Visual aids for Path Guiding

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ABSTRACT Maps are produced from the perspective of a point high above ground while the perspective of path finders is at ground level. Street networks in a metropolitan are quite complex, making path finding on it by using just maps rather difficult for some users. In this paper, we will first review some methods to aid path finding. We will then propose a methodology, which includes the use of traditional maps, perspective view maps, and sequential ground photographs, to aid path finding.

KEYWORDS Path guiding, Path finding, Wayfinding, Perspective view map, Heading-up map, Visual aids, GIS application

1. Introduction

Have you ever encountered any difficulties in finding your way in an unfamiliar city? Have you ever felt nervous and helpless when you get lost? Have you ever found it difficult to get to your destination though you have a map in hand? It is a rather challenging task for newcomers to find their way in an unfamiliar city. Studying maps beforehand can help, however when it comes to orient oneself on the ground, difficulties could still be encountered. Taking notes and descriptions of the route and bringing them along can be a solution, but when the route is complex, the large amount of information required is cumbersome to carry. Perhaps a portable electronic path guiding system would be desirable.

Traditionally map views are from high above ground. However, the view of a path finder is usually on ground level. This difference in perspective requires some training to reconcile, thus creating considerable difficulty with some users.

In the following sections, we will present an overview of the studies and experiments on path finding. We will analyze the advantages and disadvantages in using different visual aids. Next, we will propose a path guiding system using a combination of different visual aids to solve the problems caused by perspective differences.

2. Overview of existing investigations and experiments

We have found three studies comparing different visual aids for path finding. These three studies concentrated on the use of maps, audiotapes, films, verbal descriptions, and road signs.

Goldin and Thorndyke [1982] investigated and compared actual navigation and simulated navigation as a source of environmental information to aid way finding. Subjects were toured in an unfamiliar area in Los Angeles either directly in a bus driven along an 8.3 km of the area or indirectly by viewing a film taken from inside of a car traveling along the same route. The first group is called the tour group and the second group is called the film group. Within each group, the members were further divided into three subgroups provided with different kinds of supplementary information. The verbal subgroup was given verbal description, the map subgroup was given a map to study ahead of time, and the control subgroup was given nothing. Subjects were tested after the tour on three types of knowledge about the environment: landmark knowledge, procedural knowledge, and survey knowledge. Landmark knowledge refers to “memory for salient perceptual features in the environment.” [Goldin and Thorndyke, 1992] It is a test on the ability to recognize landmarks encountered before. Procedural knowledge refers to “knowledge of specific routes navigated in the environment.” [Goldin and Thorndyke] Having procedural knowledge is having knowledge of the path usually acquired and retained in a sequential manner. Survey knowledge refers to “the two-dimensional configurational relationship among location.” [Goldin and Thorndyke, 1992]. Such relationship between two locations “may be apprehended without reference to any particular route between them.” [Goldin and Thorndyke] Having survey knowledge is having knowledge of the environment in a general sense unrestricted to any specific path.

Subjects were required to explore the environment as much as they can without any guidance and restriction, then they were asked to walk a given path. In the landmark knowledge test, subjects were tested whether they recognized certain landmarks. In the procedural knowledge test, subjects were tested on the sequence of features encountered, distance between location, and orientation between some turning points. In the survey knowledge test, subjects were asked to estimate a straight distance between pairs of location, to draw a map of the test environment, and to place several landmarks in their correct position.

The result showed that within the film group, the map subgroup performed similarly as the control subgroup, while the control subgroup performed better than the narrative subgroup. The overall result of the film group was better, and this can be explained by the availability of pauses in the film tour when landmarks were encountered. Subjects would hence pay more attention on the landmarks shown. The film group concentrated more on the visual details than the tour group since images shown on the film were planned and focused along the path only. Subjects would not be sidetracked by other irrelevant road details.

Streeter et al. [1985] compared the different aids to help navigating a car along a given route. Each subject was asked to drive along an unfamiliar test area as one of the following four groups. The first is the map group given standard and customized route maps. The second is the tape group given audio directions. The third is the map-plus-tape group given both map and tape. The fourth is the control group allowed to choose whatever tool desired. It was found that those in the map group and the map-plus-tape group preferred customized maps to standard road maps. The use of tape was generally preferred to customized maps. Among the four groups, the use of tape for instruction was highly preferred. The second preference was to use both map and tape for instruction, while the third preference was to use maps only. With reference to the overall performance, tape instruction produced fewer errors and required less time for path finding.

Butler et al. [1993] performed wayfinding studies in one of the buildings at Ball State University. Subjects were asked to go from the sign-up board to the laboratory. The experiment compared the use of pure verbal guides, sign systems, and schematic maps. For the verbal guide test, subjects were given verbal descriptions by the secretary on the path to follow. For the sign system test, signs were placed along the path. For the schematic map test, a you-are-here map was placed at the starting point.

The results showed that path finders who were given just verbal directions required a longer time to associate the environment with the description, and it was particularly difficult to recollect the description if the building was complex. Besides, the results showed that the sign system was relatively more effective than the you-are-here map. Path finders were only required to follow the signs leading directly to the destination without reference to any supplementary information.

2.1. Summary of Existing Investigations And Experiments

These tests have dealt with different aspects of path finding, and they have all pointed to the deficiency of using a single aid for navigation.

It was found that the use of film taken along the route could provide sequential knowledge of the path. This can further provide a reasonable source of procedural knowledge as suggested in Goldin and Throndyke [1982]. However supplementary information such as maps was required since films can only provide limited information confined along the path. On the contrary, maps sometimes contain too much information not directly relevant to path finders but only serve to distract them.

Path finders generally pay attention to landmarks images. People would make use of prominent environmental features to know the place or to describe routes to others [Lynch, 1960; Schraagen, 1993]. Signs along the route would be helpful to path finders as these provide explicit direction. As suggested by Streeter et al. [1985], no matter how much information is included in a path guiding system, different people prefer different aids.

3. Combination of visual aids

In this project, we study the combination of navigational aids, particularly the visual ones including photographs and perspectives rendering of landmarks.

There are several methods we can use to supplement the traditional map view (Figure 1). One of them is to enhance it with ground photographs that could be annotated with guiding arrows, road names, and other navigational aids (Figure 2). Annotations are similar to the signs used in the experiment of Bulter et al. [1993].

Figure 1 Traditional map view

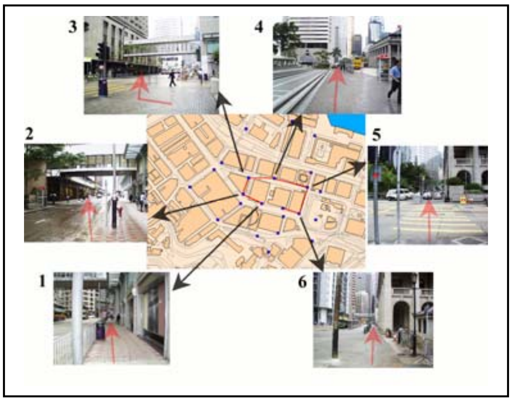

Figure 2. Map view enhanced with ground photographs

While traditional map views are better for route planning and finding one's way when lost, perspective map views are closer to the path finders' perspective (Figure 3). The perspective view can be superimposed with landmarks in photographic form. A place is known as a landmark "as long as it is a point of reference considered to be external to the observer, and they are simple physical elements, which may vary widely in scale" [Lynch, 1960].

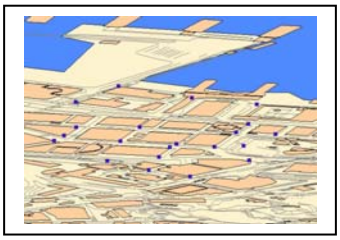

Figure 3 Perspective map view

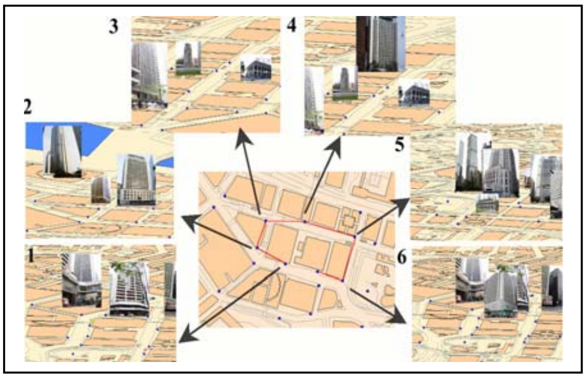

Figure 4 A Number of perspective map views enhanced with landmark photographs

The landmark photographs are different from the ground photographs in that the irrelevant background has been removed to highlight thelandmark. This makes it easier to superimpose thelandmark on the perspective map (Figure 4), giving a reasonably good perspective view of both map and photographs. A series of these enhancedperspective map views can simulate a walkthrough.

Figure 5: Panoramic View

Intersections are critical spots where the navigational skills of path finders are challenged. In order for a path finder to associate landmarks at an intersection, a 360-degree panoramic view could be provided. We will call this the panoramic view (Figure 5), and it can be effectively implemented by using the technology pioneered by Apple's Virtual Reality QuickTime (QTVR) movies.

We have described here four visual aids to supplement the map view, including perspective view, ground photographs, landmark photographs, and panoramic photographs. The photographs can be annotated to provide navigational information, and photographs can be linked in a series to simulate a walkthrough. These visual aids form the basis of an electronic path finding system described in the next section.

4. The proposed system

4.1. System Architecture

In order to solve the problems caused by perspective differences, we propose a system incorporating four visual aids to supplement the traditional map views. It is implemented with a web-based GIS software – Autodesk MapGuide for map display.

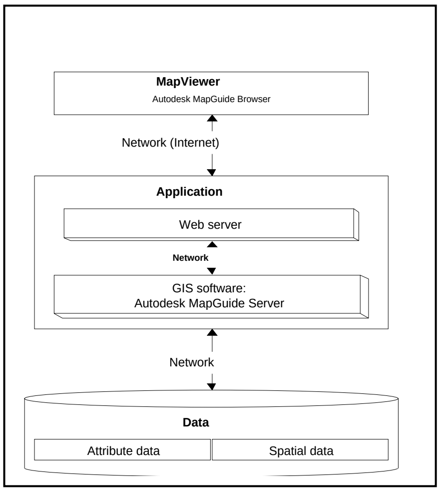

Figure 6. Autodesk MapGuide basic system architecture

The Autodesk MapGuide basic system architecture (Figure 6) consists of the MapViewer, application programs, and data. Under these three main parts are other components.

The basic components of Autodesk MapGuide are the Autodesk MapGuide Server, Autodesk MapGuide Author, and Autodesk MapGuide Viewer. To display a map in a Web browser, the Autodesk MapGuide Viewer is required. The Autodesk MapGuide Viewer is available in two versions: a plug-in for use with the Netscape Navigator Web Browser, and an ActiveX control for use with the Microsoft Internet Explorer Web Browser. End users, who want to view the published maps, must install one of the viewer plug-ins.

The Autodesk MapGuide Server and the Web server in Figure 6 communicate with the viewer and database through the Internet. Clients sent requests and receive data through the Internet to the Autodesk MapGuide server through the Web server. The result of the query can be displayed by the MapViewer.

The path guiding system is built around the Autodesk MapGuide basic system architecture (Figure 7). The first of the four visual aids is the perspective view, which is a projective transformation of the map. The other photographic aids are all linked to the traditional or perspective map through the HyperText MarkUp language (HTML) pages.

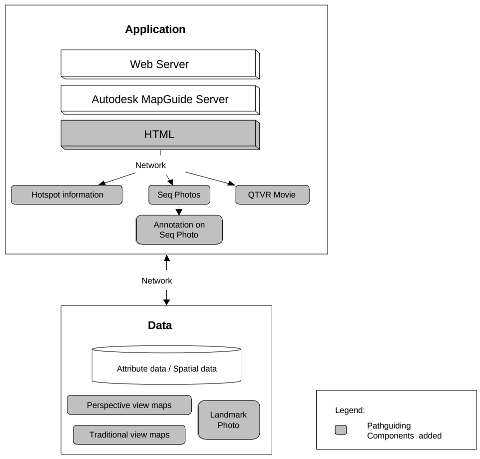

Figure 7. Path guiding system architecture

4.2. IMPLEMENTATION

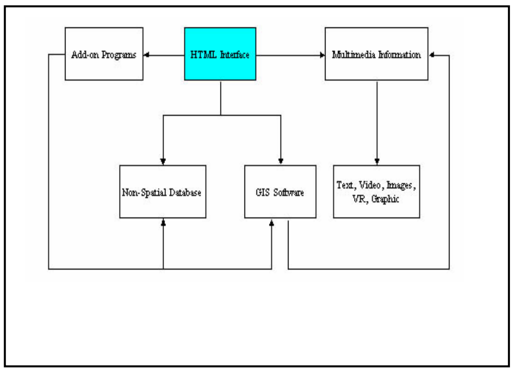

Figure 8. Data flow

The HTML interface serves as the core and central linkage with the other components (Figure 8). It links up the GIS software Autodesk MapGuide and the non-spatial database. Add-on programs are required to handle the perspective view maps and sequential ground photographs. These add-on programs are customized functions developed using the application programming interface of Autodesk MapGuide. Other multimedia information including QTVR movies and landmark information are embedded in HTML pages.

4.2.1. Creating the Map

The Autodesk MapGuide stores each individual map as a Map Window File (MWF). A MWF is composed of several layers of spatial data files (SDF) in the proprietary format of Autodesk MapGuide. The users' Web browser can identify the registered MWF type as map windows file. When users open an HTML page that contains an MWF file type, the Autodesk MapGuide Viewer will automatically be loaded to display the map. Each layer of vector data can only contains one type of map object in the form of point, text, polylines, or polygon. Developers, who want to create maps in MWF file type, must use Autodesk MapGuide Author. In this study, the Central District of Hong Kong is selected for prototype implementation. The MWF file (Figure 9) consists of five main layers: coastline, road, building, path, and road intersections. These layers of spatial data must first be converted to geographic coordinates in latitudes and longitudes and saved in the SDF file format. Autodesk MapGuide Server can read and send any requested data to Autodesk MapGuide Author and display to clients using an Autodesk MapGuide Viewer.

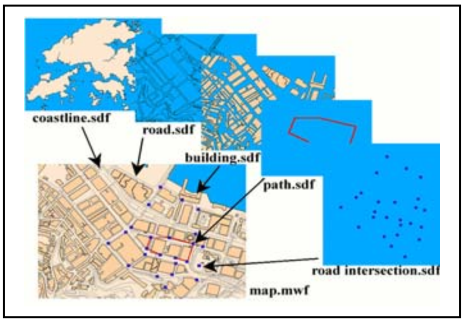

Figure 9. Map Window Files

The coastline and building layers need to be converted to closed polygons so that we can colour fill the two layers. This is done through the use of functions provided in MapInfo Professional 4.1 to convert polylines to regions.

4.2.2. Selection of Turning Points Along Roads

When the system displays the sequential ground photographs along a selected path, it changes the orientation of the map at pre-defined turning points. These nodes are therefore critical points along the path at which navigational information, particularly landmark information, would be most needed. They are usually located at road intersections. Sometimes they are located near landmarks.

These nodes must be selected ahead of time and stored as a SDF layer. After a user has selected a path, it is then the task of the system to retrieve nodes along the selected path, walk through them sequentially, and display the ground photographs at each node. For these ground photographs to be effective, a node should be located at every possible approach to that landmark and a photograph of the landmark taken from each one of these nodes. An important consideration here is to select a location providing the best, most unobstructed view of the landmark.

4.2.3. Individual Landmark Photographs

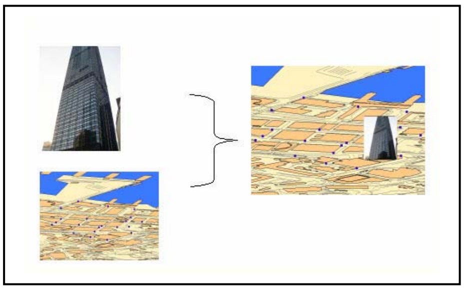

Figure 10. Display of individual landmark photograph

Landmark photographs are in raster form. The display of raster image (Figure 10) is a relatively new capability for Autodesk MapGuide Release 3.0. The raster image or raster image catalog (RIC) must accompany a georeference file. Whenever there is a request from the client side, the Autodesk MapGuide server scans through the georeference files to determine which raster image should be displayed.

4.2.4. Qtvr movies at Road Intersections

QTVR movies have already been embedded in an HTML page at the nodes. Users click on such a node will invoke the HTML page that a QTVR movie is embedded. However, in order to provide a linkage between a spatial data and the HTML page, the SDF file of the node of road intersection must be modified. The data structure of a SDF file is in the following form:

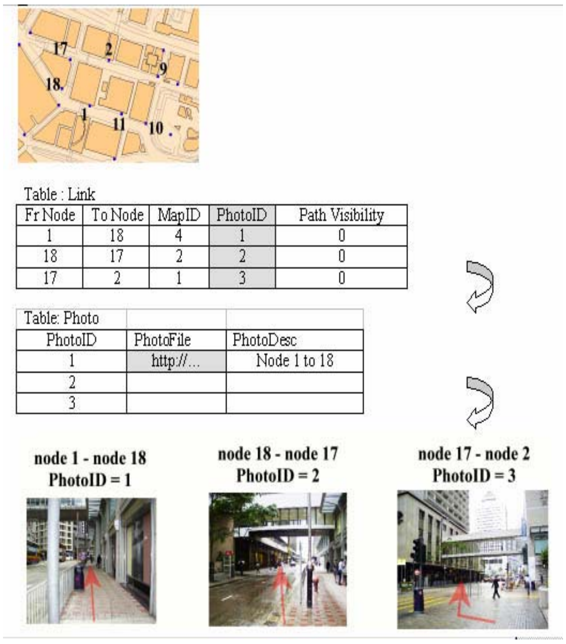

Figure 11. Sequential ground photographs

<ObjType>, <ObjName>, <ObjKey>[, <URLLink>], <NumPts>
<LatitudeValue1>, <LongitudeValue1>
…<LatitudeValueN>, <LongitudeValueN>

Where <URLLink> is an optional parameter for URL linking.

The optional parameter <URLLink> should be modified with the corresponding URL of the HTML page. So the linkage between the SDF layer and the HTML page is feasible.

4.2.5. Hotspot Information

The implementation of this is similar to that of QTVR movies. Navigational information should be stored as an HTML page. On the other hand, the <URLLink> parameter of the corresponding SDF layer should be modified with the corresponding URL of the HTML page. So a request on the SDF layer will link to a Web page and display hotspot information.

4.2.6 .Sequential Ground Photographs

Each photograph taken at turning point is given an identification number (PhotoID). A database table is used to store the location of each photograph as shown in Figure 11. In this project, we have used an ODBC-compliant database manager, Allaire's Cold Fusion, to handle the relational database.

4.2.7. A number of Perspective Map Views

Sequential perspective map views are handled in much the same way as sequential ground photographs (Figure 12). As the user walks along a selected path, both the map of perspective view and the photograph taken at turning point changed at the turning points. Instead of using a real-time procedure to generate a new perspective view at each turning point, we have decided to pre-generate the perspective views at each node. This would increase the storage space but will speed up the display.

In the database, the perspective views at a turning point are associated with a node using a method similar to the way the sequential ground photographs are associated with it.

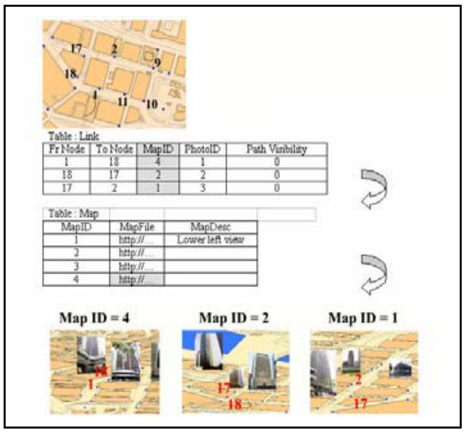

Figure 12. A number of perspective map views

The traditional map view also rotates as direction changes along the path in order to provide heading-up views. Again, we choose to pre-rotate the maps instead of performing transformations on the fly. Since the map view is for reference only, and the main orientation aid is the perspective view, we have only provided four rotations at each node: front, left, back, and right (Figure 13).

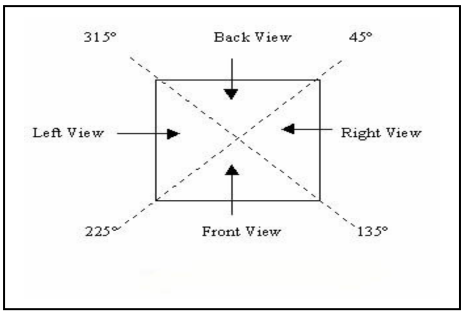

Figure 13. Map Rotation

As we can see, the ground photographs, the perspective views, and the different orientations of the map are created ahead of time and stored in the database. This has contributed to the increase of data volume and has made the database more difficult to update. The dynamic generation of them would remove some of these problems.

5. Conclusion

Finding one's way in an unfamiliar city is not an easy task. The use of path guiding tools will help to minimize path finders' hesitation in finding their way along the path. So the path guiding process along the path is being highlighted in this project.

We have tried to use a combination of visual aids to help path finding. Using traditional map views from high above ground is useful for path designing. The use of perspective map views helps to solve the problem on perspective difference, particular for those who cannot read traditional map views. A number of perspective maps and sequential ground photographs can simulate a walkthrough along a path. An annotation such as an arrow or road sign provides direct navigational information to path finders. QTVR panoramic views are effective at intersections where landmark matching is generally more difficult. Individual landmark photographs present the outlook and detail information of a landmark. The system proposed can be implemented as an electronic path guiding system, with potential applications in car navigation, electronic street guide, and so on.

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