A Multimedia Application to Support Professionals in an Environmentally Responsible Building Design Process

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ABSTRACT

One of the problems faced by the design professionals in trying to incorporate thermal and acoustic concerns when designing a building is the quantity and diversity of building materials that can be applied to improve a poor indoor environment and, in many cases, to later reduce energy consumption. The large amount of information on building materials usually provided as documents makes it almost impossible to the designer to compare products. In the light of the stated facts, the objective of this work was the development of a multimedia application, which was thought as a module of a more comprehensive system able to support professionals in an environmentally responsible building design process. The application takes advantage of the ability of computers to handle texts, images, sounds and movies to introduce several building materials and their characteristics to the designers, in an interactive way. The conclusion of this stage shows that rather than being a module of a larger system, the developed application can work as a powerful standalone multimedia catalogue of building materials that have special interest on thermal, acoustic, and thermal-acoustic applications. It is an application that are not only fundamental in a support system for effective building design, but also a powerful tool for training architecture students as part of an environmentally responsible building design process.

1 INTRODUCTION

There is nowadays a growing worldwide conscience that aesthetic attributes, building materials, and the overall building performance of any single house can be responsible in the long run for large-scale impacts on the global environment. In addition, the performance of the buildings in terms of internal comfort (thermal and acoustic) can also affect the quality of the activities and the health of those who work or live there. Because of it, there is a need of environmental standards at the building level to guide architects and engineers in an environmentally responsible design process. Even though those standards are already present in some developed countries, they are still rare in developing countries, such as Brazil.

In some developed countries one can already find instruments to raise the awareness of environmental issues not only of designers and architects but also of the building users. That is very important due to the fact that building users themselves are usually not conscious of the hazard effects of buildings on the environment. In any case, decision support systems can become important tools able to reach both professionals and building users, because they can provide a greater understanding of the way buildings affect the environment over time. By compression of time and simulation of the future those tools can help on the selection of the right decisions, acting as effective decision-making instruments that can help on planning environmentally conscious cities through, among other things, energy-efficient buildings. That is, for instance, the case of a multimedia application developed as a tool for educational purposes regarding sustainable buildings (Schmid, Schmid and van Uden 2000). The work of (Bignon, Halin and Nakapan 2000) is another example of the current trend in developed countries, in which there is a great emphasis on decision-making by using computers interactively. In their work they presented a method to extract images from web sites of French building product companies and to use them in an interactive and progressive image retrieval process.

In developing countries, on the other hand, the picture is quite different. Since most computational simulation and interactive tools are supposed to work based on reliable databases about the infrastructure of buildings and cities, which for developing countries is not often available, those tools are rare and limited. Thus, in the case of the issue of an environmentally responsible building design, one of the first challengers a designer deals with in Brazil is the amount and diversity of building materials, in addition to the poor set of technical information readily available about them. Considering that buildings are supposed to provide comfort to users and that sometimes this is not achieved without the use of specific materials to improve the indoor environment, therefore ensuring thermal and acoustics comfort, one of the first challenges faced by the designers in Brazil is the knowledge of the building materials available in the market. This information is often available in a document format that sometimes is just a brochure for marketing purposes. In that case, the lack of accurate technical information can make the evaluation and comparison of the thermal and acoustic performances of those building materials difficult to the designer.

These facts call attention to the urgent need for developing tools that can provide prompt information for professionals and even for common users about the existing building materials and their attributes. With regard to the particular aspect of the indoor environment, this kind of tool can help in the construction of an efficient decision-making instrument able to support an environmentally responsible building design process that is so much needed in developing countries. This is precisely the objective of a long-term research project carried out by our interdisciplinary group, whose effort is partially described in this paper.

The project does not ignore, however, that many computer packages for simulating thermal and acoustics performance of buildings are already available in

Brazil. Nevertheless, in most cases their libraries are unfortunately based on data of building materials from different countries. This either limits their use in the Brazilian reality or makes designers (and students) apply materials other than those available in the region. Therefore, the aim of the current paper is twofold. First, it briefly introduces the entire structure of the decision support system under development, which is being intended to support professionals in an environmentally responsible building design process. Next, it focuses on a multimedia application that was conceived as a module of the more comprehensive system. Considering that nature of the target system, this module is a tool designed to put together technical information about building materials available in Brazil that can be used for thermal, acoustics and thermal-acoustics treatments of the buildings. By this means allowing its future integration into computer software that simulates environmental performance of buildings. Those two aspects are discussed in item 2, in which the entire structure of the decision support system under development is introduced at first. It is followed by an item with the identification of the materials considered on the particular module that contains a multimedia catalogue, as well as its structure and the modeling approach used to build it. The paper ends with some concluding remarks, followed by the references.

2 DEVELOPING A DECISION SUPPORT SYSTEM

In order to better understand the nature of the tool that is under development, it is important to know how we have defined a Support System for the purpose of the current project. There are several different ways to define a Decision Support System, for instance, such as the one stated bellow, which shows it as having three distinguishing features:

> *"First, in addition to the information management capability of any information system, a DSS will support the decision maker in solving ill-defined problems. That is it will support the exploration of the various branches of a decision tree, for example allowing the decision maker to pose a series of 'what-if?' questions. Second it will normally support a high level language, which gives a friendly and powerful interface for the expression of problems. Third, it typically will incorporate analytical models, which allow the generation of complex information products. "* (Bracken and Webster 1990 p. 28)

This definition, as many others, applies basically to an active decision support (Hirschberg 1994), in contrast to what he called a passive decision support. While our global project shall lead to a comprehensive tool able to help the user finding a good solution, therefore characterized as an active decision support, the module now under completion does not have alone the same characteristic. The role played by this module can be seen in figure 1, where the entire system under development is briefly summarized.

The entire system was designed as follows. In its first stage (Module A) the user is involved mainly in design activities, making intensive use of CADD, as commonly found in many other design support systems. For the early design stages, there are even other tools, developed within and outside the architectural design discipline (see Segers et al. 2000). Next, once any initial design is proposed, the architect or designer is supposed to look for building materials that meet the project (or client) requirements in Module B. That is the stage in which most our research efforts have been concentrated until now. The problem here is not simply to list the building materials available in the market, but to make explicit some of the main features that can bring consequences to the building in terms of performance, in the two aspects presented as subdivisions of Module C in figure 1.

The focus here was the development of Module B. In order to do so, we have created what can be called a catalogue-based hypermedia tool, which was at first designed as a tool that could be directly assessed as an independent application simply by running it in an environment for Internet navigation. In that sense, the idea is somehow similar to what has been proposed in France (Halin, Bignon and Humbert 1999 and Bignon, Halin and Nakapan 2000). The difference from their concept and our view is the fact that their system was mainly a system for searching building materials based on images. In our case, we have made extensive use of images of the products and also added other features, like sound and texts with technical information, in a non-linear, hypermedia structure. In the entire system, the idea is to integrate Module B with both Modules A and C, but with a stronger connection to the later, in order to make the information retrieved from it as an input for evaluating the building performance.

Based on information extracted from Module B, the evaluation conducted in Module C can take into account two aspects: financial and environmental costs. There are many computational tools already available to perform parts of those evaluations, for instance, to the analysis and simulation of indoor climate (den Hartog, Koutamanis and Luscuere 2000); not to mention dedicated software available as commercial products. Even in Brazil one can find dedicated software that can be used in the last Module of the system, created mainly with academic purposes.

While the top-down arrows of figure 1 indicate the sequence discussed above, the whole system must allow feedback flows, as those represented on the left side bottom-up arrows, otherwise it becomes meaningless. The system is not supposed to end with those three modules, since there are other aspects that may interfere in the design process. One such a case comes from the restrictions imposed by building codes and regulations, which could be added to the system as well. In that particular case, this may be not easy to add to the system, considering that any city can have a different set of regulations. This raises an important point regarding the purpose of the system.

On one hand, the system should be able to include several possible design limitations.

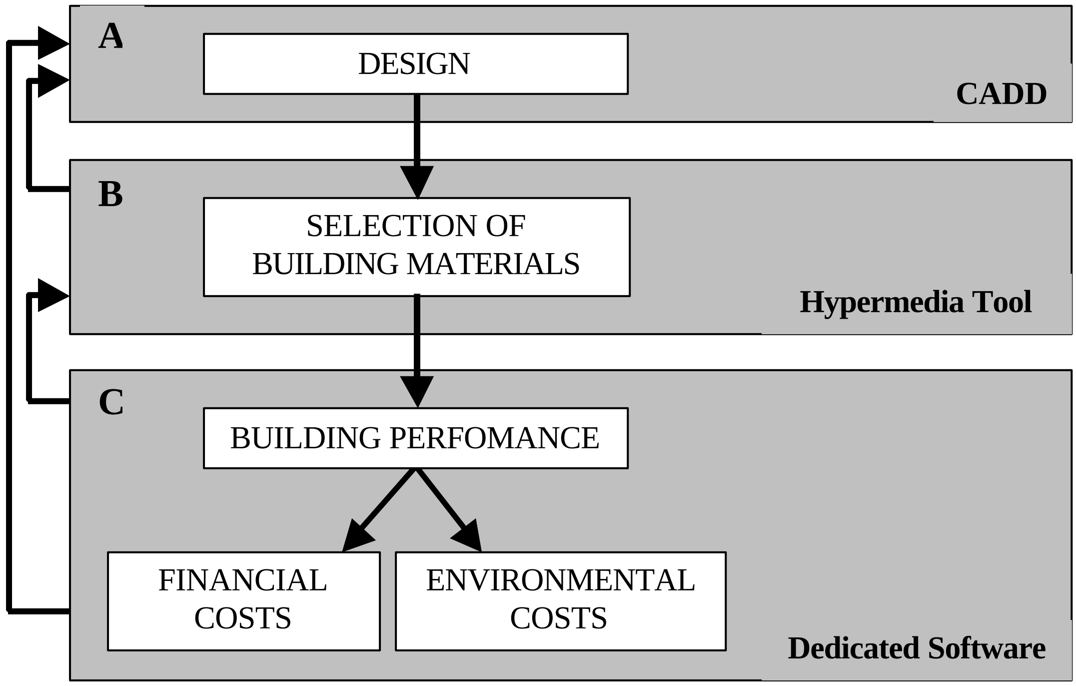

Figure 1: **Overview of the entire support system under development**

In order to do so, an object-oriented approach with multiple expert agents would be more adequate (Pohl, Chapman and Pohl 2000). The counterpoint, however, is that even considering the benefits of a more comprehensive approach, a more complex system is not really the case for developing countries, due to the several limitations currently found in terms of human resources. First, the designers have to get used to this kind of tool. Two strategies may be useful for that purpose: to find the point that allows for an optimal trade-off between simplicity and efficiency of the system, and to start training future architects, who are still students at the university, with this kind of tool. Both aspects were kept in mind while developing the current system.

2.1 **Identifying the building materials for the catalogue**

The catalogue-based hypermedia tool here presented, which is the core of Module B, should allow access to particular information about selected building materials.

The building materials here considered are those that are particularly important to ensure comfort in the indoor environment, and usually produced with that specific purpose. Due to the high variety of materials offered by building products companies as options to increase users comfort, the materials here selected were classified into thermal, acoustical and thermal-acoustics by (Souza 2001) according to their performance features, as detailed in the following sections. That classification has been chosen in order to meet the needs of the largest system.

2.1.1 *Acoustical Materials*

Acoustical performance is an architectural matter, both in urban and in indoor environment, either in order to reduce noise influences or to ensure sound propagation quality. A building should act as an element that isolates sounds from in and outdoor spaces, while allowing the sound quality mainly of the indoor environment.

Materials may absorb, transfer or reflect sounds, influencing their surrounding acoustical environment. As the materials may have very different acoustical characteristics, they belong to different classes and therefore they were here classified into absorbents, insulators or reflectors.

2.1.2 *Thermal Materials*

Not only the site characteristics influences the thermal performance of buildings, but also the partitions thermal characteristics themselves. In tropical areas, like in Brazil, the biggest problems of thermal performance are related to high temperatures and high humidity. Hence heat and moisture gains are the most important aspects to be taken into account in a thermal comfort architecture concept.

Each building element, i.e., ceiling, walls, floor, is constituted by materials that influence heat and moisture transfer. Materials with special regard to these features were classified here into thermal insulators and moisture insulators.

2.1.3 *Thermal-Acoustics Materials*

Users comfort needs, both thermal and acoustics, occur simultaneously in a building. Sometimes materials may have characteristics that cover both requirements, thus called thermal-acoustics materials. They are usually able to insulate at the same time thermal heat and sound waves or they might also offer just thermal insulation but act as an acoustic absorbent as well. For those materials the classification suggested here was: thermal-acoustical insulators and thermal-insulators but acoustic absorbents.

2.2 **Module B: Structure**

According to the classifications presented in section 2.1, the tree-like diagram of figure 2 shows the catalogue organization, which is the module B structure.

The dotted squares of figure 2 represent materials on the catalogue. The specification of each material accessed is presented to the user by the following items: classification; name; company; product description; advantages, acoustical, thermal or thermal-acoustics characteristics; appearance of the product; recommended application, application system, and others.

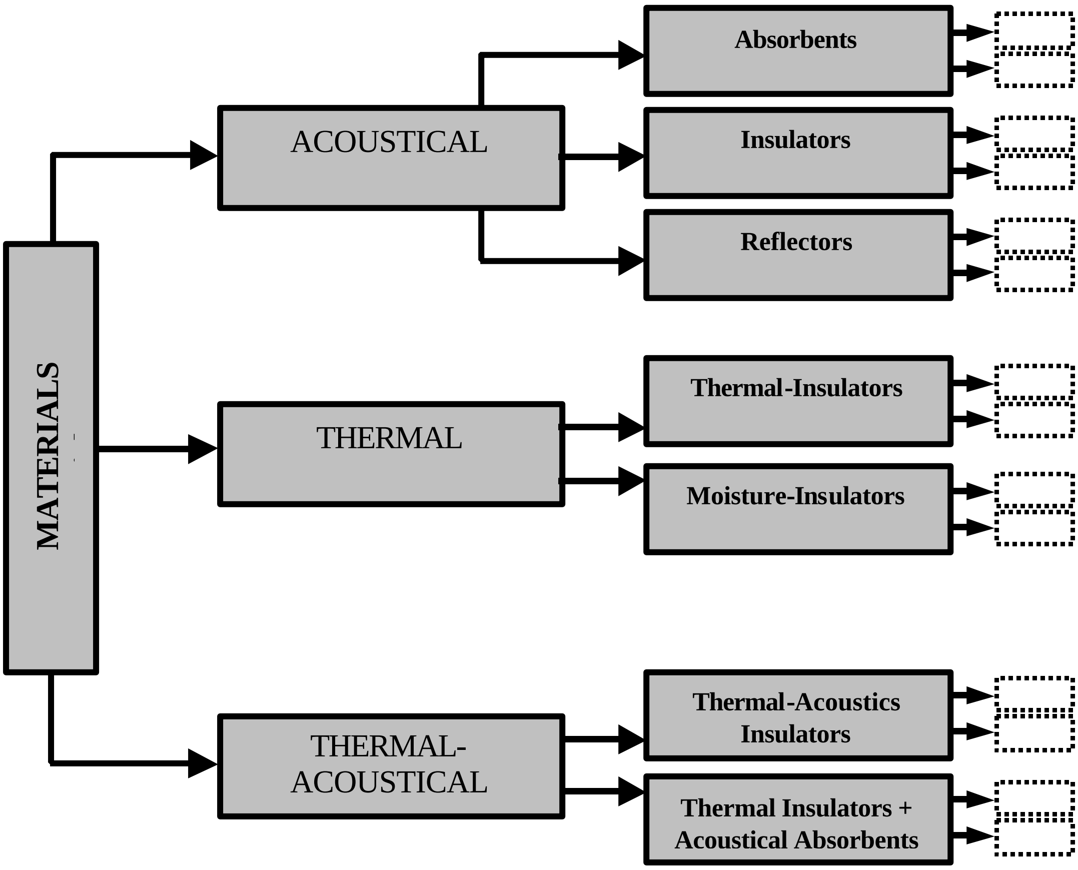

Figure 2: **Structure of the catalogue**

2.3 **Module B: Modeling Approach**

The opening page of the catalogue displays a brief informative text and links to the three categories of materials that are relevant to the indoor comfort of any building under design: acoustical, thermal and thermal-acoustic. Those links lead to pages also containing informative texts about any particular class and several other links that connect the user to subdivisions of the classification (as in figure 2). As detailed in section 2.1, those subdivisions are, in the case of acoustical materials: absorbents, insulators, and reflectors. For the second category, the materials can be thermal and moisture insulators. Finally, thermal-acoustical materials are classified either as thermal-acoustics insulators or as thermal insulators and acoustical absorbents. In any case, those second level pages link the user directly down to the next level of the classification of the materials.

When the user finally gets to the product he or she is looking for, there is one part of the information promptly available in three ways: text, image, and sound. The sounds are basically narratives of the texts available on every screen with the kind of information summarized in table 1.

What is not visible to the user, though, is a set of technical information stored in a library containing relevant variables to "feed" the dedicated software of Module C (when available). As Module C is not implemented, the link from Module B to Module C is obviously not yet operational. When that becomes the case, any time a product is selected on Module B its output information could be directed to an application of Module C as an input. As one could expect, all pages of Module B also contain the usual navigation and search tools available in most multimedia applications (as shown, for instance, in the work of (Halin, Bignon, and Humbert, 1999).

Due to the characteristics of the desired structure, an OOHDM (Objected-Oriented Hypermedia Design Model) approach has been applied in the development of Module B. The steps of development, which will be not be discussed in details here, were: *i*) definition of the conceptual model, *ii*) navigational model, *iii*) user interface definition, and *iv*) implementation. The materials were grouped in classes according to their attributes, in order to accomplish the first stage, resulting thereafter in the divisions and subdivisions already mentioned. Next, after the definition of the classes, their relationships were also established in that stage. The navigational model came next, with the definition of links that match the relationships found in the previous step. After the design of the user interfaces, the implementation was done making use of the following languages: eXtensible Markup Language – XML, eXtensible Style Language – XSL e XML Schema (Marchal 2000 and Spencer 2000).

Table 1: **Data available in material screen containing its specification**

Classification:	Identification of the specific feature of the material, i.e., acoustical absorbents, acoustical insulators or acoustical reflectors, thermal-insulators or moisture insulators, thermal-acoustics insulators or thermal insulators and acoustics absorbents.
Name:	Commercial or brand name of the product.
Company:	Name of the supplier (manufacturer or vendor) of the product.
Product description:	Description of the product and its component materials.
Advantages:	Main characteristics that can be emphasized on the product.
Acoustical or Thermal Characteristics:	Values of technical indexes that quantify some relevant acoustical or/and thermal characteristics, sometimes depicted as charts and diagrams.
Appearance:	Picture showing the appearance of the material
Application:	Use recommended by the manufacturer.
Application system:	Picture showing the steps of the specific application system recommended by the manufacturer
Other characteristics:	Some other characteristics that could be relevant to the user

3 CONCLUSIONS

Until now the tests conducted with Module B of the system here proposed have shown that it seems to be a useful tool, particularly for students of architecture who place emphasis on the quality of the indoor environment and users comfort concepts. The information contained on the catalogue already allows the knowledge of some important features of the listed materials, making easier their selection and further application on buildings design. The multimedia CD-ROM produced is an attractive tool, which organizes technical information and makes them readily available in a short period of time.

The whole decision support system that contains Module A, B and C is still under development as an open structure, to which other functions can be added, allowing large interactivity for design decisions. Yet in Module B, for instance, the insertion of videos, showing the way one can handle any particular material, could be also a future application on this catalogue, making it even more interesting and useful for practical applications. Regarding the development of the entire system, the next steps shall be the selection of dedicated software for module C and the development of the interface between modules B and C. That interface may still require some work in the output information generated in Module B, especially in that kind of information that is not really visible to the final users but that is essential to run simulation software.

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