHILIPS	Casquilho G5	22
PHILIPS	Casquilho GU5.3	15

Figure 2. Compatibility and stock of bulbs.

- The database has other characteristics relating to, light power, energy efficiency and lighting intensity of each bulb type. Based on these parameters the model can calculate the luminosity in a room or analyse the energy efficiency of the whole building (Figure 3).



Technical IdentificaçãoTécnica	*Light power* Voltagem	Potência	DuraçãoMédia	*Energetic* EficiênciaEnergétic
STANDART 75W E27 230V A55 CL 2CT	230	75	1000	n.d.
MASTER TL5 HE 35W/865 1SL	230	35	20000	A
MASTERline ES 45W GU5.3 12V 8D 1CT	12	45	5000	n.d.
HalogenA 100W E27 230V G95 OP 1CT	230	100	2000	D

Figure 3. Some characteristics of bulbs.

- The system must calculate as a function of the time parameter the predicted functional life-time of lamps or the time remaining to the next planed inspection. The database therefore, must include for each bulb the installation date, the statistics for its average lifetime, the average number of hours of its predicted functionality and the next periodic inspection date (Figure 4).

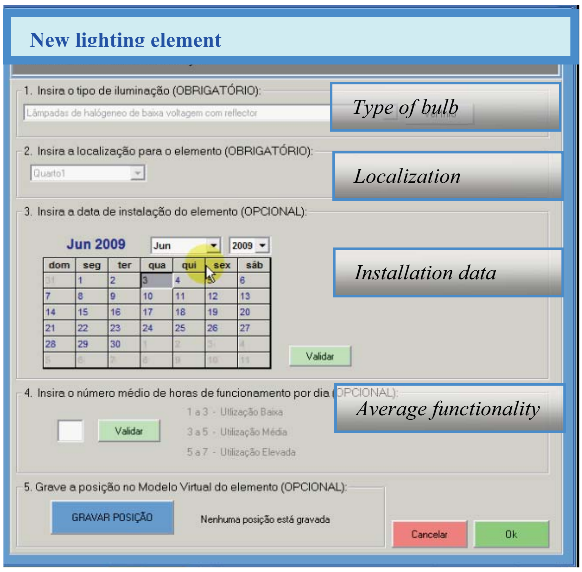


Figure 4. Interface used to specify data values.

The 3D geometric model

A 3D geometric model of a building was created. The building consists of a ground-floor, a 1st floor and an attic allocated as living space. The model was generated based on architectural design drawings: plans, vertical views and vertical sections (Figure 5).

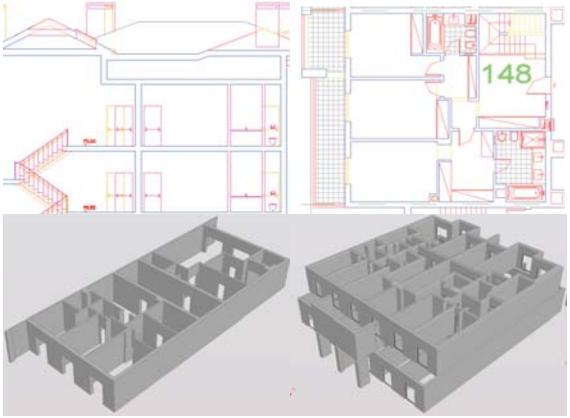


Figure 5. 3D model of the building.

Some lighting equipment considered in the building was also modelled and incorporated into the 3D model (Figure 6). The 3D model was created as 3ds file and exported to EON studio.

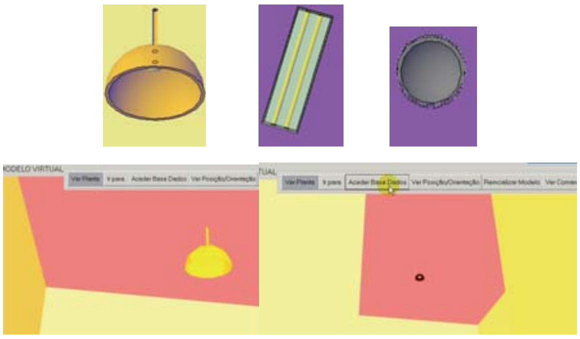


Figure 6. 3D models of lamp devices.

The interface

The process of developing the prototype interface considers the purposes of defining an interactive environment. Human perceptual and cognitive capabilities were taken into account when designing this visualization tool. It uses an interactive 3D visualization system based on the selection of elements directly within the virtual 3D world. The model enables users to pick up lighting elements, associate values to them and modify characteristics within the virtual world, which makes it easy to use.

First, the lamp is identified as a new element and a bulb is associated to it, together with all information on the chosen bulb included in the database. At this point, the lamp is properly identified as a monitored element. For each element the model allows the determination:

- Of the predicted break-time for the bulb based on the installation data and the statistic period of lifetime for that type of bulb;
- Of the temporal data for a specific date of interaction with the model, such as the time remaining to the predicted break-time or the percentage of use (Figure 7).

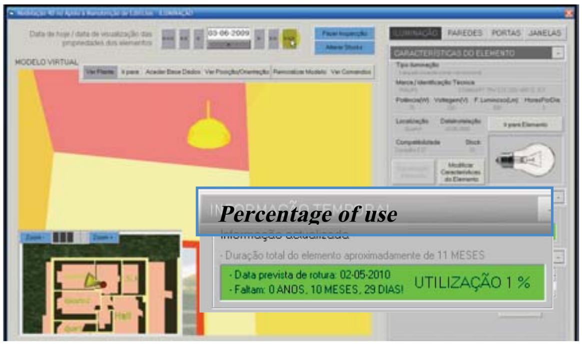


Figure 7. Temporal data.

The percentage of use changes with the date when the model is used. The colour in the interface that shows this information changes accordingly, from green (less then 20%) to red (near 100%). Figure 8 illustrate this capacity of the model. When 100% of use is reached an alert message (in red) is shown on the interface.

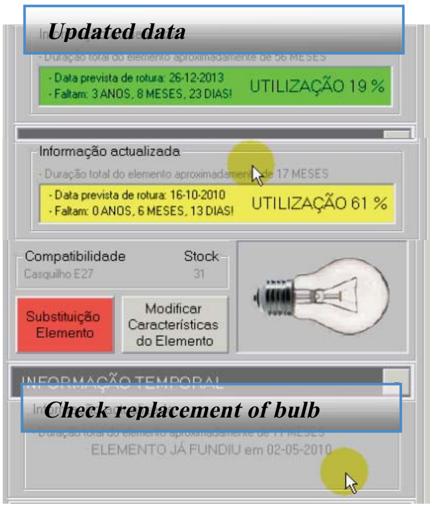


Figure 8. Colours associated to percentage of use

EXPECTED BENEFITS

The virtual model of lighting management can support analyses of preventive maintenance, the application in larger building and the study of the effects of lighting intensity.

Preventive maintenance

All elements of the model must be identified. After that, the model searches by specific characteristics: location within the building (room, kitchen), technical identification (incandescent, halogen), wattage or energetic efficiency.

As a strategy of preventive maintenance the light bulbs could be replaced when the time of useful life is nearing its end. In this way, the non-functional period of the lamp left in place can be minimized. The model can list the elements of the building by predicted break-date order. Figure 9 shows a search by predicted break-date.

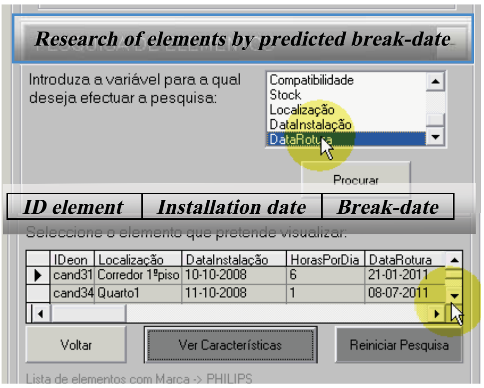


Figure 9. List of elements ordered by break-date.

Variation of lighting intensity

The VR model allows the control of the lighting intensity of each bulb in a room environment. The EON system allows the redefinition of colour obtained by an algorithm of calculation defined as a function of the value of intensity associated with each type of light bulb. A colour is defined as a set of values: R (red), G (green) and B (blue). The algorithm determines a value for each primary colour, defining in this way the colour of the surfaces of the elements in a room. Figure 10 illustrates different colours controlled by RGB values. This capacity allows the luminosity of a room to be analysed.

Figure 10. Intensity of the light bulb related to the degree of luminosity

Management support on buildings of great dimensions

The application of the VR prototype in buildings of great dimensions, such as hospitals or schools brings benefits since it can support the control of stocks and the management of periodic inspections. Only the 3D geometric model needs to be defined and then this prototype can be automatically incorporated over it, resulting in a virtual model which allows the management of a great amount of elements concerning the lighting system. The 3D geometric model is usually created by an architect. The link between the 3D model and the management prototype is defined in exactly the same way as the model presented in this paper was.

Because the model has a user-friendly interface it can be used by any manager, who can interact with the model in order to select elements from the building and update the associated information. The system supports the management of stocks for each type of bulb and alerts to the planning of local visits. Additionally, each lamp can be monitored remotely. For that a sensor must be fixed to each real lamp and connected to the virtual model. In this way any anomaly (deficient functionality or rupture) is transmitted to the virtual model, and the manager is alerted to the occurrence. In a building with large quantity of elements to be monitored the developed prototype is an important support in management.

CONCLUSIONS

A virtual model concerning the management of the lighting system of a building was defined. The presented example concerns only one type of element, the illumination devices, but it was found to be efficient in the identification of elements, in the promotion of alerts of inspection and in the management of stock, all activities related to the maintenance and management of a building. The benefits of using the model are identified as: preventive maintenance, application in large buildings and control of the lighting intensity effect over the wall surface.

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