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ABSTRACT

The graphical user interface (GUI) has become something of a standard for instructional programs in recent years. One type of GUI is the metaphorical type. For example, the Macintosh GUI is based on the "desktop" metaphor where objects one manipulates within the GUI are implied to be objects one might find in a real office's desktop. Metaphors can be divided into two classes: underlying (or primary) and auxiliary (or secondary). Auxiliary metaphors may be either complementary, adding to the underlying metaphor, or confounding, in which the user finds the metaphor too problematic and rejects the comparison. Not all objects or images that appear in a GUI are guaranteed to be metaphorical. This paper attempts to classify metaphorical interfaces along a four-point continuum from lowest level of metaphorical implementation to highest, from non-metaphorical to immersive. It explores how position on that continuum exemplifies the interaction between complementary and confounding auxiliary metaphors and determines the design demands of an interface. It also considers how the same basic metaphor may be implemented differently to meet these demands. Eleven illustrations are provided. (Contains 23 references.) (Author/AEF)

Title:

Towards A Taxonomy Of Metaphorical Graphical User Interfaces: Demands And Implementations

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The Graphical User Interface (GUI) has become something of a standard for instructional programs in recent years. Not all graphical programs' interfaces, however, implement the GUI in the same way. Some are more graphical than others and some employ a more unified approach than others. One type of graphical user interface is the metaphorical GUI. A metaphorical GUI bases its look and feel, as well as many of its operations, on an explicit or implicit metaphor. For example, the Macintosh GUI is based on the "desktop" metaphor; objects one manipulates within the GUI are implied to be objects one might well find on a real office's desktop.

Cates (1994) divided metaphors into two classes: *underlying* (or *primary*) metaphors and *auxiliary* (or *secondary*) metaphors. The underlying metaphor is the principal metaphor employed or, by default, the first metaphor introduced, while an auxiliary metaphor is a subsequent metaphor employed by the product. The underlying metaphor establishes the implied comparison and the basic framework for the interface. Auxiliary metaphors may be either *complementary* or *confounding*. Complementary auxiliary metaphors add to, enhance, and help complete the underlying metaphor. They exhibit high degrees of affinity and acceptable levels of contrast in relation to the underlying metaphor (Kittay, 1987) and they operate in ways that match the experiences of users working with the object to which the designer is comparing the product's interface (the underlying metaphor). When contrast occurs, it is of the type that encourages users to reinterpret and reconstruct their understanding of how the interface operates (Miller, 1979; Searle, 1979). A confounding auxiliary metaphor is one in which the user finds the contrast too great and rejects the comparison (Semper, 1990).

Once again using the Mac's operating system as the basis for discussion, the underlying metaphor is the "desktop." The main auxiliary metaphors are the document, the folder, and the trash can. Documents — represented by icons that look like papers — and folders are clearly objects one might find on a desktop and are complementary auxiliary metaphors, therefore. In contrast, however, the trash can auxiliary metaphor would need to be classified as confounding. While one might well expect to find a trash can in an office, it is both illogical and inconsistent — although convenient — for the trash can to reside on top of the desk (Vertelney, Arent, & Lieberman, 1990).

Not all objects or images that appear in a graphical user interface are guaranteed to be metaphorical, however. For example, once again in the Mac interface, while a computer hard disk (represented in the interface by a labeled icon of a hard drive) is clearly an object that might appear on a desktop, it is in no way metaphorical. The same is true for floppy disks (represented similarly by labeled iconic representations on the desktop). That is, in order for something to be metaphorical, it must represent one thing in terms of something else different (Black, 1979; Lakoff & Johnson, 1980). In addition, interfaces sometimes employ graphical images that are purely symbolic. For example, the Mac interface displays what appears to be a teddy bear's head attached to a 3.5" diskette "body" to represent the Fetch™ program. While the interface designers at Apple cannot be blamed for non-metaphorical program icons, there is reason to be concerned that non-metaphorical icons may serve to "break the spell" of the underlying metaphor, thus reducing the user to a non-systematic evaluation of what he or she sees on a case-by-case basis (Cates, 1993). When the spell is broken, the user no longer seems likely to benefit from the augmentative properties of metaphorical interface design that Rosendahl-Kreitman (1990) has suggested add so much to the experience of using the program. In a graphical user interface, metaphorical images can help users make linkages between their imaginal and semantic networks (Paivio, 1971, 1979, 1986), thereby creating the webs of association that help to take advantage of learners' mental models and previous experiences (Erickson, 1990; Mac Cormac, 1985).

Cates (1993) offered a three-level (superficial-literal-interpretive) model for evaluating the metaphorical promise of icons. That paper emphasized the relationship between visual images and metaphors in terms of the ways users understand and interpret interfaces. Cates (1994) suggested that designers use the five-part POPIT (properties, operations, phrases, images, and types) model to identify imaginal and semantic links and thus, complementary auxiliary metaphors. The present paper attempts to classify metaphorical interfaces along a four-point continuum from lowest level of metaphorical implementation to highest, from non-metaphorical to immersive. It explores how position on that continuum exemplifies the interaction between complementary and confounding auxiliary metaphors and determines the design demands of an interface. Along the way, we will consider how the same basic metaphor may be implemented differently to meet these demands.

Graphical But Non-Metaphorical User Interfaces (GNUI)

This position on the continuum equates with the null or end-stop position. That is, it is included here merely to indicate where metaphorical GUIs end. A GNUI is an interface that employs images and asks the user to perform actions using graphical images, but employs no underlying metaphor. That is, the user is not asked to compare what he or she is doing to actions in some other situation, setting, or condition.

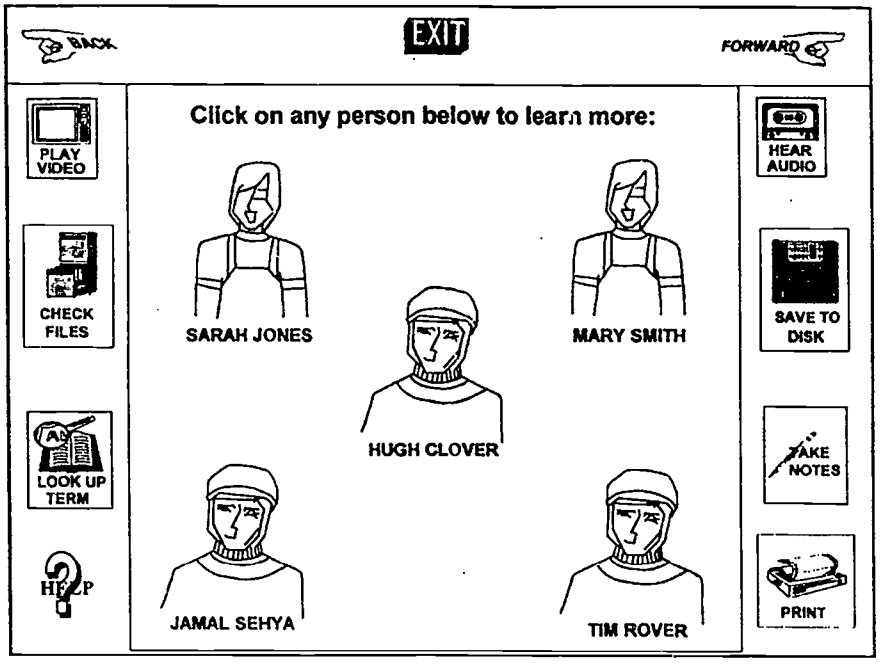


Figure 6: A sample Graphical Non-Metaphorical User Interface (GNUI).

For instance, figure 1 shows a possible GNUI implementation of a history lesson on biography and being remembered. As the figure shows, five figures to be examined are represented by abstract (cartoon) drawings. Navigation functions are represented by pointing fingers and an exit sign. While these have some minor metaphoric properties, in the absence of an underlying metaphor, these properties will most probably go unnoticed by users. The television screen, audio cassette tape, filing cabinet, and diskette are clearly visual representations of the objects themselves, not metaphors. The same is true of the pencil and printer. One might try to read something metaphoric into the glossary function and the help function here, but once again, in the absence of an underlying metaphor, these icons are primarily graphical or representational.

Mixed Metaphorical Graphical User Interface (Mixed MGUI)

A Mixed MGUI would employ an underlying metaphor, but would then employ a variety of auxiliary metaphors that were confounding. Figure 2 shows such a Mixed MGUI.

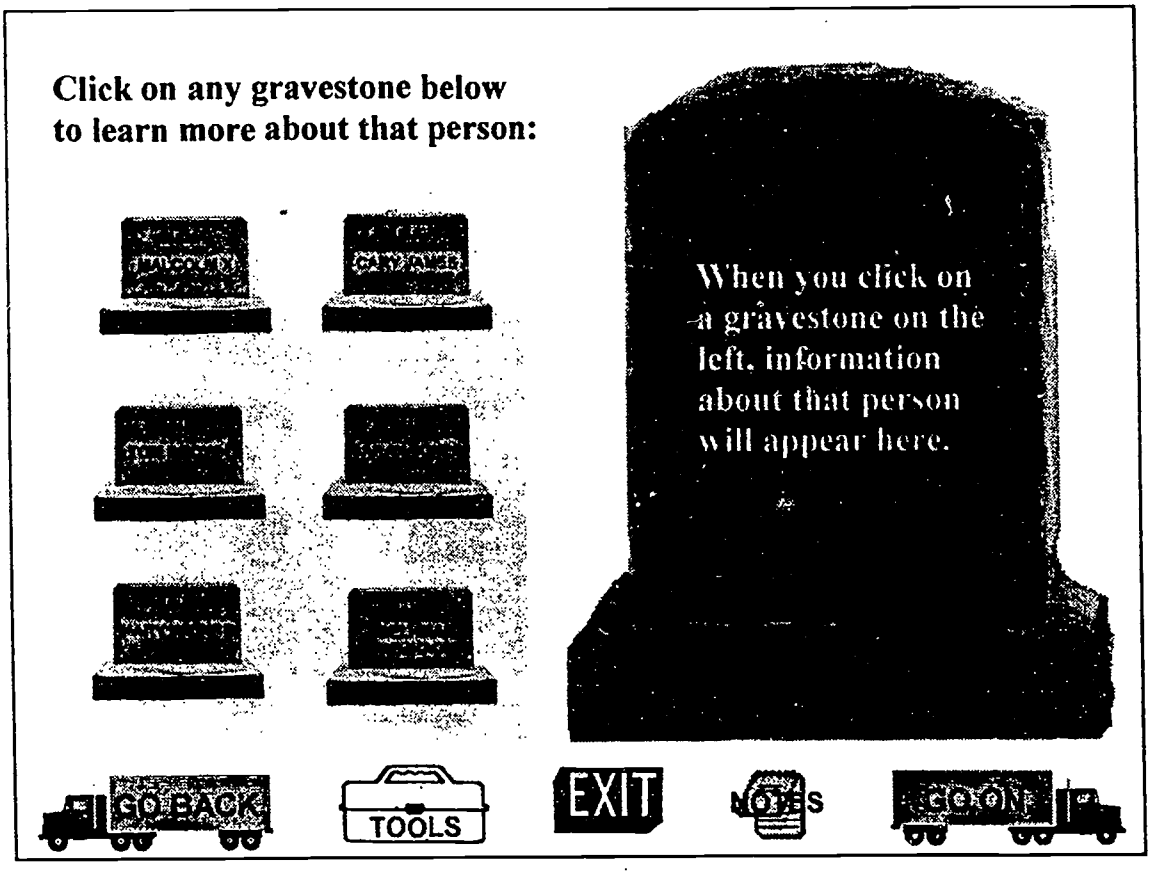


Figure 2: A sample Mixed Metaphorical Graphical User Interface.

Notice in the figure that the underlying metaphor is of a cemetery, although the metaphor is more implied than explicit, since we do not see the entire cemetery at any point. The gravestones are certainly consonant with the cemetery metaphor. Trucks for navigation and a lighted exit sign are not, however. It is unclear how a notebook or a toolbox complements the metaphor, although one might envision ways to make them consonant. This is part of the reinterpretative process that users perform in order to make metaphorical images fit (Miller, 1979). The designer has asked them, however, to make a bit of a stretch. One might think of this as stretching credibility. That is, as the user sees more images that exhibit high levels of dissonance, he or she begins to wonder whether the metaphor is appropriate. Once users reject the metaphor, they begin to think of images on the screen as devices only, not elements in a larger system that permit the user to infer and construct new understandings based on logical extensions of the metaphor itself. While images and icons of toolboxes, notebooks, and exit signs might represent reasonable auxiliary metaphors for the operations they provide or empower, in this case they clearly do not complement the underlying metaphor.

Another variation on the Mixed MGUI is an interface in which there is an underlying metaphor and some complementary auxiliary metaphors, but some images are non-metaphorical or represent confounding auxiliary metaphors. For instance, by added images of a printer, a computer disk, and other similar devices to the images in Figure 2, we could confound the metaphor further. Even if, at the same time, we added additional complementary auxiliary metaphors, it seems likely that users would be inclined to reject the underlying metaphor, defaulting instead to seeing everything on the screen as a device. In fact, the presence of non-metaphorical images seems likely to encourage them to view screen images as simply devices.

Still another variation on the Mixed MGUI is one in which the designer has employed more than one underlying metaphor, accompanied by —or resulting in— confounding auxiliary metaphors. Thus, when the user goes to certain portions of the program, the underlying metaphor changes. For instance, imagine that the initial underlying metaphor

were of a cemetery accompanied by complementary auxiliary metaphors. When the user clicks on some image, he or she is sent to a music store to listen to music that is in some way related. In effect, the underlying metaphor has changed; a music store is not a cemetery. Consider what would happen if the designer retained some or all of the same icons provided when the underlying metaphor was of a cemetery. Since the complementary metaphors for a cemetery are likely to be confounding metaphors in a music store, we would say that the designer had mixed metaphors.

There are too few clearly explicated examples in the field of interface design and many of the examples available are not as useful or well designed as they might be (Mountford, 1990). It is often easier to focus on simple graphics and pleasing layout than on making the metaphor work. In fact, Nelson (1990) suggested that an overdependence on metaphor can ruin an otherwise good design. At the same time, making the most of a metaphor may enable designers to imply more than they state and may help users comprehend without having to tell them all details (Andre & Phye, 1986). The absence of adequate explication and the paucity of strong examples may explain why so many designers' GUIs suffer from the mixed metaphor problem.

One way to prevent auxiliary metaphors from mixing dissonantly with the underlying metaphor might be to employ the POPIT model (Cates, 1994) to identify complementary auxiliary metaphors. To eliminate the problem of mixing underlying metaphors, designers could look for a larger unifying primary metaphor. For instance, a clever designer might be able to work around the cemetery/music store problem in a couple of ways. The first would be to make the cemetery not the underlying metaphor, but rather itself an auxiliary metaphor for a larger geographic primary metaphor. A second way would be to couple some sort of transitional device, either visual or navigational that conveyed the sense of going from one location to another with a changed set of auxiliary metaphors that complement the demands of the new location. Keys here would appear to be making the transition easily comprehensible and making the set of auxiliary metaphors in the new location comparable in both function and location to the set provided in the previous location.

Thematic Metaphorical Graphical User Interface (Thematic MGUI)

A Thematic MGUI is an interface in which the auxiliary metaphors are all complementary to the underlying metaphor. The icons and images employed all support the underlying metaphor and help to enhance its believability and efficacy. That is, there is a consistent theme exemplified by the interface and all aspects of the interface appear to integrate this theme. Figures 3 and 4 illustrate how a Thematic MGUI might be used in our exemplary history lesson.

Figure 3: The entrance screen for a sample Thematic MGUI.

The underlying theme of a cemetery continues to serve as the primary metaphor. The program's entrance (figure 3) and departure are accomplished through the use of a gate; once again, more similar to the way in which one actually gains access to a cemetery. The sample Thematic MGUI in figure 4 uses icons that complement the underlying metaphor. They are objects or functions one might expect to find in a cemetery. Navigation is now based on hearses. Clicking on tombstones elicits biographical data. Some gravesites have larger memorials, statues, or mausoleums. Clicking on large memorials and statues supplies information about why the deceased is better known or more impressively commemorated. Clicking on mausoleums provides information about famous families of deceased persons. Some gravesites carry markers indicating military service and some have flowers. Clicking on military markers makes it possible for the user to gain information about the person's military record. Clicking on gravesites with flowers allows the user to find out why this person is remembered. Some sites may have a person visiting the grave. Clicking on this person enables the user to gain more personal information about the deceased.

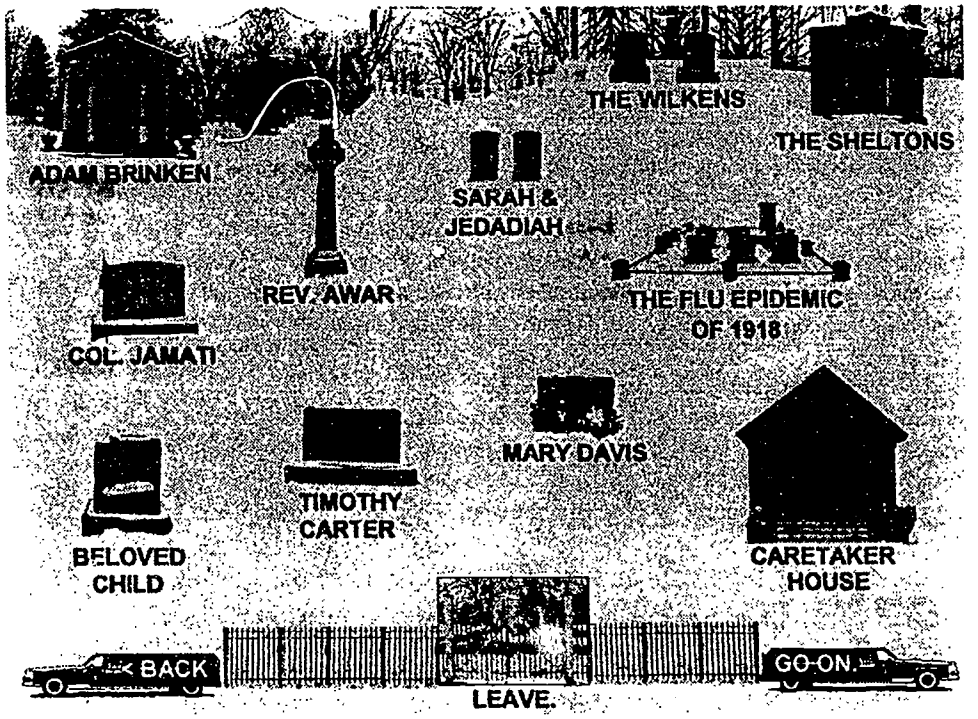
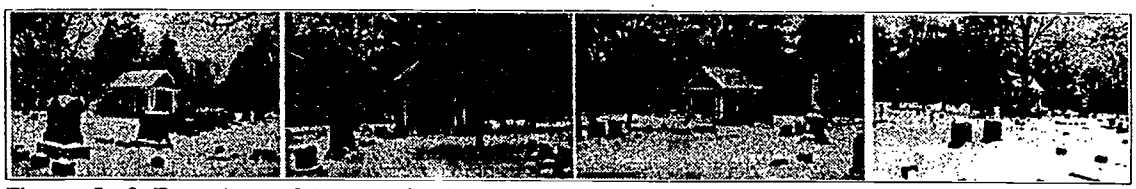


Figure 4: A sample Thematic Metaphorical Graphical User Interface.

Auxiliary metaphors go beyond grave-side information, however. Clicking on a small building on the right side of the screen provides access to a caretaker and cemetery records. The caretaker might serve as a guide or advisor, helping the user decide what to do (Oren, Salomon, Kreitman, & Don, 1990). Clicking on the record book for the cemetery could bring up a plot map of who is buried where and a brief identification of that person, in a fashion similar to what might be done for a real cemetery. There could be funeral parties on which one might click also. Some gravesites are clearly older than others with faded or weather-worn gravestones, while more recent gravesites have newer stones or may have disturbed soil. In each case, we are using aspects of the underlying cemetery metaphor to suggest appropriate complementary metaphors, while at the same time employing conventions to convey recency to users (Brown, 1988).

Thematic metaphorical GUIs are not without their problems. For instance, navigation can present a challenge. In our example, we have maintained lateral navigation across screens in a largely linear fashion. If we were to use hyper-navigation —that is, navigation by linking from one image to another across multiple screens— users could quickly become disoriented. This could prove particularly true if the links took users to screens in which the underlying metaphor were different. In our example, one could use the plot map in the caretaker's house as a navigational device to permit the user to move about the cemetery. This would make it possible to eliminate the *back* and *go on* icons, unless users were required to navigate across metaphorical screens.

Maintaining context and a sense of control are also issues here. Users need to be able to take advantage of crucial features regardless of where navigational actions have taken then. Thus, in our example, moving from gravesite to gravesite using the cemetery map should not leave the user without access to navigation and other key functions. One approach could be to maintain certain things in common locations, regardless of the setting. For example, in the cemetery metaphor, the caretaker's building could always be visible, regardless of the gravesite visited. For instance, the cemetery might be laid out in such a fashion that the caretaker's building were a central device with gravesites radiating out from it like spokes from a wheel (see figures 5 - 8).



Figures 5 - 8: Four views of the caretaker house.

Immersive Metaphorical Graphical User Interfaces (Immersive MGUI)

While thematic GUIs should help to enhance the believability and predictability of the program, they still tend to be "flat." That is, they tend to be based on back-and-forth or simple bidirectional navigation among sites or locations. The next step in GUI design would be to add the third dimension. In an Immersive MGUI, users would find themselves working through an interface that consists largely of three-dimensional representations, creating an interactive environment for the user. Some have termed such an environment a "microworld" (Rieber, 1992). Many of the objects in this environment might be manipulatable. For example, one might be able to pick objects up and examine them from different viewpoints. One might be able to move things from one location to another in a fairly realistic fashion.

Although the Thematic MGUI in figure 4 exhibits some three-dimensional properties, it does not provide much in the way of manipulation. Users click on labeled tombstones, mausoleums, statues, and the caretaker house. What they do not do is manipulate and navigate dynamically in the third dimension. In an Immersive MGUI, users might manipulate and reconstruct broken tombstones from pieces found lying on the ground. They might be asked to find missing gravesites or missing bodies by using information that was available through manipulation, perhaps even through exhumation (accompanied by appropriate ethical, legal, and religious actions). The devices offered by the Immersive MGUI might include such tools as shovels, metal detectors, sonic finders, even bulldozers and backhoes. Instead of simply clicking on objects, usually in isolation, users do more dragging and dropping and more combinatorial activities. Thus, for instance, instead of clicking on a tombstone or a box of charcoals to get a rubbing, users must drag an appropriate size piece of tracing paper to the stone, attach it properly, obtain a charcoal, and then rub the charcoal from side to side across the stone until a satisfactory image is obtained.

Two key components of Immersive MGUIs are the use of three-dimensional objects and images and the provision and expectation of enhanced manipulatability. Immersive MGUI design appears based largely on the assumption that users who are immersed in such an environment will feel a greater sense of believability and involvement. This, in turn, may lead to more active exploration and enhanced understanding.

Figure 9: Initial entry screen before user clicks.

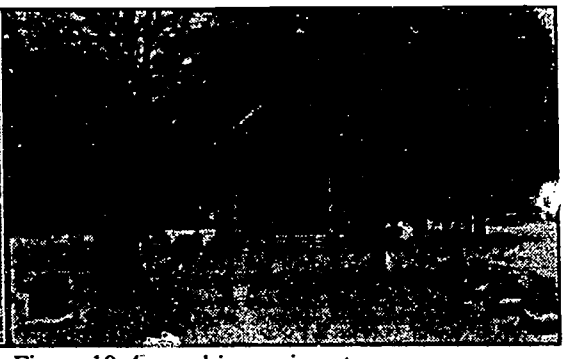


Figure 10: Second image in entry transition screen.

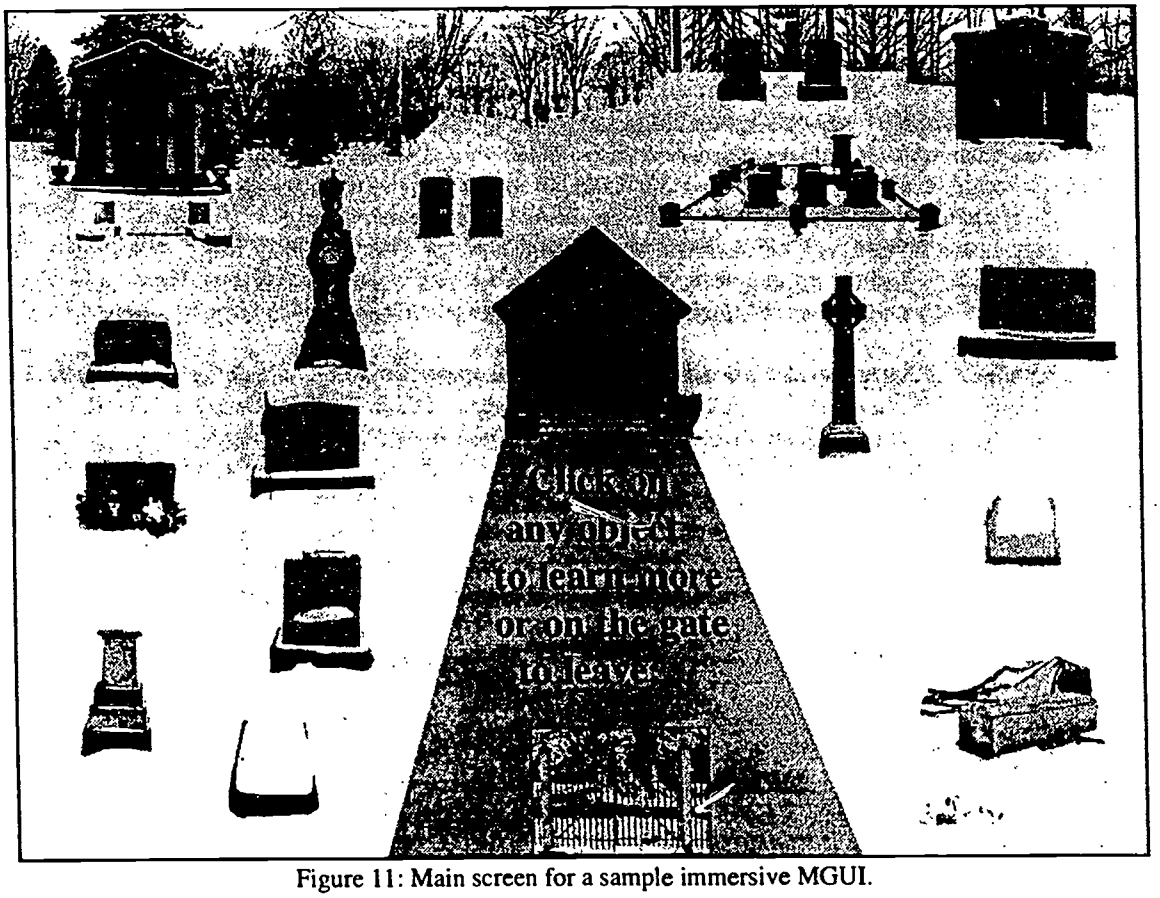


Figure 11: Main screen for a sample immersive MGUI.

It is quite difficult to portray an Immersive MGUI in still pictures. The interactive nature of the program and the advantages and impressions of animation and zooms are lost in still pictures. This paper will do its best to illustrate how our exemplary history lesson might be implemented in an Immersive MGUI. Figures 9 and 10 illustrate the transition sequence that takes a user from initial click to the cemetery's main screen.

At the end of the entry transition sequence, users will find themselves at the main screen (see figure 11). Notice that the labeled icon approach of the sample Thematic MGUI (figure 4) has been replaced by unlabeled objects. Notice also that there are many more objects visible on this screen. Recognize that this screen is actually a window on a larger "virtual" cemetery. That is, when learners move to the far right or far left of this screen, they can change viewpoint to see more cemetery and more gravesites. As suggested earlier and illustrated in figures 5-8, the caretaker house will remain a

centrally accessible device. Thus, navigation within this environment is actually rotation around the hub of the caretaker house.

The plot map in the caretaker's house is now a reference sheet, not a navigational device. Users can get a copy of the plot map to take with them if they wish. Notice that some gravesites appear covered with snow. Users will be able to obtain devices (brooms, shovels, rakes, and the like) at the caretaker's house and can use these to clear gravesites. Notice also that there is a fresh gravesite on the right side of the initial screen. Immersive MGUIs can be incredibly rich environments, providing the potential for a greater sense of user engagement and involvement.

At the same time, however, immersive metaphorical GUIs aren't for everyone or every application. They are exponentially more difficult to code. The task at hand must lend itself to manipulation, exploration, and three-dimensionality. Lots of reading isn't well served by immersion. One has to consider how navigation and manipulation will be handled. In terms of navigation, will you use arrows to tell the user that he or she can go right, left, up, and down? Will you allow the movement of the mouse pointer to cause the visible screen window to pan across some larger virtual screen? If so, how will you handle the loss of reference point so famous for inducing seasickness? In terms of manipulation, will the mouse pointer change shape or form when different actions are possible? Will you employ sounds to assist users in determining what is happening? In short, how will you help users handle the disorientation and confusion that often accompany more complex environments? (Marchionini, 1988; Oren, 1990). In order for Immersive MGUIs to function effectively, they must enhance and complement, not confuse and frustrate users.

How will you help users maintain continuity and context? Will you supply them with a backpack or a bag in which to carry useful devices? Will you supply a notebook? How will it be used and when? Will all the devices the user carries be accessible all of the time? How will you let users know what they are supposed to do while in the environment? How will you determine if the user is doing what he or she needs to do and how will you assess the user's progress toward the desired goal (if such a goal exists)? In short, there are many crucial design considerations that require thoughtful analysis and careful design.

Closing Comments

For purposes of illustration, this paper has used rather simplistic illustrations. In contrast, the demands of functionality and content may well dictate that a program provide substantially more of both. At the same time, this paper has attempted to highlight what might be considered the more salient concepts and questions in designing metaphorical graphical user interfaces.

Good interface design goes well beyond simple adherence to rules or selection of pleasing graphics. It addresses user needs and the demands of the setting in which the program will be used. Thus, interface design, like all good software design, is a creative act. It requires great care and great forethought. Since metaphorical interfaces function largely by tapping into the schemata and experiences of their users, designers need to pay particular attention to the models and experiences of those users. Although not without price, a workable and useful metaphor is a pearl of great value.

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