Effective Utilization of 3D Representation in Mobile Device for Pedestrian Navigation Aid

Mukhtar Alhaji Liman
Institute of Education, International Islamic University
Malaysia

Adamu A.Ibrahim
Department of Information System
International Islamic University
Malaysia

Abstract

Digital (Three-Dimensional) 3D map representation of a city or any location in mobile device provides information about environment to which its represents, sometimes even more details than reality. These ease the problems of reading information added by the paper map which not everyone can read. Unfortunately, in some cases using 3D representation for pedestrian navigation aid in mobile devices cannot be generalized in terms of its effectiveness. This is because in some certain situation where a user expects its benefits most, it does harm rather than good. This paper investigates the factors that determine effective utilization of 3D representation in mobile device for Pedestrian Navigation Aid. This study is conducted via qualitative interviews in order to unveil situational feelings of users with regard to the effective utilization of 3D representation in mobile devices for the purpose of solving the problems of finding unknown locations easily. Issues concerning functional specification, application content quality, and the interaction quality are the major aspect of the problems identified by the respondent of this study. Thus, findings reveal that, stability, ease of use, condition of use, accuracy, and feedbacks exert crucial influences on the use of 3D representation in mobile device for pedestrian navigation aid. We also find out that the use of 3D representation creates more visual understanding of an environment by enhancing the degree of 3D users' perception.

Keywords: 3D Map, Mobile devices, Pedestrian, Navigation Aid

1. Introduction

There are a lot of ways for providing guides to reach to any location within a city or outside a city in any part of a country. The most common one is sign boards, indicating names of streets, important buildings/structures in the city like market, company buildings, gas station, schools or sometimes even natural environmental structures like rivers, mountain etc. These information makes it easier in identify places, classically they are commonly represented in a paper map, describing more than what is available on grounds. As a result paper map can help in identifying places which their information is label either in a signboard or on the structure. The drawback of the paper map is where the information of an environment is not label on ground, or it cannot be identified easily. This means will need further description with symbols or legend and sometimes this will required a level of an expertly person to be able to read those symbols and legends (Ellard, 2010). Rather than using paper map, if a digital 3D map representation of the environment is provided where the information on ground is presented in details inside mobile devices, will alleviate the problems of reading information's added by the paper map which not everyone can read. Thus, this will make it easier to identify unknown locations within or inside a city or anywhere. However, with 3D representation in mobile device for navigation aid it will be much easier finding locations. Unfortunately the ways to use 3D representation for pedestrian navigation aid in mobile devices is not generalized, due to the drawbacks of mobile device in terms of size, power and ability to store huge 3D representation. Consequently, in some certain situation where a user expects its benefits most, it does more harm rather than good.

This research investigates the factors that influence the effective use of 3D representation in mobile device for pedestrian navigation aid. The research is conducted through qualitative interview. Certain issues based on the outcome of preliminary studies and related work such as functional specification, application content quality and interaction quality where considers during the interview as the major subject matter. In-depth information about them was extracted from the structure interviewed with some experts in the area. Other related issues concerning effective ways of utilizing 3D representation were also uncovered. The research however is much concern on the human factors which directly reflects the effective usage of 3D representation in mobile device for navigation aid. It does not consider the inner workings of the 3D representation engine (that is the design) in a mobile devices; it does not include the specification on how the system function will be implemented. Instead, it focuses on what various outside agents (people using the application), or the effective use and user's tasks (Hugo & Maguire, 2008). For example, when a user is interacting with mobile device which content 3D representation for navigation aid and want to find "where I am" or "show my location" information, the feedback might be expected to display as accurately as possible the position or will eventually not as precise as expected, thus, these might induce emotional states, such as a user can not finds his/her way and the road being blocked off and users not been able to receive feedbacks or the system was not accurate, or may be user is getting very close to the destination while depending on the guide from the device and suddenly an important information popup, or the user might be nearly crashing while interacting with the device and not been able to receive a feedback any feed. Thus, in view of the above issues this research result will contribute to the technical and practical guidelines for the successful development of 3D representation in mobile device.

2. 3D Representation for Pedestrian Navigation Aid

There are several problems when it comes to working with 3D representation for navigation aid in either small screen size mobile devices or large screen handheld devices, there are also and many researches on the area of 3D map for navigation aid currently. However, there are still lacks of generalized framework on the effective utilization of 3D map or representation in mobile device for pedestrian navigation aid. The number of 3D navigation aided applications for mobile device has steadily increased. A selection of some available applications are presented in Table1, which include lol@ (local location assistance), GiMoDig (Geospatial info-mobility service by real-time data-integration and generalization), m-Loma **(**mobile LOcation-aware Messaging Application), Mapper (Map personalization), and MONA 3D (Mobile Navigation using 3D City Models).

Figure 1. 3D map view in Mobile devices for navigation aid.(Sources: by the left is Eddie Wrenn, www.dailymail.co.uk. By the right is Jason Lee, Aving Global News.Network).

Table 1: Features of existing 3D mobile navigation systems

Name	Features
lol@(local location assistance)	Uses remote rendered data from server and stored data in the device. It is meant for tourist/pedestrian for navigation aid and provided more text information of places and restricts presentation of multiple frames in 3D bird's eye view to give the illusion of 3D scenes.
m-Loma	The application is capable of rendering photorealistic 3D city models with augmented location-based information in a smart phone. It does not use photo images for representing an environment. It can perform textual searches to location-based content and navigate with GPS assisted signal. It is primarily designed for pedestrians, and uses depend on data rendered by the server.
Google Maps 5.0	Uses vector graphics for its 2D maps in a mobile device. The vectors enable a two finger swipe to "tilt" the map to get a 3D view of the landscape. It enables offline caching of maps for frequently visited locations and entire trips that have been routed in navigation, including potential reroutes. It is suitable for pedestrian navigation aid.
Mapper	The application uses on-line data obtained from a remote server and provides route information to one or more destinations for pedestrians in a 3D format.
UpNext	Uses a 3D map/model to explore cities with an interactive touch interface for search and provides offline mode of recent map areas (pre-cached) on its device so that it can still be used offline
Navigon	It provides 3D birds eye views and symbols and uses text-to-speech directions, real-time traffic updates, and information about points of interest along the route. It sets anyone from the address book as 'destination'.
GiMoDig	A project aimed at delivering geospatial data to a mobile user by means of real-time data-integration of national primary geo-databases. The application uses on-line data information acquired from a remote server through wireless connectivity
Live Search Maps 3-D now Bing Maps	Uses bird's eye view maps and provides photo realistic textures that look relatively realistic representation of the environment. Although initially in 3D format, since November 2010, Microsoft decided to drop their 3D feature to focus on other aspects of Bing Maps.
EveryScape	Uses bird's eye view 3D photorealistic representations of cities and location to create (mostly) street-level 3D scenes and also offers: indoor panoramic scenes.
MONA 3D	This project provide mobile navigation aided system with 3D view to serve for both in-car and pedestrian usage. It has been implemented for the city of Stuttgart and the city of Heidelberg, and addressed drawbacks of limited processing power and bandwidth of mobile devices and enhance navigation efficiency by compression of 3D and smart handling of textures for building facades using and setting up a 3D spatial data infrastructure (3D-SDI) based on OGC open web services (OWS).

3. Evaluation

The evaluation was conducted by using qualitative structured interview with twenty experience participants in this area. The interview was conducted on one-on-one and face-to-face basis. The responses were collected through Audio recorder and later transcribed. The transcripts were coded and the information extracted are sorted in to themes under the factors deem to for effective utilization of 3D representation in mobile device for pedestrian navigation aid. As stated by Fetterman (1998), 'the insider's perception of reality is instrumental to understanding and accurately describing situations and behavior.' Thus, the constructs could by careful analysis be likened to the coding; a process described by Saldana (2009) as 'summative, salient, essence-capturing' of data collected from interviews, participant observation field notes, artifacts, etc. Also Miles and Huberman (1994) suggested that such coding could be likened to the process of data analysis.

The demographic information of the respondents is given in Table 2. Out of the 20 respondents interviewed, 4 are female and 16 were male. 45% of them were from the age group of 20 to 40 years, while 55% of them are more than 40 years old. There are all graduates; 25% of them are PhD holders, while 75% are both masters and bachelor degree holders. All of them are using smart phone and have an experience with the present and function of mobile applications and navigation aided application in their smart phones.

All of them have use in-car/navigation aided devices many times. 8% percent are from technical and business related to pedestrian navigation and pedestrian navigation aided devices. While 20% are from academic and administrative related to pedestrian navigation and pedestrian navigation aided devices

Table II: Demography of the Respondent

Demographic Variables / Items		**Frequency**	**Percent**
Age Group*			
	25 – 34	3	15
	35 – 40	6	30
	>40	11	55
	Total	20	100
Gender*			
	Male	16	80
	Female	4	20
	Total	20	100
Highest Level of Education			
	Bachelor's degree	6	30
	Masters Degree	9	45
	Doctoral degree	5	25
	Total	20	100
Mobile Device Type			
	Basic Mobile device	0	0
	Smart Mobile device	17	85
	Both Basic and Smart	3	15
	Total	20	100
Experience with Mobile Applications			
	Novice	0	0
	Intermediate	2	10
	Advanced	18	90
	Total	20	100
Related Job			
	Administration	1	5
	Education	3	15
	Business	10	50
	Technical	6	30
	Total	20	100
Awareness of 3D Map in mobile device for Navigation*			
	Low	0	0
	Moderately	0	0
	High	17	85
	Very High	3	15
	Total	20	100

4. Result

The information gathered during the interview, where transcribed and some in particular 5 were returned to the participants to valid the transcript. Thereafter the raw data are coded/sorted and validated by two coders with experience in the same area. Thus the sorted data where used for analysis.

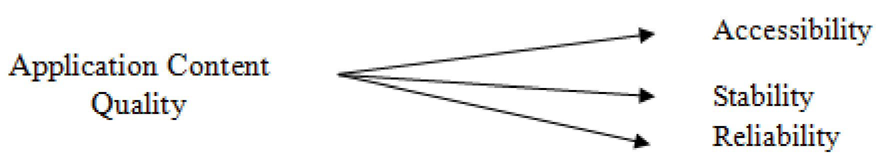
4.1 Functional Specification

The functional specification states what the proposed system is to do, that is, it describes external user and programming interfaces that the system must support. Whereas design of proposed system only states how the system is to be constructed to meet the functional specification (Fancellu, 2002). However in writing the functional specification, some consideration of design issues must take place, to ensure a realistic system is specified. Accuracy and feedbacks are the constructs that are extracted based on the responses of the respondents on functional specification from the interview sourced.

The fundamental categories or variables used to evaluate performance quality are accuracy and feedbacks in the system (Mantoro & Abubakar, 2010), although, 3D representation in mobile device for pedestrian navigation aid typically requires both intensive and extensive infrastructure for its accuracy (Jiang et al. 2009; Oulasvirta et al. 2005). Moreover, as a consequence of the dynamic nature of pedestrian while on-the-go, feedback from the system has become one of the main factors in determining performance quality (Jiang et al. 2009). When feedbacks obtained from 3D representation in mobile device for pedestrian navigation aid is accurate, the use of it will increase which will also lead to a profound effects on the use of mobile service. Thus this concur with (Nurminen, 2006) who said that performance quality has become an increasingly important factor for evaluating the use of 3D map in mobile device for pedestrian navigation aid. Therefore, what this paper do compares to the related works is to validate the variables adopted and provided some additional constructs in order to evaluate the factors for effective utilization of 3D map in mobile device for pedestrian navigation aid Although what this research discovered compared (Nurminen, 2006) is that performance is subject to accuracy and feedbacks, which are influence by the functional specification.

4.2 Application Content Quality

The application that is meant for navigation aid should have all the necessary navigation information. If a 3D map in mobile device for navigation aid does not include many environmental features, or the application is not easy to use or it does not provide users tasks, individuals relying on a route-based strategy would be in problems. Furthermore, it may not be able to provide efficient service to those who take into account distance and direction estimation good result. Thus the answers to the interview questions on the application content quality upon the analysis of the extracted data lead under three constructs as follows: stability, ease of use, and condition of use.

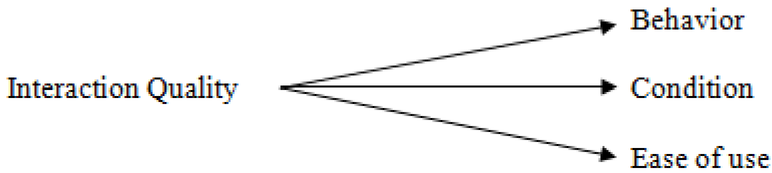


This assume that effective utilization of 3D representation in mobile device for pedestrian navigation aid, requires the system to be stable, user friendly and provide for particular group of user, and the user tasks of the system in different situation, its complexity should be clearly defined, otherwise remain simple.

4.3 Interaction Quality

The manner which users interact with mobile device that contains 3D map in different situation for navigation aid is the interaction quality. The sum total of all the navigation procedure within a user interface of an application is refers to interaction quality. Kallenbach (2008) state that, “Interaction is at the heart of user experiences. Without interaction user experiences cannot happen.”

The interview questions about the Interaction quality were based on user interface and the display of 3D map in the small screen mobile devices. Screen size is an important factor and needs to be considered in the design of personalized results presentation reflects by the varied usage and preferences of the users (Sweeney & Crestani, 2006). Screen size and resolution represent display. However the sorted responses from the respondents reflect on three major constructs as follows: Behavior, Condition of use, and Ease of use.



The need for ease of use and the behavior of the user are the major issues extracted based on the responses on the interaction quality. However, the condition of the usage, in terms of the nature of the physical and social environment is next issue extracted as the factors which influence the effective ways of utilizing 3D representation in mobile device for pedestrian navigation aid.

4.4 Summary of Some Direct Responses of the Participant's

The information gathered from the participant, in regards to interaction qualities was asked from the interview question. Each respondent was asked to suggest views apart from answering the direct question; the following interview question was asked "*What are your views about the interaction quality of mobile device with 3D representation for pedestrian navigation aid? And how will it be suitable across people at your age and gender'?* 9 (45%) of the respondents are below 40 years and consider young people, out of them 2 are female and 7 are male. While 11 (55%) of the respondents aged above 40 years are the oldest, 9 are male and 2 are female. Both the female and male, young and old people responses were found to be closely related. Among the respondent responses' are as follows:

…"is that on the small screen of mobile device 3D representation will only favor small part of an area, but when the area is large like a city, the displayed might be confusing which will make it very difficult and will waste your time also"…
…"A mobile device as a matter of being a small device should have a large display of 3D representation as much as possible in the screen"…
…"set of commands should be in the sense that many operation are executed by a single push button or touch on a touch screen mobile device"…

Some of the questions about performance qualities of 3D representation in mobile devices for pedestrian navigation aid were also answered, the questions are: *"What will you say about the precision in terms of finding unfamiliar places with the aid of 3D representation in mobile devices?" "What will you say about the reliability of 3D representation in mobile devices for pedestrian navigation aid?" "What will you say about the stability of 3D representation in mobile devices for pedestrian navigation aid?"* Although the three questions where not asked at once, each follows one after the other. Some of the responses are as follows:

…"In terms of precisions, I think that is where 3D map will be more helpful, because it can be seen as a virtual reality if the landmark details are provided"
…"I think precisions or accuracy of finding locations with 3D model of an environment does not yet fit our expectations, because several GPS navigation systems that already contains 3D panorama or photos have failed in given accurate locations for some place"…
…"largely because they depend on GPS signals, and if the signal is lost means location is lost as a result the 3D representation display halt"…
…"It's more reliable than the 2D because you can study surroundings and learn anything about your location if the information is provided"…
…"The stability of the 3D map in mobile device for walking guide will be based on the computing resources"…

When respondents were asked about: *To what extent does 3D representation in mobile device is perceived by the end-user as a real scene suitable for pedestrian navigation aid*. 16 (80%) of the respondent provide positive response with regards to the perception of 3D representation in mobile device for pedestrian navigation aid. While 4 (20%) views to the question was 3D representation in mobile device will not provide enough information necessary to convince end-users that there are in real environment when they compare it what they see in the mobile device with real scene.

5. Conclusions

This paper investigates the factors that influence the utilization of 3D representation in mobile device for pedestrian navigation aid through qualitative interview. In-depth facts were gathered from the participants and reveals that the usage of the system creates more visual understanding of places by enhancing the degree of perception based on some factors deem to be effective. Our findings suggest that functional specification, application content quality and interaction quality are the major factors influencing the use of 3D representation in mobile device for pedestrian navigation aid. Functional specification is reveals the accuracy and feedbacks of the system. Accessibility, stability and reliability are used to premeditate application content quality. Behavior of users, Condition and ease of use are used to show the effective way of interaction quality of the user and the 3D representation in mobile devices. Consequently the effective's ways of utilizing 3D representation in mobile device for pedestrian navigation aid are collectively observed by the degree of perception and assessment it gives to users. Analysis of the finding show that, Stability, ease of use, condition, accuracy, and feedbacks exert crucial influences on the effective ways of utilizing 3D representation in mobile device for pedestrian navigation aid. These findings suggest that functional specification and interaction quality are relatively more important in the use of 3D representation in mobile device for pedestrian navigation aid than Application content quality. The contribution of this research lies within indicators for effective ways of using 3D representation in mobile device for pedestrian navigation aid. The direction of future research suggests technical and practical guidelines for the successful development of 3D representation in mobile device for pedestrian navigation aid.

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