

Web-based Multiuser Interior Design with Virtual Reality Technology

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Abstract: - A Web-based interior design application system, named Multiuser Interior Design (MID), is presented. Technologies from virtual reality (VR), the Web, and database are used to implement MID. It allows users to operate in the VR fashion, interacting with 3D virtual objects and spaces through a Web browser. Users can view and elaborate designs, examine furniture, and even place purchase orders of furniture. MID contains various features, including multiuser collaboration and concurrent display of multiple views of a scene. MID can be modified for other e-commerce purposes; many of the functions serve as a reusable framework.

Key-Words: - E-commerce, Interior design, Internet, Multiuser collaboration, Reusable framework, Three-tier architecture, Virtual reality, Web-based

1 Introduction

Traditional interior designers need a substantial amount of effort to develop and present a design, and the design is usually not easy to modify. To solve these problems, virtual reality (VR) [9, 21] can be of great help. VR has been useful in many areas through advances in software and hardware technologies [13, 16, 18, 20]. Interaction and digitalized 3D models enable us to see things from a new angle and have new experiences.

This paper presents an interior design application system named Multiuser Interior Design (MID). It allows users to develop and examine interior designs in the VR fashion through a Web browser, such as the Internet Explorer and Netscape. Its potential users include interior designers, furniture vendors, and customers. Users can interact with objects in the 3D, virtual space. MID has many useful functions and features, including concurrent display of multiple views of a scene, multiuser collaboration [11], and e-commerce functions. To the best of our knowledge, it is by far the most versatile interior design software.

Users need only a Web browser to interact with MID. By visiting the MID website, one can download and display MID components in the browser window. One can then easily choose the shape of rooms, add pieces of furniture, change the colors and textures of objects, get the price quotation of products, place purchase orders, etc. To help interior designers more, five categories of built-in scenes — home, office, factory, school, and

miscellaneous — are provided. Designers can use or modify them to ease the task. On the other hand, a user who does not design can just view others' work.

A user can choose to collaborate with others when doing interior design. Any of them can modify the scene, or design, and the others can soon see the new design. In the mean time, people can exchange ideas by instant messaging. This multiuser collaboration feature allows many other possibilities. For example, a skilled user can thus teach a distant novice to use MID and to design with style.

With the same friendly browser interface, the system administrator can do more than other users. Having a special MID account, he or she can maintain various data of the furniture, textures, spaces, user accounts, etc. Particularly, new 3D furniture models and related information can be uploaded easily to be showcased.

MID can be used or modified for other e-commerce purposes. For example, it can be used directly by a furniture company to showcase and sell its products. The texture mapping and lighting functions of MID help make 3D models realistic and attractive. Customers can examine objects and place purchase orders through the browser. On-line tutoring or learning is also possible [12, 19, 22].

This paper is organized as follows. Section 2 introduces MID, including its user interface and various functions. Section 3 presents the technical aspect of MID, including its software architecture and underlying technologies; technologies from VR,

the Web, and database are used to implement MID. Section 4 introduces related work. Section 5 concludes this paper.

2 Main Functions of MID

Users access MID through its main page displayed in a Web browser, as shown in Figure 1. The main page is divided into three zones: Toolbar, on the top, Catalog, on the left, and Presentation, covering most of the page. The Toolbar zone provides access to eight main functions of MID: About, View, Design, Order, Login, Membership, Administration, and Help. By clicking any of them, its introductory information will be shown in the Catalog zone,

Presentation zone, or an additional window, when necessary. Figure 1 is displayed when MID is initially accessed or whenever the About button in the Toolbar is clicked; the Presentation zone provides introductory information about MID.

When the View button is clicked, the Catalog zone appears as that shown in Figure 1. When an item in this zone is clicked, the Presentation zone will give more information of the item. For example, if Bookshelf in the Catalog zone is clicked, the Presentation zone displays available bookshelf models as well as related information, as shown in Figure 2.

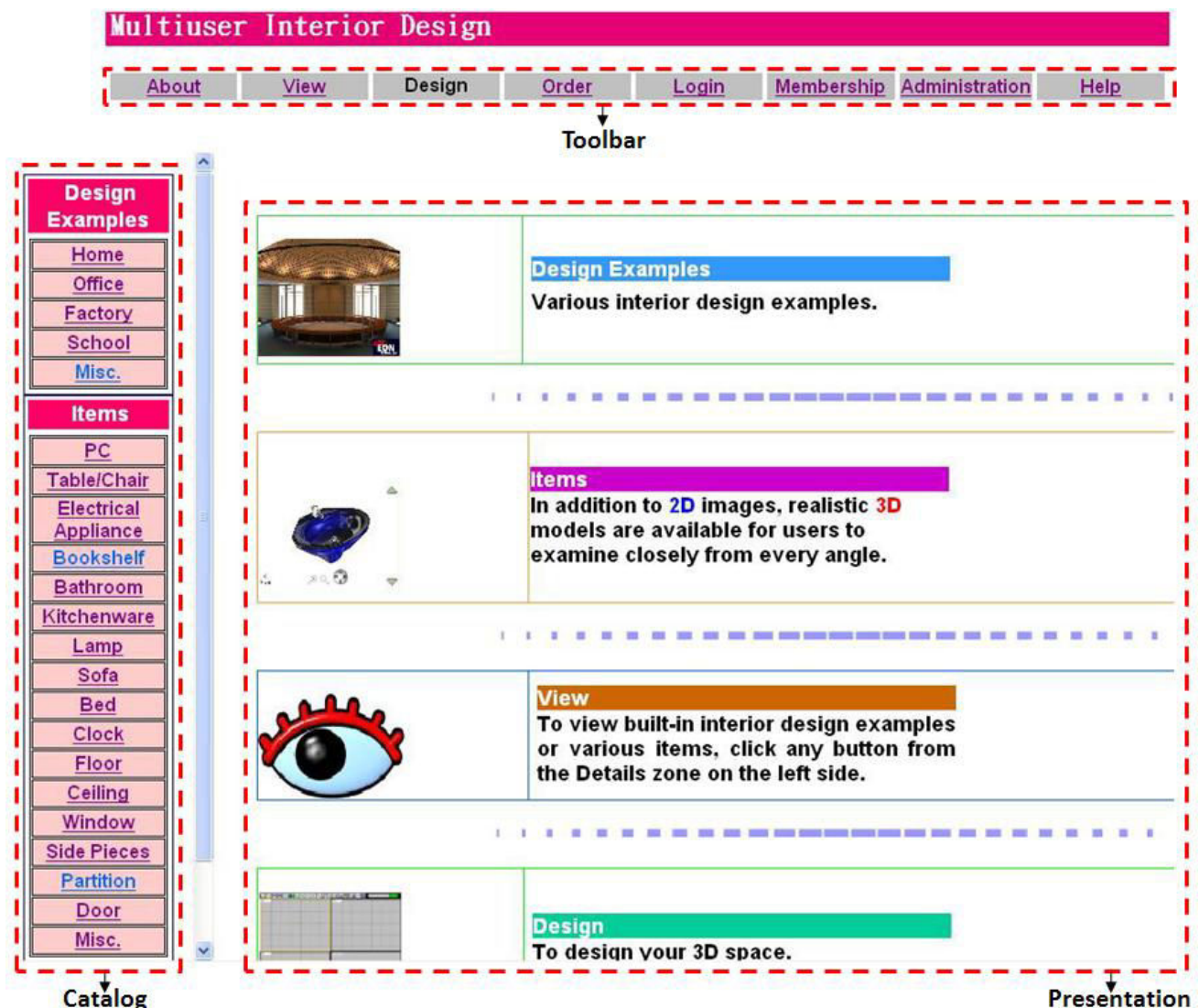


Fig. 1. Main page of MID showing three zones.

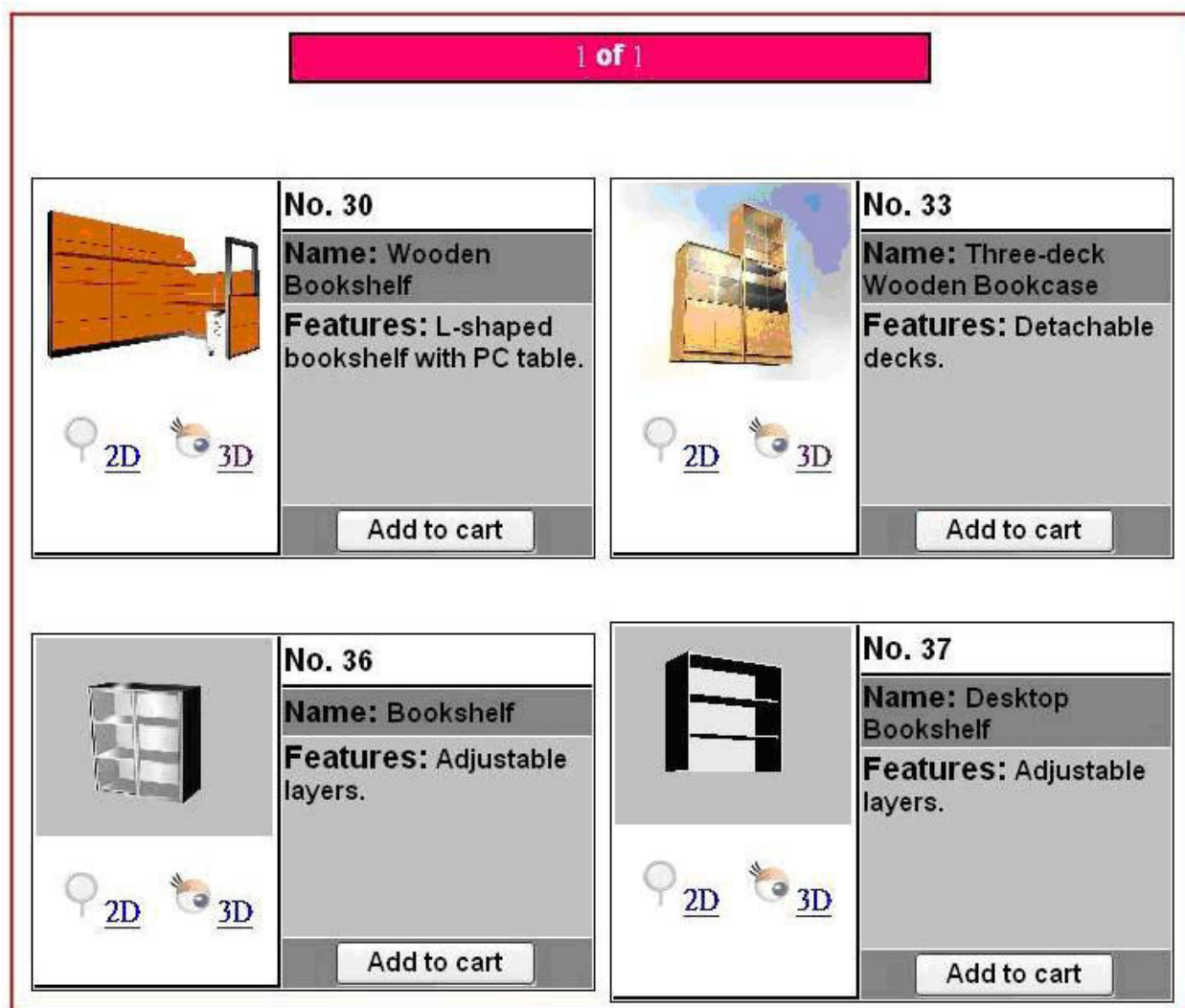


Fig. 2. Presentation zone of View page.

For any item displayed, users can click the “Add to cart” button to purchase it. Clicking the 2D button will open a new window to display a 2D image larger than that already shown above the button. On the other hand, clicking the 3D button will open a 3D window, such as that shown in Figure 3. This window allows many operations. Clicking the “Download 3D Model” button, one can download the 3D model for close examination from any angle. Clicking the “Full-Screen” button leads to full-screen display of the 3D window. Table 1 gives the functions of the icons shown in the 3D window. For example, a user can click on the four arrows of the third icon to rotate the 3D bookshelf in four different ways.

To use the Design button in the Toolbar, a user must first log in (see below). Clicking this button opens a new window for interior design, as shown in

Figure 4. This Design window is composed of three zones: Design, Attribute Selection, and Attribute Setting zones.

Table 1. Functions of icons in the 3D window.

Icon	Function
	Scroll window upward
	Scroll window downward
	Rotate 3D object for examination from different angles
	Scale up object
	Scale down object

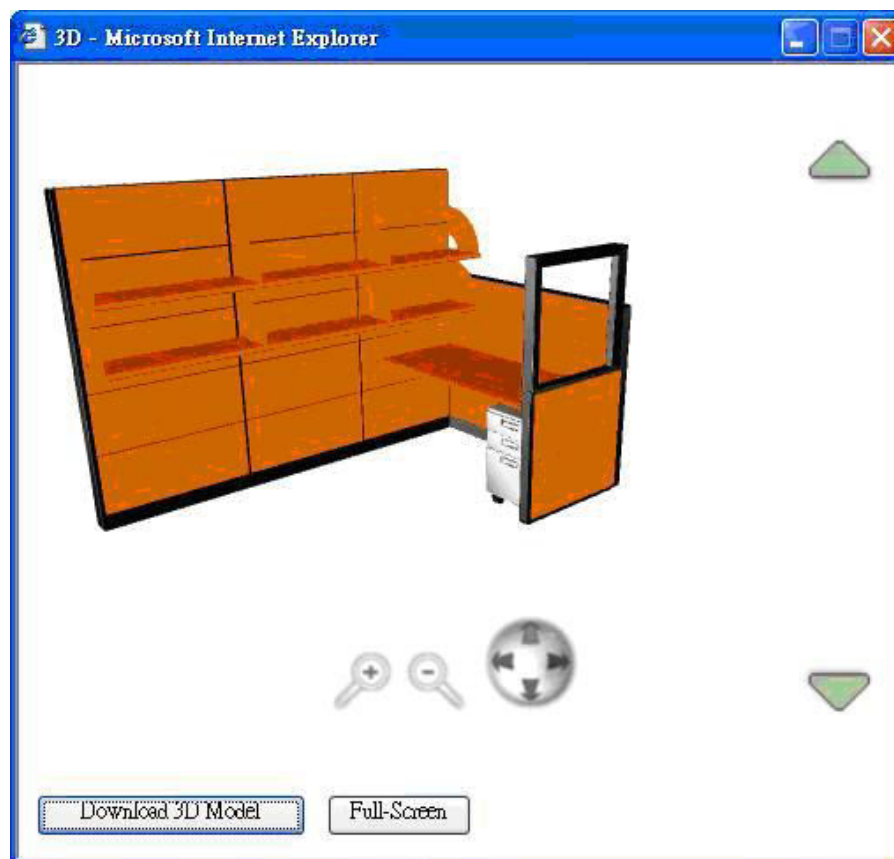


Fig. 3. 3D window.

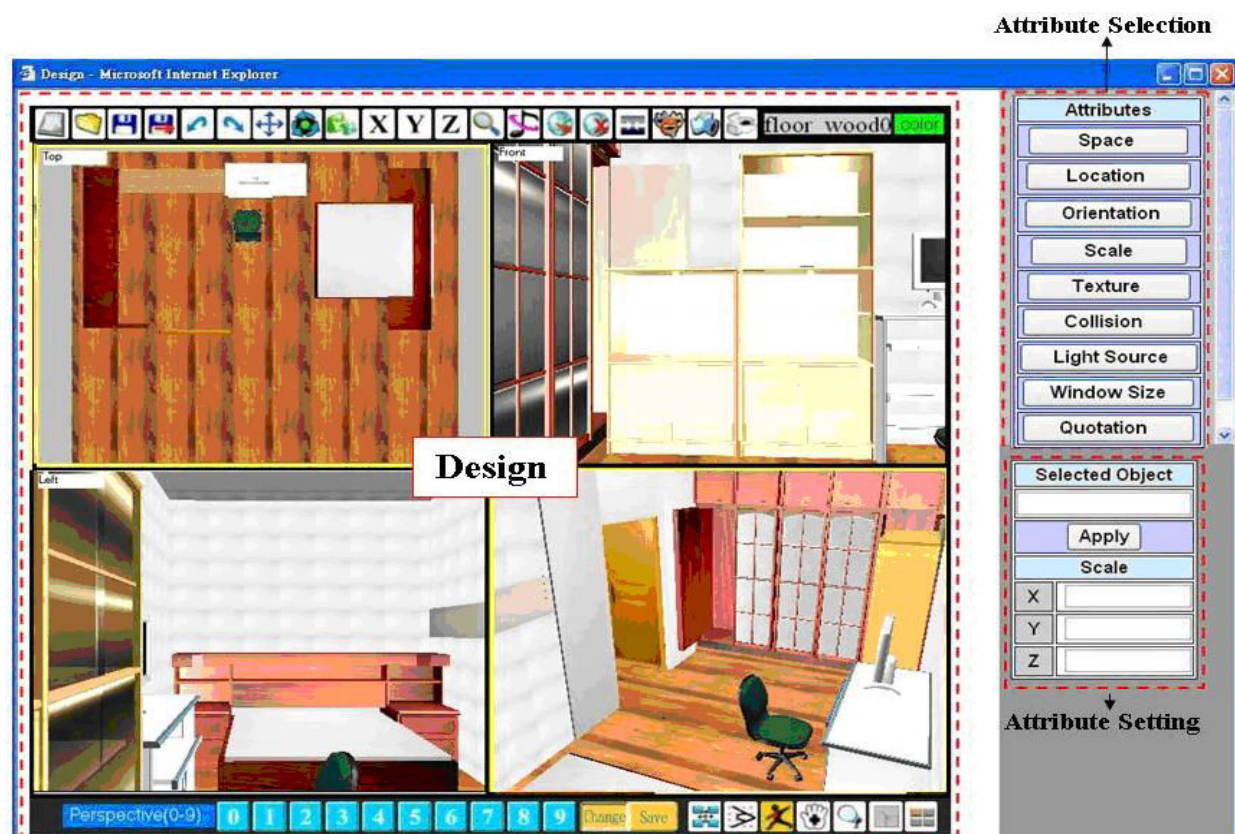


Fig. 4. Design window showing three zones.

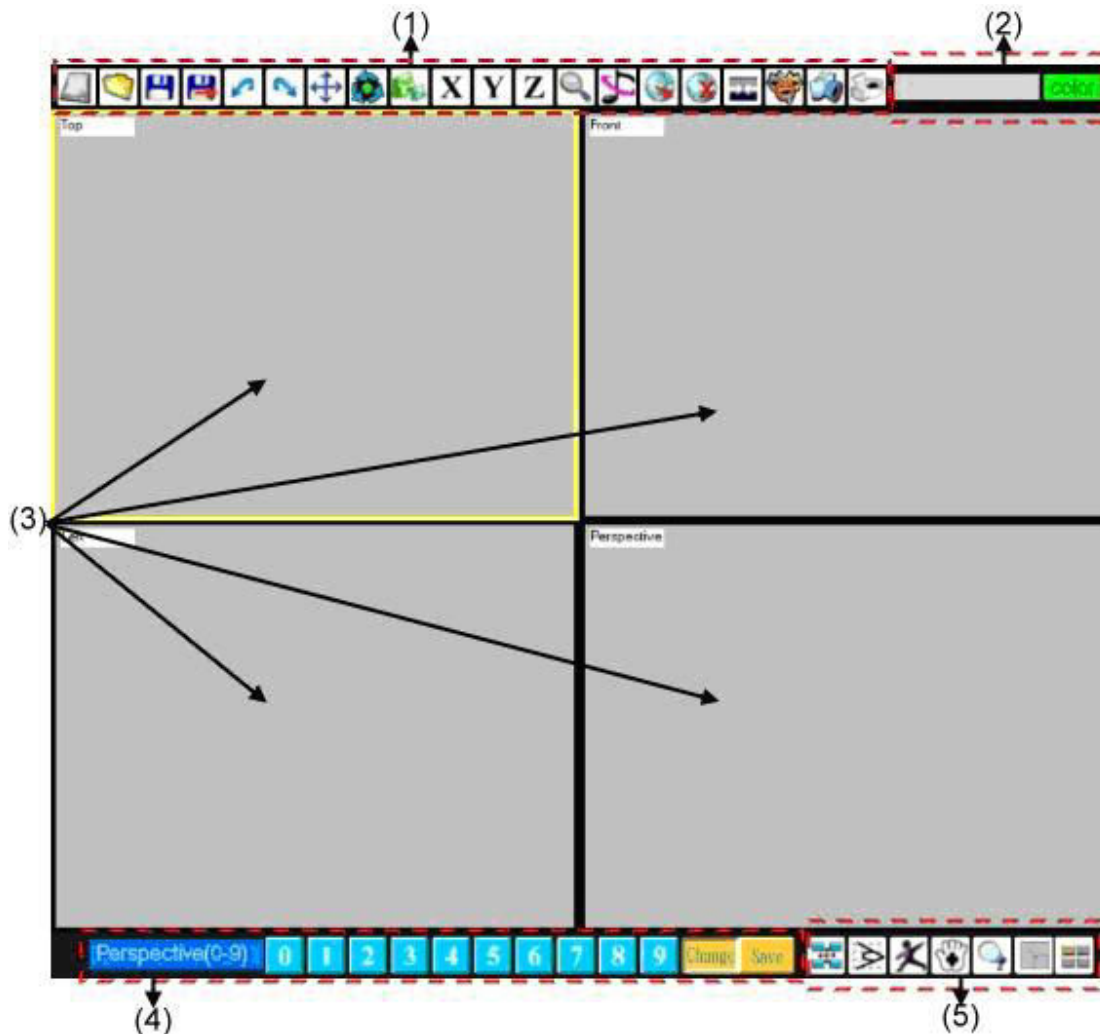


Fig. 5. Five parts of the Design zone of the Design window.

The Design zone occupies most of the window area, and the other zones are on the right. For further descriptions, Figure 5 shows five parts of the Design zone:

- (1) Design Toolbar,
- (2) Information,
- (3) Viewports,
- (4) Perspectives, and
- (5) Viewport Toolbar.

The Design Toolbar consists of 20 icons for users to perform more than 20 functions. Briefly, these icons, from left to right, are to

- (1) start a new design,
- (2) open an old file,
- (3) save the current design,
- (4) save as another design file,
- (5) undo modification,
- (6) redo modification,
- (7) move an object,

- (8) rotate an object,
- (9) scale up or down an object,
- (10) move an object along the x-axis,
- (11) move an object along the y-axis,
- (12) move an object along the z-axis,
- (13) display a selected object for close examination,
- (14) play background music,
- (15) download and add an object to the scene in the Design zone,
- (16) delete a selected object,
- (17) set or cancel collision detection of objects,
- (18) start multiuser collaboration,
- (19) save the current Design window as a PNG file, and
- (20) print the current Design window.

Note that the operations provided are actually more than those mentioned above. For example, icon 10 can also be used to rotate, scale up, or scale down

an object along the x-axis; the exact function performed depends on the user's action, which may be clicking of icon 7, 8, or 9, before clicking icon 10.

The function of icon 18 needs more explanation. Clicking this icon pops up the Collaboration window shown in Figure 6. Most of the window area is for instant messaging. A user can type in a new message and click the Send button to broadcast the message to all the collaboration participants. Clicking the "Send my design" button will transmit the user's scene in the Viewports subzone to all the other participants, and display a message "A new design has been sent to (or from) you." on the dark background. A participant can choose whether or not to click the "Display other's design" button to replace the current design with the transmitted scene in the Viewports subzone.

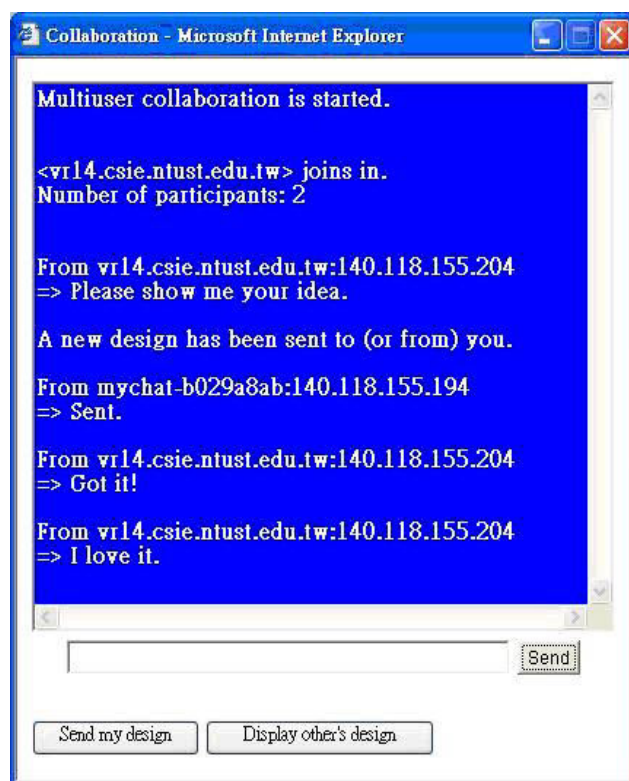


Fig. 6. Collaboration window.

This kind of communication has its merits. A user has the freedom to choose when to see a design sent from another person, and even choose not to see at all. When viewing the same scene, users can examine different parts of interest at the same time. Independent and simultaneous modifications of different parts are also possible. This may shorten the period of design development.

This kind of communication also has its drawbacks. When independent and simultaneous modifications of different parts are done on different copies of the same design by more than one person, it may take some effort to combine the changes to a single design. It may also be inconvenient when two or more collaborating people cannot see the same design being modified.

The Information subzone shows the name of a selected object in the Viewports subzone and the selected color in the palette. It helps users enhance efficiency.

The Viewports subzone has four viewports to display the top, front, side, and perspective views of the 3D interior design simultaneously. The four views of the same scene allow users to examine the scene from different angles easily. One can set the top view as 2D floor plan; the Viewports subzone then shows the scene with a 2D floor plan and three 3D views.

The Perspectives subzone contains 10 number icons and a Change/Save button for changing and saving the viewing location, or viewpoint, of the perspective view. The Change/Save button serves as a toggle switch between the change and save modes. In the save mode, clicking any of the 10 number icons saves the current perspective viewpoint; in the change mode, any number icon allows the user to change the viewpoint to a previous one saved by the icon.

The Viewport Toolbar subzone, containing seven buttons for various viewport controls, is briefly introduced in the following. The first (leftmost) button is to set the four current viewpoints as initial viewpoints when the current design is closed and then opened. The second button is to change the field of view in a selected viewport. The third is for walk-through movements and changing orientations in a selected viewport with the pressing a specific mouse button and dragging. The fourth is for changing viewpoints in any selected viewport by dragging the mouse. The fifth is primarily for toggling between the above-mentioned 3D top view and 2D floor plan. The sixth sets the whole Viewports area to display only one of the four views, and the seventh reverts to show all four views at the same time.

Now, we introduce the functions of the Attribute Selection and Attribute Setting zones already shown in Figure 4. The Attribute Selection zone contains nine buttons. The first eight should be clicked before assigning corresponding attribute values in the Attribute Setting zone below.

The functions of the attributes are described in the following:

- (1) The space attribute is for designers to choose the shape of the room. For example, the floor plan can be rectangular or round. The exact size, such as the length of each side of a rectangular room, can also be assigned.
- (2) The location attribute is for specifying a precise location to place an object to be downloaded.
- (3) The orientation attribute is to set the direction in which the front of a selected object faces.
- (4) The scale attribute is to change the size of a selected object precisely; an object can be scaled up or down along any of the three axes separately or all at once.
- (5) The texture attribute is to change the color and texture for a selected object.
- (6) The collision attribute is to set or cancel collision detection for a selected object or all the objects in the scene.
- (7) The light source attribute provides spotlight, point source, and directional lighting; users can thus adjust the brightness of the space and achieve various lighting effects.
- (8) The window size attribute allows users to specify the size of the Design window to match the resolution of the monitor screen.
- (9) The quotation button is to show the name and price of every object in the scene, as well as the total price.

The other MID main functions in the Toolbar shown in Figure 1 is relatively easy to understand. They are briefly introduced in the following. The Order function allows users to buy products. Clicking the Login button to log in, a member can thus do interior design and order products. The Membership function allows users to apply for membership and modify personal information. The Administration function is used only by the administrator to operate on databases, which include the furniture, texture, space, scene, and membership databases. Finally, Help provides information to help users use MID effectively.

3 Software Architecture and Underlying Technologies

MID has a three-tier architecture (Figure 7). It contains

- (1) a client, essentially a Web browser,
- (2) a Web server, or application server, and
- (3) a database server.

MID software components, including those implemented with HTML, JavaServer Pages (JSP) [6, 8], VBScript, and JavaScript, are stored in the Web server. Data such as members' personal information, purchase orders, 3D models, textures, and music are all kept in the database server. The Web server communicates with the database server by using SQL to inquire and modify information [1, 17].

The MID Web server is based on the Apache HTTP Server [1, 17]. The Apache HTTP Server is powerful and modular; users can choose appropriate modules to fit their needs when setting up Web servers. It can handle static HTML and images, but needs a JSP engine to run JSP programs and Java servlets [15]. Resin is used as our JSP engine [2, 14].

Java servlets are programs that implement dynamic Web pages to provide interaction between users and Web applications. JSP is for easier design of Web pages. By using servlets and JSP programs, Web servers can interact with users over the Internet. The JSP engine compiles and executes JSP programs. When a JSP program is to be executed for the first time, the JSP engine translates it into a servlet to execute. If the same JSP program is to be executed again, it need not be compiled again.

Microsoft Access 2002, a relational database management system, is used to manage MID databases. A user reads or writes database contents through JSP programs by using Java Database Connectivity (JDBC) application programming interface [15]. JDBC is a database-independent technology for querying and updating data in a database.

At the client side, EonX is installed automatically before MID is downloaded to display in a Web browser. EonX is a Microsoft ActiveX control and is needed to download MID components [10], including textures and music, to the browser. Data, such as interior design contents and purchase orders, are also downloaded or uploaded over the Internet. Note that purchase orders can be transformed to be Microsoft Excel files.

EON applications, or simulations, implement the main body of MID: View and Design functions. Creating an EON simulation requires

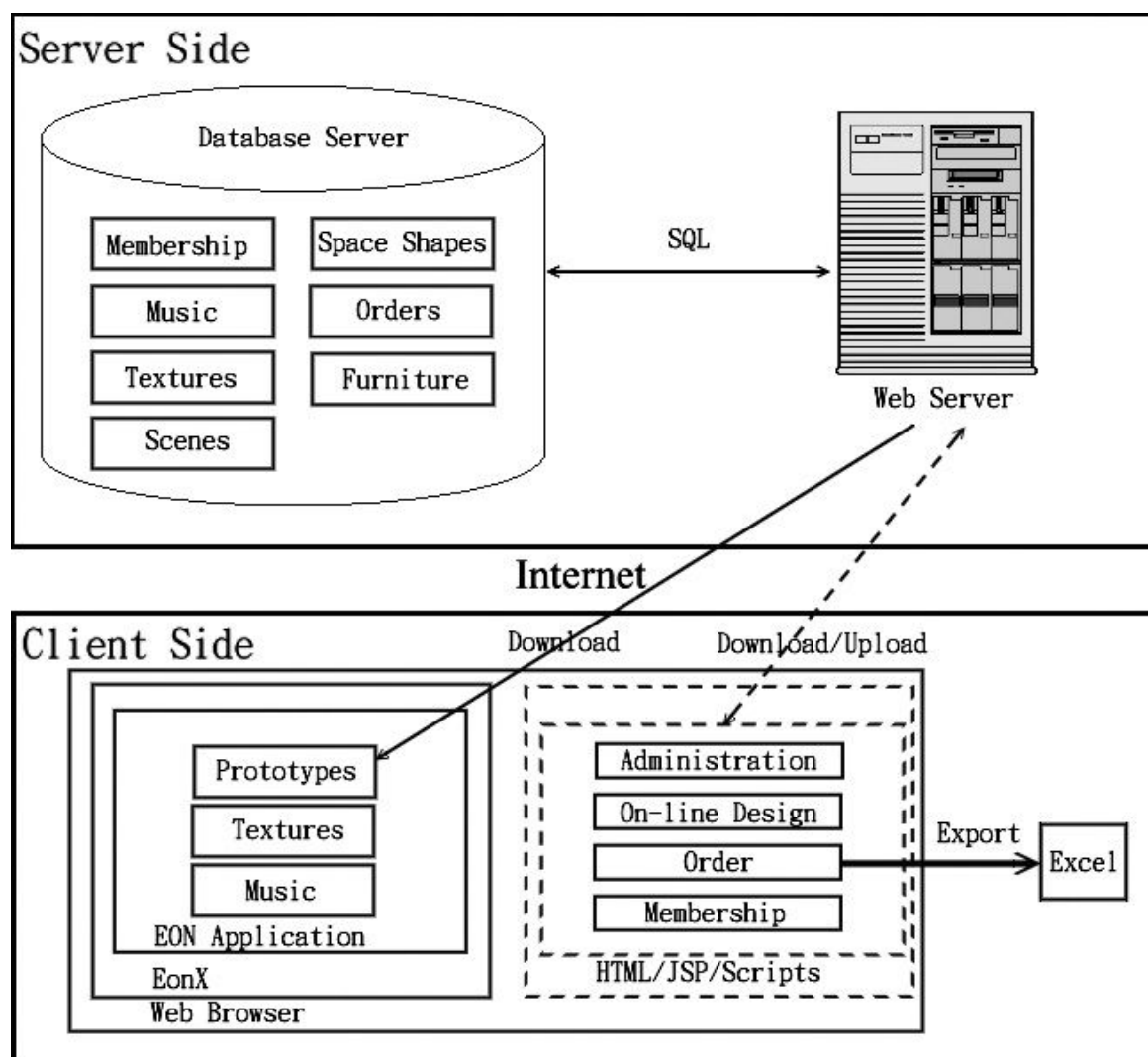


Fig. 7. MID architecture.

- (1) importing 3D graphic models,
- (2) assigning behavioral properties for these models, and
- (3) specifying users' interactions with the models when running the simulation.

With EON Studio, an interactive authoring tool for generating 3D/VR simulations [7], an EON application is built from basic components called nodes. Each node exhibits a feature or an element in the simulation, and can interact with other nodes. The information received by a node results in some action, such as moving a 3D model. EON provides more than 120 built-in nodes. A special Script node allows creating new nodes; thus, many MID functions are implemented in VBScript.

EON Studio has many features; a few of them are as follows. It has a graphical user-interface and thus

is easy to program. It allows the user to design vivid simulations interactively. The file size of EON applications is small, making it suitable for Web accesses. EON applications can be included in other software, such as Visual Basic and PowerPoint, to exhibit 3D, interactive simulations.

The MID Design window is implemented with quite a few software products and technologies. The 3D models are created with 3ds max, which is a 3D model authoring tool, while 2D pictures are designed with PhotoImpact. The interactive simulation shown in the Design zone is created with EON Studio. The Attribute Selection and Attribute Setting zones are implemented with JSP and HTML. These two Attribute zones need to communicate with the Design zone for data transfers. JavaScript programs, embedded in HTML, are used by the two zones to

pass data via EonX to a Script node. On the other hand, the EON application uses a Script node to send data to the Attribute Setting zone via EonX.

The multiuser collaboration is implemented with the client-server model. The server is implemented in Java, and client processes are Java applets. A client process takes care of the Collaboration window, which is already shown in Figure 6. When a user clicks the Send (respectively, "Send my design") button, the typed message (respectively, interior design) is first sent by the client process to the server. The server then broadcasts the received content to all the other collaboration participants' client processes. These client processes display the message automatically, but do not display the scene automatically; they inform users of the scene transmission by a message in the Collaboration window. Users can receive the scene or not. If they do, they click the "Display other's design" button so that the client process will notify MID to display the received design in the Design window.

Specifically, the implementation of the Collaboration window, including the Send (instant message) function, at the client side is straightforward and is implemented with Java applets. On the other hand, when the "Send my design" button is clicked, the client calls a JavaScript function to obtain scene data from the Design window component of the EON application via EonX; then, the client sends the scene to the server. When the "Display other's design" button is clicked, the client calls another JavaScript function to inform the EON application of the event via EonX; then, an EON Script node implemented in VBScript displays the scene.

4 Related Work

EON Planner [3] is a Web application for interior design. It allows users to define the layout and size of the virtual space. They can then add furniture to the space. Once the users are satisfied with the design, they can save and print it. The price quotation of the selected products can also be printed out. However, EON Planner cannot change the color and texture of furniture. Moreover, unlike MID, it has no correspondence between its 2D and 3D views, and does not support multiuser collaboration.

Room Planner [4] provides a 2D virtual room for interior design. Users can decide the room size and add furniture to the room. Although users can save the design, print the design, and buy the items in the room, its functionality is quite limited. For example,

it has no 3D views; thus, users may not be able to tell a round table from a round mat.

Outline3D [5], in general, is more powerful than EON Planner and Room Planner, but it does not support, for instance, multiuser collaboration, light source setting, and background music. It has fewer functions and capabilities than MID.

5 Conclusions

MID is an interior design system implemented with technologies from VR, database, and the Web. It provides users with a Web-based, interactive, 3D, and user-friendly interface to ease the task of interior design. Users can, for example, view others' interior designs, develop their own designs, examine products, and place purchase orders. In addition to the functions provided by other similar software, MID includes many unique features, such as concurrent display of multiple views of a scene, multiuser collaboration, light source setting, and background music.

MID can be easily modified for other purposes. Data and information-related parts may need modification, but many of the functions can be reused as a framework. For example, MID can be easily modified for selling almost any goods on the Internet. The collaboration feature is a plus for many services; this is particularly true for on-line tutoring or learning applications.

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References:

- [1] Apache: The Apache Software Foundation, <http://www.apache.org>.
- [2] Cauchon: Resin with Apache, <http://www.cauchon.com/resin-3.0/install/cse-apache.xtp>.
- [3] EON Reality: EON Planner, http://www.eonreality.com/products/eon_planner.htm.
- [4] Furniture.com: Room Planner, <http://www.furniture.com/common/roomplanner>.
- [5] ParallelGraphics Outline3D, <http://www.outline3d.com>.
- [6] Sun: JavaServer Pages Overview, <http://java.sun.com/products/jsp/overview.html>.
- [7] EON Reality, Irvine, CA: EON Studio 4.1, 2003.
- [8] H. Bergsten, JavaServer Pages, 3rd ed., O'Reilly, 2003.

- [9] G. C. Burdea and P. Coiffet, *Virtual Reality Technology*, 2nd ed., Wiley, 2003.
- [10] D. Chappell, *Understanding ActiveX and OLE*, Microsoft, 1996.
- [11] E. F. Churchill, D. N. Snowdon, and A. J. Munro, *Collaborative Virtual Environments: Digital Places and Spaces for Interaction*, Springer-Verlag, 2001.
- [12] J. de Lara and M. Alfonseca, Visual interactive simulation for distance education, *Simulation*, Vol. 79, 2003, pp. 19-34.
- [13] E. Ginters, A. Cirulis, and V. Akishin, Virtual environment use in e-learning, *Proceedings 6th WSEAS International Conference on E-Activities*, Tenerife, Spain, 2007, pp. 12-16.
- [14] R. Hightower and J. D. Gradecki, *Mastering Resin*, Wiley, 2003.
- [15] J. Hunter and W. Crawford, *Java Servlet Programming*, 2nd ed., O'Reilly, 2001.
- [16] N. Ibrahim, M. A. M. Balbed, A. M. Yusof, F. Hani, M. Salleh, J. Singh, and M. S. Shahidan, Virtual reality approach in acrophobia treatment, *Proceedings 7th WSEAS International Conference on Applied Computer & Applied Computational Science*, Hangzhou, China, 2008, pp. 194-197.
- [17] E. Naramore, J. Gerner, Y. L. Scouarnec, J. Stolz, and M. K. Glass, *Beginning PHP5, Apache, and MySQL Web Development*, Wiley, 2005.
- [18] N. Sala, Multimedia and virtual reality in architecture and in engineering education, *Proceedings 2nd WSEAS/IASME International Conference on Educational Technologies*, Bucharest, Romania, 2006, pp. 18-23.
- [19] C. Schmid, A remote laboratory using virtual reality on the Web, *Simulation*, Vol. 73, 1999, pp. 13-21.
- [20] P. L. Seiciu, I. D. Filipoiu, and T. Laurian, Theoretical aspects related to the design of a mechatronic system for recovery of the disabled persons, *Proceedings 9th WSEAS International Conference on Automation and Information*, Bucharest, Romania, 2008, pp. 230-235.
- [21] W. R. Sherman and A. B. Craig, *Understanding Virtual Reality*, Morgan Kaufmann, 2003.
- [22] W. T. Sung and S. C. Ou, Web-based learning in the computer-aided design curriculum, *Journal of Computer Assisted Learning*, Vol. 18, 2002, pp. 175-187.