An Orientation System Design for Pedestrians: A Case Study at Selcuk University

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Abstract. Location based services (LBS) use geographical location of mobile devices and provide services related to this location. Due to advanced technologic possibilities and wide-usage of mobile devices, the use of LBS applications also rapidly increases. LBS applications are most commonly used in car and pedestrian orientation systems. Orientation software produced today generally address to the navigation of cars. However, navigation needs of pedestrians are different from those of drivers. Particularly, the usage of landmarks is vitally important in human navigation. For this reason, number of studies on orientation services for pedestrians has rapidly increased in recent years. In this study, an orientation system design for pedestrian orientation system developed using LBS technologies in Selcuk University campus will be explained in detail. With this study, we aim to provide free route information with landmark orientation for pedestrians in our study area. In this context, information will be provided on the use of landmark orientation, Open Street Map data which is open all users, results of poll administered to determine user profile, kiosk and mobile applications. An approach for landmark orientation is shared and preliminary results are also given.

Keywords. Location Based Services, Landmark Orientation, Pedestrian Navigation


1. Introduction

Location Based Services are information systems which determine the location of users through mobile devices and addresses to various location based needs of the users using this determined location (Gartner 2004). Location based services (LBS) came to the fore with the importance of the locations of mobile devices and thus their users in terms of information systems. The applications developed for LBS range from simple text applications which use base station limits in telecommunication network (cell based) which approximately shows 2D location of the user (e.g. the list of shopping malls within the coverage) to highly complex applications that rely on accurate positioning and advanced analytical tools to support specific context for making decision (emergency services etc.) (Raper 2007, Jiang & Yao 2007). Possibility of developing software, positioning (GPS etc.) systems, increased graphic screen and memory capacities of mobile devices make LBS applications widespread (Gartner et al. 2007). Although the use of cartographic map and interface is not required in all LBS applications (Reichenbacher 2004), the use of cartographic products make LBS applications more functional (Gartner et al. 2007). Navigation applications are one of the most common areas where LBS applications are used. Orientations applications refer to the software which are used to provide various information to the user to ensure that the users reach from one point to a destination point in optimum manner. Particularly car navigation applications are widely used around the world. These software generally provide information that the drivers might need during their ride (e.g. after 300 m turn right) However, navigation needs of a pedestrian moving to an unfamiliar environment significantly vary from those of a driver (Millonig & Schechtner 2007). For example, the roads the pedestrians will follow do not have to be the same with car roads (Millonig & Schechtner 2007, Bogdahn & Volker 2009). In addition, positioning accuracy provided by GPS (Global Positioning System) is mostly adequate in car navigation, it might not be adequate for pedestrian navigation particularly when the pedestrian moves less than the accuracy of GPS in two sequential point where he/she receives GPS signals and when GPS signal might be interrupted (e.g. closed areas and narrow streets) (Brunner-Friedrich 2004). For these reasons, pedestrians pay more attention to landmark objects and use these objects to find their directions. Similarly, it is often more effective to say turn right from the hospital than turn right after 500 m in pedestrian navigation (Elias & Sester 2002). On the other hand, in addition to short distances, safety and appropriateness for a comfortable journey of the selected route are of importance for pedestrian navigation (Millonig & Schechtner 2007). In car navigation, generally the shortest distance is preferred. For these reasons, number of studies on pedestrian navigation rapidly increased in recent
years. Radoczky (2003), Reichen bacher (2003), Nivala & Sarjakoski (2007), Gartner et al. (2007) investigated the effects of cartographic products on route description for pedestrian navigation; Retscher (2002) analyzed the level of location accuracy for pedestrian navigation; Kolbe (2003) analyzed the use of augmented reality applications on pedestrian navigation; Gartner et al., (2003), (Milloni & Schechtner 2007) discussed how pedestrian navigation can be used in closed areas and Delikostidis (2011) investigated the properties of existing pedestrian navigation systems and made suggestions for ideal pedestrian navigation. Similarly, the literature contains a large body of research on the use of landmark objects in pedestrian navigation.

In this study, pedestrian orientation system in Selcuk University Campus which was designed to conduct a test for the LBS studies in Turkey will be explained in detail. With this study, we aim to provide free route information with landmark orientation for pedestrians in our study area. In the second section we will try to explain landmarks and why do we need landmarks in pedestrian navigation. In the third section, information will be given on data of Open Street Map (OSM) which is open to all users, and why do we use it. In application section, results of the poll conducted to determine user profile in the study area and the organization of the system according to poll results will be determined. Kiosk and mobile applications will be explained in detail and the details of the algorithms developed for the use of landmarks for pedestrian orientation will be explained.

2. Landmarks and Navigation

Prominent objects around which help users to understand their surrounding and to navigate are called landmarks (Sorrows & Hirtle 1999). To be a landmark, an object has to have a specific characteristic that differs from others. This might be a visual characteristic, location or any characteristic that differs from others (Raubal & Winter 2002, Elias 2002). In pedestrian navigation, the users want to use the landmarks on the route in addition to the direction description (Michon & Denis 2001). Landmarks have a very important role in shaping of the environment in the minds of users (Brunner-Friedrich 2004). In addition, the pedestrian check whether they are on the right way according to these landmarks (Michon & Denis 2001, Elias & Sester 2002, Huang 2010) and when they encounter landmarks during the route, they feel more comfortable. Particularly at decision making points, these objects play a vital role in orienting the users to the right direction (Klippel 2003).
Landmarks were categorized in a wide variety of types in the literature. Lovelace et al. (1999) categorized landmarks into four as follows: choice point landmarks (at decision points), potential choice landmarks (landmarks which are not used in the current route but will be potentially used in case of re-orienting) on-route landmarks (landmarks on the route which are not at a choice point) and off-route landmarks (the landmarks at a distance however visible on route). Similarly, Raubal & Winter (2002) categorized landmarks into two as global landmarks (e.g. off-route landmarks) and local landmarks (e.g. choice point landmarks and on-route landmarks). Sorrows & Hirtle (1999) investigated landmarks in three categorized according to their prominent characteristics: visual, structural (at significant locations) and cognitive (different in terms of their functions).

Raubal & Winter (2002), Elias et al. (2005) developed algorithms to automatically derive on-route landmarks. Brunner-Friedrich (2004) analyzed 6 different landmark derivation methods and investigated what type landmarks should be derived and which method should be used. However, all of these methods have some disadvantages. Whether the landmarks are visible on the route should be particularly taken into account. Applications such as data-mining and laser scanning techniques are included in these methods to add visibility analyses of landmarks into these methods. However, these combined methods are very difficult to apply. Due to these difficulties in automatic derivation of landmarks, Millonig & Schechtner (2007) and Delikostidis (2011) determined landmarks by analyzing user behaviors in their study areas. In this method, several users who were unfamiliar to the study area were followed on the selected routes and the objects considered as landmarks by these users were determined. The results of this study reveal that determination of landmarks with this method was more appropriate for user needs. The landmarks in the application which will be explained in the present study were determined by the poll administered to the users.

There are different approaches regarding the visualization of landmarks in LBS applications. The principle aspect is to ensure that landmark is visualized in such a way to be distinguished from other objects. Elias & Sester (2002) developed various methods on landmark visualization based on graphic variables. These methods can be listed as follows: Marking the object with an arrow; coloring the object or emphasized visualization of the object; simplified other objects and normal visualization of the landmark; merged less important objects and separate visualization of the landmark; visualization of the object with specific symbols. In addition to all these approaches, Radoczky (2004), Kolbe (2003), Hile et al. (2009) suggested that 3D models, geotagged photos and video sequences might be used for identification of landmarks with augmented reality applications. Elias & Paelka found that buildings constituted 50% of the landmarks used in their
applications and defined four different categories for landmark buildings: well-known shops (e.g. chain markets), shops referenced by their type (e.g. restaurant, cafe etc.), buildings with a certain name or function (e.g. hospital, mosque etc.) and buildings known for their visual characteristics. The researchers prepared a table about possible visualization of the buildings in each category at different visualization levels (Figure 1) (Table 1). Since the landmarks selected in the study area of the present study involved buildings, our landmarks were categorized and visualized according to this table. The application of this method in our study area will be explained in application section in detail.

![Figure 1: Visualization of a church at different abstraction levels (Elias & Paelka 2007)](image)

<table>
<thead>
<tr>
<th></th>
<th>Image</th>
<th>Drawing</th>
<th>Sketch</th>
<th>Icon</th>
<th>Symbol</th>
<th>Words</th>
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</thead>
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<tr>
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<td>+</td>
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</tbody>
</table>

Table 1: Design proposals for landmarks (Elias & Paelka 2007)

3. Open Street Map

OpenStreetMap (OSM) is geographic data production project initiated by Steve Coast in 2004 to create geographic data covering the entire world with the participation of world-wide users. The project can be used free of charge by all map users. Worldwide users can include their geographic data into this system through various software and use this data or any data they need by connecting to the system via internet or by downloading the data of the region they need to their computers. The system began to be widely used due to its various features such as possibility of making necessary up-
dates and changes, data infrastructure appropriate for programming, high-quality cartographic maps. OSM is recently preferred in academic circles particularly because the infrastructure of widely used Google map fails to cover the entire world, its geographic data cannot be downloaded and it is not possible to enter or update user data to the system. It is possible to transfer an available GPS data or geographic data of various formats into OSM using OSM tools. This feature makes OSM to be widely used. Detailed information on various issues such as how to use OSM data and how to add data to OSM can be obtained from URL1 address.

Since Google map data did not cover our study area and it is not possible to add data into Google map, data of our study area was transferred to OSM using OSM tools such as JOSM (Java Open Street Map). Since OSM data also creates an infrastructure appropriate for programming, this data was used as base map in our mobile application which will be explained below.

4. Application

4.1. Study Area
Selcuk University campus was founded in 1990. The university has a wide campus with approximately 5 sqm area. There are 16 faculties, 4 colleges, 13 research centers, 1 library, 1 shopping center and dormitories. Free wireless internet connection is available in the campus. There are approximately 50000 students and 3000 academic and administrative personnel in the campus.

4.2. The poll
We conducted a poll study to determine user profile in our study area and the objects considered as landmark by the users. A total of 423 participants were included in the poll. Of the participants 76% were males and 80% were between the ages of 18-45. A total of 96% of the participants believed that it was necessary to conduct a study on the orientation of pedestrians. Similarly, 93% of the participants believed that orientation through mobile phone or navigation device would be helpful when one goes to an unfamiliar place. Of the participants 75% reported that they could connect to internet for navigation on condition that it is free of charge.
Figure 2: Properties of our participant’s mobile phone

Figure 3: Landmark buildings according to our participants
Only 20% of the participants had mobile phones with advanced features such as GPS, WiFi and operation system (Figure 2). For this reason, to ensure that more users make use of our application, in addition to mobile application, we conducted a kiosk application. This application will explained in detail in the next section.

To determine which buildings in the campus were considered as landmark by the participants we asked the questions “which of the following buildings in the campus would you use to describe a place to a person who is unfamiliar with the campus?”. Landmark buildings were determined based on the responses of the participants (Figure 3).

4.3. Kiosk Application

Results of the poll revealed that only 20% of the users had mobile phones with advanced features such as GPS, (Figure 4). To ensure that more users make use of the system we will build, a kiosk application was designed. This application was operated on the kiosks placed in the study area. This kiosk application was created with ARCGIS Server 10 software. In this scope, kiosks were planned to be located on a total of 13 points (see Figure 4). Since the study aimed pedestrian navigation, firstly commonly used pedestrian ways were determined and were included in the system.
As it is important to find entrances of the building for the pedestrians, building entrances were added to the system and pedestrian ways and these entrances were associated (Figure 4). A web application that finds and shows the route between the two points selected by the user in the screen was created using ArcObject objects and python script language. This application was operated in kiosks.

In this kiosk application, when the user pushes “Find Route” button on the kiosk, he/she can receive route description including two or more points he/she wants. Since the locations of the kiosks are also registered in the system, the users are able to take road description from his/her current location to other locations. The software draws the route asked by the user on the screen. If the user would like to see road description, he/she can get route description by pushing “download” button on the left frame. (Figure 5). Thus, one part of the campus pedestrian orientation system was completed. The users who did not have mobile devices that can run the mobile application explained in the next section could use these kiosks.

![Figure 5: The final screenshot of the kiosk application](image)

4.4. Mobile Application

After completing kiosk application, mobile application was prepared to use the system in mobile devices. With this study, we aim to provide free route information for pedestrians in our study area. In this scope, an application for mobile devices with Android operation system was planned as it is free...
of charge. An important reason for choosing these devices was that mobile devices with Android operation system allowed for software development with free Java programming language. Our application was a Java application which can be operated in Android 2.2 and higher operators. Similarly, above-mentioned OSM data was used as base map since they also support Java programming in this application. Osmdroid (URL2) open street map android packages were used during the application.

Firstly, as the data which will be used as base map in mobile application were not present in OSM, this data was transferred from ARCGIS to OSM using JOSM editor. The first version of the mobile application using these data was produced. In this context, zoom in, zoom out features, map scale, compass features with which the user can activate and orientate the map were included to the application (Figure 6).

![Figure 6: Study area in our mobile application](image)

To include the landmarks explained in section 2, which are of great importance for pedestrian navigation, the approach proposed by Elias & Paelka (2007) explained in section 2 was applied. In this context, based on the characteristics of the buildings which are considered as landmark according
the poll results, a table was formed on the visualization of these landmarks (Table 2).

<table>
<thead>
<tr>
<th>LANDMARKS</th>
<th>Visual aspect</th>
<th>Name / Function</th>
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<th>Shop (name)</th>
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<th>Drawing</th>
<th>Sketch</th>
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<tr>
<td>Bank ATM</td>
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<tr>
<td>Süleyman Demirel Cultural Center</td>
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<td>Vakıfbank Bank</td>
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**Table 2: Landmark Classification and Visualization in our study area**

As indicated in the table, mosque, Selçuklu Faculty of Medicine and Campus Rectorate buildings were evaluated as global landmarks as they are high, visible from all over the study area and for their functions. These buildings were shown in drawing in our application (Figure 6). These drawings were associated with varying zoom levels and appropriate visualizations were provided. Other landmark objects were included in the application with their symbols and names. Then to use these landmarks in orientation, a 100 m-radius coverage was defined for each landmark object (Figure 7(d)).

After including the landmarks in the application, the current location of the user is taken in the system using the GPS feature of the mobile device. This location is shown with person image in our application (Figure 7(c)). Routing application is formed and landmarks are used for orientation within this application. In this context, “Find Route” button was added to the application. When the user pushes this button, all destination points in the study area appear on the screen. When the user selects one of these destination points, Cloudmade (URL3) route algorithm operates and route is drawn on the screen (Figure 7(a-b-c)).

Landmark orientation application starts to operate at this stage. In this context, while moving on the route, when the user enters the coverage of each landmark, the name of the corresponding landmark flashes. This animation continues until the user exits the coverage of that landmark. When the user exits from the coverage of a landmark, he/she always enters into the coverage of another landmark. Number of landmarks and radius of coverage are determined in such a way to ensure that the user enters into the coverage of at least one landmark each time he/she moves on the route (Figure 7(d)).
Figure 7: Phases of mobile application
(a) FindRoute button b) Destinations window c) Drawing route d) Landmark orientation
Thanks to this orientation approach, the user can check that he/she is on the right route and landmarks reach him/her to the destination point. Thus, the user was prevented to go off the route due to various reasons; he/she was enabled to safely reach the destination point. The user can click “Find Route” tab and ask orientation to another point if he/she desires.

5. Conclusion

This study explained the details of Selcuk University Campus pedestrian orientation system designed as a test application for LBS studies. In this framework, it was emphasized that pedestrian navigation differed from car navigation and that landmark objects should be used for navigation. With this study, we aim to provide free route information with landmark orientation for pedestrians in our study area. For this aim, we used Android mobile devices and Open Street Map data for mobile application. The results of the poll administered within the study area, the details of kiosk application and mobile application decided as a result of the poll were explained in detail. The details of the approach particularly developed for pedestrian orientation using landmarks were explained. In this application, number of landmark and radiuses of coverage should be determined in such a way to allow the user to always associate with a landmark on the route. Since it will be easier to determine landmarks and radius of coverage, it was believed that this application can be comfortably used in small areas like our study area and that it will make a significant contribution to pedestrian orientation. Mobile part of the study was completed in Vienna University of Technology. For this reason, the results were tested only on emulator. In the next stage mobile application is planned to be tested with real users in the study area.

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