CAD Software and Interoperability

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INTRODUCTION

Decisions taken during the conception phases in huge architectural projects influence a lot the cost and the schedule of the building construction. To ease this decision-making, many mock-ups have been used as a project prototype. This prototyping is useful to test and to improve the conception of projects. Nowadays, collaborative sites that appear on the Web greatly improve the flexibility of the framework's actors of a distant project [Aliakseyeu, Martens, Subramanian, Vrouble, & Wesselink, 2001; Balaguer & DeGennaro, 1996; Klinker, Dutoit, Bauer, Bayes, Novak, & Matzke, 2002). Digital mock-ups are used to represent future 3D elements of the final product. Digital mock-ups are known to be often employed in the architectural field. Indeed, the visualization of the future buildings in 3D by architects and engineers is a way to facilitate the testing of the choices, the scheduling of costs and processes, and the completion dates. In the architectural field, all types of activities have developed tools for special prototyping: structural analysis, thermal and fluidic networks, and so forth. Unfortunately, this development is completely chaotic. Sometimes existing tools in the same type of activity cannot exchange information. Moreover, information stored by tools is in most cases bound by a set of files that contain only geometrical descriptions of the building. Not every actor of a project has necessarily the same knowledge as the other actors to understand and to interpret information. Thus, the collaboration between the actors as well as the data interoperability seems to be difficult to evolve without a new kind of tool. The following section presents two examples of platforms using digital mock-ups to handle conception data. The section "Collaborative Web Platform" focuses on our solution through the presentation of the Active3D collaborative platform. The section "Interoperability Demonstration" presents the Active3D platform as a central point of collaboration with the help of use-cases examples. The last section concludes on the work being undertaken.

BACKGROUND

The collaborative work between distant actors on the same project improves the conception of a prototype by reducing the time between each update. A lot of CAD software packages were modified to allow virtual prototyping, but this was done independently of specific project requirements. Unfortunately, most of these solutions do not join together the essential capabilities of interaction and collaboration for the completion of an engineer project. To avoid this problem many projects were suggested. The project Cavalcade (Cavalcade, n.d.) is based on a distributed architecture, allowing several distant teams to collaborate on a conception, to test, to validate, and to exchange documents. Cavalcade provides a visual system of 3D visualization. Contrary to classical ideas on simulation tools, the virtual representation of a prototype concerns only the visual aspect of attributes of which the objects of the building are composed. These attributes are functions like "is a part of a subsystem" and documents like technical files or Web links. The 3D model becomes then a visual interface of information requests. Cavalcade aims to manage conception data. To exchange the models created with the help of CAD software, the developers of this software use specific format files for their requirements. The set of files that forms the conception of the project constitutes the digital mock-up. The 3D model of the conception object is generally integrated in this mock-up and a set of information allows management of the project by itself.

In addition, the organization of the engineering and design department must be reconsidered. To facilitate the pooling of data, a digital mock-up should be installed. The conception work is then immediately possible from the mock-up. Access to the last updated data avoids expensive errors related to the use of data not up to date. The sharing of conception data is obviously a requirement in order to accelerate the conception cycle. Several problems must be taken into account in the conception of a 3D collaborative platform.

The first problem concerns the choice of an information storage structure. There are two kinds of information storing: files and databases. In the field of 3D, the file formats are very numerous. Although the principal information of

these files is the geometrical representation in 3D of the objects, each kind of file has its own levels of abstraction. The higher the abstraction level of information is, the more semantics contains the file. This semantics is an additional knowledge on geometrical information, making it possible to re-use in a better way the geometrical file and its definitions. Databases ensure the storage of large quantities of information by structuring and indexing information. In general, the databases carry the subjacent semantics of information which they store. Indeed, the structures which receive information model information that they must contain, therefore these structures form metadata on information. The databases are, thus, of primary importance to organize information so that it becomes possible to search for relevant data in a vast set of information such as a file.

The second problem concerns the definition of an optimized 3D interface that allows a flexible and fast handling of stored information. Certain applications require at the same time a lot of memory and a minimum speed of execution. For instance, the computer-aided design often produces complex 3D geometrical models that have a very large size. Thus, the recurring problem in graphical application is the data visualization. Indeed, with the advent of design techniques, the growth of the volume to be computed is largely higher than the increase of the capacity of the graphic material. Consequently, a phase of optimization is necessary. It is located at the data model and at the data themselves. Many techniques of optimization and acceleration for interactive navigation were developed. These include calculations of visibility (Pearce, Partial, & Day, 2004), geometrical simplification (Hoppe, 1996; Pailot, Merienne, Frachet, & Nevfeu (2003), and the image-based representation (Christopoulos, Gaitatzes, & Papaioannou, 2003; Gortler, He, & Cohen, 1997; Levoy, & Hanrahan, 1996; Mark, McMillan, & Bishop, 1997). All these techniques were combined successfully to render architectural models (Funkhouser, Teller, Sequin, & Khorramabadi, 1996) and urban models (Wonka, Wimmer, & Sillion, 2001). The GigaWalk project is a rendering system that makes it possible to render CAD projects of more than 10 millions of polygons. The most striking example is the design project "DoubleEagle tanker" made up of more than four gigabytes of data, that is to say 82 million triangles and 127 thousand objects. The rate of calculation is 11 to 50 images per second which permits to navigate in real time through the digital mock-up after a time of approximately 40 hours pre-calculation (Baxter, Sud, Govindaraju, & Manocha, 2002). However, there is no perfect system. Each technique has advantages and disadvantages but certain combinations with precise conditions are very effective. These techniques described previously proved their reliability within a static framework, that is, the optimized scene is calculated once for several visualizations. In fact, the pre-computing time before the accessibility of the scene can sometimes take several days. The pre-computing of the optimized scenes is the major problem of all these techniques because if the 3D models evolve during this time then the management of the data synchronization must be taken into account. These synchronizations are not always possible because the complete structure of the scene can sometimes change. Other ways must be explored to allow for the visualization of a 3D scene to evolve during this time. Optimizations are always carried out in comparison to the geometry or the topology of the scene. On the one hand, the nature of the geometrical objects was not taken into account for computing optimization. The nature of the objects, thus, proves to be an undeniable way for research. This nature depends on the scene structuring but if it is limited to geometrical information then only geometrical optimizations are applicable. On the other hand, if information on the nature of the objects is indicated then this information provides a new way of research on the handling of geometrical information and their storage.

COLLABORATIVE WEB PLATFORM

Nowadays, the fundamental needs of all the actors in architectural engineering projects relate to a simple tool which allows a coordinated management of the actions carried out in a project. This tool must allow management of data generated during the lifecycle of the project through a 3D visualization of a digital mock-up and must also allow its access to all project actors through a collaborative Web platform. This section presents the ACTIVe3D-Build platform which makes it possible for the actors of a project, geographically dispersed - from the architect to the plumber - to exchange documents directly in a virtual environment during the lifecycle of a civil engineering project. A 3D visualization makes it possible for the actors to move around the building that is being designed and to obtain information on the objects. This section is divided into three parts. The first part presents the format used to describe the data. The second part deals with the data structuring. The third part presents the division method and exchange of data.

Data format: CAD software used in civil engineering projects models each building element by a set of vectors. In this formalism there is no semantic information on the objects that compose the building. Thus, there is no way to select automatically objects by their nature. To solve these problems the International Alliance for Interoperability (IAI) proposed a standard called IFC (Industrial Foundation Classes – http://www.iai-international.org/) which describes the representation of the objects that can be found in an architectural project. The IFC file format is a model which associates trade semantics with 2D/3D geometry for each element constituting the building. The addition of trade semantics makes it possible to limit the redundancies of information because it identifies instantaneously each element that the building is composed of for a faster

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