Servicing Photographs for Route Guidance in Navigation Systems

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Abstract: For successful route guidance, navigation systems should provide to users more realistic and actual information such as photographs than those in either 2-dimensional and 3-dimensional models. In this paper, we propose a method for servicing photographs for route guidance in navigation systems. The method includes how to acquire photographs with the most successful view for the guidance, how to construct link information among them and navigational map data, and how to provide the images to users efficiently.

Keywords: Route Guidance, Photographs, Navigation Systems.

1. Introduction

With the advancements in mobile computing and the popularization of Global Positioning System, navigation systems have come into wide use. Nowadays, most navigation systems are based on 2-dimensional models. Currently, 3-dimensional model based navigation systems are under research. But, for more successful route guidance, navigation systems should provide to users more realistic and actual information than both 2-dimensional and 3-dimensional models. Photographs provide more realistic and actual information than 2-dimensional and 3-dimensional models.

In this paper, we propose a method of servicing photographs for route guidance in navigation systems. Servicing photographs for route guidance is providing photographs with registered guidance information at key areas in a given route.

It has the following advantages. First, it helps a user select the right path. The gap between real objects and virtual images, 2-dimensional or 3-dimensional models, is an obstacle in providing route guidance. Because photographs display the actual environment along with guidance information, users can select a correct route easily. Second, it gives detailed area information to users. Photographs can provide an actual portrayal of an intersection, neighborhoods and buildings. This is useful for users in selecting a transit route or destination.

To accomplish this, we acquire photographs of key locations and devise a technique to link information between photographs and navigational map data. Also, we devise a technique to serve photographs for route guidance in navigation systems. Finally, we show the effectiveness of our method by implementing a prototype navigation system with photographs.

This paper is structured as followings. In section 2, related works are introduced. In section 3, we propose the method of servicing photographs for route guidance in navigation systems. We explain how to obtain useful photographs and link photographs to a navigation map. In addition, we describe how to serve the photographs in navigation systems. We present the prototype system in section 4. Finally, in section 5, we conclude this paper.

2. Related Works

The combination of geographic information and multimedia has not been widespread until recent years. But even now, multimedia, especially videos and photographs are widely used to support an explanation and give a clear portrayal of objects.

From a historical point of view, the BBC Domesday Project [1] is a significant project involving the combination of geographic information and multimedia. In this project, it presents a map of Great Britain that allows users to watch video clips, aerial photographs and listen to natural sounds from certain places simply by clicking on the location in the map.

Recently, Nobre [2] presents a methodology based on direct video frame indexation to the real space represented in the video images. This approach facilitates the exploration of space through multiple videos. It allows users to define the direction of camera movement throughout the space comprised by the videos. The result is that each frame is precisely geo-referenced. A GPS is synchronized with the camera in order to store its position at every instant in the recording, which allows them to compute the position of each frame. They suggest it can be used to support forest fire decision support systems. In the event of a fire, it is very easy to obtain video of the affected area to assist firefighters.

Also, Yoo [3] design and implement a prototype system for an image-based personal navigation system. The system provides a navigation service for browsing spatial geographic data, images, and web pages via links based on location data acquired from a GPS receiver.

The main functions of the proposed system are 1) to search and to display spatial geographic data, images or web pages of a specific location, and 2) to browse and to present spatial geographic data through selected images, and vice versa.

In addition to these projects, there are many projects that combine multimedia with geographic information [4, 5]. In this paper, we combine photographs with a navigation system which is killer application in regards to geographic information systems. Since navigation systems with photographs give users more accurate information, users can obtain successful route guidance.

3. Serving Photographs for Route Guidance

To serve photographs in navigation systems, photographs which are useful in providing route guidance must first be acquired. Next, link information between the photographs and navigational map must be constructed. Finally, photographs can be served for route guidance in navigation systems. In subsection 1, we explain how to get photographs which are useful for route guidance. Then, in subsection 2, we propose a method of linking photographs to navigational maps. Lastly, we propose how to serve photographs in navigation systems in subsection 3.

1) Acquisition of useful photographs for route guidance

Serving photographs in route guidance requires the process of updating the images with registered guidance information at key areas along a given route. In this paper, key areas include intersections and main roads adjacent to landmarks, such as City Hall, a rail-road station, post-office, etc.

To serve photographs in navigation systems, the acquisition of photographs is the first requirement. In this paper, since photographs are served to users for successful route guidance, we gather photographs which are useful for route guidance in navigation systems.

Photographs which are useful for route guidance must satisfy the following conditions. 1) Geographical features and road layouts should be clearly visible. 2) Objects, such as buildings, bridges, and parks, must be recognizable. To satisfy these conditions, the elevation from where the photograph is taken and the field of depth of the images acquired is important.

First, we consider the elevation at which the images are acquired. Since images acquired at too low an elevation do not clearly portray geographical features and road layouts, they are not suitable for navigation systems. A photograph acquired at a elevation of 1.5 m is shown in Fig. 1. In this photograph, it is difficult to recognize any geographical features and the layout of the road.

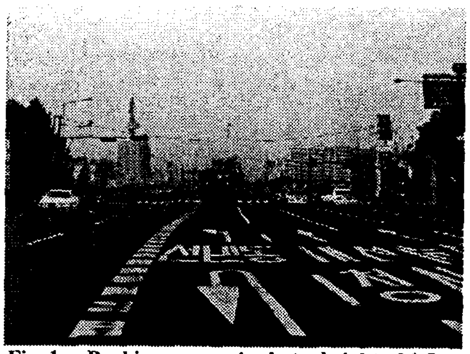

Fig. 1. Real image acquired at a height of 1.5 m

A photograph acquired at an elevation of 12 m is shown in Fig. 2. Unlike Fig. 1, we can recognize geographical features, a river and bridge, an intersection, and the shape of the road.

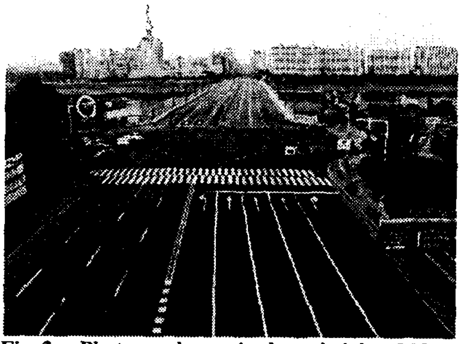

Fig. 2. Photograph acquired at a height of 12 m.

As photographs are taken from higher elevations, geographical features and road layouts become clearer. But if a photograph is acquired from too high an elevation, for example satellite images or aerial photographs, the appearance of objects may be difficult to recognize simply due to the scale. Additionally, it is difficult to obtain photographs from higher elevations. For these reasons, we obtained photographs captured from an elevation of 12 m. The objects in photographs acquired from an elevation of 12 m are easily recognizable by humans and can be easily obtained using a ladder truck.

Now, we consider the distance between the target area and the position from where the photograph is acquired. Photographs acquired from too far a distance from the target area show the target area as being too small. On the other hand, photographs acquired from too close a distance from the target area may not contain all the information of the target area due to cropping. As a result, the distance between the target area and the distance from where photograph is acquired must be carefully considered.

Photographs acquired from distances of 80m, 40m, and 20m are shown in Fig. 3, 4, 5. In the photograph acquired from a distance of 80 m, an intersection is visible, however the target area is too far for the image to be useful for route guidance. In the photograph acquired from a distance 20m, the target area is too close so we are lacking road information and information regarding the vicinity of the target area. In the photograph acquired from a distance of 40m, we can recognize the layout of the road and information regarding the area surrounding the target area. From our trials, we have decided to use photographs acquired from a distance of 45m.

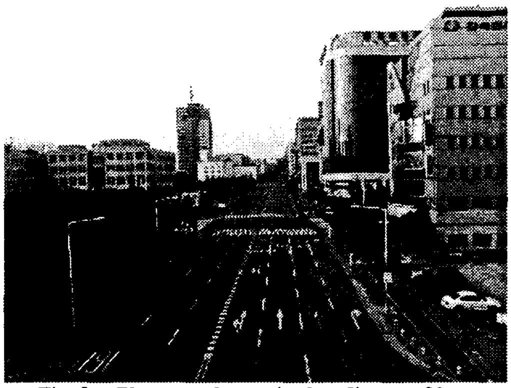

Fig. 3. Photograph acquired at distance 80 m.

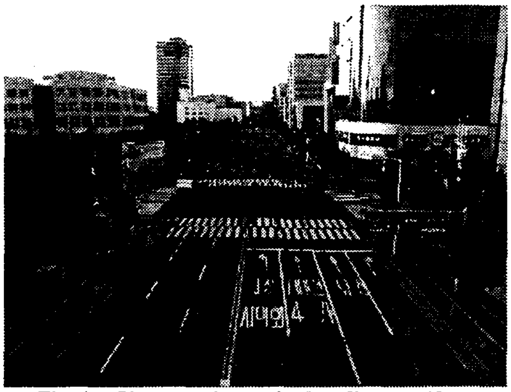

Fig. 4. Photograph acquired at distance 40 m.

Fig. 5. Photograph acquired at distance 20 m.

When we obtain photographs, we capture additional information to construct relational information between the photographs and navigational map data. The additional information used includes the following four types- the GPS data from where the photograph was captured, the target intersection name, the preceding intersection name, and the succeeding intersection name– the target intersection is the center of the photograph and can be reached from the preceding intersection. Similarly, the succeeding intersection can be reached from the target intersection. The GPS data is used to determine the positions while constructing relational information between the photographs and navigational map data. The positions of the three types of intersections are used to determine two links in navigational map data, one is a link to the photograph and the remaining links are used to determine the next section of the route. We explain these in more detail in section 2.

2) Construction of relational information between photographs and navigational map data

Route guidance is implemented by a guidance path which consists of a set of links and nodes in navigational map data. So, to serve photographs in route guidance, we must construct relational information between the photographs and navigational map data. A photograph is associated with two links data, one includes the position of where the photograph was acquired and the other is a link to the next section of the path.

To construct relational information between photographs and navigational map data, we propose a method of using GPS data and the three types of intersections which are gathered when we acquire photographs. First, we find a link including the position where photograph was acquired. One way of finding the link is using GPS data. We can match the GPS data, the position of photograph acquired, with the data in the navigational map data. Another way of finding the link is using two intersections – the target intersection and the preceding intersection. Because intersections are matched with node data in the navigational map, we can find a link including the position of a photograph using data from the two nodes. For accuracy, we use both two ways. Next, we find the next section of the path. To do so, we specify two types of intersections, the target intersection and the succeeding intersection. It is obtained in the same manner as finding data containing the position of photograph.

After finding data related to the photographs, relational information between the photographs and navigational map data is stored in a database. The relational information table and low level data in the database is shown in Table. 1. ImageID is the image identifier, CurrLinkID identifies the current position of photograph, and NextLinkID identifies the next section along the route.

Table 1. Relation information table and low level data.

ImageID	CurrLinkID	NextLinkID	......
img001	Lnk5	Lnk4	......
img002	Lnk5	Lnk3	......
img003	Lnk3	Lnk5	......

3) Service photographs in navigation system

To serve photographs for route guidance, they must be modified to be effective for route guidance and linked to navigational map data. Modifications for route guidance include registering guidance information, such as guidance arrows and guideposts. A guidance arrow is a directed arrow identifying the direction of the next section of the path, which is expressed by one of these actions-go straight, turn left or right, U-turn. A guidepost shows the destinations that can be reached by taking a given path from an intersection. A photograph with a guidance arrow and guideposts is shown in Fig. 6.

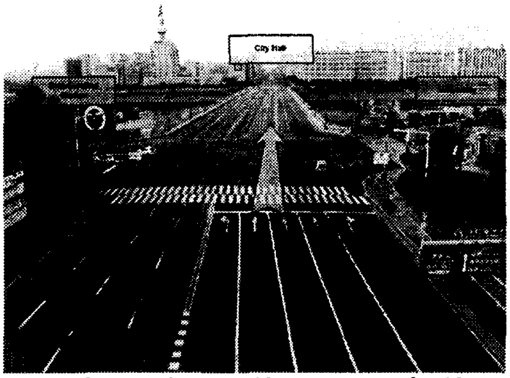

Fig. 6. Photograph with guidance arrow and guidepost.

There are various ways to express guidance information in photographs. One method is drawing guidance information dynamically as the routing path is generated. But, to simplify the architecture of prototype system, we pre-embed the guidance information, both guidance arrows and guideposts, into the photographs.

Basically, while performing route guidance, a navigational map is displayed. Photographs for route guidance are displayed at key areas such as intersections or on main roads while adjacent to landmarks. As a user approaches a key area, the photograph associated with that area is displayed. Also, a navigational map must be displayed to give basic navigational information.

The procedure for serving photographs for route guidance is as follows. During navigation, first, a routing path for route guidance is generated by the routing module. Next, queries for photographs are executed by using a pair of links in the routing path and an image identifier is selected by result of each query. Finally, the images are loaded by the image identifier of the navigation system and displayed.

4. The prototype implementation

The prototype navigation system implementing our method is shown in Fig. 7. The navigation system consists of two parts – the navigational part (left) and image part (right). In normal driving, only the navigational part is seen. But, at key areas, an image part is displayed and assists users in obtaining successful route guidance.

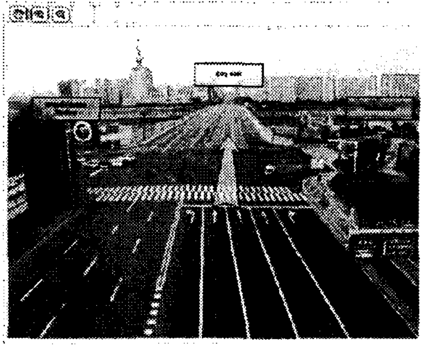

Fig. 7. The prototype navigation system adapting our method.

Our prototype system was developed on a telematics device running a 266MHz Geode CPU with 512Mbytes of Compact Flash memory. The operating system running on the device was Windows CE 4.2.

5. Conclusions

In this paper, we propose a method of serving photographs for route guidance in navigation systems. To accomplish this we 1) design a method of obtaining photographs which are useful for route guidance, and 2) devise a technique to construct relational information between the photographs and navigational map data. Also, 3) we devise a technique to serve photographs for route guidance in navigation systems. Finally, we show the effectiveness of our method by implementing the navigation system with photographs.

Navigation systems are widely used and many companies perform research into how to provide successful route guidance. Our proposed method decreases the gap between real objects and virtual images, 2-dimensional and 3-dimensional models. From these outcomes, we see that it is helpful to users in obtaining successful route guidance.

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