



3D GRAPHICS VISUALIZATION FOR MOBILE
USER NAVIGATION

BY

ADAMU ABUBAKAR IBRAHIM

A dissertation submitted in fulfilment of the requirement
for the degree of Doctor of Philosophy in
Information System

Kulliyyah of Information and
Communication Technology
International Islamic University
Malaysia

DECEMBER 2012

ABSTRACT

3D maps in mobile devices for navigation aid have been created to overcome the weaknesses of conventional 2D maps which require users to interpret its various symbols and legends. Now it has become possible to render large and detailed 3D map of cities in mobile devices at interactive rates over 5fps (frame rate per second) to 30fps. Mobile devices with low computing resources may also use manipulated photos in order to give the illusion of 3D presentation. Owing to this recent development, the concept of 3D representation in mobile devices for multi-users interactive navigation aid is proposed. It is aimed at helping people to navigate in unfamiliar locations. In today's world, mobility and communication have become essential. People may frequently find themselves asking: 'Where am I right now?', 'How do I get from X to Y?', and 'How can I tell Z?' The proposed system of 3D maps in mobile devices for navigation aid allows several mobile device users to view their own and the other users' locations at the same time, while being stationary or on-the-move. Voronoi diagram/Delaunay triangulation and A-star pathfinding are the algorithms for establishing user locations and their distances, apart from finding the shortest part from Location X to Y. A prototype of this system was developed to demonstrate the pros and cons of the practical application of this new concept. This research uses an observational research, field experiment, qualitative interview and quantitative survey to investigate navigation practices with 3D representation in mobile devices as a navigation aid. The research findings include discussion of the features of navigation practices with the aid of 3D representation in mobile devices and a critical assessment of the factors influencing its usage.

خلاصة البحث

تم ابتكار تطبيقات الخرائط ثلاثية الأبعاد على الأجهزة النقلة للحصول على خدمة مساعدات الملاحه والتنقل للتغلب على نقاط الضعف الموجودة في تطبيقات الخرائط التقليدية ذات البعدين التي تتطلب من المستخدمين تفسير رموز ومفاتيح مختلفة لفهم الخريطة، وقد كان للتقدم في العلوم التقنية فضل كبير حيث أصبح من الممكن في الوقت الحاضر عرض الخرائط الثلاثية الأبعاد لمدن بأكملها في الأجهزة النقلة، وذلك بمعدلات إطار تتراوح ما بين 5 و 30 إطارا في الثانية الواحدة؛ فحتى بالنسبة للأجهزة النقلة ذات الموارد الحسائية المنخفضة يمكن معالجة الصور ثنائية الأبعاد للإيجاء للمستخدم بأنه ينظر الى صورة ذات ثلاثة أبعاد، ونظرا لهذا التقدم التقني، فإننا نقدم مفهوم العرض الثلاثي الأبعاد في تطبيقات الأجهزة النقلة لتقديم خدمة تسهيل التنقل والملاحه لعدد من المستخدمين في هذا البحث. إن هدف التطبيق هو مساعدة الناس على التنقل في المناطق غير المألوفة بالنسبة لهم، فقد أصبح التواصل والتنقل شيئين أساسيين في عالمنا اليوم، وقد يجد الشخص نفسه يتساءل في كثير من الأحيان: "أين أنا الآن؟" أو "كيف أصل من النقطة أُلْف إلى النقطة باء؟"، وهنا يتيح النظام المقترح للخرائط الثلاثية الأبعاد للأجهزة النقلة لعدد من المستخدمين إمكانية تحديد مواقعهم ومواقع المستخدمين الآخرين في آن واحد، في حالتي التنقل والتوقف. يستخدم النظام ثلاث خوارزميات لتحديد موقع المستخدم والمسافات بدقة، وهذه الخوارزميات هي: رسم فوروني "Voronoi"، ومثلثات "Delaunay"، وأي-ستار "A-star". وإلى جانب تحديد أقصر المسالك بين النقطتين أُلْف وباء، تم تطوير نموذج أولي من هذا التطبيق لبيان الإيجابيات والسلبيات في التطبيق العملي للفكرة الجديدة، حيث قام الباحث باستخدام البحث والرصد والتجربة الميدانية وإجراء المقابلات النوعية والمسح الكمي للتحقق من ممارسة التنقل باستخدام العرض الثلاثي الأبعاد مع التمثيل في أجهزة النقال بوصفه مساعدا في التنقل، هذا فضلا عن تقديم البحث تقييماً نقدياً لمدى فائدة التطبيق للمستخدم.

APPROVAL PAGE

The dissertation of Adamu Abubakar Ibrahim has been approved by the following:

.....
Teddy Mantoro
Supervisor

.....
Media Ayu
Co-Supervisor

.....
Al-Sakib Khan Pathan
Internal Examiner

.....
Alias Abdul Rahman
External Examiner

.....
Imad Fakhri
Chairman

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Adamu Abubakar Ibrahim

Signature:.....

Date:.....

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

**DECLARATION OF COPYRIGHT AND AFFIRMATION OF
FAIR USE OF UNPUBLISHED RESEARCH**

Copyright © 2012 by Adamu Abubakar Ibrahim. All rights reserved.

**3D GRAPHICS VISUALIZATION FOR MOBILE USER NAVIGATION IN
UBIQUOATOUS COMPUTING ENVIRONMENT**

No part of this unpublished research may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronics, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below:

1. Any material contained in or derived from this unpublished research may only be used by others in their written with due acknowledgement.
2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purposes.
3. The IIUM library will have the right to make, store in a retrieval system and supplies copy of this unpublished research if requested by other universities and research libraries.

Affirm by Adamu Abubakar Ibrahim

.....
Signature

.....
Date

*This work is dedicated to my late father Abubakar Ibrahim and my late elder brother
Ibrahim Abubakar.*

ACKNOWLEDGEMENTS

I would like to thank Almighty Allah for given me health and knowledge to complete this research work against many odds. I would also like to express my deep gratitude to my supervisor Associate Professor Dr. Teddy Mantoro for his support, inspiration and patience throughout my graduate study. His originality, hard work, energy and enthusiasm to scientific research set a great role model for me. I have learned a great deal from his extensive knowledge in design theory and methods and his brilliant and creative ideas. His consideration and encouragement have made my life in Malaysia both fruitful and enjoyable. He has taught me innumerable lessons and insights on the workings of academic research in general. I am sure I will take the benefits of this experience throughout my whole life. My thanks also go to my co-supervisor Dr Media Ayu for her countless time, support and inspiration rendered to go through my work several times despite her tight schedules.

I sincerely thank Department of Information Science and Computer Science International Islamic University, Malaysia. My special thanks goes to Prof Abu Usman for giving me an opportunity to work at the department and Dr. Murni Mahmud who has been giving me valuable advice especially in the area of research tactics. I would like to acknowledge my colleagues in INTEG LAB and brothers for working with me on my research study whilst answering my queries at any time of the day and proof reading for my shared understanding the study.

I thank my Danlami Muhammed Abubakar for his support and innumerable assistance rendered to me during the period of my studies. My special thanks to all my families, brothers and sisters, friends from all parts of the world for their tremendous assistance rendered to me.

TABLE OF CONTENTS

Abstract	ii
Abstract in Arabic.....	iii
Approval Page	iv
Declaration Page.....	v
Copyright Page.....	vi
Dedication	vii
Acknowledgement	viii
List of Tables.....	ix
List of Figures	x
CHAPTER ONE: INTRODUCTION	1
1.1 Background of the study	1
1.2 Statement of Problem	4
1.3 Research Questions	5
1.4 Research Objectives	6
1.5 Research Methodology.....	6
1.6 Scope of the Research	8
1.7 Contributions of the Research	9
1.8 Outline of the Thesis	10
CHAPTER TWO: THEORETICAL FRAMEWORK	12
2.1 Introduction	12
2.2 Theoretical Framework	12
2.2.1 Navigation Practices	13
2.2.2 Model of Navigation Practices	19
2.2.3 Model of Pedestrian Movement	23
2.2.4 The Social Force Model	25
2.3 System Architecture for 3D Mobile Pedestrian Navigation Aid	28
2.4 Existing Navigation aids using 3D maps in Mobile Devices	32
2.5 Summary.....	35
CHAPTER THREE: CONCEPTUAL FRAMEWORK	36
3.1 Introduction.....	36
3.2 Conceptual Framework	36
3.3 3D maps in Mobile Devices for Navigation in a Ubiquitous Computing environment	41
3.4 Voronoi Diagram	43
3.5 Pathfinding technique	50
3.6 Visibility Techniques	61
3.7 Summary	65
CHAPTER FOUR: 3D VISUALIZATION ON MOBILE DEVICE FOR NAVIGATION AID	66
4.1 Introduction	66

4.2 3D Visual Transformations	67
4.3 3D Graphics support for Mobile Devices	69
4.4 3D Maps for Mobile Device	71
4.5 Proposed design Framework of the Concept Prototype	73
4.5.1 3D Model for Mobile Devices	78
4.5.2 Polygonal Modeling	80
4.5.3 3D modeling for the Prototypes	82
4.6 Development of Prototype	85
4.6.1 Concept Prototype: Functional Approach	86
4.6.2 Concept Prototype: System Approach	90
4.7 Summary	97

CHAPTER FIVE: NAVIGATION PRACTICES WITH THE AID OF 3D MAP IN MOBILE DEVICE98

5.1 Introduction	98
5.1.1 Navigation Tasks	100
5.1.2 Experimentation on navigation with the aid of 3D Map in Mobile Device	101
5.2 Navigation Practices: Experiment with 3D Map in Mobile Device in an Overt Observation Scenario	103
5.2.1 Participants	104
5.2.2 Experimental Tasks and Procedure	105
5.2.3 Result and Analysis	106
5.3 Navigation Practices: Experiment with 3D Map in Mobile Devices in Observation Scenario	112
5.3.1 Participants	112
5.3.2 Experimental Tasks and Procedure	113
5.3.3 Result and Analysis	114
5.4 Navigation Practices: Experiment with 2D/3D Map View in Mobile Device in A road Trip Observation Scenario	118
5.4.1 Participants	118
5.4.2 Experimental Tasks and Procedure	119
5.4.3 Result and Analysis	120
5.5 Multi-user Interactive Navigation Practice with 3D map in Mobile Device	123
5.5.1 Participants	124
5.5.2 Experimental Tasks and Procedure	124
5.5.3 Result and Analysis	125
5.6 Summary	138

CHAPTER SIX: EVALUATION OF 3D MAP VIEW IN MOBILE DEVICE FOR NAVIGATION AID140

6.1 Introduction	140
6.2 Qualitative Interview Evaluation	140
6.2.1 Sampling and Demography of the Respondents	141
6.2.2 Face-to-face and One-to-one Interviews	143
6.2.3 Interview Transcription (verbatim)	143
6.2.4 Data extraction	144
6.2.5 Analysis of the Respondents Responses	148

6.2.5.1 Interactive qualities of 3D representation in mobile devices	148
6.2.5.2 Performance quality of 3D representation in mobile devices for navigation aid	160
6.2.5.3 Perceptions of navigation tasks with 3D view in mobile devices with respect to the reality	166
6.2.6 Summary of the evaluation	172
6.3 Quantitative Survey Evaluation	173
6.3.1 The research model	176
6.3.2 Population and Sampling	176
6.3.3 Sample sizes	177
6.3.4 Data Collection Technique	179
6.3.5 Pilot Study	180
6.3.6 Interactive qualities of 3D representation in mobile devices	181
6.3.7 Response Rates and Profile of the Respondents	183
6.3.8 Analysis of relationship among the factors influencing the use of 3D map view	186
6.4 Summary	191
CHAPTER SEVEN: CONCLUSION AND FUTURE RESEARCH	193
7.1 Introduction	193
7.2 Summary of the Major Findings.	193
7.2.1 Multi-user Interactive Navigation aid with 3D representation in Mobile Devices	194
7.2.2 Engagement/Disengagement with mobile device and environment while-on-the-go and interacting with 3D view in mobile device for navigation aid	196
7.2.3 Factors influencing the use of 3D representation in mobile devices for navigation aid	197
7.3 Future Work	198
7.4 Conclusion	199
BIBLIOGRAPHY	202
APPENDIX I: Field Experiment Scenarios	213
APPENDIX II: Interview Questionnaire	214
APPENDIX III: Survey Questionnaires	215
APPENDIX IV: Factor Loading of the Survey Items	219
APPENDIX V: Detailed Descriptive Profile of Variables	222

LIST OF TABLES

<u>Table No.</u>		<u>Page No.</u>
2.1	Features of exiting 3D mobile navigation system	33
3.1	Ubiquitous Computing Paradigm	43
4.1	Summary of responses by the respondents	89
4.2	Reference point of the study area used in the prototype	92
5.1	Observational chart of the road trip	122
5.2	Navigation Information of the Participants	126
5.3	Distance covered by all participants	137
6.1	Demography of respondents (qualitative interview)	142
6.2	Interaction quality quoted responses	153
6.3	User Interface quoted responses	158
6.4	Selected quoted responses on perception	168
6.5	Reliability test result of the pilot study instruments	180
6.6	Data reduction and reliability test result	182
6.7	Profile of the respondent of the survey	184
6.8	Correlation Analysis among the Factors influencing the use of 3D map view in mobile device	187
6.9	Standard multiple Regression Analysis of the variables	188
6.10	Hypothesis Result for the relationships among the variables	191

LIST OF FIGURES

<u>Figure No.</u>		<u>Page No.</u>
2.1	Landmarks (dots), routes (lines), and their relationship connections	13
2.2	Pedestrian navigation ontology (Corona & Winter, 2001)	16
2.3	General Framework for the Navigation process. (adapted from Jul & Furnas, 1997)	21
2.4	A model of navigation (modified from Jul and Furnas 1997, adapted from Darken & Perterson, 2001)	22
2.5	The Pedestrian Navigation framework (Aslan & Kruger, 2004)	30
2.6	General Framework of Proposed Pedestrian Navigation System (Chakraborty, & Hashimoto, 2010)	31
3.1	Modules involves for the Conceptual Architecture	37
3.2	Conceptual Design Flowchart	38
3.3	Conceptual Framework of the Navigation Practices	39
3.4	A remote rendering network setting	40
3.5	Ubiquitous computing environments	41
3.6	Voronoi diagram (presenting space with points and regions)	44
3.7	Points within a region of Euclidean plane	46
3.8	Voronoi polygon (tessellation of points within a region)	47
3.9	Example of decomposing 3D virtual environment	48
3.10	Class diagram for the voronoi diagram generation	49
3.11	The Flow chart of heuristic in A Star path finding	53
3.12	The Astar pathfinding search process	55
3.13	3D Map and Pathfinding in separate layers	56
3.14	The region division of the testing area (Niu & Zhuo 2008)	57

3.15	Interactive navigation positioning and connection within a location	58
3.16	Delaunay triangulation	59
3.17	Flow chart of A* Pathfinding Algorithm	60
3.18	Visibility culling techniques (Cohen-Or et al., 2003)	61
4.1	Proposed design framework of the concept prototype	74
4.2	Accuracy of GPS on Android device measured by GPS Test (first 2 at the top) and GSP Status (bottom 2)	75
4.3	The integration of the 3D dataset, algorithms and the base map layers	77
4.4	Polygonal meshes (Physicsarchive.com)	80
4.5	Layout of zones A to D, IIUM Gombak campus	83
4.6	3D model of zones A to D, IIUM Gombak campus	85
4.7	The mobile device interface's navigation scenario presenting the research functional concept prototype	87
4.8	The screen grab of the mobile device interface's navigation scenario presenting the research functional concept prototype	90
4.9	Application launcher icon in the home screen of Samsung GT-S5830 (left), and Samsung P-1000 (right)	95
4.10	The user interface of the concept prototype: System Approach	96
4.11	The user interface of the prototype displaying location of many users	97
5.1	Navigation tasks	100
5.2	Overview of map showing the locations of the field experiment	104
5.3	Navigation interruption/continuation orientation of Participant 1	107
5.4	Navigation interruption/continuation orientation of Participant 2	107
5.5	Navigation interruption/continuation orientation of Participant 3	108

5.6	Navigation interruption/continuation orientation of Participant 4	108
5.7	Overview of map showing the locations of the road trip	118
5.8	The study area in IIUM main Campus	125
5.9	North/South direction orientation of User Red in degrees of latitude	128
5.10	East/West direction orientation of the Red user in degrees of longitude	129
5.11	Red user's navigation path behaviour from starting point to destination	129
5.12	Red user's distance covered from starting point to destination	130
5.13	Red user's bird's eye view from starting pont to destination	130
5.14	North/south direction orientation of Blue user in degrees of latitude	131
5.15	East/west direction orientation of Blue user in degrees of longitude	132
5.16	Blue user's navigation path behaviour from starting point to destination	132
5.17	Blue user's distance covered from starting point to destination	133
5.18	Blue user's bird's eye view from starting pont to destination	133
5.19	North/south direction orientation of Green user in degrees of latitude	134
5.20	East/west direction orientation of Blue user in degrees of longitude	134
5.21	Green user's navigation path behaviour from starting point to destination	135
5.22	Green user's distance covered from starting point to destination	135
5.23	Green user's bird's eye view from starting pont to destination	136
5.24	Navigation orientation of all users	136

5.25	Distance covered by all participants	137
6.1	Visualization coded constructs	145
6.2	Navigation coded constructs	146
6.3	The percentage coverage of respondent's responses on Interaction quality construct	152
6.4	The percentage coverage of respondent's responses on Screen size construct	154
6.5	The percentage coverage of respondent's responses on Resolution construct	155
6.6	The percentage coverage of respondent's responses on Zooming construct	156
6.7	The percentage coverage of respondent's responses on Grab and Drag construct	157
6.8	The percentage coverage of respondent's responses on User Interface construct	160
6.9	The percentage coverage of respondent's responses on Accuracy Construct	163
6.10	The percentage coverage of respondent's responses on Perception construct	167
6.11	The percentage coverage of respondent's responses on interaction in land and sea construct	170
6.12	The percentage coverage of respondent's responses on Concentration constructs	171
6.13	The percentage coverage of respondent's responses on Distraction constructs	171
6.14	The percentage coverage of respondent's responses on Orientation constructs	172
6.15	The research model	174
6.16	The Research Model hypothesis testing	175

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

3D Maps integrated into mobile devices for pedestrian navigation support improve the efficiency of mobility services. Handheld GPS tools enable people to identify the precise latitude and longitude of their present locations or destinations, even in the remotest of places. Evidently, the introduction of GPS technology for in-car navigation offers new solutions for finding one's way in urban areas and on the highway. Consequently, the social dynamics involved in traveling on the road have been transformed (Leshed et al., 2008). However, people still get lost or are unable to follow given directions to reach a particular destination. In certain unfortunate situations, a wrong turn can mean the difference between life and death (Ellard, 2010). Technically, the role of 3D maps is to offer more detailed information than what is available on conventional maps. Although geographic maps represent any space, real or imagined, without regard to context or scale but they have certain drawbacks (Airey et al., 1990), as follows: (1) Representation of landmarks is with symbols or legends and contours line, which requires map reading awareness. (2) Representation of route or road network mostly lacks orientation. (3) It doesn't represent realistic view, (reality as it exist) that is why it requires the translation of added legends which may call for a certain level of expertise on the part of the user. In the case of a 3D map, the proper reading is generally much easier and symbols are more straightforward. Therefore, 3D map representation downloadable on a mobile device which represents a certain area in more detail helps the user to identify locations and decide which course to navigate at an instant.

The creation of 3D visual maps available for mobile devices which can be used for pedestrian navigation is the result of the drawbacks perceived with the conventional 2D approach (Jiang et al., 2009; Mantoro et al., 2009; Mantoro, & Adamu, 2010). The information provided in a 2D map is generally limited due to its fixed representation ratio and lack of interaction with the user (Nurminen, 2008a). The perception and interaction of 2D representations in some cases is limited to the interpretation of symbols explained in the legend which not every user knows how to use efficiently, however, 2D digital map linked with geospatial database generate useful information that will extract clues about the map representation. 3D representations, on the other hand, are able to produce realistic visualizations of navigation fields. A realistic 3D representation has strengths its 2D counterparts to not possess, for example, they are much more precise. The key benefit of a 3D representation is the higher potential for accuracy in presenting spatial data, which is the exact representation of reality and that means reality is brought closer by 3D representation. Besides that, it offers a better platform for multiple cues and small-scale features which are better suited for pedestrian to locate and identify unknown places. There are other related systems which claim to be 3D maps although their representation of the environment is restricted or has no 3D components at all (Nurminen, 2007). For example, car navigation systems commonly support 2D projection which creates an illusion of 3D through the perspective view even though the actual data are only two-dimensional. Visually, these environments can convey the likeness of a 3D special representation. Creating a navigation tool with the help of a 3D model in mobile devices is undoubtedly a complex task but certainly worth the investment (Oulasvirta et al., 2005). A functional system capable of delivering an adequate 3D dataset requires

that the interface should allow users to display whatever is currently needed as quickly and easily as possible. (Mantoro & Adamu, 2010; Nurminen, 2006). Therefore, a 3D map of an environment should represent the most detailed description of that particular environment possible.

A mobile 3D map is expected to be at least electronic, navigable interactive and real-time rendered, running on a PDA or smart phone. Furthermore, such mobile system is expected to be physically small, to fit in the pocket, and independent of external power sources. In this context, a device embedded permanently in a car is not considered mobile (Nurminen, 2008a). Although this might not be always true when considering other forms of handheld computers and personal navigation system used mostly when users are visiting unfamiliar places. Mobile phones are the most widely used mobile devices used for navigation aid and have made considerable progress in enhanced input, computing power, memory, storage, and are equipped with graphical hardware for enhanced display functions. Combined with wireless networking capabilities and Global Positioning System (GPS) reception, mobile devices offer an opportunity to interact with a map display showing the current location and orientation, and can even be populated with real-world entities, such as moving people and vehicles.

This research is proposing the concept of a multi-user interactive navigation scheme which allows its users to navigate with the aid of a 3D map integrated into a mobile device. The efficiency and sustainability of the scheme is proven by evaluating the navigation practices involved in the process of interacting with 3D representations as part of navigation aids in mobile devices.

1.2 STATEMENT OF THE PROBLEM

People visiting unfamiliar places and searching for particular locations require guides. Mobile devices, particularly smart phones, have been equipped with enhanced computing resources, wireless networking capabilities, and Global Positioning System (GPS) reception. It has become possible to install large, detailed 3D maps onto mobile devices at interactive rates of over 5 frame rate per second (fps), even without hardware acceleration. Even with 3D hardware, the interactive rates exceed 30fps, which allows the installation of navigation aided applications.

Nevertheless, up until now, pedestrian navigation by way of 3D mobile navigation aided applications which offer dynamic user interaction have yet to become commonplace (Mantoro & Adamu, 2010). Mobile devices featuring multi-user interactive 3D positioning applications have yet to conquer the market and serve the millions of potential users who may benefit from it, despite the huge potential this concept possesses. Uncountable numbers of people frequently find themselves asking: ‘Where am I right now?’, ‘How do I get from X to Y?’, and ‘How can I tell Z?’ Since continuous real-time communication between individuals has become common practice since the introduction of instant messaging, Facebook and Twitter, the situation where two or more people make an appointment and want to interact and monitor themselves and others while on the move, arises more and more often.

Only a few studies have been conducted so far investigating how 3D maps as part of mobile device applications which contribute to the knowledge of human spatial behavior with regard to engagement and disengagement of 3D map interaction for navigation. Moreover, pedestrian navigation practices with 3D representation in mobile devices have to be considered a feature mobile device

services. While considering the above mention problems, there is a need for providing solutions to the following problems featured in previous research which have yet to be resolved:

- The concept of 3D maps in mobile devices used as pedestrian navigation aids. This is a complex problem. Design solutions can be contradictory, namely in cases where the more realistic the visualization of 3D details in a mobile device are, the more demanding it becomes in terms of mobile device computing resources and the screen size of those mobile devices (Nurminen, 2008b).
- Navigation tasks efficiency while interacting with 3D representations in mobile device is a highly context sensitive issue. It might be the more realistic the 3D map visualization in a mobile device is and the more accurate it becomes, the more users will be able to identify the real world; it might not be true or might be too generalized.
- How dynamic is interactive entity navigation of the environment (i.e. ‘How do I communicate where I want to go with others?’ and vice versa) with 3D representation in mobile devices? This service is not currently offered in mobile device services, despite its high level of usefulness. For in-car navigation system Leshed et al. (2008) suggest that social networking features could be used to promote carpooling by linking users with others who commute in similar routes.

1.3 RESEARCH QUESTIONS

This study seeks to answer the following research questions:

- i. What concept is capable of providing pedestrian multi-user interactive navigation aid with 3D representation in mobile devices?
- ii. What are the appropriate navigation practices taking into account engagement and disengagement with environment and mobile device while on-the-go and using 3D representation in the device for navigation aid?
- iii. What are the factors that influence the use of 3D representations in mobile devices as pedestrian navigation aids?

1.4 RESEARCH OBJECTIVES

Based on the research questions stated above, the objectives of the study are set out as follows:

- i. To explore and present a concept of providing pedestrian multi-user interactive navigation aid with 3D representation in mobile devices.
- ii. To investigate appropriate navigation practices by engagement and disengagement with mobile device and environment while on-the-go and using 3D representation in the devices as a navigation aid.
- iii. To investigate the factors influencing the use of 3D representation in mobile devices as a pedestrian navigation aid.

1.5 RESEARCH METHODOLOGY

The methodology of the research is briefly described in the following outline:

1. Basic research in evaluating a concept suited for the proposed pedestrian multi-users interactive navigation aid with 3D representation in mobile devices.

2. Designing a study employing a triangulating, ethnographic observational method with qualitative interview techniques and quantitative survey to evaluate navigation practices for pedestrian with the aid of 3D representation in mobile device.

This methodology been chosen for this research because it can be observed that there seems to be a huge departure from what 3D map applications in mobile devices offer and what people say these applications can do compared to what these applications actually do or what they are supposed to do. The only way to ascertain the truth about these applications is through observation, experiment and both qualitative and quantitative approach. However, there are also aspects which users fail to mention or perceive during a face-to-face interview conversation. There also seems to exist a measurable discrepancy between what people do with the navigation assistance in general and what they claim. Thus all these unanswered questions can be resolved by observing the relevant details in an experimental setting. Although observation generally alters behavior in the sense that in the presence of an observer a person or group may demonstrate changed behavior, nevertheless mixing covert (unnoticed observation) and overt (noticed observation) in an experiment would help in extracting facts that can produce a sufficient amount of data which can be interpreted and used to better understand the problem under consideration. The observational field study is aimed at highlighting incidents of environmental engagement and disengagement while using 3D representation in mobile devices. Its purpose is to closely observe a navigation scenario where people navigate from one location to another while maintaining orientation in the physical world, attending to landmarks along the way, and socializing with other people. A similar study focusing on car navigation

entitled “In-Car GPS Navigation: Engagement with and Disengagement from the Environment” has been completed by Leshed et al. (2008). Furthermore, the models developed by Kim et al. (2009) and Darken and Peterson (2001) are used and some of their variables are deemed to be evaluated during both experiment and observational studies. Thereafter, both quantitative and qualitative studies followed in order to provide more depth to the analysis of the result.

1.6 SCOPE OF THE RESEARCH

The scope of this research lies within navigation practices with 3D map view in mobile device as a navigation aid and providing positive evidence in support of the concept of multi users interactive navigation practices. This is undertaken by developing a prototype, experiments and both qualitative and quantitative evaluations within but not limited to the scope of the following aspects:

- The use of 3D maps designed with 3D computer graphics applications (3D graphics design software), in particular (3Ds Max 2010). This is because in order for the 3D model to be suitable for mobile devices, model simplification techniques need to be used. 3Ds Max provides in-core model simplifications object that help in reducing the model size at the same time maintaining its recognizability. However, other 3D graphics software also provide model simplifications objects.
- User studies and field experiments as methodology for validating the use of 3D models in mobile devices for navigation.
- Qualitative interview and quantitative survey as the methodology for extracting additional facts from well informed experts.