

## MULTIUSER INTERIOR DESIGN OVER THE INTERNET

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### ABSTRACT

This paper presents a Web-based interior design application named Multiuser Interior Design (MID). We use technologies from virtual reality (VR), the Web, and database to implement MID. It allows users to operate in the VR fashion, interacting with objects in the 3D, virtual space. Users need only a Web browser to view and elaborate designs, examine furniture, place purchase orders, etc. MID contains many useful functions and features Web-based multiuser collaboration. We introduce the user-interface and main functions of MID that users will operate. The technical aspect of MID, including software architecture and underlying technologies, is also presented. MID can be easily modified for other purposes; only information-related portions need modification, and the other portions serve as reusable framework.

### 1 INTRODUCTION

This paper presents an interior design application named Multiuser Interior Design (MID). We use technologies from virtual reality (VR), the Web, and databases to implement MID. It allows users to develop interior designs in the VR fashion. Users can interact with objects in the 3D, virtual space. MID contains many useful functions, and features, among others, multiuser collaboration through a Web browser, such as the Internet Explorer and Netscape. To the best of our knowledge, it is by far the most versatile interior design system.

The user interface to MID is a common Web browser. Using the correct URL, one downloads MID to the browser window. The user can easily shape the space, add pieces of furniture, change the color and texture of objects, get price quotes for the added products, etc.

A user can choose to collaborate with others on-line. Any of them can modify the scene, or interior design, and the others can soon see the new design. In the mean time, people can communicate with instant messaging. The mul-

tiuser collaboration feature allows many other possibilities. For example, a skilled user can easily teach a distant novice how to use MID or how to design with style. A user who does not design can view others' design. To ease interior designers' work, we provide built-in scenes that are classified into five categories: home, office, factory, school, and miscellaneous. Designers can directly use or modify these built-in scenes.

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

MID is not just good for interior design. For example, a furniture company can use MID to showcase and sell its products. Texture mapping and lighting help make 3D models attractive. Customers can examine furniture and even make purchases on-line.

This paper is organized as follows. Section 2 introduces MID, including its user-interface and main functions that users will operate. Section 3 presents the technical aspect of MID, including its software architecture and underlying technologies. Section 4 introduces related work. Finally, Section 5 concludes this paper.

### 2 MAIN FUNCTIONS OF MID

Users access MID through a Web browser. The main page of MID is divided into three zones called Toolbar, Details, and Presentation, as shown in Figure 1. The Toolbar zone displays eight main functions of MID: About, View, Design, Order, Login, Membership, Administration, and Help. By clicking any of the eight functions, information about the function will be shown in the Details zone, in the Presentation zone, or in an additional window. Figure 1 is displayed when MID is initially accessed or whenever the About button in the Toolbar is clicked.



Figure 1: Main Page of MID Showing Three Zones

When the View button is clicked, the Details zone is exactly the same as the Details zone in Figure 1. When an item in this zone is clicked, the Presentation zone will give more information. For example, after Bookshelf in the Details zone is clicked, the Presentation zone in Figure 2 shows bookshelf models as well as their related information.

For any item in the Presentation zone, users can click the “Add to cart” button to purchase it. Clicking 2D will open a new window to display a larger 2D image than that above the 2D button. On the other hand, clicking 3D will open a 3D window, such as the one shown in Figure 3. Figure 3 allows many operations. Table 1 gives the functions of the icons shown in the 3D window when the icons are clicked. Clicking the “Download 3D Model” button, we can download the 3D model for examination from any angle. Clicking the Full-Screen button leads to full-screen display of the 3D window.

To click the Design button in the Toolbar, a user must have logged in (see below on how to log in). By clicking this button, the Design window is opened, as shown in Figure 4, for interior design. This window is composed of three zones: Design, Attribute Selection, and Attribute Setting zones. Figure 5 shows five parts of the Design zone: (1) Design Toolbar, (2) Information, (3) Viewports, (4) Perspectives, and (5) Viewport Toolbar.

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

The Design Toolbar contains 20 icons for users to perform more than 20 functions. Briefly, these operations, from left to right, are to (1) start a new design, (2) open an old file, (3) save 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 only a selected object for close examination, (14) play background music, (15) download an object and add it to the scene, (16) delete a selected object in the Design zone, (17) set or cancel collision detection of objects, (18) start multiuser collaborative design, (19) save

the current Design window as a PNG file, and (20) print the current Design window. Note that the operations supported are actually more than the above-mentioned. For example, icon 10 can also be used to rotate an object about the  $x$ -axis, scale up an object along the  $x$ -axis, and scale down an object along the  $x$ -axis. The exact function performed depends on other details, such as the previous clicking of icon 7, 8, or 9. The function of icon 18 deserves more description. When this icon is clicked, the Collaboration window appears (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 Design window to all the other participants, and display a message “A new design has been sent to (or from) you.” in the Collaboration window. A participant must then click the “Display other’s design” button to display the transmitted scene in the Design window.

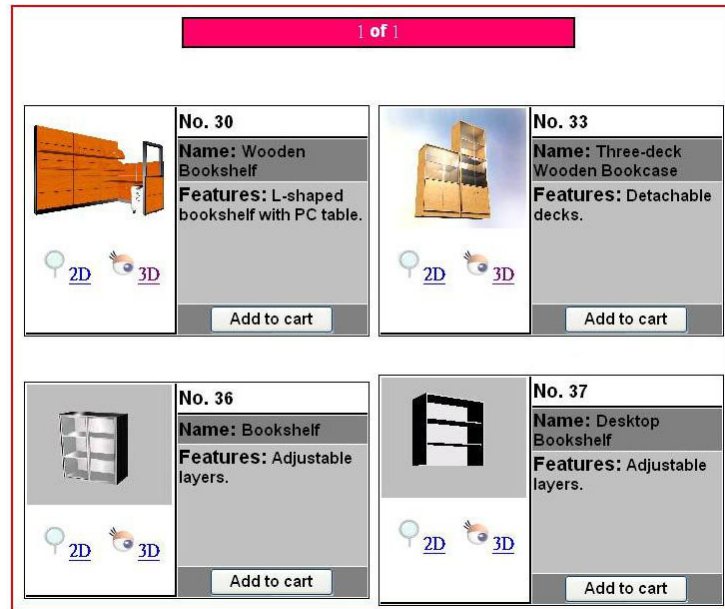


Figure 2: Presentation Zone of View Page



Figure 3: 3D Window

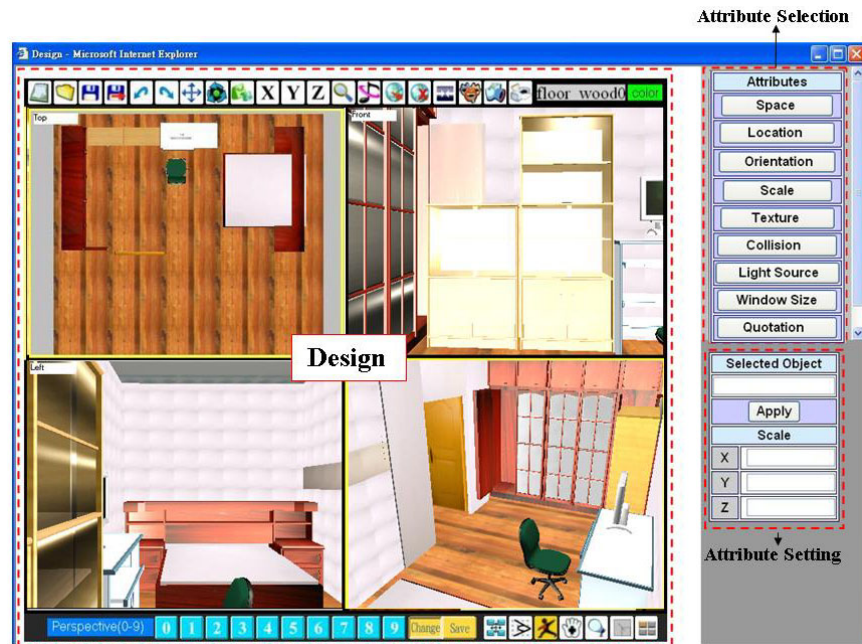


Figure 4: Design Window Showing Three Zones

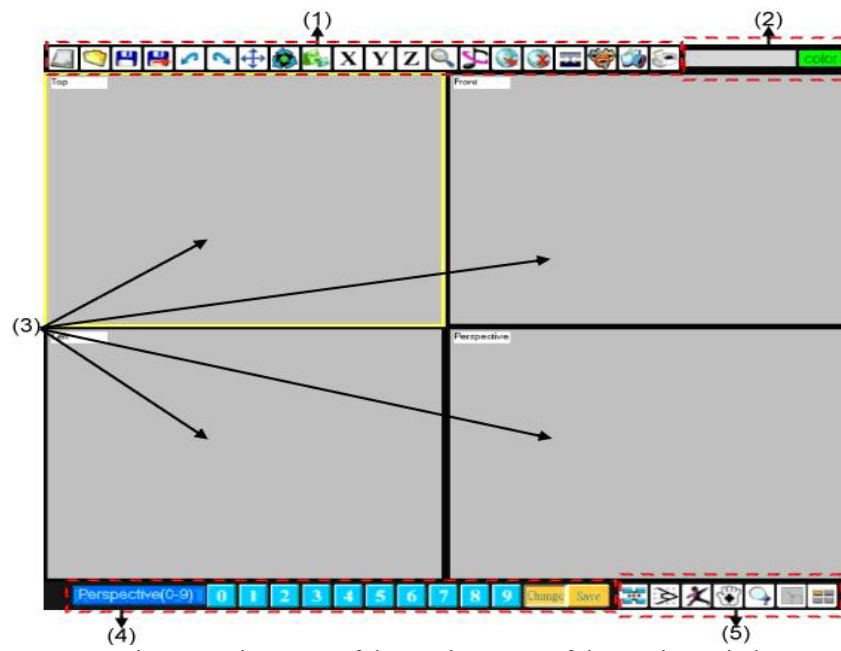


Figure 5: Five Parts of the Design Zone of the Design Window



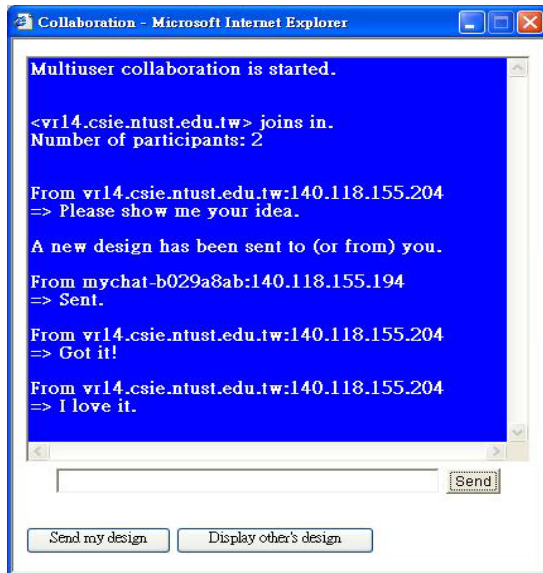


Figure 6: Collaboration Window

The Information subzone shows the name of a selected object in the Viewports subzone and the selected color in the palette. They remind users of their operations.

The Viewports subzone has four viewports to display the top, front, side, and perspective views, respectively, of the 3D interior design. 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 three 3D views and a 2D floor plan.

The Perspectives subzone contains 10 numbered icons and a Change/Save button for saving and changing viewing locations, or viewpoints, in the Perspective viewport. The Change/Save button serves as a toggle switch between the save and change modes. In the save mode, clicking any of the 10 icons saves the current viewpoint in the Perspective viewport; in the change mode, any of the 10 icons allows the user to change the viewpoint to a saved one.

The Viewport Toolbar subzone contains seven buttons for various viewport controls; which we briefly introduce here. The first (leftmost) button is to set the current viewpoints of the four viewports as initial viewpoints, respectively, when the current design file is re-opened. The second is to change the field of view in a selected viewport. The third is for various walk-through movements and viewpoint changes in a selected viewport with the help of pressing one of the three mouse buttons and dragging. The fourth is for changing the viewpoint in a selected viewport. The fifth is used for toggling between the 3D top view and 2D floor plan. The sixth sets the whole Viewports subzone to display only one of the four views, and the seventh reverts to show four viewports.

As shown in Figure 4, the Attribute Selection zone contains nine buttons. The first eight can be clicked to as-

sign the corresponding attribute values in the Attribute Setting zone. 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 or the radius of a round room, can also be assigned. The location attribute is for specifying a precise location to place the object to be downloaded. The orientation attribute is to set the orientation of a selected object. 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. The texture attribute is to choose the color and texture for a selected object. The collision attribute is to set or cancel collision detection for a selected object or all the objects in the scene. The light source attribute provides spotlight, point source, and directional lighting; users can thus adjust the brightness and achieve various lighting effects. The window size attribute allows users to specify the size of the Design window to match the resolution of the monitor screen. Finally, 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 in Figure 1 are briefly described here. The Order function allows users to buy the products offered on the Web server. Clicking the Login button, a member can log in to design and order furniture. The Membership function allows users to apply for membership and modify personal information. The Administration function is only used by the administrator to operate on databases, such as the furniture, texture, space, scene, and membership databases. Finally, Help provides information to help users.

### 3 SOFTWARE ARCHITECTURE AND UNDERLYING TECHNIQUES

MID uses a client-server architecture, as shown in Figure 7. Its software components, including those implemented in HTML, JavaServer Pages (JSP) (Bergsten 2003, Sun), 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 using SQL to query and modify information.

The MID Web server is based on the Apache HTTP Server (Apache, Narnmore et al. 2005), which is commonly used in Web servers. Apache is powerful and modular; users can choose appropriate modules to fit their needs. It can handle static HTML and images, but needs a JSP engine to run Java servlets and JSP programs (Hunter and Crawford 2001).

Java servlets are used to ease the implementation of interactive programs over the Internet. JSP is introduced to further simplify the design of dynamic Web pages. By us-

ing servlets and JSPs, Web servers can interact with users to respond to their requests.

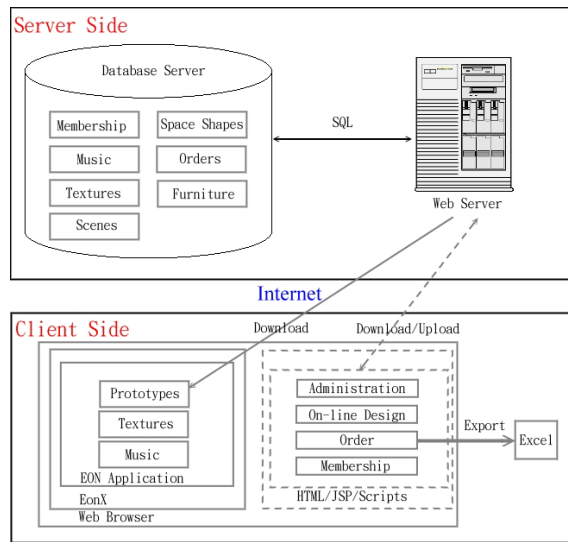


Figure 7: MID Architecture

The JSP engine compiles and executes JSPs. When a JSP is executed for the first time, the JSP engine translates the JSP into servlets. If the same JSP is executed again, it is not compiled again. We use Resin (Caucho, Hightower and Gradecki 2003) to process servlets and JSPs.

Microsoft Access 2002 is a relational database management system. It is used to manage databases for storing MID data on the server side. When a user reads or writes database contents through JSPs, Java Database Connectivity (JDBC) is used (Hunter and Crawford 2001). JDBC is an application programming interface for querying and updating data in a database.

At the client side, EonX must be installed before MID can be downloaded to display in a Web browser. EonX is a Microsoft ActiveX control. It is used to download EON simulations, or applications (Chappell 1996), including textures and music, which implement the main body of MID: View and Design functions, to the Web 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 readable by Microsoft Excel.

Creating an EON simulation requires importing 3D graphic models, assigning behavioral properties for these models, and specifying users' interactions with them when running the simulation. EON Studio is an interactive authoring tool for generating 3D/VR simulations (EON Reality 2003). It has many features, four of which are: a graphical user-interface which facilitates programming; it allows the user to design vivid simulations interactively; the small file size of EON applications make it suitable for Web accesses; EON applications can be included in other

software, such as Visual Basic and PowerPoint, to exhibit 3D, interactive simulations.

With EON Studio, an application is built from basic components called nodes. (More than 120 built-in nodes are provided.) 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. The EON Script node, which allows one to create new nodes; is used to implement many MID functions in VBScript.

The MID Design window is implemented with several software products and technologies. The 3D models are created with 3ds max, which is a 3D model authoring tool; 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 communicate with the Design zone to pass data. JavaScript programs, embedded in HTML, are used by the two zones to pass data via EonX to a Script node. The EON application uses a Script node to send data to the Attribute Setting zone via EonX.

Multiuser collaboration is implemented as a client-server architecture. The client process works with the Collaboration window (Figure 6). A user can send a typed message using the "Send button" or a design using the "Send my design". When the server receives the message or the design, it broadcasts the received content to all the other collaboration participants' client processes. Client processes receiving the design do not display it automatically, so users who have read the notification of scene transmission in the Collaboration window must click the "Display other's design" button; the client process then notifies the Design window to display the received design.

The server is implemented in Java; client processes are Java applets. (The client-side implementation of the Collaboration window, including the Send function, is straightforward and is implemented with Java applets.) On the other hand, when the "Send my design" button is clicked, a client-side JavaScript function is called to obtain the design data from the EON application, which implements the Design window via EonX; the client then passes the data to the server. The "Display other's design" button works similarly; another client-side JavaScript function uses EonX to inform the EON application of the event and then an EON Script node implemented in VBScript displays the new design.

#### 4 RELATED WORK

EON Planner (EON Reality) is a Web application for interior design. It provides a virtual space for users to define the layout and size of the space. Users can place furniture such as tables and chairs in the space and explore different layouts. Once the users are satisfied with the virtual envi-

ronment, 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 (Furniture.com) provides a 2D virtual room for interior design. Users can choose the room size and add furniture to the room. Although users can save and print the design, and buy the items in the room, its functionality is quite limited. For example, it has no 3D views; thus, users cannot tell a round table from a round mat.

Outline3D (ParallelGraphics), in general, is more powerful than EON Planner and Room Planner, but it does not support multiuser collaboration, light source setting, and background music. It has fewer functions and capabilities than MID.

## 5 CONCLUSION

MID is implemented with technologies from VR, databases, and the Web. It provides users with interactive, 3D, and on-line interface for creating interior design. Users access MID through a Web browser to view or to create interior designs, examine products, and place purchase orders. In addition to functions provided by other similar software, MID provides unique features, such as multiuser collaboration, light source setting, and background music.

MID serves as a reusable framework that can be easily modified for other purposes (e.g., MID can be used for selling almost any goods over the Internet). Only the information-related portions need modification. The collaboration feature is useful for many services, specially, for on-line instruction or learning applications.

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