DEVELOPMENT OF A SOFTWARE TOOL FOR APPLICATION OF CAD3D-BIM TECHNOLOGY IN FURNITURE INDUSTRY

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Abstract. *The BIM (Building Information Modeling) is an approach used to facilitate the creation and manipulation of information linked to a digital model of building, allowing the simulation of the construction project in a virtual environment. This model integrates information from the geometry, spatial relationships, in addition to the quantities and properties of materials and components used in the project, connecting all information necessary for building, measuring and constructive analysis throughout the project life cycle to design elements. So it is possible to obtain cost sheets quickly and accurately, showing new values with greater agility when changes are made. Another advantage is the automatic propagation of changes made in one part of the project in other parts, ensuring a better integration between the project participants. This occurs because of the centralization of existing information in a single database, so changes in one model will be replicated automatically to all objects that use this model. The automatic update of the changes is one of the concepts of CAD3D-BIM. The main objective of this work is to develop a software tool for Google SketchUp software, adding new features to the program to support the concepts of CAD3D-BIM technology. The software was developed using the Ruby programming language with the API available to developers. For the storage and retrieval of information was used a MYSQL database, accessed via Javascript instructions, allowing the manipulation of data inside the SketchUp environment. The software creates a new menu where each designed model is classified as one of the previously defined categories and these categories are organized hierarchically, according to the concepts of Group Technology. Thus, the construction of a new object is made by importing the elements of others categories that will be part of this object. The reuse is another concept of the CAD3D-BIM. An important feature is to have various information associated with each model, not only geometric information but also others relevant information (metadata) such as manufacturer name, coating material, unit cost, color, allowing the generation of reports quickly and efficiently. The metadata is stored in the database and are loaded with the model for the SketchUp's environment during the import. The use of the tool software speeds development of projects, because it isn't necessary redraw the components, and the centralization of information allows multiple users to share the same database, providing a collaborative development. The reports can be used in all life cycle of project, serving in decision-making, because the detailed analysis of the report can help to identify where changes can be made.*

Keywords*: CAD3D-BIM, building projects, group technology*

1. INTRODUCTION

The use of computing in the development of construction projects started around 1980 and revolutionized the creative process, design and conception of space. In 1982 programming codes were inserted into calculators to develop a 3D design of a nuclear power plant in Hungary. With the improvement of the program, the company that owns the system began to serve architects, because applications from other software development companies in need of very powerful computers (Frank, 2008). At that time the term CAD (Computer Aided Design) was created to represent the technology. CAD systems are meant to assist the creation and manipulation of information and knowledge that should be under the engineer, showing the design data and providing the information reuse (Kerry, 1997).

Scheer et al (2007) say that CAD technology is the most important innovation of the last 40 years. They identified three distinct generations in the evolution of computer use in construction: the first is the computer-aided design, the second is the geometric modeling and, finally, product modeling. With the many economic changes, globalization of markets and increasing pressures on companies in the late 1970s, the concept of product modeling is gaining strength. This field of study covers everything that is related to any activity between design and final product. The product modeling was created to integrate two sets of information in all processes of the life cycle of a product: geometric information design (shapes, positions, sizes) with non-geometric information (costs, weights, resistance). The union of this information combined with a new collaborative approach throughout the development project creates a new technology, known as BIM (Building Information Modeling).

BIM can be defined as a tool used by design industry to develop and document a project, and provide better communication between all participants (KRYGIEL, 2008). Similar to product modeling, BIM includes concepts, activities, techniques, tools and actors included in complex relationships and spread over all activities related to the building industry (AYRES, 2009). The development through constant feedback is a fundamental characteristic of BIM.

The project is composed of different groups of people, so all modifications and enhancements are automatically processed in the all sheets of the building, allowing a significant increase in the quality of communication and consequently on the quality of the final product (Souza et al, 2009; KYMMELL, 2008). This approach allows the simulation of a construction project in a virtual environment through computational tools, where is possible execute experiments, modifications and identify errors before the real project upgrade. Errors in a virtual environment do not generate major problems when they are identified early in the process and different aspects of the project are addressed before finalizing the instructions for the actual construction.

2. METHODOLOGICAL APPROACH

The furniture industry in the state of Rio Grande do Norte is one sector still using the traditional process of manufacturing furniture, with little or no automation. How this sector consists of small manufacturers, this market segment cannot afford to purchase software that can improve the performance of the processes involved in this activity (CARVALHO, 2010). Therefore, the aim of this work was to develop a software tool to improve greater integration between the processes of designing and manufacturing of modular furniture. This software has a *plugin* for the SketchUp environment and a web-based system. The development of the Web system passes through processes of software engineering. The structure is shown in Fig. 1.
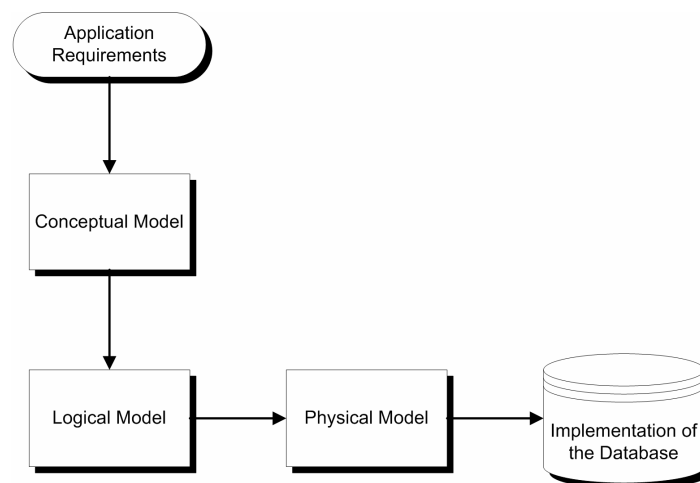

Figure 1. Development phases of a Web system

Originally the first step is the conceptual model to determine which data to be stored. At this point requirements analysis are made using documents with specifications provided by some manufacturers for identify all objects in the real world and their interrelationship. With these results is developed a database to allow creation of model's collections to modular furniture. The second step is the logic model that aims to specify how the data will be represented computationally, a breakdown of how individual information will be stored in the system. The last step is the physical model which is the implementation of previous models in computer system engineering. From the physical model we determine the architecture and technologies involved. With this interface the information about these components can be registered to a simple way. After registration of a new component, the user can draw the corresponding model in SketchUp's environment and save this model, using the option available in the main menu provided by plugin. Then a link is made between the information registered in the database and the drawn model, which will be storage like a *skp* file. When a component is imported through the import option of the plugin, so its geometric model and the information related to this component that were registered in the database are loaded to the SketchUp's environment. This process is illustrated in the Fig. 2.
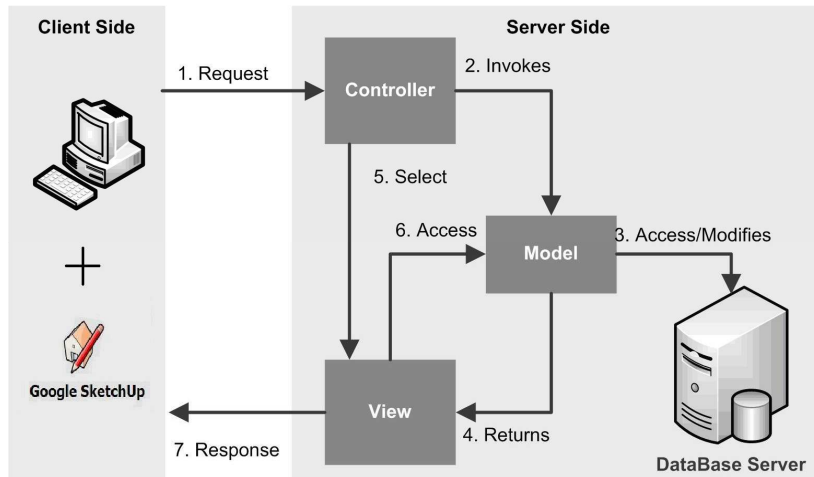
Figure 2 – Diagram of MVC Architecture applied as a pattern to the system.

3. DEVELOPMENT

To build the database and maintain a link between the various components used in assembling modular furniture was necessary to classify these elements and define a hierarchy between these classes. This thinking is based on a technological approach call Group Technology. This technology takes advantage of the similarity between design and manufacturing process of distinct components, through classification and coding of similar parts. The use of Group Technology can achieve greater standardization of the components of a product, and avoid duplication of parts. The information about the development of design and manufacturing process are stored in the database, allowing less experienced users to retrieve this information by taking advantage of previous experiences. Observing the processes of design and manufacturing has been defined two basic entities because they are not assembled by the manufacturer, but acquired from its suppliers or these elements are indivisible. These entities were called parts and accessories. For example, a doorknob is classified as accessory while a piece of wood that make up the side of a cabinet is classified as a part. A product composed of one or more accessories or parts is classified as group and a product composed of one or more accessories, parts or groups is classified as a module. These relationships are shown in Fig 3.
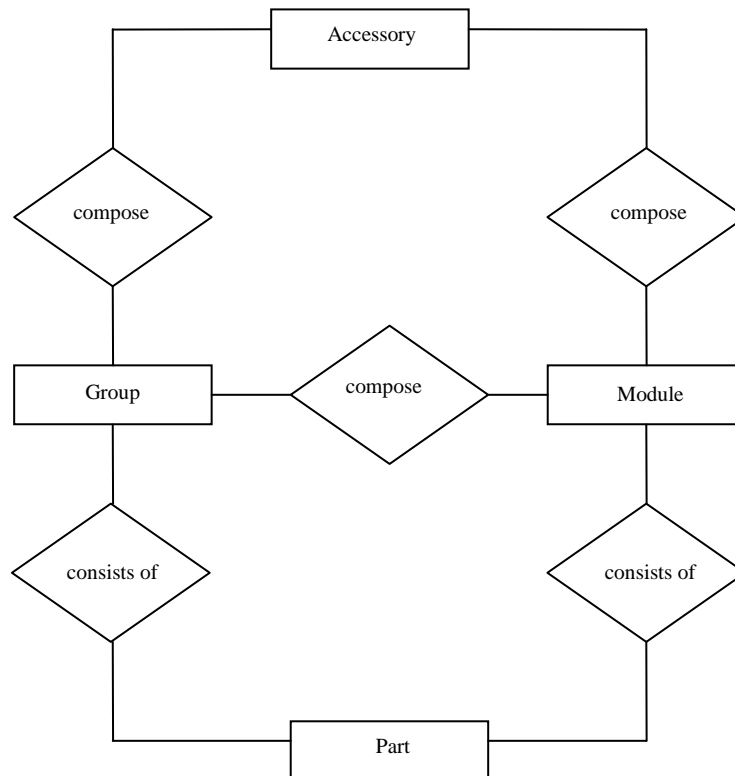

Figure 3. Relationships between the components of modular furniture

These relations are stored in the database because in the moment that a new group is inserted, for example, the user is asked to indicate what accessories or parts compose this component, how shown in Fig 4, so when the user will draw the new group's model, it can be make simply import the models of accessories or parts that will compose the model of this group, how shown in Fig 5.

Figure 4. Registration screen for new group. (a) Basic information about the group, (b) Accessories or parts to compose the group
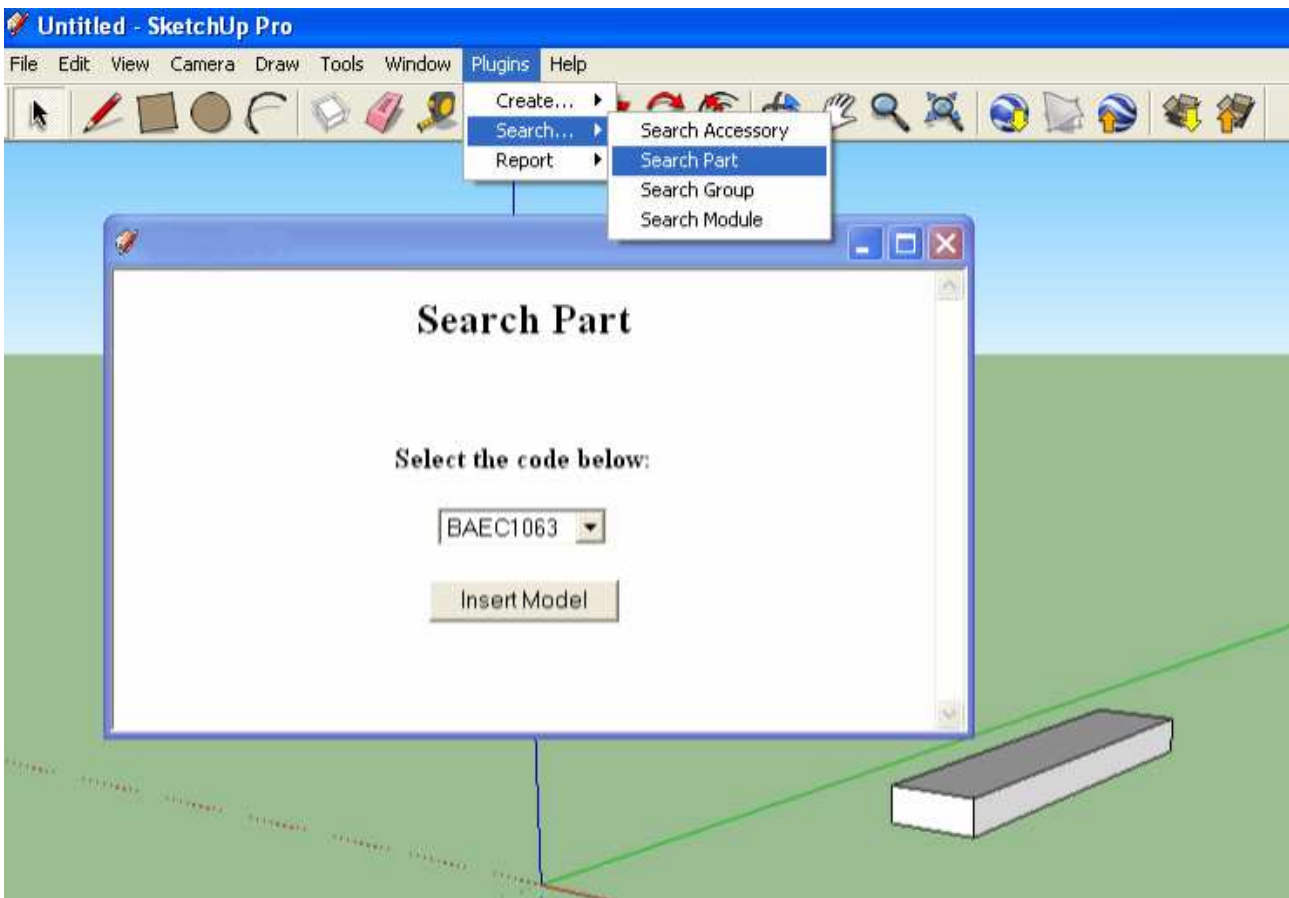

Figure 5. Import part model to compose a new group previously registered.

That occurs because in the database structure is a link between the metadata information and the corresponding model, saved in a skp file. This link is done when the user finishes the draw and then he uses the plugin to inform which component has that model. Selecting the option to generate report, the user will have access to a spreadsheet with all the elements that make up the project and the metadata of each component, for example: the price of these elements and their respective characteristics, how shown in Fig 6.
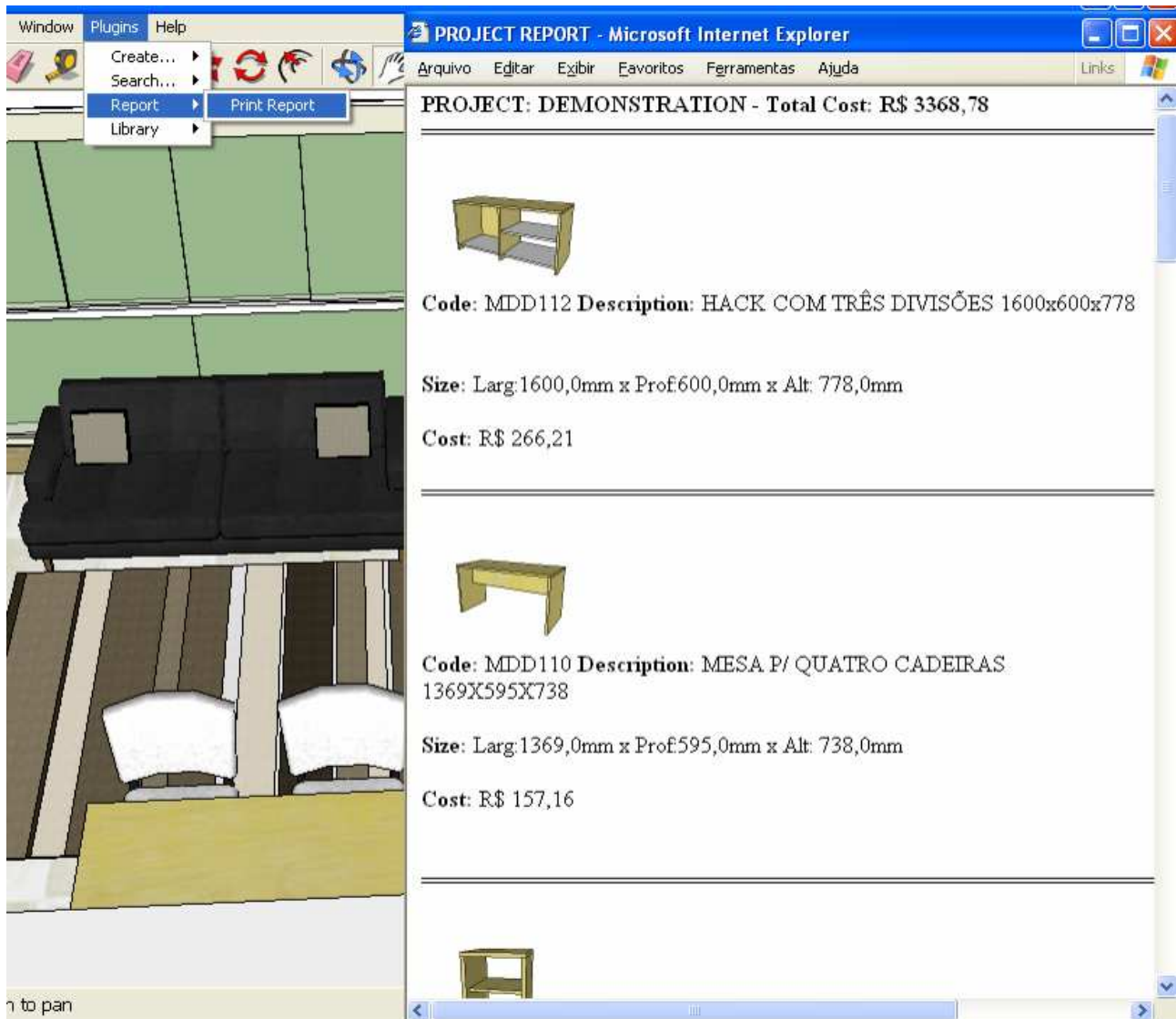

Figure 6. Generate Report from a Project

The use of spreadsheet like the one shown in Figure 6, with detailed data and pictures of each project component, simplifies the process of manufacturing, because information will be well more organized, reducing mistakes in this phase. The application of this software in the local furniture industry will allow project cost estimates are more accurate, improving the planning manufacturing phase, and with the use of Group Technology, the pieces inventory will be done more efficiently. Another important feature is the export tool models to VRML format contained in the Google SketchUp, because models generated can be viewed in a virtual reality environment. So, the local industry can make presentations of its projects using a custom virtual catalog, providing a greater interactivity between the client and the project. All communication between the plugin inside the SketchUp's environment and the database is made with JavaScript's instructions. This language is supported by the developer's API and can be used inside the Ruby codes.

4. RESULTS AND CONCLUSIONS

With the reuse of models, both to compose new groups or modules and to design new parts or accessories with similar models, there was a gain of time developing the project since it was not necessary to redraw the whole new piece. Another advantage is the automatic calculation of costs associated with the model, allowing comparisons between the resulting values when changes are made, thus helping in choosing pieces that will compose the new component, based in the cost of the project. The report also helps the manufacture process because this report provides all the necessary information, including a picture of each component's model used in the project.

The development of this work accomplishes some significant conclusions:

▪ the conceptual modeling is an important step in database construction since in this stage defined the requirements and the entire structure of the data to be stored and their interrelationships;

▪ the proposal methodology can be applied to support design projects in other areas of activity, like engineering or architecture, making the appropriate adjustments;

▪ the adopted technology is manageable, customizable and at low cost, which enables the deployment of solutions in full project life cycle.

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6. RESPONSIBILITY NOTICE

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