

**DEVELOPING MOBILE AUGMENTED
REALIATY APPLICATION FOR CAR MUSEUM**

**A THESIS SUBMITTED TO THE GRADUATE
SCHOOL OF APPLIED SCIENCES
OF
NEAR EAST UNIVERSITY**

**By
MOHAMMED MUKHTAR MAGAJI**

**In Partial Fulfillment of the Requirements for
The Degree of Master of Science
in
Computer Information Systems**

NICOSIA, 2017

**MOHAMMED MUKHTAR
MAGAJI**

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Mohammed Mukhtar Magaji

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To my family...

ABSTRACT

Information and communication technologies were being used in different areas such as education, health, military, museum, and business etc. Multifunctional mobile devices like tablets and smartphones wind up progressively and improve the day to day liveliness of human activities. Due to advancement of technology that gives rise to Augmented Reality technology as new trends in technology been popular in many sectors especially museum around the world. In NEU car museum, all the cars are expensive, old and historical, this makes them valuable, distinctive, special and precious that need to be kept untouched and safe to avoid any damages or broken down by any person or individuals that will reduce the quality of the cars, which will cost the huge amount of money to be repaired. The NEU car museum is located in Cyprus which make it difficult for the visitors coming from abroad. For this reason, this study aim is to develop mobile Augmented Reality application on Android Operating System for NEU car museum as a guide to individuals who cannot go to the museum or museum users. This application serves as a guide to visitors to view information about the car in the NEU museum through the image target and view the objects in 3D view. The developed NEU-MAR application goes a long way in solving museum problems and bringing about positive results to NEU car museum. To taste the effectiveness of the developed application random volunteer survey was conducted where 35 students took part, used the developed application before filling the questionnaire. The results of the case study pointed out that the developed application is enjoyable and user-friendly. In addition, the aim has been achieved and that the developed NEU-MAR application can be used anytime and anywhere in the world to helping museum visitors or individuals who cannot go to the museum to view full information about cars found in NEU car museum by using the application in the comfort of their home anytime and everywhere in the world. The NEU car museum should adopt and lunch this new trends technology of augmented reality application in their car museum. In the future, will include more cars in the NEU magazine catalog and developed an application that is suitable for IOS, Window, and other operating systems. More programmers should concentrate on developing AR application for other car museums.

Keywords: Information technology; smartphone; mobile application; augmented reality; augmented reality museum; Museum

ÖZET

Bilgi ve iletişim teknolojileri eğitim, sağlık, askerlik, müze ve işletme gibi değişik alanlarda kullanılmaktadır. Tablet ve akıllı telefonlar gibi çok fonksiyonlu cihazlar hergün gelişmekte insanların günlük yaşamlarındaki aktivitelerini kolaylaştırmaktadır. Artırılmış gerçekliğe yol açan teknolojik gelişmeler müzeler başta olmak üzere dünyada birçok sektörde popüler olarak kullanılmaktadırlar. Yakın Doğu Üniversitesi (YDÜ) araba müzesinde bulunan bütün arabalar oldukça pahalı, eski ve tarihi olduğundan çok değerli olup herhangi bir şahıs tarafından dokunulmadan ve zarar verilmeden güvenilir bir şekilde muhafaza edilmeleri çok önemlidir. Olabilecek herhangi bir zararda arabaların kalitesi düşebilir ve tamirleri de son derece pahalı olabilmektedir. YDÜ araba müzesi Kuzey Kıbrıs'tadır ve dolayısıyla ada dışındaki ülkelerden ziyaretçi gelmesi kolay değildir. Bu nedenle, bu çalışma YDÜ araba müzesi için bir kılavuz olarak hazırlanmış ve özellikle müzeyi ziyaret edemeyecek olanlar göz önünde tutularak Android işletim sistemi kullanan bir mobil Artırılmış Gerçeklik uygulaması olarak yapılmıştır. Geliştirilmiş olan bu mobil uygulama ziyaretçilere YDÜ araba müzesini 3 boyutlu olarak görme imkanı tanımakta ve müze hakkında geniş bilgi vermektedir. Geliştirilmiş olan NEU-MAR uygulaması müze problemlerini çözüp YDÜ araba müzesi için olumlu neticeler vermektedir. Uygulamanın verimliliğini araştırmak için rastgele seçilmiş 35 gönüllü öğrenci ile anket yapılmış ve ankete katılanlardan anket sorularını cevaplandırmaları istenmiştir. Anket sonuçları, geliştirilmiş olan mobil uygulamanın kullanıcı için kullanımının kolay ve zevkli olduğunu göstermiştir. Buna ilave olarak, NEU-MAR uygulaması herhangi bir zamanda ve dünyanın herhangi bir yerinde müzeyi ziyaret etmek isteyen fakat ziyaret edemeyenler tarafından kullanılabilir. Uygulama sayesinde kullanıcılar müzedeki arabalar hakkında geniş bilgiye arzu ettikleri zamanda ve arzu ettikleri yerde tam olarak erişebilirler. İleriki çalışmalarda IOS, Windows ve diğer işletim sistemleri için de uygulama geliştirilebilir. Daha çok programcıların dünyadaki diğer müzeler üzerine Artırılmış Gerçekçilik alanında çalışma yapmaları arzu edilmektedir.

Anatar Kelimeler: Bilgi teknolojileri; akıllı telefon; mobil uygulama; artırılmış gerçekçilik; artırılmış gerçekçilik müzesi; müze

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LIST OF ABBREVIATIONS

AR:	Augmented Reality
DOF:	Degrees of flexibility
IBM:	International Business Machine
GIS:	Geographic Information System
FOSS:	Free and Open Source Software
MAR:	Mobile Augmented Reality
ICT:	Information Communication Technology
IOS:	iPhone Operating System
IT:	Information Technology
NEU:	Near East University
OOSE:	Object orientated software engineering
OS:	Operating System
PC:	Personal Computer
SDK:	Software Development Kits
SDLC:	Software Development Life Cycle
UCD:	Use Case Diagram
UD:	User Document
UML:	Unified Modeling Language
URD:	User Requirement Document
VR:	Virtual Reality

CHAPTER 1

INTRODUCTION

This chapter explains statement of problem, the aim of the study, importance of study, study limitations, duration and overview of the study.

1.1 Information Technology, Smartphone, Augmented Reality

Technologies where been utilized in various sections such as education, health, business, and in developing systems with learning purposes etc. There is no uncertainty in it. Multifunctional gadgets such as tablets and mobile phones wind up progressively. Nowadays, technology has changed the way many people experience their day-by-day lives, both socially and monetarily along these lines gaining it a factor that will improve human lives (Jacob, 2016).

A Smartphone is a progression of mobile phone which integrates much usefulness, for example, making telephone calls, sending messages, video calls, getting to the web with bunches of handling capability, its fit for running numerous applications concurrent (Joo & Sang, 2013). Since the initiation of smartphone in 1994 by International Business Machines (IBM), the gadgets been acknowledged around the world (Mark, 2016). The acceptance of the Smartphone is expanding every day with no indication of declining. Current facts announced by users of smartphone in 2014 by Statista estimated that the reception of a smartphone will increment by 1 billion clients in 2019 this infers a quick development of Smartphone appropriation by clients (Statista, 2017).

The Smartphone make individuals to remain in contact with their love once and at different ranges, so they conveniently stay at home for communicating information or correspondences with family and companions. It can further power social life since it is conceivable to possibly be rejected from families geologically and still have the capacity to contact their love once (Kurniawan, 2008).

Mcllroy (2015) announced that around 2 billion people utilize smartphones around the world, with over a huge countries relying upon smartphone day by day. This high ubiquity

by smartphone infers that there is the potential for objective smartphone information to be use to address look into exploration in this present reality (MacKerron & Mourato, 2013).

The smartphone has this unique advantage (portability); you can carry it around and has lots difficult to embrace the technology with all its functions due to some factors that affects mainly the adult population (Smith & Chaparro, 2015).

Everyday a new technology came along and changes everything, nowadays AR technology is well known in different department in various parts of people existence. AR generally alludes overwhelming and intelligent idea advanced integrated parts like 3D models and anticipated onto the physical world or media are straightforwardly combined. The entire advanced layer of AR change is regarding real-world changes, it takes a very long while for AR to end up what it is today. AR has been a new technology in these current years characterized as a real environment and virtual environment which is also called mixed reality it has capabilities of the audition, smell, vision, touch, and taste try out or even taste, touch and smell. Augmented Reality technology been popular in many sector specially museums around the world.

Ling and Seng (2011) presented a structure utilizing the smartphone together with machine vision in such a way that mobile users can view the surrounding site identifying the road safety of moving vehicles through traffic alert sign application. The driver is able to detect any traffic signs in various modes relying upon the client's inclination. Expandability concentrates on the straightforwardness of the activity that the alarm sign received and yield different applications inside same equipment gadget. This gives a choice to different engineers to utilize or extend their own particular applications by utilizing the consequence of the proposed application.

The AR is innovation that joins what is in all actuality and what is produce from PC by improving what we see, feel, hears, and smell feel (Agrawal, Kulkarni, Joshi, & Tiku, 2015). This innovation is, for the most part, executed to give clients constant, clearer and more intuitive information. In past research, AR had been executed in zones, for example, education (Di Serio, Ibáñez, & Kloos, 2013), health (Hansen, Wieferich, Ritter, Rieder, & Peitgen, 2010), military (Graham, Zook, & Boulton, 2013), advertising (Scholz & Smith, 2016), entertainment (Lv, et al., 2015), furthermore, route field, for example, Metaio, Layar and Wikitude.

The design showed up in 20th century, however the acceptance it got just in the most recent couple of years, it was not only making of sci-fi creators but rather experiments and real concepts. Many technologies were put together in creating instructive PC frameworks, nearer to reality. AR is one of the technologies that have been utilized as a part of numerous applications for the individuals to interact with the real world in many ways. AR before long will battle its way into our regular day-to-day existences. A standout amongst the most encouraging regions of computerized media that opened an extra zone of cooperation amongst users and its interaction with AR applications, since mid-2000 AR has progressively turned into a zone of improvement in numerous enterprises (Nicas, 2016).

Kirner and Kirner (2008) demonstrated that AR is about overlapping of virtual with the physical objects in an environment, being appeared to the user progressively through a technological device, utilizing the environment condition interface and changed in accordance with imagine and control real and virtual objects. Interface user can communicate with the systems with their hands or reference markers to control virtual objects in the real situations. It is a technology that utilizes techniques characterized in Virtual Reality, Computer Vision, and Computer Graphics, enabling the clients to see real world and virtual objects inside a similar domain.

Santana, Juárez and Magaña (2013) research also proposed an AR framework that enables Mexican secondary education students to get extra educational knowledge using the AR to identify their course readings materials, framework perceives the pictures imprinted in the book as a major aspect of standard showed subjects and shows mixed media substance that supplements the themes shrouded in the book. These substances are produced through service oriented modern design, ease of use testing augmented reality framework demonstrated a client fulfillment of 97%.

This study will develop a Mobile Augmented Reality application for a car museum using Android operating system. A Jaguar XK 120 roadster 1949 car and museum catalog magazine were used in the development process. The users can see objects in 3D view and information about the car in the museum through the magazine cover; it goes a long way in helping visitors or individuals to view full information about cars from a car museum by using the application in the comfort of their home anytime and everywhere in the world.

The use of MAR application car museum found to be well enjoyable, useful, although it also makes the development more tasking. AR is very expensive and difficult to develop as such there are no much or little scientific research done based on car museums, which makes it vulnerable to left on many part of the development process.

1.2 The Problem

Due to advancement in technology, particularly in AR as new trends in technology, AR application are used in different areas like education, health, business, travel, navigation, entertainment, museum, maintenance/repair and military, etc. AR thought to be in its infant stage and they are still has not yet been completely utilize, which needs to encourage characterize AR legitimately relying upon the usage technique and territory (Van Krevelen & Poelman, 2010).

Ihma and Hsieh (2015) older grown-ups, including a populace section more helpless against social disengagement amid the late life stages, will probably be avoided from the advantages of information and correspondence advances (ICTs) and additionally, from the concentration of ICT explore. Investigations by (NTIA, 2013; Smith, 2014; Zickuhr, 2013) recommend that grown-ups may be subjected to various ICT conformity and acceptance use conditions, showing that the inconsistencies in getting to ICTs are as yet a pivotal issue. Mobile application should be accessible to more users in their dialect. The mobile application should give visual materials and in addition sound-related materials (Turan & Keser, 2014).

In NEU car museum, all the cars are expensive, old and historical. This makes them valuable, distinctive, special and precious that need to be kept untouched and safe to avoid any damages or broke down by any person or individuals that will reduce the quality of the cars, which will cost huge amount of money to be repair. Cyprus is a small island and as such many people in Cyprus do not have opportunity to visit the NEU car museum, The NEU car museum is located in Cyprus which make it difficult for the visitors coming from abroad. He long tour guide by the person in charge of explaining the information about the car features or history of the cars is time consuming, tiring and sometimes even boring to so many visitors. It is cost effective for the University. Individuals different perceive, comprehend in terms of memorizing the car specifications as well as reading and understanding ability is a problem to many museum visitors or users of museum. The

future is uncertain to anyone and in case of natural disaster; this MAR application can serve as an electronic platform for archiving useful information about the car museum in real time.

The advance of AR has now made the use of mobile application better, easier and more attractive, although it also makes the development more tasking. By developing MAR application for the NEU car museum (NEU MAR), it will take care of these problems and the NEU will save more money giving to the person who is always there to explain the car features.

1.3 The Aim of the Study

This study aim is to develop mobile Augmented Reality application on Android Operating System for NEU car museum as a guide to individuals who cannot go to the museum or museum users, which will go a long way in solving museum problems and bringing about positive results to NEU car museum.

1.4 Importance of the Study

A standout amongst the most troublesome difficulties about AR is educating the larger society or market, many people are not exposed to AR consistently and do not see its wide-achieving applications in their everyday lives. Notwithstanding, there are a lot of AR encounters accessible today that simply needs an introduction in the showcase. Likewise, it is vital to construct a solid pipeline of rising ability in the AR so that people or groups to proceed to advance and build up this technology. It is important that people should be introducing to this technology. It is anything but difficult to be threatening by developing technology, however, with an early introduction; AR can turn out to be more available. This NEU MAR application is important due to the following points:

- **Accessibility:** The museum can be reach by anyone, anywhere and at any time through the AR mobile application
- **Protection:** It helps in providing protection to the museum cars from any individual and all other unforeseen circumstances i.e. wear and tear.
- **Marketing:** The MAR application will serve as a good avenue for marketing both the museum, the University and Northern Cyprus at large.
- **Guide:** The application will serve as a tourist guide to all museum visitors.

- **Upgrade:** The AR application will also uplifting the standard of the car museum to meet world standard.
- **Popularity:** Due to the technology involved while designing the application, its uniqueness and display the application will attract more people, thereby making the museum more popular.
- **Time efficient:** Due to the opening and closing hours of the museum, many people were not able to visit the museum within those hours but with the application they no longer need to worry themselves, the application has taken the museum to them.
- **Impaired People:** People with certain disability will not be able to visit the museum but with the application, there is no restriction.
- **Cost effective:** The application will enable the NEU to cut cost of long tour guide by person in charge of explaining the feature of the cars.
- **Archive:** The application will serve as another means of data storage in case of any natural disaster.

1.5 The Limitations of the Study

In spite of the fact that this mobile development using AR will accomplish its points, in any case, there is some limitation connected to it because of the impediment.

- The development date was 18 September 2017 – 30 November 2017.
- This study targets only the NEU Car Museum.
- The mobile application design and specification is only limited to one Car (Jaguar XK 120 Roadster 1949).
- Detection of the image is base only on NEU magazine cover.

1.6 Overview of the Study

The whole thesis contains five chapters:

Chapter 1 is the introductory part of the thesis and explains the problem definition, importance of study, aim of the study.

Chapter 2 this chapter presents the related research done by other researchers on the same area of interest on Augmented Reality Application use in the museum. It gives previous general overview on AR development used in different sectors. It gives a relatives head up papers based on researched and at the end filled up the missing gap based on literature. The

last paragraph shows the originality of my study on the developed mobile augmented reality application for car museum.

Chapter 3 this chapter presents the theoretical framework to be used for this study, thereby explaining augmented reality, introduction to its application, brief history of AR, AR usage and advantages of AR as the selected framework. Mobile application development, types of mobile application, smartphone, usage in the world and its advantages.

Chapter 4 this chapter explains in details on the developed Mobile Augmented Reality application for Car Museum using Android Phone. System requirements of the whole study, software development cycle, Hardware, Software, system architecture, flowchart, use case diagram block diagram, and Operating system that shows design of the developed system as visual.

Chapter 5 this chapter gives exploration and navigation guide to the user of the developed NEU-MAR application. With simple structure buttons that are consistent, enjoyable, and feedback in an easy way by user.

Chapter 6 this chapter wraps up my study conclusively, and as well contains recommendations, suggestions for future works.

CHAPTER 2

RELATED RESEARCH

This chapter presents the related research on the new trends in Augmented Reality Application, museum and smartphone. It gives a relative head up papers based on researched and at the end filled up the missing gap based on literature. The last paragraph shows the originality of the mobile augmented reality application.

2.1 Museum Augmented Reality Application

Cianciarulo (2015) depicted a test AR model in a little Viggiano museum (South Italy–Basilicata Region) Viggiano is a little museum that portrays the neighborhood conventions with a major accumulation demonstrate from the ranch in Museum Viggiano (MUVIG). Museum of local traditions clarified the utilization of AR changed typical observation and increment the attention to going too little yet certain and locally imperative exhibition hall. It has made additional interest in this innovation and numerous guests went to the museum just to attempt to encounter this advancement. Suggested that in arranging the creating of new AR focuses inside the MUVIG.

Turan and Keser (2014) created mobile application museum guide empowers users to listen to the most outstanding features in English and Turkish language. In this manner, the application utilizes visual as well as gives data to the users who cannot communicate in Turkish. The examination depends on 32 guests of Near East University Classical Car Museum. A discretionary module gives the users chance to take a photograph and transfer it with their remarks to the framework. This module empowers guests to share photograph file, solicitations, grumblings, and recommendations. Visual and sound portable application intended to give data about the substance of the historical center. Mobile application should be accessible to more users in their language. The mobile application should give visual materials and in addition sound-related materials.

Jang et al. (2014) employed Platform as a Service (PaaS) of distributed computing enabling users to get to museum data whenever and anywhere. Activating digital museum

explorer is tweaked for Taiwan National Palace Museum (NPM), which is one of the best five world-prestige museum centers, as delineation. Mobilizing digital museum explorer tweaked for Taiwan's National Palace Museum. The stage comprises of cloud benefit framework and versatile display stage. The cloud benefit framework underpins information administration, XML based information trade, and push notice. Museum center imaginative administrations that bring users absolutely new encounters on exhibition museum ancient rarities.

Amato et al. (2013) proposed a novel administrations stage for the cultural heritage space. The framework abuses the Internet of Things innovations keeping in mind the end goal to make objects of a museum display ready to "talk" amid clients' visit and able to do naturally recounting their story utilizing sight and sound offices. Specifically, redid the framework for an indoor historical center, giving to visitors customized going byways by a legitimate suggestion technique. Proposed innovation likewise considered the related cost and advantages, as far as power utilization and support needs.

Jankaweekool and Uiphanit (2013) developed Coin Treasury Museum guide (CTMG) with AR innovation to exploration is to uncover the clients' sentiments on a Mobile application which decide clients' behavioral examples and their subjective fulfillment, and the connection between them while playing application. The guidebook AR turnout to be intuitive manual can be utilized as instructive devices to shape as learning museum with fun. The numismatic museum can team up to build client's appreciation for coin historical center through the versatile application.

Ghiani et al. (2009) built up an intuitive AR guide for museum utilizing the innovation SpanoUbiCicero on a mobile phone, a multi-gadget, area mindful gallery control ready to entrepreneurially misuse extensive screens when users are close-by, which is outfitted with an RFID reader that recognizes close-by labeled fine arts. The (Calci, Italy) museum of natural history and the (Carrara, Italy) marble museum. In future suggested better approaches to improve personalization of the guide UI, specifically in assemble visits. Multimodal communication highlights will be considered, likewise to acquire a variant ready to help outwardly debilitated individuals through the programme discovery of user's area and introduction and potential obstructions.

Damala et al. (2008) composed and broke down completely practical model of AR mobile application with text, sound etc. museum guide, which was executed in the Museum of Fine Arts in Rennes, France. AR model on an Ultra Mobile PC (UMPC) Samsung Q1 running on Windows XP and equipped with normal webcam. New model and address all components that may support or back off the acknowledgment of portable AR empowered sight and sound applications. AR empowered mixed media applications model will likewise be executed and tried in a similar setting, with the desire to come more like a guide which ought to in a perfect world be lively, available for a bigger open, unique, spurring, intuitive, inquisitive, astounding, yet in addition subjective and delicate. Museum guests may have the likelihood to appreciate a rich interactive media yet, in addition, passionate experience, utilizing their self-possessed portable, AR empowered gadgets, giving consequently historical centers instructors and guardians with an option strategy for conveying rich and differing show related, in situ, understanding material.

Bruns, Brombach and Bimber (2008) introduced a museum framework called PhoneGuide. It utilizes camera-prepared mobile phones for on-gadget protest acknowledgment in specially appointed sensor organizes and gives area and protest mindful media substance to museum users.

Wojciechowski et al. (2004) created Augmented Representation of Cultural Objects (ARCO) depicts a framework, that encourages museum to make Virtual and Augmented Reality displays in a snappy and instinctive way. On touch-screen shows introduced inside displays on the Internet. This enables guests to connect with the contents in an instinctive and energizing way. Historical centers to show their digitized accumulations utilizing distinctive types of information introduction, for example, Web pages and Virtual and Augmented Reality techniques. Future works incorporate the outline of cutting-edge perception layouts for exhibiting social protests in a more alluring and engaging way. The likelihood of utilizing haptic gadgets and projection equipment in regard to ease of use in genuine applications will be researched easily. Segments of the AR establishment will be combining into a smaller shape, which could be less demanding introduced in a museum site.

2.2 Augmented Reality and Mobile Application

Patil (2016) created desktop-based AR tool in the sector of engineering model that utilizes predetermined printed examples to track PC graphics that permit as to make new patterns

to augmented designs on it using C#. By holding the marker before a camera, at that point, it will perceive the marker, track the marker co-ordinates with the bearing of 3D view, at that point shows the information as an augmented outlook. This framework executes 3D models as activity contribution as well as provisions a user interface that permits even nontechnical user to take an advantage from AR.

Pryss et al. (2016) developed a kernel that allows spot rationale mobile AR applications in the AREA (Augmented Reality Engine Application) concentrates on performance and robustness. Demonstrated its value regards to different applications, running on windows phone, iOS, or Android. The new part takes into account dealing with point of interests (POI) groups of tracks, new ideas introduced shows the appropriateness apply it with regards to different mobile applications. AREAv2 utilizes a particular design that backings mobile applications engineers. Additionally demonstrated that business applications can be executed utilizing AREAv2. Execution tests that assess important pointers of AREAv2 methodically. Appropriate ideas are required towards the pattern of mobile executioner applications.

El-firjani and Maatuk (2016) build up an intuitive catalog that utilizations AR to give full item description to users. The AR as an interactive catalog application created utilizing Unity 3D. JDK, Android SDK and Unity Extension 3.0.9 were introduces on a PC with a specific end goal to manufacture an APK document. At the point when Interactive Catalog begins and comes once again the focused on the part, if the picture marker exists on the portable screen, at that point, it shows the objective video on the screen from target assets. Corel Photo Impact and Video studio 12 where utilized. The primary impediment of the created application is that it works just on Android mobile phones. More highlights could be added to the application, e.g., different dialects and greater adaptability. It is conceivable to make the application more intuitive by including a 3D module and intelligent catch that can work well ordered. The analyst who is keen on wandering into the future takes a shot at this task should give clients the capacity to make an examination between various brands of items and to have the capacity to download the inventory for future references.

Capece, Agatiello and Erra(2016) developed client-server applications that utilization Augmented Reality (AR) to conceptualize geo location information. It shows geo-information that enable users to comprehend and react viably to the setting in which the

application is sent. Given a versatile and adaptable engineering for the improvement and administration of the user, the server and the information that is utilize by the applications. The objective is to envision these layers through virtual items overlaid onto the genuine condition. Each layer relates to a data set called a Point of Interest (POI), which must incorporate data around 2D/3D items to be show as content, 3D models, surface, pictures, bulletins, and so forth.

Khan and Khusro (2015) compared relative investigation of the augmented reality browsers that helped analysts and engineering researchers to distinguish the most important AR program for particular applications like question following, content overlaying and guaranteeing authenticity up to a major extent. Outdoor and indoor authenticity has accomplished an improved path either by utilizing Maker or Marker-less methodologies. Purpose of intrigue goes about as a holder for holding AR as content, pictures, sound, video and 3D models. Subsequently found out Argon AR browser is leading an edge over others because of existing web technologies such as JavaScript, HTML5, and CSS3. This investigation points out rules to cutting-edge advanced, consistent and AR browsers.

Agarwal et al. (2014) explored AR based application utilized SLARToolkit for Windows Phone and Silverlight library to make constant AR applications. It utilized basic squared markers for AR applications. The markers are design pictures with .pat expansion. Made the UI application utilized code behind the XAML in C#. Basic viewfinder and two radio buttons called content and picture, the Text catch overlaid the content. Marker and Image catch overlaid a picture over the marker. SLARToolkit' smarker detector identifies strategy at that point takes contribution from this cushion and this data is utilized to change the UIElement. Point of view in 3D. A client can switch between the picture and content whichever he/she needs to be shown. A versatile stage actualized portrayed highlights and joint effort amongst versatile and increased the truth is being illustrated.

Cubillo et al. (2014) displayed a learning situation in light of AR, which utilizes both by instructors to create quality AR instructive assets and by students to secure information in an area. They consider endeavors to ease these issues by giving a simple to-utilize authority apparatus for educators called Augmented Reality Learning Environment (ARLE), taking into account a simple making of learning encounters containing AR items, questionnaires, and descriptions. ARLE, the aim is to advance a device that encourages

educator in creating training encounters with AR, because of the way that the current composing devices utilized as a part of instruction are particular to a specific territory and restricted to showing virtual content.

Patkar, Singh and Birje (2013) proposed AR application on Android, well matched with the current and new version of OS. The idea is to empower the client to see the virtual object in actuality using a marker-based AR structure. The client could give photos of the inquiry, top, base, back, front and right side object preview. After can be set onto a 3D strong shape block that will make up the aggregate virtual object. The user uses the preview as the virtual object in 3D view from all angles. AR in scene runs in real-time in other to give users the chance to move it within the space to bring out the exact rendered augmented image. All the angles of view can to collect directly from vendor websites and modeled in 3D objects and augmented, Pictures of articles from different perspectives can be brought straightforwardly from merchant's sites; same could be displayed into 3D questions and enlarged. Additionally, numerous items will be enlarged which is as of now a major test.

Emmanouilidis, Koutsiamanis and Tasidou (2013) surveyed and examination of the mobile guides' writing. The exploration concentrated particularly on various parts of the mobile applications space unpredictability. Contextualized by considering the distinctive functionalities offered by such mobile applications. Ostensibly, impressive potential for setting the user well inside the mobile direction experienced. Future more extensive selection of mobile guides largely relies upon the level to which mass-personalization and the social idea of people when playing out a visit are exploited by additionally look into, and additionally business advancement endeavors. Offers a scientific categorization of mobile guides considering different criteria.

Hahn (2012) purposed AR application utilized of graphical overlays to compose racks for library stock control, imagined the utilization of graphical overlays for helping the user in a continuous dynamic and responsive research help while in the library book stacks. An alternative is for libraries to try different things with building up the AR application in-house, applying their information resources get to skill to this developing trend. Library Professionals May decide to inside create administrations like the OCR suggestion benefits that specialists; this includes setting up improvement situations for support research.

Santana-Mancilla et al. (2012) portrayed the development of AR application with a service oriented architecture and an ease of use test was done on AR framework. AR technology can emphatically bolster Mexico secondary education. Ease of use assessment that the secondary school students generally welcomed our instructive AR framework. Students in center school can get to smartphones, this leads smartphones to keep dropping. Utilization of smartphones step stage to convey AR applications in the area of education is satisfactory, utilization of a service oriented architecture and AR guarantees conveyance of avant-garde of students at all level of educationa.

Table 2.1: Summary of related research papers

Authors Names	Type of Technology	Features
EL-firjani and Maatuk (2016)	AR Mobile application (Android)	Interactive catalogue, web server
Gangurde et al. (2016)	AR, Marker based technology, desktop system	Web camera, video and audio, ART Toolkit, C#
Pryss et al. (2016)	AR Mobile application (iOS, Android, and Windows)	AREAv2, Kernel algorithms
Capece, Agatiello and Erra (2016)	PC and Mobile app	RFID, Json
Cianciarulo (2015)	AR mobile app, Aurasma	Visual interpretation, video/interviews
Khan and Khusro (2015)	Mobile application	
Wojciechowskiet al. (2014)	Web application	X-VRML,
Jang et al. (2014)	AR mobile app	Vuforia and OpenGLS, cloud server, cross platform
Turan and Keser (2014)	AR mobile app	Visual and audio information in 2 languages, image upload and comment,
Agarwal et al. (2014)	Mobile application	ARToolkit, C#
Cubillo et al. (2014)	Mobile learning	ARLE
Emmanouilidis, Koutsiamanis and Tasidou (2013)	Computer application	Content design, X-VRML
Amato et al. (2013)	Internet of things	media content server, Wireless Sensor Network, using Bluetooth technology
Jankaweekool and Uiphanit (2013)	Mobile application	
Patkar, Singh and Birje (2013)	Mobile application (Android)	cloud server
Santana-Mancillaa et al. (2012)	Mobile application	
Ghiani et al. (2009)	Mobile application	RFID reader
Damala et al. (2008)	Ultra-Mobile PC (UMPC) Samsung Q1 running on Windows XP	ARToolkit
Bruns, Brombach and Bimber (2008)	AR Mobile application	RFID reader, cloud server
This Thesis	Android application	Vuforia SDK, Video, Audio, lightning, share, C#, Cloud server, Cross platform, Open Doors/Bonnet/, Zoom in/ out

2.3 Summary

There is a missing gap in the literature particularly in the area of car museum; some many of the relative literature found in the study are relate to museum but not car museum while others are of different type of mobile application used in the museum. There is no much --- study or research based on the car museum. This show that by developing MAR application for NEU car museum it is importance and also relevant particularly for those who want to make research or study on this section of MAR application use in the car museum can be executed efficiently and conveniently.

CHAPTER 3

THEORITICAL FRAMEWORK

This chapter presents the theoretical framework to be used for this study, thereby explaining augmented reality, introduction to its application, brief history of AR, AR usage and advantages of AR as the selected framework. Mobile application development, types of mobile application, smartphone, usage in the world and its advantages

3.1 Augmented Reality

The technology started in 1962 when a photographer created a sensorama (a simulator with sense of virtual sound, vibration and smell). The first AR application was a head up display in a spider jet, where symbols are projected into a transparent glass screen which takes away the distraction of looking at gauges and allows the pilot to aim their weapon better. It might be GPS speed and separation to the objective, gyroscope, compass, and found the need for cinema interaction between environment and a human (Daponte et al., 2014).

The AR is a term for true condition whose components are enlarged by PC information generation, position and orientations of user or target are necessary to superimpose objects by image either recognition or geo localization techniques. Digital content, like pictures, video, content, sound, and so forth, are inlay in AR onto physical areas or objects, and it is commonly experienced by looking through the camera focal point of an electronic gadget, for example, a mobile phone, tablet, or optical head-mounted show e.g. Microsoft HoloLens.

The AR is characterizing as a procedure that permits interaction with virtual object display as a graphics onto the user view. Between the real environment and virtual environment there is augmented reality and virtual augmented gave birth to mixed reality. In Figure 3.1 below demonstrates the Milgrams continuum (Milgram & Kishino, 1994).

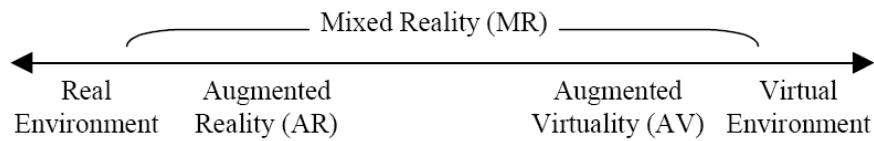


Figure 3.1 Milgrams continuum (Milgram and Kishino, 1994)

Augmented Reality utilizes diverse ideas and different methods for enhancing our daily activities. Bring about, an idea of advancing people view surroundings site in real to be utilized everywhere. An application was add to upgrade it. Positive territories where AR may get larger attention in area activities such as gaming, commerce, education, military, medicine, healthcare, traveling and shopping. AR appears in BMW as the first pioneer using head up, it display information such as speed and navigation project on the console of dash board onto the glass where only driver can see it.

Objectives of Augmented Reality: To enhance imagination of youths, to coordinate it into day by day lives to help the majority, so as to accomplish and attained that are constrained in the real world environment, challenge the unthinkable and to make a virtual object more entertaining for client experience.

3.1.1 Types of Augmented Reality

Basically, AR application are of two (2) types the marker based that make use of the camera and visible indication to serves as a target, while marker less deals mobiles global positioning system and compass from the positioning information.

Marker based: AR markers are pictures that can be recognize by a camera and utilized programming in the area such as virtual resources set in a scene. High contrast mostly, however, colors can be utilizes as long as a camera can appropriately perceive the complexity between them. Basic expanded reality markers can comprise of at least one essential shape of dark squares on top of a white background. Markers that are intricate can be made utilizing directly pictures that are still perused legitimately by a camera and these codes can even appear as tattoos.

AR programming using a camera to recognize AR markers in all area for virtual objects. An outcome is then displayed as picture to be seen, even live as reality, on a screen and computerized resources is set on the scene in the area of the markers. Impediments of this

kinds of expanded markers reality that can be use depending on the product that remember. While they have to remain genuinely straightforward for correction of error, they can incorporate an extensive variety of various pictures. The least difficult sorts of expanded reality markers are highly contrasting pictures that comprise of two-dimensional (2D) standardized identifications.

Marker less: Another type of AR is the marker-less AR the picture is assembling through the web and showed in a particular area e.g. can be accumulated utilizing global positioning system. The application does not make use of marker to show the substance. Very Intuitive than marker-based augmentation. The difference from a customer point of view is that the surface the question is etched on does not need to have that.

3.1.2 Importance of Augmented Reality

The AR applications are important in many different areas among which are Tracking, Mix, and Recognition. In acknowledgment any picture, protest, confront, a body or space is perceived on which virtual question will be superimposed. Tracking real time localization in space of the object face, image, space or a body is perform lastly, media as content, 2D, 3D, video, and so forth are superimposed over it.

With the AR technology rapid development it potentials is endless, it is a medium of marketing it a way to drive people to advertise their product or retained engagement. Many brand has adopted this new marketing strategy e.g. IKEA (2013) catalog came up with AR designed to recognize various pages in catalog and overlay 3D furniture instead of seeing the videos you actually look at the catalog with camera in the apps and virtualizes the object or picture in the page and show you exactly how it works. Operational manual and internal structure are superimposed on a machine procedure of maintenance in 3D animation. Quiver 3D coloring app that brings AR experience to coloring book, educational app of CosmoCaixa for viewing an animated 3D model of a triceratops with photo realistic quality and superimposing anatomical information giving surgeons and doctors a chance to look at a holographic perspective of patients inside life structures that is reproduced from CT/MRI etc.

Marker-based AR Systems utilizes physical-world images as a kind of perspective point for PC graphics to be overlay. In this framework camera, consistently target the object snapshots and process the picture to gauge the position, angle, and variation of the

representation shown as for the object target. For instance, a 2-dimensional printed marker is put before a webcam. The PC at that point translates this image to overlay an on-screen realistic as though it were specifically over the marker in the physical world. Lighting and center related issues restrain the execution of AR services by using this framework.

With AR technology rapid development its potentials are endless, it is a medium of marketing it a way to drive people to advertise their product or retained engagement. Earlier research recommends that the user friendly of mobile applications is especially critical for compelling users encounters (Adipat et al., 2011). Building up mobile application usability is problematic in light of the fact that smart phones have moderately little screens and the info components are small in respect to customary PC keyboards (Chen et al., 2010).

Harrison, Flood and Duce(2013)directed a little survey of mobile usefulness models and played out a writing research to assemble a gathering of studies that assess the portable application and after that assessed the studies utilizing model. People at the Center for Mobile Application Development (PACMAD). The writing survey has likewise uncovered various novel association strategies that are been investigated at present, for example, weight-based info and spatial awareness. These procedures are in their early stages yet with time and more research, it may long run be received.

Wedyan et al. (2016) developed an AR application Joguide that finds and bring out information to the user the about certain environment sites the application is to assist a user in urban territories or tourism. Displaying information about settings when pointing the at image target it will exact outcomes about the scenes and areas. Giving the choice of sparing they went to sites (triptracker) this choice will require sparing information in a land nearby database, giving a vocal direction choice to a user with incapacities, creating forms of the application that chips away at an alternate stage (IOS for Windows Phone, iPhones).

Khan et al. (2015) overviewed on AR application, frameworks, and patterns, a survey on stages, perusing and improvement situations for investigation of increased spaces on a mobile phone. Illuminate specialists, modern researchers, who want to construct answers for this present reality issue in the zone of versatile based AR. Inescapable registering is effortlessly change to increase processing, as AR has the maximum capacity of catching, controlling, design coordinating of sensors and associated gadgets. Advancement of

increased AR frameworks on a mobile phone needs change in right now accessible equipment gadgets and sensors sponsored by monetary power utilization designs for serving productively in whole vitality expending applications. The eventual fate of cell phone will fill in as a visual figuring gadget that will mean to release each part of intelligence on mobile phone tending to normal and particular needs of the broadened clients.

3.1.3 Usage of Augmented Reality

The AR use variety of methods, so many avenues to make every day interesting. Therefore, the idea, concept of making individual view of their real surroundings may be utilize anytime. Application was add to enhance it. The most suitable areas where AR may get large attraction particularly in market and other departments such as entertainment, gaming, commerce, education, military, medicine, healthcare, traveling and shopping etc.

Increased reality utilizes diverse ideas and different methods for advancing our day-to-day routine. Consequently, the idea of upgrading individuals' perspective of real surroundings might be utilized all over. Keeping in mind the end goal to change recognition AR utilize PC graphic and computerize stuff. Particular will demonstrate the real world sphere of individuals' life. Additionally, add an application that created to improve it. Most ideal regions where AR may get larger market part are gaming, business, and education.

Development company Niantic game, like Pokemon go and Ingress. The two games attempt to commit players to see the real world to get the game at point. Along these lines, the inverse to a different game that might be played at home.

Another company by the name LyteShot, and additionally Niantic, attempt to exchange game grounds from a computerized in-gadget world in the real surrounding. Rather than controlling the virtual character, players take the majority of game activities on themselves. By moving, watching, stowing away and utilizing extraordinary instruments they play win or lose. For this situation term action game turns out to be real activity, not simply dynamic tapping on a catch.

Muchtar (2017) present AR for finding the Potential resources like, offices, individuals, groups, associations, traditions that influence the attributes and the lifestyle in Medan. Along these lines, the AR innovation show information to the user with more intuitive

features and more intelligent and effortlessly comprehended by the client. This innovation will be executed in versatile applications utilizing global positioning system (GPS) based following and characterize the arrange of client's cell phone as a marker so it can help individuals progressively and effortlessly discover the area of potential resources in the closest zone in light of the heading of client's view on camera. Usage of enlarged reality innovation can help individuals effectively locate the potential resources in their closest zone in Medan. This application can give the client point by point data about the potential resources, for example, its address or bearing, progressively and all the more genuine as indicated by its real position in light of client's view on camera.

Hazidar and Sulaiman (2014) developed an AR on visual method as a medium to present the cardiac anatomy human. Explained how Cardiac Learning Recognition is create to verification of idea of AR in medical student and take in the life structures of the human body, particularly heart viewpoint. An Android platform can turn into an imaginative approach that could point a bit by bit increment social intellectual aptitudes of mentally unbalanced subjects. An android smartphones can increment enormous potential users essentially because of the part of a smartphones in giving security to users who required it.

Zhang et al. (2012) present the development AR as structure of Campus View application and an assessment of key system segments to evaluate their utilization of mobile phone's devices. Possibility of Campus view mobile application with state of art, and preparatory reliability test, a smartphone based setting and area mindful video sharing. That gives university grounds display scenes and varieties to graduated class and potential students. Furthermore assisted an area based video recording, with ability to comprehend directions, areas, users, and mine the connection among users and areas GPS directions. Involvement with Campus View arrangements from other Chinese universities should be regarded in future.

Musliman, Rahman and Hanis (2014) integrated AR and geographic information system (GIS) that improved surrounding and recognized learning areas in a mobile domain. With 3D GIS database to envision the underground or behind solid dividers utilities. The user area, time, or physical states that improved setting and understand learning in a mobile. The created application indicates huge result in a method for which information can be dispersed and exhibited to the user. Adjacent highlights can be effectively recognized, the user can be acquired logical information continuously, information got in view of area

arranged builds user awareness about occasions in their region. In this way, it expands the level of tour guide knowledge.

Wang et al. (2014) researched on the approach with its supporting building information modeling (BIM) and AR tool that improved structural representation in building life cycle. Customary ways to deal with envision structural outline focus on static pictures or three-dimensional (3D) scale models that cause issues, for example, costly effective, an absence of involvement of stakeholder's communication and restricted reusability. Quality and steadiness of AR-supporting scenes ought to be enhanced, particularly in the area of marketing mobile. Building Architectural Visualization System (BAAVS) was acknowledged by coordinating two sorts of representation strategies.

Jadhav and Phursule (2016) developed AR application together with global positioning system (GPS) that find places on user point of view like ATM, Bank, Café, Bus Stop, Restaurant, Hotel, film Theater, etc. Using compass sensors and area sensor equipment can decide the phone angular distance and longitude and in addition a place name. This application is used in case of emergencies, discover an area of the close-by place and place details. The application enables you to set radius and it likewise underpins AR. It naturally finds your present area and plots in on a guide. Security and spam, build up the content layers of substance to show.

3.2 Augmented Reality in Museum

Chen, Chang and Huang (2014) demonstrate AR based guidance that will serve as museum guides to be utilize. The goal is to convey the new guide for the museum with natural and easy to understand associations amongst person and machine in light of PC vision strategy. The developed application uses a camera to detect movement together with printed pictures, examined shortly to parse the assigned activities of the direction framework and quickly output the image in 3D. The application shows and information about the image around 3D models of historical center artifacts and media materials to clients in real time.

3.3 Augmented Reality Software Development Kits

Generally, building up an AR application for an apprentice is exceptionally troublesome because it essentially incorporates design recognition, picture handling, object rendering, connection capacity etc. Every one of these procedures must be done out and out then just it is capable to show a virtual object in a real environment. In this way, building up an AR

application in custom can be tedious and troublesome. Be that as it may, few AR organizations, for example, Vuforia: Qualcomm, Layar, Metaio and numerous more have created AR Software Development Kit (SDK) which empower AR application to be produced viably and some SDKs don't really require any programming aptitudes. The following are a portion of the AR SDKs for reference.

For some many years back programming skill was required to develop AR app, nowadays programming skill is not required due new development tools which enable us to create an app. In 2017, So far there are eight (8) best AR SDK for AR development for Android and IOS.

- Vuforia
- EasyAR
- Wikitude
- ARToolkit
- Kudan
- Maxst
- Xzing
- NyARToolkit

Vuforia: Vuforia had been the most prominent SDK around the world. It provides AR engineers with effective and agreeable apparatuses. By utilizing PC, vision tech and gives plausibility to perceive and track target pictures. The application may extend 3D objects or Media progressively. It has a standout amongst other qualities of negligible points of markers based and has insignificant prerequisites for tracker permeability of covered targets. Plus, the dependability of unflinching and portable markers. Vuforia platform; Unity Editor, Android. IOS and UWP.

Specimen's exhibit suggested configuration design for guaranteeing a successful user encounter.

Find the penguin test demonstrates on how to utilize the Rotational Device Tracker and User Defined Targets to make an application like Pokémon Go, where a character is show in reality. Vuforia allows you to stay a character to the ground so you can really stroll around it and get nearer. Penguin test demonstrates on how to utilize Smart Terrain to make a diversion that can connect with the objects on a tabletop. Books test demonstrates

on how to utilize Cloud Recognition to check a book cover and overlay acquire information. Utilizing the Cloud Recognition can be utilize to perceive different diverse targets running from pages in magazines to names on items.

- **Component of Vuforia platforms:** Three main part of Vuforia components namely: Vufora Engine, Tool and Cloud recognition.

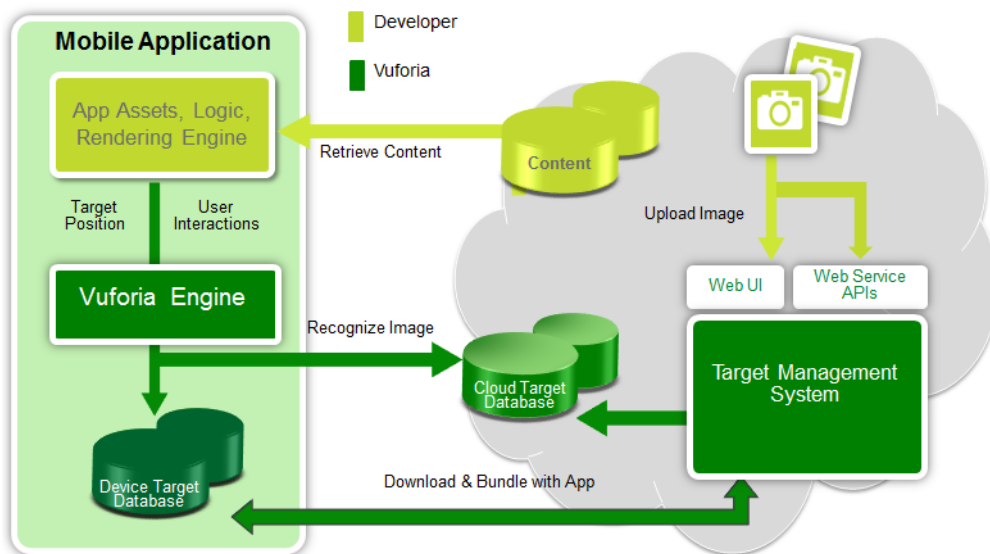


Figure 3.2: Components Vuforia platforms (Gravityjack, 2017)

The Figure 3.1 above gives a review of the development application process with the stage. The stage comprises of the Cloud Target Database, Vuforia Engine (SDK inside) and the target management system facilitated by the portal developer. A programmer uploads the input image for the target that he intended to track. The mobile app through the target resources can then be access in two ways:

- Downloaded in a device target database to be bundled with the mobile app
- Accessed from a cloud target database using web services

The text recognition, in this regards the programmer can choose a set of words that can be recognize, using the following text data sets:

- Optional word list filters (black or white lists) to explicitly include and exclude the recognition of specific words.

- Word lists in the VWL binary format (Vuforia Word List)
- Additional word lists, which can be specify via simple text files.

The word lists and filter files are bundled with the mobile app and loaded at runtime using the API.

- ***Vuforia Web Service:*** These specimens exhibit how to utilize the Vuforia Web Services API. The PHP and JAVA tests demonstrate to oversee cloud target from your own particular management system content. Generation of VuMarks and implement the Cloud Recognition Web API is demonstrating in Python.
- ***VuMark Designer:*** The VuMark Designer allows you to create your own VuMark using Adobe Illustrator. VuMarks are completely customizable and designing them is easy. First, select an encoding type based on the type of data that you want to encode, such as a URL or serial number. Next, create a custom design around a logo or image of your choice. Finally, upload your exported VuMark to the target manager and generate as many as you need.
- ***Vuforia Object Scanner:*** This enables you to scan an object with an Android phone by creating the target. Essentially introduce the application, scan an object on the Vuforia target filtering. The application gives you constant visual input on the output advance and target quality and sets up an organizational framework so you can build immersive encounters with accurately adjusted computerized content. The test mode enables you to assess the acknowledgment and the following quality of the application before you begin any improvement. Finish directions are found in the guide. The Vuforia object scanner is just upheld on the Samsung Galaxy S6 and Galaxy S7.
- ***Software Implementation usefulness of Vuforia:*** Acknowledgment of the diverse sorts of visual objects like a box, plane, and cylinder. Environment and text, VuMark like QR-code and a blend of picture. Likewise, utilizing VOS (Vuforia object scanner), filtered and make object targets. The acknowledgment procedure is executed utilizing the use of database e.g. Cloud or local. Which is easy to combine and very strong in the Unity plugin.

EasyAR: This is free and easy to utilize as another option to Vuforia substitute. It supports rendition of EasyAR image recognition as it were. Platforms support by: Mac,

Windows, IOS, Android, UWP, Unity Editor and Windows.Version2.0 will incorporate the accompanying highlights:

- Cloud recognition
- Smart glass solution
- 3D Object Recognition
- Environment perception
- App Cloud Packaging

Wikitude: Wikitude SDK made mobile platform initially to work with Wikitude AR program. Likewise, the primary SDK that gives a JavaScript API to improve AR skill. What's more, it underpins Native API for Android and IOS. It gives an extensive variety of capacities that incorporate SLAM innovation and geo location. Bolster stages. Android, iOS, Smart Glasses. Hammer answer for AR applications was discharged by Wikitude SDK 6, with the functionalities e.g. picture acknowledgment and tracking which joins first-rate picture acknowledgment and following, 3D following innovation (SLAM based), Geo information e.g. enhanced working with geo referenced information, Cloud acknowledgment e.g. permits to spare the picture database in a cloud for recognizable proof. Wikitude SDK 6 gives highlights like; the extended tracking will be improved together with the advanced camera choices options and positioning.

It offers a great chance to attempt the free trial form with full platform power and watermark. Plug-in in Unity module provide tools to make 3D objects and a database of image. However, do not allow Unity Editor to work with it, which confuses the AR improvement procedure.

ARToolKit: This is an open source for tracking library for AR.

ARToolKit Implementation Usefulness

- Fast enough for the AR application
- Optical head mounted display
- Camera calibration and optical stereo calibration
- Tracking of planar image
- Stereo-camera camera position or single camera /orientation tracking
- Plugins for Unity and OpenSceneGraph
- Free and open source software
- Tracking of Single Square.

Diverse capacities make it hard to integrate the library and sets aside greater opportunity to investigate all choices and settings. Bolstered stages: Android, iOS, Smart Glasses, Linux, Windows, and Mac OS.

Kudan: This has more speed than the majority of the frameworks since it gives a boundless number of perceived pictures. Less memory is required for its libraries; SDK may turn into a decent simple of Wikitude and Vuforia. In any case, engineers should realize that in a few parameters it is inferior compared to Vuforia and does not have a few elements of Wikitude e.g. geolocation and cloud recognition are not supported rather support cloud recognition and Android.

As indicated by surveys and productivity comparisons, it is the fundamental rival of Vuforia, which makes the development of AR easy. Utilizing the SLAM innovation Kudan permits to perceive the straightforward pictures and 3D objects and gives way to generate the database in the Unity Editor. Detriments of Kudan; Crash Editor e.g. here and there it is the fundamental reason of applications slamming on a gadget, trouble in test permit key establishment is that not every time takes up the key.

Maxst: This offers two unique tools for environments recognition and image. The database generation is online by means of manager tracking. 3D scan objects are utilized applications for Android and IOS. It only works with 32-bit version in Unity Editor Maxst. Bolstered stages: Android, iOS, Windows, Mac OS.

Xzing: In this SDK, application AR base allow three items to work with like, augmented vision, augmented face and magic face. One perceives and tracks faces with Unity, while another one perceives and tracks planar pictures with Unity while the last one is face to substitution and makeup apps. It also permits the rearrangement of straightforward pictures and highly contrasting markers. Upheld; PC, Android, iOS, Windows, and WebGL.

NyARToolKit: NyARToolkit AR library that in light of ARToolkir, as of now utilized just for distinguishing proof and image tracking. Streamlined rendition of ARToolkit and utilization a similar web instrument for a database generation as ARToolkit. Easy to coordinate with the library, however, there is no access to English version. Bolstered stages: Android and iOS.

3.3.1 Comparison of AR SDK

The Table 3.1 above compare all the eight (8) top most popular AR SDKs and summarizes based on: Maximum distance capturing/ holding marker (m), Recognition stability of immovable marker, Recognition stability of movable marker, Minimum angle recognition, Minimum visibility for recognition overlapped marker, Geo-Location, 3D Recognition, Cloud Recognition, SLAM and 2D Recognition. At the end Vuforia SDK stand out to be the most popular and best among the SDKs with overall total rating of 7.1 when developing AR application.

Table 3.1: Feature comparison of SDK (Thinkmobile, 2017)

	Vuforia	EasyAR	Wikitude	ARToolKit	Kudan	MaxST	Xzing	NyARToolkit
Maximum distance capturing/ holding marker (m)	1.2 / 3.7	0.9 / 2.7	0.8 / 3	3 / 3	0.8 / 3	0.5 / 0.9	0.7 / 5	0.7 / 1
Recognition stability of immovable marker	10	7	6	8	10	7	8	5
Recognition stability of movable marker	6	3	4	6	6	2	7	3
Minimum angle recognition	30	35	40	10	30	50	35	45
Minimum visibility for recognition overlapped marker	20%	10%	30%	100%	25%	50%	10%	75%
Recognition 2D	✓	✓	✓	✓ (bordered)	✓	✓	✓	✓
Recognition 3D	✓	-	✓ (beta)	-	✓	✓	-	-
Geo-Location	-	-	✓	-	-	-	-	-
Cloud Recognition	✓	-	✓	-	-	-	-	-
SLAM	-	-	✓	-	✓	✓	-	-
Total (rating)	7.1	4.4	7.5	2.8	6.9	5.2	4.7	3.1

3.4 Mobile Application

A mobile application is software that runs on a mobile operating system or mobile devices such as smart watches, tablet computers, and smartphones. It runs on the mobile device unlike the web application, which runs in web browsers and desktop computers. Mobile applications are developed to provide users with a kind similar service to the personal computer software. They are small software units with limited functions. It is relatively new and fast growing in Information and Communication Technology (Islam, Islam and Mazumder, 2010).

Mobile applications are planned with a thought of the requests and requirements of the device and furthermore to exploit any particular capacities they have. Gaming applications, for instance, may exploit the iPhones accelerometer. A portable application likewise might be known as an application, web application, online application, online application, iPhone application or cell phone application. Mobile applications are used many area and functions can be placed into different categories that include Business, communications, games, education, multimedia, productivity, and travel.

A mobile application is a software application designed to run on mobile devices such as smartphone or tablets computers. In other word, is a software application developed specifically for use small, wireless computing devices such as smartphones or tablets computers and this software apps can be categorized as web-based or native apps which are created specifically for a given platform.

3.4.1 Mobile Application Development

Mobile application development is the process involved in the designing and writing of codes for small and wireless computing devices. Just like any other software application development, mobile application development follow the conventional software development methods that ensure optimum performance of an application on a giving type of device or platform, the application needs to be developed natively on the target device.

3.4.2 Types of Mobile Application

The Mobile applications are in some cases arranged by whether they are online or local applications, which are made particularly for a given stage. An outsider classification, crossbreed applications, consolidates components of both local and web applications. As

the advances develop, it is normal that portable improvement endeavors will concentrate on the formation of a browser-based, gadget rationalist web applications and Figure 3.3 below show the three types of Mobile Application.

- **Native Apps**

Native applications live on the gadget and gotten to through symbols/icons on the gadget home screen. They are produce particularly for one stage and can take the full-preferred platform of all the gadget highlights like a camera and so on. If you are going to create a native application, you need much resources or highly performance criteria, most native apps uses objective C, iOS and Android. IOS use objective C and Android use JAVA. Native applications are introduced through an application store, for example, Google Play or Apple App Store

- **Mobile web Apps**

Mobile web applications are not genuine applications; they are truly sites that, from numerous points of view, closely resemble native applications, yet are not executed overall. They are controlled by a program and regularly written in HTML, CSS and Java Scripts which can be access via a browser on the device

- **Hybrid Apps**

Hybrid applications are combination of both native application and web application, when we are talking about hybrid apps; we are talking about IONIC, METEOR FRAME, and CORDOVA/PHONE GAP. They use web-based technology, which are HTML, CSS and JAVA SCRIPT. It control and render HTML directly on web view. Below show in Fig. 3.2, the three types of mobile application.

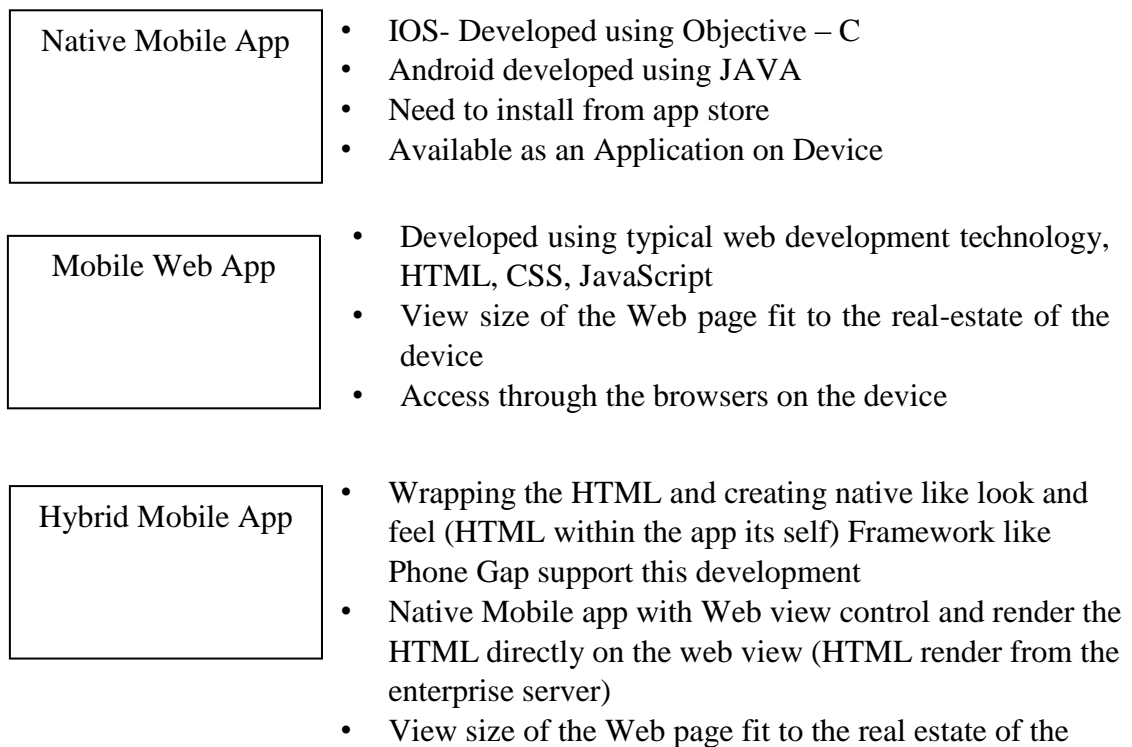


Figure 3.3: Types of Mobile Application (Leanup, 2017)

3.5 Smartphone

The International Business Machine (IBM) created the principal Smartphone in the year 1994 called the IBM Simon and later Nokia built up its initial model of a smartphone called the Nokia Communicator 9000 in the year 1996 as shown in Figure 3.2. The two gadgets were made with primarily the highlights of the smartphone and the individually advanced collaborator (PDA), both gadgets were greater, superior to its antecedent (smartphone), and were utilized as a part of overseeing user contacts and logbook.

From that point, in the year 2000 a superior smartphone with even more preparing force and highlights was discharged by Ericsson called the Ericsson R380. Later on different organizations like Apple, Palm, and Blackberry discharged some arrangement of smartphones, the iPhone shunned the equipment catches in the cell phone, and making the cell phone a full touch screen gadget, which is day, and day utilized something like date as a format for generally smartphones.

Prior to the creation of smartphones, phones were for the most part utilized for making simply call, with the smartphones you can execute tones of highlights running from web

perusing, social media, live refresh news, music play, recordings, observe live transmission and parcels more. Smartphones offer parts more than its antecedent (mobile phone), they resemble little PCs that can be fit in your pockets. These days' smartphones accompany touchscreen that traded the typical catch utilized for controlling the smartphone by signals and taps, and they likewise accompany an extensive memory and a higher handling power that can run heaps of projects at the same time. Smartphones conveys a portion of the underneath functionalities:

- Taking photos, videos and audio files.
- Playing music and sharing media files.
- Playing built in games or downloaded games.
- Accessing of the internet and browsing the web.
- Playing music and sharing media files.
- Making video calls.
- Making voice calls.

By and by, smartphones come in various models however; we will take a gander at the significant makers, for example, Samsung, Apple, HTC, Nokia, LG, Motorola, RIM, Palms et cetera.

3.5.1 Operating system of mobile device

In any case, these diverse models of smartphones all work utilizing distinctive smartphone working framework, OS is the basic program that runs everything on the smartphone simply like your PC. The principle major smartphone working frameworks are three:

- **Android** is the most broadly utilized working framework in smartphones today, and there are bunches of producers and models that make utilization of this working framework, the google android resembles the iPhone (iOS), you click a symbol/icon to fire up an element in the android.

The Android OS is open source, this implies you have full control over the OS by altering the center highlights that it accompanies it to your own particular taste, nonetheless, the equipment makers like Samsung, HTC, finish most customization and so on.

The makers of the telephones elude to this an interface; most producers have distinctive highlights on their gadgets, which made Android gadgets like each other yet not the same. Unique models accompany diverse predefined capacities and highlights.

- **Apple iOS** is made by the Apple organization, they run significantly on all Mac gadgets of various models, running from iPod, iPad, and iPhone, the iOS is extremely easy to utilize you dispatch an element by tapping on a symbol goes ahead the Apple.
- **Windows Phone** are outlined by Microsoft and it's like the new Windows 8 interface. Touching one of the onscreen deters differing applications and the telephone capacities.

The three recorded here may be the genuine phone working structures; in any case, they are far from the fundamental ones. You may in like manner encounter Bada, Symbian, Maemo, BlackBerry and Palm.

They all work a little extraordinarily as opposed to the android, IOS and Windows Phone systems you may go over.

3.5.2 Smartphone advantages for car museum

Smartphones today have transformed into a basic bit of our step-by-step lives because of the helpful impacts they have on people, according to a report by Caglar (2016). This device goes with different functionalities going from making calls, to messaging, informing, e dealing with a record, e-mending office, tune in to e-addresses, Google mapping, recording media reports, for instance, accounts, sound archives, making photos.

3.5.3 Smartphone usage in world

The amount of smartphone utilization worldwide is anticipated to create from 1.5 billion out of 2014 to very nearly 2.5 billion of every 2019, with the smartphone entrance rating extending moreover. Somewhat more than 36 percent of the aggregate people is foreseen to use the smartphone by 2018, up from around 10 percent in 2011 (Mark, 2016).

The country of China, the most swarmed country on the planet, drives the smartphone organizations. The amount of China potential smartphone usage is anticipated to create from very nearly 480 million of every 2013 to pretty much 690 million by 2019. About

portion of Chinese masses is foreseen to use a smartphone by 2018. This infers by 2018, a fourth of most smartphone users on the planet will arrange in China. In addition, United States is furthermore an essential market for smartphone advertising, with around 170 million smartphone customers in 2014. By 2019, a number of smartphone users in the U.S. are depended upon in add to 236 million.

Android by Google's and iOS by Apple are the most common smartphone working systems in the business. At first, seventy five percent of 2015 alone, around a billion smartphone with Android or iOS working systems were sold out to users around the globe. Around 80 percent of the arrangements was finished by Android phone, drives the business. Strangely, around 15 percent of all smartphone sold to end customers have iOS as their working structure. The principle smartphone vendors are Samsung and Apple, with around 25 percent and 15 percent of the offer separately, trailed by Huawei, Lenovo, and Xiaomi. The following is a measurement of the smartphone users around the world As shown in Figure 3.4 below(Letsnurture, 2017).

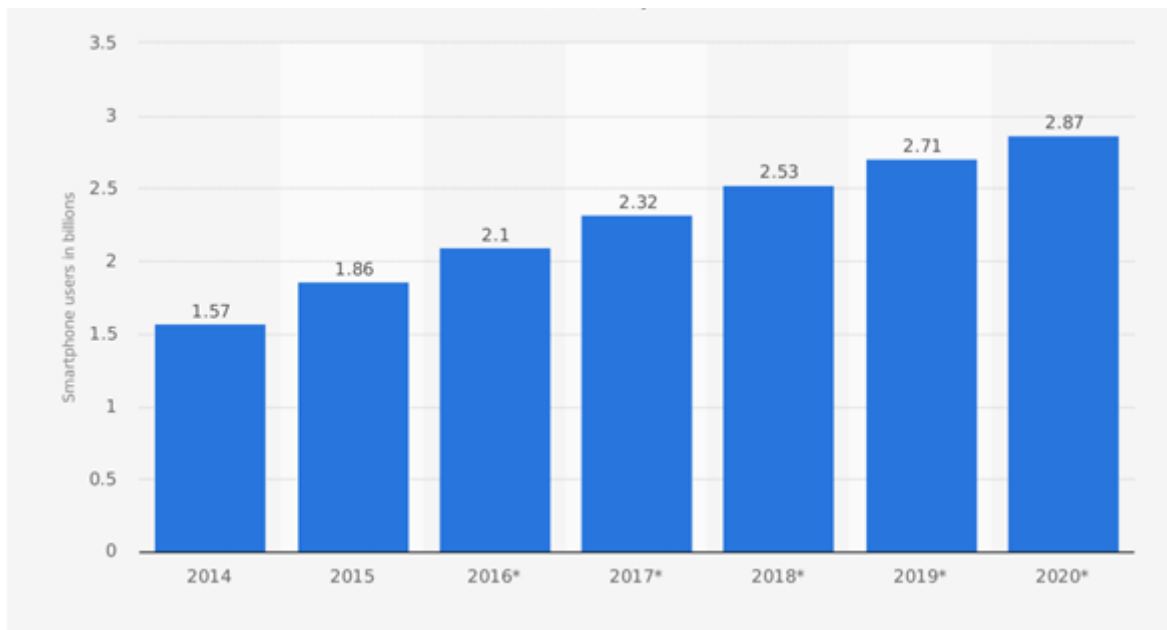


Figure 3.4: Number of smartphone users worldwide from 2014 to 2020 (in billions)

(Letsnurture, 2017)

CHAPTER 4

SYSTEM DEVELOPMENT

This chapter explains in details on the developed Mobile Augmented Reality application for Car Museum using Android Phone. System requirements of the whole study, software development cycle, Hardware, Software, system architecture, flowchart, use case diagram block diagram, and Operating system that shows design of the developed system as visual.

4.1 Software Development Cycle

The software development life cycle (SDLC) is a structure characterizing assignments performed at each progression in the software development process. It described all the processes from; analysis, design, development, testing, and maintenance up to the development of the application. It comprises of a point-by-point design portraying how to create, keep up and supplant particular programming. A waterfall model was used as a model, which has five, processes as shown in Figure 4.1.

- System Analysis
- Design
- Development
- Testing
- Maintenance

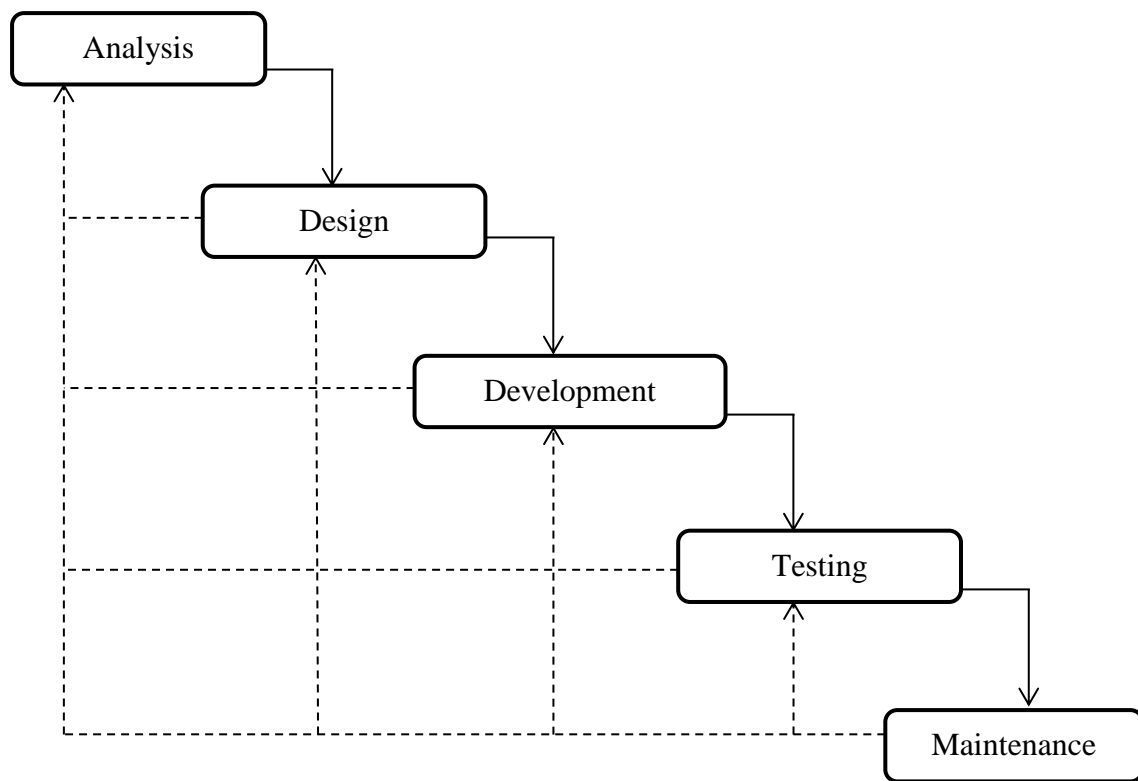


Figure 4.1: Software development life cycle using waterfall model (Bassil, 2012)

4.1.1 System analysis

The system analysis is fundamentally, what is expected of the system. This analysis can be seen to be the need and need as far as the analysis quality, the system functionalities, and features. It involves initial assessment and feasibility study on the system. The system analysis is fundamentally sorted into two gatherings, which is demonstrated below.

A-Functional requirement: This type of requirements are the requirements and needs that are expected from the system in regard to the practices and the functionalities that the system can perform, what the system should do or what is expected from the system. The function of a system or its segment is a function that described as a set of inputs, outputs, and behavior. The functional requirements of NEU-MAR application can be seen beneath:

- The user should be able to enjoy the NEU-MAR application
- The user should be able to use the NEU-MAR application conveniently
- The user should learn new experience in using NEU-MAR application

- The user should learn about information in the NEU car museum through the application
- The user can use the NEU-MAR application anywhere, and anytime to find the information about the car museum
- The user should find the NEU-MAR application as a car museum guide
- The NEU-MAR application should be user friendly
- The user should be able to recommend friends to use the NEU-MAR application
- The user should be happy when using NEU-MAR application
- The screen colors used in NEU-MAR should be pleasing to the user

B-Non-functional requirement: These types of requirements are the properties that are relied upon of a system to have. These properties are utilized to characterize the nature of the system and additionally used to judge the operation of the framework as opposed to portraying what the system ought to do and be determining the practices. The non-functional requirements put imperatives on the outline. These requirements of NEU-MAR application can be seen Table 4.1 below:

Table 4.1: Non- functional requirements and description

Requirements	Description
Security	Access is granted by installing the NEU-MAR application on user Android phone
Usability	The NEU-MAR application shall be simple with easy clicks even for non-technical users
Availability	The NEU-MAR application shall be free for to the interested potential users
Performance	The NEU-MAR application should be executed with high speed, within quickest response time and maximum efficiency
Reliability	It NEU-MAR application should be reliable in performing its functions under certain conditions over life time
Maintainability	The NEU-MAR application should allow update and modification to meet new requirements

4.1.2 Design

User requirement is a user requirement document (URD) or user document (UD) can be utilize as a manual for planning cost, timetables, testing, milestones, and so forth. The express idea of the URD enables the user to demonstrate it to different partners to ensure every single important element is described. Existing system evaluation of the designed application.

4.1.2.1 Architectural system design

The NEU-MAR application is designed using vuforia SDK that has a capacity of storing image target and support multiple targets and communicating with device databases with application on the user device. The object recognition detect image and track the 3D object in order to display it to real life, hence experiences the augmented. The developed NEU-MAR application architectural system design is described the structure below in Figure. 4.2.

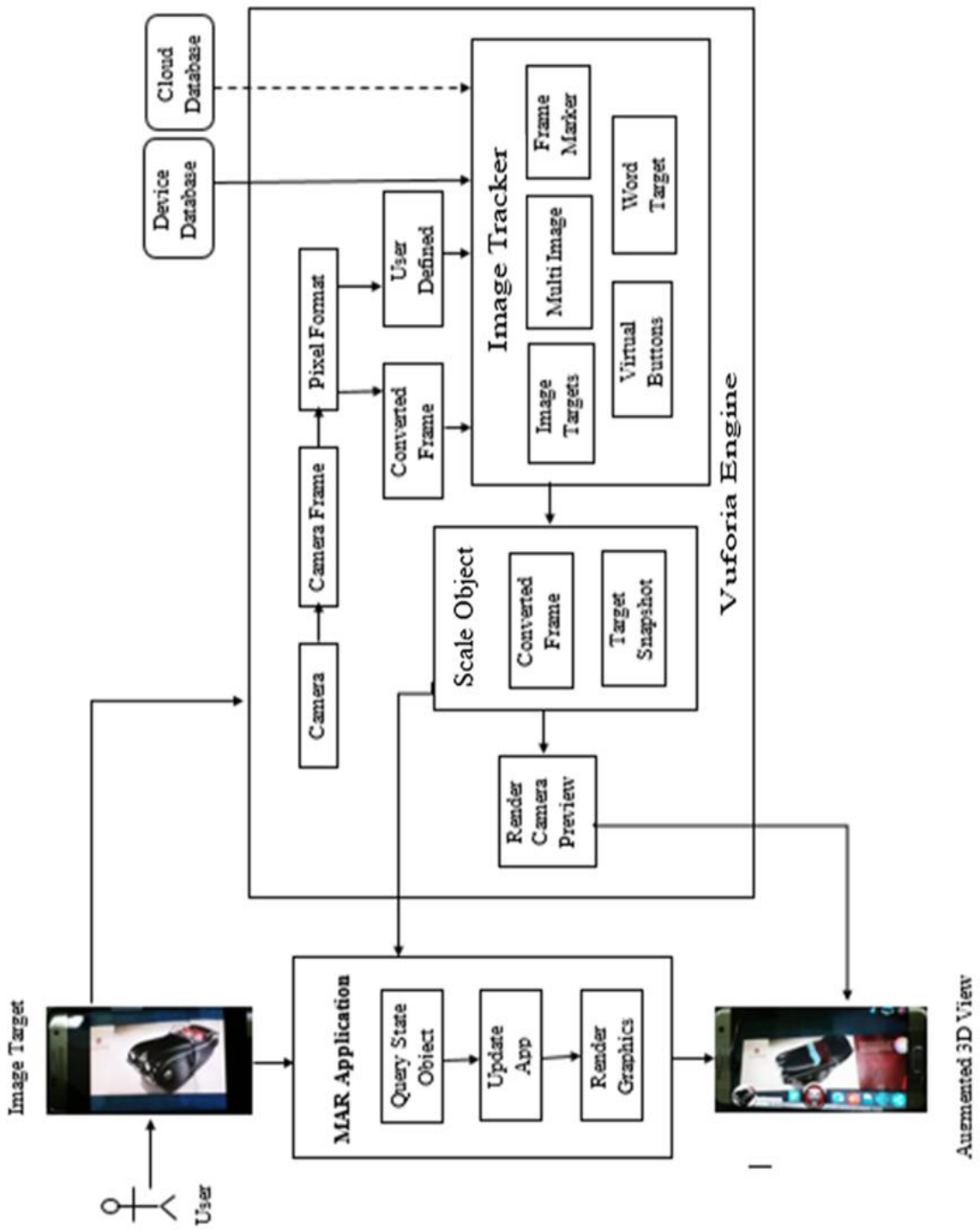


Figure 4.2: Mobile Augmented Reality System Architecture

The users open the application to detect the image target through the camera and the captures the preview frame and passes it to the image tracker. The image converter uses the pixel format converter and converts the default format of the camera to a format suitable for openGL ES rendering tracking. Tracker detects and tracks the real world objects in camera preview frame using image recognition algorithms then the results are stored in the state object which is passed to the video background renderer, render the camera image stored in object and augmented it on to the camera screen.

4.1.2.2 System Description

Mobile phone having Marker-based AR application search through the camera device for an image target, it captured the digital image on the object and software identified it and bring out the real image as an animated digital image or 3D for a better practical knowledge displayed. Recognition based AR is another name for maker based AR approach. Marker-based AR applications known about the object and recognize it. Working principle of Marker-based AR effectively demonstrates the application below in Figure 4.3.

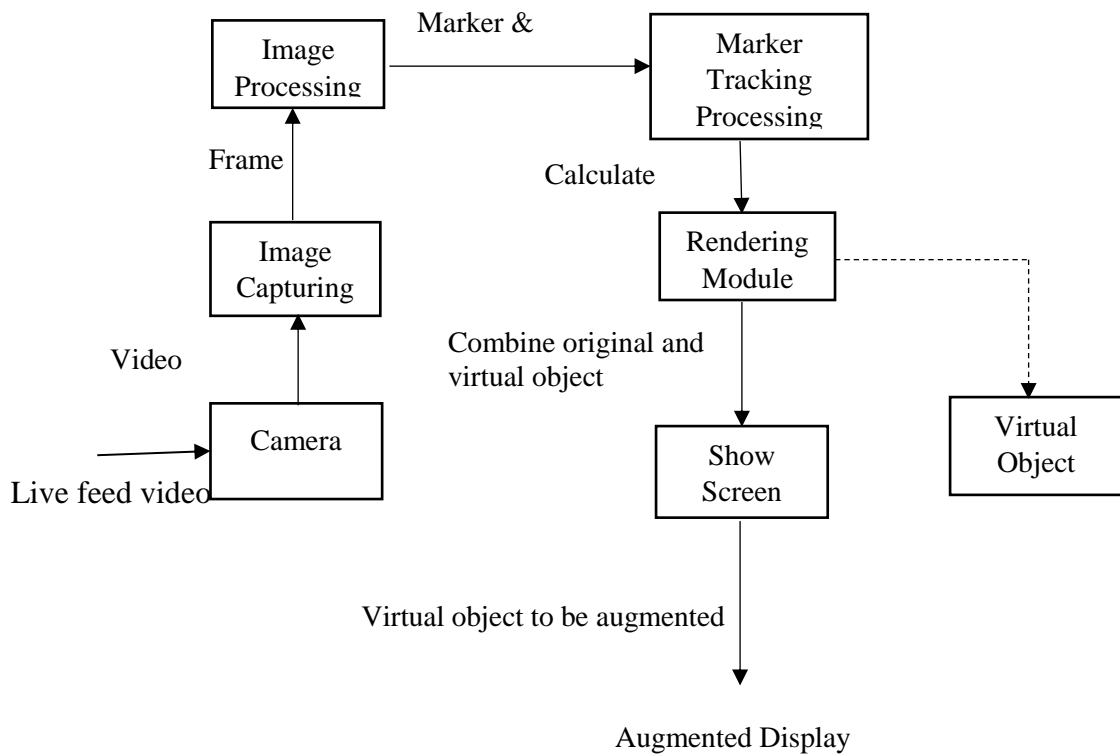


Figure 4.3: Mobile Augmented Reality Block Diagram Architecture

The developed AR Architectural block diagram above shows the following integral parts:

Camera: When camera device is open a real-world live video is nourished as an input from the Android phone camera and passes to the Camera module. Showing this live video from the Android phone camera is the truth in AR. This live video stream is given as a contribution to the Image Capturing Module.

Image Capturing Module: this described the input to the Image Capturing Module is the live video feed from the camera of a cell phone, analyzing the camera feed, by each edge in the video. It then generates and produces a binary picture e.g. an advanced picture that has just two conceivable esteem for every pixel. Ordinarily, the two colors utilized for a paired picture are highly contrasting. The Image Processing Module will be outputted as the result of binary images.

Image Processing Module: In the case of inputs to image processing module are the double pictures from image capturing module. These double pictures are prepared to utilize a picture handling strategy to recognize the AR Marker. Identification of AR Marker is basic to decide the position, where to put the virtual object. Once the AR Marker is recognized, its area is given as a contribution to the tracking module.

Marker Tracking Module: The marker tracking is the main engine or heart of the AR framework; it ascertains the relative posture of the camera continuously. The term posture implies the six degrees of flexibility (DOF) position, e.g. 3D area and a 3D object orientation. The rendering module as an input to the calculated pose.

Rendering Module: Initially is the calculate pose from the tracking module and other is the Virtual Object to be augmented. The rendering module joins the first picture and the virtual parts utilizing the computed posture and renders the expanded picture on the show screen of the Android phone.

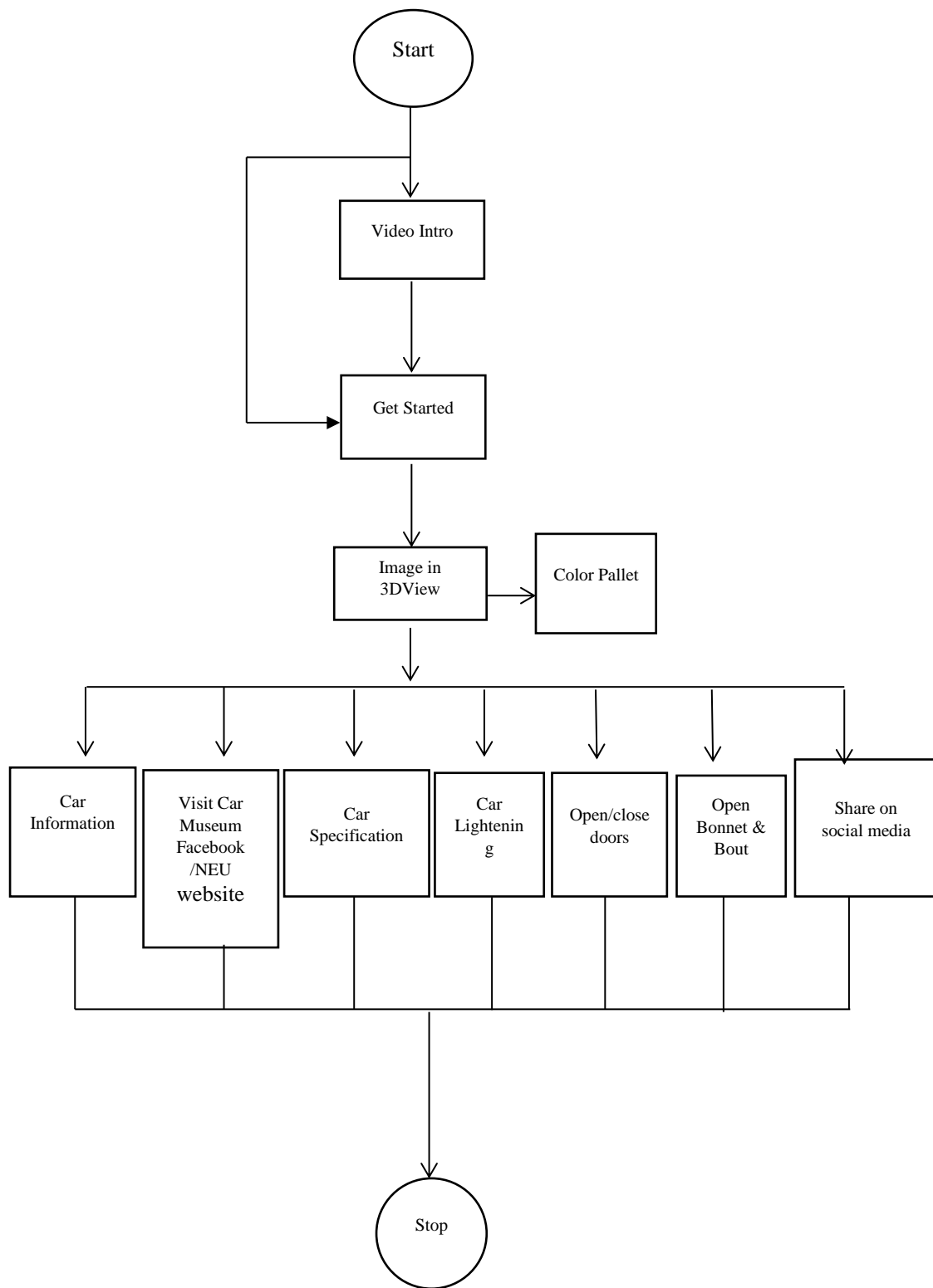


Figure 4.4: Flow chart of the developed system

4.1.2.3 Unified modeling language (UML) diagrams

UML is defined as a visual language that is utilized as the standard displaying language in object oriented software engineering (OOSE). It is a general multipurpose demonstrating language in the software engineering field, which gives a visual outline of a framework. It is utilized to make the procedure graph to be utilized as a part of recognizing, actualizing, reporting and creating different parts of a framework. Outlines are utilized to make the illustration of models simple and henceforth, help the client of the framework to additionally comprehend the functionalities, parts, and conduct of the framework more.

4.1.2.4 Use case diagram

This demonstrates a given presentation picture of the practicalities that can be performed while utilizing a specific application from the user point of view. Utilize Case Diagrams, for the most part; demonstrate the collaboration amongst user and NEU-MAR application based on the design. Each utilization case demonstrated depicts an undertaking that the user can do successfully on the application.

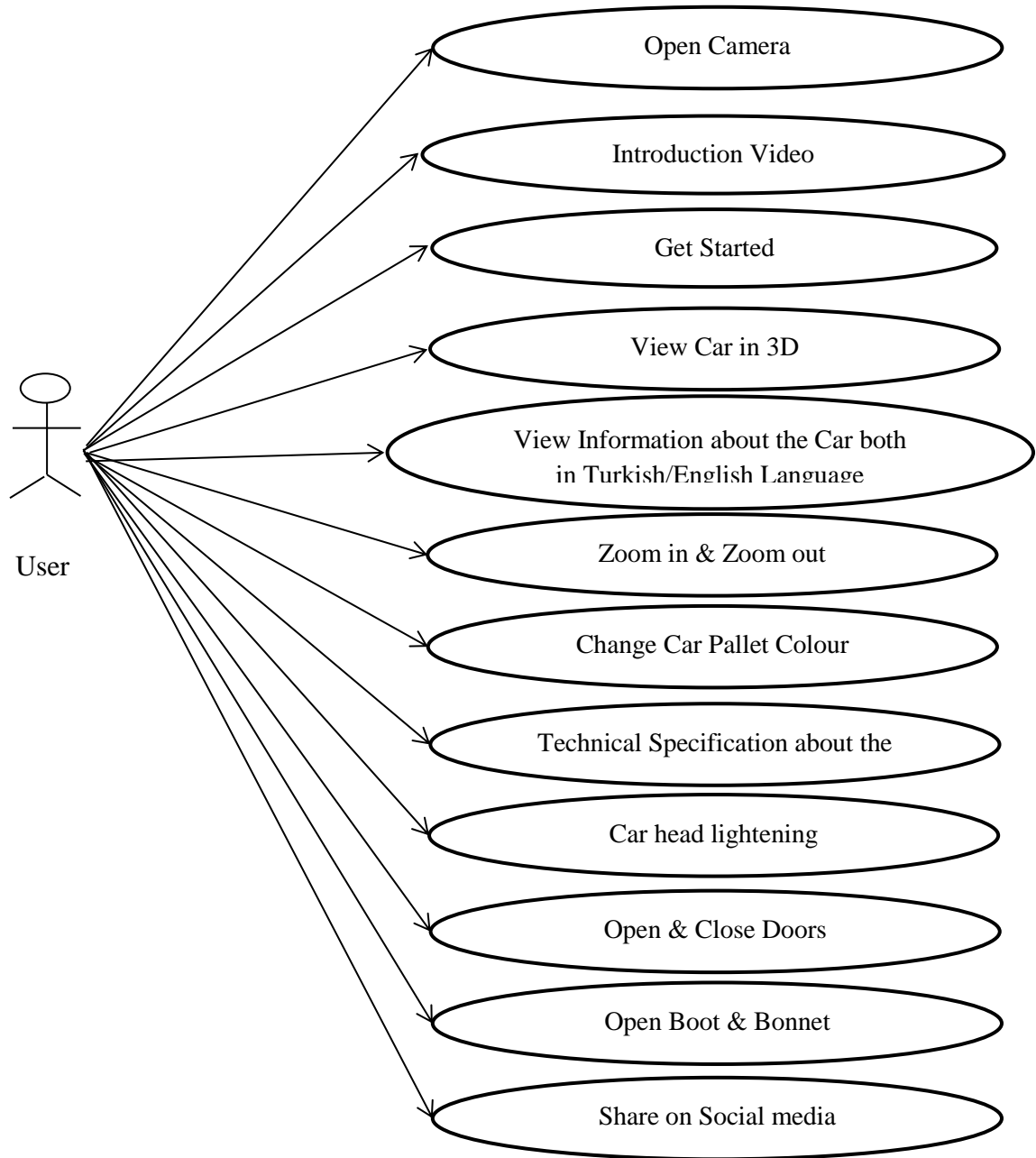


Figure 4.5: Developed application use case diagram (UCD)

The above UCD above show that the client of the developed application complete while utilizing the application. The step taken on each Use Case in the outline speaks to a one of a kind usefulness, which the client will have the capacity to execute when utilizing the application.

4.1.3 Development

After the requirements specifications then comes the design phase which involves the design of an inner structure of the whole system, the modules and classes that the system needs, and the inter-relations among all classes and modules in the system are specified. If the software structure is not well -designed, then the system will be difficult to build, test or maintain. Before starting the modeling process, the objects of the system have been identify and used the approach, which depends on the personal experience. Detailed system specification application is been implemented, the programming languages, applications and framework used

4.1.3.1 Unity3D

Unity3D is an effective cross-stage 3D engine and easy to understand in the development application. Sufficiently simple for the amateur and sufficiently intense for the master, Unity should intrigue anyone who needs to effortlessly make 3D diversions and applications for desktop, mobile, consoles, and web.

The Unity application is a totally 3D environment, appropriate for laying out levels, making menus, doing an activity, composing contents, and sorting out the project. The UI is efficient; the boards can be completely redone by dragging, and dropping. The Project Board is the place where asset within a project is kept. At the point when assets are transported in, they will initially show up here. The chain of command board is the place assets are sorted out in a scene. Resources from the Project board can be dragged into the Hierarchy board to add them to the present scene.

The Inspector board gives you a chance to investigate and alter the selected asset. Everything from its rotation and position, to whether it is influenced by gravity or ready to cast a shadow. The Scene board is a 3D viewport where you can physically orchestrate resources by moving them around in 3D space. You can explore the viewport by panning, pivoting, and zooming the view. In the event that you have utilized Maya by any stretch of

the imagination, you should discover these hotkeys well known. As shown below Figure 4.6 Unity Scene app in 3D.

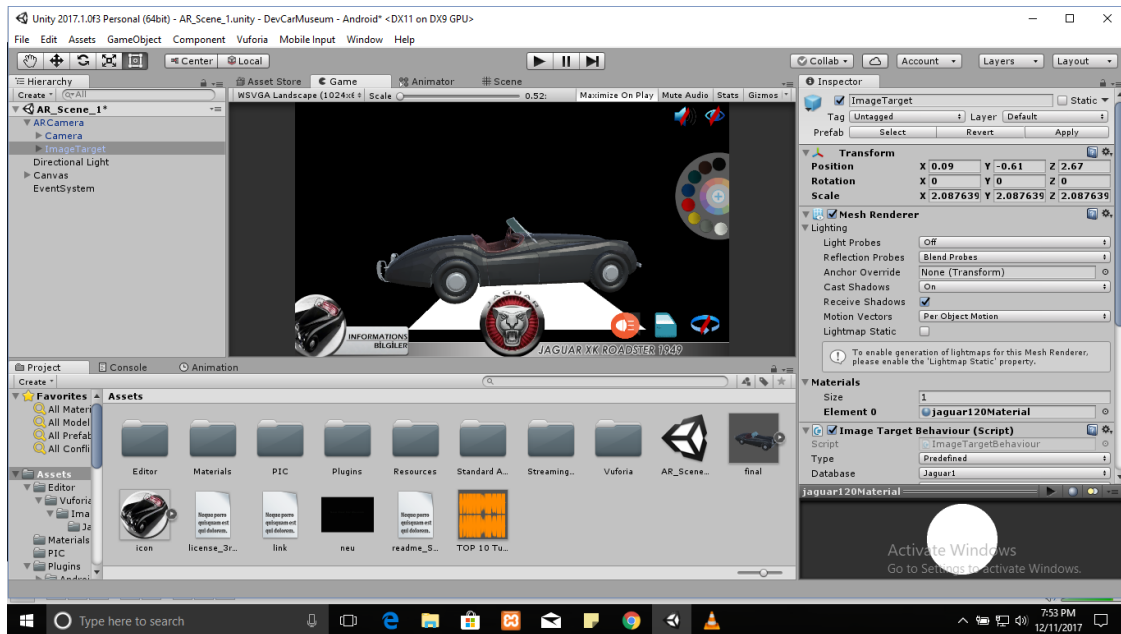


Figure 4.6: Unity scene application in 3D

The Unity application is a total 3D animation, appropriate for laying out levels, making menus, doing animation, composing contents, and sorting out projects. The UI is efficient and the boards can be completely customized by drag and dropping.

Concerning running your developed application, it is easier. Simply press the play button. Press the play catch once more to stop it; you can even interruption your model play to investigate your scene.



Figure 4.7: Unity augmented reality scene area

A Unity project is a common envelope containing each asset that has a place with your scene. Making another task is a direct issue.

- Click File > New Project
- Click the Create New Project tab
- Browse to a suitable folder
- Click Create

The outcome is an undertaking project containing subfolders named Assets, Library, and Project Settings. Resources are any asset your Unity Scene uses. These incorporate 3D models, text styles, materials, scripts, sound, and contents, to give some examples. Other than, a couple of basic objects, for example, shape and circles, Unity cannot really create most of these benefits. Rather, they should be made remotely utilizing 3D modeling applications and painting devices and after that imported into Unity.

Gratefully, Unity's advantage bringing in is strong and canny. Customarily, a 3D engine has as a rule been finicky things and are extremely specific about what records you give them, compelling developer to deliberately change over every one of their documents. Not Unity. It will acknowledge all mainstream 3D record positions including Film Box with all the gear, Blender, 3D Studio Max, and Maya, materials, and surfaces in place. Solidarity likewise underpins all normal picture record designs, including JPEG, TIFF, and PNG and

even layered PSD documents straightforwardly from Photoshop. Concerning sound, Unity underpins AIF and WAV, perfect for sound impacts, and OGG and MP3 for music.

4.1.3.2 Vuforia SDK

Lee and Choi (2014) explained that Vuforia continuous picture target are created, which encourages the user to superimpose animal model in 3D when a user clicks a photograph of any scene. With this user can put the 3D and demonstrate the object wherever they need it to be.

Vuforia is a standout amongst the most prominent stages to enable you to work with augmented reality development. Upheld stages: Unity Editor, UWP, iOS and, Android. The product executes the accompanying functionalities: recognition of the distinctive sorts of visual articles (cylinder, plane, and a box), environments recognition and text, VuMark (a blend of picture and QR-code). Additionally, utilizing Vuforia Object Scanner, you can filter and make question targets. The recognition procedure can be actualized utilizing the database (cloud storage or local). Unity plugin is easy to incorporate and intense. All functionalities and plugins of the platform are free to incorporate the Vuforia watermarks. The confinements simply identify with the quantity of VuMark and the quantity of Cloud acknowledgment.

Multi-target recognition, target following, virtual catches, Smart Terrain, and Extended Tracking are a portion of the highlights of Vuforia SDK. Vuforia underpins the identification of a few sorts of targets e.g. English content, objects, pictures. Particularly for picture acknowledgment purposes, Vuforia permits applications to utilize databases that are either neighborhood on the gadget or in the Cloud; the stage is accessible for Android, iOS, and Unity. There is likewise a form of the SDK for keen glasses (to be specific Epson MoverioBT-200, Samsung GearVR, and ODG R-6 and R-7) that is at present moving to its beta stage and is open for early access applications from qualified designers.

The following of the picture targets is dependable and utilizing the SDK turns out to be simple after a touch of research.

4.1.3.3 Unity Scripting Language (C#)

Up course, everyone has his own favorite scripting language, and the utilization of various programming languages advances after some time. Unity have support three scripting languages these are, Unity Script (otherwise called JavaScript for Unity), Boo and C#. Without a doubt Unity standout amongst the open-ended cross-platform apparatuses for creating 3D and 2D games mobile on a groups of platforms, for example, OSX, Windows Phone, Android, iPad, and iPhone. Very effective motor rendering, inventive, creative group, and guide the developer to develop this technology for 2D and 3D mobile game using different programming languages. The language inclinations, for this situation, a C# standout amongst the most satisfying, enjoyable part of Unity 3D. The C# unquestionably has more favorable environment over JavaScript or Boo (Unity3d, 2014).

(Fine, 2017) currently highlighted about Unity Script and C# and found out that they are reasonably equally coordinated as far as usefulness and execution: whatever you can do with Unity Script you can equally do with C#. Evidently, clear shows that C# is the champion concerning the developer-supporting infrastructure. In addition tooling support, such as refactoring and intelligence in Visual Studio.

At present, as indicated by unity3d editor investigation insights, the level of contents made in the three scripting languages percentages this way in Figure 4.8 below.

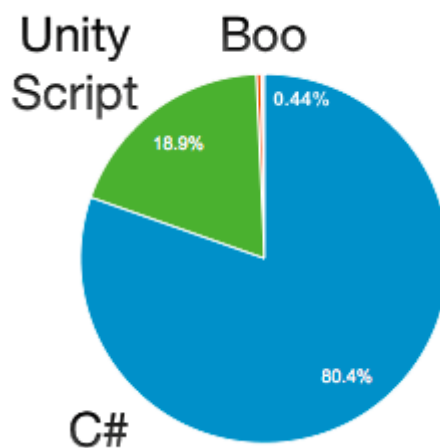


Fig 4.8: Percentages of the three Scripting languages (Blog.Unity3d, 2014)

4.1.3.4 Autodesk 3Ds max software

The software 3ds Max offer a complete motion graphics artists, rendering, particle animation, 3D modeling, and compositing solution for games, animation, and film. These days, there are numerous product bundles that make it simple for engineers and student to show and portray imaginary thought in better quality and a superior sense. It perspective matching and crowd generation tools in 3ds Max as demonstrate in Figure 4.9, Figure 4.10, Figure 4.11 and Figure 4.12 Below.

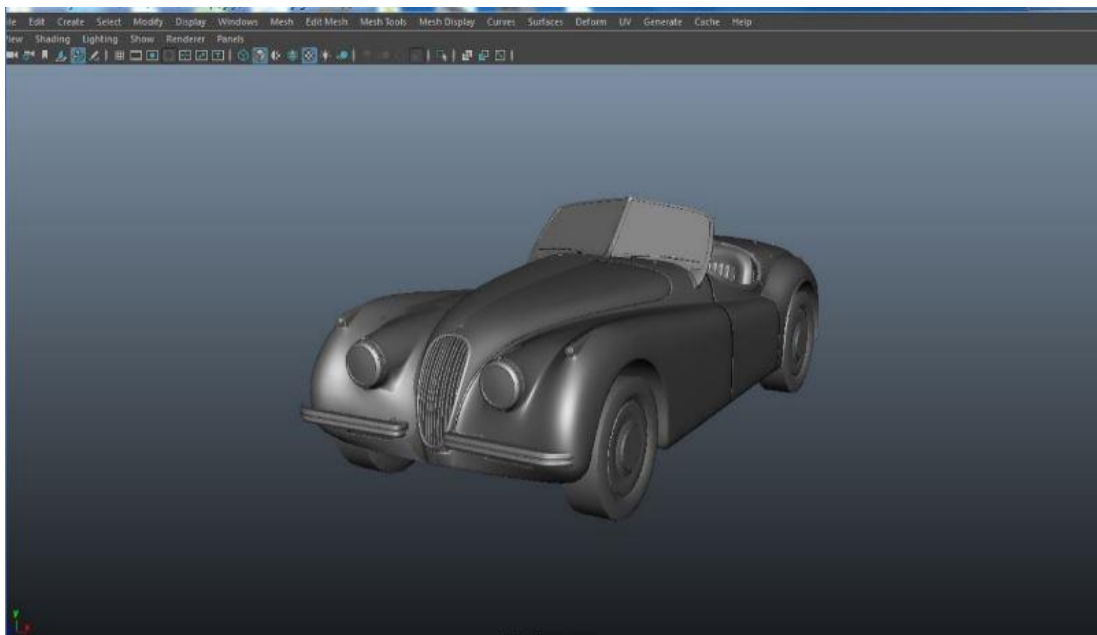


Figure 4.9: Perspective 2D view

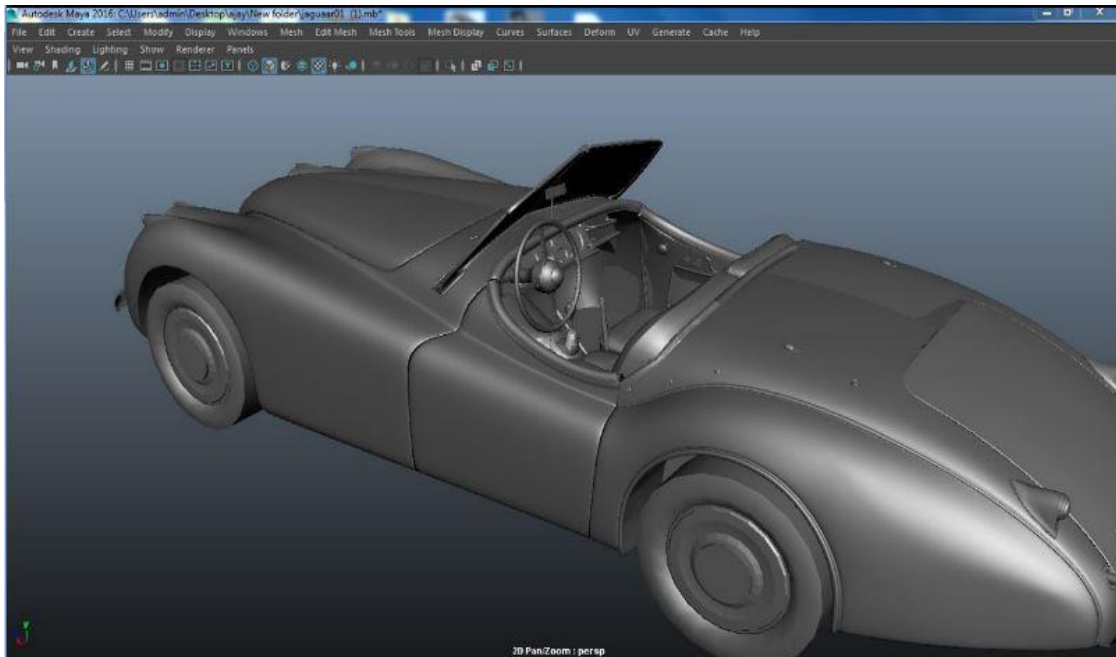


Figure 4.10: Pen zoom perspective

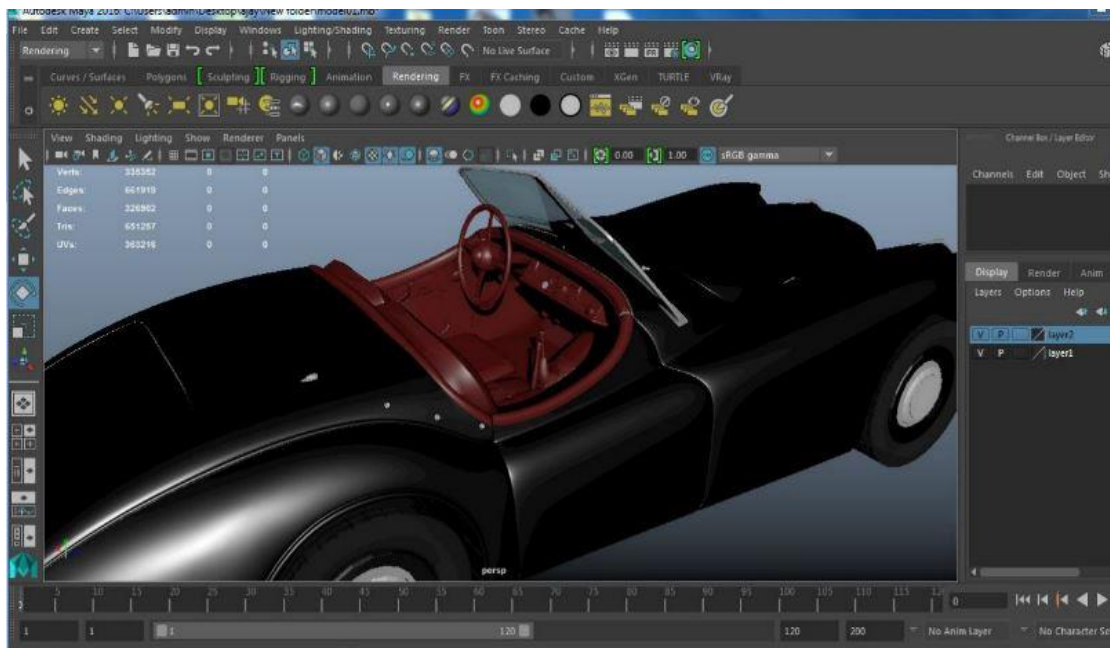


Figure 4.11: Rendering perspective view

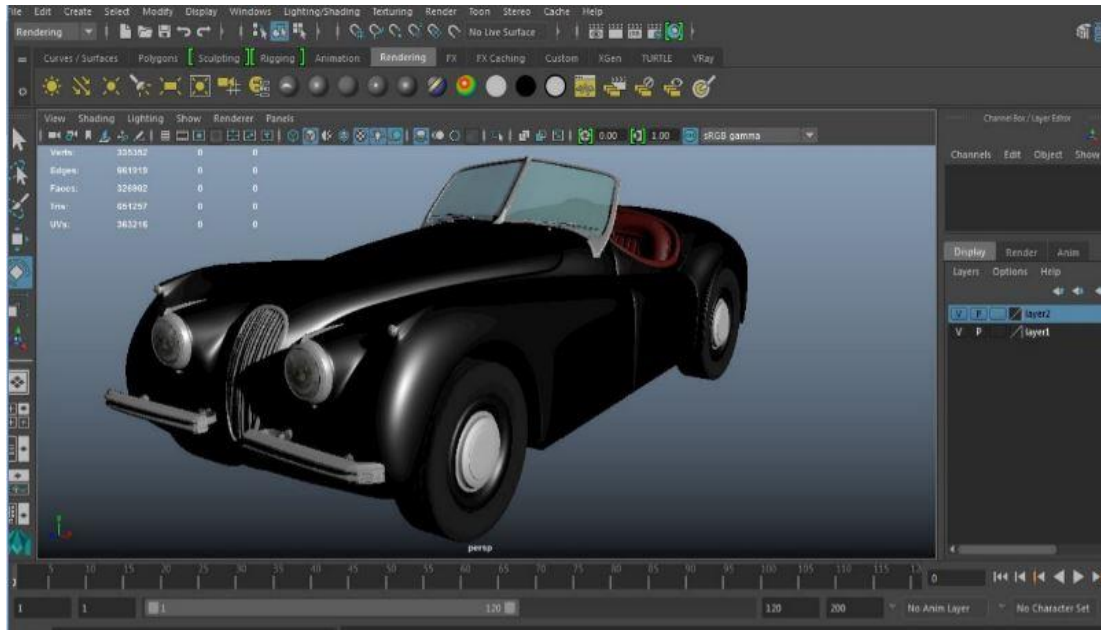


Figure 4.12: Rendering 2D view perspective

4.1.4 Testing

Testing is essentially the way toward running an application with the point of identifying error so they can be revised and to learn that the application fills in of requirements. To determine whether the application meets the predetermined practical prerequisites. Coding, testing, debugging Installation, and fine-tuning of the NEU-MAR application.

4.1.4.1 Types of testing

There are two kind of testing performing on this application to decide the accuracy and functionalities are precisely not surprisingly can be demonstrated below:

- **Unit testing:** This is the type of testing is done by segregated a unit or each piece of the application and tried to determine or demonstrate that the individual parts are working effectively. The unit testing is utilized to test the application functionality exclusively and the outcomes can be found in the experiments. In this regards, 3 random volunteer end-user are chosen to test each parts component of the developed NEU-MAR application.
- **Integration testing:** This is generally done after unit testing on an application that has just been tested are joined and the interface between them is tested. In this part

9 random volunteer were chosen in order to test both the component together with the interface of the developed NEU-MAR application.

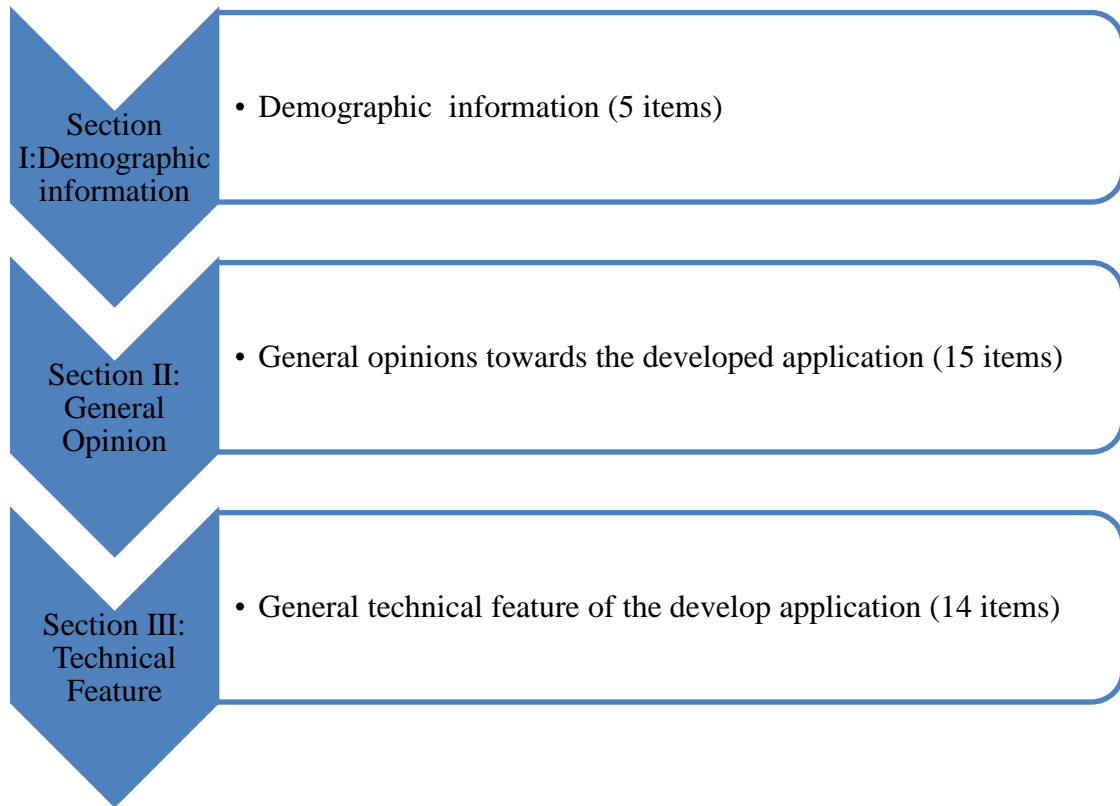


Figure 4.13: Structure of the questionnaire

4.1.5 Maintenance

This refers to as Programming support in programming designing is the adjustment of a system item after delivery to revise flaws, to enhance execution or different qualities. A typical view of support is that it only includes fixing the errors. The developed application is made with a specific end goal to improve and meet the needs of users. Both the maintenance and application development is to manage how the design is, programming codes, testing the developed system, improve the application as well as removing any error from the develop the application.

4.2 Android Operating System

Android operating system was chosen because it is free and open source. Since the appearance of 2017, more anxiety has been given on the use of free and Open Source Software (FOSS). Android is driving the current O.S and since it is open source and created by a consortium of more than 86 driving multinational corporations called Open Hand Allowance (O.H.A). Because of effectiveness and popular O.S in market share, Android additionally is displayed and expressed as one the most quickly developing advancements. So many developed applications has been modified or produced by third party client.

The Android operating system is a modern MOS that is based on the open-source Linux OS (Singh et al., 2016). The Android is designed purposely for mobile device or terminals. Google reveled android in 2017 along with a consortium of hardware, software and telecommunications companies, which are dedicated to advancing open standards for mobile devices. The Android has the biggest market share among all smartphones operating system. Android architecture is designed to make ease of development ability for developers because it has very few restriction for developers (Mohini et al., 2013).

4.2.1 Advantages of android operating system

The Android operating system has more advantages over all the mobile operating system that exists in the technology world, these advantages ranges from technological down to economical aspect. These advantages that the android mobile operating system hold demonstrated below:

- The Android OS make easy access to thousands of applications that are ready to be downloaded for free via the Google Play Store.
- The Android OS is built to be an open standard OS for smartphones and mobile devices promoted by the open hand alliance (OHA), a consortium that brings about the collaboration of different mobile hardware device manufactures like the Huawei, Samsung, HTC, Gionee and others to be powered on the android platform.
- The Android OS is a trending mobile OS now because it powers billions of mobile hardware devices mostly tablets and smartphones.

- The Android OS is built based on the kernel of the powerful Linux computer OS and it is completely open-source and free for anyone to build or develop application.
- The Android OS is the most widely used mobile OS because android hardware devices are the highest selling because they are relatively cheap and inexpensive to acquire with wide variety of phones to suit your budget.

4.3 Research Schedule

This study started in August 2017 and was completed in January 2018. Figure 4.14 gives a detailed description of the tasks and its duration during the course of the research.

Figure 4.15 shows the Gantt chart for the thesis. The researcher financed all expenses incurred during the study; hence, they have been excluded in the schedule on Figure 4.16.

4.3.1 Gantt chart

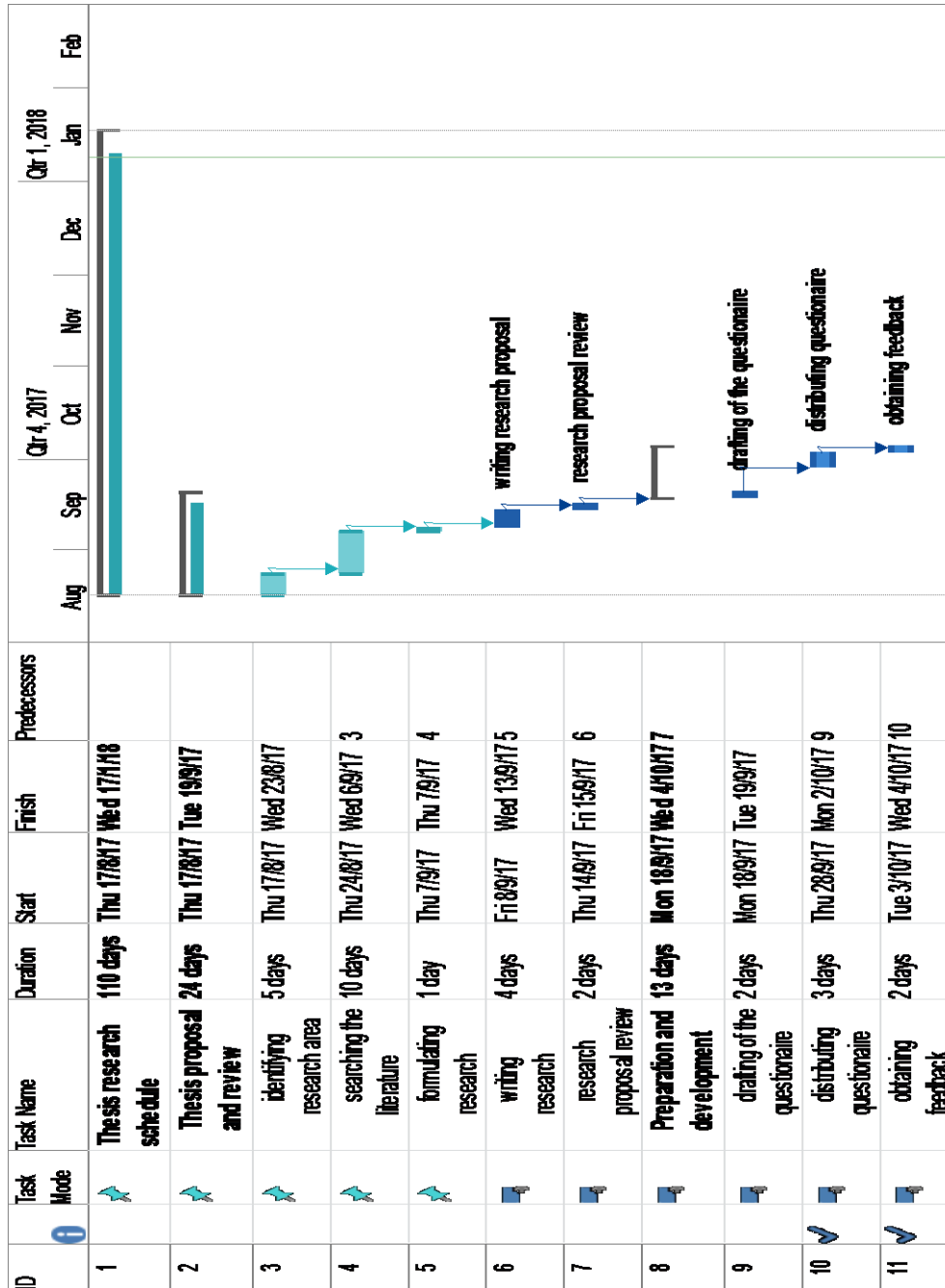
Gantt chart is a useful tool for the presentation of time information concerning plans. This can be a presentation of predictions of future timings or graphical representation of achievements and disasters (Goldratt, 1997). A Gantt chart is an example of a project structure that can be used to describe a given project. A Gantt chart is a graphical representation that shows the time dependency of several tasks of a project within a calendar. A Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project.

Gantt charts can be used for scheduling generic resources, so as well as their use in project management; they can also be used in scheduling production processes and employee fostering. In the latter context, they may also be known as time bar schedules. There are many computer applications supporting the use of Gantt charts for employee scheduling. “Gantt charts can be used to track shifts or tasks and also vacations or other types of out-of-office time.”(Wiki, July 2014).

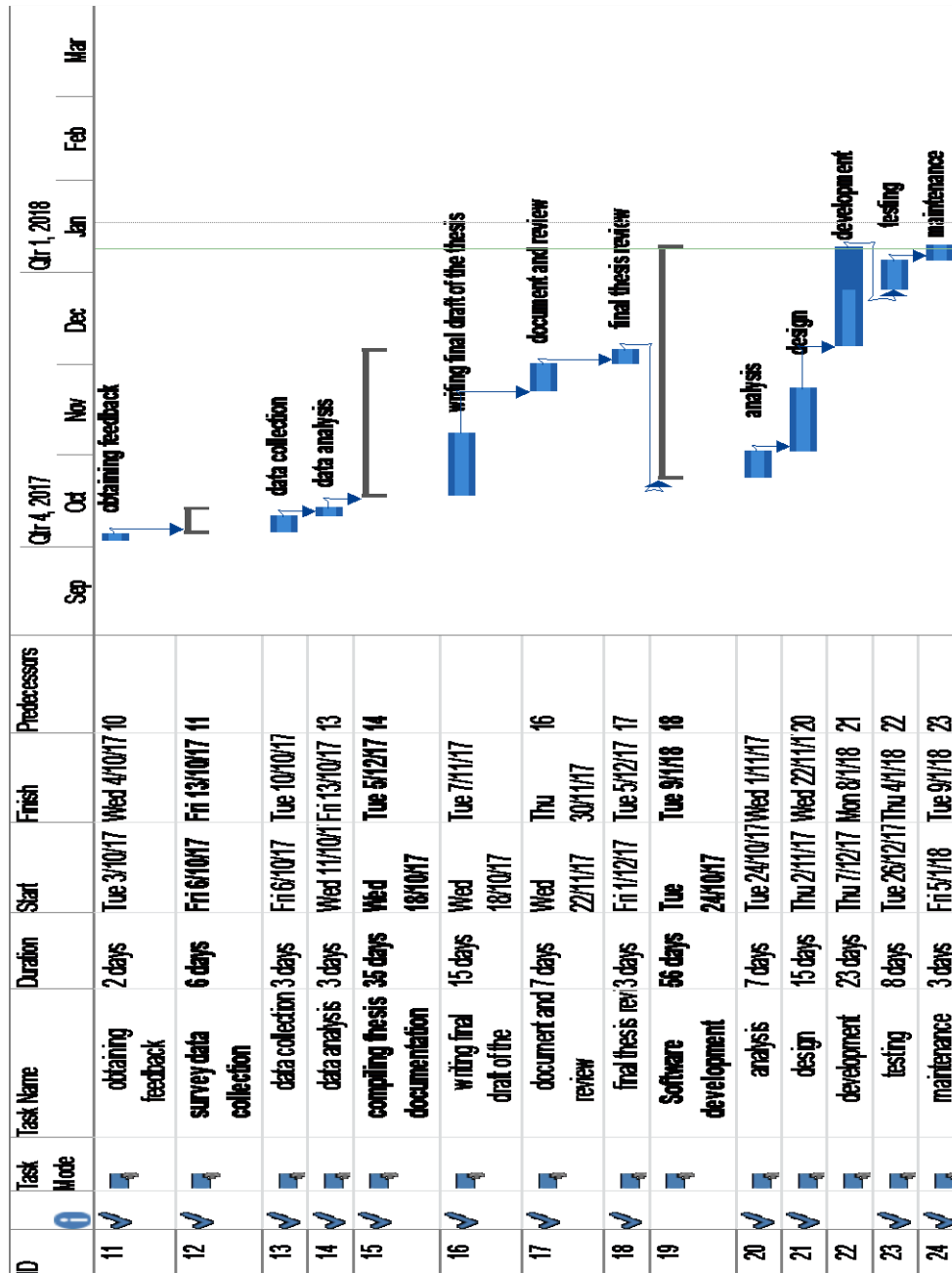
In other words, A Gantt chart, commonly used in project management, is one of the most popular and useful ways of showing activities (tasks or events) displayed against time. On the left of the chart is a list of the activities and along the top is a suitable time scale. Each activities is represented by a bar; the position and length of the bar reflects the start date, duration and end date of the activity. This allows you to see at a glance: various activities

are, when each activity begins and ends, how long each activity is scheduled to last, where activities overlap with other activities, and by how much the start and end date of the whole project.

The following section will show the screen shots of the software used during the time analysis.



(a) Gantt chart of thesis research schedule



(b) Gantt chart of thesis research schedule

Figure 4.14: Research schedule for the study using Gantt chart

CHAPTER 5

SYSTEM IMPLEMENTATION

This chapter gives exploration and navigation guide to the user of the developed mobile Augmented Reality. With simple structure buttons that are consistence, enjoyable, and feedback in an easy way by user.

5.1 NEU Car Museum Magazine Catalog

The user must have NEU magazine catalog and open the page that contained Jaguar XK 120 Roadster 1949 as image target. Install NEU-MAR application on your Android mobile phone and open the application then point your camera device directly to the image. The developed application will automatically detect car on the page and display in 3D model real time view of the car information to the user view. The NEU car museum catalog in Figure 5.1 shows below.



Figure 5.1: Image target from NEU car museum magazine catalog

5.2 Home Screen

Home screens usually consist of a grid of application buttons, links or shortcuts that can often be arranged over multiple screens, which serve as the user main method of accessing phone functions. It also tends to include a dock along an edge of the screen, where application buttons can be accessed from the home screen to the user view. This application allow user to conveniently play around the on home screen and select the appropriate buttons you want to access.

In addition to applications buttons, home screens are also capable of displaying information, such as short video on NEU-MAR application. Nevertheless, there are different buttons that are user friendly and enjoyable. Furthermore, the increased relevance of the information can come at the cost of various functions of the application is well integrated, and the ease of recognition afforded by application buttons.

- ***Welcome screen button:*** This is the first step to see once the users open NEU-MAR application as an introduction to the user. The access to the application is granted by pressing the button that provide a short video playing screen so that the user can preview all the cars available in the NEU car museum with high quality and maximum efficiency as show in Figure 5.2 below.
- ***Get started button:*** This allow user to experience the view-augmented reality of the car in 3D model view in real time. The user has the option to skip the short video explained above and jump into the main scene of the application by pressing the get started button. Show also in Figure 5.2 below.

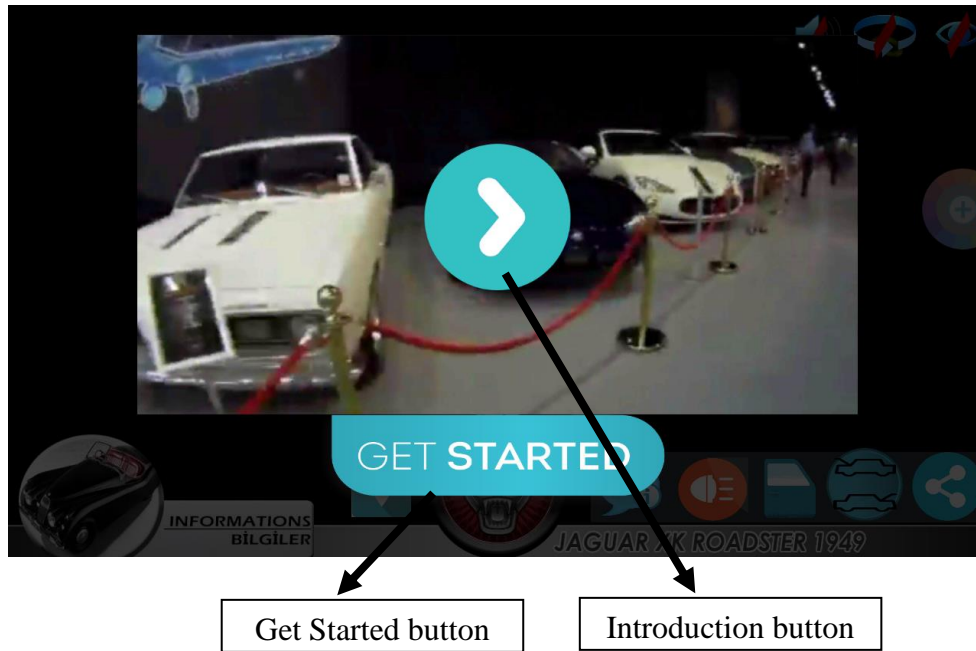


Figure 5.2: Welcome screen showing the introduction and get started buttons

5.3 Main Screen

The main screen is a graphical control component comprising of a window containing a picture, a logo, and the present startup application screen. The main screen typically shows up while a game or application is being launched. In other words, the main screen serves as the main page of the application. The main screen may cover the whole screen, or may be a rectangle close to the focal point of the screen. These main screens are normally utilized by informing the client that the application is in loading stage running stage. A splash screen vanishes when the application's primary window shows up. Additionally, the Main screens regularly serve to upgrade the look and feel of an application, henceforth they are frequently outwardly engaging. They may likewise have sound, movements, and illustrations.

- **Car 3D model view:** Display low poly 3D model view of the image target in real time.



Car 3D model Low poly of Jaguar XK 120

Figure 5.3: Car 3D view as augmented in real time

5.3.1 Supporting pinch/zoom gestures

Adding motions to an application can altogether enhance the user familiarity with the application. There are many kinds of motions, from the basic single-touch swipe signal to the more multi-touch turn motion, where the pointers or touch focuses move in various sections. This case demonstrates to identify the pinch/zoom signal, which utilizes pointer occasions to recognize whether the user draws two pointers nearer or more remote separated from each other.

This pinch motions for zooming easy to assist the user in determining how much smaller or bigger you can make the content zoom factor in a single and enjoyable method. Making those few strides permits your parchment view to help the pinch motions for zooming your content. The supporting pinch-out and pinch-in zoom signals are standard motions that application clients hope to utilize while zooming in and out. In this case, you utilize the pointer occasions to at the same time recognize two pointing image of any sort, with the two fingers. The pinch in (zoom out) signal, which pushes the two pointers toward each other, changes the objective to bigger. The pinch-out (zoom in) signal, which moves the two pointers far from each other, changes the objective smaller .The user can conveniently

zoom in/out of the 3D model to a reasonable size. Figure 5.4 demonstrates cases of the pinch signals support.



(a) Zoom out



(b) Zoom in

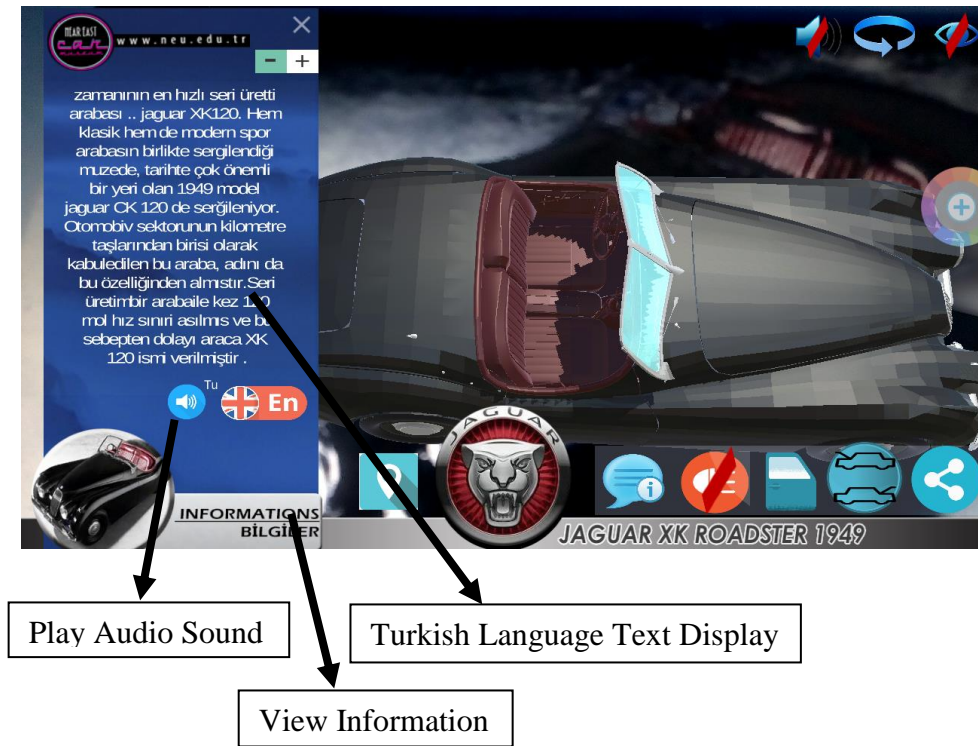
Figure 5.4: Supporting the pinch zoom gestures

5.3.2 History about the car buttons

It interesting to know that the application have the capacity to add, store and display text highlighting an importance of the car placed and role in the automotive history of museum. Additionally, the application has a Language option where the user can if decided to play audio sound button and listen to information about the car Jaguar XK 120 Roadster 1949either in English Language or in Turkish Language. The Turkish Language was used because it is a native language of Cyprus while English Language because many University students visit the NEU car museum and it is a global Language that make it open door to the outside visitors. However, due to uniqueness and flexibility user with eye sight can at any time increases or decreases font size of the application see in Figure 5.5 below.



(a) Information in English Language

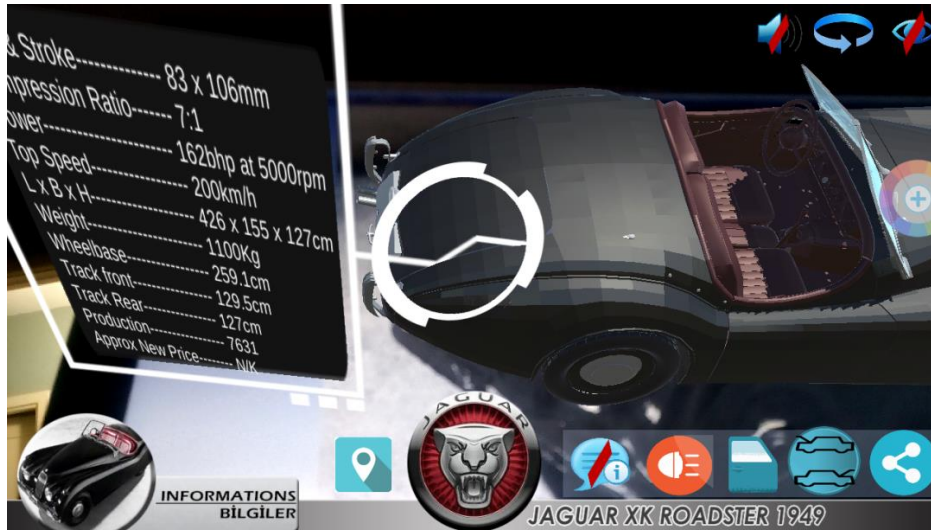


(b) Information in Turkish Language

Figure 5.5: General history about the car

5.3.3 Technical specifications about car button

This displayed the specifications of Jaguar XK 120 Roadster like compression ratio, track rear, track front, top speed, bore/stroke, wheelbase, power, Length x breath x height, motor six cil in line and weight. The straight-six engine or inline-six engine (often abbreviated I6 or L6) is an internal combustion engine with the cylinders mounted in a straight line along the crankcase with all the pistons driving a common crankshaft (straight engine).



(a) Technical specification about the car



(b) In line six internal combustion engine L6

Figure 5.6: Technical specification of the car

- **Open/close boot button:** The user can open and close the boot of the 3D model car by pressing the below button.



(a) Boot cover

Boot button

- **Open/close bonnet button:** The user can open and close the bonnet of the 3D model car by pressing the below button.



(b) Bonnet cover

Bonnet button

Figure 5.7: To open/close car boot and bonnet buttons

- **Doors Open/Close button:** The user can open and close the doors of the 3D model car by pressing the below button.

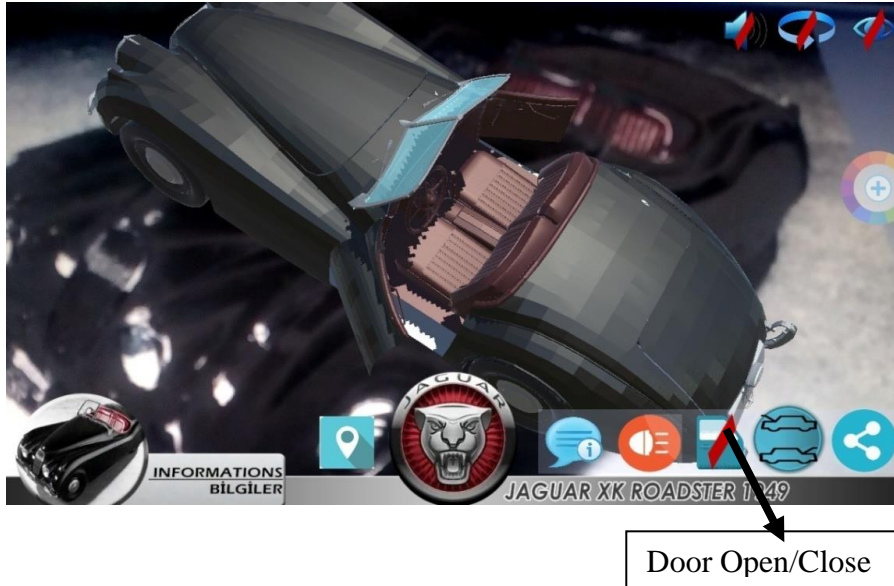


Figure 5.8: Button to open/close car doors

- **Car head lightning button:** The user can light on/off of the 3D model car by pressing the below button.



Figure 5.9: Turn on/off car head light button

- **Information on web buttons:** This give a user opportunity to visit NEU car museum Facebook page and Near East University Website by pressing the below buttons.



Figure 5.10: Navigation to car museum facebook and University website page button

- **Resize font size buttons:** It gives a user chance to increase and decrease text font size.

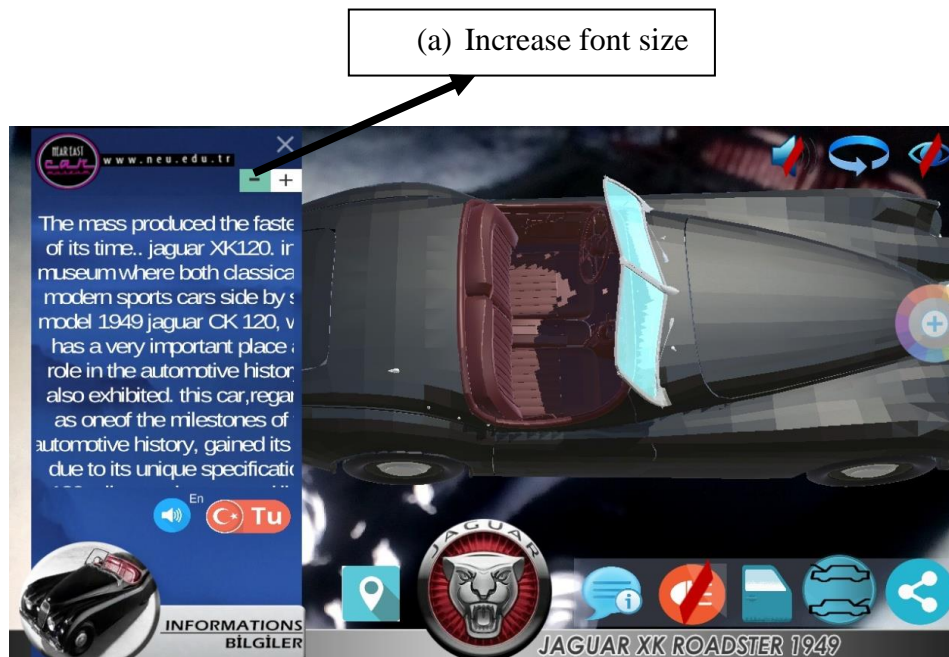


Figure 5.11: To increases/decreases the information about the car font size

- **Hide all screen buttons:** It gives a user chance to enable/disable all screen Icons anytime when using the application.

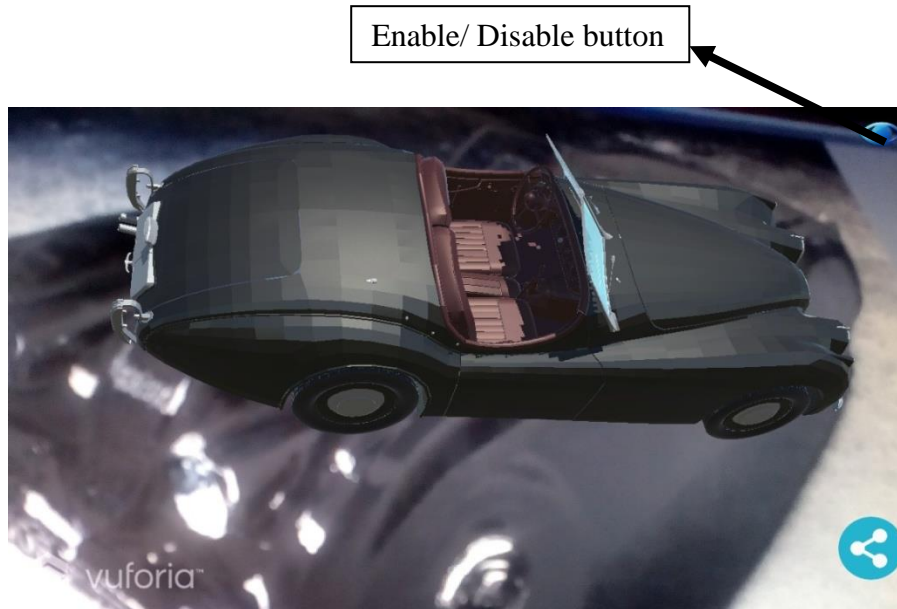


Figure 5.12: Icon to hide all screen buttons

- **Mute Audio sound buttons:** It allow a user to enable/disable audio sound when using the application.



Figure 5.13: Button to mute audio sound

- **Stop rotation buttons:** It allow a user to enable/disable audio sound when using the application.



Figure 5.14: Button to stop car from rotation

- **Color pallet:** This is one of the interesting button of the developed application were end user can easily play with different color of the car by pressing each desire color from the button below.

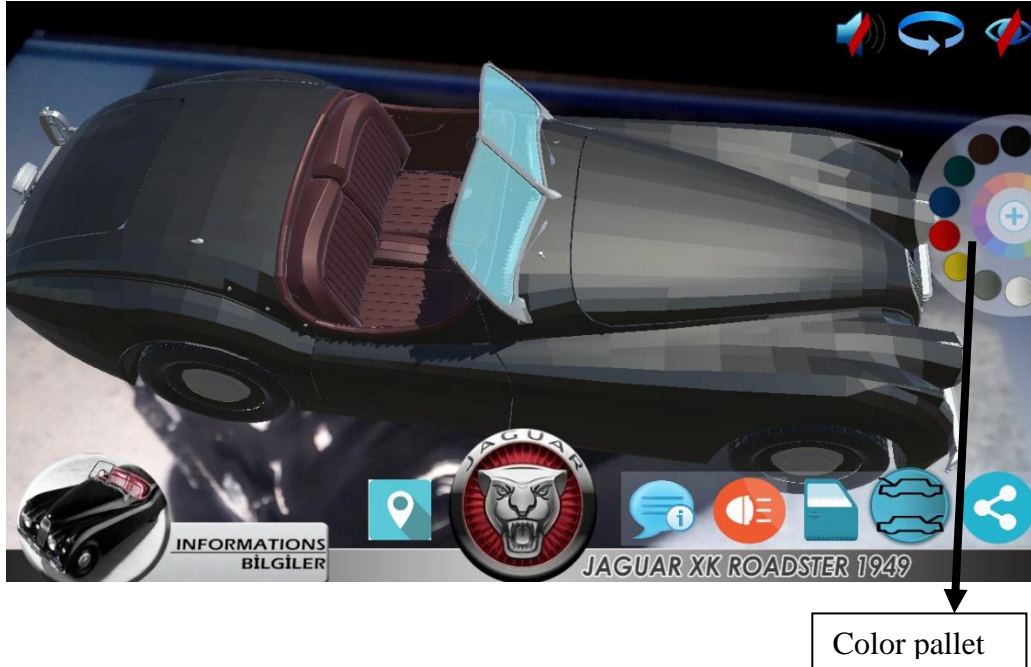


Figure 5.15: Color pallet buttons

- **Share button:** It allow a user to screenshot and share their experience or knowledge of the developed mobile augmented reality application with their friends on any social media.

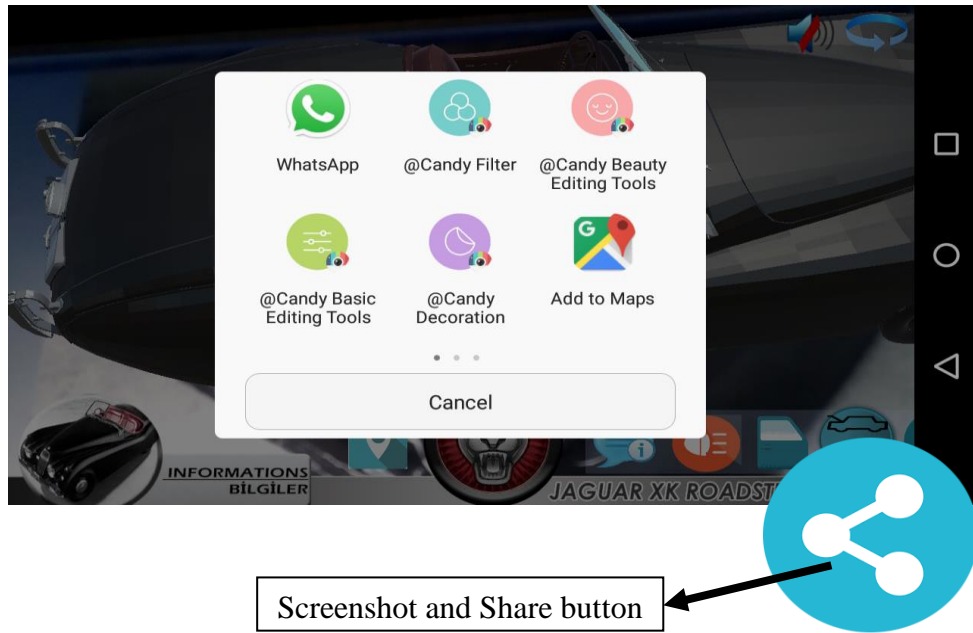


Figure 5.16: Share on social media

5.4 Classification of data

This is a process of gathering information by means of grouping the data, sorting, arranging, ordering methods and organizing your data collection.

5.4.1 Participants

These explain the participants that filled the questionnaire. There are 35 random volunteer students that took part on the survey to use the developed application and collect their ideas, of which 24 a male students and 11 female students within the ranges of less than 19 to greater than 21. Each of the participants is of different nationality, departments and academic background levels. All the questionnaire were developed by the Author. Their frequency and percent are demonstrated below based on the chosen participant see in Table 5.1, Table 5.2 and Table 5.3.

Table 5.1: Frequency of male and female participants

Gender	Frequency	Percent
Male	24	68.6
Female	11	31.4
Total	35	100.0

The above shows the frequency of 24 are males and 11 females with the percent of male 68.6% and female 31.4%.

Table 5.2: Academic level showing the frequency and percent

Academic Level	Frequency	Percent
Undergraduate	13	37.1
Masters	14	40.0
PhD	8	22.9
Total	35	100.0

This indicates the number of each frequency of student academic level, 13 are undergraduate, 14 masters, and 8 PhD which shows the percent as 37.1%, 40%, and 22.9% respectively.

Table 5.3: Showing the frequency and percent of participants nationality

Nationality	Frequency	Percent
Nigerian	5	14.3
Palestine	3	8.6
Iranian	3	8.6
Pakistan	2	5.7
Kenyan	1	2.9
Cyprus	11	31.4
Algeria	2	5.7
Zimbabwe	2	5.7
Turkey	6	17.1
Total	35	100.0

The above demonstrate the participants based on nationality with their frequency and percent as shown on the Table 5.3.

5.4.2 Data Collection Tools

In order to find out the usefulness and effectiveness of the NEU-MAR application, a student random volunteer only took part in the survey. The students were asked to use the developed NEU-MAR application before filling the survey questionnaire in order to receive their feedback on the use of the developed application. Thirty five (35) carefully prepared questions were given to students to answer. The questionnaire consisted three sections, section I: demographic information, section a: metacognitive skills for NEU-MAR application and section b: problem-solving skills, all to determine whether the NEU-MAR application has positive response from the students. The survey was carried out at the Near East University Campus. The questionnaire was in English language and composed of three sections.

5.4.3 Data Analysis

The questionnaires were used to collect the data. The data was then analyzed and interpreted using SPSS version 20.0. Descriptive analyses were used during the analysis process.

The following table can be used for a better understanding of the knowledge level of the NEU-MAR application that the end-user possessed.

Section I: Demographic Information: Requested the participant information such as gender, age group, department, Academic level of study and Nationality of the students.

Section II: General opinion: The aim of this section was to gain an insight of the participants such as knowing the effect of metacognitive skills for the developed NEU-MAR application. This section comprised of 15 items in total, whose goal was to search and identify the general opinions of the participants towards developed application, and how the participants feels when using the NEU-MAR application and achieving the goal. In this study, the Cronbach's Alpha for the whole scale was calculated 0.90. Therefore proving that the questionnaire is indeed reliable (Sipahi, Turtkoru & Cinko, 2010) because of α is greater than 0.70. With questionnaire used in which participants were asked to assign the scale measurement based on the 5 Likert scale ranked with "Strongly Disagree" (1point), "Disagree" (2 point), "Neutral" (3 point), "Agree" (4 points), "Strongly Agree" (5 points). This can be seen below in Table 5.4.

Table 5.4: Showing the descriptive statistics of general scale of student opinion

S/N	Survey items	Mean	SD
1.	I found NEU-MAR application for car museum enjoyable.	4.60	.60
2.	I found NEU-MAR application for car museum convenient.	4.34	.64
3.	I found NEU-MAR application for car museum brand attitude.	4.23	.77
4.	I learnt a lot about the cars in NEU museum with the help of the NEU-MAR application for car museum.	4.14	.91
5.	I found NEU-MAR application for car museum useful.	4.43	.61
6.	I will recommend NEU-MAR application for car museum to my friends.	4.46	.66
7.	I will be happy if NEU-MAR application for car museum is done to all the car in the museum.	4.69	.53
8.	The NEU-MAR application for car museum helped me save time from going to the museum.	4.37	.94
9.	The NEU-MAR application for car museum helped me save money from paying to enter the museum.	4.20	1.05
10.	I found NEU-MAR application for the car museum very effective to learn information about the old car.	4.54	.66
11.	I believe it is good idea for the car museum to adopt this kind of NEU-MAR application.	4.63	.55
12.	I was satisfied to use the NEU-MAR application for the car museum.	4.34	.68
13.	Playing with application assist me in learning more about NEU-MAR application for the car museum interesting and motivational.	4.40	.60
14.	The NEU-MAR application for the museum can be used anywhere and anytime to find information about the car.	4.34	.73
15.	I found the NEU-MAR application for museum as a guide to all car museums.	4.37	.73
Average mean and standard deviation		4.41	0.71

Scoring: 5 = Strongly Agree, 1 = Strongly Disagree

- ***General opinions of students towards the NEU-MAR application***

The mean opinion scores and standard deviations of students' random volunteer survey responses are given in Table 5.1. At a glance, the results suggest that students had high positive opinions of the NEU-MAR application (7th question, M=4.69). The eighth question "*The NEU-MAR application for car museum helped me save time from going to the museum*" and fifteenth question "*I found the NEU-MAR application for museum as a guide to all car museums*" have the same high scores (M=4.37). The second question "*I found NEU-MAR application for car museum convenient*", the twelve question "*I was satisfied to use the NEU-MAR application for the car museum*", and

the fourteenth question “*The NEU-MAR application for the museum can be used anywhere and anytime to find information about the car*” have the same high scores (M=4.34). The reasons for this is that the students are satisfied, helpful, guide to car museums using the NEU-MAR application as now could be learn anywhere and anytime.

It is very interesting to notice that meaningful response to the NEU-MAR application is “*I found NEU-MAR application for car museum enjoyable*” with (M=4.60). This shows that the students enjoyed the developed NEU-MAR application. And the least meaningful response is “*I learnt a lot about the cars in NEU museum with the help of the NEU-MAR application for car museum*”, with (M=4.14).

Section III: Technical features: The aim of this section was to get the participants general ideas about the technical feature of the NEU-MAR application and to concentrate thoroughly on problem-solving techniques to find out what modification or improvements the students wishes to see in the developed application. My thesis supervisor help me based on the developed application designed the structure of the questionnaire. The section comprised of 14 items in total, whose goal was to build a full understanding of the problem with developed application, make analysis, comparisons of the solutions, outcomes, categorize, combine, and modify a design and make the developed NEU-MAR application better. According to the findings, and clearly shows that the scale is very reliable (Sipahi, Yurttkoru & Cinko, 2010) the Cronbach’s Alpha for these dimensions in the questionnaire were calculated 0.93 with ordinal questionnaire used in which participants were asked to assign a scale measurement based on the 5 Likert scale ranked with “*Strongly Disagree*” (1point), “*Disagree*” (2 point), “*Neutral*” (3 point), “*Agree*” (4 points), “*Strongly Agree*” (5 points). Below in Table 5.5.

Table 5.5: Showing the descriptive statistics of technical feature scale of student

S/N	Survey item (N=35)	Mean	SD
1.	NEU-MAR application for car museum is user friendly.	4.34	.73
2.	NEU-MAR application for car museum has great user interface.	4.23	.77
3.	The NEU-MAR application for car museum is efficient	4.23	.81
4.	The NEU-MAR application for car museum does not have compatibility issues	3.89	.90
5.	I felt very confident using NEU-MAR application for car museum.	4.29	.71
6.	I found NEU-MAR supportive	4.29	.67
7.	I liked the screen layout of the NEU-MAR application for the car museum.	4.31	.68
8.	I found NEU-MAR interactive	4.34	.68
9.	I found the various function of NEU-MAR application well integrated	4.20	.68
10.	Graphical user interface of NEU-MAR application for the car museum satisfied me.	4.20	.83
11.	The user interface of NEU-MAR application for car museum helped me avoid making error.	4.00	.77
12.	NEU-MAR application includes all the information about the car in the museum handbook.	4.17	.89
13.	NEU-MAR application helped me learn things that I wanted to learn about the car museum.	4.20	.80
14.	The screen colours used in the NEU-MAR application were pleasing for my eye.	4.29	.67
Average mean and standard deviation		4.21	0.76

Scoring: 5 = Strongly Agree, 1 = Strongly Disagree

- ***General opinions of students about Technical feature of the NEU-MAR application***

The mean opinion scores and standard deviations of students' random volunteer survey responses are given in Table 5.2. This shows that the results suggest that students had high positive opinions of students about the NEU-MAR application. The first question "*NEU-MAR application for car museum is user friendly*" and eighth question "*I found NEU-MAR interactive*" have the same high scores (M=4.34). The fifth question "*I felt very confident using NEU-MAR application for car museum*", the sixth question "*I found NEU-MAR supportive*", with the same score (M=4.29) and so also the second question "*NEU-MAR application for car museum has great user interface*" and third question "*The NEU-MAR application for car museum is efficient*" have the same high

scores (M=4.23). The reasons for this is that the students found interactive, user friendly and efficient using the NEU-MAR application.

It is very interesting also to notice that least meaningful response to the NEU-MAR application is “*The NEU-MAR application for car museum does not have compatibility issues*” with (M=3.89). This shows that the students do not encounter any compatibility issues when using the developed NEU-MAR application.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

This chapter wraps up my study conclusively, presents the work done on the developed application and pointing out findings as well as summarizing the main points of the whole study. Contains recommendations based on the developed application findings and subsequently achieving the set aim of the thesis, and also highlighted on the future works.

6.1 Conclusion

It worth noting that, implementation of this NEU-MAR application has merits that cannot be overemphasized, owing to the fact that this developed application is of standard, multimedia and high quality to use for the NEU car museum. Because it is helpful, time efficient and user-friendly application, the results of the survey were positive and in favor of the developed application. The end-user opinions showed satisfaction and enjoyment with the developed application.

The aim of the study has been achieved and that the developed NEU-MAR application can be used anytime and anywhere in the world. In addition, the results of the case study pointed out that the developed application enjoyable and user friendly.

6.2 Recommendations

I will recommend the Near East University car museum should adopt and lunch this new trends technology of augmented reality application in their car museum. In the future, will include more languages will be added and more cars in the NEU magazine catalog and develop an NEU-MAR application that is suitable for IOS, Window and other operating system. Many developers within the growing field of digital technology are beginning to explore how AR can be utilize, as a viable medium of engagement people. AR is a cutting-edge, complex technology; there are a number of user-friendly platforms that allow people with no previous coding experience to create compelling augmented reality experiences.

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APPENDICES

SECTION I: GENERAL OPINIONS TOWARDS DEVELOPED APPLICATION

ITEMS	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I found NEU-MAR application for car museum enjoyable.	()	()	()	()	()
2. I found NEU-MAR application for car museum convenient.	()	()	()	()	()
3. I found NEU-MAR application for car museum brand attitude.	()	()	()	()	()
4. I learnt a lot about the car in NEU museum with the help of the NEU-MAR application for car museum.	()	()	()	()	()
5. I found NEU-MAR application for car museum useful.	()	()	()	()	()
6. I will recommend NEU-MAR application for car museum to my friends.	()	()	()	()	()
7. I will be happy if NEU-MAR application for car museum is done to all the car in the museum	()	()	()	()	()
8. The NEU-MAR application for car museum helped me save time from going to the museum.	()	()	()	()	()
9. The NEU-MAR application for car museum helped me save money from paying to enter the museum.	()	()	()	()	()
10. I found NEU-MAR application for the car museum very effective to learn information about the old car.	()	()	()	()	()
11. I believe it is good idea for the car museum to adopt this kind of NEU-MAR application.	()	()	()	()	()
12. I was satisfied to use the NEU-MAR application for the car museum.	()	()	()	()	()
13. Playing with application assist me in learning more about NEU-MAR application for the car museum interesting and motivational.	()	()	()	()	()
14. The NEU-MAR application for the museum can be used anywhere and anytime to find information about the car.	()	()	()	()	()
15. I found the NEU-MAR application for museum as a guide to all car museums.	()	()	()	()	()

SECTION II: GENERAL TECHNICAL FEATURE OF THE APPLICATION

ITEMS	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. NEU-MAR application for car museum is user friendly.	()	()	()	()	()
2. NEU-MAR application for car museum has great user interface.	()	()	()	()	()
3. The NEU-MAR application for car museum is efficient	()	()	()	()	()
4. The NEU-MAR application for car museum does not have compatibility issues	()	()	()	()	()
5. I felt very confident using NEU-MAR application for car museum.	()	()	()	()	()
6. I found NEU-MAR supportive	()	()	()	()	()
7. I liked the screen layout of the NEU-MAR application for the car museum.	()	()	()	()	()
8. I found NEU-MAR interactive	()	()	()	()	()
9. I found the various function of NEU-MAR application well integrated	()	()	()	()	()
10. Graphical user interface of NEU-MAR application for the car museum satisfied me.	()	()	()	()	()
11. The user interface of NEU-MAR application for car museum helped me avoid making error.	()	()	()	()	()
12. NEU-MAR application includes all the information about the car in the museum handbook.	()	()	()	()	()
13. NEU-MAR application helped me learn things that I wanted to learn about the car museum.	()	()	()	()	()
14. The screen colors used in the NEU-MAR application were pleasing for my eye.	()	()	()	()	()

APPENDIX 2

SOURCE CODE (C#)

```
using System;
#if UNITY_EDITOR
using UnityEditor;
#endif
using UnityEngine;

namespace UnityStandardAssets.CrossPlatformInput
{
    [ExecuteInEditMode]
    public class MobileControlRig : MonoBehaviour
    #if UNITY_EDITOR
    , UnityEditor.Build.IActiveBuildTargetChanged
    #endif
    {
        // this script enables or disables the child objects of a control rig
        // depending on whether the USE_MOBILE_INPUT define is declared.

        // This define is set or unset by a menu item that is included with
        // the Cross Platform Input package.

        #if !UNITY_EDITOR
        void OnEnable()
        {
            CheckEnableControlRig();
        }
        #else
        public int callbackOrder
        {
            get
            {
                return 1;
            }
        }
        #endif

        private void Start()
        {
            #if UNITY_EDITOR
            if (Application.isPlaying) //if in the editor, need to check if we are playing, as start is also called just after
            exiting play
            #endif
            {
                UnityEngine.EventSystems.EventSystem system =
                GameObject.FindObjectOfType<UnityEngine.EventSystems.EventSystem>();

                if (system == null)
                { //the scene have no event system, spawn one
                    GameObject o = new GameObject("EventSystem");

                    o.AddComponent<UnityEngine.EventSystems.EventSystem>();
                }
            }
        }
    }
}
```

```

o.AddComponent<UnityEngine.EventSystems.StandaloneInputModule>();
}
}
}

#if UNITY_EDITOR

private void OnEnable()
{
EditorApplication.update += Update;
}

private void OnDisable()
{
EditorApplication.update -= Update;
}

private void Update()
{
CheckEnableControlRig();
}
#endif

private void CheckEnableControlRig()
{
#if MOBILE_INPUT
EnableControlRig(true);
#else
EnableControlRig(false);
#endif
}

private void EnableControlRig(bool enabled)
{
foreach (Transform t in transform)
{
t.gameObject.SetActive(enabled);
}
}

#if UNITY_EDITOR
public void OnActiveBuildTargetChanged(BuildTarget previousTarget, BuildTarget newTarget)
{
CheckEnableControlRig();
}
#endif
}
}

```