An Online Augmented Reality Based Car Showroom

By

Siti Sarah Binti Md Zahari

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
(Business Information System)

JANUARY 2011

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

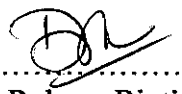
An Online Augmented Reality Based Car Showroom

by

Siti Sarah Binti Md Zahari

A project dissertation submitted to the
Business Information Systems Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(BUSINESS INFORMATION SYSTEM)

Approved by,



.....

(Dr. Dayang Rohaya Binti Awang Rambli)

Dr. Dayang Rohaya Awang Rambli
Senior Lecturer
Computer & Information Sciences Department
Universiti Teknologi PETRONAS

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

.....

(Siti Sarah Binti Md Zahari)

ABSTRACT

This report aims to give a comprehensive explanatory of the project entitled the augmented reality car showroom. The project is initiated to address current limitations of physical car showroom whereby it requires a lot of cost and resources just to sell a car. For players in automotive industry, an alternative that can reduce larger portion of cost is an interesting way to be discussed. Thus, this project has come into the picture with the objectives of gathering background information about current business model, advantages as well as its' limitations. The project also objectively created to provide the solution from the previous stated objective by developing a web-based application embedded with AR technology. The scope of study for this project revolves around the basic concept of augmented reality, customers behaviours toward overall car buying process, the basic concept of 3D modelling for car model, the functionalities of conventional car showroom and marketing, the web design and development, the integration of augmented reality technology in web-based application as well as developing a prototype that up to displaying a 3D car model. This report consists of five (5) major chapters including introduction, literature review, methodology, result and discussion and conclusion.

ACKNOWLEDGEMENT

Alhamdulillah, after almost 5 months doing this Final Year Project II, the author's Dissertation Report are finally done. First and Foremost, the author would like to express her gratitude to Allah S.W.T with His blessings for her to complete the report with silky and victorious. There were many people involved during the development of the project, which has contributed immeasurable amount of guidance, advice and assistance. The author's heartfelt thanks go to all of them for their commitment and supports in realizing the goals and the successful completion of the project.

The author wants to point her special thanks to Dr. Dayang Bt. Awang Rambli who had supervised her throughout her project development period. The author really appreciates Dr. Dayang kindness and time to guide her to get through all phase. As a supervisor, she is really concerned and gave the author guidance for the sake of the author knowledge and experiences in completing this project.

The author also wants to express her utmost gratitude to all volunteers and participants for pre-survey and post-survey that willing to spend their precious time in order to share their opinion and experience related to this project. All the feedback in understanding the project needs were truly important in ensuring the successful completion of the project objective.

Finally, the acknowledgement is considered incomplete without thanking all the fellow colleagues, friends and family who have been giving great support and encouragement to the author to complete the Final Year Project II.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF GRAPHS

CHAPTER 1
INTRODUCTION

1. INTRODUCTION

1.1 Background

1.1.1 Augmented Reality

Back in early 1960's, the research related of Augmented Reality or more known as AR has been started by Morton Heilig, a cinematographer, whereby he and his partner have developed the Sensorama[6], a motorcycle simulator that allow the player to experience of riding a motorcycle the streets of Brooklyn[7] together with visuals, sound, vibration as well as smell. Research related of AR then has been evolve by the invention of the head-mounted display (HMD), a common hardware use to experience and apply AR applications by Ivan Sutherland in 1966[6].

***Figure 1.0** A man evaluating and learning the structure of stones using AR technology trough HMD*

Since then, the research area has been further expand with the creation of AR laboratory called Videoplace by Myron Krueger in 1975, that allows the user to interact with virtual environment and the surrounded will respond their movements without the need of fully equipped with goggles and gloves. Jaron Lanier then tries to commercialize Virtual Reality (VR) by producing VR applications and creates the first commercial business around a virtual world in 1989. Another big name in AR area is Tom Caudell which has point out the value of AR while he is in Boeing which helps the workers to assemble cables into airplane [6].

Since then, there a lot of researches and invention related to AR been conducted to further utilize and unleash the possibility in AR technology. Today's, this field is not only for the usage of scientist in their lab but has been commercialize and mass produce in different fields such as advertisement, education, medical, military and across multiple areas.

1.1.2 Car Showroom

It is very synonym for us to relate showroom with automotive car retailing. This is because since the earlier stage of this industry, marketing people found that showroom is vital to promote their products [3]. Serve as shelve like for a car, they spend millions just to ensure that their showroom will keep in time and as par with their competitors.

Customer on the other hand choose to visit this car showroom, just to get a close look at each model before they can make any decision; either to buy or just window shopping. The present of dealer, also purposely to give assistant for their visit and giving the best deal to the customer.

With the rising of Internet usage, people find that online shopping is not as bad as what some of us think plus it is so convenience. It saves lots of time and effort for the customer to view and get a better picture for what they want to buy. Automotive industry also not been left to far behind. Some of the dealer has a virtual showroom and some with AR

technology. But it is still new for this industry and plenty of limitations and setback that can be improvise from there.

1.2 Problem Statement

Car showroom always plays important roles of promoting and delivering cars to its final users. It has been used as an intermediary between manufacturers and customers with the dealers as intermediaries. For more 100 years history of industry, customers have been trained to follow this process in order to buy a car. To get a closer view of a car, they need to make a visit to nearest car showroom to get a closer look at desired car.

For a car manufacturers and dealers, in order to full fill this 'traditional' buying process, for sure, they need to prepare the car showroom. For every showroom, the most basic, it must have an enough space to fit at least numbers of cars with different models. The greater the number of car they want to display, the larger space that they are required, which is translated into greater capital that they are required to have. With the growth in demand for cars and numbers of car manufacturer, the choices of cars out there also increase. With the size and ability of current showroom, it will be hard time for the dealers to cop with the trend as well as grab its advantages.

In short, there are number of setback in current car showroom as mediator for car manufacturer to market their products. They are:

- Higher cost of set up depending on the size of showroom. Larger room is required to display larger number of car models.
- Restriction of locations. Number of dealers might be interested to open in the same area because of the same target market.
- A showroom might not have all the models and require the customer to go to other showroom for the viewing purposes only.
- One-to-one contact with dealers sometimes create bad customer experiences

- Time consuming. With nowadays trend, where people are preferred to do online shopping rather than conventional purchasing, visiting car showroom has become more inconvenience for the customer.

1.3 Objectives

1.3.1 Aim and Objectives

The main aim of this project is to develop an application that can imitate and serve the same or better purpose of conventional car showroom with help of augmented reality (AR) technology. This application will include 3D models of cars that will be displayed to the customers using AR technology as replacing the conventional way of displaying cars by giving the users to explore the features of each model from home conveniently via the Internet. With the development of this application, it will allow automotive industry to grab the competitive advantage from the emergence of Internet and globalisation.

To achieve the aim stated previously, the following objectives are defined:

- To conduct pre-survey on the user of current conventional car showroom including the owner as well as the customer in order to get a picture of current business model, the characteristics, advantages as well as drawbacks.
- To develop a web-based application integrated with AR technology to display models of cars in 3D format as an alternative of conventional car display.
- To evaluate usability of the application towards the users.
- To evaluate the perception of target users about the application.

1.4 Scope of Study

In order to proceed with this project, there are several areas that needed to be learned and covered before the final product can be produce. There are:

- The basic concept of augmented reality
- Customers behaviours toward overall car buying process
- The basic concept of 3D modelling for car model
- Functionalities of conventional car showroom and marketing
- Web design and development
- Integration of augmented reality technology in web based application.
- Development of prototype – up to displaying a model with 3 choices of colour.

CHAPTER 2
LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Augmented Reality

2.1.1 Definition of Augmented Reality

Azuma (1997) defined augmented reality (AR) as systems that combined three major features including combination of reality and virtual scenes, work in real-time, and registered in 3D. In short, augmented reality can be defined as improvement of the real world with computer-generated data in real-time using technological devices. The phase of augmented reality can be explained by Figure 2.0, adapted from the reality-virtuality continuum proposed by Milgram (1994).

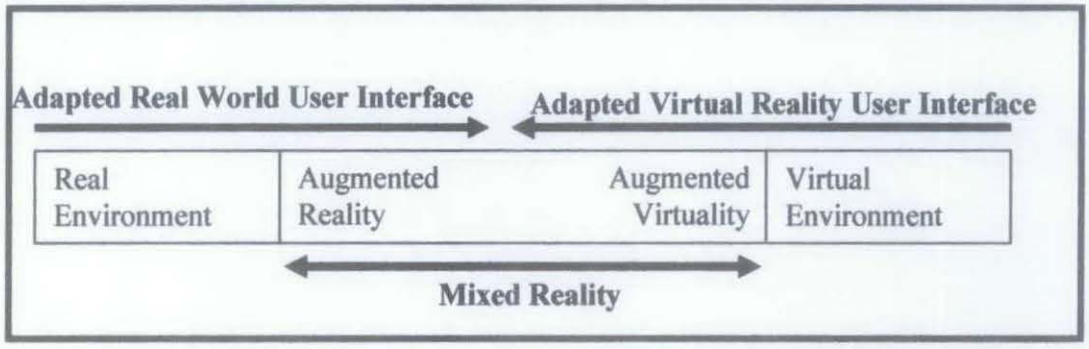


Figure 2.0 Mixed reality environment (Adapted from Milgram, 1994)

In augmented reality, using reality as user interface, the technology brings the virtual world to reality world. In this concept, the user can see and/or interact with virtual object in real environment (Kirner & Kirner, 2008).

In short, AR can be defined as a technology that can combined reality and virtual environments, which is interactive in real-time. The virtual object that been registered in the real environment can be stationary or be manipulated where there is set of activities between them.

2.1.2 Characteristics of Augmented Reality

In Azuma's survey article, he has highlighted the following characteristics which are important and essential for an AR system:

- ***Combination of real and virtual***. In AR system, generated graphics and images of the real environment are combined. This is the main feature of AR.

- ***Real-time interactivity***. The virtual image elements presented to the user are generated in real-time, and their appearance is sensitive to user input and changes in the environment.
- ***Three-dimensional registration***. Graphical information in the AR environment has a correct spatial alignment relative to the actual surroundings of the user. In order to achieve such a useful registration, the head of the user or the camera used in the system has to be tracked. This consistent three-dimensional alignment is the distinguishing feature of augmented reality.

2.1.3 Technology

2.1.3.1 Hardware

The main hardware components for augmented reality are: display, tracking, input devices.

- ***Display***
  i. ***Monitor-Based Display*** (non-immersive) or also known as "Window-on-the-World" (WOW), is referring to display systems where computer generated graphics are either analogically or digitally overlain on live or stored video images.

***Figure 3.0** Example of AR Application using Monitor-based Display*

ii. ***Head-Mounted Display (HMD)*** is a display device which is will be worn like a helmet on the head and has a display optic in front of eye or both. Look likes a lab goggle. HMD can display computer-generated images (CGIs), show live images from real world or a combination of both.

***Figure 4.0** A Binocular Head-Mounted Display (HMD)*

According to Wikipedia, HMD[4] places images of both the physical world and registered virtual graphical objects over the user's view of the world. The HMD's are either optical see-through or video see-through in nature.

Optical see-through approaches use optical combiners, which are placed in front of the user's eyes. These combiners are

partially translucent, thus, the real world remains directly visible.

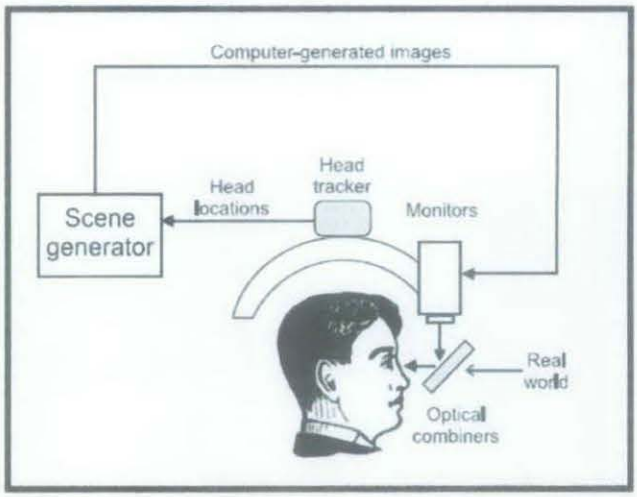


***Figure 5.0** Optical-Sees Through Approach*

On the other hand, in ***video-see through*** AR, a video camera is used for recording images of the real environment. The acquired digital images then serve as background bitmaps, over which the virtual graphical objects are rendered. The resulting combined digital images are presented to the user on non-transparent display devices like closed-view head-mounted displays (HMDs).

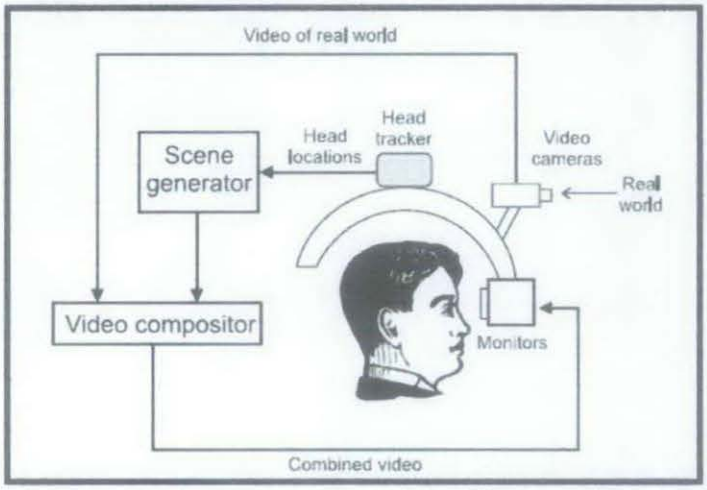


***Figure 6.0** Video-Sees Through Approach*

ii. ***Handheld Display*** is a small computing device with a size that fits in a user's hand. It uses video see-through techniques

whereby the graphical information will be superimposed to the physical world. Most of nowadays smart phones can use the AR application/ based systems because the portable nature of these devices and ubiquitous nature of camera phones.

***Figure 7.0** Augmented Reality Application running on smart phone (Apple iPhone)*

iii. ***Spatial Display*** on the other hand is using digital projector to display graphical information on physical objects. The advantage of using spatial display compare to the other two displays mention previously is it serve the same purpose without the need of for the user to wear or carry display devices (HMD or smart phone) plus it allows multiple user to collaborate and interact with each other.

- ***Tracking***

  Among the tracking devices for today's AR technology are digital camera and/or optical sensors, accelerometers, GPS, gyroscopes, solid state compasses, RFID, wireless sensors. Each device will provide different results of accuracy and precision.

- ***Input Devices***

  Some systems, such as the Tinmith system, employ pinch glove techniques. Another common technique is a wand with a button on it. In case of a smartphone, the phone itself could be used as 3D pointing device, with 3D position of the phone restored from the camera images. [4]

- ***Computer***

  With the basic of using camera as based systems, it requires powerful CPU and certain amount of RAM in order to process the images. Some application might also require sound procession hardware as an addition. The computer also required to be equipped with graphics processing units like NVidia GPU by Toshiba to combine the technology of computer with AR systems.

2.1.3.2 Software

For a real time emergence of reality with 3D images, graphic information / virtual images should be attached to real-world in visually realistic way. That process is known as image registration as per defined in the definition section about AR by Azuma.

Image registration uses different methodology of computer vision which is usually related to video tracking. Those methods consist of two major components. First stage is interest points or fiduciary markers which use feature detection methods. Second stage is a real-world coordination system is restored from the data attained in the first stage.

There are numbers of development software available either open source or with license to develop an AR application. Few of them are as follow:

- ***ARToolKit***

  Originally developed by Dr. Hirokazu Kato from Nara Institute of Science and Technology in 1999, later was released by the University of Washington HIT Lab. It is a computer vision tracking library that allows creation of AR applications that overlay computer generated graphics over the real environment.

  - ***Method:***

    - It uses video tracking ability in order to calculate the real camera position and orientation relative to square physical markers in real time.
    - Once the camera has been position, then the 3D model will be drawn to overlay the marker.

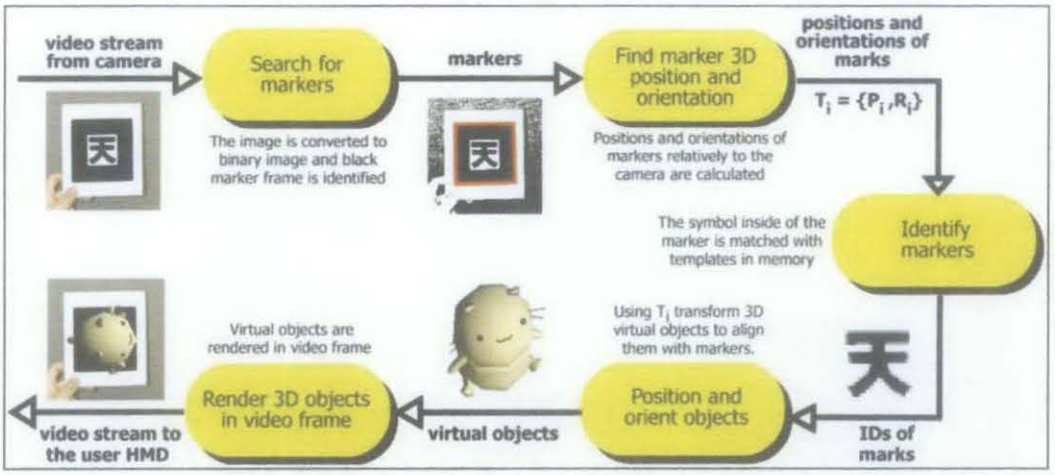


***Figure 8.0** How ARToolKit Works?*

- ***Feature:***
  - Single camera position/ orientation tracking.
  - Use simple black square marker as tracking code.
  - The ability of using any square marker patterns.
  - Easy camera calibration code.
  - Quick real-time responds.
  - Free and open source.
- ***Limitations:***
  - Virtual object will only appear when *tracking marks are in view*. It includes if the user has covered part of the marker, maybe by their finger, the visual object will disappear.
  - *Range issue*. The larger the size of marker, the further away the pattern can be detected. Following table is taken from ARToolKit website depicting the relationship between pattern size and the distance of pattern can be detected:

Patter Size (inches)	**Usable Range** (inches)
2.75	16
3.50	25
4.25	34
7.37	50

***Table 1.0** Tracking Range for Different Sizes of Pattern*

- *Pattern complexity.* The simpler marker with larger black and white regions, the better it is and more effective. Simpler marker reduces the tracking distance.
- *Marker Orientation* relative to the camera position. As the user hold the marker more tiled or horizontally, lesser the effectiveness for the camera to track the pattern.
- *Lighting condition.* Overhead lights might create shadow to the glare spot on the marker. Thus, make it more difficult for the camera to find the marker square.

- ***FLARToolKit***

  FLARToolKit is free to use for non-commercial applications under the GPL license. This means the complete source code for your application must be made available to anyone that asks for it. FLARToolKit is based on the ARToolKit library under the GPL license and so the source code for any FLARToolKit applications that are made needs to be GPL as well.

  - ***Method:***
    - Like using ARToolKit, by using this software, it will detect the marker from an input image, and then a 3D image will be overlay onto the marker. Same concept.

- ***Features:***
  - AS3 ported version of ARToolKit .
  - Based on NyARToolKit; Java ported version of ARToolKit.
  - Use various major 3D engines including Papervision3D, Away3D, Sandy, Alternativa3D.
  - Allow to experience AR application through web-browser.

- ***MXRToolKit***

  The MXRToolKit consist of all necessary libraries of routines to develop mixed reality application. All the codes are called using 'C' style function calls and structures.

  - ***Method and Structure:***

Structure Name	Purpose
mxrCamera	Describes real-world camera model parameters
mxrCaptureStream	Holds information about the video capture source – height and width
mxrImage	Holds a single image from the capture stream
mxrFrame	Describes the marker or object in the world to be tracked
mxrTransform	Describes relative position and orientation of marker and camera
mxrMedia	Holds information about 3D models / media clips
mxrFrustum	Describes rendering volume that matches the real camera parameters

Table 2.0 *Data Structure of MXRToolKit*

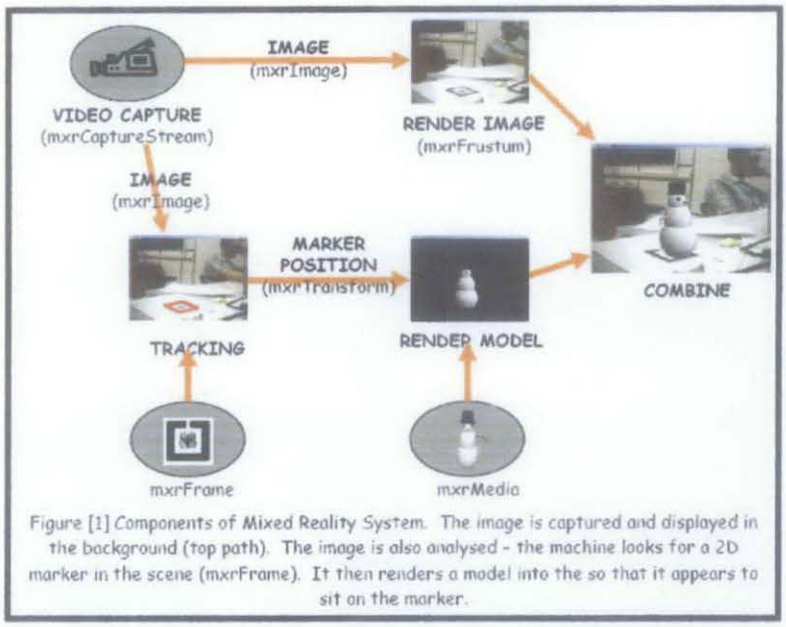


Figure [1] Components of Mixed Reality System. The image is captured and displayed in the background (top path). The image is also analysed - the machine looks for a 2D marker in the scene (mxrFrame). It then renders a model into the so that it appears to sit on the marker.

***Figure 9.0** Method and Data Structure in MXRToolKit*

- ***SLARToolKit – Silverlight Augmented Reality Toolkit***

  SLARToolKit is a flexible Augmented Reality library for Silverlight with the functionality that allow it's user to develop a real time AR application using Silverlight as easy and fast as possible. It can be used with the Webcam API in Silverlight 4 or with any other CaptureSource and WriteableBitmap.

  This toolkit is based on the well-known AR toolkit; NyARToolKit and ARToolKit. It uses a dual license model and could be used for open or closed source applications under several terms and conditions.

  - ***Features***

    - Direct support for Silverlight's CaptureSource
    - Flexible through a generic and a WriteableBitmap detector
    - Multiple marker detection
    - Simple black square markers
    - Custom markers
    - Real time performance

- Easy to use
- Documentation including a step by step Beginner's Guide
- Based on established algorithms and techniques
- Uses the Matrix3DEx library

- ***NyARToolKit***

NyARToolKit is a complete port of ARToolKit that was written exclusively in Java. This makes it slower in execution than the original, but completely architecture independent. Like ARTooKit, NyARToolKit is a library of functions visual interpretation and integration of VR data into physical environment, including real-time camera vision functionality, 3D rendering of virtual objects, and integrating both into the output stream.

The name is due to the degree of self-promotion by its developer; Japanese man known as Nyatla in 2008, so the Ny got added to the toolkit name

Despite the language is written in Java, this toolkit also works well with C# and the Android operating system. Various other ports based on this toolkit, account for other languages and set-ups.

  - Features
    - Simple framework for creating real-time AR applications
    - Overlays 3D virtual objects on real markers (Magic Symbol)
    - A multi platform video library with multiple input sources, multiple formats supported, multi camera tracking supported, and GUI initializing interface.

- Fast and cheap 6D marker tracking (real time planar detection)
- Extensible marker patterns approach
- Easy calibration routine
- Simple graphic library
- Fast rendering based on OpenGL
- 3D VRML support
- Simple and modular API (in Java)
- Support Android phone natively
- Complete set of samples and utilities

- ***AR-media™ Plugin for Google™ SkecthUp™***

  This application allows its users to visualize their 3D models using AR directly in the real physical environment around them. Through AR-media™, 3D models can be visualized out directly on users' desktop, by connecting a webcam and attached the software with suitable code.

  This application also has an Export feature whereby it allows us to create and publish AR files freely. Other advanced visualization functionality is created to serves two main purposes:

  - Communicate 3D projects astonishingly
  - Study and analyze scaled virtual prototypes in real environments

- ***LinceoVR***

  LinceoVR is a one of most complete software for augmented reality, rendering and animation. This application is not open source software whereby the user needs to pay for its functionalities. The prices are as low as €25 and differ depends on the type of LinceoVR. This application also comes with total

support for Wowee Rovio (WiFi remote controlled AR Robots) and Vuzix iWear with CamAR (AR goggle).

- Features
  - Ravio AR Drones
  - Vuzix Eyewear native support
  - Augmented Reality
  - Batch Render
  - Realtime Animation
  - LinconeVR viewer

- ***HandyAR***

Figure 10.0 *Example of HandyAR*

HandyAR is a vision-based user interface that tracks a user's outstretched hand and uses it as the marker/ reference pattern for AR inspection. Through frame-by-frame reconstruction of the camera pose relative to the hand, the application will project 3D model on top of the hand, allowing the user to view the model conveniently from different viewing angles in AR.

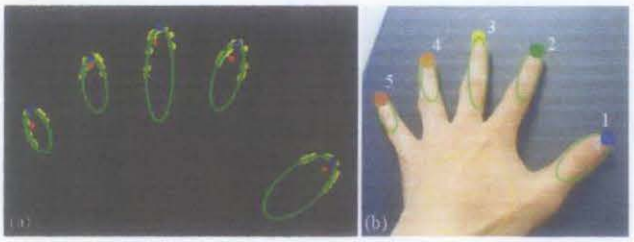


Figure 11.0 *Fingertips Detection in HandyAR*

This application is using fingertips detection technology whereby fingertips are detected using a curvature-based algorithm in the contour of user's hand. The contour point with a high curvature value is sought as a candidate fingertip point. Then an ellipse is fitted to accurately locate the fingertip. Five fingertips are detected and ordered based on the position of a thumb so that the fingertips are used as point correspondences for a camera pose estimation algorithm.

- ***D'Fusion Studio***

  D'Fusion Studio is brand that stands for the development of compelling AR applications with a high level of quality, using simple coding and secure content. This application recognizes and tracks 2D and 3D existing objects without requiring specialized markers.

  D'Fusion composed of two main modules: D'Fusion AR for animating and rendering 3D objects and D'Fusion Computer Vision for calibration and tracking of 2D/3D objects.

  - Benefits
    - Reduce time and cost for development isung Lua scripting and graphical authoring tool.
    - Uses existing customer products for AR tracking instead of requiring specialized markers.
    - Protects customer's brand name with a powerful encryption mechanism.
    - Create application once with D'Fusion and run it on any kind on platform.
  - Features
    - Compatible with Windows PCs.

- Design scene, define behaviours and interactions using common Lua language.
- The authoring tool is embedded into Auto Desk Maya to produce, preview and export 3D model into a real time engine.
- Optimized for camera and sensor calibration.
- Powerful rendering engine.
- Open framework, to easily add new plug-ins to match specific needs.
- Robust 6D tracking of 2D and 3D targets with point detection and a powerful face tracking mechanism.

2.1.4 Applications of Augmented Reality

AR is currently a growing field whereby it has been used across multiple fields including engineering, archaeology, medical, education, as well as advertisement and marketing. The following are some examples of current application using AR:

- ***Sports***

  Common example of AR application utilisation in sport is the yellow "first down" lines seen in television broadcast for American Football using the 1st & Ten system whereby TV viewers see "yellow line" (refer Figure 10.0) during a live broadcast of this game. This line is not physically present on the field and it only can be seen through television. AR application in sports also can increase user's watching experience even though they just watching from home instead of in the real location by identifying and informing the viewer about specific athletes or vehicles.

***Figure 12.0** "Yellow Line" in American Football.*

- ***Medical***

***Figure 13.0** AR Application in Medical Field.*

Utilising AR technology in medical field can increase doctors' accuracy in operating or diagnosing their patient. It is including enhancement of body-view with a virtual x-ray view, or anatomical elements as well as real time images from ultrasound or open NMR devices.

- ***Advertisement***

With the interactivity and exciting moment attached with this technology, currently, AR has been trends among marketer and advertiser to promote their products. Some of the company such Mini Copper has published the marker to view their new Mini Caprio (Figure) model by print it on the back of magazine.

Figure 14.0 MINI Cabrio viewed using AR Technology

2.2 Automotive Retailing - Dealership.

2.2.1 Physical Showroom.

For more than a century, car industry has been well established with marketing strategy using dealer as a middleman whereby a physical car showroom will be the office for them. With all the models of car that want to be displayed in the showroom, the customers can have a look or test-drive here with help from the dealer. Buying process taken in a showroom involving only interaction between the customers, the dealers, as well as the car model. The only source of information for the user is from the dealers there. The success of each transaction is highly dependent with effectiveness of services provided by the dealer itself. But high interaction with person (in this case is the dealer) has contribute to a lot of bad customer buying experience which is contributing to dissatisfaction. This problem has threatened car manufacturers as well as the dealers.

Figure 15.0 Physical Car Showroom

In short, physical showroom has limitations including:

- Limited number of models and choices for each model of vehicles available for evaluation (including colour, specification).
- Uninformative and unskilful dealer also will create dissatisfaction among the customer.
- Lot of effort for the customer to travel to the showroom just to see and evaluate possible car for them to purchase.

With the risen of Internet and its advantages, utilisation of new information technology has been seen as new escape for problem stated previously. According to paper return by KPMG, entitled, Developments and Success Factors in Automotive Retail, they predict that in 2015, only half of new cars sold in Germany and Switzerland will be sold via traditional dealership. The other will include direct sells between the customers and the manufacturers. This is on of evidence for utilisation of Internet in their business process. The changes in this industry have been seen with the emergence of Virtual Showroom and AR Showroom which I will discuss in next sections.

2.2.2 Virtual Showroom

With the emergence of Internet and E-Commerce application, some of car dealer has start to change their way of doing business and utilising Internet for their future expansion. Virtual showrooms have been seen as new trend of displaying and market their vehicles as a replacement or alternative for traditional dealership. This type of showroom doesn't require a real extra-location to display the cars plus the dealer just need to upload all the information and pictures about specific models and their contact information for the interested customer can contact them.

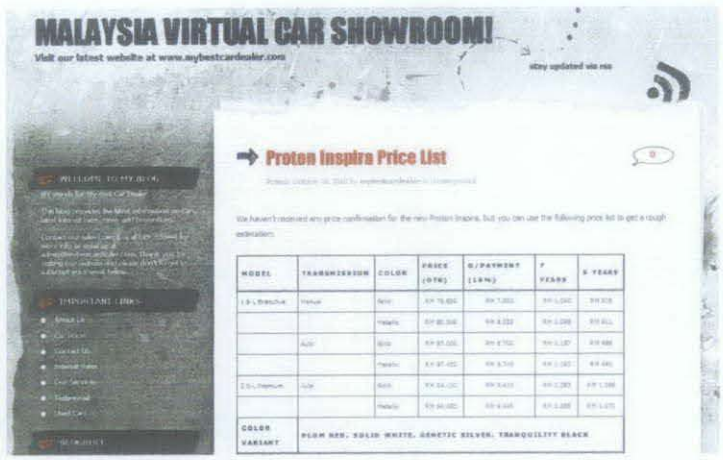


Figure 16.0 Example of Virtual Car Showroom

Even though the showroom had tried to overcome the second and third problem in physical showroom, but it is not a complete solution. There are certain limitations in this kind of showroom as follow:

- Limited picture of each models
- Each model's picture only available in one or two colour.
- Unattractive 2D picture for each model.

2.2.3 AR Showroom.

Another alternative for car manufacturer or dealer is by using AR showroom. Most of AR showrooms that available nowadays are being used to promote new model. Because of the interactivity in this technology some manufacturer and dealer this AR is a new way of advertise it. With the view 3D models overlay on the reality, this type of ad has increased its popularity and recently greater number of automotive companies are utilising it.

For instance, Nissan has developed a web-based application with AR technology as a promotion for their new model of 370Z.

Figure 17.0 Nissan 370Z AR Website

For Audi, on the other hand, they have used AR as an in-store application by installing a touch-screen kiosk and allow the user to interact with the 3D model of the car before it's arrives in the showroom.

***Figure 18.0** Audi A1 Model Launches using AR*

Although the idea is there for AR car showroom, but each idea has setback if it is need to be consider as replacement of traditional car showroom. Following are limitations of current AR showroom:

- Each website/application only provides one model of car with no specifications and choices of colours.
- Some of the website/application only allows the user to view the exterior design of the model and not the interior.

2.2.4 Augmented Reality and Car Showroom

In short, there are lots of limitations and challenges in marketing cars in automotive industry by using physical showroom, virtual showroom, and current AR showroom. A showroom should serve as place where the customer can evaluate each model exteriorly and interiorly. But with the emergence of Internet into picture, we tried to utilising and bring all the vital attributes of physical showroom to the customers but via Internet. Thus, this project will solve the limitations that have been addressed earlier in previous section by providing features as follow:

- Bring the showroom to customer via Internet through website application.
- Provide 3D model of car through AR technology.
- Allow interactivity between user and the application using marker and buttons on the application.

CHAPTER 3
METHODOLOGY

3. METHODOLOGY

3.1 Prototyping-based Methodology

In this project, in order to produce a final web-based application for car showroom integrated with augmented reality technology, the best method is to use prototyping-based methodology. This type of methodology is chosen to develop this application since we are converting conventional business model into Internet-based. Some of the features will be a new features but it will serve the same purpose. Therefore, we need to a way to define these new features as well as test it with the possible users in order to ensure it is achieving the objectives.

The prototyping-based methodology performs the analysis, design, and implementation phases concurrently, and all three phases are performed repeatedly in a cycle until the system is completed. The process can be pictured by **Figure 19.0.** With this method, as the analysis is being done, it will give us some ideas and features of this application and it will help us to improve it if it is required. It also will help the user to better understand the application without need to until the final stage and it will reduce the chances of producing undesirable product.

The prototype also will help the user to familiarize with the application as it delivers some of the features of final product. I can also can obtain feedback from the users before delivery process and have more time to improve and repair it based on the responds. The prototype also ensures that we are developing application that right on track.

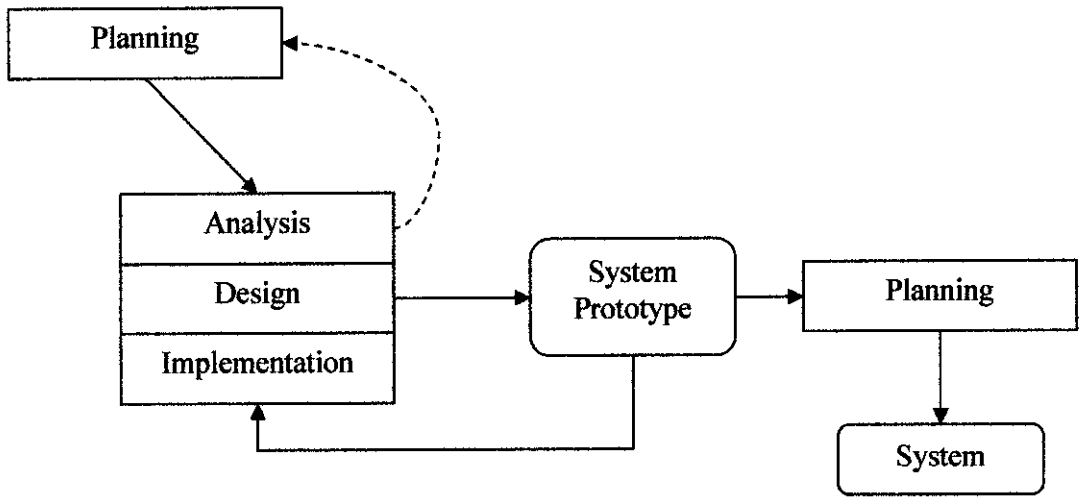


Figure 19.0 A Prototyping-based Methodology (Adapted from Systems Analysis and Design with UML Version 2.0)

3.2 Planning Phase

3.2.1 Introduction

The first step in any development project is to plan every step and technique that will be conduct during the whole project duration. In short, this phase will further refine the feasibility of this project, as well as the flow of it. In the next section, I will further analyse the idea of developing this project in terms of technical, economic as well as organizational to measure the success rate of this project. The second part of this section is to discuss the progress and flow for the whole project under project management.

3.2.2 Feasibility Analysis

3.2.2.1 Technical Feasibility Analysis

- ***Familiarity with Application***: AR application has emerged more than 20 years but the usage is still not as popular or familiar as other applications. But the simplicity of it by just integrating web-cam, website as well as provided marker, I believe that the users can easily adapt themselves to use this application well as other application. For me as the developer, it is unfamiliar technology

that I need to learn by myself to develop it. But, with the usage of Internet and available online tutorial, I believe that this application is possible to be developed.

- ***Familiarity with Technology***: This application is projected to use web-based application with the integration of web-cam. These two technologies/devices are used in today's daily activity with most of available software. With enough and simple guidelines, it should be a problem for the users as well as developer.
- ***Project Size***: Time allocated for this project is 12 months (1 year) which has been divided into 2 major sections; first half for documentation preparation and second half for application development. Even though I will develop this project alone, but with enough duration (1 year), I confident that I will achieve the objective at the end of this project and deliver the application.
- ***Compatibility***: Since this is web-based application, I believe the issue of compatibility is only on the usage of camera because some of the users might not have web-cam attached to their PC or laptop. Thus, this problem lead to the inability to view the final product.

3.2.2.2 Economic Feasibility Analysis

In terms of cost of developing this project, for the entire project, there will be a few hardware and software that I require in order to achieve the objective. For hardware, a PC and webcam are required. For software, development tools are available online in open source. Thus, I believe no extra cost required because it only require basic hardware that I already have and open source software.

3.2.3 Project Management

3.2.3.1 Gantt Chart

Month	1	2	3	4	5	6	7	8	9	10	11	12
Planning												
Analysis												
Design												
Implementation & Testing												
Delivery												

***Table 3.0** Gantt Chart*

3.3 Analysis Phase

In this stage, my effort are focusing on requirements determination that needed by the application. The purpose of this process is to turn a very high-end initial idea that I have previously into more precise list of requirements that can be used as inputs to the rest of analysis.

3.3.1 Requirements Definition

3.3.1.1 Non-functional Requirements

- ***Operational Requirements***
  - The application will operate in Windows environment
  - The application will be able to view in Internet Explorer 8.0 and above
- ***Performance Requirements***
  - The website should be available for use 24 hours per day, 365 days per year.
  - The users that have webcam should be able to view 3D model of car.
- ***Security Requirements***
  - No special security requirements are anticipated
- ***Cultural and Political Requirements***
  - No special cultural or/and political requirements are anticipated

3.3.1.2 *Functional Requirements*

- ***Printing***
  - The user should be able to print the provided marker in specifies size
- ***Make choices***
  - The user should be able to select the model and colour of the 3D car while using the application

3.3.2 Requirements – Gathering Techniques

For this project, in order to collect all the requirements and features of this application, I've decided to do three techniques for gather the requirements. They are:

- ***Observation***

  Through this technique, I've collect and compare available sites on Internet that provide information as well as giving services using showrooms that have been explained in the previous section (refer section 2.2: Automotive Retailing – Dealership). Using this method, I've gather certain basic requirements needed by a showroom as well as their advantages and limitations. This technique is the simplest and cheapest one since it does only require browsing and reading on Internet. For the time being, this is the only method in requirement gathering technique that I've done to get certain information and idea for this project.

- ***Questionnaires***

  A questionnaire is use for the third requirements-gathering technique to obtain from large group of people. As mention earlier, this project is objectively to understand customer purchasing behaviour towards buying cars using current available showroom. Thus, this questionnaire has been design to obtain their opinion towards current process as well as their awareness on AR technology.

  This survey will target on two groups of people. The first group is the dealer or showroom provider. The second one is the customer or more

on buyers of car. For the reference purpose, kindly refer on Appendix 2 for set of questions in this survey

3.4 Design Phase

3.4.1 Initial Idea

With the growing of Internet usage and upward trend of e-commerce application, I've saw lots of brick-and-mortar businesses have loss their competition unless the change their strategy. Most of it that still survives and expand is the one that have their store available online. But, for automotive industry, their involvement in online business is quite slow. Some of the reasons are because dealership system as well as function of showroom.

Showroom always serves as display room for car. Since each car have lots of features, thus, a showroom can give the opportunity for the interested buyer to observe and analyse it before they can make the decision. Some of the dealers have changed their steps by setting up their website and display pictures and information that vital for their prospect. But, this is still not enough because the customer loss the feeling and excitement that they can get from the observation at showroom. That is by seeing the physical car live.

Through AR technology, I believe that this main limitation can be overcome by giving the customers chances to observe 3D model of car similar to the one they can get from the showroom. Even though the size is not the same, but the feeling might be better than just view the 2D pictures. Initially, I've imagine that the interface will be look like something as follow:

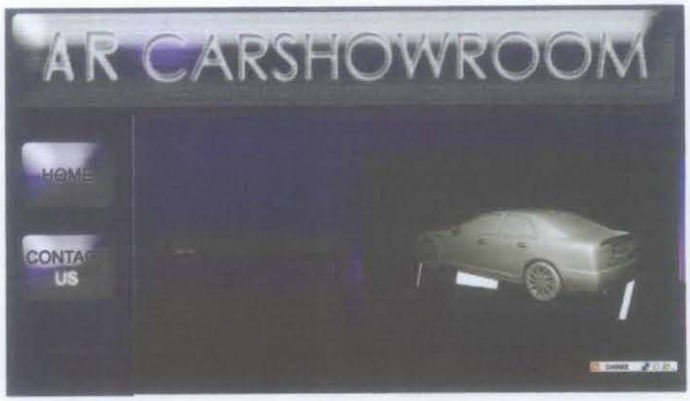


Figure 20.0 Initial Ideas for AR Car Showroom.

The interface should be as simple as possible because the main purpose is to allow the user view and interact with car's 3D model. That's why 70% of the website is focusing on the AR application. The button for this page also should be minimized to reduce user's confusion while using this web-page.

3.5 Implementation Phase

Implementation phase will start in month 7th after finish planning, analysis and design phase. Since, after all those phases, I should already have enough information and requirements to start the development phase.

3.5.1 Tools / Hardware

To develop a web-based application for car showroom with integration of AR technology, for sure my focus is on how to merge AR features to the website. As discussed and explained previously in the chapter two, I believe the most suitable technology for display for this chapter is to use monitor-based display.

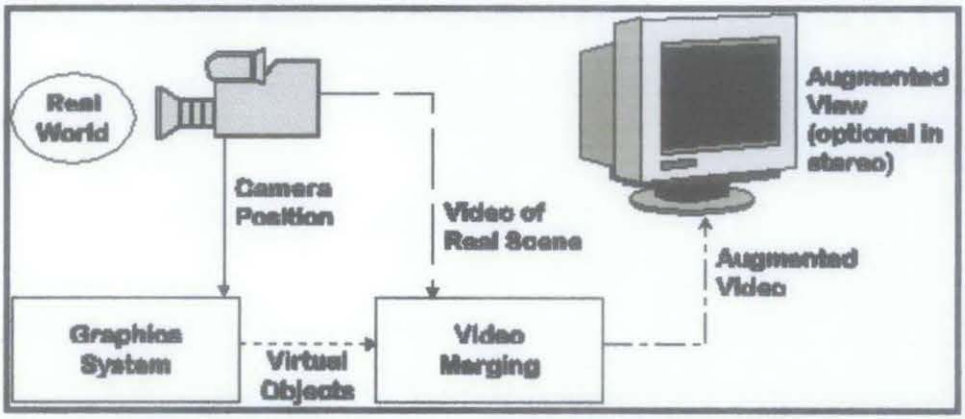


Figure 21.0 Monitor-based displays in Augmented Reality

Based on the above figure (figure), the main hardware that should available for using this type of display are:

- ***Webcam***: To track the position of pattern/marker for the overlaying of 3D graphics with the real environment.
- ***Computer Monitor***: To display the video of real environment with the 3D image in it.

3.5.2 Software

As per discuss in chapter 2, there are numbers of development tools available for developing AR application. But, after evaluating all the available tools, I've decided to continue the implementation for this project using:

- ***FLARToolKit***

  The main reason is because this tool allows me to apply AR technology to a web-based application. This is important since this project is really relying on website as a medium to convey the AR technology to the users.

  Secondly is because it is open source. For a project with limited fund, it is convenience for me to use free software with easy to access and download the software online. Free online tutorial provided by the provider as well as the community also will help me a lot in understanding and master the usage of this software.

- ***Adobe Flex***

  Adobe Flex is a software development kit (SDK) released by Adobe Systems for the development and deployment of cross-platform rich Internet applications based on the Adobe Flash platform. It can be written using Adobe Flash Builder or any other freely available Flex compiler from Adobe. Using Flex, I will integrate AR technology with my website.

3.5.3 Testing Phase

Software testing is conducted to get the feedback and the quality of the software. Software testing is purposely conducted to [19]:

- Meet business and technical requirements that stated during analysis and design phase,

- Software is working as expected, and
- Can be implemented with the same characteristic.

For this project, to evaluate the usability and the perception towards this system, two methods will be conducted; System Usability Scale (SUS) and Post-Interview with the users.

3.5.3.1 System Usability Scale (SUS)

SUS is a software testing method to test the usability of software or a system using Likert scale. It has been defined in the ISO standard ISO 9241 Part 11, and can be measured by take into consideration the usage of the system [20].

Key indicators in this method are:

- Effectiveness (can the user achieve their objectives)
- Efficiency (how much effort and resources taken to achieve those objective)
- Satisfaction (is it the experience give a satisfactory to the user)

3.5.3.2 Post-Interview.

To get better picture about the perception of users of this system, this second method is also important. Since every opinion can be subjective, post-interview can give a clearer picture about what people feel about this application and if there any improvement that can be done to overcome any limitations.

Group of people that will be interviewed to get their opinions are:

- Owner and dealer of showroom
- Customers at car showroom

Set of post-interview question has been attached in the Appendices section (refer Appendix 2)

CHAPTER 4
RESULT & DISCUSSION

4. RESULT & DISCUSSION

4.1 Application Prototype

4.1.1 Interface Design

After considering the initial design of the website as well as the storyboard, I've come up with a new design for the website. But, the main function for this website still remains the same. The new design for this prototype is as follows:

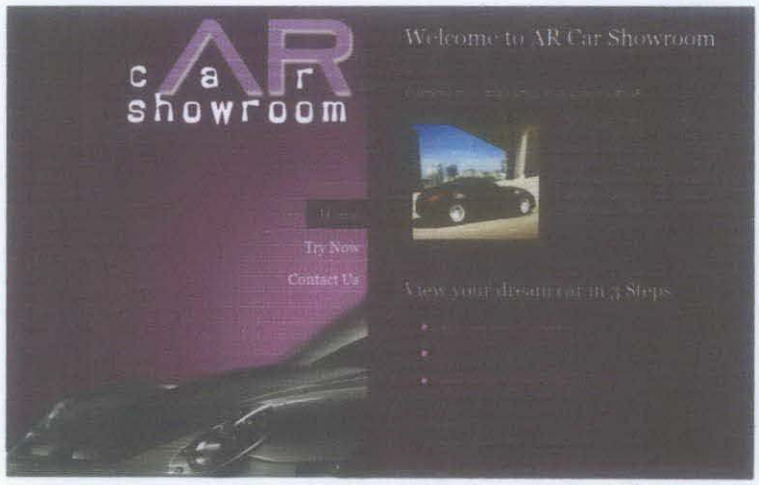


Figure 22.0 Homepage for AR Car Showroom website

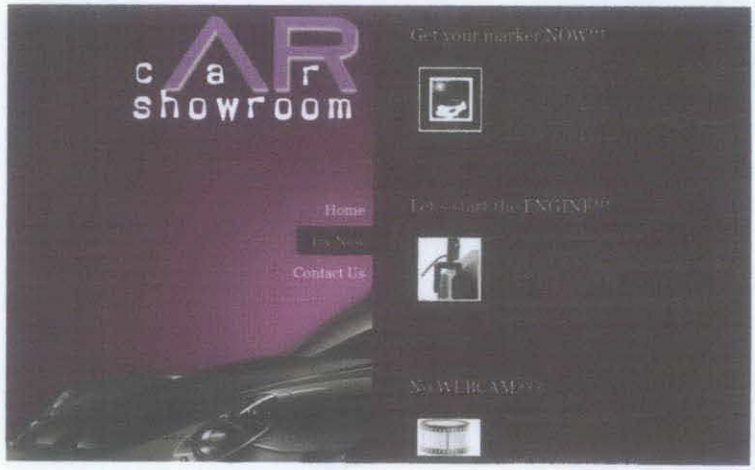


Figure 23.0 "Try Now"-page for user to try AR

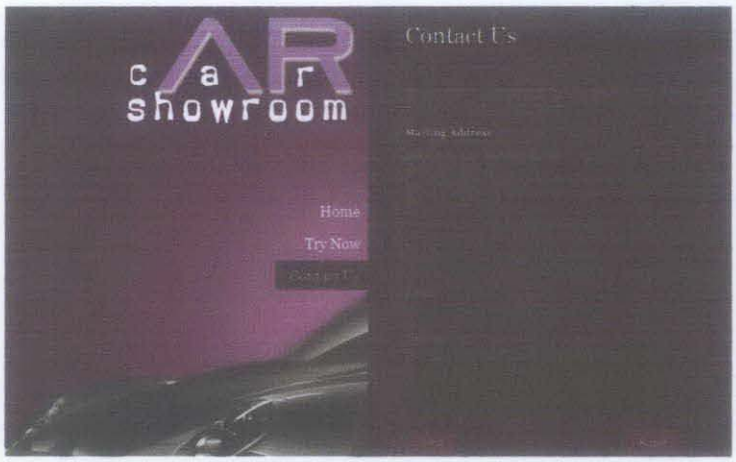
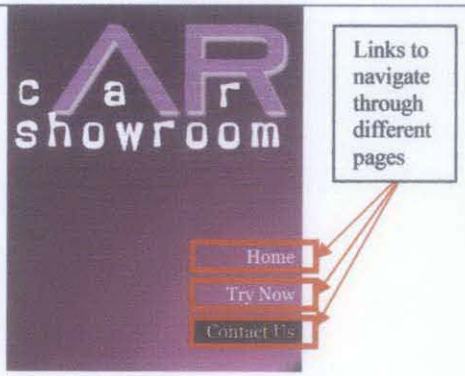
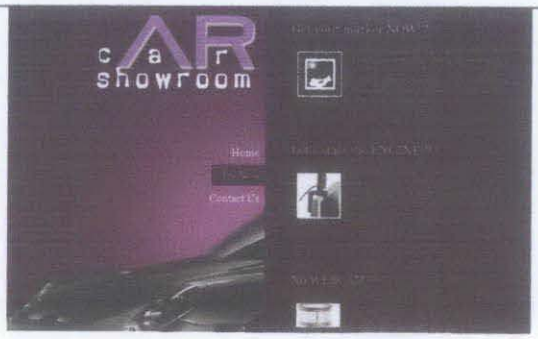
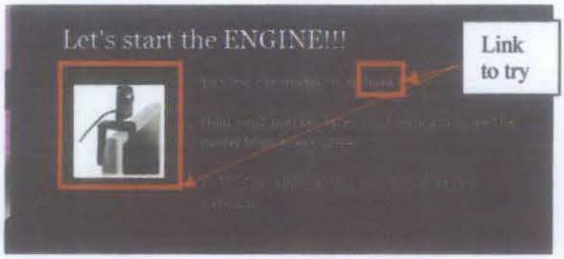


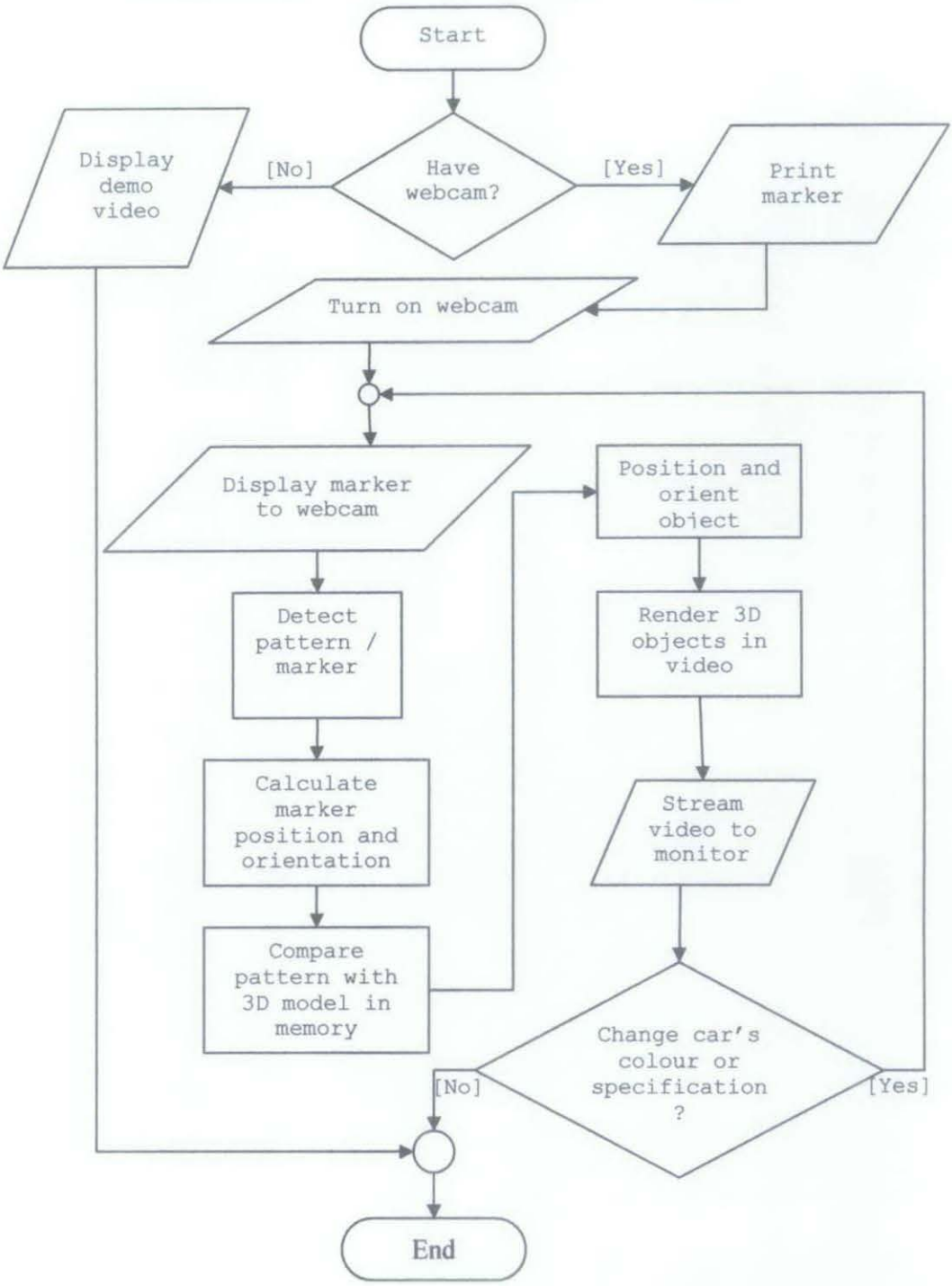
Figure 24.0 "Contact Us" page

The website will contain features as follow:

Features	Description
 *Figure 25.0 Main Menu Interface*	Main Menu
 *Figure 26.0 Page contains AR Interface*  *Figure 27.0 Link to download and print AR marker*	AR Application

Features	Description
 ***Figure 28.0** Link to try AR application*  ***Figure 29.0** If the users click on the link.*  ***Figure 30.0** Option for those who do not have webcam.*	AR Application (continue)

4.1.2 Flowchart *(Figure 31.0 Flowchart of System Prototype)*



4.1.3 System Prototype - Marker

I also already prepared the marker that will be downloaded and used by the user of this website to view the 3D model.

Figure 32.0 Marker for AR

4.2 Pre-Survey Result

This pre-survey is purposely design to collect the data regarding buying experience and their perception of using physical car showroom. For the details of the questionnaire question, please refer to Appendix 1. This questionnaire has been divided into 3 major parts; Participant's details, Part 1: Customer Experience and Perception and Part 2: Knowledge about Augmented Reality Application. In the two latest parts, the question is divided between question about customer experience towards car showroom and their opinion about AR application.

- **Participant's Details:**

  Number of Participants: 40

  Male: 13

  Female: 27

  Age – Bellow 30: 38

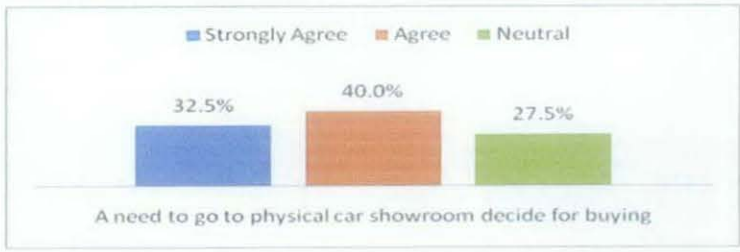
  Age – Above 30: 2

  With Car Buying Experience: 12

  No Car Buying Experience: 28

- **Part 1: Customer Experience and Perception**

1. **Question 1:** I need to go to car showroom/exhibition before I can decide to buy a car.



***Graph 1.0** Pre-Survey: Question 1*

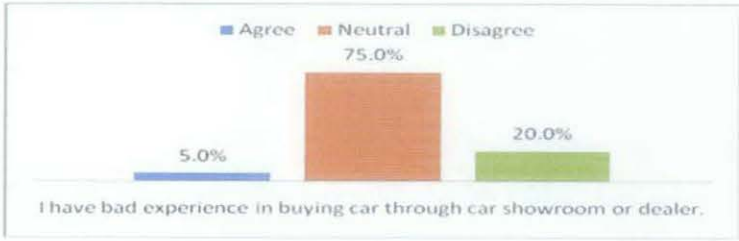
Excluding 'Neutral' responds, more than 70% respondents agreed to the importance of visiting car showroom in order to help them in decision making process.

2. **Question 2:** I found that car showroom and the dealer really helpful in assisting me to buy a car.

***Graph 2.0** Pre-Survey: Question 2*

Based on the above graph, more than 60% of the respondents are satisfied with the services provided by the dealers. But still, there are 5% of them that dissatisfied with the given services. Even though the percentage is small but still it has proved that some of dealers have been a caused to bad customer experience.

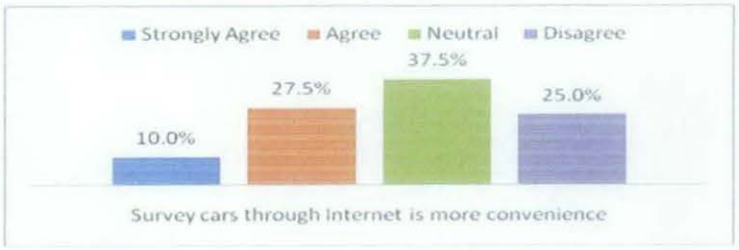
3. **Question 3:** I have bad experience in buying car through car showroom or dealer.



***Graph 3.0** Pre-Survey: Question 3*

This question is proved a similar result to Question 2 which is related to customer experience while buying car through the dealers.

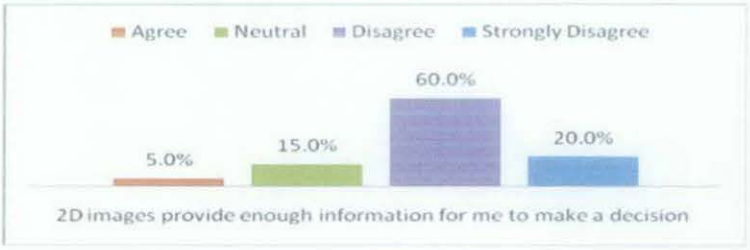
4. **Question 4:** It is more convenience for me to survey a car through Internet



***Graph 4.0** Pre-Survey: Question 4*

Almost 40% of the respondants agreed that Internet is a convenience medium for them to do survey about cars. Only 25% from them that disagree to this statement. While the rest, remain neutral.

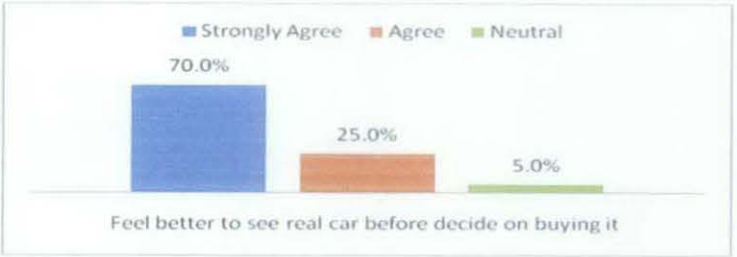
5. **Question 5:** It is enough for me to make decision by just viewing 2D picture of the car.



***Graph 5.0** Pre-Survey: Question 5*

80% of the respondents believed that it is not enough to just viewing 2D picture while deciding for car purchasing. On the other hand, the current website of most automotive company is only allows their customer to just view 2D pictures on their websites.

6. **Question 6:** I feel better to see a real car before I want to buy it rather than just a photo.



***Graph 6.0** Pre-Survey: Question 6*

This question is to re-stress the importance of viewing real car model before the customer can decide whether to buy it or not. As a result, more than 90% of them agreed to this statement while the rest stay neutral.

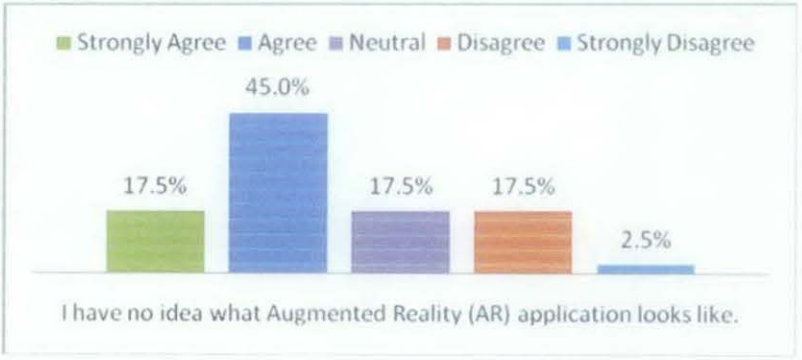
7. **Question 7:** I have a hard time to decide my car's colour because I can't imagine without seeing it.

***Graph 7.0** Pre-Survey: Question 7*

Through this question, we can conclude that more than 70% of the user have difficulties to imagine the prospective colour for their car without looking to the example of it. Thus, it is important for the dealers and automotive company to prepare a medium whereby the customer can see how to model will look like in different colours.

- **Part 2: Knowledge about Augmented Reality Application**

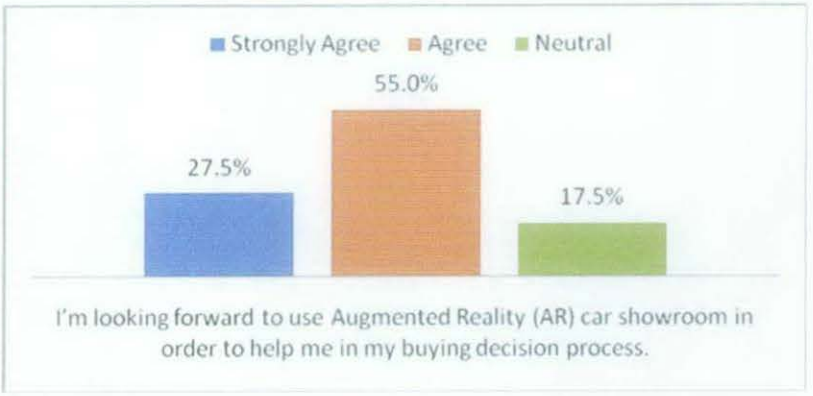
1. **Question 8:** I have no idea what Augmented Reality (AR) application looks like.



***Graph 8.0** Pre-Survey: Question 8*

From this question, we can see that more than 60% of the respondents have no idea about Augmented Reality application.

2. **Question 9:** I'm looking forward to use Augmented Reality (AR) car showroom in order to help me in my buying decision process.



***Graph 9.0** Pre-Survey: Question 9*

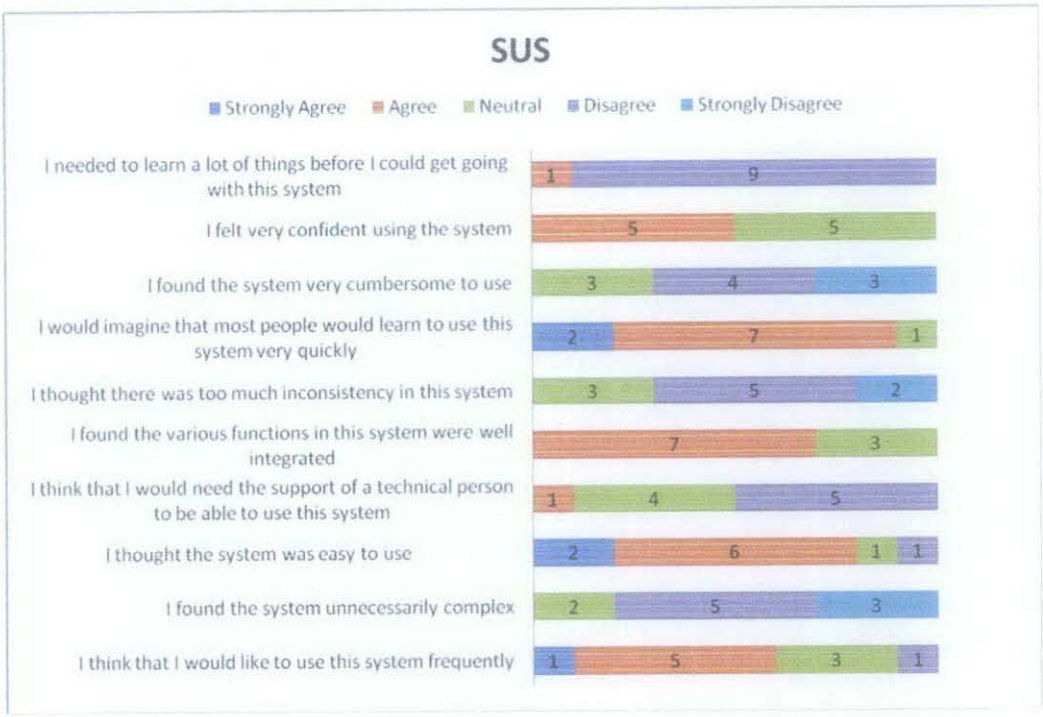
From this question, we can say that more than 80% of the respondents are interested to try using an application improved with AR technology in order to help them in making decision in buying process.

4.3 System Usability Scale (SUS)

In order to evaluate this system using SUS, I have tested it to 10 volunteers. The score from this questionnaire have been calculated using formulas as follows:

- For odd items: subtract one from the user response.
- For even-numbered items: subtract the user responses from 5.
- This scales all values from 0 to 4 (with four being the most positive response).
- Add up the converted responses for each user and multiply that total by 2.5.
- This converts the range of possible values from 0 to 100 instead of from 0 to 40.

The total respond from all participants are represented by graph bellow:



***Graph 10.0** Pre-System Usability Scale Responds*

Average score is 70.25% which is indicates that this system is good in terms of usability as stated as rule of thumb for this SUS is if the average score is more than 60%, than the system is good in term of usability.

4.4 Perception of Target Users

Along with SUS, I also have asked their perception towards this system in terms of viewing car models. Basically, there are two kind of perception towards it. One group think that this system is really interesting because it provide an interactive website whereby the user can interact with website on real-time basis. On the other hand, there are also respondents that feel this system is not enough to give them the view and feel of car models as good as car showroom.

Some of the comments are as follow:

- "It is interesting to have 3D display of car without going to the exact shop. Compare to most website, they give still 2D picture that doesn't show 360° of the car prospect."
- "Convenient at time to see the car 360° view."
- "It is better if to compare with existing website but still lacking in many aspects such as car specifications which is also important in making a decision for buying a car."

CHAPTER 5
CONCLUSION

5. CONCLUSION

In a nut shell, based on the pre-survey and post-survey that have been conducted related to the project entitled, An Online Augmented Reality Based Car Showroom, it has indicated the importance of viewing car models before a buying decision can be made. Most people feel it is not enough by just viewing a 2D picture in order to help them in their decision making process. They also feel that current showroom and dealers has giving big help in terms of this matter, but some also complaint that they have encountered a bad one. Most of them also believed that Internet has make things easier for them to do their own survey instead of going to every showroom.

Thus, with those input that I've received from this pre-survey plus with my observation of current websites, I've come out with my own design and development of the system whereby it has integrated the Internet and 3D model into one, with the help of AR technology. I've successfully developed the prototype that allows the user to see the 3D models and interacting with it using AR concept.

Based on this prototype, I've asked few of target users to test it and see their respond in terms of usability and perception towards the system prototype. In terms of usability, as per discuss in Chapter 4, it has achieved average score of 70.25% which can be concluded as very usable. In terms of perception, the result is very subjective but most of the responds can be concluded as a positive respond but there is still room for improvements.

REFERENCES

1. ***Simulation and Modelling, Current Technologies and Applications*** (2008) by Asim El Sheikh, Abid Al Ajeeli & Evon M. O. Abu-Taieh.
2. Allan Dennis, Barbara Haley Wixom, David Tegarden (2005). ***System Analysis and Design with UML Version 2.0***, United States of America, Wiley International Edition.
3. ***Information Technology: Changing the face of automotive retailing?*** (2004) by Gary Reed, Vicky Story & Jim Saker.
4. ***Augmented Reality.*** From Wikipedia website: en.wikipedia.org/wiki/Augmented_reality
5. ***What is FLARToolKit?*** From Spark Project website: http://www.libspark.org/wiki/saqoosha/FLARToolKit/en
6. ***A brief history of Augmented Reality (AR) and names of key researchers associated with AR.*** http://augreality.pbworks.com/History-of-AR-and-Key-Researchers-
7. ***Mortoin Heilig*** http://en.wikipedia.org/wiki/Morton_Heilig
8. ***Jaron Lanier***. http://en.wikipedia.org/wiki/Jaron_Lanier
9. ***Videoplace***. http://en.wikipedia.org/wiki/Videoplace
10. ***Components of AR***.http://www.tech-faq.com/augmented-reality.html
11. ***Rendering Methods for Augmented Reality.*** http://www.janfischer.com/publications/Fischer06_PhdDissertation.pdf
12. ***Introduction to Augmented Reality.*** http://www.se.rit.edu/~jrv/research/ar/introduction.html
13. ***ARToolKit.*** http://www.hitl.washington.edu/artoolkit/
14. ***Developments and success factors in automotive retail.*** http://www.kpmg.sk/dbfetch/52616e646f6d4956b711729ff43b6a8cf10c2afd8737de4fe9f584cd5937e4f4/automotive_retail_-_dealership_-_web.pdf
15. ***Malaysia Virtual Car Showroom!*** http://mybestcardealer.wordpress.com/ourservices/
16. ***My Best Dealer.com.*** http://www.mybestcardealer.com/

17. ***Audi's Digital Showroom.*** http://touch.schematic.com/2010/03/audis-digital-showroom/

18. ***iQ_Reality. Experience the new iQ in 3D.*** http://www.toyota.co.uk/cgi-bin/toyota/bv/frame_start.jsp?id=iQ_reality

19. ***Software Testing.*** http://en.wikipedia.org/wiki/Software_testing

20. ***System Usability Scale.*** http://en.wikipedia.org/wiki/System_Usability_Scale

21. ***SLARToolKit – Silverlight Augmented Reality Toolkit.*** http://slartoolkit.codeplex.com/

22. ***NyARToolKit.*** http://www.virtualworldlets.net/Resources/Hosted/Resource.php?Name=NyARToolKit

23. ***AR – media™ Plugin for Google™ SketchUp™.*** http://www.inglobetechnologies.com/en/new_products/arplugin_su/info.php

24. ***LinceoVR.*** http://linceovr.seac02.it/

25. ***HandyAR.*** http://ilab.cs.ucsb.edu/projects/taehee/HandyAR/HandyAR.html

26. ***Total Immersion - D'Fusion Studio.*** http://www.t-immersion.com/en,on-stage-presentation,33.html

27. ***Adobe Flex.*** http://en.wikipedia.org/wiki/Adobe_Flex

APPENDICES

1.0 Appendix 1: Questionnaire

Participant's Details.

Gender :	☐ Male	☐ Female
Age :	☐ Bellow 30	☐ Above 30
Have experience in buying car?	☐ Yes	☐ No

Kindly (/) on related fields.

Legend

SDA: Strongly Disagree **A:** Agree

DA: Disagree **SA:** Strongly Agree

N: Neutral

	SDA	DA	N	A	SA
Part 1: Customer Experience and Perception					
1. I need to go to car showroom/exhibition before I can decide to buy a car.					
2. I found that car showroom and the dealer really helpful in assisting me to buy a car.					
3. I have bad experience in buying car through car showroom or dealer.					
4. It is more convenience for me to survey a car through Internet.					
5. It is enough for me to make decision by just viewing 2D picture of the car.					
6. I feel better to see a real car before I want to buy it rather than just a photo.					
7. I have a hard time to decide my car's colour because I can't imagine without seeing it.					
Part 2: Knowledge about Augmented Reality Application					
8. I have no idea what Augmented Reality (AR) application looks like.					
9. I'm looking forward to use Augmented Reality (AR) car showroom in order to help me in my buying decision process.					

Thank you for participating in this survey

2.0 Appendix 2: SUS and Perception Post-Survey

System Usability Scale

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Perception

In words, please state what you feel after using this system.

_____

_____

_____