Exploring Mobile Augmented Reality Navigation System for Pedestrians

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Summary
Mobile augmented reality has been introduced rapidly through various mobile applications ever since smart phones became widespread. Geographic information system applications, especially those using location based service, have adapted this new computer vision technology, but current mobile AR applications which contain POI data only display location information. This forces the user to switch from an AR view to a conventional 2-dimensional view in order to receive continuous spatial information that covers a user's entire route. This paper will use a scenario-based approach and propose a solution that will provide linear spatial data, particularly route information, in mobile augmented reality applications.

KEYWORDS: Augmented Reality, GIS, LBS, Navigation, Pedestrian

1. Introduction

The appearance of smartphones featuring a Global Positioning System (GPS) receiver, a digital compass, and accelerometers has led to an acceleration of spatial information use in the mobile environment. These advanced mobile devices have allowed us to detect not only a user's location, but also his/her heading and pitch, and they have incorporated that data into their display systems (Jang & Hudson-Smith, 2010). These motion-detecting sensors have also made it more feasible to build practical Augmented Reality (AR) applications on mobile devices. AR is a variation of the Virtual Environment (VE) (Azuma, 1997; Höllerer & S. Feiner, 2004). AR has been used as a new visualisation method on mobile devices, in various fields such as games, retail, Social Network Services (SNS), and so on. Geographic Information System (GIS) applications, especially those using Location Based Service (LBS), have immediately adapted this new computer vision technology. One of the benefits of using AR in LBS applications is that it can provide an intuitive and user friendly interface (Wagner et al. 2005). This is possible because an augmented reality interface dynamically superimposes interactive computer graphics images onto objects in the real world (Poupyrev et al. 2002). In that sense AR can provide a powerful user interface, particularly when we use location-aware technology, because the real world becomes the user's interface (Höllerer & S. Feiner, 2004). In order to produce an AR interface, however, registration of virtual objects is essential. This is recognised as one of the most basic problems in producing an AR interface (Azuma, 1997). Most of the current mobile AR applications which use POI data only display location information as a point in their AR view, forcing the user to switch from an AR view to a conventional 2-dimensional view in order to receive continuous spatial information that covers the user's entire route. In this article we present a scenario-based approach to developing a mobile augmented reality system which uses spatial information, in particular route data for pedestrian use.

2. Related work

Many researchers have investigated the use of AR with spatial information for outdoor usage while other researchers have explored mobile-based navigation systems. The ARVino (King et al. 2005) was developed to investigate the possibility of using AR for agricultural use. The application uses GIS data (e.g. a vegetation index map) to display an image of the type of grapes, which augmented on

top of a live image of the vineyard itself. The authors of this paper pointed out several challenges to properly use AR outdoors, including transparency and clarity of virtual objects, sunlight on the display, and what the authors call "the long-flat viewing problem," caused by depth perspective, in which it becomes difficult to show distances between objects located far away on a flat distance. The wearable computer has been popular in Mobile AR navigation applications. Hollerer and his colleagues (T. Hollerer et al. 1999) studied four types of mobile AR interfaces: an outdoor User Interface (UI), a handheld map UI, an Indoor UI, and an indoor/outdoor interaction. In order to determine a user's location indoors, Radio Frequency IDentification (RFID) was implemented (Tenmoku et al. 2003). Map Torchlight (Schöning et al. 2009) uses a projector to superimpose POIs, streets, and additional spatial information on top of a paper map.
Baus and his colleagues investigated map-based mobile guides (Baus et al. 2005). The authors pointed out that a perspective view is preferred by mobile navigation system users over a birds-eye view. Luca and Daniele developed a mobile navigation system that can be used for evacuation purposes (Chittaro & Nadalutti, 2008). Their evacuation navigation system used location-aware 3-dimensional models to reduce navigation errors in emergency situations.

3. Scenarios and functionality

3.1 Scenarios

The scenario approach has been introduced in the Human-Computer Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) communities to fill the gap created by the "traditional approach" to design. It seeks to do so by imposing a technological orientation, abstraction, and other "user-distant" features (Giboin et al. 2002). This paper adapts this method to describe how to implement an AR interface in mobile GIS applications. We present three scenarios below:

3.1.1 Scenario 1: Mrs. Smith wants to find her son's new flat

Mrs. Smith is visiting London to see her son who is a student at University. She is new to London and wants to find her son's flat near Russell Square. She has a London A to Z map but she is having a hard time reading the map and orienting it with roads in the real world. This scenario is intended to highlight the potential of AR navigation systems which can overlay route information onto a physical world. Providing route information in an AR view to Mrs. Smith has the added benefit of ease of use: she understands spatial information (in this case route information) intuitively.

3.1.2 Scenario 2: Henry wants to find his way around campus

Henry Smith is a freshman at UCL. He attends lectures and seminars everyday but his lecture rooms and seminar rooms are spread throughout the UCL campus. He is always checking Google Maps to find routes to his classes. Henry wants to have a UCL building map so he can easily select his lecture room from a menu and find directions easily. This scenario focuses on providing an AR navigation system in a defined area such as a university campus. It could be equally useful in an amusement park, a shopping centre, an Olympic complex, and so on.

3.1.3 Scenario 3: Henry and Jin Woo want to meet for lunch

Henry Smith made a new friend in his University, Jin Woo Kim. Henry and Jin Woo want to have lunch together, but they are both new to campus. They are in different UCL buildings and they have only one hour free for lunch. They want to choose an intermediate location that is between them, and they want their smartphones to route them to that location from their present locations. This scenario focuses on sharing routes among chosen users and finding an intermediate location between them. In addition, it updates the intermediate location according to each user's relative walking speed.

3.2 Functionality

One of the common functions in all three scenarios is the ability to provide route information in an AR view. Doing so will allow the user to avoid having to read a 2-dimensional map. Each of the scenarios describes a slightly different situation.

Table 1. Functionalities

	Scenario 1	*Scenario 2*	*Scenario 3*
Common Functions	• Display route information in a AR view • Detect user location automatically • Display destination location • Continuously detect/update user location		
Unique Functions	• Provide an input interface for user- defined destination	• A selection of destinations in a defined area	• Exchanging user location information among various users • Calculate/show intermediate location

4. System architecture and visualisation

4.1 System Architecture

Figure 1 describes an overview of the system architecture for mobile AR applications that are made for this research. In this research we use the Android platform (Android 2.3: Gingerbread) and Java. The Samsung Galaxy Nexus S has been used as the mobile device. The Galaxy Nexus S has a 1 GHz ARM cortex A8-based CPU, 512 MB RAM, a 4-inch glass touchscreen and a 5-megapixel rear camera. Google Maps have been used as a background map and additional UCL building data in scenario 2 was created in the JSON format (Figure 2).

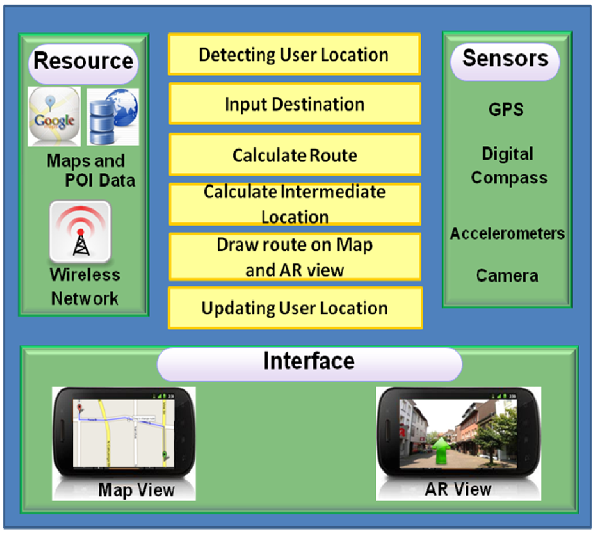

Figure 1. System Architecture


```
{
"type":"building",
"name":"Alexandra House",
"lat":51.52215073,
"lng":-0.123167038
},
{
"type":"room",
"name":"Anatomy B09",
"lat":51.52367566,
"lng":-0.133753046
},
```


Figure 2. UCL building JSON

4.2 Visualisation and user interface

The system supports two navigation modes and the user can switch between them by pressing a button on the mobile device.

4.2.1 Map view

In map view, the system is continuously choosing the higher accuracy location sensor by comparing between its GPS and signals from the network provider, and using these to determine the user's location. After the device initialises the user's location, it displays that location on the map (Figure

3). After determining the user's desired destination, the system connects to the Google server using the Google Maps Application Programming Interface (API) in order to obtain route information. The calculated route information is sent by KML format (which contains a list of geo-coordinates) and it is drawn on the map (Figure 4). The user is provided an option in the map view to convert to from a street map view to a satellite view (Figure 5).

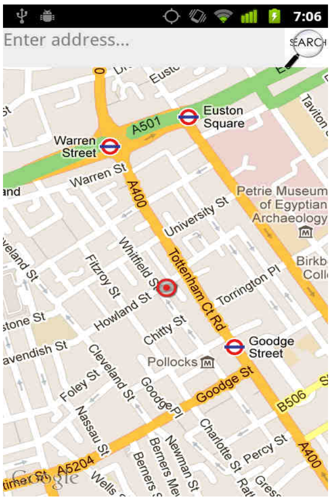

Figure 3. User location

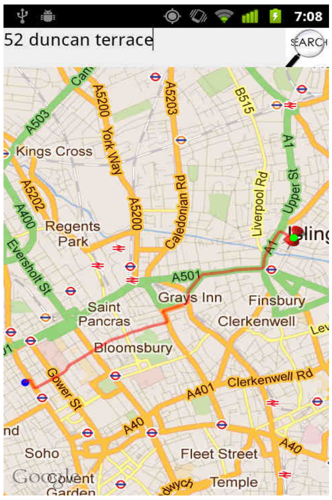

Figure 4. Route visualisation

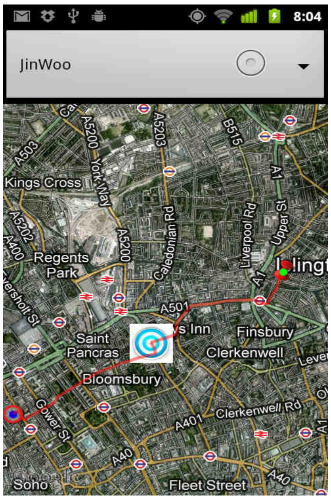

Figure 5. Satellite view

Figure 6. AR view

4.2.2 AR view

In the AR view the route information is communicated through an arrow image (figure 6). In order to visualise the route line correctly on AR view the haversine formula is applied from the given route information by the Google map server. The directional arrow is superimposed on the real world scene that is being displayed on the mobile device's screen, so enhancing the sense of location and route finding.

5. Conclusion and future work

In this paper we have constructed three scenarios that benefit from the use of an AR interface in a navigation system for pedestrians. There are a number of reasons why AR will make for a superior interface. Firstly, an AR interface can be complementary to a conventional navigation interface which uses 2-dimensional maps or a birds-eye view. This benefit will be especially appreciated by users who have difficulty orienting maps to the real world. Secondly, an AR navigation system can be efficiently implemented within defined areas such as university campuses, shopping centres, amusement parks, and so on. Today's mobile application ecosystem allows users to download mobile applications ubiquitously. Thirdly, we suggested the possibility of sharing a route in real-time among a group of users and of providing an intermediate point. There are many directions in which we would like to extend this work. Firstly, we would like to compare user interfaces, namely an AR interface, a conventional interface, and a hybrid interface to compare which can most efficiently provide route information. Secondly, by extending a navigation system's point of view, we would like to implement a seamless indoor/outdoor navigation system within one AR interface. Finally, in terms of improving the user interface in the AR view, we would like to add extra information such as distance which can help to reduce navigation errors, moving towards an effective mobile AR application for pedestrian usages.

6. Reference

Anders, H., Mark, O. & Mark, B., (2005). Mobile phone based AR scene assembly. In *Proceedings of the 4th international conference on Mobile and ubiquitous multimedia*.

Azuma, R.T., (1997). A survey of augmented reality. *Presence-Teleoperators and Virtual Environments*, 6(4), pp.355-385.

Baus, J., Cheverst, K. & Kray, C., (2005). A survey of map-based mobile guides. *Map-based mobile services*, pp.197–216.

Feiner, Steven et al., (1997). A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment. In *The 1st International Symposium on Wearable Computers*.

Giboin, A. et al., (2002). Assessment of ontology-based tools: a step towards systemizing the scenario approach. In *Proceedings of the International Workshop on Evaluation of Ontology-based Tools (EON2002)*.

Höllerer, T. & Feiner, S., (2004). Mobile augmented reality. *Telegeoinformatics: Location-Based Computing and Services. Taylor and Francis Books Ltd., London, UK.*

Hollerer, T. et al., (1999). Exploring MARS: developing indoor and outdoor user interfaces to a mobile augmented reality system. *COMPUT GRAPHICS(PERGAMON)*, 23(6), pp.779–785.

King, G.R., Piekarski, W. & Thomas, B.H., (2005). ARVino-outdoor augmented reality visualisation of viticulture GIS data. In *Mixed and Augmented Reality, 2005. Proceedings. Fourth IEEE and ACM International Symposium on*. pp. 52–55.

Poupyrev, I. et al., (2002). Developing a generic augmented-reality interface. *Computer*, 35(3), pp.44-50.

Reitmayr, G. & Schmalstieg, D., (2001). Mobile collaborative augmented reality. , pp.114-123.

Schöning, J. et al., (2009). Map torchlight: a mobile augmented reality camera projector unit. In *Proceedings of the 27th international conference extended abstracts on Human factors in computing systems*. pp. 3841–3846.

S.H. Jang & A. Hudson-Smith, (2010). GIS and Augmented Reality in 2015. *The AGI Foresight Study -The UK Geospatial Industry in 2015*.

Tenmoku, R., Kanbara, M. & Yokoya, N., (2003). A wearable augmented reality system for navigation using positioning infrastructures and a pedometer. , pp.344- 345.

Thomas, B. et al., (1998). A wearable computer system with augmented reality to supportterrestrial navigation. , pp.168-171.

Wagner, D. et al., (2005). Towards Massively Multi-user Augmented Reality on Handheld Devices. In H.-W. Gellersen, R. Want, & A. Schmidt, eds. *Pervasive Computing*.

8. Biography

Sung Hyun Jang is a Ph.D. student at the Centre for Advanced Spatial Analysis (CASA) at University College London. He works for the South Korean Ministry of National Defence and he holds a M.Eng. in Geographic Information Science. His research focuses on the fusing of Augmented Reality and GIS.

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