A Better User Experience in Mobile Indoor Navigation System using Augmented Reality

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Abstract. Various indoor navigation systems have been introduced which include the use of Wi-Fi based systems, Bluetooth, RFID and QR codes. These indoor navigation solutions tend to be susceptible to signal degradation and indoor interference which could affect the accuracy of the tracking system. This paper sets to present an inexpensive mobile software application that uses hybrid solution of visual recognition and Pedestrian Dead Reckoning (PDR) system to create an interactive content of indoor navigation system using Augmented Reality (AR) called SunMap+. User satisfaction and feedback survey have been gathered and studied to further improve the proposed interface and interaction of indoor navigation system.

Keywords: Indoor navigation system, augmented reality, visual recognition, pedestrian dead reckoning system, location-based services.

1 Introduction

With the advancements of mobile technologies, particularly in the area of indoor location-based services (LBS), a navigational system using mobile devices could aid users in locating the desired destination easily. In addition, most of today’s mobile devices have components such as accelerometer, gyroscope, compass, camera, GPS, Bluetooth, and Wi-Fi which are often used to develop various indoor navigation systems. Most LBS systems offered today, use GPS to provide the primary navigational capabilities while Wi-Fi and cell tower triangulation are used to provide secondary or assisted geographical information to mobile users [1]. However, these systems require additional installation of equipment and transmitters in order to function effectively in an indoor environment. Henceforth, the keen interests in the area of indoor location-based applications have spurred new challenges in utilizing the onboard mobile device’s sensors more efficiently and effectively to compensate for the inability of the GPS to work in an indoor environment [2].

This paper presents a cost effective, easy-to-use interactive navigational solution which aids users in locating their intended destinations in an indoor environment. The approach is based on an offline hybrid approach that utilizes visual image processing and object recognition capabilities coupled with a Pedestrian Dead Reckoning (PDR) system. Further, this interactive indoor navigation system uses Augmented Reality...
(AR) to enrich information representation and enhance user perception and experience [3]. AR refers to the technology whereby computer generated sensory inputs and information is blended into our physical view of the world in real-time via the camera live feed that is being displayed to the user [4]. We leverage on the AR concept to overlay an interactive virtual 3D map of the indoor environment together with its navigation path to guide visitors to their intended destinations. User satisfaction and feedback survey has been conducted to evaluate the SunMap+ prototype in terms of user friendliness, usability and navigation accuracy.

2 Related Work

We examine the use of various indoor positioning technologies that are currently being researched and applied in various scenarios such as personal virtual tour guide, indoor evacuation system and targeted mobile advertisements. Table 1 provides a comparison between various indoor LBS applications such as Nintendo 3DS Guide: Louvre [5], CAViAR [6], and Roodin [7] in relation to our proposed SunMap+ application. The comparisons were made in terms of the applications’ tracking and mapping capabilities and also its underlying indoor positioning technology used.

Table 1. Summary of the characteristics and attributes of the indoor LBS systems evaluated

<table>
<thead>
<tr>
<th>Application Name</th>
<th>Proposed SunMap+</th>
<th>Nintendo 3DS Guide</th>
<th>CAViAR</th>
<th>Roodin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods for LBS</td>
<td>Visual Recognition + PDR</td>
<td>Wi-Fi</td>
<td>Visual Recognition + PDR</td>
<td>QR Code + PDR</td>
</tr>
<tr>
<td>Additional equipment, transmitters or tracking tags required</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Susceptible to radio frequency interference and attenuation</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Training data required</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Secondary tracking system</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Supports augmented reality</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>3D mapping of the environment</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Shortest path recommendation</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Turn-by-turn navigation</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

Based on the Table 1, it could be seen that the use of AR coupled with the visual recognition approach provides various advantages over the existing indoor LBS solutions evaluated. Furthermore, the inclusion of the PDR system as an additional secondary tracking system in the SunMap+ provides increased reliability and robustness that is lacking in most of the existing indoor LBS solutions that we have evaluated. This is because the PDR system works by calculating the distance travelled from a given starting position and track the user’s movement through foot step detection [8]. The SunMap+ application also differs from the Roodin application [7] which uses a QR code approach which is also coupled with a PDR system. This is because the SunMap+ application leverages on real-world object recognition instead...
of constraining our system to the use of specially embedded codes. Hence, the experience is natural and intuitive for the user as it enhances their visual perception of their surrounding environment instead of locating QR codes that are placed in known locations.

3 Overview of the Proposed System – SunMap+

The SunMap+ [3] prototype was developed to demonstrate the feasibility and functionalities of the application in using the Vuforia SDK’s visual recognition capabilities and AR features to localize the position of the user. In order to enhance the accuracy and tracking ability of the user’s position, the PDR system has been implemented in the SunMap+ application. The step counter uses this information to estimate the distance travelled by the user. The PDR system is also coupled with the inbuilt compass sensor to provide directional and bearing information. This is important in determining the orientation of the user at any given time. Once the location of the user has been identified, the information would be passed to the routing algorithm in the SunMap+ application. We use A* algorithm [9] to determine the shortest path from our reference point to the intended destination. The routing information is calculated and the shortest route is then displayed on the camera live feed. The information overlaid on the camera feed will indicate to the user the most suitable path that the user should take. As such, the overall system design requires the use of the sensing capabilities of the mobile device and is dependent on the user behavior to navigate to the destination.

4 Results and Conclusion

In order to gauge the level of acceptance of the SunMap+ application, a user satisfaction and feedback survey has been conducted. The survey is separated into three distinct categories covering the different aspects as shown in Fig. 1. A total of ten (10) participants were chosen randomly for this survey with a sample population consisting of six (6) males and four (4) females from varying age groups. From the feedback collected, 80% of the respondents agreed that the user interface of the SunMap+ is simple, intuitive and relatively easy to use. However, the survey indicated that 20% of the users found the application unsatisfactory due to the interface of the application. This includes having font size and button size which are too small, unattractive color scheme which are dull and not contemporary. Respondents shared their views that the use of AR enables them to visualize the navigation path with ease as the information overlaid on the camera live feed is relevant and context sensitive in nature. In addition, the 3D view of the virtual map is seen as an important element in improving the users’ understanding and perception of the campus layout. Furthermore, majority of users found that the use of AR in the SunMap+ application enabled them to navigate their environment with more confidence and perceive their environment better in locating their destination.
As a conclusion, the proposed SunMap+ application has demonstrated the possibility of using visual recognition technique complemented by a PDR system to track a user's movement and location in an indoor environment. It has also successfully achieved its objective of using AR to enhance the usability of the system as it provides users with a better perspective and understanding of their environment. Henceforth, the use of AR in indoor positioning technologies is seen as an area with great research potential that would yield many benefits. AR technology could one day be seen as the linkage to bridge the divide between the physical world and its digital counterpart to provide an integrated solution to having intelligent and context-sensitive information.

References