3D-dvshop: a 3D Dynamic Virtual Shop

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Abstract. In recent years, virtual reality has shown all its potential in a large spectrum of applications: training, simulation, CAD, and so on. Although existing technologies allow the creation of immersive virtual reality browsing experiences, little has been devoted to applying this new tool to electronic commerce (e-commerce) since almost all e-commerce web sites present products in a 2D on-line catalog. In this paper we present 3D-dvshop, a dynamic 3D virtual shop: a user can build his or her own shop, choosing a set of products that will be dynamically placed in a collection of specially created "rooms". The use of technologies such as VRML and Java allows full 3D interaction with products. In this way, the browsing experience can be more natural, attractive, realistic, and fun.

1 Introduction

E-commerce allows a new kind of business since enterprises can promote their products without temporal and physical constraints: users can consult, at any time, on-line catalogs and purchase objects otherwise not accessible. Although e-commerce is growing alongside the expansion of the Internet, some problems remain concerning the human/machine interface. Almost all e-commerce web sites offer the user a "simple" 2D on-line catalog where object characteristics are often restricted to 2D pictures.

This kind of approach is different from that experienced when we go shopping. People like and want to interact with the objects to *discover* them and the experience of shopping, involving meeting other people, looking windows and so on, is absolutely natural and fun. However, most common user interfaces are flat and cannot completely satisfy a consumer; a traditional e-commerce web site (using HTML) can be suitable for some products such as books, but not for objects with which a user may want to interact.

Although virtual reality (VR) has been widely used in some applications (for instance training, simulation, medicine, and entertainment) there have been few attempts to create more exciting virtual reality browsing e-commerce experiences. A real 3D interface could allow consumers to immerse themselves in a virtual shop where it is possible to interact with products, to meet other people (represented by their avatars), to hear sounds, and so on; in this way, people could experience perceptions similar to the real ones.

Three main reasons have inhibited the development of 3D commerce on the web:

- performance: only recently have PCs are being able to manage interactively realistic 3D objects/environments, and modem connections for downloading large and complex 3D scenes can take a very long time,
- navigation: although our perceptions are tuned to operate in 3D worlds, it could be difficult for a customers to navigate and orient themselves in order to find objects of interest in a virtual shop,
- technology: the description of text and hyper-text on the web has been standardized by the HTML language but only the definition of VRML 2.0 [1] (published on August 1996) has provided web designers with a standard tool for designing 3D interactive and animated virtual worlds. Concurrent with VRML, a set of proprietary technologies has been developed, but they often only allow insertion of 3D interactive objects into HTML pages.

The proposed project 3D-dvshop (3D-dynamic virtual shop) attempts to tackle these issues in order to dynamically generate a virtual shop ad hoc for each user; in this way, only products of interest are placed into the virtual world that can be organized according to a customer's choices. The option of retrieving only selected information from the database allows both reduction of the amount of data composing a scene (lower connection latency times) and greater ease of navigation for the user. The technology used for developing 3D-dvshop is as much as possible standard since VRML and Java have been used to describe and create both the rooms of the shop and the interactive and animated objects. Moreover, a set of interfaces allows the web site administrator to easily manage the product database.

The paper is organized as follows: Section 2 reviews the main examples of 3D technologies devoted to 3D e-commerce and introduces the concept of user interface metaphor, while a detailed description of the proposed project is presented in Section 3. Finally, remarks and evaluations can be found in Section 4.

2 Background

2.1 Technologies for 3D e-commerce

Cult3D [2] is an interactive 3D solution allowing designers to build and display high-quality interactive 3D graphics for web sites, Microsoft Office and Adobe Acrobat. It is targeted toward product visualization, e-commerce, distance learning, gaming and entertainment applications. A Cult3D object is designed in three steps: creation of the model in 3D Studio Max, export of the object by Cult3D Exporter, and addition of animation and interaction effects by means of Cult3D Designer. Although Cult3D objects look very realistic (effects such as: bump and environment mapping, bilinear filtering, transparency, high resolution texture, stereoscopic 3D are supported) the web implementation is not a real 3D environment but a collection of traditional HTML pages including some 3D objects.

3DAnywhere [3] enables web site authors to present three dimensional objects over the Internet and allows the viewer to rotate and control object size and shape. 3DAnywhere is entirely written in Java, so it will run on any Java-enabled system; this means that no platform- or browser-specific plug-in is required.

Shout3D [4] is an approach to online visualization and immersion that lets any standard web browser display interactive 3D graphics without needing extra plug-ins; in fact, Shout3D starts from models described in a slightly modified VRML language and converts them into Shout3D applets that can be inserted in HTML pages as JavaScripts. Shout3D objects can look very realistic since sophisticated graphic effects as well as integrated sound are supported.

Superscape e-Visualizer (SeV) [5] is a technology specifically designed for the web that allows designers to integrate photo realistic interactive 3D objects with the 2D components on their web pages. The main advantage of SeV is the reduced size of the file to be transmitted; even systems with slow modem connections can take advantage of this kind of solution. 3D objects are regenerated on the client machine by means of a subdivision surface algorithm. The subdivision surface consists of a control mesh, which is the original polygon model, and a set of instructions that generate new polygons based on the positions of the vertices on this starting shape.

Blaxxun3D technology [6] is based on Extensible 3D (X3D - a subset of the existing standard VRML97), a project coordinated by the Web3D Consortium [7]. Blaxxun3D characteristics can be summarized as follows:

- compact standard Java applet (approximately 55KB),
- no plug-in and therefore no extra download or installation required,
- simple integration with existing home pages,
- platform-independent (PC, Mac, Linux),
- compatible with VRML/X3D,
- supports 3D objects and interactivity,
- extensible with built-in API interfaces.

Janet3D [8] is another Java-based technology for creating interactive 3D applications on the web; the two base components of Janet3D are netMarker and 3Dcatalog. The former is a 3D communication system supporting the design process within a CAD environment, the latter a 3D catalogue.

Anfy3D [9] claims to be the fastest interactive 3D renderer today with shading available in Java technology; Anfy3D API is the Anfy3D engine for the Java language.

On the other hand, Kaon technology [10] allows conversion of several 2D digital images of a product into 3D models. The result of a conversion is a fully 3D polygonal model with photographic surface images. Surface textures come in both low resolution for quick downloading and high resolution for detailed viewing.

It is worth stressing how all these technologies produce realistic and interactive 3D objects and can add animations to models, but do not provide the user a 3D environment where avatars can walk and move around the objects.

A completely different approach is used by PanoramIX [11] where a set of photos is used to generate a virtual environment where the user can move and follow links.

Like PanoramIX, Photovista [12] can produce extremely compact files, often a third to a quarter the size of QuickTime VR [13] files and typically less than 100KB. Photovista does not require any plug-in and generated panoramas can be directly browsed by Internet Explorer 4.01 or higher, or Netscape Navigator 4.07.

QuickTime VR [13] (QTVR) encompasses three basically distinct technologies:

- panoramas overview: the view from a single point in space out to a surrounding environment,
- objects overview: the view from multiple points in space onto a single point, or object,
- scenes overview: QTVR scenes are a collection of one or more QTVR panoramas and/or object movies linked together via as set of links called: hot spots. In QTVR scenes, users can navigate from panorama to panorama, panorama to object, object to panorama, or object to object as they move about in the scene.

A plug-in is necessary to display QTVR panoramas/objects/scenes.

In these cases, the user is surrounded by the environment but cannot interact with objects since this is not a real 3D technology.

With respect to previously presented solutions, VRML [1] is a free, open and standard technology designed for 3D rendering on the web that describes a scene by means of a text file that has to be interpreted by a VRML browser. VRML 2.0 allows the description of dynamic worlds and scripting capabilities can be associated with the objects. VRML and Java have been used in the project VRCommerce [14] in order to carry out an immersive 3D solution for e-commerce. VRCommerce consists of an editor for creating 3D malls and stores and has some tools to provide an easy and smooth navigation within them.

The Java 3D [15] application programming interface provides a set of object-oriented interfaces that support a simple, high-level programming model. Three basic characteristics are the strength of Java 3D:

- the Java 3D API's scene-graph model allows creators to focus on object and scene composition,
- the Java 3D API incorporates geometry compression as part of its specification, which allows very large 3D objects to be quickly downloaded over the network for remote viewing and manipulation,
- the "write once, run anywhere" model has reduced the complexity and the cost normally associated with producing software on and for multiple distinct hardware platforms.

2.2 User Interface Metaphor

A major problem for users of modern information systems is the retrieval of new and previously viewed information from the system. Typical "WWW worlds" are often a collection of heavily interlinked and structured information and appropriate navigation metaphors can help to make the structure easier to understand, and therefore, easier to use [16].

The information space structure can be communicated to the user through a graphical representation of the space and the elements in it. Examples of such visualizations are the Information Visualizer [17], the Navigational View Builder [18], the Narcissus system [19], Chalmers landscape metaphore [20], the visualizations for the Hyperwave system [21] and Celentano's work for generating VR interfaces from XML and DTD documents describing the web site structure [22].

Recently, Russo et al. in [23] have defined the concept of *metaphor-aware navigation*, that is, the navigation is tightly bound to the visual metaphor used and the way the user moves in the virtual world is determined by the metaphor that the same world is based upon.

In the e-commerce contest an effective navigation metaphor should allow the user to retrieve, as fast as possible, the desired products; this can be a very difficult task when users navigate virtual malls comprising several shops and corridors. The proposed project 3D-dvshop (3D-dynamic virtual shop) tackles this problem by dynamically generating a shop where only the selected objects are placed; a set of rooms, connected by enter/exit doors, contains the objects that are arranged on shelves.

3 3D-dvshop Architecture Description

3D-dvshop is a system composed by three entities: database server, web server, and clients. Database and web servers can be on the same machine, but logically they are two separate entities. The database engine is Oracle 8i Enterprise 8.1.6 running on Linux. The choice of Oracle mainly depends on its capability to manage "objects" called BLOB (Binary Large Object) that allows insertion into the database of files containing text, images, sounds and so on as binary streams. Apache web server has been chosen and an engine for the dynamic generation of the virtual shop (entirely written in Java by means of Servlet technology) has been developed; the engine extends the functionalities of the web server and is executed by the Apache Servlet Engine. Finally, a client can be any VRML browser supporting VRML 2.0 specifications. VRML allows both egocentric (moving a viewpoint through the world) and exocentric (moving the world in front of a point of view) navigation.

3.1 Database

Each product belongs to a specific category and can be obtained as a composition of more objects; moreover, each product can be represented by more than one

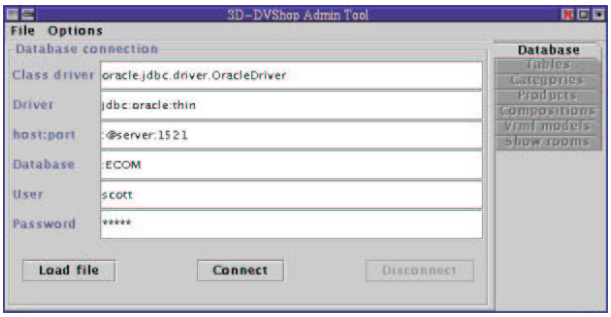

Fig. 1. The Administrator Tool interface

VRML model. In general, a VRML model is a collection of heterogeneous files: VRML code, textures, JavaScripts, Java code, metadata and so on, and it must be referred to an interface. Each VRML model is related to a bounding box that completely encapsulates it; bounding boxes are used to place products over shelves without collisions. In the same way as products, rooms are represented by VRML models.

Table generation can be performed in two different ways: by means of SQL commands or by using a program of administration expressly developed for 3D-dvshop. The Administrator Tool (AT) (Fig. 1) has been entirely developed in Java and it employs JFC for the graphic interface and JDBC for database connections. At the start of a connection the Database Panel is the only active panel, allowing database connection/disconnection operations; the following parameters are required for a connection: class driver, driver, host:port, database name, user, and password. Connection parameters can be also inserted by file. The second panel of AT (Tables Panel) allows table operations (creation, visualization, deletion, emptying) and presents the user a hierarchical structure where state information (for instance the number of records) is reported for each table.

The Categories Panel manages product categories providing insertion, update, and deletion operations. A category is specified by a unique code and by a name.

The Products Panel allows product management; in particular, the administrator can assign a product to a category. For each product a name, description, trade-mark, price, size and weight may be indicated.

The Compositions Panel describes how a product can be composed of a set of objects, while VRML Model and Show Room Panels manage object and room VRML models, respectively.

A bounding box size must be specified for each object and start points and sizes have to be indicated for shelves in room models. It is important to note how complex VRML models containing sounds, scripts, metadata (such as MPEG) and so on are also managed as BLOBs and loaded as binary streams; in this way, an object is seen as easily manageable within a hierarchical structure. Therefore, an object is a directory containing all files of the arbitrary hierarchical struc-

ture and a file having `.proto` extension representing the model prototype (see VRML specifications about prototype definition). Moreover, each object is given a standard initial position representing its orientation on a shelf.

3.2 Engine for Shop Generation

A virtual shop is built by means of two "components": a set of VRML models representing products and one or more rooms where products are placed. Each room is a VRML model in the same way as a product, while the prototype file `room.proto` contains the following parameters:

- room: environment prototype,
- exit: defines the enter/exit door placed in the first room of the virtual shop,
- nextRoom: defines a door for the access to the next room of the shop (if it exists),
- previousRoom: defines a door for the access to the previous room of the shop.

Exit, NextRoom, and PreviousRoom have been described as doors, but they could be any other enter/exit system.

3D-dvshop generates a virtual shop by a servlet called `SceneServer` that receives a user query for a search in the database; a query is performed by a form managed by the `ServForm` servlet.

A product search can be performed according to a set of fields; the first three text fields can be left blank or filled to match the *Name*, *Description*, and *Trade-Mark* that the objects have in the database. Other fields allow searching by category, use of Boolean operators (AND/OR), and selection of the type of room in which objects will be placed. The compiled form is sent to the `SceneServer` servlet that finds objects satisfying the search keys in the database and builds a virtual shop.

The user sees a page split into two frames: on the right the 3D scene and on the left the list of the objects found. For instance, searching for category and selecting "Notebook", a shop containing two objects will be displayed as shown in Fig. 2. When the user approaches an object, all information about the product will appear in the left frame (see Fig. 3). Moreover, users can interact with objects by rotating and moving them and, if defined, can activate any animations associated with the objects themselves. In the second example the search has been performed on *all categories* and only the kind of room has been specified; in this case, seven objects have been retrieved from the database, and since it is impossible to place all them within just one room, two environments linked by a door are automatically generated. Fig. 4 shows four products placed in the first room and the connection door labeled by *NEXT*.

Object orientation depends on shelf position, as a shelf is described in the database by: a starting point, an orientation angle, and a bounding box. The orientation angle allows rooms of arbitrary shape to be generated, making the virtual shop more realistic. A movie of 3D-dvshop can be found in EG digital library.

Fig. 2. Result of a search for category

4 Remarks and Evaluations

Evaluating the complexity involved in building a shop or a product is a very difficult task; it mainly depends on the appearance the "object" must have; if it has to appear as realistic as possible, a long time has to be spent in the design phase. However, almost all recent 3D modelers (for instance, 3D Studio Max) provide easy and intuitive tools for creating extremely realistic 3D models that can be successively exported into VRML.

On the other hand, database management is a straightforward task, since all database operations (adding and deleting products, modifying object properties, inserting new kinds of room, organizing products for categories) can be performed by the Administration Tool described in Section 3.1.

From the user point of view, the system evaluation mainly concerns the usability. Environments and the objects are created on the fly according to the user requests; in this way, only the products of interest, instead of the entire database, are presented. This has two main advantages: reduced size of the VRML model (i.e. lower connection and rendering times) and displaying to the user only specified objects of interest. Objects are placed in one or more rooms according to search results; rooms are sequentially connected by doors to minimise the chance of a customer missing a product of interest. Moreover, some VRML browsers (for instance CosmoPlayer [24]) can receive compressed textures, further reducing download latency times, and navigation can take advantage of accelerated graphic boards now available at low cost.

5 Conclusion

3D-dvshop is a tool for 3D e-commerce browsing experiences and the whole system is entirely written in Java and VRML, two standard and free technologies.

Fig. 3. Approaching an object and interacting with it

It provides realistic appearance since both the environments and the products are fully 3D, interactive, and possibly animated. VRML and Java allow description of very realistic objects both in appearance and behavior; moreover, the database's capability to manage binary streams allows easy inclusion of metadata.

A customer can move inside the virtual shop; at the moment 3D-dvshop implements a WoW (Window on World Systems) paradigm (also called Desktop Virtual Reality System) where the scene is displayed on a monitor, but this only concerns the human/machine interface and does not involve the system architecture. Visualizing products into separate windows could be another choice, but this would not allow the same feeling of immersion.

Acknowledgments

This work is supported by The National Research Council (CNR) in the frame of the project *Strumenti e Tecniche per la Realizzazione di Negozi Virtuali Distribuiti.*

We thank Ing. Giampiero Alberelli for his support in developing 3D-dvshop.

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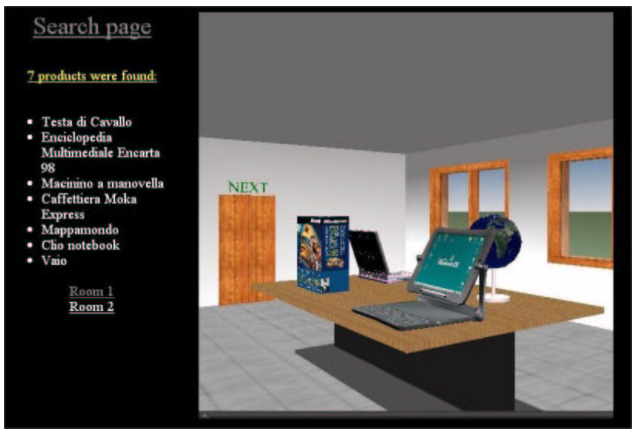

Fig. 4. Two rooms are automatically generated

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