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Evaluation of augmented reality technology for the demonstration of KIA EV6

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The authors declare that they are the sole authors of this thesis and that they have not used any sources other than those listed in the bibliography and identified as references. They further declare that they have not submitted this thesis at any other institution to obtain a degree.

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ABSTRACT

In this thesis, the augmented reality application is developed for the demonstration of the KIA EV6 car. This application demonstrates the car to the users, the user can experience the detailed view of the car right in front of their eyes just by sitting in their houses and having great information. The survey is conducted based on performance, portability, and scalability. The motivation of the thesis is to evaluate the users' feedback when they experience the augmented view of the KIA EV6 car.

Background: Augmented reality commonly known as 'AR' is a system that supplements the real world with virtual objects that appear in the same space as the real world [1]. The word Augment is from the Latin word Augere which means "to increase" or "to add". So, AR adds the information which is the virtual information to the existing real world [2].

Objectives: The main objective of the thesis is to evaluate the users' experience when they encounter the augmented reality of the KIA EV6 car. The survey conducted on users' experience is evaluated and many metrics are measured like the system response, the performance, the previous knowledge of the user, etc.

Methods: In the research, the demonstration of the KIA EV6 model car is implemented for the AR view and to evaluate the users' experience. This implementation includes the 3D model for the user to have detailed knowledge of the car's physical appearance, the demonstration also includes the 360-degree view and inner view of the car through which they can get into details of the physical features of the car. Based on these features, the user provides their experience through the survey by comparing the real-world demonstration i.e., when a person gives a demonstration orally by showing the image of the car and when the person gives an augmented demonstration. A survey is conducted and, in this survey, the metrics are used to measure the scalability, performance, and portability of the augmented reality application of the KIA EV6 model car. This implementation can be achieved using "Unity" and "Vuforia engine". In unity, using the vuforia engine a video of the KIA EV6 car is superimposed on to the image of the KIA EV6 car, which is the image target. The survey is conducted for 34 users and all the users experienced the application and provided their feedback.

Results: The augmented reality application is developed and the users view the application i.e., the demonstration of the KIA EV6 car. The survey is conducted, the results are obtained and the results are depicted in the bar chart and pie charts.

Conclusions: The user experience of the demonstration of the KIA EV6 car, is evaluated based on the metrics i.e., performance, quality, and interaction of the AR application. Upon evaluating these metrics through a survey, it is observed that users are interested in investing in these kinds of applications for a better experience.

Keywords: Augmented reality, Superimposition based augmented reality, Survey evaluation, Unity, Vuforia.

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LIST OF ACRONYMS

Acronym

3D

AR

GPS

HMD

QR code

VR

Unfolding

Three dimensional

Augmented Reality

Geo-Positioning System

Head Mount Display

Quick Response code

Virtual Reality

1 INTRODUCTION

Buying a car has always been a huge task, when people buy a car, they need to check the options available and then filter it further. The filters when a person buys a car would be namely color, price, and last but not the least features. Features play the important role in buying a car, to exactly know how efficiently the car operates or works. One must know what sort of features a car consists of and they end up going to the car showroom to get to know in detail, not particularly one showroom, but, more than the fingers on our hands, which further is a difficult and time-consuming task.

Ever thought of going through the features of the car by sitting in your own space. To make the users' lives easier, the implementation of one such application which shows the feature of the car by sitting in your workspace. With the help of this application, the user can save a lot of time, and money. To have access to this application the user needs two things, one is the image of the car which in general will be provided in the pamphlet of the car company. The other will be the application through which the image is scanned and the features of the car are viewed through the application. The application used here is made by using the most sophisticated technology known as "Augmented reality".

"An Augmented reality is also known as 'AR', it is a technology that imposes the real world with virtual objects that appear to coexist in the same space as the real world" [1]. The properties of augmented reality: combines real and virtual objects in a real environment, runs interactively, and in real-time, and aligns real and virtual objects with each [1, 3]. The word Augment is from the Latin word Augere which means "to increase" or "to add" [1]. So, AR adds the information which is the virtual information to the existing real world [2].

In AR the developers increase the part of the physical world of the user with the help of the input that has been generated by the sophisticated machines. In this, the developer gives the input to the application such as the video, graphics, GPS overlays, sound, etc., [4] When the user uses the application then the deployed input is shown to the users in no time as soon as the application starts working. It is said that the AR started back in 1901 [4]. In 1990 AR was evolved as a technology by Thomas Caudell. while designing to help Boeing workers visualize intricate aircraft [4]. This technology was further advanced in 1992 while working for the US Air Force [4]. Augmented reality notably released the following into the real world, they are the AR Quake game in the year 2000 and the design tool AR Toolkit in the year 2009. In technological explosion happened in the early 2010s, one of the examples is the Microsoft HoloLens in the year 2015, this invention was way beyond the classical understanding of the augmented reality, during this time the AR software was immensely increasing and was affordable and popular [4].

In the 2010 the augmented reality developers made a long step; in this time the AR lessons were quite cheaper. In 2014 Pokémon GO was developed using augmented reality, the Pokémon GO is a gaming application and a GPS-oriented application. In this application, the Pokémon characters are inserted into users' environment and the users have to find the character on the device screens such as mobile or desktop. Another example is Google's AR stickers where users give the real image to the cameras, user find these stickers more entertaining and appealing. Using the AR application, the user can experience virtual things which seem to be real, engaging, and fun. AR can be further seen in the application and education.

AR has different modals such as vision, audio, and sense of touch and motion. It uses cameras, sensors, and, HoloLens to see and understand the physical world. The AR glasses and the phone, map the environment and also keep track of where we are in relation. This process allows the user to place virtual information into the real world, which makes the user believe, that it is actually in front of them [5].

To implement the project using augmented reality, an application is developed, which is indeed implemented using the “unity” and “Vuforia engine”, to demonstrate the KIA EV6 car. The object used in this is the image of the KIA EV6 car, on this object the augmented information is superimposed. The perception of the AR view is achieved using the graphic systems in the Unity. The application is implemented for android mobiles, when the user scans the image of the KIA EV6 car through the application the augmented reality demonstration of the vehicle appears on the image. After the demonstration, a survey is conducted which helps in deriving many user experiences and then evaluating the results obtained. Usage of headset is not required in the process and the outcomes can be viewed on the object used with the help of the android mobiles [5].

Augmented reality, is used in many industries like entertainment, engineering, marketing, hospitality and many other areas because of its ability to combine real and augmented world [5]. AR encounters in everyone’s daily life unknowingly.

- **Gaming:**

AR has been part of the gaming industry for about almost 4 years. Pokémon Go application was one of the most famous gaming applications, in past 2016. This game application made of augmented reality is GPS based, it uses the user’s location details to display virtual characters which are present in the game into their physical world [5]. This game is known to have more than 65 million users, in 2017 [5]. Minecraft, one of the evolving AR games is providing entertainment to the users [5].

- **Sports Broadcasting:**

Similar to gaming, sports play a vital role in our everyday lives. More than 80% of the world population watch sports whether that may be live, on TV, etc., to make the lives of the people easy in sports, AR have been evolved in the sports industry. Due to AR in the sports industry immense traffic and the quality of the live sports were increased. By introducing the o sports, the audience can easily connect to the game, in the game the live display of the score is seen. With the help of the AR the person watching the match through television can have the same experience as that of the person in the stadium, and to make this happen AR glasses are used.

- **Shopping:**

Earlier, if someone has to do shopping then they must visit the store, but after improvising the shopping industry with the AR, the user can sit in their home and can shop just by adding the details of the product such as the name, color. With the help of the AR the user can view the 3D orientation of the AR.

- **Video conference:**

The video conference came into utilization in the late 90’s before the evolution of the video conference, people used to write a letter to interact. But with the immense increase in technology, video conference has evolved over the years, with the help of augmented reality one can apply any sort of video and can live stream. “Instagram video chat” is an example of this type of evolution.

In the same manner, mentioned above, in this thesis, the AR application is developed for the demonstration of the KIA EV6 car. This application demonstrates the car to the users, the user can experience the detailed view of the car right in front of their eyes just by sitting in their houses and having a piece of great information. The survey is conducted based on performance, portability and scalability, and many more metrics. The motivation of the thesis is to evaluate the users’ feedback when they experience the AR view of the KIA EV6 car.

1.1 Aims and objectives

The aim of the thesis is to develop and evaluate the user experience of the Augmented reality application of the KIA EV6 car using the “UNITY” game engine. Here, the augmented view of the car is developed by superimposing, and then the survey is conducted.

Objectives are as follows:

1. Gather the data of the KIA EV6 model car and also the data of the object, which is to be superimposed.
2. The superimposition is implemented in Unity with the help of the Vuforia engine for AR.
3. The superimposed file is built for the android applications.
4. Testing the obtained apk file on the android application, with the help of user experience apk file is validated.

1.2 Research Questions

1. How does the users’ experience differ between the real and the augmented view (virtual world) during the KIA EV6 car demonstration?

Motivation: The motivation of this research question is, most of the time when the user views the brochure of the KIA EV6 car then they may not get the clear overview of the car. They end up going to showroom to get detailed information, which consumes a lot of time. To avoid that the AR application of the KIA EV6 car is implemented, and then the users’ experience is evaluated. The evaluation that is conducted is survey evaluation. Through this evaluation, the difference between the real and virtual demonstration is observed. The results are obtained based on the users’ experience, when they view the AR demonstration of KIA EV6.

1.3 Scope of the thesis

The focus of the thesis is to develop an augmented reality application for KIA EV6 car which consists of the details of the car. When scanned the target image of the KIA EV6 car using the android mobile with the application the AR view appears on the screen. Then, the survey is conducted to the users of the application and then the user experience is evaluated.

1.4 Overview

The thesis consists of chapters and their subdivisions and structure in the following way:

Chapter 1 consists of the introduction of the thesis it also consists of the fields like aim, objectives and research questions. The introduction displays the information about augmented reality and the aim and objectives are the things achieved in the project. The next chapter consists of the background in the background the types of augmented reality are specified and also the evaluation methods are also mentioned. The 3rd chapter consists of the related work, the papers are applications similar to our thesis are researched and a summary of each paper is provided in this section. In the 4th chapter, the main method of how the thesis is developed is provided and the next chapter consists of the results of the method and the analysis here the survey analysis is performed and evaluated. The 6th chapter consists of the discussion and analysis and how the research question is addressed is mentioned in this section. The 7th chapter consists of the conclusion that can be drawn after the execution of the thesis and what can be further implemented in the future.

2 BACKGROUND

2.1 Augmented Reality (AR)

Augmented reality which is commonly known as ‘AR’ is the technology of superimposing the virtual objects on to the real-world environment. It is a fast-evolving technology that has successfully landed into many sectors, in no time. There is always a confusion between virtual and augmented reality [6] as shown in figure 2.1. Virtual reality also known as “VR” is the technology which stimulates the realistic environment i.e., in the virtual reality the participants or the users are placed in to the virtual world consisting of the virtual objects and environment [7]. To achieve the virtual reality the requirements can be: sensors, effectors and reality simulators [7]. And there is the combination of both virtual reality and augmented reality and that is known as Mixed reality. Even this requires hardware like HoloLens, holograms [8].

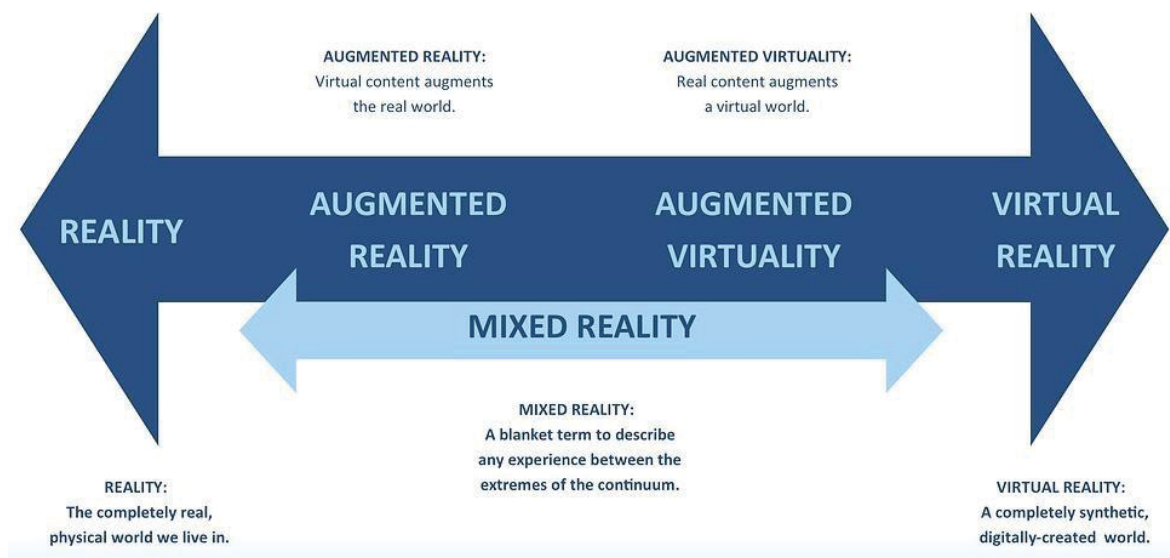


Figure 2.1 Reality-virtuality continuum created by Paul Milgram [3], [9],[10].

AR further consists of:

- The first one is the marker-based AR
- Next is the marker less AR
- Followed by the Projection based AR
- The last one is the Super imposition-based AR

2.1.1 Marker-Based AR

This is a type of augmented reality in which a marker is used, the visual marker can be a QR code or any 2D object. First a camera is used to scan the QR code after the camera senses the code then augmented output is present [11]. Here marker detection algorithm can be used and the distance of the camera to scan the marker is calculated and kept in a way that it detects the marker. The marker can be a simple object from the real world like banners, brochures, logos or any QR code [12]. In this using the marker-based detection algorithm the images are divided into regions and they are divided in such a way that the images are detected [11]. Then the segments that is the background or the things in which the object is placed are found and merged into lines. These were merged so as to keep the distance correct dimensions of the marker.

2.1.2 Marker Less AR

In this type of augmented reality, no objects like markers are used but here the access is given to location for the good experience of navigation. This can be done with the help of digital compass, accelerometer, velocity meter or Geo positioning system [11]. Here the main objective and detection are of the colors, styles and other features. It also detects the flat surfaces and places the augmented objects and view. Example of this AR can be the Pokémon Go [13].

2.1.3 Projection-Based AR

This augmented reality can also be called as Spatial augmented reality [12], here in a specified zone the objects and users can move, and even view the augmented objects. Here the light is projected on to the surface and the view is possible by the interaction of touch on the surface [11]. When the users touch the light projected area then the view is possible, this can be seen in the weather reporting news channels. When the reporter touches a particular place, the rainfall and the weather conditions in that particular area appear on the screen [12].

2.1.4 Superimposition-Based AR

This is a type of augmented reality where the object i.e., the image target plays a crucial role, when the user scans the image target then the video that is superimposed appears on the object. IKEA augmented reality furniture application is the example of the superimposition based augmented reality [11].

In this thesis to implement the augmented view of the KIA EV6 car superimposition-based augmented reality is used. A video demonstrating the KIA EV6 car features is superimposed i.e., laid over the object, in this case, the image of the KIA EV6 car is used and the whole application is developed in Unity 3D.

2.2 Evaluation

Evaluation can be done in two ways they are: Formative evaluation and Summative evaluation [14]. Formative evaluation is the evaluation takes place before the implementation. Based on this the outcome will yield good results based on the evaluation [15]. The summative evaluation is the evaluation that takes place after implementation is completed. The testing of the implementation gives a proper functioning. The evaluations are of 5 types:

- Analytical
- Expert
- Observational
- Survey
- Experimental

2.2.1 Analytic evaluation

The analytic evaluation, is an evaluation that is used when there has to be a connection between the data to be evaluated and the standard metric of evaluation of the data. In this analytic evaluation, the evaluation is done by the experts and there can be no users for the evaluation. This consists of two methods they are cognitive walk-through method and Heuristic method [16]. In cognitive walk through, the experts evaluate in a way that the users had to go through. In this the complete description of the data has to be provided, the tasks that the user has to perform are analysed. Detailed explanation of who the users are, what kind of knowledge and experience they can have, is specified. By defining the inputs and knowing the sequel of tasks the information has to be stored, in this way cognitive walk through can be used. Then coming to the heuristic method, here the usability experts evaluate the data [17]. It helps in understanding the usability problems in the user interface designs [16]. The experts give a thorough

check of the user interface and use the heuristic principles to fix the issues. In this way analytic evaluation can be achieved.

2.2.2 Expert evaluation

In this expert evaluation, experts perform the evaluation for the projects. Here the experts are the people who have the knowledge over the perspectives of the project or task, and have experience in them [18]. They will analyse the problems and find solutions, sometimes the experts even use heuristic principles to compare and evaluate the projects. This expert evaluation can be categorized under the formative evaluation. The evaluation is done before the implementation is performed and can make changes if necessary. It can considerably save time and is easy as there is no task of the contribution and collecting of users' feedback and experiences.

2.2.3 Observational evaluation

Observational evaluation method consists of the observers or the researchers. In the observational evaluation, the participants go through the project or product. When the participants are going through that, the researchers observe the interactions, their activities, problems faced while interacting, behaviour and analyze the users' behaviour [19]. Observation can also be a direct observation i.e., directly when the user is going through the process or it can be observing through the video recording. It can also be a verbal protocol that is thinking out loud.

2.2.4 Survey evaluation

Survey evaluation is the evaluation, in which the data or the information is collected in a derived way. Here the participants are the users of the product and they were asked to give feedback in the form of open and closed questionnaires. The questions of the survey are to be logical, simple to understand and in a way that the users can answer them after their experience with the provided task. Closed ended questions consists of the scales, ranks, multiple choice, check lists. The open-ended questions are those that are free to the users i.e., they can freely answer the questions in their own descriptions. Open-ended questions start with the "w" questions like 'who', 'how', 'what', 'which', 'why' and also with 'tell me about', 'describe' [20]. In this way, the users' feedback is collected and that is evaluated to know more about how the product or project works and what loopholes need development.

2.2.5 Experimental evaluation

The experimental evaluation is that, the people who are evaluating the product/ project or the task give in different input variables and yields the measurements of the outputs. They will analyze the outputs depending on the input variables given. The input variables are independent but the output depends on the respected input variables [21]. In this, the evaluators formulate the goal of evaluation then they provide inputs to yield the outputs and hypothesize the results.

In this thesis the evaluation method that is used is the survey evaluation, here closed questionnaires are provided to the users who have got to experience the demonstration of the KIA EV6 car. The users gave their feedback of the augmented view of the car through google forms.

3 RELATED WORK

In the research article [22] gives the information about the augmented reality application used enhancing the interior design using marker and marker less tracking. The main idea of this is that to see if the furniture that people are purchasing may or may not fit in the place, they wish it to be in their homes [22]. So, to help the customers they have developed an android augmented reality application. This application helps to visualize how the furniture pieces look like in the homes. For this they have created 3D models and then developed an application using Unity. Next, they have performed three experiments to test the application they are image analysis with marker tracking, image analysis with marker less tracking and users' satisfaction of using the application [22].

The research paper [23] depicts the evaluation of augmented reality technology for the design of an evacuation training game. Most of the people do not have idea what to do when any dangerous situation like earthquakes, fire accidents take place when they are in their particular buildings [23]. So, to train the people to safely evacuate or escape the devastation this AR design is used. In this the authors developed a game using augmented reality technology to educate the employees in a particular building when events like earthquake, fire and chemical attack takes place [23]. For this they have used Unity 3D for the objects and ARkit to combine these digital objects with the environment. They collected feedback from the emergency support team and also analysed the response of 36 participants [23].

Jad Chalhoub and Steven K. Ayer [24] have implemented AR technology in the construction layout tasks. In this, points lay out the construction site practitioners generally mark points i.e., locations where the construction devices have to be installed or the construction space to work. They have used a head mount display for hand-free viewing of the content [24]. They had twenty-three practitioners who participated in the point lay out tasks and were questioned based on the accuracy, and performance of the view. The results clearly praised the AR which enabled a faster layout of points rather than using physical and mental efforts [24].

In the research paper [25] the authors have created an augmented reality application for museums and provided a QR code to scan which leads to an augmented view of the artifacts. In this when the QR code is scanned the particular video or the audio appears for the user which gives valuable information about the museum art. Then they conducted the usability evaluation, the aspects that they considered are functionality, easy learn, easy to remember, effectiveness, efficiency, satisfaction, understanding, and design standards. The augmented reality (AR) interface is first evaluated for the cognitive walkthrough and also with the questionnaires and most of the participants were android mobile users. The users were asked to give feedback about the usability aspect of the augmented application of the museum and were also asked to answer the subjective questionnaire.

In the research paper [26] the authors depicted that augmented reality is a vital technological development that has an influence on customer demand and technological solutions for the demands. In this, the authors used two case studies to evaluate the user's experience with the mobile application. The augmented reality mobile applications that were selected were "INKHUNTER" and "ARILYN" [26]. The user experience evaluation tool was the expert evaluation and user experience questionnaire tool, for the data collection and analysis they used the structured user experience and expert evaluation questionnaire, and for data analysis, they used Microsoft excel [26]. Expert evaluation, user experience, and, scientific literature review methods were used in this. They have compared the advantages and disadvantages of the two mobile applications of augmented reality based on the responses from the users. The overall user experience consists of the dimensions like attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty and also semantic scales to evaluate [26]. They have included 30 respondents for the evaluation [26].

In the [27] the augmented system support was developed in two phases using holoLens. The focus was to use augmented technology in aeronautical industry with user experience. The main aim is to evaluate the user experience to decrease the errors while executing the procedures. Lot of memory, cost and time efficiency of the training are needed. For these two phases they have used Edcar-augmented reality in the first phase and WEKIT trail for second phase [27]. In the evaluation methods they have used observation and expert evaluation for the first project. They evaluated the user experience and usability by testing the user, let the users freely make comments rather than predefined questionnaire [27]. For the second phase the participants are provided with questionnaires to submit the feedback, the questionnaires that were included are System Usability Scale (SUS), Smart Glasses User satisfaction (SGUS) and User interaction satisfaction (QUIS) [27]. These were used for the measuring of the usability, learnability, subjective satisfaction. In the participants four were experts and two were students [27].

In the research paper [28] the authors focus was to evaluate the user experience of augmented reality in learning media, computer system department, Andalas university [28]. In this they have used User experience questionnaire (UEQ) to measure the attractiveness, pragmatic quality and hedonic quality. In pragmatic quality, they have perspicuity, efficiency, and dependability and in hedonic quality, they have stimulation and novelty. They have provided a scale of -3 to 3 in the UEQ scale, based on the results they have concluded that users feel that the augmented reality applications increase effective learning [28].

In the research paper [29] evaluation of labelling methods is done based on the image analysis. In this the images were viewed and the 2D labels were superimposed. The parts of the image were displayed when the image is scanned, The Vuforia engine is used as a tracking tool. The labels don't change size, shape, and orientation as the camera moves. A pottery figure is used to indicate the respective labels. In the end, the three search space methods are conducted they are top layout, bottom-top layout, and counter clockwise layout. Finally, the labeling of the figure was done in three layouts and the figures' parts are labeled using the augmented view.

The above works are the applications and developments in the same field i.e., augmented reality, and evaluation. In this thesis, we are developing the super imposition-based augmented reality of the KIA EV6 car and evaluating the users' experience by survey evaluation. Here, we do not need any Head Mount Display (HMD) for viewing the outcomes. The users just need to have the application on their mobiles and then the picture of the KIA EV6 car which has to be scanned using the mobile camera through the application.

4 METHOD

In the research, the demonstration of the KIA EV6 model car is implemented for the AR view and to evaluate the users' experience. After the implementation of the AR view, the users get to view the demonstration of the KIA EV6 car and evaluate users' experience. This implementation includes the 3D model for the user to have detailed knowledge of the car's physical appearance, the demonstration also includes the 360-degree view and inner view of the car through which they can get into details of the physical features of the car. Based on these features, the user evaluates the experience through the survey by comparing the real-world demonstration i.e., when a person gives a demonstration orally by showing the image of the car and when the person gives an augmented demonstration. In this survey, the metrics used to measure the scalability, performance and portability of the AR application based on the KIA EV6 model car. This implementation can be achieved by using "Unity 3D" and "Vuforia engine". The survey is conducted through Google forms, and the users provide their answers to the questionnaire. 34 responses are collected from the users for the augmented demonstration of the KIA EV6 car. In this method, the questionnaire used to conduct the survey is mentioned.

4.1 Tools

Unity 3D, a popular game engine was founded in the year 2004 in Copenhagen by David Helgason, Nicholas Francis and Joachim Ante. This is used to create games-based application and many more. Goofball is the first game application developed by Unity, 2005 [30]. Unity 3D provides many features in its free version. With the help of unity, many games were developed such as Pokémon Go, Heath stone, Rim world, Cuphead, and many more. The 3D refers to the name of Unity 3D, in general, it also supports the development of the 2D s. The Unity 3D itself is integrated with the C# programming language and the Visual Data studio these integrated features make developers develop the application easily.

For the developers who are not familiar with the Visual studio, Unity 3D also provides the Java Script as a scripting language and the MonoDevelop as IDE, alternatively [30]. Unity provides easy and understandable features for the starters, which cannot be seen in any other game engine platforms like Unreal, Gadot, etc., Applications can be developed on any platform such as mobile, desktop, console, and the web, in Unity 3D. The developer can easily use the Unity 3D game engine but, in unity, the developers need to create each and every single feature to work, but in the other platforms, it works more like a template.

A software development kit named was launched in 2011, and is used to develop AR applications, named the Vuforia engine [26]. With the help of the Vuforia engine application, developers can add advanced features and functionality such as the vision to the system, which allow the users to interact with the real world. Vuforia can develop the AR application in android, iOS, Lumin, UWMP, etc. The Vuforia version used in this AR application is 10.6. The basic plan of the Vuforia is completely free, which is used to build and publish the applications [26]. To publish the more advanced features such as the Model Targets and Area Targets in applications the premium plan is used. To start with the Vuforia engine, first, need to create the account in the vuforia web application. The next step after successfully creating the Vuforia is to download the Vuforia engine [26]. The new version of the Vuforia engine i.e., 10.6, is downloaded to develop. In this thesis the Vuforia is downloaded for the android mobile, considering the android users are more in number compared to the iOS and the others such as lumin, UWP.

4.2 Experiment

The specifications of the device in which the experiment is performed is as follows:

- RAM: 8.00 GB
- System Type: 64-bit operating system, x64-based processor
- Processor L: AMD Ryzen 5 3500U with Radeon Vega Mobile Gfx 2.10 GHz

To create the application using Unity 3D, the application needs to be downloaded. After downloading the application, install the application by setting the path, as shown in figure 4.1 allow access for the application to make the changes on the system.

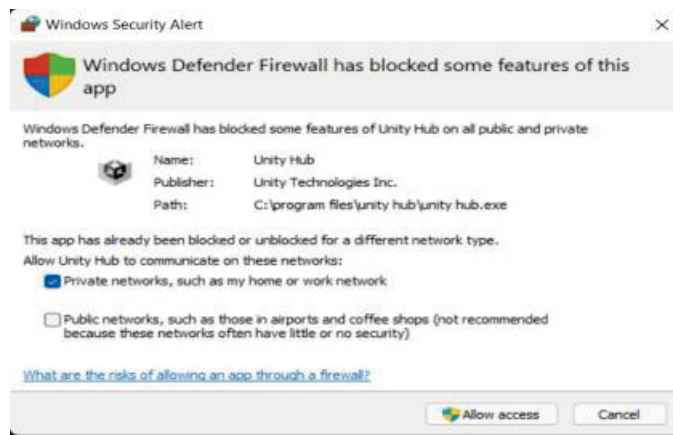


Figure 4.1 Allowing firewall permission for unity

- As shown in figure 4.2 the next step is followed by the successful installation of the Unity is, installing the editor in the Unity 3D.

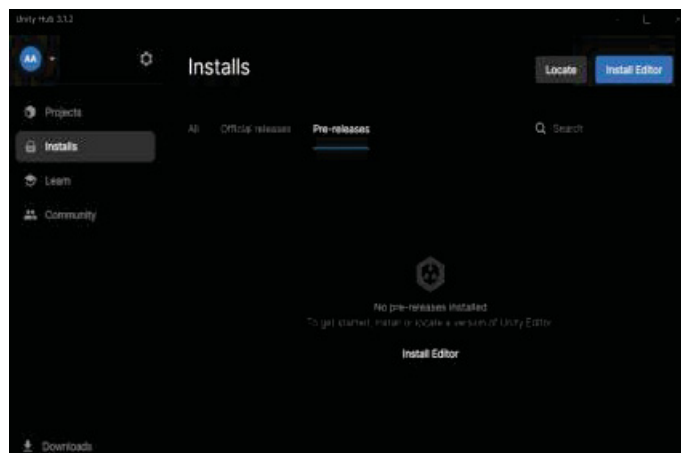


Figure 4.2 Successful installation of unity

- The editor version recommended by the game engine i.e., unity 3D is the 2021.3.2f1 as shown in figure 4.3. The modules inside the editor can be customized according to the features required by the developer. For developing the AR application for the android mobiles, the android modules are used which are present in the editor.

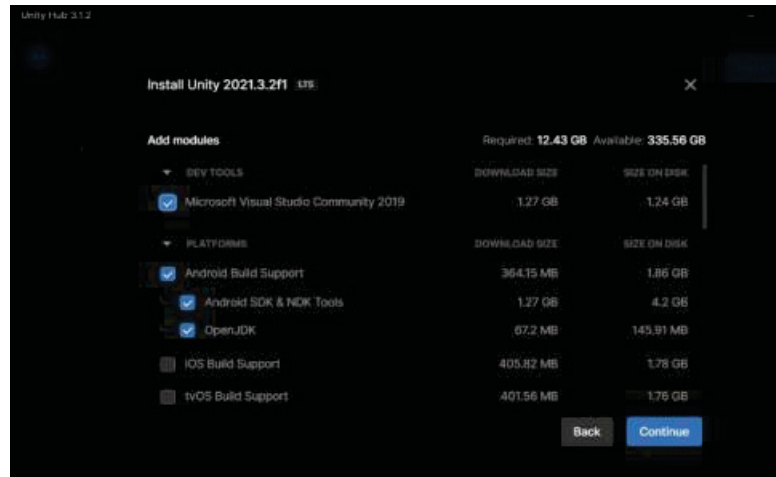


Figure 4.3 Installation of editor

- After the successful installation of the editor add the project where the project needs to be implemented and set up the suitable environment for the required project. Here to develop this application the project required to be selected is the 3D core as shown in figure 4.4. By adding the name of the project and by clicking upon create project, the new project is created with the required modules and the editor.



Figure 4.4 Adding new project

- On creating the project successfully, the new scene is shown on the unity, where the AR view of the application is deployed as shown in figure 4.5.

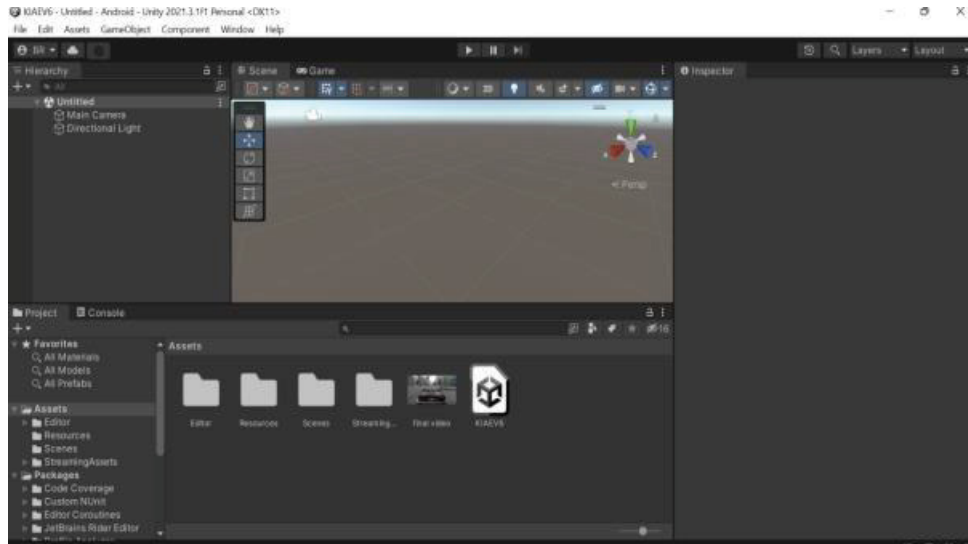


Figure 4.5 Adding new scene in unity

- For developing the AR view of the application, AR camera is required. AR camera is found in the Vuforia engine and it is to be added on the left side of the panel under untitled as shown in figure 4.6. In this case, there is no need of the main camera as the scene already consists of the AR camera. The image target from the Vuforia is now added on the scene.

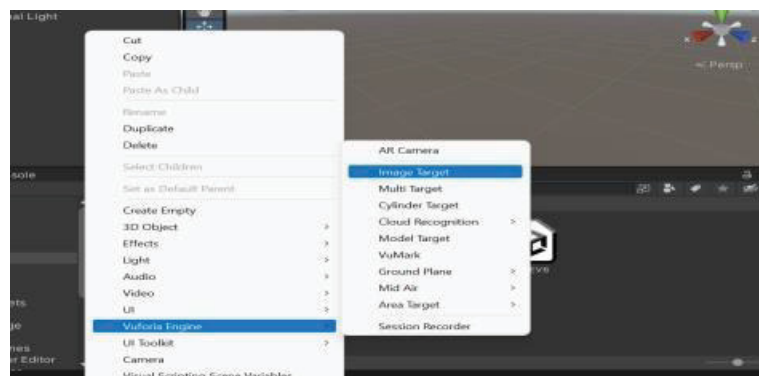


Figure 4.6 Adding AR camera

- Upon selecting the image target as shown in figure 4.7 the default image is created on the scene, and also the details of the image target details, such as adding the image and the orientation of the image can be changed.

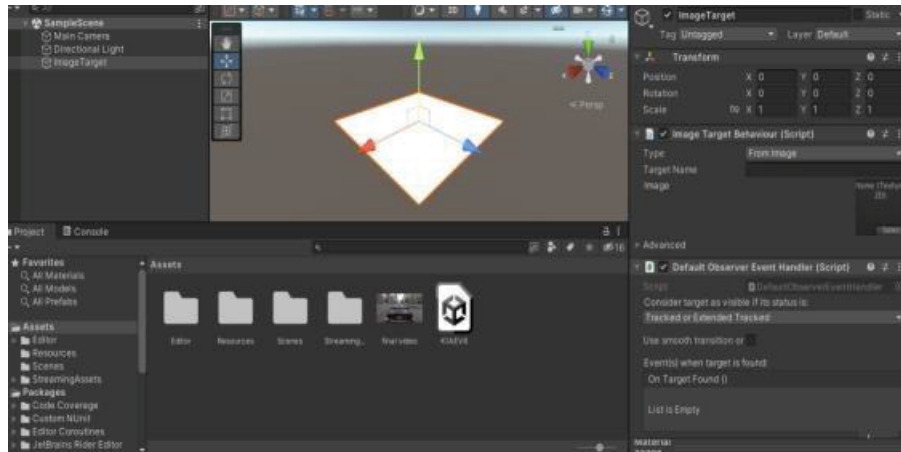


Figure 4.7 Adding image target

- To add the image in the Unity 3D the image needs to be added in the Vuforia first.
 - To add the image in the Vuforia, get into the “develop”.
 - Under develop, get into the target manager.
 - Upon clicking the database, the name of the image target is listed under the target manager. The database added for this application is the KIAEV6 as shown in figure 4.8.

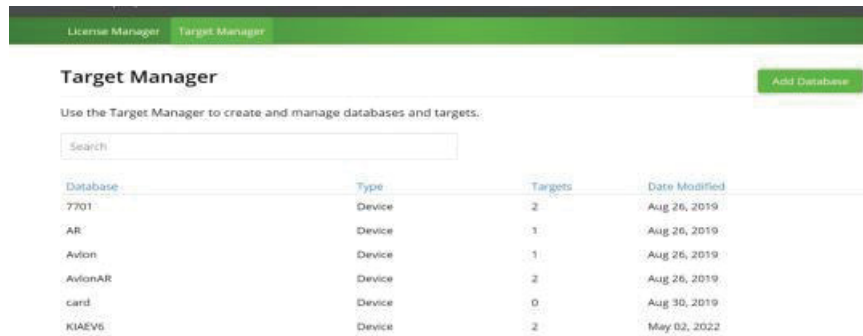


Figure 4.8 Target manager

- On clicking the KIA EV6 data base, the developer gets into the add target window, where the target image is added from the developer’s system as shown in figure 4.9. Upon successfully adding the target click on the download database.

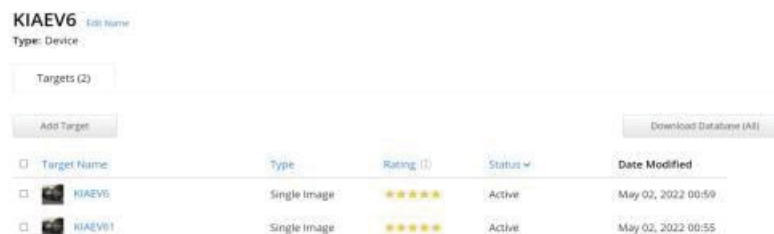


Figure 4.9 Downloading target manager

- The image target is added under the image target script of the inspector window as shown in figure 4.10. To add the image target, the type is selected as from Database and the Image target and the data base is selected as the KIA EV6 (as per the database name created in the vuforia)

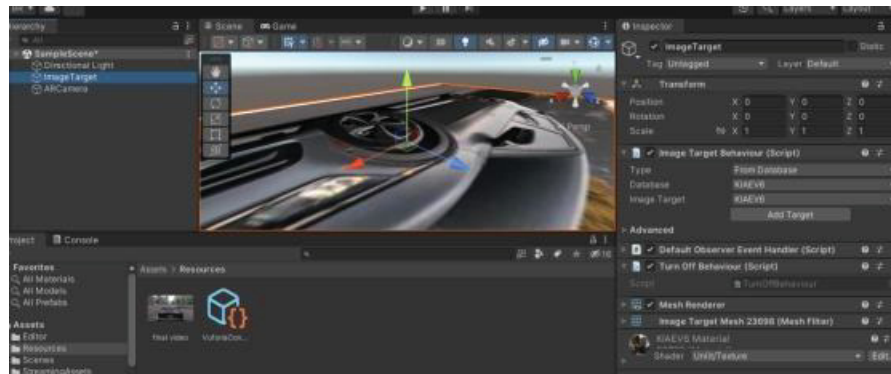


Figure 4.10 Adding image target

- The data base created by the name of the KIA EV6 car contains the license key which needs to be copied and pasted under the Vuforia configuration under the inspector window of the AR camera. The license key is found in the same name of database created as shown in figure 4.11, which is further present under license manager.

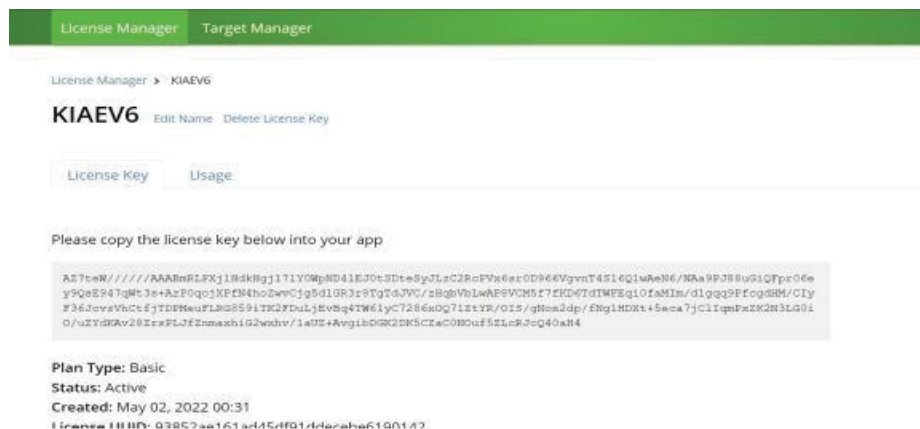


Figure 4.11 License key in license manager

- Paste the license under the App license key of the AR camera inspector as shown in figure 4.12.



Figure 4.12 Adding license key in unity

- Now, the video which is to be superimposed on the target image is added and to add the, video the 3D object i.e., the quad needs to be placed on the image target as shown in figure 4.13. The Quad must be the child of the image target, by this the superimposition occurs. The orientation of the quad should be correctly overlapped with the image target, by correctly overlapping the quad the with the image target flickering can be avoided. Upon clicking on the add component in the inspector the “video” component is selected and the video which needs to be superimposed is dragged under the resources. Now, the video is added under the video clip of the video player.

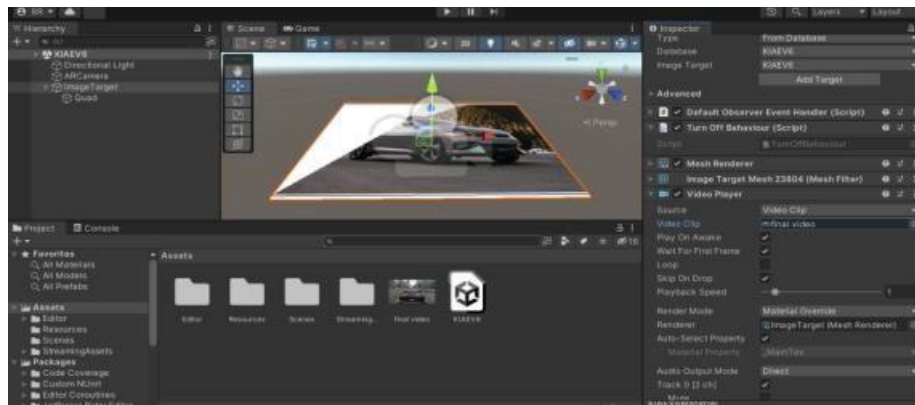


Figure 4.13 superimposing quad and image target

- The image target and the video are superimposed on each other, now to verify whether it is superimposed or not, click on the play button, the video is clearly superimposed if not the orientation needs to be adjusted.
- Save the scene and to whole process needs to be stitched and is deployed under the apk to view the AR view. For the apk development click on the build settings, select on the platform where the application needs to be developed as shown in figure 4.14. In this project the application is developed for the Android mobiles. Upon selecting the build and run the apk is successfully developed.

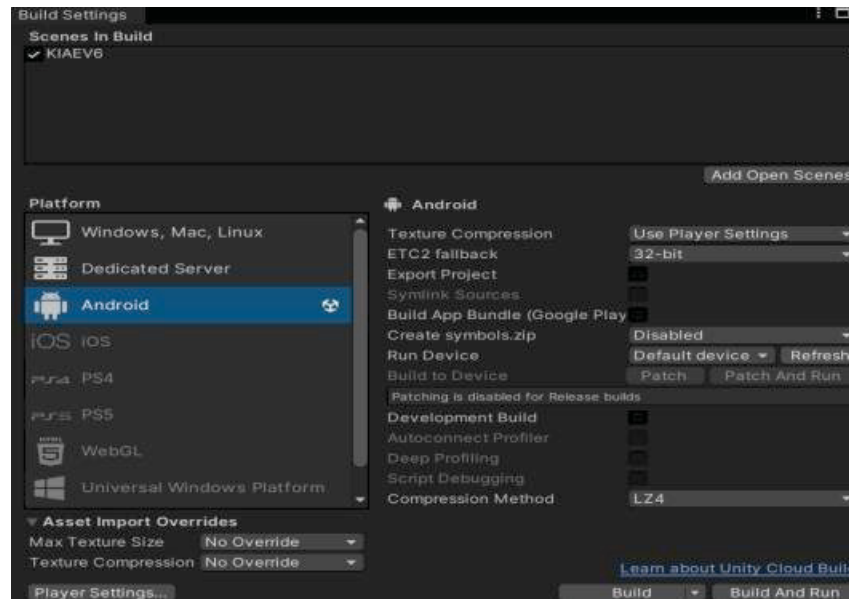


Figure 4.14 Building the apk for android mobiles

- The application is now ready to test on the android mobile and the AR view can be successfully seen of the image target in the screen as shown in figure 4.15. The graphic system feature in unity helps to demonstrate the AR view of the car. To view the AR view of KIA EV6 can be only viewed when the application scans the same image which is added as the image target.

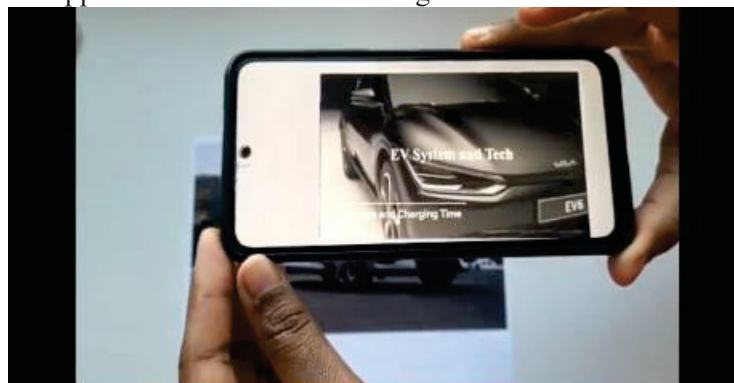


Figure 4.15 Final results of AR application

Users get to experience the whole process i.e., the AR view demonstration of the KIA EV6 car and give the feedback based on their experience. The feedback is collected and by the Google forms. The evaluation method that is used is the survey evaluation method. The survey is conducted for the evaluation of 34 users who experienced the AR demonstration of the car by answering the open ended and closed questionnaires. A google form, which consists of the questionnaires is provided to the users who experienced the demonstration and based on their feedback the process is analysed.

4.3 Questionnaire

The survey evaluation method is used to evaluate the feedback collected from the users after experiencing the application of KIA EV6 car. The questionnaires below are provided in the google form to the users, these questions are based on the developed AR application. They are as follows:

1) *Have you ever tried augmented reality?*

The options are as follows:

- Yes
- No

This question is to get an idea if the users have any experience of the augmented reality before irrespective of the fields.

2) *Did you get a clear overview of the KIA EV6 car which is represented through augmented reality?*

The options are as follows:

- Yes, it gave a clear overview
- No, it didn't give a clear overview

This question is to evaluate if the users has got the better understanding of the car from their experience after coming across this application.

3) *My interaction with the video made using augmented reality was?*

The options are as follows:

- Easy
- Intermediate
- Difficult

This question was to know when the users are experiencing the application how was their interaction with the video was it easy or intermediate or difficult.

4) *The content in the augmented reality video was?*

The options are as follows:

- Knowledgeable
- Interactive
- Easy to understand

This question is to know whether the content that is being displayed when the users are experiencing the application is knowledgeable to the user or is it interactive to them or is it easy to understand to the users.

5) *I felt that the amount of information displayed on the screen was?*

The options are as follows:

- Suitable, connecting to the cause
- Unsuitable, not connecting to the cause

This question is to know whether the information that is displayed to the users was really connecting to the cause and to know if it is suitable or distracting from its actual cause.

- 6) *System response time of the augmented reality application was?*
The options are as follows:

- Slow, it is responding very slowly
- Moderate, it responds at a medium pace
- Fast enough, it is responding in the correct way

This question is to know how the system is responding to the users while they are experiencing the augmented reality application of the KIA EV6 car. To know if the system response is slow or moderate or responding in a correct way as it should respond.

- 7) *I feel that interaction with this application requires a lot of?*
The options are as follows:

- It requires physical effort
- It requires mental effort
- It requires both physical and mental effort

This question is to evaluate what are the requirements needed from the user's physical effort or the mental effort or whether they need to have both physical and mental efforts for experiencing the application.

- 8) *I feel that the display of the augmented reality video on the image (image of KIA EV6 car) was?*
The options are as follows:

- It was flickering too much
- It was flickering moderately
- It was not flickering

This question is to evaluate if the video that is the application when placed on the image is flickering too much or moderately or if it shows no flickering to the users.

- 9) *The performance of augmented reality video on the image of KIA EV6 car was?*
The options are as follows:

- Supportive
- Co-operative
- Obstructive

This question is to evaluate whether the performance of the application throughout the entire user experience has been supportive cooperative or obstructive.

5 RESULTS AND ANALYSIS

After setting up the environment to the project i.e., developing application. The image needs to be scanned by the application, for the superimposition. The AR view of the car obtained and is superimposed when the object is scanned by the application, the type of Augmented Reality in this application used is the superimposition type. After the demonstration of the KIA EV6 car the user are asked to evaluate the overall experience. Google forms are used to collect the users' experience, based on the questions provided in the google form user can give the feedback. The following questions in the google form along with the users' responses after watching the AR view of KIA EV6 car. For the evaluation 34 user experiences are taken into the consideration and the user the results are evaluated based on their responses.

5.1 Survey results

The age and the gender are generally asked to know the impact of the application and to categorize whether this application is helpful for every age group of the people or not.

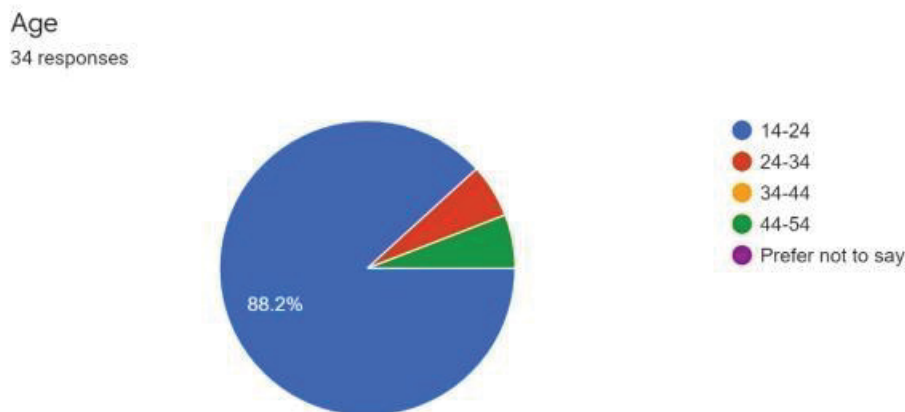


Figure 5.1 Survey results of age

From the above figure 5.1, validation of the pie chart, it is concluded that the users who viewed the demonstration of the KIA EV6 car, gave the feedback are mostly 88.2% from the age group of 14-24. There were also a few users from the age group of 24-34 and 44-54 who gave the feedback based on their experience.

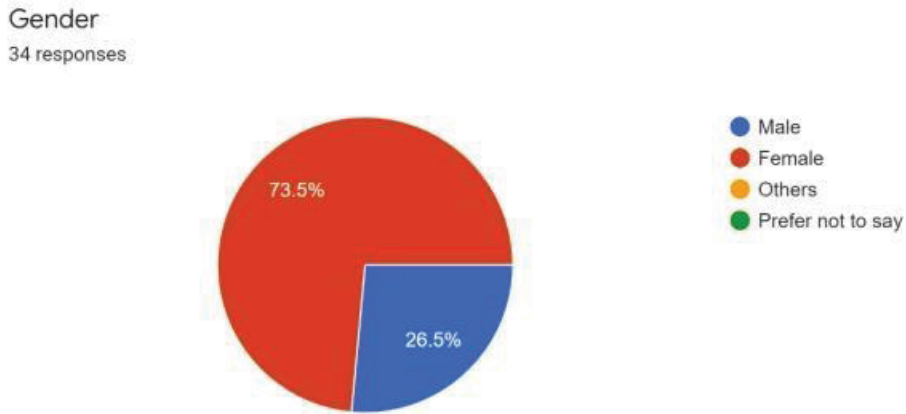


Figure 5.2 Survey results of gender

The figure 5.2 depicts that out of 34 responses 73.5% of the users provided the feedback are female and the rest 26.5% are male. This question helps to understand whether the user, providing the feedback have the prior knowledge of the augmented reality or not. If the user has the prior knowledge of the Augmented Reality it helps in the better understanding of the operation and handling the AR application.

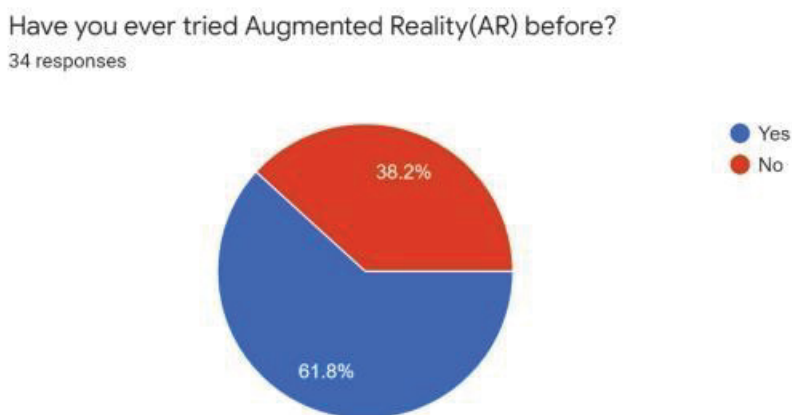


Figure 5.3 Percentage of users experiencing augmented reality

The figure 5.3 explains that out of 34 responses 61.8% are familiar with the augmented reality, from which we can conclude that these group of the users doesn't have any issues while operating the AR application. The rest 38.2% of the users doesn't have any prior experience or exposure of the augmented reality.

Did you get a clear overview of the KIA EV6 car which is represented through augmented reality?
34 responses

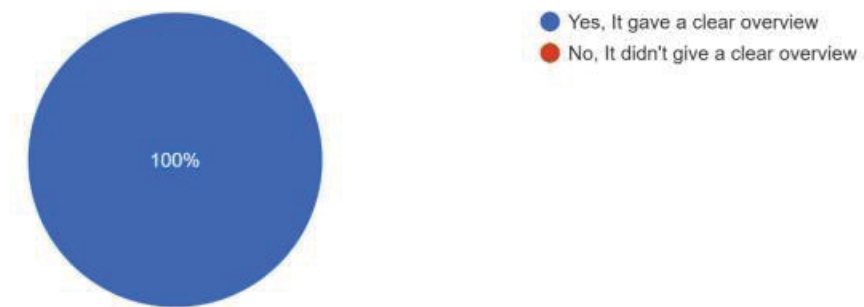


Figure 5.4 Survey results of clear overview

This figure 5.4 helps us to understand, the percentage of the of users who got the clear overview of the KIA EV6 car. The pie chart depicts that 100% of the users who gave the feedback, got the clear overview of the demonstration. The interaction with the application helps to understand whether the application has any errors or any issues with the application deployment.

My interaction with the video made using Augmented reality was:
34 responses

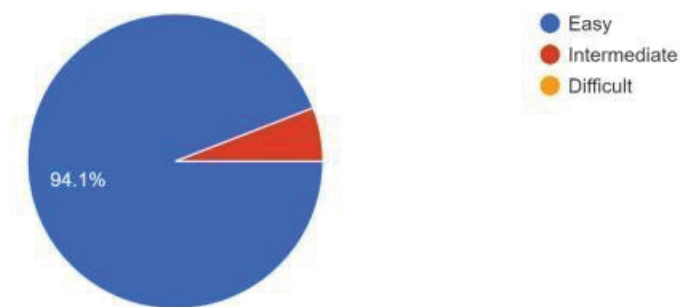


Figure 5.5 Survey results of interaction with video

Figure 5.5 shows the interaction with the Augmented reality was easy for most of the users i.e., for 94.1%, and for the rest of the users, the interaction with the application was intermediate. Therefore, the interaction with the whole system is easy and doesn't contain any errors.

By questioning the content in the augmented reality video, the amount of knowledge gained is measured. It also measures whether the content created is interactive and easy to understand. It measures the amount of engagement of the AR video with the users.

The content in the augmented reality video was:
34 responses

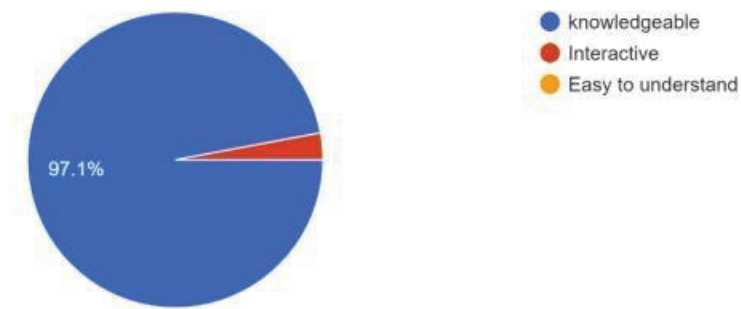


Figure 5.6 Survey results of content in video

Figure 5.6, says that among 34 users for 97.1% of the users' the content is knowledgeable and for the rest of the users it is interactive. This clearly, depicts that the AR video is quite knowledgeable.

I felt that the amount of information displayed on the screen was
34 responses

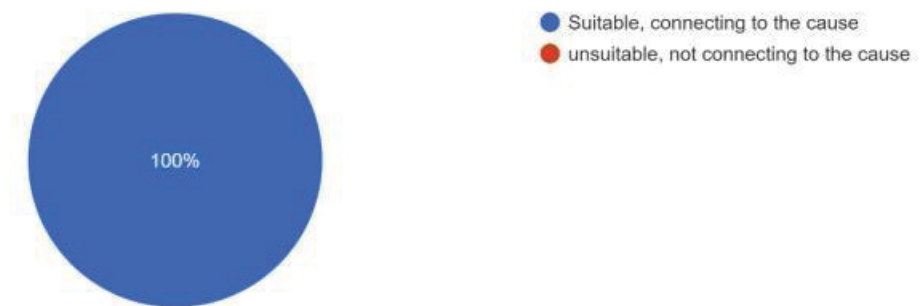


Figure 5.7 Survey results of information displayed on screen

From this figure 5.7 one can evaluate whether the amount of the information displayed on the screen was suitable and connecting the cause or not. 100% of the users can connect to the cause of the AR video demonstration of the KIA EV6, which clearly says that the users can easily connect with the screen time and the demonstration.

When the user scans the object i.e., the image of the KIA EV6 car with the AR application then it should show the AR video in no time, this is known as the system response time. If the AR video is taking time to respond then the it says that the application has a low response time or moderate response time.

System response time of the augmented reality application was
34 responses



Figure 5.8 Survey results of system response time of the AR application

The figure 5.8 shows that 91.2% of the users experienced a fast response time, fast response shows that the system is responding accurately. The rest of the 8.8% of the users experienced the moderate screen time and it also responds at a medium pace, that is most probably because of the internet issues.

I feel that interaction with this application requires a lot of:
34 responses

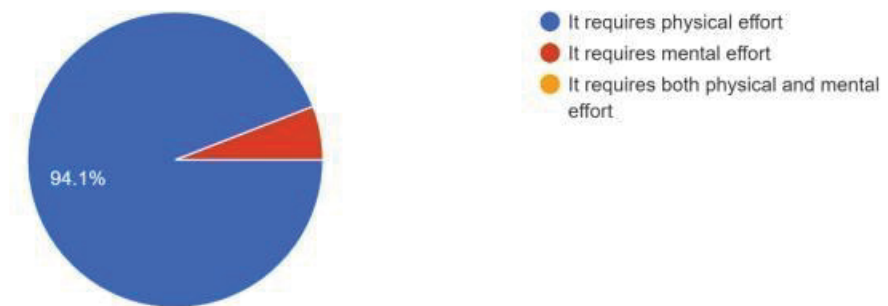


Figure 5.9 Survey results of user interaction with application

From the figure 5.9 it is evident that the evaluation of the user interaction is done based on the physical effort and mental effort, while using the application the efforts required by the user to interact with the application are evaluated. From the pie chart, 94.1% of the users required a lot of the physical effort and the rest of the users required the mental effort.

I felt that the display of the augmented reality video on the image(image of KIA EV6 car) was:
34 responses

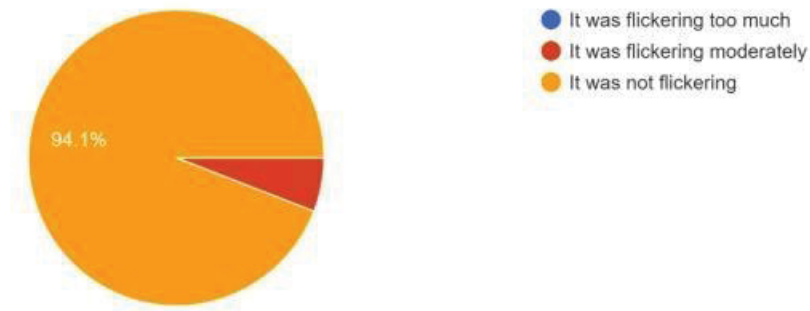


Figure 5.10 Survey results of AR video on the image target

When the image is scanned by the application then the AR video may not be in the position of the image or it shows the unclear display known as the flickering. This question is used to evaluate whether the image is flickering or not, if the image is flickering then it means that the video of the KIA EV6 car is not properly superimposed on the object.

Figure 5.10 depicts that in case of the 94.1% of the user the flickering was not observed, which means that the superimposition is done properly. The rest of the 5% of the users experienced the flickering. The reason behind the flickering might be the slow response time of the users' system or the network issues of the user's system.

The performance of augmented reality video on the image of KIA EV6 car was:
34 responses

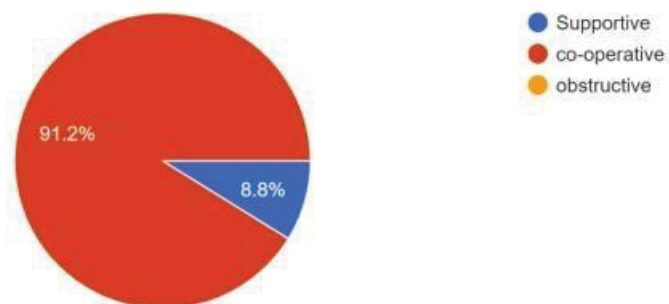


Figure 5.11 Survey results of performance of augmented reality video

In figure 5.11 the performance of augmented reality video on the image of the KIA EV6 car was 91.2% co-operative and 8.8% reviewed the performance as supportive.

How much do you rate the entire idea?

34 responses

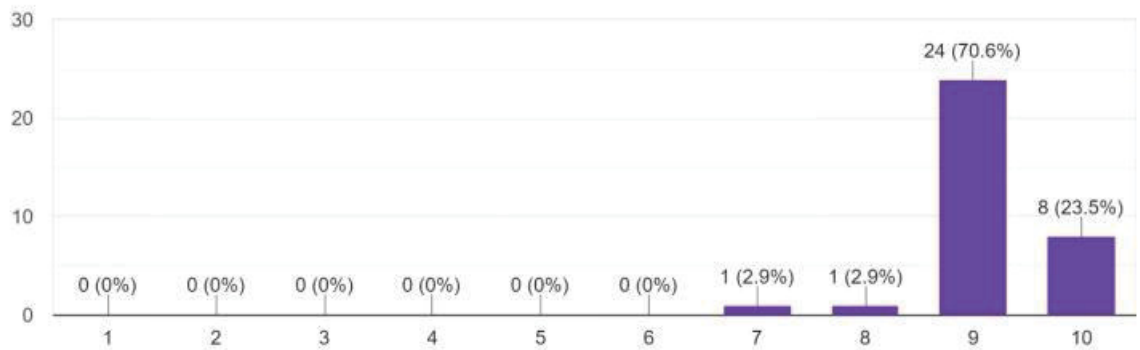


Figure 5.12 Survey results of rating the idea

The figure 5.12 is used to evaluate the entire idea of the project i.e., the demonstration of the KIA EV6 car. 70% i.e., 24 users out of 34 users rated the entire idea as 9 out of 10.

5.2 Analysis

The analysis for this section is based on the suitable metrics that were analysed as pie charts in survey results. The graphs i.e., the bar charts are plotted between the suitable metrics and analysed further for better evaluation of the results obtained

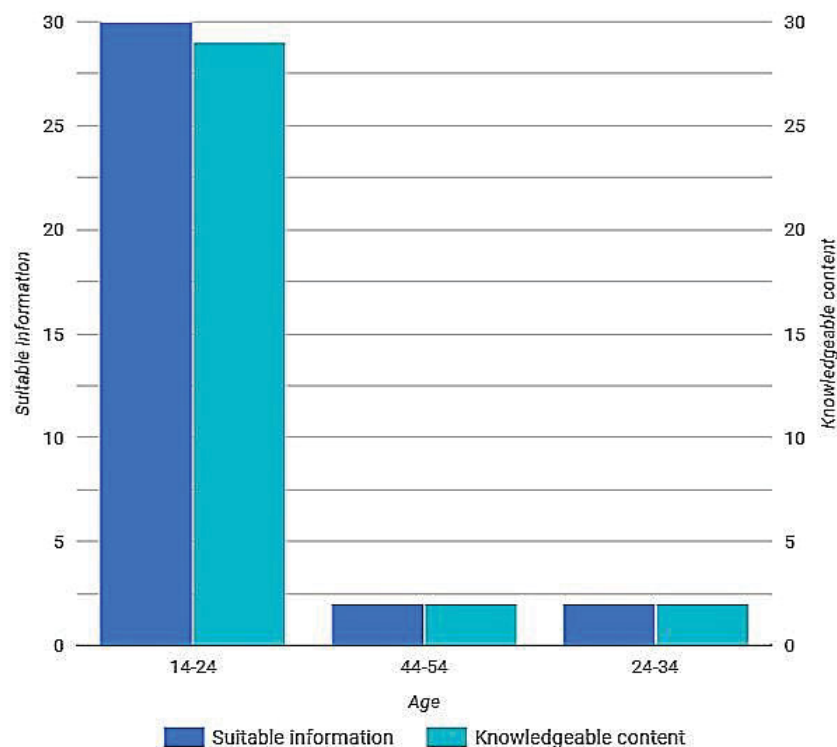


Figure 5.13 Information displayed & content by age

- Figure 5.13, depicts the number of users who feel the amount of information displayed on the screen was suitable. And the content in augmented reality was knowledgeable at the same time, the graph is categorized by the age group.
- The graph says that, out of 34 users from the age group of 14-24, 30 users feel that the information displayed on the screen was suitable. 29 users feel that the content in augmented reality is knowledgeable.
- From the age group of 44-54, 2 users feel that the information displayed on the screen was suitable and the same users feel that the content in the augmented reality is knowledgeable.
- There are 2 users from the age group of 24-34 who experienced the demonstration, and felt that the amount of the information displayed on the screen was suitable and also the content in the AR video was knowledgeable.
- The rest of the users i.e., 1 user out of the 34 users feel that the content in the AR video is **interactive**.

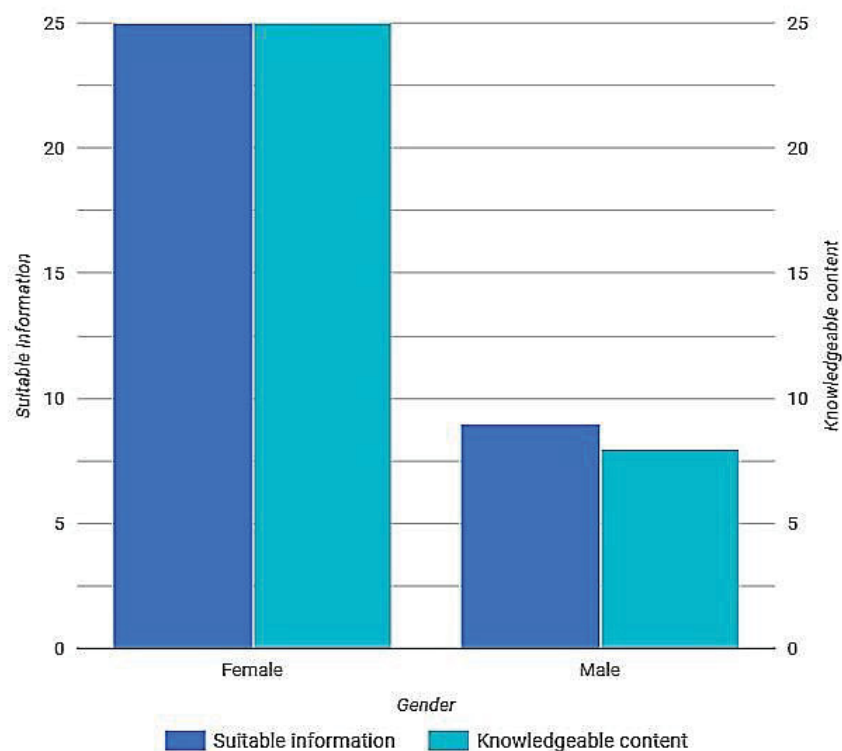


Figure 5.14 Information displayed & content by gender

- The figure 5.14 depicts the number of users who felt the amount of the information displayed on the screen was suitable. And the content, in augmented reality was knowledgeable at the same time, the graph is categorized by the gender group.
- The graph says that, out of 34 users from the gender female, 25 users feel that the information displayed on the screen was suitable. At the same time, they also feel that the content in the augmented reality is knowledgeable.
- The male users, who experienced the demonstration feels that, 9 users feel that the information displayed on the screen was suitable. The 8 users feel that the content in the augmented reality is knowledgeable.
- The rest of the users i.e., 1 user out of the 34 users feel that the content in the AR video as **interactive**.

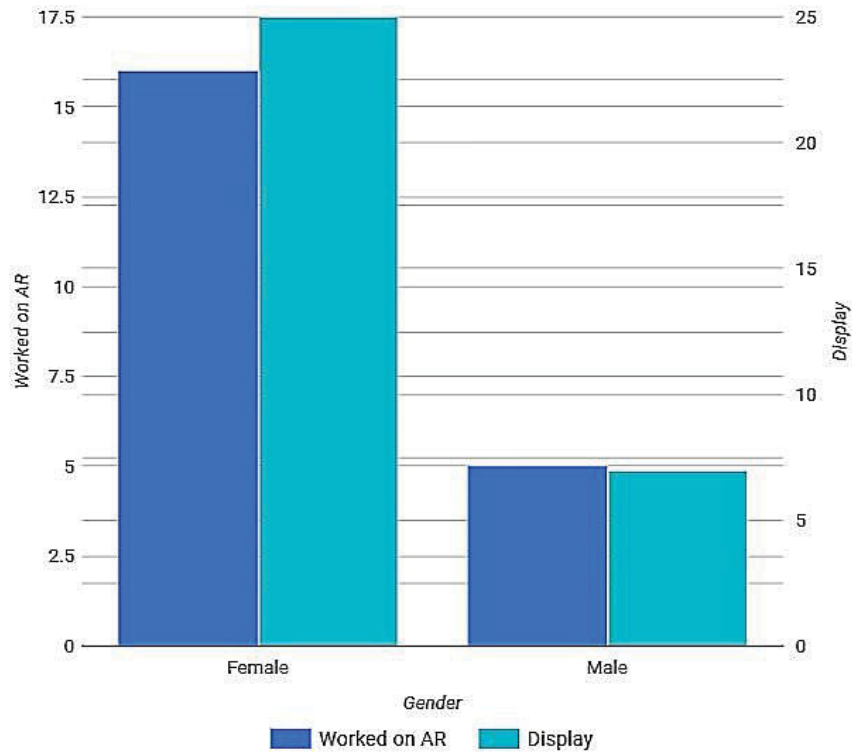


Figure 5.15 Tried AR before & display of video by gender

- The figure 5.15 depicts the number of users who tried the augmented reality before and whether the displayed information of augmented reality video on the image was flickering or not. By evaluating these metrics, it can be depicted that the person who has used AR can have better knowledge of how to operate the augmented application, which decreases the flickering. The graph is categorized by using gender as a dimension.
- The graph says that, out of 34 users from the gender female, 16 users tried the AR application earlier, and 25 users from the female flickering isn't experienced. This depicts that, the users who have not used the application, had a good experience indeed. It says that the application is developed properly, by superimposing the Target and the 3D object properly.
- The male users who experienced the demonstration show that 5 users have experienced the AR application earlier and the 7 users finds the application is not flickering.
- The rest of the users i.e., 13 users out of the 34 users haven't experienced or worked with AR application before and the 2 users find it, flickering. This possibly might be because the user might be experiencing the augmented reality for the first time and internet issues, users issue in the system might be one of the problems.

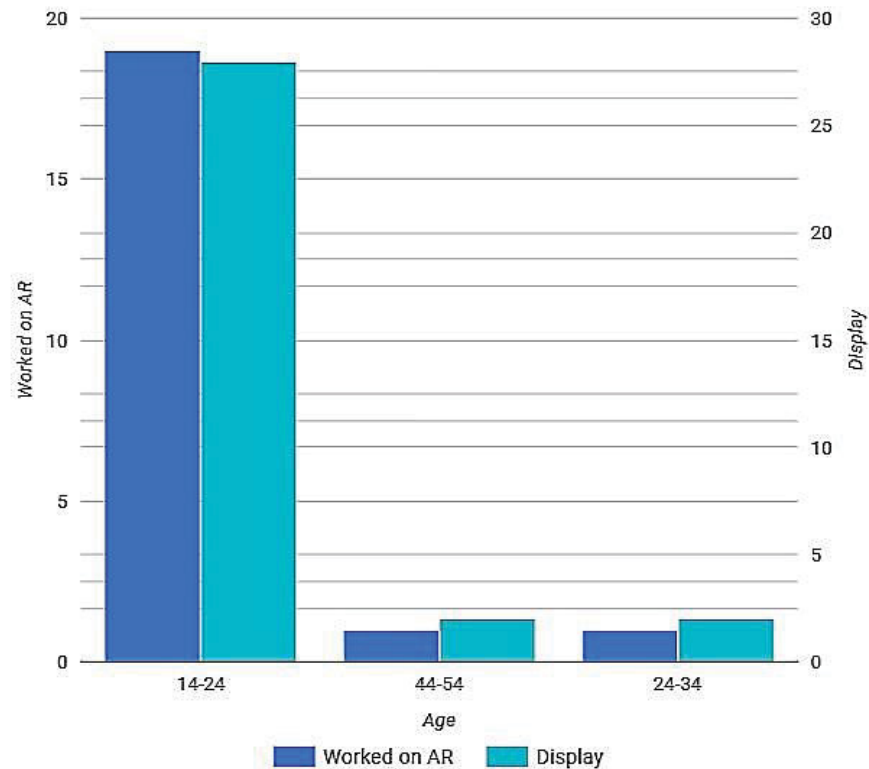


Figure 5.16 Tried AR before & display of video by age

- The figure 5.16 depicts the number of users who tried the augmented reality before and the information display of the AR video on the image was flickering or not. By evaluating these metrics, it can be depicted that the person who has used augmented reality can have better knowledge of how to operate the AR application, which decreases the flickering. The graph is categorized by age group.
- The graph says that, out of 34 users from the age group of 14-24, 19 users tried the AR application earlier, and 28 users haven't experienced flickering. This shows that the flickering issue have been handled properly through the application.
- The age group of 44-54 users, who experienced the demonstration shows that, 1 user have experienced the AR application earlier and the 2 users finds the application is not flickering. Which again evaluates that the user of age group isn't aware of this technology earlier.
- From the age group of 24-34, 1 user out of the 34 users has experienced or worked with augmented reality applications before and the 2 users find the AR applications as not flickering.

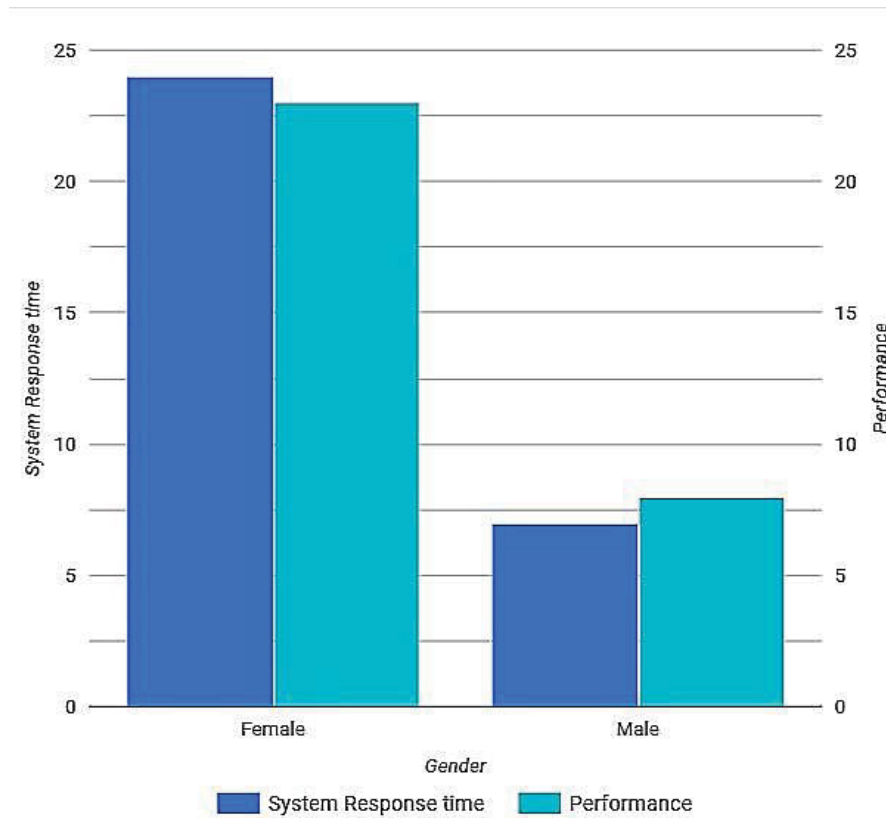


Figure 5.17 System response & performance by gender

- The figure 5.17 depicts how the users experienced the system response time fast enough and the performance of the AR video on the image as co-operative. By evaluating these metrics, it can be depicted that the user who had the fastest response time will have the better performance as co-operative.
- The graph says that out of 34 users of the gender female, 24 users have the fastest system response time. The 23 users from the same group have the performance as co-operative. Here the one user who have the fast system response time experienced the performance as supportive. This might be probably because of the poor alignment of the application on the image.
- The male users who experienced the demonstration show that the, 7 users have the fastest response time. The 8 users from the same group have the performance as co-operative.
- The rest of the users i.e., 3 users out of the 34 users have experienced a moderate system response time, and the same set of users experienced as supportive.

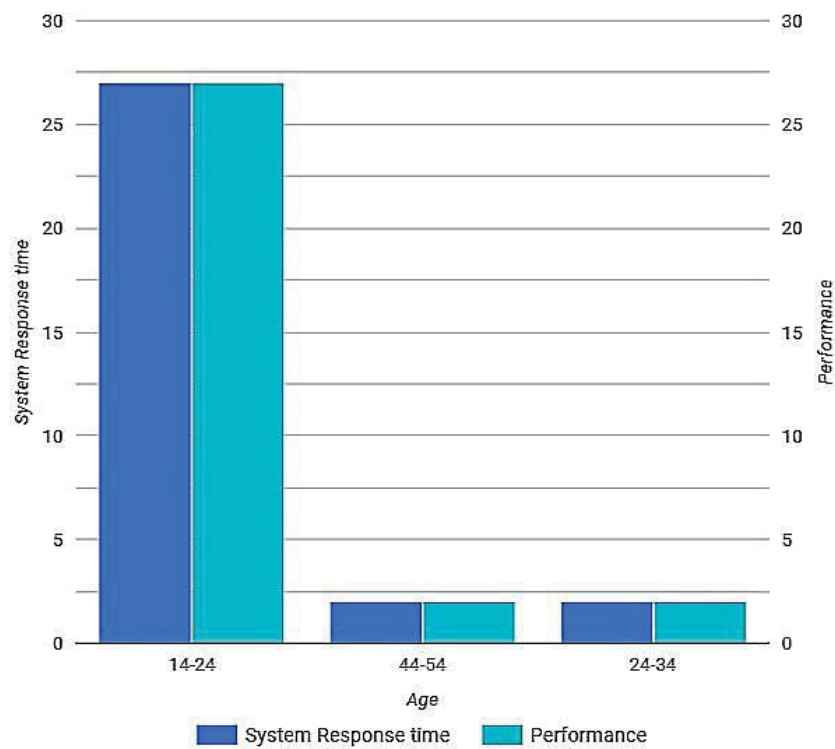


Figure 5.18 System response & performance by age

- The above figure 5.18 depicts how the users experienced the system response time fast enough and the performance of the AR video on the image as co-operative. By evaluating these metrics, it can be depicted that the user who had a fastest response time will have the better performance as co-operative.
- The graph says that, out of 34 users from the age group of 14-24, 27 users have the fastest system response time and the users from the same group have the performance as co-operative.
- The users from the age group of 44-54 who experienced the demonstration show that, the 2 users have the fastest response time. And also, same set of users from the same group have the performance as co-operative.
- The users from the age group of 24-34 who experienced the demonstration show that the, 2 users have the fastest response time and same set of users from the same group have the performance as co-operative.
- The rest of the users i.e., 3 users out of the 34 users have experienced a moderate system response time. The same set of users experienced as supportive.

6 DISCUSSION

In this chapter, the discussions are made on the results of the survey conducted through Google forms. The survey consists of questions that were answered by the users and these results are compared and graphs were plotted from the outputs.

In figure 5.13 it is evident that 34 users feel that the content in the augmented reality video was knowledgeable. Most of the participants have tried augmented reality before and feel that the demonstration of the KIA EV6 car in the augmented video was knowledgeable. The users who feel knowledgeable are those who feel that the information that is being displayed on the screen was suitable and connecting to its cause. Only one member found the content was interactive.

In figure 5.14 it can be seen that most of the females feel that the content is knowledgeable, and also the information displayed on the screen was suitable and connected to its cause. Out of the 34 participants, 26.5% are males and they feel that the content in the augmented reality video is knowledgeable and the information is suitable and connecting to its cause.

In figure 5.15, 3.5% of the female who participated in the survey experienced augmented reality and 26.5% of males experienced AR before. Here out of 34 responses, 32 users believed that the display of the augmented video on the image of the KIA EV6 car was not flickering and just two people who didn't experience the augmented reality felt that the video was flickering moderately on the image. It also might be because of the user's poor internet connection or low performance of their mobile.

In figure 5.16 the users between the age group 14-34 feel that the video was not flickering, but the 2 users who feel that it was flickering moderately were from the age group of the range 44-54 and 24-34.

In figures 5.17& 5.18, the system response time of the application of the KIA EV6 car was fast enough and was responding accurately for the majority of the users. The performance of the video was cooperative and 8.8 % feel that the performance was supportive. These users also feel that the system response time of the application was moderate and responds at a medium pace.

Research question:

How does the users' experience differ between the real and augmented view (virtual world) during the KIA EV6 demonstration?

The research question is answered based on the survey evaluation of the users' experience. Here, the real view can be seen as the pamphlet explanation of the car whereas the augmented view is to see the demonstration through an AR application. In general, most users feel that it is tiring but exciting to see the real-world view of the car. By using this application of augmented reality, they can just sit at home and view the augmented demonstration of the car rather than just a pamphlet of the KIA EV6 car. The users feel that the performance of the application was cooperative. They even want to try augmented reality in many ways and apply it in various fields in the mere future. They feel that the knowledge is just in their hands and can even know the hardware parts of the car just by sitting at their home.

The users got an overview of the car and feel that the augmented world was understandable, and the content was knowledgeable. They came to know the difference between the real, and virtual world and also came across this type of application which is made of unity. Even though they feel the need to put physical effort as they have to hold up the mobile to the image. They have rated the entire idea as excellent and will obviously choose the virtual world over the real world to view the demonstration and buy the car. Because of its performance and portability.

7 CONCLUSION AND FUTURE WORK

7.1 Conclusion

Based on the results obtained by the users, it is concluded that the overall user experience from the augmented reality demonstration of the KIA EV6 car is serving the cause of the development. The evaluation depends on the factors such as performance, system response time, display, interaction, and reliable content. The feedback is given by the user after experiencing the AR view of the KIA EV6 car demonstration. The results obtained are further evaluated and analyzed. After the analysis of the evaluated results, it is shown that the

It can be concluded that 100% of the users got a clear overview of the KIA EV6 car by the augmented reality view, here it depicts that the purpose of the project is fulfilled. 94.1% feel that the interaction with the AR application is easy. 97.1% of the users feel that the content displayed by superimposing the augmented reality application is knowledgeable. 100% of the users experienced the information displayed as suitable. 91.2% of the users experienced that the system response time was fast. Out of the 100% of the users, 94.1% of them experienced the AR application as not flickering. The performance of the augmented reality was cooperative, and it is supported by 91.2% of the users. Overall, the entire project idea was rated as 9 out of 10 by 70% of the users and 23.5% of the users rated it as 10.

From the above analysis, it can be concluded that the entire project idea and working of the AR applications were serving the purpose. Though there are few users on a scale of 2 who were facing the performance issue, system response time issues, and the interaction issue.

7.2 Future work

The development of the thesis can be done further in the following ways:

- In future development, the AR application will be developed by the user control tools such as pause, replay, etc.
- This application is only limited to viewing the augmented reality application of the KIA EV6 car. In the future, the application will be developed with no limitations.
- To avoid flickering i.e., the performance of the application, the advanced superimposition of the image target and the quad is to be implemented.
- 100% fastest system response time will be implemented in future works.

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