Landmarks to aid navigation in a graphical user interface

Christopher Dryer
California Institute of Integral Studies

Shumin Zhai
Google Inc.

Proc. of Workshop on Personalized and Social Navigation in Information Space

Landmarks to Aid Navigation in a Graphical User Interface

Wendy Ark D. Christopher Dryer Ted Selker Shumin Zhai
IBM Almaden Research Center
650 Harry Road
San Jose, CA 95120 USA
+1 408 927 1912
{wsark,dryer,selker,zhai}@almaden.ibm.com

Abstract

People use landmarks to orient themselves and to organize information. As electronic information space becomes more complex, landmarks may become a useful navigation aid. To examine this possibility, we have assessed people's ability to find and remember the locations of objects in various graphical user interfaces (GUIs). Some of these GUIs featured an intentionally designed landmark; the rest did not. Subjects in the experiment performed significantly better with the GUIs that had a landmark than they did with those that did not. This is likely because landmarks simplify the search space and provide enhanced memory structure to the user.

Introduction

To survive, people need to understand their world, a world that bombards them with an overwhelming amount of information. To manage this information people must impose upon it a simplifying structure. For example, people will associate objects and places with important bits of information so that the information can be recalled when the external reminders are encountered (Findlay et al., 1988). Our goal with the present study is to examine how such physical world strategies may be leveraged in the realm of electronic information.

Many others have been working towards this same goal. One popular method is to apply a spatial metaphor to the user interface. For example, Vicente and Williges (1988) aided the performance of users by having them use a spatial metaphor while navigating their file system. Dieberger (1994) with the Information City, Microsoft's Bob, and General Magic's Magic Cap, among many others, have employed the use of physical metaphors. The level of success with these interfaces range. It is crucial to understand which properties of the metaphors are assisting people and which need to be improved.

The implicit assumption underlying the increasingly popular attempts to develop compelling 3D environments is that users will find it natural and intuitive to navigate virtual spaces (e.g., Reeves and Nass, 1996). We need to look at the spaces in which we are successful in organizing and remembering our information and gather the important properties into a way we can organize and recall electronic information. The properties can create a foundation on which interfaces can be based in order to increase functionality of the product, deal with increased complexity while maintaining ease-of-use to the user, and efficiently utilize the user's time.

We can look at things such as the navigation in natural space, the development and organization of cognitive maps, cognitive collages and spatial mental models, and the navigation in a web space. The fundamental commonality shared by all of these spaces is the presence of landmarks.

Background

Landmarks are critical to people's organization of information. People's ability to distinguish landmarks has been seen as early as 6 months of age (Acredolo & Evans, 1980; Rieser, 1979). In fact, experimental results show young children can encode spatial location only in the presence of landmarks (Acredolo, Pick and Olsen, 1975; Herman and Siegel, 1978).

Landmarks are numerous in natural space. It is quite evident that people rely on landmarks for spatial orientation. If someone asks where a person lives, a common response would be to relate the location of that person's house to a place or an object which is visually salient, which would represent a landmark, at least in the mind of the person giving directions. For example, "I live in Mountain View, near the San Antonio shopping center. Do you know where that is?" If the person receiving the information is familiar with the speaker's landmark, then this information simplifies the space of which they are talking. Siegel and White (1975) suggest that a knowledge of spaces begins by forming and recognizing landmarks. By linking the landmarks, route knowledge is formed. By possessing route knowledge, survey knowledge (a bird's eye view) can be developed. Landmarks also may be thought of as the redintegrative elements (Horowitz & Prytulak, 1969) of a spatial schema. Specifically, landmarks organize (tie together) the associations among the various elements of a spatial system. Perceiving a landmark allows access to a knowledge structure that gives meaning to (allows understanding of) the system.

The way by which people understand their orientation in a natural space is through cognitive maps and mental models. In fact, the popular belief is that landmarks are the first elements to the development of` a cognitive map. In spaces which are unfamiliar or so big that detailed information cannot be known about the environment, Tversky (1993) defines the term cognitive collage. She states that cognitive collages are similar to cognitive maps except that cognitive collages lack the coherence of maps, but do contain figures, partial information, and landmark data. In environments which are simple or well-learned, people develop spatial mental models which consist of the coarse spatial relations among landmarks. All of these internal representations of a person's environment indicate the importance of having landmarks in order to understand the space around them which is crucial for navigation.

Architects have long realized the significance of landmarks and, therefore, have intentionally designed physical spaces with landmarks to aid navigation. For example, in designing his theme parks, Walt Disney set himself the goal of designing a place "where you can't get lost ... unless you want to" (quoted in Dunlop, 1996). In order to accomplish this goal, these spaces have a strong landmark -- such as a fantasy castle -- that is visible from most regions of the park and serves as a orienting centerpiece.

When referring to "surfing" the World Wide Web (WWW), Dieberger (1995) states that reading hyperdocuments is a task of navigation through an information space defined by the linking structure. Maglio and Barrett (1997) have found that a user's cognitive map used to navigate though the WWW is similar to that of a person's cognitive map used to navigate in natural space in terms of landmarks and routes. Maglio and Barrett monitored experienced WWW users while trying to find specific pieces of information and later asked them to verbally retrace their steps. The results showed that the subjects were only able to recall a few of the many sites they visited. These sites were the crucial sites that led to the target information which are referred to as anchor points, a prominent landmark. An anchor point is defined as a starting place from which a route can be followed which leads to a target place without requiring the use of explicitly recalling a site or typing in a URL. Because of the immense size of the WWW, it would be impossible to remember the path to take to find each piece of information that was ever encountered. Catledge and Pitkow (1995) and Tauscher and Greenberg (1997), after monitoring dozens of college students surfing the web, found that web users do not often follow the same routes. However, Tauscher and Greenberg did notice that there was a 60% chance of revisiting web pages previously visited. This has many implications to how people orient themselves in this information space. In a space which is growing bigger by the second, where information is constantly being updating, it is important for people to have anchor points, or landmarks, in order to understand the structure of the environment and thereby making navigation of the space possible.

Landmarks are the basis for our alignment and formation of our mental models. We can use the information from the landmarks to decide where we are located. What does this mean for the information inside of a computer? This means that we can provide the users with a methodology for locating the information faster and for constructing mental models, lessening the cognitive load and helping them with whatever task they are trying to accomplish.

It is important to define what is a landmark. Presson and Montello (1988) state the minimal sense of the term landmark is of elements of features in space that might serve as points-of-reference. In this sense, a landmark is any distinct object of feature that is noticed and remembered. A landmark can also be defined as a stationary object marking a fixed position in a space, but as Pick, Montello and Somerville (1988) point out, a landmark can be a moving object such as the sun or a fixed object (e.g., a high-water mark) whose purpose is to indicate the position of something that moves such as the incoming tide. Benyon and Höök (1997) point out that landmarks can be time dependent in the realm of information space. Technology is constantly changing and computer systems are quickly being updated which can disrupt the way a user visualizes the information space. So, as Pick and colleagues asked the question, "When is a landmark?" for the purpose of understanding natural spaces. We would like to ask the same question to understand the electronic information space.

Our focus in this study is to incorporate landmarks into a GUI. Landmarks are often inherent in a GUI, but we can extract the most important features of landmarks and strategically map them so that we help the users locate the information for which they are searching. If users are subconsciously recording landmark data, and their performance could depend upon recognizing their spatial orientation, then well planned landmarks will increase their performance.

Method

We will define a landmark on a GUI as a visually or cognitively salient object whose location can be associated with the locations of other objects. In our model, landmarks help people form a schema for an information space. A landmark necessarily must be an object which gives the user a point of reference. Because people perceive other objects in relation to this point of reference, a landmark will organize a space when people are searching for information (navigation). Because people remember the locations of objects relative to the landmark, the landmark also facilitates memory. A landmark on a GUI can be something as simple as the edge of the screen , the center of the screen or even an isolated icon. Our goal is to construct landmarks which will guide the user through the complex information space.

We would like to examine objects such as the ones mentioned above which could be landmarks. How can we make landmarks more salient? What landmark features can we draw upon to make other landmarks which should be as equally salient without being a distraction to the previous landmarks (i.e., too many landmarks create a chaotic looking GUI)? Can we force people to recognize and utilize certain landmarks?

In this empirical study we are interested in whether landmarks in the GUI can create a framework for the user to better understand the information space inside their computer system. Specifically, we have investigated whether landmarks will have a positive effect on performance time because of improved memory and because they provide the user with the ability to simplify a search space.

In order to examine the effects of landmarks in the GUI for finding information, we designed a two factor (2X3) experiment resulting in a total of 6 experimental conditions. One factor, with 3 levels was landmark, consisting of no landmark, an arbitrary (non-semantic) landmark, and a semantic landmark. . A semantic landmark is a salient object which lends information to the interface by being an appropriate addition to the scene, such as a bookshelf in an office metaphor.

The second factor is the GUI interface style: traditional 2D iconic interface and 3D realistic interface. Our early study had shown that the richer cues in 3D realistic interface helped user retrieve objects in a faster speed (Ark, Dryer, Selker and Zhai, 1998). We were interested in if landmarks affect differently in these two styles of GUI.

As shown in Figure 1, the 2D iconic representations were in 8-bit color and were surrounded by identical rectangular boxes. The regular layout consisted of rows and columns typical to a user interface. The 3D realistic representations were in 16-bit color, rendered in a 3D space and were not surrounded by boxes. The non-regular layout consisted of the 30 objects placed randomly in a possible 150 locations. Our early study (Ark et al 1998) showed that people retrieved information faster with the non-regular layout. The average size of the 30 3D realistic objects and 10 targets were the size of a 2D iconic object.

In order to account for the size discrepancies between the 2D and the 3D icons and also the difference in the placement of the icons, Fitts law (Fitts, 1954) analysis was used to ensure all conditions had similar average indexes of difficulty.

The six experimental conditions were: 2D regular layout, no landmark; 2D regular layout, arbitrary landmark; 2D regular layout, semantic landmark; 3D non-regular layout, no landmark; 3D non-regular layout, arbitrary landmark; 3D non-regular layout, semantic landmark. (Appendix A)

The test was written in Macromedias Lingo and displayed using Director on an IBM Thinkpad with a 17" monitor and a standard mouse attached.

Subjects

Twelve subjects were used. All used computers on a daily basis.

Procedure

The experiment used a balanced, within subjects design. The subjects were asked to find an object as quickly as they could and then select the object by using the mouse to click on the object or the objects label. The subjects were assigned by a Latin square equally into one of six groups where each group consisted of a different order of the six conditions.

There were ten objects to locate per condition and three trials within each condition with the sequences varying per trial.

The test consisted of an instruction screen which was followed by the name of an object to find. When the subject was ready, they were asked to click on a "GO" button so as to position the cursor in the center of the screen. Once the subject clicked on the object or its label, the test continued to the next object. The refreshed scene forces the subject to get reoriented to the interface and does not give way to any advantages for neighboring objects. Errors were recorded along with the time it took to find each object.

Results

We were interested in whether landmarks (absent, arbitrary, or symbolic) and object representation (2D iconic or 3D realistic) would impact the time it takes people to search for and click on objects. We therefore examined the mean completion times across three trials for each of the six conditions. These results are illustrated in Figure 1.

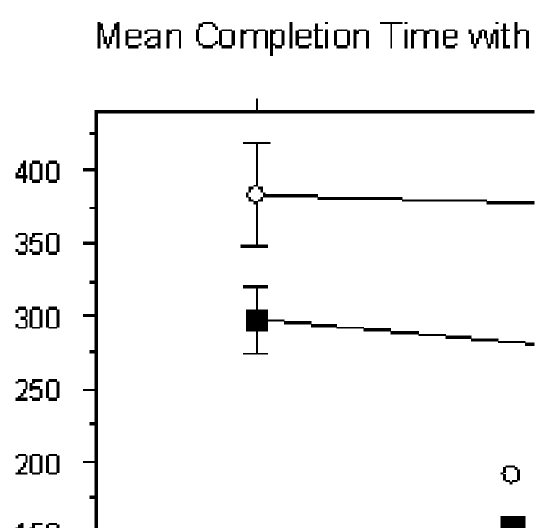


Figure 1. Subjects time performance

We analyzed these data with a 3 (landmark) X 2 (object representation) repeated measures analysis of variance with the order of the experimental conditions as a six-level between-subjects factor. The analysis revealed that the main effect and interaction effects for order of conditions were nonsignificant.

The analysis also revealed two significant main effects; for landmark, $F(2,22) = 8.13$, $p < .005$, and for object representation, $F(1,44) = 37.08$, $p < .001$. People found objects more quickly when the UI included a landmark than they did when it did not. Likewise, people found objects more quickly when the objects had a 3D representation than they did when the objects had an iconographic representation. This is consistent with our early findings (Ark et al 1998).

To examine the impact of the different kinds of landmarks, we distinguished the levels of the landmark factor with a planned orthogonal contrast. This contrast revealed that the means for the no landmark condition and the arbitrary landmark condition were marginally significantly different, $F(1,11) = 8.76$, $p < .05$, and that the means for the arbitrary landmark and semantic landmark conditions also were marginally significantly different, $F(1,11) = 7.53$, $p < .05$. In other words, a UI with an arbitrary landmark helped people perform the task better than a UI with no landmark at all, but a UI with a landmark that are more appropriate in the scene helped people perform the task even better.

The interaction between landmarks and object representation was not significant; that is, these factors impacted performance independently. People found objects most quickly when the UI featured a semantic landmark and 3D representations of objects, and they found objects least quickly when the UI featured no landmark and iconographic representations of objects.

Discussions and Conlusions

Landmarks have long been employed in way finding in the natural physical world. The current study has demonstrated that they can be also useful in constructing computer graphical user interfaces so that a user can find information faster in the electronic space. Moreover, our study suggests that the positive effects of visually and cognitively salient objects, i.e. landmarks, appear to be independent of the interface style. They can be effective in either traditional 2D iconic interfaces or in 3D realistic interfaces.

Consistent with findings in our early studies (Ark et al 1998, Selker et al 1997), 3D realistic interface in this study once again demonstrated to be more efficient than 2D iconic interfaces, but the addition of landmarks further enhanced users ability to quickly find target objects.

The degree of performance enhancement due to the presence of landmarks depends on the design of the landmarks. In particular, this study showed that semantic landmarks that were appropriate to the scene were more effective than arbitrary landmarks that were merely visually salient.

To date, our studies on alternative graphical user interface styles (Selker et al 1997, Ark et al 1998) have shown that there are many ways to improve he current GUI interfaces. Conformity with more compelling physical metaphor, more realistic 3D representation of information objects, more ecological layout of these objects, and the construction of salient landmarks may all further improve users ability to search and remember the information space residing in the computer systems.

Acknowledgement

We thank our colleagues at the IBM Almaden Research Center, in particular, Ian May for his graphics work and Paul Maglio for his suggestion of studying the semantics of the landmarks.

Bibliography

Acredolo, L.P. & Evans, D. (1980). Developmental changes in the effects of landmarks on infant spatial behavior. *Developmental Psychology*, 16, 312-318.

Acredolo, L.P., Pick, H.L. and Olsen, M.G (1975). Environmental differentiation and familiarity as determinants of children's memory for spatial location. *Developmental Psychology*, 11, 495-501.

Ark, W.S., Dryer, D.C, Selker,T, Zhai, S, (1998) Representation matters: the effect of 3D objects and a spatial metaphor in a graphical user interface, IBM Research Report RJ10090.

Benyon, D. and Höök, K. (1997). Navigation in information spaces: Supporting the individual. In Human Computer Interaction: INTERACT '97, 39-45.

Catledge, L. & Pitkow, J. (1995). Characterizing browsing in the World-Wide Web. In *Proceedings of the Third International World Wide Web Conference*.

Dieberger, A. (1994) Spatial environments to organize and navigate information and to communicate about this organization. Presentation at ECHT'94, the European Conference on Hypermedia technology. Edinburgh.

Dieberger, A. (1995). Providing spatial navigation for the World Wide Web. *Spatial Information Theory,* 93-109.

Dunlop, B. (1996). *Building a Dream: The Art of Disney Architecture*. Harry N. Abrams: New York.

Findlay, J.M., Davies, S.P., Kentridge, R., Lambert, A.J., and Kelly, J. Optimum Display Arrangements for Presenting Visual Reminders. *Proceedings of the HCI'88 Conference on People and Computers IV*, 1988, British Informatics Sociey Ltd, 453-464.

Fitts, P.M., The information capacity of the human motor system in conntrolling the amplitude of movement. *Journal of Experimental Psychology*, 1954, 47, 381-391.

Herman, J.F & Siegel, A.W. (1978). The development of cognitive mapping of the large-scale environment. *Journal of Experimental Child Psychology*, 26, 389-406.

Horowitz, L.M., & Prytulak, L.S. (1969) Redintegrative memory. *Psychological Review*, 76, 519-531.

Maglio, P.P. and Barrett, R. (1997) On the trail of information searcher. In *Proceedings of the nineteenth annual conference of the Cognitive Science Society*. Mahwah, NJ: LEA.

Pick, H.L., Montello, D.R., & Somerville, S.C. (1988). Landmarks and the coordination and integration of spatial information. *British Journal of Developmental Psychology*, 6, 372-375.

Presson, C.C. & Montello, D.R. (1988). Points of reference in spatial cognition: Stalking the elusive landmark. *British Journal of Developmental Psychology*, 6, 378-381.

Reeves, B. & Nass, C. *The Media Equation*. Cambridge University Press: Cambridge, 1996.

Rieser, J.J. (1979). Spatial orientation of 6-month-old infants. *Child Development*, 50, 1078-1087.

Selker, T, May, I, Zhai, S (1997) Representation matters: Sptial Interface can facilitate target acquizition, IBM Research Report RJ 10085

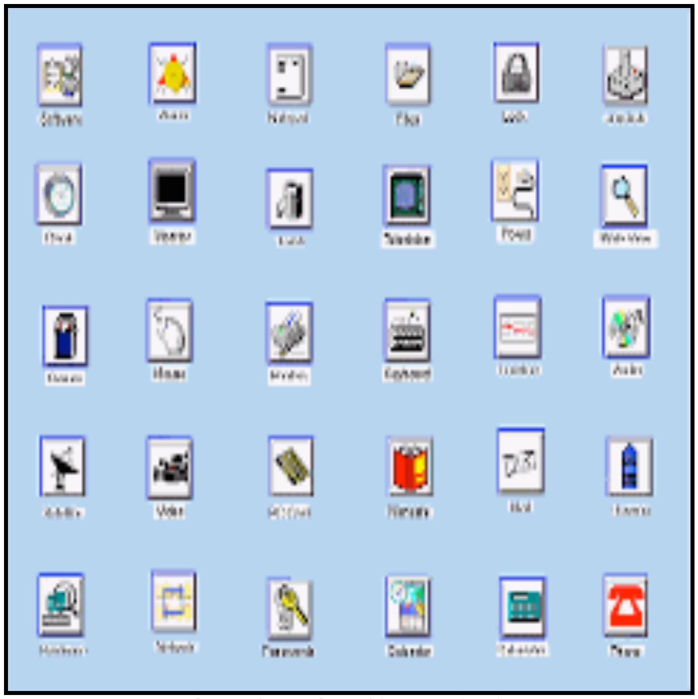
Siegel, A.W. & White, S. (1975). The development of spatial representation of large-scale environments. In H. Reese (Ed.), *Advances in Child Development and Behavior*, vol. 10, New York: Academic Press.

Tauscher, L. and Greenberg, S. (1997) Revisitation patterns in World Wide Web navigation. In *Proceedings of the Conference on Human Factors in Computer Systems* (CHI'97), p 399-406. New York,NY: ACM Press.

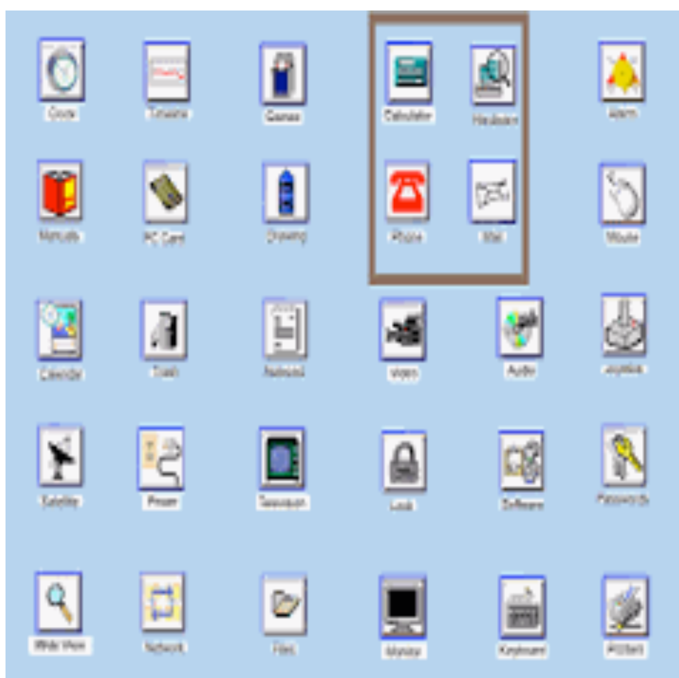
Tversky, B. (1993) Cognitive maps, cognitive collages, and spatial mental models. *Spatial Information Theory*.

Vicente, K.J. and Williges, R.C. (1988). Accommodating individual differences in searching a hierarchical file system. *International Journal of Man-Machine Studies*, 29, 647-668.

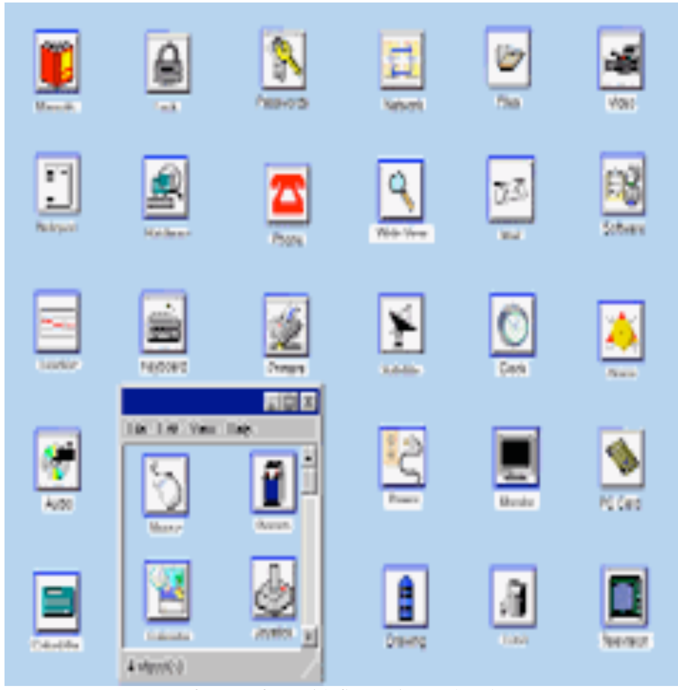
Appendix: Stimuli used in the experiment



2D Iconic Interface with No Landmark



2D Interface with Arbitrary Landmark



2D Interface with Semantic Landmark

3D Realistic Interface with No Landmark


3D Interface with Arbitrary Landmark


3D Interface with Semantic Landmark