IOP Conf. Series: Earth and Environmental Science **44** (2016) 042027 doi:10.1088/1755-1315/44/4/042027

Landmark Orientation and Map Design for Pedestrians: Prototype of a Selcuk University Campus Area Pedestrian Navigation System

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Abstract. Orientation software produced today is generally designed for the navigation of cars. However, the navigation needs of pedestrians are different from those of drivers. The aim of this study is the design of a cartographic interface that supports the navigation of pedestrians in unfamiliar areas using landmarks and evaluation of this geo-mobile application by usability testing. In this study, an approach to landmark orientation based on the Voronoi diagram is proposed. Furthermore, the developed mobile application that uses this approach is explained in detail. The results of user tests are also given.

1. Introduction

Location Based Services (LBS) are information systems that determine the location of users through mobile devices and address various location based needs of the users using this determined location [1]. Although the use of a cartographic map interface is not required in all LBS applications [2], the use of cartographic products makes LBS applications more functional [3].

Navigation applications are some of the most common areas where LBS technology is used. In particular, car navigation applications are widely used around the world. However, the navigation needs of a pedestrian moving in an unfamiliar environment vary significantly from those of a driver. For example, the roads the pedestrians will follow do not have to be the same as roads used by cars [4, 5]. In addition, it is often more effective to say 'turn right at the hospital' rather than 'turn right after 500 m' in pedestrian navigation [6]. In addition to short distances, safety and the requirements for a comfortable journey along the selected route are very important for pedestrian navigation [4]. Furthermore, the positioning accuracy provided by GPS (Global Positioning System) is generally adequate in car navigation. It might not be adequate for pedestrian navigation, particularly when the pedestrian moves with less than the accuracy of GPS in two sequential points where he/she receives GPS signals and when the GPS signal might be interrupted (e.g. closed areas and narrow streets) [7]. For these reasons, pedestrians pay more attention to landmarks and use these objects to find their directions.

With this study, we aim to develop a pedestrian navigation system that uses landmarks for navigational purposes in a form that is proper to the user's needs and cartographic principles. Also, the usability of the system will be determined in the scope of this study with user tests. For this purpose, the Selcuk University Campus Area Pedestrian Navigation System has been designed in order to use it as a test application for the LBS in Turkey. In this context, firstly a poll was conducted in order to determine the user's needs and profiles, and the system was formed according to this poll. The Landmark Orientation Approach whose details will be given in the application section was used in the designed system. The mobile application prepared was tested with user's tests. According to the user's tests results, the issue of which information should be presented to the users in the four stages defined for pedestrian navigation was determined and suggestions were made.

2. Landmark Orientation

Landmarks are very important for pedestrian navigation, as explained above. For this reason, a landmark orientation approach for pedestrians is used in this study. We want to ensure that the user relates to at least one landmark when he/she moves on the route. To achieve this, Voronoi cells are defined around the landmarks in our study area so the user enters into the coverage of at least one landmark each time during the trip.

In mathematics, a Voronoi diagram is a special kind of decomposition of a given space, determined by distances to a specified family of objects (subsets) in the space. These objects are usually called the sites and to each such object one associates a corresponding Voronoi cell, namely the set of all points in the given space whose distance to the given object is not greater than their distance to the other objects. It is named after Georgy Voronoi, and is also called Voronoi tessellation or Voronoi decomposition. Voronoi diagrams can be found in a large number of fields in science and technology, even in art, and they have found numerous practical and theoretical applications, [8, 9, 10].

With the Voronoi approach, the user moves along the route and relates to the nearest landmark and since the entire study area is covered by Voronoi Cells, when he/she exits from the coverage of one landmark, he/she always enters into the coverage of another landmark. So users can check whether they are on the right path according to landmarks and the landmarks lead them to the destination point. The details of this approach are explained in the application section.

3. Stages of Pedestrian Navigation and Suggestions for Cartographic Map Design

Pedestrian navigation studies have revealed that representation of other map details together with landmarks is also important on navigation applications. For pedestrian navigation, when users came to an unfamiliar area, they pass through several stages from the recognition area to arriving at the destination and they need different information at different stages. Delikostidis [11, 12], Elzakker et al [13], and Delikostidis et al [14] have determined four stages for pedestrian navigation by observing the behaviour of pedestrians (Figure 1). According to this approach, user wants to recognize environment in the first stage, then identify the destination. After, he/she requires the route control in the third stage and the last stage includes the confirmation of destination. In these stages, the detailed information that is shown in figure 1 must be given for each stage to cover the navigation needs of the pedestrians in the navigation software.

4. Application

Firstly, we conducted a poll study to reveal the user needs and user profiles in our study area, and to determine the landmarks. A total of 423 participants were included in the poll. The results of this poll are explained by Selvi et al [15] in detail. Landmark buildings were determined based on the responses of the participants. After completing the poll, a mobile application with Android operation system was developed for pedestrians. Our application is a Java application that runs in Android 2.2 and higher operation systems. Since Google map data did not cover our study area and it is not possible to add data into Google maps, data of our study area were transferred to Open Street Map (OSM) (for further details please refer to [16]) using OSM tools such as JOSM (Java Open Street Map). Since OSM data also create an infrastructure appropriate for programming, these data were used as the base map in our mobile application. Then the first form of the mobile application was produced in the Java environment by using these data and the mobile application was named SelcukLBS.

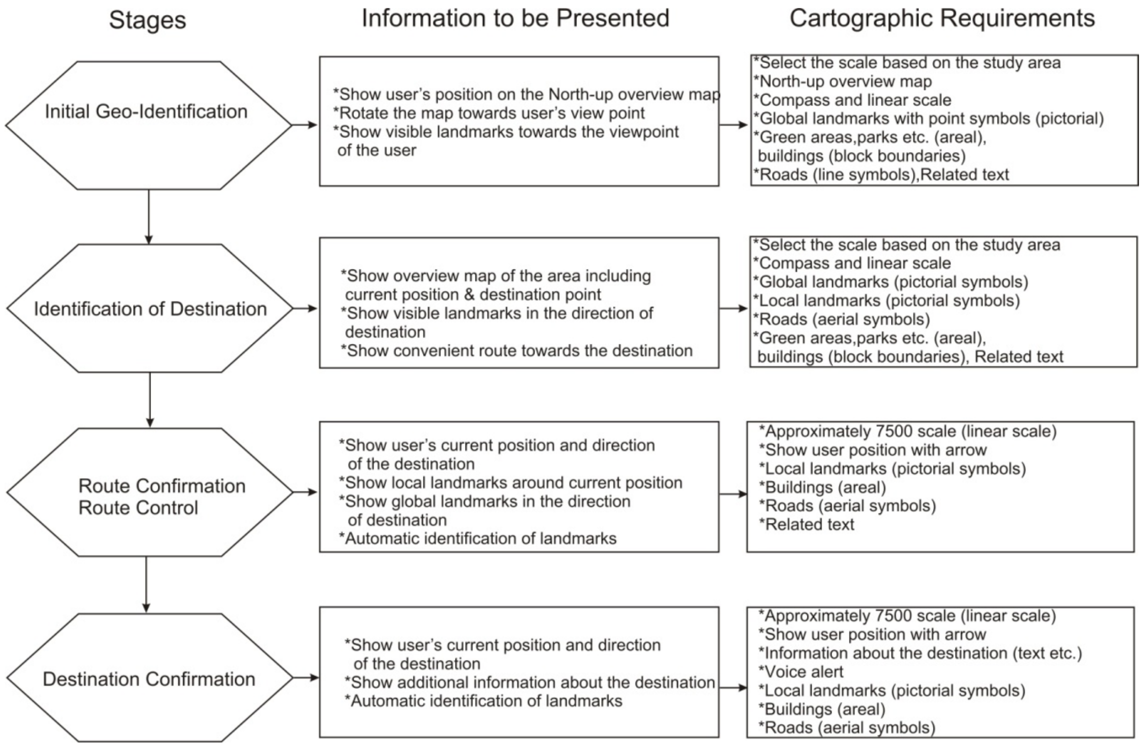

Figure 1. Representation levels in pedestrian navigation (improved by making [12])

In this context, for the first stage (initial geo-identification) that is mentioned in the third section, the current position of the user on a north-up map that covers all the study area, the zoom in and zoom out properties, linear scale, compass property, which can be activated whenever the user wants, and the global landmarks, which are very important in perceiving the position of the user and his/her establishing a relationship between the real world and the map, are included in the application (Figure 2.a). At this point, the OSM 14 Zoom level, which covers the study area, was used. The legend was not added to the system after the small size of the screen was considered. For this reason, it was aimed that the user would use the map without using the legend but by using the OSM elements and easy-to-understand symbols. Again at this stage, the position that is needed by the user was taken into the system with the help of the GPS property of the mobile device, and shown on the map with a person icon (Figure 2.a).

The approach proposed by Elias and Paelke [17] was used to visualize the landmarks in the application. In this context, the properties of the buildings that were considered as landmarks according to the poll results were taken into consideration and a table was formed to help the visualization of these landmarks (see [15], Table 2). Global landmarks are shown with drawn models in the application since it has been evaluated that it would be more useful in mobile device capacities (Figure 2.a). These drawings have been associated with the changing zoom levels and we ensured that they were seen well at each level. The other landmarks are the buildings that are separated from other buildings generally by their functions. For this reason, these buildings are evaluated as the local landmarks and are shown with chosen symbols at relevant stages by using the OSM opportunities.

After Stage 1 is completed, Stage 2 starts in which the user determines the destination point and its direction. The route application has been formed after the position of the user has been taken into the system, and the landmarks have been used in orientation within the application. For this reason, the “Find Route” button has been added to the application (Figure 2.b).

When the user clicks on this button, all the destination points found in the study area appear on the screen (Figure 2.c). When the user chooses one of these target points, the Cloudmade [18] route algorithm starts, and the route from the user’s current point to the destination point appears on the screen (Figure 3.a). At this stage, the zoom level of the map is selected as the current location of the user and the destination point will appear on the screen. At this stage, the global landmarks are shown with pictorial drawings, and the local landmarks are shown with pictorial symbols that can be understood easily by the user.

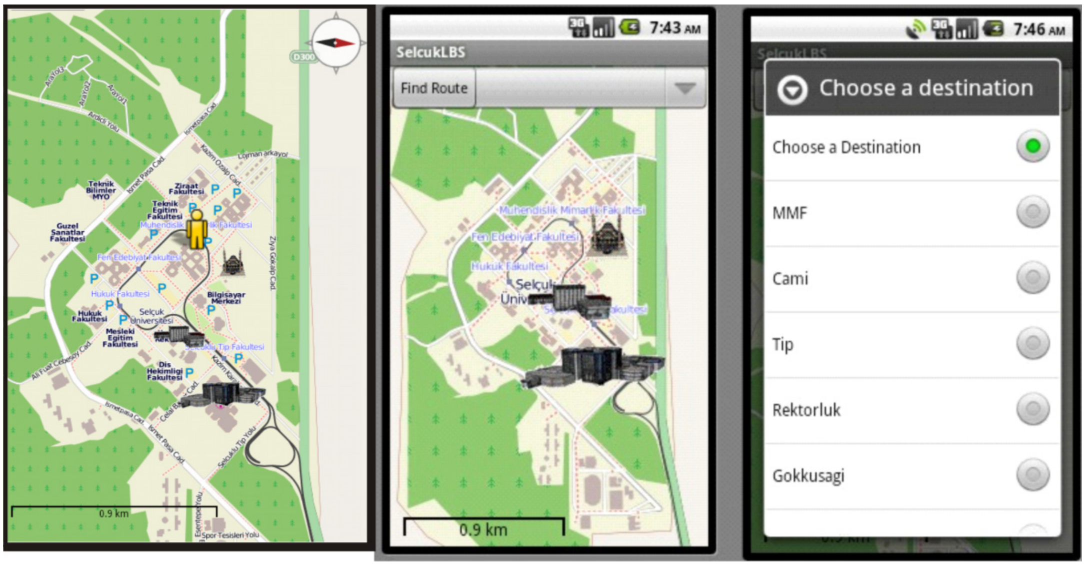

Figure 2. a) The study area on mobile application (left) b) Find Route Button (center) c) Destinations window (right)

After Stage 2 is completed, Stage 3 in which the user will move along the route and check whether he/she is on the true route begins. The necessary information that is needed by the user in order to check the route is given to the user at this stage. The position of the user has been taken into the system with the help of the GPS, and has been shown with an arrow that shows the direction of movement. In each update of the position, the map takes this position into its centre and the local landmarks have been shown with pictorial symbols, the roads have been shown with the areal symbols, and the buildings are shown as areas by using the 16th zoom level of the OSM, which corresponds to approximately 7500 scale which was proposed by Gartner and Uhlirz [19] and Nagi [20] for pedestrian navigation. At this stage, the landmark orientation application starts to work in order to prevent the user from losing the route and to make it possible for him/her to verify the route. In this context, as the user moves on the route, when he/she enters the coverage of a landmark that is defined above, the name of that landmark flashes and a sign appears on the location of the landmark (Figure 3.b).

This animation continues until the user moves out of coverage of that landmark. When the user moves out of the coverage of the landmark, he/she definitely enters the coverage of another landmark. In order to ensure this condition, the Voronoi Cells that were explained in Section 2 were formed around the landmarks in the study area. With this orientation approach, the user can control whether he/she is on the right route or not, and the landmarks lead him/her to the destination.

In Stage 4, which is the latest stage of the pedestrian navigation that is described in section 3, the user can verify whether he/she is on the right destination point or not. At this stage, the destination point is shown with a pushpin and the name of the destination is shown with animation (Figure 3 b). In addition, the user is reminded that he/she is closer to the destination point as he/she moves towards it.

4.1. Testing the mobile application

When the mobile application was completed, it was tested on a route that was selected within the study area (Figure 3.a). There is a global landmark (the mosque) and two local landmarks on the route selected. In order to test the application, eight men and six women, 14 participants in total, were selected and were asked to test the application on the selected route and to fill in the questionnaire given to them. 11 of the participants were between 18 and 25 and three of them were between 25 and 30. All of the participants were first-comers to the study area.

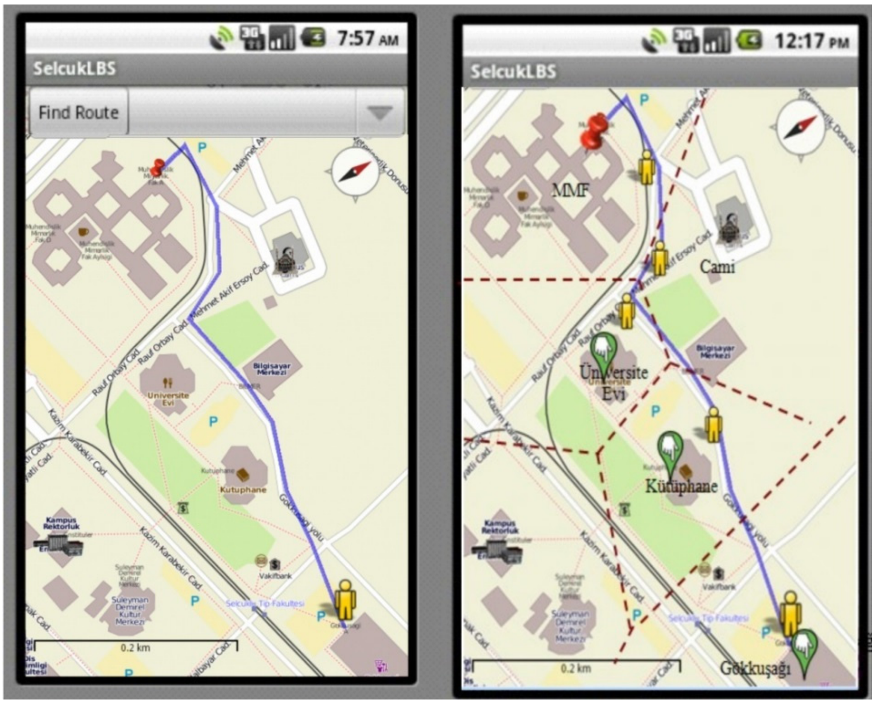

Figure 3. a) Drawing the route (left) b) Landmark Orientation (right)

4.2. User feedback

When the questionnaires were completed, it was observed that the participants considered that the mobile application would be useful in intra-campus orientation of pedestrians. Again, all of the participants stated that the application was helpful for them in finding the global landmarks that were shown in the application with drawings (Figure 3.a).

Participants were asked to identify the buildings that were located on the route and all of them stated that they had seen all the buildings that were selected and brought to the fore as the landmarks. This result shows that the application was successful in selection and visualization of the landmarks. Again, the participants evaluated the scale, zoom and compass properties of the application as being necessary and sufficient.

5. Conclusions and Recommendations

In the scope of the study, a mobile application has been designed for the purpose of pedestrian navigation. With the idea of pedestrians having four stages during navigation in mind, separate solutions for each stage were developed. To this end, the landmarks around the route are used in navigating the user. With the user tests it has been determined that the application will be used in pedestrian navigation systems and will be very useful. Especially with the increase in the use of improved mobile devices, it is clear that the need for such applications will increase. The inclusion of cartographers in the preparation stage of such projects is important in that it will ensure that the users will use true maps and establish the relationship between the maps and the real world. User needs are of vital importance in pedestrian navigation. For this reason, conducting polls etc. is very important in order to determine the user's needs and user's profiles before designing a pedestrian navigation application. Again, the landmarks must absolutely be used in pedestrian navigation by considering the issue of the right direction of the pedestrians along the route and facilitating the relationship between the real world and the map.

Acknowledgment
We would like to thank to Prof. Dr. Rahmi Nuran Celik, who inspired this study with his precious thoughts; and especially to Prof. Dr. Georg Gartner and to the Cartography Research Group of the University of Vienna.

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