A MOBILE PLATFORM FOR LOCATION-BASED SERVICE APPLICATIONS USING AUGMENTED REALITY: ONLINE MAP, TRACKING AND NAVIGATION ON GOOGLE ANDROID SMARTPHONE DEVICE.

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I hereby declare that this Master's Project is the result of my own work, except for quotations and summaries which have been duly acknowledged.

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ABSTRACT

This project paper is about Augmented Reality (AR) using location-based visualization and implementation on the smartphone devices. That is partly because smartphone comes packed with built-in sensors have grown and become popular over the years. This will explore the interactive and interaction Location Based Services that AR allows on Android devices. The use of mobile applications and advancement in mobile technology such as Global Positioning System (GPS), compass and accelerometer sensors are able to identify and determine the location and orientation of the device, location-based applications with augmented reality views are possible. AR combines the real world with virtual, the integration of information in the user's environment in real time, the user interaction techniques of representing rich, intuitive information data of the real world. The AR application which typically takes the image of the integrated camera, positioning location as a representation of the real world and project objects on top of this image to create the AR view. The research was initiated by exploring and reviewing literature related domain and existing AR application available on Android devices. There are a number of AR applications available and the rapid development of Android smartphone devices has provided an improved platform for the application of mobile AR technologies. Developing application will help the researcher explore the topic while going through this technology. The aim of this study is to develop a combination of location-based information and AR features by blending both visual, map-based and non-map based elements like live projection of a nearby landmark on camera preview on mobile devices, utilizing free and open source software development tools. In the context of this paper a prototype application, based on the Android platform and Mixare engine library is developed. This paper showed the initial thoughts on this application and overall process that leads to the final system development. This report describes MyARTGuide, a prototype application of augmented reality designed to be run over Android based smartphone. The user can now look through their phone as if taking a picture to look at the augmented world which leads to a better user experience. MyARTGuide is developed for experiment, simulation and to test the AR functionality of these project objectives is not a fully functional product. Thus, there are still more areas that can be improved and new features can be added. With the use of AR and Andorid technology it is possible to spread the experience which will be shown in this report

KEYWORDS: Augmented reality, android, navigation, open source, usability, prototype development

ABSTRAK

Kertas projek ini adalah mengenai pengunaan *Augmented Reality* (AR) berasaskan visualisasi lokasi yang diimplementasikan keatas peranti telefon pintar. Projek ini disokong dengan kelebihan dan perkembangan telefon pintar yang dilengkapi dengan sensor yang mana telah menjadi peranti yang semakin popular sejak beberapa tahun kini dan seterusnya memberikan peluang dalam menerokai teknologi AR secara interaktif dan interaksi bersama perkhidmatan berdasarkan lokasi pada peranti telefon pintar Android. Penggunaan dan kemajuan aplikasi dan teknologi mudah alih seperti Sistem Kedudukan Global (GPS), kompas dan *accelerometer* sensor dapat mengenal pasti dan menentukan lokasi dan orientasi peranti, kelebihan aplikasi berasaskan lokasi yang mana memungkin penggunaan bersama teknologi AR dalam projek ini. AR merupakan teknologi yang menggabungkan dunia sebenar dan maya secara *real-time*. Aplikasi AR secara tipikalnya mengambil imej dari kamera, memposisikan kedudukan dalam persekitaran sebenar dan memfokuskan objek keatas imej tersebut dan seterusnya membentuk pandangan AR. Projek ini dimulakan dengan mengkaji dan menerokai kertas kajian terdahulu yang berkaitan AR dan aplikasi tersedia ada pada peranti telefon pintar Android. Pembangunan aplikasi di dalam projek ini dapat membantu penyelidik mengeksplorasi tajuk kajian dan dalam masa yang sama untuk lebih memahami teknologi aplikasi yang dibangunkan. Tujuan kajian adalah untuk membangunkan aplikasi informasi berasaskan lokasi dengan ciri-ciri teknologi AR dengan mengabungkan kepelbagaian elemen visual, elemen berasaskan peta dan bukan peta seperti unjuran langsung *marker* yang berhampiran, pengunaan perisian pembangunan dan utiliti sumber terbuka yang percuma. Dalam konteks ini, satu aplikasi prototaip mudah alih berasaskan system operasi Android dan kerangka kerja Mixare dibangunkan. Projek ini mengetengahkan idea dan proses pembangunan aplikasi dari awal kepada pembangunan sistem akhir. Laporan projek ini menghasilkan aplikasi prototaip AR yang dikenali sebagai MyARTGuide yang dibangunkan dan beroperasi dalam sistem pengoperasian Android. Pengguna kini boleh menggunakan kamera telefon pintar mereka sebagai peranti yang menyediakan pandangan AR dan seterusnya memberikan satu lagi pengalaman pengunaan yang berbeza dan lebih baik. MyARTGuide dibangunkan untuk tujuan eksperimentasi, simulasi dan untuk menguji fungsi AR dan aplikasi ini dibangunankan tanpa meliputi fungsi keseluruhan produk. Oleh itu, terdapat banyak lagi fungsi dan keupayaan yang boleh ditambah dengan ciri-ciri baru yang lebih baik. Pengunaan teknologi AR dan Android memungkin satu pengalaman navigasi baru yang akan dibentangkan dalam laporan projek ini.

KATA KUNCI: Augmented reality, android, navigasi, sumber terbuka, kebolehgunaan, pembangunan prototaip

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LIST OF ABBREVIATIONS

API	Application Programming Interface
AR	Augmented Reality
CAGR.....	Compound Annual Growth Rate
GPS	Global Position System
GS.....	MGlobal System Mobile
GUI.....	Graphical User Interface
HMI	Human Machine Interaction
ICT	Information Communication Technology
JSON	JavaScript Object Notation
JVM.....	Java Virtual Machine
LBS	Location Based Service
POI	Point of Interest
SDK.....	Software Development Kit
USP	Unique Selling Proposition
QR	Quick Response
VR	Virtual Reality
WIFI	Wireless Fidelity

CHAPTER 1

INTRODUCTION

1.0 GENERAL

The first chapter outlines an introductory content consists of nine sub-sections, that are, overview of the project, project approach, problem statement, project objective, project motivation, scope and significance of the project, expected output, method sources and project report organization. This will provide all the basic information that will be needed to understand this master project.

1.0.1 Project Overview

The evolution of science and information technologies with the rapid growth of interest in human computer interaction (HCI), multimedia, computer and mobile technologies have become vital elements and worked wonders in many fields. The massive growth of adoption of these technologies which are widely implemented around the world led to an increased use of different techniques in all areas of life. Technologies have evolved as the buzzword of modern mobile information technology and are gaining increased attention in the media, through a variety of applications which uses information on the geographical position of the mobile device. Thus, demand for access to specific location points of interest (POI) through mobile devices is on the rise as user preferences increasingly spill over into a particular firm or industry. Portable technology allows users to create, present, and combine media elements (images, graphics, videos, music etc.) with text, links and other tools which enables navigation, interaction, creation, presentation, and dissemination of information through a conversational approach.

Mobile devices are becoming multi-purpose information appliances, incorporating everyday services such as telephone, messaging, chat, games, internet browsing, location finding, tracking and navigation. Technology requirements for personal or professional purposes has now evolved into a need to combine portability with technology. Users' now demand their professional or personal applications are ported on to a mobile platform so they are not bound to any specific location and can remain productive wherever they are. Mobile platforms have thus evolved into powerful and compact devices capable of running cutting edge applications and technologies. Over the last decade, the rapid evolution of this mobile technology application has yielded new ways to develop more immersive interactive applications and frameworks.

The collaboration of immersive technologies in mobile platform lead to new interactive techniques by using new evolution of virtual reality technology known as Augmented Reality. Abbreviated as AR, Augmented Reality is the integration of digital information with physical real-world environments in a real-time session. Augmented by overlaying the real world with virtually generated renders such as, videos, graphics, sounds and text provide enriching and complementing reality with immersive ability to view content information, navigate, communicate and changes the way user interact with their environment. Therefore, AR simply adds to reality in a way that enhances or improves upon what is displayed in a mobile application. With the use of AR and mobile integrated sensors, the combined technology has the capability to interact with blended environment and source of geographical database with rich content-enabled information that can be fed directly to mobile phone devices.

The emerging technology not only adds to enhance the end user's experience or significantly improving methods of information delivery but also makes information accessible in a new and interesting way, aiming to improve the users' experience. Thus, this project paper

discusses and examines how to develop mobile application that uses AR to help users' search, navigate, track and retrieve relevant information.

1.0.2 Project Approach

Rapid development of information and communication technology has continually merged digital and physical world. The adoption of the multimedia and internet power, more applications deliver interesting ways for people to benefit from the convergence of these and other technology trends, hence, augmented reality has become an alternative preference.

Augmented reality and mobile phones have been studied for a long time and have been used in different areas. With the emergence of smartphone platform such as Android, the mobile phone performance development is on a track and is gaining computing power in the ratio similar to Moore's (Law Moore, Gordon E., 1965). Some research has proven that the mobile devices have the capabilities to run some computer-generated content, vision and tracking-based algorithm. Thus, mobile devices are now pushing technology every further (Boukerche, A., 2008).

Functionalities such as, web browsing, mobile photography, and multimedia playback are fairly standard, coupled with increased storage, and advances in mobile computing platforms, portable devices are increasingly becoming capable of running full versions of applications, which only a decade ago, required powerful desktop computers to function. Manufacturers are also bundling mobile devices with powerful and useful sensors to further increase capability of the device. Sensors such as, gyro-meters, barometers, GPS etc. enable devices to become more "aware" of the environment they are being used it, enabling devices to measure distances, location, elevation, and even environmental conditions. The features of Android smartphones and integrated digital sensors such as compass, gyro meter, accelerometer, barometer, proximity, light sensor and touch screen that able to retrieve and analyze required

raw data into meaningful information and bring the augmented mobile vision application to the users. A few other projects dealing with Augmented Reality on Android phones have been reported in chapter-2, literature review.

Augmented reality or AR technology has a large potential approach to aid users, provide dynamic reliable information, innovative ideas, new methods and technique and solution thus, it plays important roles and features of real-world objects, locations, POIs etc. to be virtually tagged for referencing, storing or sharing purposes. It's where the digital domain blends with the physical world. Previous research has helped in introducing new ways of dissemination of information and one of the methods is by using AR technology that can be used as a powerful three dimensional method to be integrated with mobile platform system.

Overlaying digital information onto the real world, viewed through a camera phone, is technically impressive and immersive. Thus, location-tracking, mapping, location-finder and route navigation is one of the focuses in this project paper. The minimum requirement for AR is a display, a camera for tracking, sensors and a processing unit by simply viewing it through an Android phones camera. Figure 1.0 illustrates how AR technology helps people to navigate and have immediate information by overlaying virtual and reality into life environment.

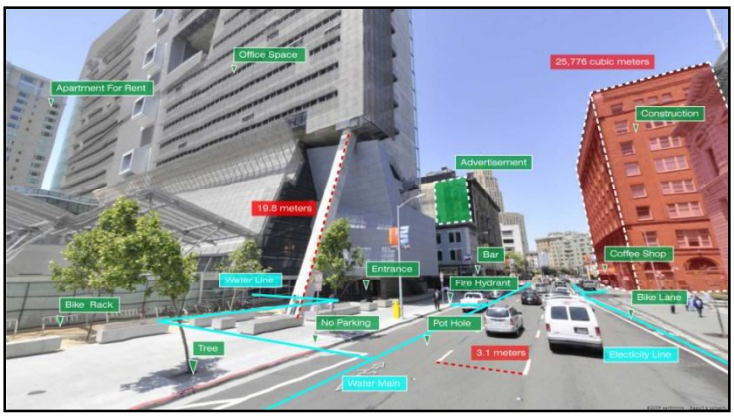

Figure 1.0: Augmented reality tracking and navigation. Source: Chris Davies (2014).

This project paper presents potential and interesting features for the creation of immersive augmented reality applications on the users-owned mobile devices such as an android smartphone. The software runs on a broad range of devices and has been used for several solutions some even commercial applications. More initiatives are required to develop a new application and interactive program using immersive AR elements and tools to support a content-rich navigation application. More precisely, shows how to develop the core of a location-based augmented reality travel and tracking application for the smartphone based on the Android platform. Most of the available tour applications, traveler guides, conventional 2D maps were included in the project, some of the popular applications, for instance Google Maps, Open Street Map and Wikipedia. All related information is taken into account, meaning researcher looked at the characteristics of the applications and other resources and grouped like items together (Nickerson, et al., 2009).

The process began with gathering lists of location based applications such as travelling and tourism apps and included searches on the smartphone platform portals for example iTunes, android play and android market. Where possible, the application was downloaded and used so that its capabilities could be understood from a user perspective. In cases where the application was not available to download, the general description of the application was used to judge the capabilities and the level of interactivity. Once the taxonomy of applications was compiled, each app was evaluated according to the established criteria. This project paper will give researchers the opportunity to explore and perform the experiments of AR and Android technology on mobile platform and to develop a location based application prototype that will adopt new human computer interface technology as a solution to support and enhance location based information and provide augmented assistance. This approach will significantly increase the usable information space and the user's ability to navigate it.

1.1 PROBLEM STATEMENT

Previous research suggests that traditionally, users, travelers or tourists have relied on gathering information across various contexts for their local surroundings or travelling destinations through books, articles, guides, magazines, television, radios, and even newspapers (Pocock, 1992; Fodness & Murray, 1998). Typically, once this information is accessed, it is recorded in an offline manner (for example, jotting down relevant information, phone numbers, locations, addresses, POIs etc. in a notebook). While this is advantageous for purposes of easy retrieval of recorded information, the information itself is not updateable easily without further research and make quickly become irrelevant. Advances in mobile technology has served to change how people travel or find locations, with the travel industry innovating on newer, more intuitive, and easy ways of connecting users with destinations.

The full potential for the travel and tourism industry, using a smartphone, has still not been fully explored. This paper is an attempt at exploring the benefits of using AR technology on a smartphone device for travelling and tourism purposes and should serve to offer insights how users receive this new technology. The main unique selling proposition (USP) being using AR systems instead of a real-life tour guide for travelling purposes is that the whole experience becomes more personalized. Instead of touring a destination on someone else's schedule, the user can visit places at their own pace and simply point the mobile device camera at an object to view useful information or discover newer places.

AR technology, using Location Based Services, requires access to various built-in components of the device. For purposes of the current project, the prototype application is intended to make use of a device's built-in GPS (Global Positioning System), GIS (Geographical Information System), and LBS (Location Based Services).

When travelling, the main activity for most tourists is to look for major attractions within a city, as well as, discover new sights. This concept applies to non-tourists as well, who may be

looking for a particular location or address. AR based LBS systems on mobile devices are the perfect companions for such activities, the application can display information on nearby landmarks, along with directions to that location, and provide pertinent information for the location, alternately, for locals or non-tourists, the application serves as a direction guide to replace a traditional GPS navigation system. In concert with geo-tagging or geo-location technologies, Smartphone mobile can use augmented reality to add a new layer of reality that's contextual and location-specific. There are three problems that must be solved in this project:

a. How to design and develop Android based augmented reality application that leverage camera functionalities, maps, GPS and sensors that offers usability, tracking and navigation.
b. To create a mobile Android based system that provides access to user retrieved information by using AR interfaces.
c. The project should demonstrate a prototype application that extends the location based AR experience as users will perceive augmentations from their environment from specify instances.

The problem statement is therefore creating immersive prototype application for use in the situation where users through use of an Android smartphone device can interact with a virtual environment. The first problem concern is the design, development and implementation while the second problem concerns the information that is presented to the user via the application. These problems will be addressed throughout this project.

1.2 PROJECT OBJECTIVE

Generally the focus of this project paper underpins the integrated use of augmented reality on android powered smartphones with integrated sensors capabilities. Exploring and emphasizing importance, capabilities of mobile AR and to develop Android mobile application with an improved virtual experience for user. The objective is to develop and implement smartphone AR mobile prototype application by given information about the local landmarks which are in the vicinity of the current location. This mobile application is a location aware application, as this application incorporates location based services to receive location updates. The application is able to help the users to learn about their surrounding areas, locating and navigating through their respective environments and this is done by showcasing the possibility of using smartphone features and takes advantage of the different sensors available on most android based phones such as sensing capability of GPS, digital compass, accelerometers, audio/video recording and text annotation.

This application uses the information to populate a list of nearby landmarks. It gives an accurate map view representation and also shows the user's current location on the map. The application also uses the knowledge of the current location and nearby landmarks to augment them on the camera preview, thereby bringing a more contextual experience to users. The application has the ability to overlay the view obtained through the device camera with useful information about places. Additionally, the project concludes the following objectives:-

a. To identify and explore AR and Android technology and to provide a general idea of the development and implementation process.
b. To develop android based AR prototype application as the test environment which is able to overlay digital information which is accessed through a smartphone Android device.
c. To evaluate and test the prototype application and public response to the application.

d. To identify the strengths, limitations and recommendations for future developments.

This researcher aims to understand the life-cycle of the Android Development Process, particularly, how to code the application, what is the process involved in developing the application layout, how the Java platform interacts with the Android framework, and how to emulate the application using an Emulator and on the device itself. The final application should enable users to point their mobile phones at stationary and mobile objects and get overlaid information that sticks to the identified item of places or things.

1.3 MOTIVATION

There has been a hot topic discussion why is Augmented Reality or AR an interesting subject and what are the advantages and benefits of combining real and virtual objects in augmented environment (Itagged, 2014). AR has its own distinct strengths and capabilities to enhance a user's perception of and interaction with the real world. By combining these strengths, AR able to improve existing methods and produce new techniques and tools to the users. The information channeled by the virtual objects helps a user perform real-world tasks or specifically to get the information and re-render the images has great applications in people's life. In general, it can put very useful virtual information into the real scene.

It would be more interesting if AR can be presented and practically applied on mobile phone technology. For example, pointing smartphone at a superman comic book and watch Clark Kent step off the cover and begin to fly, it will be sorely tempted to look past the phone's screen to see if it is real. Imagine an operator in an assembly shop being presented with digital assembly instructions and demonstrations in his field of view, based on the task at hand or imagine a maintenance operation in which computer-generated information is superimposed on the actual part, showing the tasks that need to be carried out and how these

tasks can be done. Another example, imagine a personalized learning environment that provides context- and user-sensitive information overlaid in the real world. These are some examples of new opportunities that augmented reality can provide. A more important reason is that with the growing computational power of modern systems, devices and applications become more complex and integrate more features. Software and hardware that is only available to a small amount of specialists a few decades ago, is now a well integrated part of everyone's daily life. Good user interface design is therefore no longer an option but a hard requirement for developing highly usable applications. AR thereby blurs the distinction between the real world and the user interface and combines them in a natural way allowing the creation of simple and intuitive user interfaces even for complex applications.

Furthermore, modern mobile phones have become increasingly technological making the platform a perfect place to develop in Augmented Reality (AR). Most smartphone devices these days contain a high specification camera, a GPS, multi functions sensors with high processor speed. Researcher notices an increase of emerging interaction between humans and computers that are starting to redefine the phrase human-computer interaction. Beyond just delivering straightforward information to users, the research of AR on mobile platform has focused more attention and interactive dimensions in navigation in order to motivate users to do self-exploratory activities and enhance spatial awareness of physical spaces.

1.4 PROJECT SCOPE

The project is to develop a prototype application based on integrated approach which would meet the requirements and objectives of the project. Thus, the scope of this project research is to explore, design, develop, integrate, implement, testing and to identify specification and elements of developing mobile based AR which is riding over the Android smartphone platform and then to provision and testing. A basic feature of the AR prototype application

that has a user interface will get to the database, retrieve and will be displayed to the user. The prototype at least is able to determine the user's location, track point of interest, accesses online/offline databases, create, modify and access private database, track and mark travelling point, find out location.

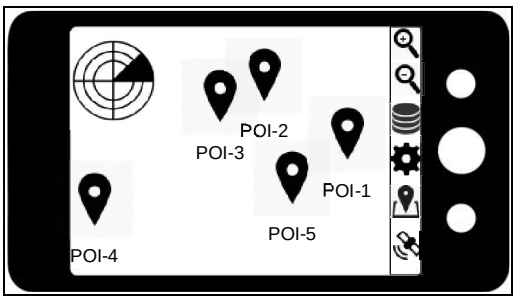

Figure 1.1: Mobile Location based Augmented Reality in action.

Next present these POIs as a floating circle/arrow marker together with the textboxes, which are aligned according to the direction the user is facing, and superimposes them onto the device's camera feed. The scope will also represent the basics of Android development. Figure 1.1 is a basic concept of how results are presented in an Augmented Reality location based service application.

1.5 PROJECT PLAN

A project plan outlines steps and serves as a guide as to how a project should execute. Particularly, the plan lists the processes involved in the process, how a research works on the projects and the tools used to achieve project completion.

1.5.1 Project Phases

To develop a well-structured project it is essential that project phases are outlined after completion of a project phase as outlined in the Project Plan. After completion of each phase,

an assessment is done to understand if the objectives of the phase have been achieved before moving on to the subsequent phase. This assessment is recorded in a Project Phases outline.

1.5.2 Methods

During any project, a research may use different approaches to conduct research, these approaches may include both, development of a theoretical and developmental phases. For the current project, both groups will be utilized. Literature Review will constitute the theoretical base for which this researcher will use books, articles, journals, as well as web related sources such as, web sites, tech discussion forums, tutorials, coding forums etc. Through such diverse research bases the researcher will gain a better understanding of the design methodology, principles, AR programming tips, tips on development on an Android based platform, understanding mobile development, java programming structure, and research principles and technologies, which will contribute to successful development of AR on an Android Platform.

1.5.3 Pre-study and form the theory background

Successful development of any application requires research of the different approaches, where to focus, and the capabilities of a development platform (in this case, Android) before proceeding to the developmental phase. This theoretical background may be researched from various sources such as, books, journals, research articles, etc. and will serve to highlight the many aspects of augmented reality and the focus thereof on an Android based mobile platform or device. This theoretical research will serve as an introduction to the developmental methodologies and approaches for the next phase.

1.5.4 Development method

SDMs (Software Design Methodologies) serve to highlight recurring, general design based problems and outline solutions to such problems.

1.5.5 Create eligible environment and procure all the necessary tools.

For this phase, the test environment will be parsed of all un-necessary software to minimize problems with interference and conflicts from other applications. A clean test machine will have the Java Runtime Environment and Android SDK (Software Development Kit) with Eclipse installed. The purpose of installing Eclipse is to enable the developmental environment to gain access to the cloud-based infrastructure in order to select pertinent web services.

1.5.6 Design a model of future application.

This phase will require feedback from the Project Plan, as well as, Android Developers Community to help outline and design the future layout of the application.

1.5.7 Implement concept into prototype application.

This phase involves implementation of our coded application into a run-time environment, through execution of the application layout and classes. Furthermore, the prototype version of the application will connect to a web-service. This phase includes describing the principles and technologies using during development of an Android application.

1.5.8 Testing and evaluation the prototype application

Functionality and usability testing is conducted during this phase to verify the application interface and functionality through an Emulator tool. Outlined used cases will be utilized to

test the working of the prototype application.

1.6 PROJECT SIGNIFICANCE

AR technology is continually revolutionizing how we interact with the world around us, be it in business or personal context. AR enables showcasing of useful information such as, articles on any object or location, distances from current position to another position or destination, navigation routes to the destination etc. The technology fully takes advantages of a device's built-in sensors such as, a GPS, Barometer or GIS to provide location based services in an extremely easy manner. The user is intended to simply point a device's camera at an object or location and get the relevant information. Garcia-Crespo et al. point out the potential of AR technology for businesses. As location services gain greater accuracy, AR application may be used for route tracking, location mapping etc. on campuses, while travelling, within vehicles or even inside buildings, for navigation, as well as, object identification purposes. The system provides a base for further evolution towards greater interactivity and entertainment with the world around us.

With the increasing use of the Internet for travelling purposes, the product has become more transparent empowering the users to get in contact with the destination prior to the actual trip. This project makes a number of project contributions to the field of tourism and travelling for AR Android Smartphone. GPS is primarily intended for location and navigation purposes, while AR can further the platform by offering pertinent annotations and other useful information, along with GPS navigation data for a more interactive user experience. The contributions contained in this project are the following but not limited to:

a. View variable information about an object of interest that is placed immediately in context.
b. Provide simple and easy to use interface over Android Smartphone platform.

c. Improve the user's vision of AR in terms of technical concept, techniques and practical applications.
d. Provide location aware guidance for travelers and tourists, for example listing out on a map nearby POIs or landmarks within a particular vicinity of the city.
e. Enrich the whole travel experience by integrating multimedia elements.

1.7 METHOD AND SOURCES

Combination of the theoretical method, development method and system testing are few methods used to help researcher in this project. In researching the subject a lot of papers were studied both on mobile technology and on the theory of AR computer vision. Few books which were important and invaluable for the research were Prototyping Augmented Reality, Pro Android Augmented Reality and Augmented Reality for Android Application Development. Other sources were the, inevitable Internet and other thesis work found on the subject of AR and Android mobile.

1.8 EXPECTED OUTPUT

Expected results from this project are as follows;

a. Any application's user interface must be designed with the "usability" factor in mind. Application interfaces are intended as showcases for presenting output or receiving input for execution by the application. Hence, a 'more is less' approach is recommended to populate the screen with only relevant information output for users.
b. Developing a "Prototype AR Mobile" demo system, which is easy to use. Tasks may be split into two major headings namely, Java Android programming and AR framework integration. Java Android programming is achieved through templates or

off-the-shelf packages, while AR Framework are based on a open source engine and software tool installed on a GPS enabled mobile device.

c. A complete report of how the research project will be presented, analyzed, implemented, test and development of the prototyping.

1.9 ORGANIZATION OF REPORT

This project report has six chapters and is organized as follows:

Chapter 1: Project overview and outlines the main problem areas that the project aims to tackle, the objectives, scope of the project and methods that may be applied to the problem.

Chapter 2: The second chapter outlines implementation of AR on Android mobile platforms, past attempts, current development, and characteristics of AR on a mobile platform. The chapter also explores current business applications for Android mobile with AR technology, as well as, current limitations due to application development, awareness, or platform deficiencies, along with charting out a roadmap for future evolution. Through examining literature, an examination is made of developing an effective AR environment and hardware and software for taking full advantage of this new technology.

Chapter 3: An examination of current research and exploration of current AR and Android development areas is examined in this chapter. An assessment is conducted of the tools and technology used in the context of developing a prototype AR application, where it lacks, and a brief discussion is conducted on future development directions.

Chapter 4: This chapter forms the crux of this research attempt and will outline the techniques and tools used towards development of an AR prototype

application for purposes of this project. Each of the tools and techniques used are assessed, listing their capabilities, possible outcomes, and shortcomings, along with a discussion on the methodology used for development and testing of the application.

Chapter 5: The Chapter 5 explains the evaluation results and conclusion from testing performed in the previous chapter.

Chapter 6: The Chapter 6 explains the final assessment of the product against the objectives set in the initial objective, the project plan and a summary of lessons learned from the project.

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