Use of semantics to manage 3D scenes in web platforms

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INTERNET AND 3D SCENES

Computer graphics has widely spread out into various computer applications. After the early wire-frame computer generated images of the 60s, spatial representation of objects improved in the 70s with Boundary Representation (B-Rep) modeling, Constructive Solid Geometry (CSG) objects, and free-form surfaces. Realistic rendering in the 90s, taking into account sophisticated dynamic interactions (between objects or between objects and human actors, physical interactions with light, etc.) now make 3D-scenes much better than simple 3D representations of the real world. Indeed, they are a way to conceive products (industrial products, art products, etc.) and to modify them over time, either interactively or by simulation of physical phenomena [9,10,11].

The exponential development of Internet tends toward two domains which may seem contradictory. On the one hand, we note the increasing importance of the visual aspect of the Web inasmuch as the text that initially composed pages of the first WEB sites has been replaced by pictures and animation. We note the breakthrough of software such as Flash from Macro-media [4] in this domain. On the other hand, the informative aspect of the Web has undergone major development with the interconnection of databases with HTML pages using ASP, PHP and so on. Such information becomes intelligent, adaptived to the behavior of the connected users. The breakthrough in the interconnection of databases with the HTML pages has permitted the creation of new dynamic sites. Today, a Web site must be lively, attractive, intelligent, active and interactive.

Nevertheless, limits do exist. In terms of the visual aspect, 3D representation on Internet is expanding rapidly. However, it is often limited to short animated sequences short animated sequences, due to the important resources needed to use 3D on the network. In terms of the informative aspect, it is often limited to the interfacing of database with the HTML code.

Large amounts of data can be generated from such variety of 3D-models. Because there is a wide renge of models corresponding to various areas of applications (metallurgy, chemistry, seismology, architecture, arts and media, etc.) [17,18], data representations vary greatly. Archiving these large amounts of information most often remains a simple storage of representations of 3D-scenes (3D images). To our knowledge, there is no efficient way to manipulate i.e. archive, extract and modify scenes together with their components. These components may include geometric objects or primitives that compose scenes (3D-geometry and material aspect), geometrics transformations to compose primitives objects, or observation conditions (cameras, lights, etc.). Difficulties arise less in creating 3D-scenes, rather than in the interactive reuse of these scenes, particularly by database queries, e.g. via Internet. Managing 3D-scenes (e.g. querying a database of architectural scenes by the content, modifying given parameters on a large scale, or performing statistics) remains difficult. This implies that DBMS should use the data structures of the 3D-scene models.

Unfortunately, such data structures are often of different or exclusive standards. Indeed, many « standards » exist in computer graphics. They are often denoted by extensions of data files. Let us mention, as examples, 3dmf (Apple's Quickdraw 3D), 3ds (Autodesk's 3D-Studio) , dxf (AutoDesk's AutoCAD) , flt (Multigen's ModelGen) , iv (Silicon Graphics' Inventor), obj (Wavefront/Alias), etc. Many standardization attempts strive to reduce this multiplicity of various formats. In particular, there is STEP (Standard for the Exchange of Product model data) [6] an international standard for computer representation and exchange of products data. Its goal is to describe data bound to a product as long as it evolves, independently of any particular computer system. It allows file exchanges, but also provides a basis for implementing and sharing product databases. Merging 3D information and textual information allows the definition of the project's mock-up. Indeed, 3D information describes CAD objects of the projcet and textual added information gives semantic information on geometries. The main issues are the sharing and the exchange of the digital mock-up. The next section explains how we use a digital mock-up to create an information system with the help of the semantic included in geometric information. Information is exchanged and shared through a Web Platform.

B A C K G R O U N D

With the emergence of new powerful computers, the 3D models created by computer-aided design tools are huge and very complex. The plans of a boat, a plane or an architectural structure can exceed a gigabyte in size. The GigaWalk [1] project is a rendering system making it possible to display projects of CAD with more than 10 million polygons. The design based on the simulation of these data cannot make a useful contribution without the possibility of generating an interactive display through a virtual visit of the model. Many optimizations and acceleration techniques for interactive display were developed for this type of data. These techniques include visibility computations, object simplification and image-based representation. All these techniques have been combined successfully in the rendering of specific data including architectural models [2] and urban models [3]. The digital mock-up greatly impact the financial and strategic choices of companies during the design phase. To improve the quality of prototyping and refined strategic choices, collaborative platforms were developed on the Web. Along with digital mock-up, these platforms allow designers and decision maker architects to work directly with geographically distant companies [5].

Nevertheless, these collaborative platforms do not allow the geometrical handling of a great quantity of polygons in real time without a prohibitory pre-calculates time. A way to solve this problem is to structure the 3D scene according to semantic criteria or to start from the only geometrical criteria only. Semantics is a crucial point for Web platforms because it influences the three characterizing axes of platforms, namely data, communication and processes.

- Data is the information which is handled through the system. This information inclues the data from the digital mock-up, the data of concerning model management like users and rights associated with users, and a set of meta-data allowing data management on a higher level of abstraction. This level allows the handling of the semantics of information and thus making the information more relevant to the situation of the user.

- Communication is the infrastructure which is installed to transfer information between processes and project actors. Transfer of more relevant information will limit the size of information exchanged and thus will improve the response times in the communications between processes.

- Processes carry out actions which are ordered either by another process or by an actor of the project. Processes are either generic or specialized. A set of generic processes forms the core of the system, making it possible to carry out simple actions which correspond to the use context of the platform. Specialized processes are composed of a sequence of simple processes and specialized processes to undertake a complex action. For example, a simple process will make it possible to insert an individual into a database and a complex process will make it possible to insert a hierarchy of individuals into a database. This specialized process uses two simple processes which is the insertion of a person and the creation of a hierarchy link between two people in the database.

The next section describe a emerging approach, ACTIVe3D, and the influence of semantic on the three characterizing axes of a Web Platform.

A NEW APPROACH

The ACTIVe3D method proposes a solution which makes it possible to associate semantics trade with the objects represented in complex geometrical 3D models. This association provides contextual trees which associate dynamically, using rules, a knowledge trade with groups of polygons to generate 3D trade objects. The dynamic feature of this method relates to the automatic generation of the 3D scene starting from the CAD files and the possibility of handling each trade object in the scene and of associating specific documents or functions with it. For example, it is very useful to select a door in a 3D scene to obtain the corresponding invoice and/or to activate the Web service which provides a description of the product based on the catalogue of the supplier. The use of contextual trees limits the geometrical complexities of the model which enables its use on Internet within reasonable deadlines.

To do this, ACTIVe3D is based on an ontology, which specifies semantic information contained in project information. This ontology defines vocabulary, concept and relationships for the manipulation of hierarchical data. It also defines a formal framework to manage information according to its semantics and not only according to structure, thus allowing the dynamic creation of 3D scenes by context. The context view of the 3D scene is a trade association view, which shows a relevant view of the digital mock-up. Thanks to this new abstract level, the three axes of Web platforms are redefined.

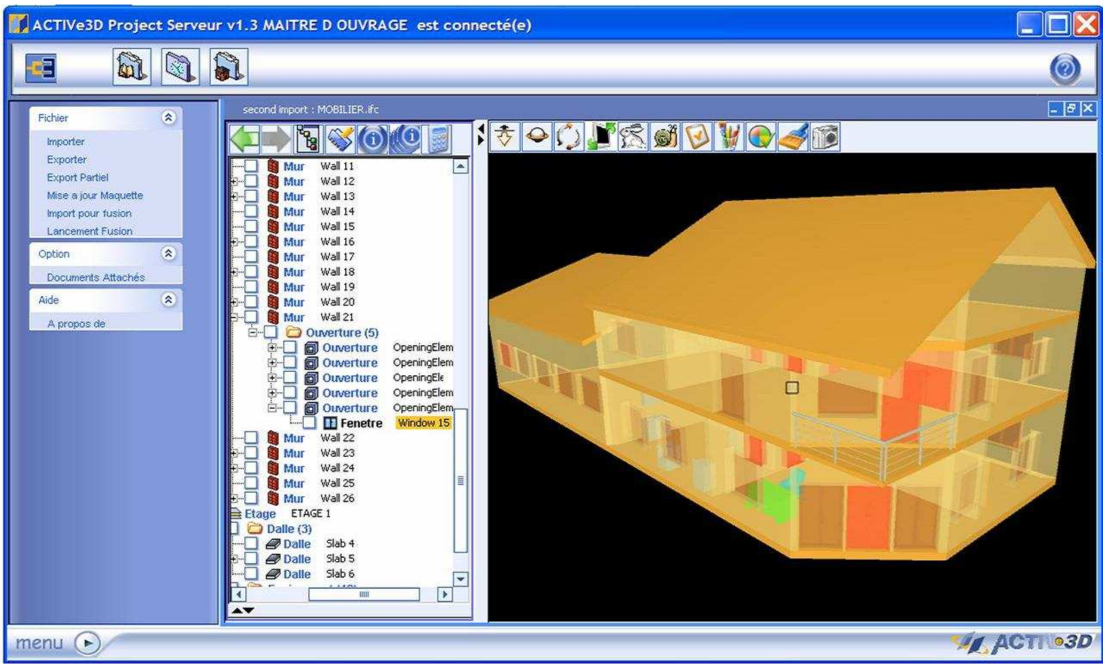

Figure 1. IFC Tree of capacity and 3D graph

The data axis uses “Industrial Foundation Classes” (IFC) which is an ISO norm that defines all components of a building in a civil engineering project. IFC files are textual files whose size can reach 100 megabytes. Several IFC files can coexist on the same civil engineering project. Due to their size, their handling and sharing is a complex task. An IFC file for a standard building can contain more than 300 000 business objects organized in a cyclic graph. Each node of the graph includes partial semantic information. To obtain complete semantic information on a trade object, it is necessary to analyze several nodes which are not inevitably directly dependent. To address this problem we have developed a methodology based on graph analysis and tree classification. This methodology is articulated in two steps.

- The first step is an analysis and conversion of each object and connection from the source file into acyclic graphs called contextual trees. This process is undertaken using business rules. An example of a business rule is “*a window is in an opening element in a wall*”. The main tree resulting from this process, is the geometrical contextual tree which contains the topological relations between the various objects. Other contextual trees are built starting from the IFC files, such as the contextual tree of capacity defining object composition (a building contains two floors, a floors contains beams, walls, and so on.) This step is completed when all information contained in the source IFC files are represented in contextual trees. Figure 1 displays a snapshot containing the view of a capacity tree and geometrical tree.

- The second step is dedicated to 3D modeling [12, 13, 14, 15]. In the 3D scene generation process, all the geometry contained in IFC files are converted into triangular surface model [7]. During this conversion, the 3D objects are associates with the GID. The GID is the general identifier used to identify each business object in an IFC file. This GID is used to link the 3D visualization with the information stored in the databases. All insertion of new data in any base is referenced by a GID corresponding to an IFC object. All trees generated in the platform are XML trees. We have developed a specific database schema dealing with the semantic and the 3D aspects of the IFC. This schema is based on the ACTIVe3D ontology. The trees and the component elements are stored in a relational database and manipulated using SQL. From this database and the GID, all types of information can be attached to the 3D visualization of a business object.

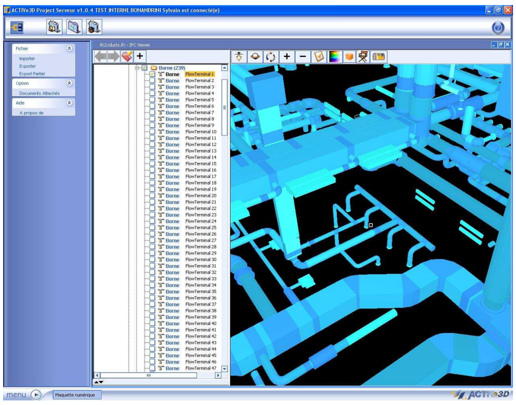

Figure 2. A 3D scene in a plumbing context

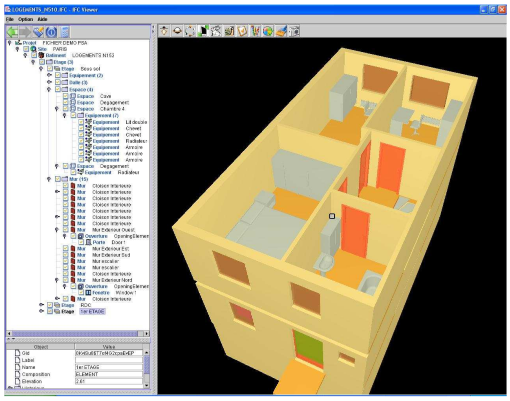

Figure 3. A 3D scene in a architectural context

The communication axis will be adapted to facilitate the exchange of information through the network. All trees generated in the platform are XML trees, so Web Services gives us a framework to easily carry XML information with the help of HTTP network level. The data flows use Web Services, but we have also defined an internal structure of information exchange. Indeed, the ACTIVe3D architecture based on a central router, allows each specialized module to exchange and co-operate in order to answer user queries. The database module contains a set of processes that allows the inter-operability of several local and distant databases. The GED modules allow the user to associate documents attached to the 3D objects. The other modules developped in the ACTIVe3D platform concern specific business processes from civil engineering. The web services contained in each module can be combined by the router to resolve user queries.

The processes axis uses the contextual trees. Each functional unit and each context are manipulated as XML documents through web services. The document can be converted into IFC in the output of the system. This conversion allows the civil engineering participants to exchange maps throughout the life cycle of a civil engineering project. IFC Services provided on the ACTIVe3D server are XSL processes associated with a context. The use of XSL is extended to generate other documents such as technical reports and so on. In the same way, the graphic contextual trees are transformed into X3D documents. X3D is an XML language for the description of 3D scenes. Thus, the 3D scene is customized according to the service concerned. For example, as figure 2 and figure 3 show, it is possible to generate two different 3D scenes from two differents contexte trees in real time resulting from two the same information source. Moreover, the graphic elements preserve connections with corresponding trade objects stored in the databases. Thus, the data contained in the systemes can be manipulated from the 3D scenes or from the context trees.

C O N C L U S I O N

This paper presents the technical evolution in 3D manipulation and storage. Currently, research in this domain concerns the combination of semantics with 3D representation. The focus of this article concerns the fact that the semantic approach is useful in managing 3D scenes in business environments. Indeed, semantics allows users to extract relevant information from a relational database depending on the context. Moreover, extracted information is less complex then the complete model. Semantics therefor helps us validate partial extracted information from our information system. Thus, semantics expressed by textual information validates geometrical information. For example: We cannnot put a wall in a door, and the capacity graph validates this information into memory or from the database by means of simple process. The semantic approach also allows users to validate more complex information that combines textual and geometrical information. Indeed, semantics is a powerful tool in computer aided mistake detection in engineering projects and in 3D scenes as well. Imagine that we want to discover if a wood beam “kind x232” cross a load-bearing wall. First, we have to extract the scene graph of bounding box with only business objects as wood beam and load-bearing wall. Next, we start a process to detect if a bounding box of a wall in the scene graph crosses a bounding box of a load-bearing wall. In this example, we note the two steps required to arrive at detection. The first one consists in defining which kind of information we need to create a dynamical graph. This graph will contain all information required in the second step. The second step consists in defining rules concerning business objects and relation elements with the help of mathematical logic. The result of the mistake detection will use data from both steps. Our future work consist in the creation of a formal framework allowing users to define customized rules for mistake detections. This framework will help users to define each kind of business object managed and each logical rule need to extract mistakes.

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TERMS AND DEFINITIONS

ISO norm: "International Organization for Standardization" is a network of the national standards institutes of 148 countries, on the basis of one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. ISO is a non-governmental organization. *http://www.iso.org*

XSL style sheet: XSL is a language for expressing style sheets. An XSL style sheet is a file that describes how to display an XML document of a given type. *http://www.w3.org/Style/XSL/*

Cyclic graph: A graph of n nodes and n edges such that node i is connected to the two adjacent nodes i+1 and i-1 (mod n), where the nodes are numbered 0, 1, …, n-1. *http://mathworld.wolfram.com/CyclicGraph.html*

B-rep: In boundary representation (B-Rep) complex geometrical forms are described using their boundary surfaces. In this process, the surface of an object is broken down into smaller polygons, mainly triangles. This therefore makes this type of modeling particularly suitable for irregularly shaped surfaces. Most animation programs use this method.

CSG: There are few ways to describe a three-dimensional model. One of the most popular is Constructive Solid Geometry (CSG). In CSG, a model is compiled from primitives and Boolean operators linking them. Data are stored in the tree structure, where the leaves are the primitives, and the nodes are the operations: intersection (AND), union (OR) and complement (NOT).

CAD: (Computer Aided Design) The use of computer programs and systems to design detailed two- or three-dimensional models of physical objects, such as mechanical parts, buildings, and molecules.