Landmark-based pedestrian navigation

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KEYWORDS: Navigation Services; Landmark; Path finding; Pedestrian Navigation; Seamless positioning;

1. Introduction

Car navigation has become one of the most widely used examples of Location-Based Services (LBSs). However current car navigation systems are not fully suitable for the navigational needs of pedestrians mainly because walkers are not as restricted as car drivers. Pedestrians can easily go into a building or underground to get to their destination where GPS signals are unavailable. Seamless indoor and outdoor navigation is one of the most important features which should be handled in a pedestrian navigation application.

Another aspect of pedestrian navigation which is not applicable to car navigation are alternatives to turn-by-turn navigational instruction delivery. In contrast with drivers, pedestrians have a higher degree of freedom in their movements. They are not constrained by road networks (for example vehicle lanes, turn restrictions, one-way streets) and can walk in places where vehicles are not allowed to move, such as squares, parks, grasslands or pedestrian malls, which can be traversed freely in any direction. As current turn-by-turn navigational instructions to be given to vehicle drivers are mostly based on graph-based or street network-based algorithms, this way of navigating is not fully suitable for pedestrians as they do not only move on streets.

In both of these challenges for useful pedestrian navigation systems, seamless indoor/outdoor positioning and non-turn-by-turn navigational instructions, other information such as the use of landmarks can be helpful. It is possible to calculate the position of a user based on proximity to known landmarks. Their relative position can be sensed using wireless systems, ultrasound, dead-reckoning and inertial sensors as well as conventional GPS. Landmark extraction can be performed manually or semi-automatically using conventional cartographic data-capture techniques or using technologies such as aerial image processing or laser scanning. Since landmarks can be detected and labelled both indoors and outdoors, it is possible to use them with users' locations seamlessly.

Several researchers in the field of spatial cognition assert that navigating humans rely on three forms of spatial knowledge: landmark, route and survey knowledge (Siegel, 1975), (Werner, 1997). Exploring an unfamiliar environment, pedestrians first notice outstanding objects or structures at fixed locations. These unique objects or places are easy to recognize and can be kept in memory without difficulty (Millonig, 2005). The importance of landmarks for pedestrian navigation and wayfinding instructions has been demonstrated (Michon, 2001), (Tom, 2003), (Lovelace, 1999), (Raubal, 2002).

If landmark data is stored in a spatial database, it is possible to provide users with navigational instructions landmark-by-landmark rather than turn-by-turn. A landmark-based navigation service would provide users with navigational instructions of the form “turn right when see Tower A”, and “go straight on passing by Statue B. whenever they approach each landmark. One of the most important advantages of landmark-based navigation is that it makes the pedestrian sure that they are on the correct route, since they can see the very landmark which was used as a part of navigational instruction. Also this approach is more compatible for tourists and visitors. It is possible to add some attribute data or images of landmarks while navigating, so they will see more while visiting an area in addition to being directed.

In order to implement our model, the campus of National University of Maynooth was considered. Buildings and important features, such as sports pitches and library were stored in a spatial database as outdoor landmarks. In addition, indoor landmarks such as main entrances and geo-tagged wall features (notice-boards etc.) were stored as indoor landmarks. All the landmarks were modelled with polygonal shapes, four pictures were captured and also attributes such as the name in English, name in Irish, land use and description were collected and stored in a spatial database. After locating the user, navigational instructions are provided using a description and pictures of the nearest landmark on the pre-calculated route. To select a picture of each landmark, the direction of user movement is used to find the most similar to the view the user has.

2. Landmark-based Navigation

A landmark can be defined as anything which is easily recognizable, such as a monument or a building. Landmarks are of particular interest to tourists especially if of notable physical features or historical significance. Landmarks are often used in casual navigation by ordinary people, such as when giving directions (Millonig, 2005). Their familiar use in verbal route instructions indicates they should be appropriate for pedestrian navigation systems.

After extracting important features as landmarks, the best path between the current location of the user and their selected destination is found. The “best” path may involve many criteria to be optimized. For example, in order to find the shortest path between two points, standard algorithms look for the minimum distance to be traversed. In the campus navigation application, users are pedestrians so the shortest path and the fastest path algorithms should have the same outputs. We provide another option which calculates the most “reliable” path, which is the path that is easiest to follow (Elias, 2003).

Most of the occasions users when need navigational instructions are when they do not know the area very well. In this case, usually users prefer the most reliable path rather than the shortest one (Elias, 2003). Taking the most reliable path may reduce chance of being lost. In addition, most users of a tourist navigation application want to see monuments and landmarks which may involve deviating from the shortest path. Landmark-based path-finding algorithm provides a more attractive and, at the same time, more reliable path. Since users are seeing more landmarks on the way, they are assured that they are taking the right way. Also a bonus may be more interesting and more attractive routes.

In landmark-based path-finding (Hile et al, 2009) we are looking for a path which traverses a shorter distance to get the destination but passing more landmarks on the way. So landmark-based path finding algorithms are trying to maximize the result of:

Number of landmarks of each edge / length of that edge.

Once the route is calculated it is possible to navigate the user by providing images, and descriptive text of the landmarks to be viewed from this route (Fang et al., 2011).

3. Implementation

The implemented landmark-based navigation system was intended to provide navigation services to pedestrians on the campus of National University of Ireland Maynooth. Overall, there are four main steps in our landmark-based navigation system design. Firstly, landmarks must be defined, extracted and stored in a spatial database. In this step both spatial and non-spatial characteristics of each landmark are stored. Then the position of the user is calculated using the stored landmark positions. Then, based on a routing algorithm that gets starting and destination points as two inputs, the best path is calculated. Finally, navigational instructions using landmarks are generated.

Using landmarks stored in the spatial database, it is possible to find the best path and navigate users to get their destination. The architecture used to provide user with landmark-based navigational instructions is illustrated in figure 1. The landmark-based navigation system implemented in NUI Maynooth consists of four main components; a positioning system, spatial database, navigation service calculation engine and users' mobile devices.

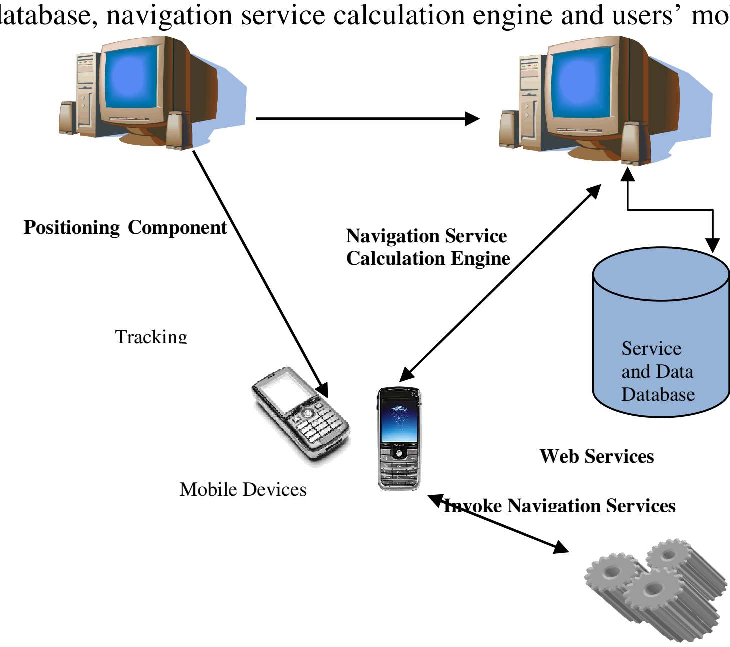

Figure 1. NUIM Campus Landmark-based Navigation System Arcitecture

The positioning component is responsible of tracking users. The navigation service uses the position of the user in two main issues; first it calculates the best path using the user's current location and selected destination and secondly, based on location of a moving user, it provide him/her with landmark based navigational instructions. In order to do both of these tasks, the navigation service calculation engine needs to have access to the spatial database in which are stored landmark information, edges and nodes data.

Figure 2 shows one of the calculated routes from NUIM south campus main entrance to Callan Building room number 1.38. After route calculation, the user is provided with navigational instructions to follow the calculated route. In this step, the navigation service calculation engine uses tracking information provided by the positioning engine and also information on landmarks to be seen from the calculated route, stored in the spatial database such as images and attributes. Whenever the user approaches one of the landmarks or whenever the user is in a position from where a landmark is visible, a new set of navigational instructions is provided. For example, “go straight forward untill you see John Paul II library then turn right.” It is also possible to provide them with an image of the library which shows the building from their point of view or to give more information about the history and other attributes of the building.

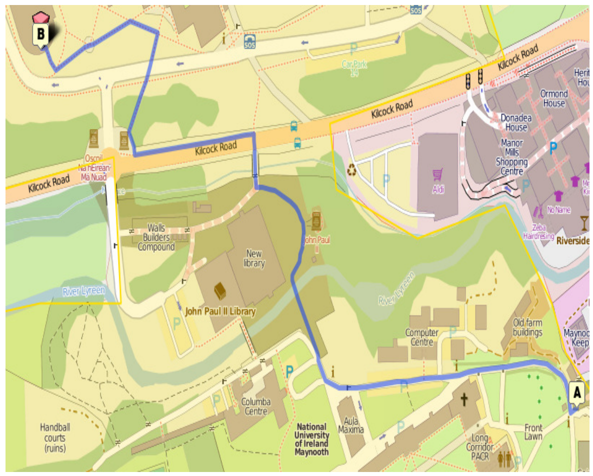

Figure 2. Suggested Route based on landmark-based path finding algorithm

4. Acknowledgements

Research presented in this paper was funded by a Strategic Research Cluster grant (07/SRC/I1168) by Science Foundation Ireland under the National Development Plan. The authors gratefully acknowledge this support.

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Biography

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