A PROJECT REPORT ON

HISTORICAL INSIGHTS USING AUGMENTED REALITY

SUBMITTED TO SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF ENGINEERING
(Computer Engineering)

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CERTIFICATE

This is to certify that the project entitled

”HISTORICAL INSIGHTS USING AUGMENTED REALITY ”

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is a bonafide work carried out by Students under the supervision of Prof. Priti Vaidya and it is approved for the partial fulfilment of the requirement of Savitribai Phule Pune University, for the award of Bachelor of Engineering (Computer Engineering).

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ACKNOWLEDGEMENT

It gives us great pleasure in presenting the preliminary project report on ***'HISTORICAL INSIGHTS USING AUGMENTED REALITY'****.*

We would like to take this opportunity to thank our internal guide ***Prof. Priti Vaidya*** *for giving us all the help, guidance and motivation we needed from time to time. We are really grateful to her for her kind support. Her valuable suggestions were very helpful.*

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ABSTRACT

India, a nation steeped in history and tradition, is losing its heritage sites fast. This part of the world has an intriguing and fascinatingly rich and varied heritage that is thousands of years old. Monuments and paintings, are strong reminders of the many identities and histories that form the collective consciousness and becomes an inalienable part of us. Some forms of threat to heritage monuments can be lack of awareness about the culture, misguidance by people, tampered boards, etc.

The project is focused on the importance of using modern technologies in preserving and exploring Cultural Heritage . Specifcally, Augmented Reality (AR) has the potential to enhance the user experience related to cultural heritage. Augmented reality is "an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (as a smartphone camera)."

The project provides a system which combines location-based multimedia retrieval with an augmented reality client for mobile devices. The system will enable users to query collections of historic multimedia content for perspectives of their current surroundings and overlay them onto their current view using a mobile device. This way, the system offers a virtual window into the past.

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CHAPTER 1

INTRODUCTION

1.1 MOTIVATION

The development of Augmented Reality (AR) technologies is creating new opportunities and challenges for the developers of AR systems. The keen interest by developers in AR applications and the good feedback from the users has led to an expansion in the application genres of AR. One of the applications that has attracted the users most is AR based Tourism and Travel applications. The main motivation behind AR based tourism application is to be able to convey information about the monuments, in an innovative manner to spread awareness about legacy that we have inherited from our ancestors and be able to intellect the philosophies passed onto us. And not let the monuments just be left as mere ruins, visited just for amusement purposes.

1.2 PROBLEM DEFINITION AND OBJECTIVES

To develop a mobile tour guide system using augmented reality to guide the tourists with respect to their visit and provide them the visual experience of the history of a particular monument.

1.2.1 Goals and objectives

The goal of the project is to develop an application system which will help the user to explore the historical significance of the monument using augmented reality.

Goals

- To help explore the rich heritage, culture and diversity of India through her glorious monuments and heritage sites.
- To enable users to travel back in time and hear fascinating stories about the monuments.
- To provide comprehensive and accurate historical data curated from the archives of renowned organizations and institutions.

Objective

- To learn rendering methodologies.
- To learn plane detection algorithm.
- To learn the art of creating 3D models/assets.
- To learn how to detect the geolocation and link it with the 3D models/assets.
- To learn and follow the proper user interface necessities
- To build a mobile tour guide system using augmented reality to guide the tourists and provide them the visual experience.

1.3 PROJECT SCOPE AND LIMITATION

1.3.1 Statement of scope

- The proposed system is intended to take input from the camera module, hence getting a visual of the actual site in front of it, and detect the plane in-order to display the 3D models.
- The input from camera module is intended to be either in portrait or landscape form.
- The proposed system is intended to focus on being able to detect the plane, and display the 3D models according to the anchors placed in the visual environment.

1.3.2 Major Constraints

- The plane detection requires to visualize a grid, if the ground or plane in front of the camera, is supposed to be distinguishable. Smooth white planes make plane detection more difficult.
- Internet connection is required in-order to be able to access the location.
- Due to obstacles rendering becomes difficult.

1.4 METHODOLOGIES OF PROBLEM SOLVING

To perform plane detection, and to be able to render 3D objects; grid visualizer function is being used. These methodologies make use of the ARCore SDK.

- Plane detection function

  When the camera module starts, and then divides the mesh into various polygons to be able to differentiate between the planes.

- Ray Casting function

  Rendering is a process by which the virtual environment is linked with the real environmet, and hence it builds it as it keeps on learning about it by using the ray casting function.

- Anchor function

  To display the 3D models at given location. the anchor function of ARCore is used. Anchoring means placing the particular 3D model at the specified location in the virtual environment and hence, being able to access it in real environment.

CHAPTER 2

LITERATURE SURVEY

- ***L.Sauter,L.Rossettoand,H.Schuldt,"Exploring Cultural Heritage in Augmented Reality with GoFind!", 2018 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR), Taichung, Taiwan, 2018.[2]:***

  In 2018, L. Saute, L. Rossetto, and H. Schuldt, presented an application named GoFind for tourists and historians which gives a virtual view in city's past via augmented reality-based user interface. Historic photo collections are important for cityscapes development but are buried in archives. With their proposed system the historic multimedia collection is brought to mobile devices. Their system provides the overlay of past and present view. In their system the back-end handles retrieval queries and front-end handles user's interaction.

- ***K.Meriem,M.Makramand,I.R.Farah,"Virtual and Augmented Reality in the Valuation of the Tunisian Cultural Heritage: Application to Thysdrus(ElJem) Amphitheater", 2018 International Conference on Intelligent Systems (IS), Funchal - Madeira, Portugal, 2018, pp. 652654.[3]:***

  In 2018, K. Meriem, M. Makram and I. R. Farah, presented two applications to expose cultural heritage using virtual and augmented reality in Tunisian cultural heritage. One part of their proposed system uses a picture on magazines as markers to superimpose the 3D model of that place. Along with superimposition their system also provides interactive augmented reality for guided tours. Their system uses real-time 3D imaging.

- ***S. Chelaramani, V. Muthireddy and C. V. Jawahar, "An Interactive Tour Guide for a Heritage Site," 2017 IEEE International Conference on Computer Vision Workshops (ICCVW), Venice, 2017, pp. 29432952.[7]:***

  In 2017, S. Chelaramani, V. Muthireddy and C. V. Jawahar, presented a system for interactive story generation, for a casually captured video-clip of a heritage site tour. It leverages the user interaction to improve the relevance of the stories presented to the user. Their system takes the feedback from user for stories related to the current segment of the video and dynamically adjusts the stories taking the interaction into account.

- ***Akil. H. Sayyad, Santosh. A. Shinde, "Android Mobile Based Tour Guide System using Augmented Reality", International Journal of Science and Research(IJSR), 2016.[8]:***

  In 2018, Akil. H. Sayyad, and Santosh. A. Shinde, presented an application which consisted of a mobile tour guide system with augmented information. This application helped the tourist to find the accurate location also the information about the required places and it also provided the augmented view so that the interaction between the tourist and the place will be easy. The GPS facility was also available for the tourist to find the places easily. The tourist would experience the physical presence of the location on their mobile phones which user wants to visit.

- ***X. Wei, D. Weng, Y. Liu and Y. Wang, "A tour guiding system of historical relics based on augmented reality", 2016 IEEE Virtual Reality (VR), Greenville, SC, 2016, pp. 307-308.***[9]:

  In 2016, X. Wei, D. Weng, Y. Liu and Y. Wang, presented a game-based guidance system for Yuanmingyuan and a time travel game called MAGIC-EYES using Augmented Reality technology. Their proposed system could help the tourists immerse themselves in the mystical legend. MAGIC-EYES makes use of plaques, stone tablet, patterns of buildings and geographical location information to identify the user's location, which is then combined with AR-based interactive game to complete the guided tour. The traditional guidance system uses the traditional audio, cartoon and GPS to guide a tourist to reach the designated place and display the historical legend.

- ***Athanasios Kountouris,Evangelos Sakkopoulos,"Survey on Intelligent Personalized Mobile Tour Guides and a UseCase Walking Tour App", 2018 IEEE 30th International Conference on Tools with Artificial Intelligence, 2018***[1]:

  In 2018, Athanasios Kountouris, and Evangelos Sakkopoulos, presented an electronic guide application for android smartphones and tablets to help users to reach the places of their interest. Their proposed system with the help of internet technologies helped the users to reach user preferred locations instead of using a personal guide, a tour guide book or any online website. Their system includes designing software for showing cultural sites, inserting or deleting cultural sites of user interest, study of navigation system using smartphone.

- ***D. E. Kurniawan, A. Dzikri, M. Suriya, Y. Rokhayati and A. Najmurrokhman, "Object Visualization Using Maps Marker Based On Augmented Reality," 2018 International Conference on Applied Engineering(ICAE),Batam, 2018, pp. 1-5.***[4]:

  In 2018, D. E. Kurniawan, A. Dzikri, M. Suriya, Y. Rokhayati and A. Najmurrokhman, proposed a system which uses augmented reality as a tour guide on Batam island. Their system used marker-based tracking for displaying 3D objects in the tour. Their proposed system is built with the help of software's like Unity and Vuforia. Their system also provided navigation to the tourist attraction along with displaying 3D tourist object that is present on the map.

- ***E. Pyshkin and P. Korobenin, "Just walk: Rethinking use cases in mobileaudiotravelguides,"2017 Federated Conference on Computer Science and Information Systems(FedCSIS),Prague,2017,pp. 281-287.***[5]:

  In 2018, E. Pyshkin, and P. Korobenin, presented a model which provided appropriate multimedia assistance of outdoor travel tours with using geo-positioning for better tour recommendation and playback automation. The system not only had on-demand audio guides but also had a framework which allows tour users and tour creators to indirectly collaborate. The proposed system provides the time and distance required for the tour along with the information about the best and worst visiting period. System also allowed users to create travel diaries and sync it with their Facebook account.

- ***S. TsungWu and B. Lee, "An Innovative Way of Guided Tour: A Virtual Experience of Dark Tourism", 2017 International Conference on Information, Communication and Engineering(ICICE), Xiamen, 2017, pp. 208-210.***:

  In 2017, S. TsungWu, and B. Lee, presented the idea of promotion that introduced the Taiwan dark tourism through the augmented VR experience. The information about Taiwan's dark tourism destinations was used to build up an augmented virtual reality project for guided tour. GoPro Hero 4 six-camera set, Kolor Autopano Giga and Panotour Pro software, and the web platform Holobuilder were applied in this experiment. Few places were selected to carry out and implement the idea and a tour itinerary was designed for the same.

- ***Rudiger Pryss, Philip Geiger, Marc Schickler, Johannes Schobel, Manfred Reichert, "Advanced Algorithms for Location-Based Smart Mobile Augmented Reality Applications", The 13th International Conference on Mobile Systems and Pervasive Computing, 2016.***:

  In 2016, Rudiger Pryss, Philip Geiger, Marc Schickler, Johannes Schobel, and Man- fred Reichert, presented Insights into the development of the framework of an augmented reality kernel for smart mobile devices are given in this piece of work. It presented that mobile augmented reality is a complex endeavour that must be continuously improved. Explanation about AREAv2 and how it used a modular architecture that supports mobile applications is given. Also, new functions like POI cluster handling are presented.

CHAPTER 3

SOFTWARE REQUIREMENT SPECIFICATION

3.1 ASSUMPTION AND DEPENDENCIES

Augmented Reality is a growing field, and it has come to life due to these advancements in technology. Hence, augmented reality experiences cannot be aimed for all the mobile devices available in the market. There are certain requirements in the versions of the user's mobile software as well as services available on the said software.

3.1.1 Assumptions

- The user is using an android phone
- Android device is assumed to have Android API level 24 or higher to run ARCore
- Android device has a working camera and location sensor
- The user has a stable internet connection to retrieve data from the database
- User's access to the Fused Location Provider API calls is continuously operating
- The user grants permission for the app to use the camera
- The user grants permission to use location data

3.1.2 Dependencies

The system consists of 2 modules:

- Module 1 : Android Module which accepts input from user i.e. the prefered location and choice of monument
- Module 2 : Unity Module which accepts input from Module 1 and renders the 3D structures of the monument

The above mentioned modules are dependent on each other.

3.2 FUNCTIONAL REQUIREMENT

3.2.1 Running on an Android device

A compatible Android device is required for a proper functioning of the application system.

3.2.2 Processing of permissions upon first launch

- The application is intended to prompt for location permissions
- The application is intended to prompt for camera permissions

3.2.3 Providing an interface for credentials

- The application is intended to provide OTP (One Time Password) verification step, if incorrect login will not be operational
- The application is intended to disable functions that need the credentials if the credentials are incorrect
- The application is intended to provide a module to view the monument's information in text form

3.2.4 Grid Visualizer function

- The grid visualizer function is intended to create the mesh
- The grid visualizer function is intended to divide the mesh into polygons
- The grid visualizer function is intended to detect the plane

3.2.5 Location management

- An implementation of PlayServicesLocation is provided
- The location services function is intended to retrieve the device's coordinates
- The caves manager function is intended to place a cloud anchor at given a location

3.3 EXTERNAL INTERFACE REQUIREMENTS

3.3.1 User Interfaces

- The user interface is intended to be prompted with the logo of the application as a welcome upon executing the application
- The user interface is intended to be prompted with the logo of the application as a welcome upon executing the application
- The initial load is intended to request, upon the first launch of the application, permissions that will be specified by the user
- Next, the application is intended to instantly gain access to the device's camera, location services, and device storage
- Create new user/Login is intended to prompt after the welcome screen
- Upon logging in, the main screen is intended to appear with the different modules for all the cities available, along with the various modules for all the monuments available in the application
- Upon selecting the Phalke Samarak (for demo purpose) module, a screen is intended to appear with the information in the text form and a 3D view button
- Upon selecting the 3D view button, the augmented reality tour is intended to begin
- After the tour screen opens, a slide-navigation bar is intended to appear with the options for the audio available in three different languages namely, Hindi, English, and Marathi. And other options to go to the next scene, previous scene, and on the last screen to exit the tour
- Once a plane is detected the 3D model is intended to appear at the position it is intended to be anchored at

3.3.2 Hardware Interfaces

- Android mobile devices are the supported device types
- Android mobile devices with a front-facing camera
- Android mobile devices with a location (GPS) sensor
- Android mobile devices with a magnetic sensor (required by ARCore)
- Android mobile devices with a gyroscope sensor (required by ARCore)
- Android mobile devices with internet access

3.3.3 Software Interfaces

- Android mobile devices with API level 24 & up
- Firebase extension
- Autodesk Maya
- Blender
- ARCore SDK

3.3.4 Communication Interfaces

- HTTP GET
- HTTPS GET

3.4 NON FUNCTIONAL REQUIREMENTS

3.4.1 Performance Requirements

The application is intended to perform smoothly, taking at most 5 seconds to retrieve calls from the database with a decent internet connection.
The application is intended to take at most 5 seconds to retrieve calls from the Unity workspace.The number of simultaneous users, initially, should support one or two dozen.

3.4.2 Security Requirements

Users are intended to have credentials for visiting the monument premises, according to the visiting hours given as per the monument authorities.User is expected to be aware of their surroundings. User is expected to obey posted signs (ex. ‘Restricted Area’, ‘No swimming’, ’No Trespassing’).

3.4.3 Software Quality Attributes

Software Quality Attributes define the quality of software.
The different attributes are:

- **Reliability**:
  Whether the software is trustable to obtain correct result (low error rate).
  The system correctly renders the desired 3D model within 40 seconds. So, the system is reliable.

- **Learnability**:
  Whether the design of user interface is simple and easy to understand and the instructions provide clarity and the simplicity for the usage of application.Also the interface should present information as close to reality as possible.

- **Maintainablity**:
  Whether the software is suitable for modification and debugging with ease.
  The code for the system is well commented which makes it readable, and therefore updations can be done comfortably. Errors occuring during the integration of modules were easily debugged due to readable code. Incase of any defects, understanding the code to repair the defects will also be efficient. So, the system is maintainable.

- **Portability**:
  Whether the software can work in different environments of different platform without errors.The system is portable since it is suitable to function on almost 70% of Android devices.

3.5 SYSTEM REQUIREMENTS

3.5.1 Database Requirements

The system requires a database to store the details of the user to maintain the identity and contact details in case of successful login. Firebase is used for maintaining database.

Database Name : AR-Verify-OTP

Attributes : Details of the User

3.5.1.1 Other Information Requirements

- Text data
- Audio data
- Location data : Longitude, Latitude, Address
- Grid Data
  - Mesh data from the previous session, divided into polygons
  - Vertices transformations to be in the plane's centre
- Cloud anchor data
- HTTPS GET / HTTP GET
- Firebase data
  - Access is intended only through methods related to handling OTP (One Time Password) verification
  - Access is intended only through methods related to handling user data
- 3D models : Access is intended only through methods related to handling the monuments
- Location : Access is intended only through methods related to handling the location services

- Grid Data : Access is intended only through methods related to generating the grid
- Data entities and their relationships.

3.5.2 Software Requirements

Platforms :

- Android Studio
- Unity
- Blender
- Google Firebase

Google Firebase

Firebase, a Realtime Database is a product from Google Research, which is a cloud-hosted database. Data is stored as JSON and synchronized in realtime to every connected client. When you build cross-platform apps with our iOS, Android, and JavaScript SDKs, all of your clients share one Realtime Database instance and automatically receive updates with the newest data.

3.5.3 Hardware Requirements

Various hardware requirements in the Android device for proper functionng of the application are:

- Operational front-facing camera
- On-board storage
- On-board operating system
- Enough battery life
- Touch screen capabilities

3.6 ANALYSIS MODELS : SDLC MODEL APPLIED

Software Development Life Cycle (SDLC) is a procedure used by the software industry to design, develop, and test high quality software. The SDLC intents to produce high-quality software that sees or surpasses customer expectations, reaches to an accomplishment within times and cost estimates.
The project development has followed the Waterfall SDLC Model.
The Waterfall Model, also referred to as a linear-sequential life cycle model. In a waterfall model, each phase must be completed before the next phase can begin and there is no overlapping in the phases. By using the waterfall model, requirements are very well documented, clear and fixed.
The various phases of waterfall life cycle are :

- Requirement Analysis
- System Design
- Implementation
- Testing
- Deployment
- Maintenance

Requirement Analysis

The information about the monuments needs to be collected, a few monuments and cities are selected.The information about various algorithms to navigate in AR (Augmented Reality) needs to be collected, and an appropriate algorithm is selected.The information about various rendering algorithms needs to be collected, and an appropriate algorithm is selected.The information about the various platforms available for developing 3D models needs to be collected, and an appropriate platform is selected.

The information about the various platforms available to build visualization-based applications needs to be collected, and an appropriate platform is selected.The information about various SDKs available for AR needs to be collected, and an appropriate SDK is selected

System Design

The user is intended to be notified about the location, hence the Play Services Location is used.The user is intended to only, be able to see the 3D model on the display screen. Hence, ray casting is used.The platforms Autodesk Maya, Blender and Unity are used for creating and editing the 3D models.The Unity platform is used for the 3D model rendering, plane detection, and anchoring of the 3D models at given location.The Android Studio platform is used to develop user interface. The ARCore SDK is selected.

Implementation

Autodesk Maya, Blender and Unity are used in combination to create, model, give material and texture to the 3D models.The Unity module includes the plane detection, rendering of 3D models, anchoring 3D models at given location, and providing audio part of the augmented tour.The Android Studio module includes the user interface, OTP (One Time Password), Firebase database, and text view of information.

Testing

The system implemented in the programming language is then tested to ensure it's proper functioning and guarantee that it is bug free. Different types of testing like blackbox testing, whitebox testing, testing to check performance are performed in this phase.
The unit testing of the modules was carried out with the development of the modules itself. The proposed application is integrated by merging the functions of the two modules namely, Unity Module and Android Module. A button is created in android studio and linked to a function from Unity to display the 3D tour.The proposed application is manually tested for all the modules.

Deployment

After testing, when the developed software is bug-free, it is deployed. Deployment means releasing the ready software for the client to use.
The proposed application is deployed on the Android platform. Hence, forming an android application.The system was then installed and used in environment similar to that of it's expected working environment.

Maintenance

Bug-free software is a myth. After the deployment of the application, defects in the system will be reported by the user. In such cases, updations in the software are required. This is covered in the final phase of Waterfall SDLC i.e. maintenance phase. Any defects found in the system in future will be debugged. This is the initial launch of the proposed application. Hence, additions will be made after the feedback is received.

CHAPTER 4

SYSTEM DESIGN

4.1 SYSTEM ARCHITECTURE

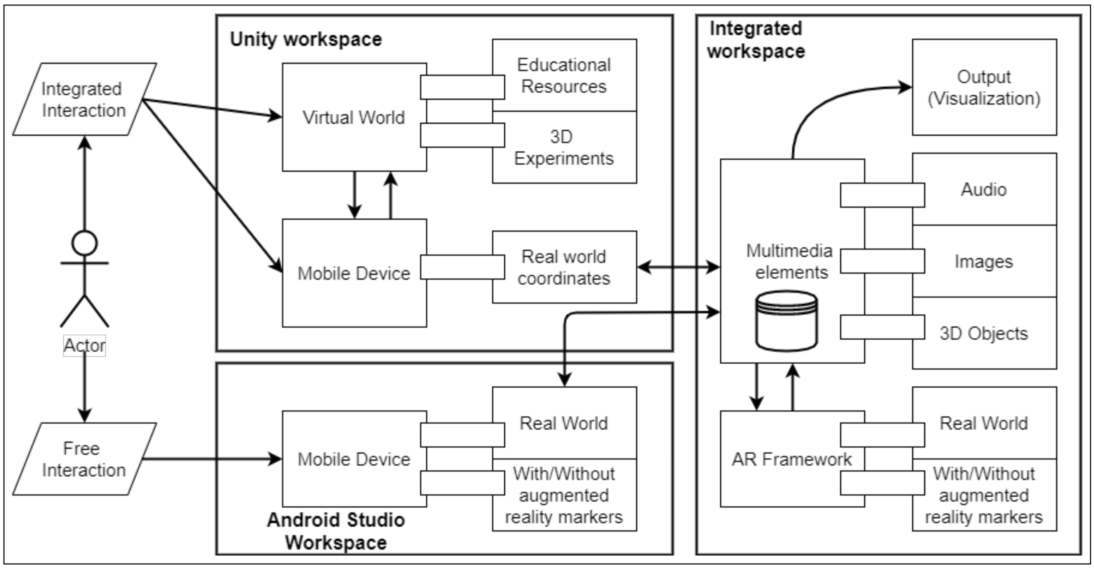

Figure 4.1: System Architecture

Figure 4.1 shows the architecture of the system with different algorithms and interfaces.The system architecture consists of mainly three modules namely, Unity workspace, Android Studio workspace, and Integrated workspace.

- **Unity module:**

  The following functionalities are accounted for in the Unity module:

  A framework is required to place the 3D models in the virtual environment and editing them, and Unity is the framework that has been used for development purposes in this project. The functionality of adding material, and textures to the 3D models is done using Unity. In Unity the scenes are created in the manner of how they will pose in the real-world environment.

  The placing of the 3D models, giving them direction, and making them adaptive is done using Unity. The audio clip, being a part of the augmented tour is supposed to play alongside the models being displayed, to give a complete experience. Hence, the addition of the audio clips based on the information being conveyed through speech and the model being displayed is synchronized in Unity. The key requirement to be able to render a 3D model is the system being aware of its environment.

Hence, for the mobile device's camera to be able to detect the space in front of it, the plane detection algorithm from ARCore is also developed in Unity. Since, the application consists of multiple models to displayed on multiple sites with different locations on the globe. The use of cloud anchors from ARCore is utilized to place these models at a certain location using Unity.

- **Android Studio Module:**
  The following functionalities are accounted for in the Android Studio module: One of the key requirements of the user interface in the application is that, the application should be easy to access and navigating through the application should be in a flow. The user interface is developed using the Android Studio IDE. The functionality of OTP (One Time Password) verification is developed in the android studio module. The OTP assures the user that, the application is protected. The login process cannot be completed without the OTP verification step.
  The interface consists of modules of the places available in the system. The information based on the monuments available in the system is displayed. From there the user can select the option to read the information about the monuments or go for the 3D view, which consists of the augmented reality tour of that place.

- **Integrated Module:** The integrated module consists of the following functionalities from the combination of the Unity module and the Android Studio module:
  The augmented reality tour is developed on the Unity platform. The interface is developed in the android environment. Although we can build the Unity module on the android platform, the application built needs to be integrated in android studio for it to be able to run as an android application. Hence, on a button click in android studio, we are able to call the 3D models, audio and the UI built from Unity to the application.

4.2 MATHEMATICAL MODEL

- Input : Input to the system is live location of the user and operational camera
- Output : The system provides a 3D model of the monument as an output as well as audio narration, information of the monument
- Set Theory Let S be the proposed system, where
  S = {I,O,D,Q,C,E,L,F} , where
  - I (Set of inputs) = {I1,I2} where,
    * I1 = live location
    * I2 = (User details(age,contact details, language,etc.))
  - D: Set of locations and models stored in the database
  - Q: Set of extracted frames from the input video for plane detection
  - C: Content database where the user information is stored
  - E: Information database where the information related to the monument is stored
  - L: Location of the device
  - F(Set of functions) ={F1,F2,F3}
    * F1 : F1(I1,D) $\rightarrow$ Q
      Function which takes the location of user and detects the plane using camera and matches with the one's in the database
    * F2 : F2(I2) $\rightarrow$ (O2)
      Function which takes the user preference of language and provides narration about the history of the monument
    * F3 : F3(D,C,L) $\rightarrow$ (O1)
      Function which renders the image onto the screen of the user device
  - O (Set of outputs) = {O1,O2} where,
    * O1 = 3D rendered image/video as output, which shows the vision of monument in the past
    * O2 = pre-recorded narration, explaining the significance of the place

4.3 DATA FLOW DIAGRAM

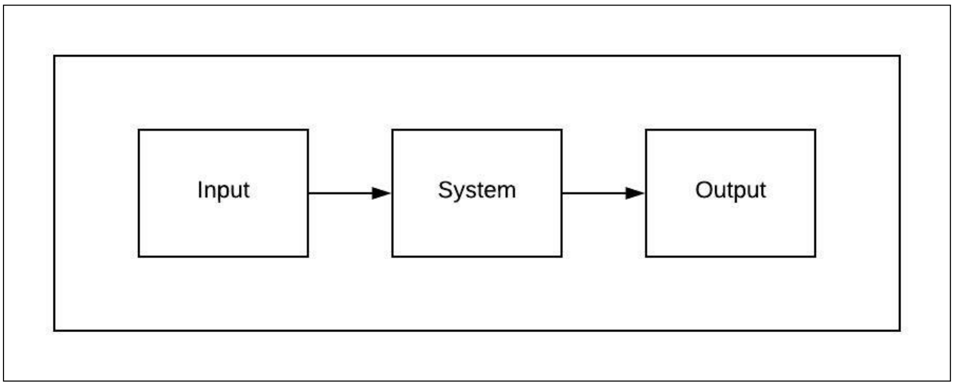

Figure 4.2: Level 0 Data Flow diagram

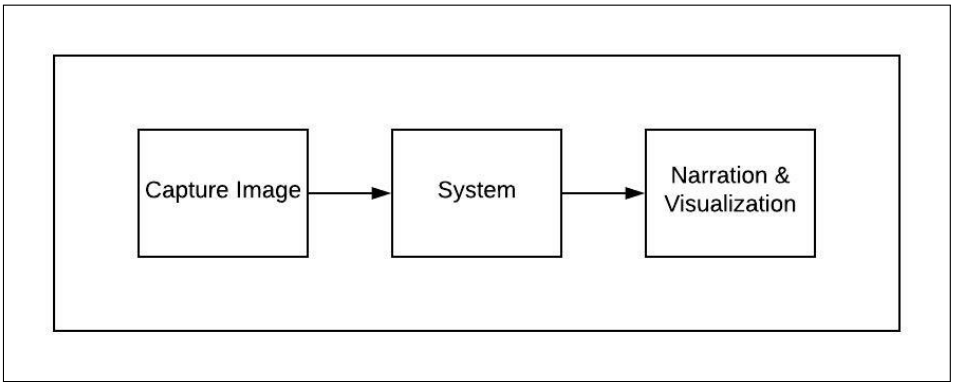

Figure 4.3: Level 1 Data Flow diagram

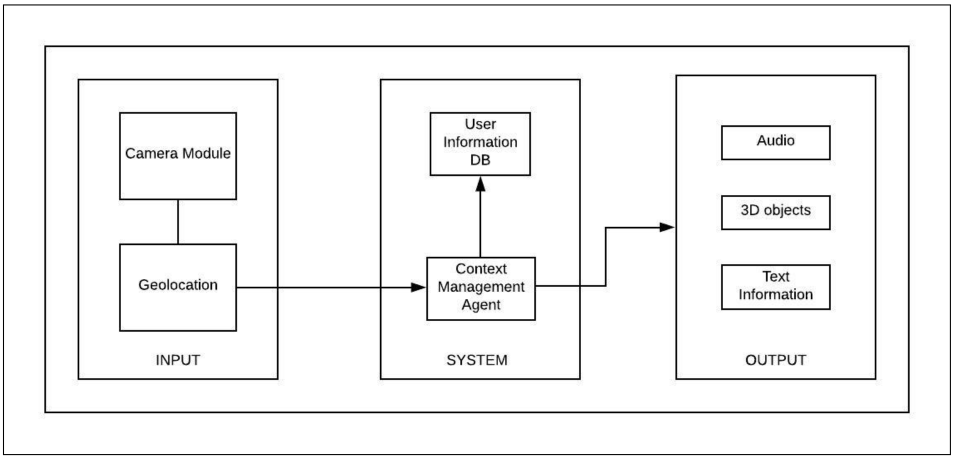

Figure 4.4: Level 2 Data Flow diagram

Figure 4.2 gives the high level (most abstract) view of the system. Figure 4.3 gives first level view of the system, showing the input, processing and output of the system. Figure 4.4 gives the detailed view (level 2) of the input, processing and output of the system.

4.4 ENTITY RELATIONSHIP DIAGRAM

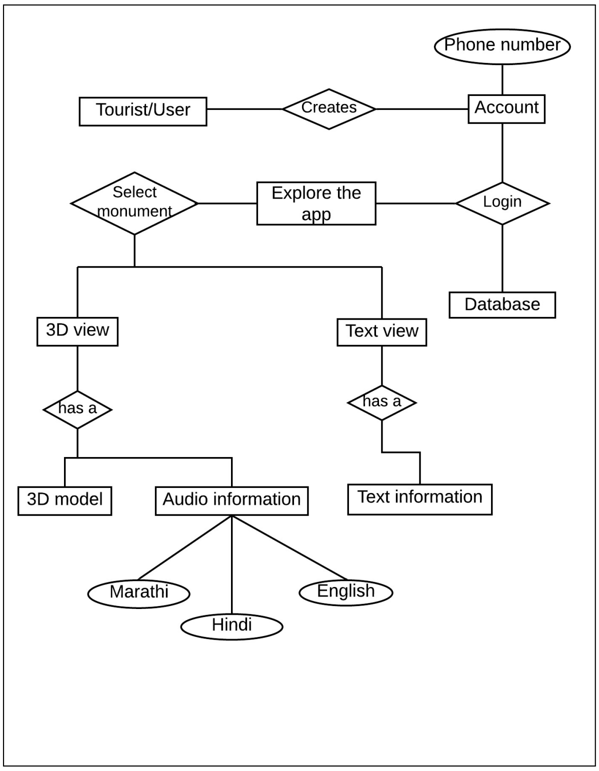

Figure 4.5: ER diagram

Figure 4.5 gives the Entity Relationship of the system

4.4.1 Data Description

The system requires location of the user and the choice of historical monument. So, the database maintains details of the registered users. Some location functions are used to verify the user location and compare inorder to display the desired 3D model of that particular monument.

4.4.2 Data objects and Relationships

The 3D structures are the major data in the system. Along with the images, basic details of the monument are maintained.

4.5 UML DIAGRAM

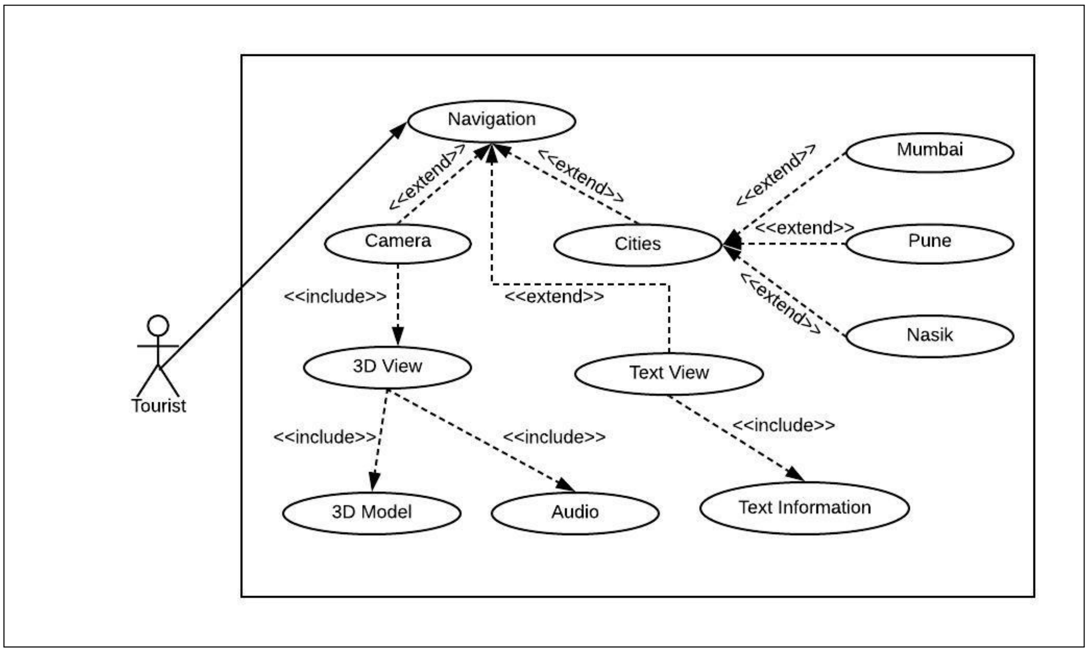

Figure 4.6: Use Case Diagram

Figure 4.6 shows Use Case of the system. Here, the actors involved are the Tourists i.e. User of the application to view the details and augmented vision of the desired monument with audio narration in various languages.

CHAPTER 5

PROJECT PLAN

5.1 PROJECT ESTIMATE

5.1.1 Time and Cost Estimate

All the resources used for developing the application are open source, and is used on student license. Hence, no software has been used that consists of cost features.The development of the application among four group members, took approximately eight months.

5.1.2 Project Resources

Hardware Resources

- Processor i5 or higher
- Minimum 4 GB RAM
- 2.66 GHz or Faster CPU speed
- Graphics card DirectX9 or later with WDDM

Software Resources

- Windows 10
- C# , .Net
- .Net Visual Studio
- Unity
- Android Studio
- Android SDK
- Android NDK
- Blender
- Autodesk Maya
- ARCore SDK

5.2 RISK MANAGEMENT

This section discusses Project risks and the approach to managing them.

5.2.1 Risk Identification

Risk 1: No end-users are enthusiastically committed to the project and system to be built.

Risk 2: End users have unrealistic expectations.

Risk 3: Project requirements are not stable.

Risk 4: No customer has been involved in the definition of requirement.

Risk 5: Software requirements should be matched by the end-user.

Risk 6: Climatic conditions such as, rain, and fog might disrupt the rendering of the application.

Risk 7: Internet access required on the end user's side.

Risk 8: Skills are required for making the 3D model.

Risk 9: Augmented Reality overlays real-time, computer-generated visual, audio, and haptic signals onto a person's natural field of vision, the system should be able to take the load.

Risk 10: Augmented Reality systems have been associated with having security threats from hackers breaching the Augmented Reality system, which could result in privacy invasions as well as digital data and physical security risk.

5.2.2 Risk Analysis

The risks for the Project can be analyzed within the constraints of time and quality Table 5.1 gives the various risks involved which may lead to system failure. The probability of how likely the risk will occur and the impact of that particular risk on the development schedule, quality and on the system system is given.

ID	Risk Description	Probability	Impact		
			Schedule	Quality	Overall
1	Software requirements should be matched by the end-user	Medium	Low	Low	Medium
2	If there are bad weather conditions	Medium	Low	Medium	Medium
3	If the user does not have internet access	Medium	Low	Medium	Medium
4	If the model does not portray the information aimed for	High	High	High	High
5	If the end user's mobile is not able to take the load of the application	Medium	Low	Medium	Medium
6	Security threats	Medium	Medium	High	High

Table 5.1: Risk Table

Probability	Value	Description
High	Probability of occurrence is	$> 75\%$
Medium	Probability of occurrence is	$26 - 75\%$
Low	Probability of occurrence is	$< 25\%$

Table 5.2: Risk Probability definitions

Table 5.2 gives the quantitative measure of the probabilities of the risk.

Impact	Value	Description
Very high	$> 10\%$	Schedule impact or Unacceptable quality
High	$5 - 10\%$	Schedule impact or Some parts of the project have low quality
Medium	$< 5\%$	Schedule impact or Barely noticeable degradation in quality Low Impact on schedule or Quality can be incorporated

Table 5.3: Risk Impact definitions

Table 5.3 gives the quantitative measure of the impact of risks.

5.2.3 Overview of Risk Mitigation, Monitoring, Management

Following are the details for each risk.

Risk ID	1
Risk Description	Software requirements should be matched by the end-user.
Category	Technology
Source	Software requirement Specification document.
Probability	Medium
Impact	Medium
Response	Accept
Strategy	Aiming for the software systems that match with the version required.
Risk Status	Identified

Risk ID	2
Risk Description	If there are bad weather conditions
Category	Risk associated with climatic factors
Source	This was identified during primary development and testing
Probability	Medium
Impact	Medium
Response	Mitigate
Strategy	The mobile phones cannot be operated in bad weather conditions
Risk Status	Identified

Risk ID	3
Risk Description	If the user does not have internet access.
Category	Technology
Source	Software requirement Specification document.
Probability	Medium
Impact	Medium
Response	Mitigate
Strategy	Internet connection needed only to access location, even if the location cannot be accessed end-user can still experience the tour.
Risk Status	Identified

Risk ID	4
Risk Description	If the model does not portray the information aimed for .
Category	Technology
Source	This was identified during primary development and testing.
Probability	High
Impact	Medium
Response	Mitigate
Strategy	Use of proper combination of information and tools.
Risk Status	Identified

Risk ID	5
Risk Description	If the end user's mobile is not able to take the load of the application.
Category	Technology
Source	This was identified during primary development and testing.
Probability	High
Impact	High
Response	Accept
Strategy	Aiming for the software systems that match with the software requirements.
Risk Status	Identified

Risk ID	6
Risk Description	Security Threats.
Category	Technology
Source	This was identified during primary development and testing.
Probability	High
Impact	High
Response	Accept
Strategy	Using OTP authentication during registration.
Risk Status	Identified

5.3 PROJECT SCHEDULE

5.3.1 Project Task Set

Major Tasks in the Project stages are:

- Task 1: Collecting information about the monuments selected
- Task 2: Developing of the 3D model, which in development terms are called as assets; to be rendered
  - Collecting the various designs for the model
  - Creating the model on the selective platform

- Giving materials and textures to the model

- Task 3: Developing plane detection, to be able to detect the plane from the mobile camera. And importing the 3D models in Unity
- Task 4: Developing UI (User Interface), and location module in Android Studio
- Task 5: Linking of UI and rendering application

5.3.2 Task Network

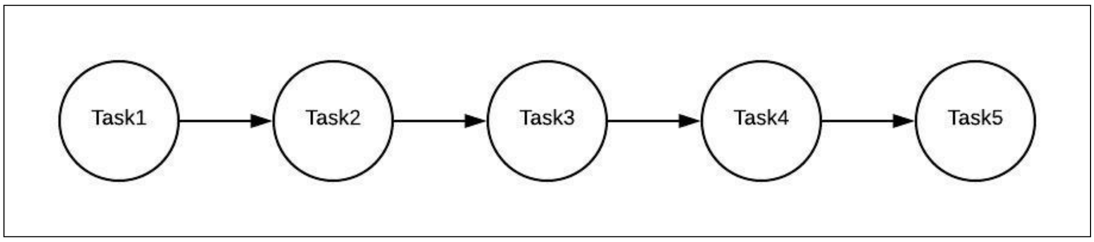

Figure 5.1: Task Dependency Graph

Figure 5.1 shows the task dependency graph for the system development.

Tasks	Effort Weeks	Deliverable	Milestones
Study of existing systems	3 weeks		
Literature Survey	3 weeks		
Designing and Planning	2 weeks		
System Flow	1 week		
Implementation	10 weeks	Primary System	
Testing	2 weeks	Test Report	Formal
Documentation	2 weeks	Complete Project Report	Formal

Table 5.4: Plan

Table 5.4 shows the plan followed to complete the project.

Phase	Tasks	Descriptions
1	Analysis	Analyze information given in the IEEE paper
2	Literature Survey	Collect raw data and elaborate on literature survey
3	Design	Design the process flow
4	Implementation	Implement the code for the system
5	Testing	Test the code for overall process
6	Documentation	Prepare the document with conclusion and future scope

Table 5.5: Plan Description

Table 5.5 gives the description of the phases followed in the development plan.

5.3.3 Timeline Chart

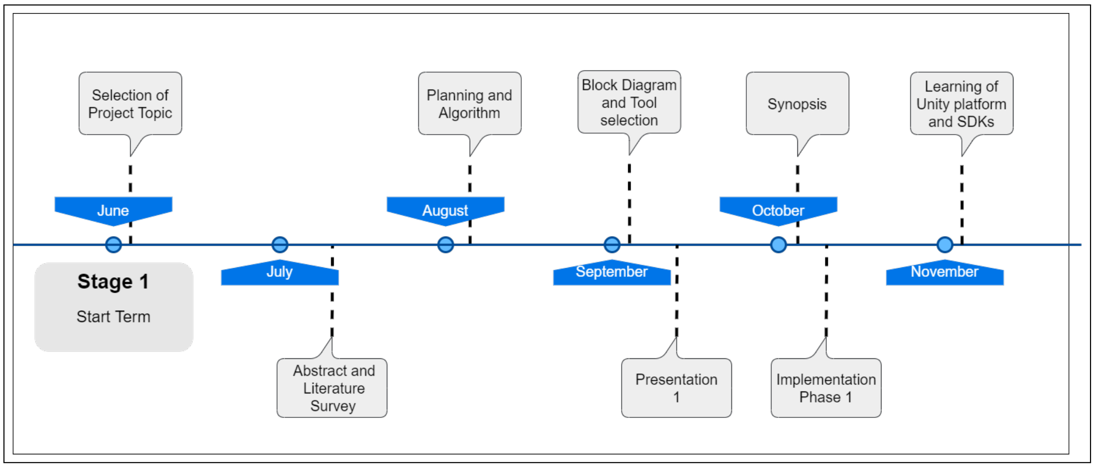

Figure 5.2: Timeline Chart-1

Figure 5.2 and Figure 5.3 give the graphical representation of the timeline and schedule followed for the project development.

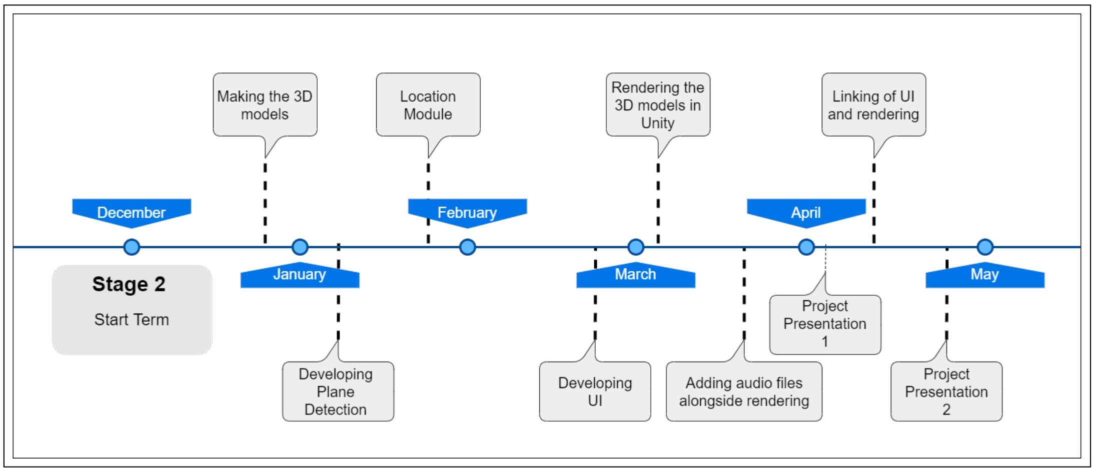

Figure 5.3: Timeline Chart-2

5.4 TEAM ORGANIZATION

The project was planned under the guidance of project guide **Prof. Priti Vaidya** and project coordinator **Prof. Monali Mahajan**.

5.4.1 Team Structure

The team consists of 4 members, where the tasks related to the project are roughly distributed equally. The team members and assigned responsibilities :

- **Harpal Kaur Dhindsa** : Developing of the 3D model for monuments, Unity Scripting and Rendering of modules
- **Anjali Trimukhe** : Unity Scripting for Audio narration and UI Scripting for providing information in texual form
- **Rashi Tugaon** : UI Scripting in Android module for handling the database with user details and Linking of modules
- **V. Rashmi Ramkumar** : Building of the 3D models for various monuments and Rendering of models

Documentation was equally divided as per modules.

5.4.2 Management Reporting and Communication

A dedicated project log-book, project log-sheets are maintained to trace the communication of the project work between the team members and project guide. The project slots available in the semester timetable were utilised for the discussions related to the difficulties faced and progress reports of the project with the project guide. Also, time-to-time progress updates were communicated to the guide through e-mails and video meetings.

CHAPTER 6

PROJECT IMPLEMENTATION

6.1 OVERVIEW OF PROJECT MODULES

The system has been developed with a combination of two languages, C# and Java with Android Studio. Both these languages are used for the front-end design implementation and scripting for the rendering of the 3D models. Java is used for database purpose in the back-end. The database primarily consists of data about the user that has to be stored for registration purpose and the information about the monuments to be displayed.
C# is used with Unity for scripting the rendering of 3D models as well as the speech rendering, as a part of the tour. Java is used in Android Studio for developing the UI, as well as for providing the location services, and for the database management. The project includes 3 modules. Following is the list of modules.

1. **Creating 3D models**

   This module is a framework which is required to place the 3D models in the virtual environment and editing them, and Unity is the framework that has been used for development purposes in this project. The functionality of adding material, and textures to the 3D models is done using Unity. In Unity the scenes are created in the manner of how they will pose in the real-world environment.

2. **GUI for database and User details**

   One of the key requirements of the user interface in the application is that, the application should be easy to access and navigating through the application should be in a flow. The user interface is developed using the Android Studio IDE.

3. **Rendering of models on the user's device**

   The augmented reality tour is developed on the Unity platform. The interface is developed in the android environment. Although we can build the Unity module on the android platform, the application built needs to be integrated in android studio for it to be able to run as an android application.

6.2 TOOLS AND TECHNOLOGY USED

Hardware requirements

Sr. No.	Parameter	Minimum Requirement	Justification
1	CPU Speed	1 GHz	For Processing
2	RAM	4 GB	As per basic requirements
3	Camera	12 MP	1080P

Table 6.1: Hardware Requirements

Table 6.1 gives the details of the different hardware requirements.

Tools

1. **C#**: C# is a universally useful, multi-worldview programming language encircling powerful composing, lexically scoped, declarative, functional, basic, object-oriented, and component-situated programming disciplines. It is created by Microsoft as a feature of its .NET activity. Mono is the name of the free and open-source project to build up a compiler and runtime for the language. C# is one of the programming dialects intended for the Common Language Infrastructure (CLI).

2. **Java**: Java is a broadly useful programming language that is object-oriented, class-based, and intended to have as hardly any execution conditions as could be expected under the circumstances. Java applications are commonly ordered to bytecode that can run on any Java virtual machine (JVM) paying little attention to the fundamental PC design. The grammar of Java is like C and C++, yet it has less low-level offices than both of them.

3. **ARCore SDK**: ARCore is a software development kit developed by Google, which allows for augmented reality applications to be built. ARCore uses three crucial technologies to integrate virtual content with the real world as seen through your phone's camera, it allows the developer to advance to six degrees of freedom allows the phone to understand and track its position relative to the

world, environmental understanding, and light estimation.

4. **Android SDK**: The Android software development kit (SDK) includes an inclusive set of development tools. These contain debugger, libraries, a handset emulator based on QEMU, documentation, sample code, and tutorials. All languages which are not supported by JVM, such as Go, JavaScript, C, C++ or assembly, need the help of JVM language code, that may be abounding by tools, likely with limited API support. Third party tools, development environments, and language support have also sustained to progress and increase since the initial SDK.

5. **Android NDK**: Code written in C/C++ can be compiled on ARM, or x86 native code (or their 64-bit variants) using the Android Native Development Kit (NDK). The NDK uses the Clang compiler, used to compile C/C++. Native libraries can be called from Java code running in the Android Runtime using System.loadLibrary, part of the standard Android Java classes.

6. **Visual Studio Community 2019**: Microsoft Visual Studio is an integrated development environment (IDE) introduced by Microsoft. It is utilized to create PC programs, just as sites, web applications, web administrations and portable applications. It can create both native code as well as override code. Visual Studio underpins 36 distinctive programming dialects and permits the code proof-reader and debugger to help (to shifting degrees) about any programming language, gave a language-explicit assistance exists. Worked in dialects incorporate C, C++, C++/CLI, Visual Basic .NET, C#, F#, JavaScript, TypeScript, XML, XSLT, HTML, and CSS.

7. **Android Studio**: Android Studio is the authorized integrated development environment (IDE) aimed for Google's Android operating system. It is built on JetBrains' IntelliJ IDEA software and designed precisely for Android development. It is offered for download on Windows, macOS and Linux based operating systems. It is a used as the primary IDE for native Android application development, a replacement for the Eclipse Android Development Tools (ADT). These are some of the features provided in the current stable version:

- Gradle-based build support
- Android-specific refactoring and quick fixes
- Android Virtual Device (Emulator) to run and debug apps in the Android studio

8. **Unity**: Unity is a cross-platform game engine industrialized by Unity Technologies. As of 2018, the engine had been prolonged to sustain more than 25 platforms. The engine can be used for the following purposes, to create three-dimensional, two-dimensional, virtual reality, and augmented reality games, as well as simulations and other experiences. The engine has been embraced by industries outside video gaming, such as film, automotive, architecture, engineering and construction.

9. **Autodesk Maya**: Autodesk Maya, generally condensed to just Maya, is a 3D computer graphics application that is available to operate on Windows, macOS and Linux platforms, it provides a special license for educational purposes, presently owned and developed by Autodesk. It is used for the creation of assets for interactive 3D applications (including video games), animated films, TV series, and visual effects.

10. **Blender**: Blender is an open-source 3D computer graphics software toolset. It is used to produce animated movies, visual effects, art, 3D printed models, motion graphics, interactive 3D applications, and computer games. Blender provides the following features, 3D modelling, UV unpacking, texturing, raster visuals editing, rigging and paring, fluid and smoke simulation, particle simulation, soft body simulation, and sculpting. Other features such as animating, match moving, rendering, motion graphics, video editing, and compositing, can also be implemented using Blender.

6.3 ALGORITHM DETAILS

6.3.1 Plane detection

Plane detection is a prerequisite to a wide variety of vision tasks. The method could avoid detecting wrong planes due to the complex geometry of the 3D data.
Procedure: Grid Visualizer
The algorithm works in following steps :

1. Create a mesh polygon as a list of vectors.

2. Create an awake() function with mesh component and mesh renderer component.

3. Create an update() function, which will continuously check if the tracking state is tracking as well as detecting the plane, or else the renderer will be disabled.

4. Create an initialize() function, that initializes the detected plane visualizer with a detected plane.

5. Update mesh with a list of Vector and plane's centre position.

6. Convert the polygon to a mesh with two polygons, inner polygon. Render with 100% opacity and fade out to outer polygon with opacity 0%

7. Fill transparent colour to vertices 0 to 3

8. Add vertex 4 to 7

9. Generate triangle (0, 1, 4), (4, 1, 5), (5, 1, 2), (5, 2, 6), (6, 2, 3), (6, 3, 7), (7, 3, 0), (7, 0, 4)

10. Keep previous frame's mesh polygon to avoid mesh update every frame.

6.3.2 Ray casting

Ray Casting algorithm involves following steps :

1. Start from the left-most column of the projection plane.

2. Finding the height of the floor that the player is currently standing on (Call it current_height).

3. Casting a ray and checking intersections as before.

4. If the casted ray hits a floor that has different height than the current_height, then that floor is either raised/sunk. (A raised floor is just a wall.)

5. If it is raised, then it will be visible. Project it, and render it. (Figure 30 below illustrates the math behind this.)

6. If it is sunk, then we don't need to project it because it will not be visible.

7. Draw the floor from the point of where the height changes are occurring until the point where the top of the last wall slice is projected onto. (Initially, the top of the last wall slice will become the bottom of the projection plane.)

8. Repeat until the ray is extending pass the limit of the world map.

9. Repeat step 2 to 8 for all subsequent columns.

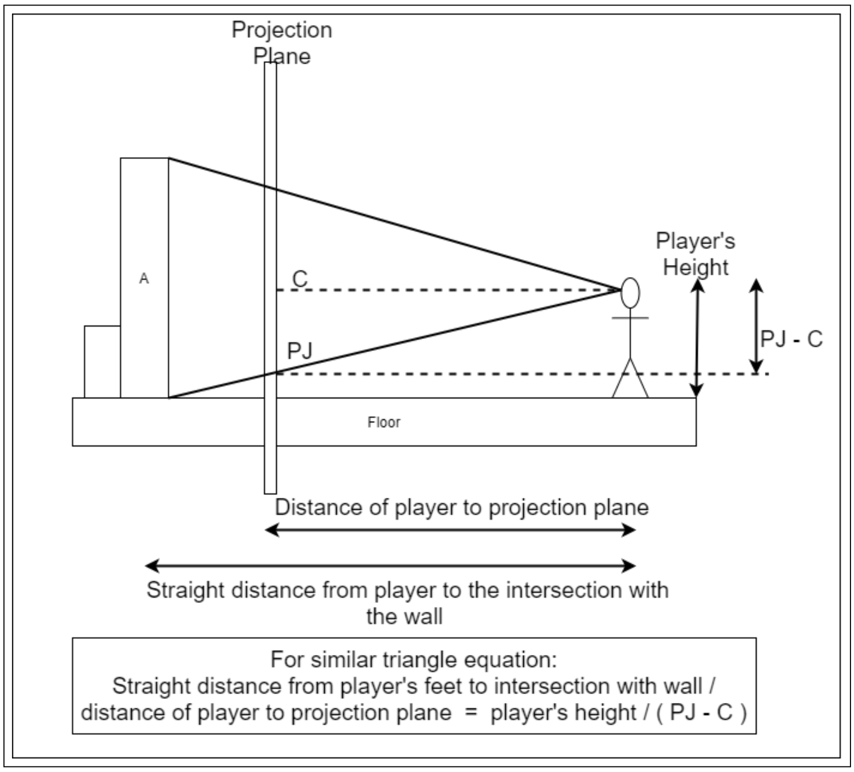

Figure 6.1: Ray Casting Algorithm

CHAPTER 7

SOFTWARE TESTING

SOFTWARE TESTING

Software testing is a process, to evaluate the functionality of a software application with an intent to find whether the developed software met the specified requirements or not and to identify the defects to ensure that the product is defect free in order to produce the quality product. Various types of testing were performed to ensure quality and bug-free working model.

7.1 TYPES OF TESTING

The different types of testing carried out in the development of the project are listed below :

- Functional Testing
- Unit Testing
- Integration Testing
- GUI Testing
- Back-end Testing
- System Testing
- Usability Testing

Functional Testing

Testing performed to check whether the code works as it is expected in terms of the functionality that the code should provide.

Example:
Function for rendering of models is checked if it correctly renders the model on the user screen.

Test Case ID	FT-01
Test Case Description	Rendering model according to the specified location.
Input	Location of the user.
Expected Output	Model of that particular monument is rendered and visible to the user.
Actually Output	Model of the monument is visible to user.
Test Status	Pass

Unit Testing

Testing performed to ensure proper functioning of the project module or the smallest functional unit of the project.

Example:
Module for OTP generation is checked whether it works correctly with proper functionality as an independent unit.

Test Case ID	UT-01
Test Case Description	OTP should be sent to specified recipient on the registered phone number.
Input	Phone number of the user.
Expected Output	OTP should be sent on registered number.
Actually Output	OTP is sent to user on the registered number within seconds.
Test Status	Pass

Integration Testing

Testing performed when multiple (two or more) project modules are integrated together to check if they wor correctly together with expected interaction throught the module interfaces.

Example:
The android module (Module-1) is integrated with unity module (Module-2) and testing is performed to ensure that the modules work together with expected functionality.

Test Case ID	IT-01
Test Case Description	Check the working after integration of Module-1 and Module-2.
Input	Location of the user and access to the device camera.
Expected Output	Location given by user in Module-1 should be accepted as input by Module-2 and Module-2 displays the desired output.
Actually Output	Module-2 accepts input generated by Module-1 and displays the desired output.
Test Status	Pass

GUI Testing

Testing performed to check the front-end of the project.

Example:
Testing the different pages for correct display of different monuments and information.

Test Case ID	GT-01
Test Case Description	Check the aesthetics and display of all the buttons, links on all pages.
Input	Checking all the pages.
Expected Output	Pages should be displayed properly.
Actually Output	Pages are displayed properly.
Test Status	Pass

Check whether the application displays 3D models on user interface.

Test Case ID	GT-02
Test Case Description	Check whether the application displays 3D models of the requested monument.
Input	Selection of monument.
Expected Output	Monuments should be displayed properly.
Actually Output	Monuments are displayed properly.
Test Status	Pass

Check whether the application plays audio as per user request.

Test Case ID	GT-03
Test Case Description	Check whether the application plays audio as per user request through the interface.
Input	Selection of audio.
Expected Output	Audio should be displayed properly.
Actually Output	Audio is displayed properly.
Test Status	Pass

Back-end Testing

Testing performed on the database to check whether the database stores the data of the user by performing various operations.

Example:

Executing the insert operation of the phone number and check the database whether the number is stored or not.

Test Case ID	BT-01
Test Case Description	Insert the number and check the database whether the user is stored or not.
Input	Phone number of user.
Expected Output	User phone number should be stored in database.
Actually Output	User phone number is stored in database.
Test Status	Pass

System Testing

Testing performed on the entire system as a whole.

Example:

Entire system containing all the modules it tested to verify proper functioning.

Test Case ID	ST-01
Test Case Description	Check entire system as a whole after integration.
Input	Details of the user location and monument.
Expected Output	All the modules should execute successfully and of successful display of 3D model should be achieved.
Actually Output	The system works correctly and displays the 3D model of monument.
Test Status	Pass

Usability Testing

Testing performed on the system to check the user-friendliness and functioning from user point of view.

Example:

Testing the various GUI pages to verify that the GUI is user-friendly.

Test Case ID	UT-01
Test Case Description	Check the user-friendliness of the GUI by examining the Registration and OTP Verification, Display pages and exploring all possible options on the pages.
Input	None.
Expected Output	All the buttons and pages should be easily accessible without any complexity to the user.
Actually Output	All the buttons and pages are easy to handle.
Test Status	Pass

CHAPTER 8

RESULTS

8.1 OUTCOMES

The Application System generates output in the form of:

- Monuments in the 3D augmented form
- Audio narration of the historical significance of monument in three different languages(English, Hindi, Marathi)
- Information and facts related to the monument in the texual form

8.2 SCREENSHOTS

8.2.1 GUI

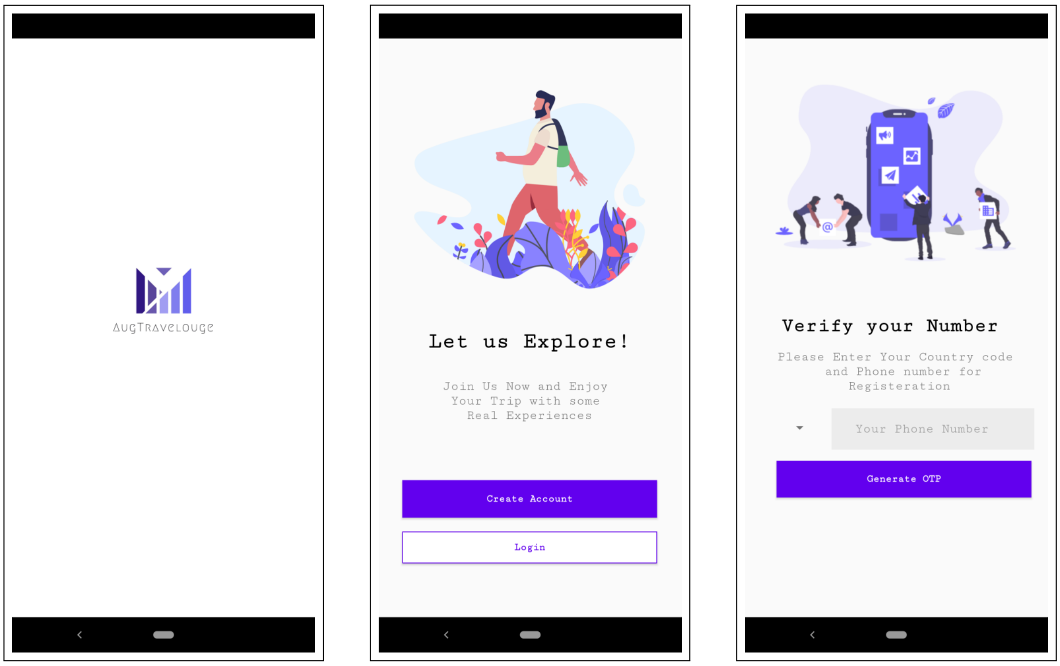

Figure 8.1: UI for Registration and Login

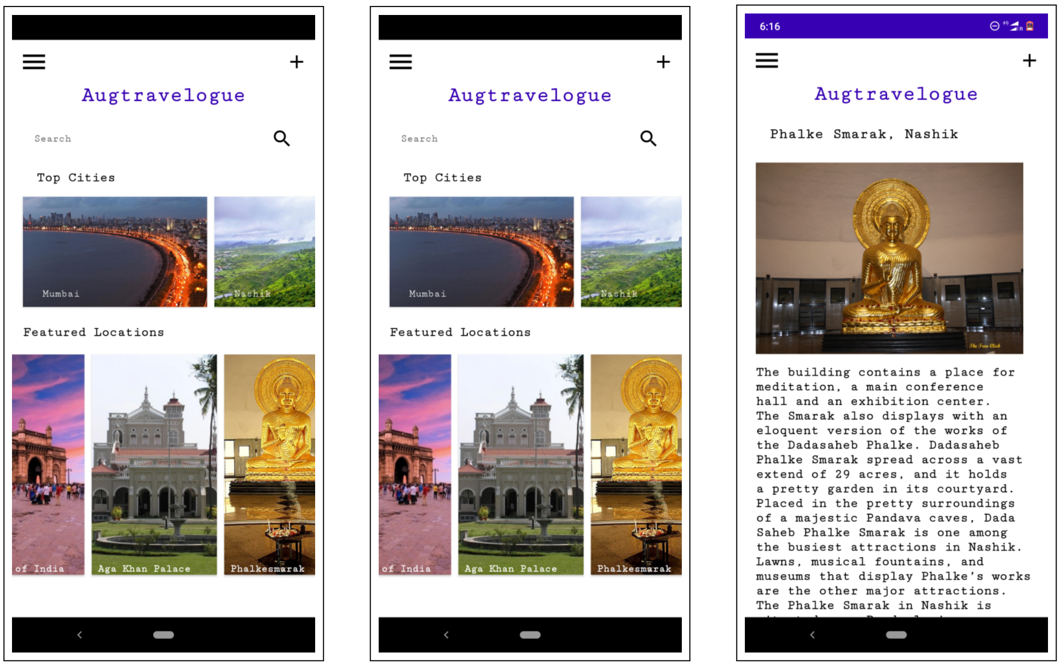

Figure 8.2: Various Monuments and their history displayed

8.2.2 Output of Augmented Reality

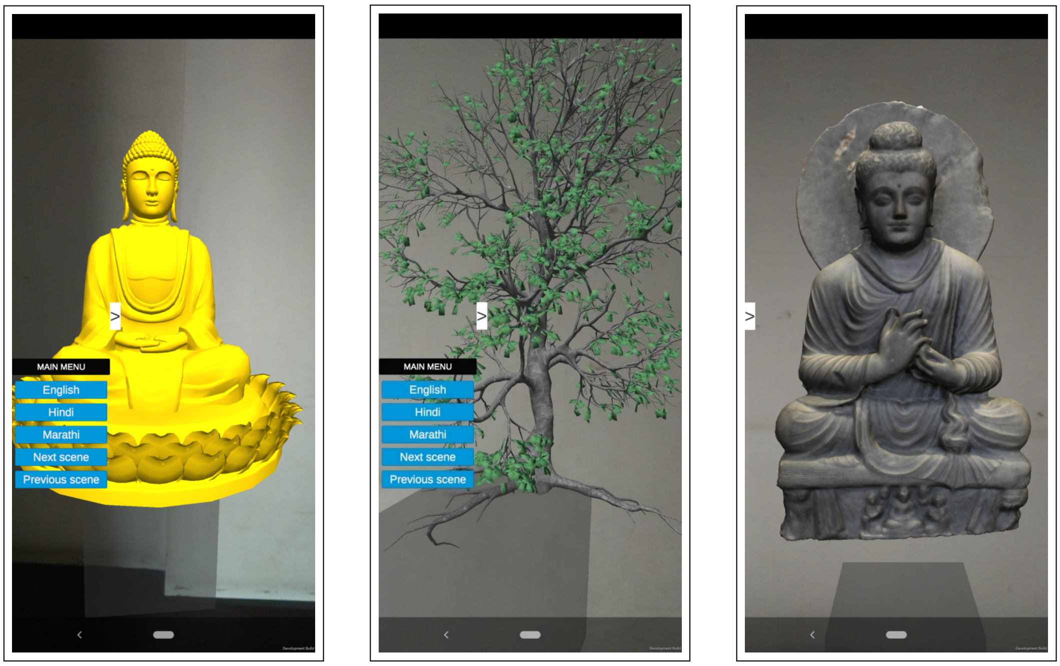

Figure 8.3: Various monuments in 3D form

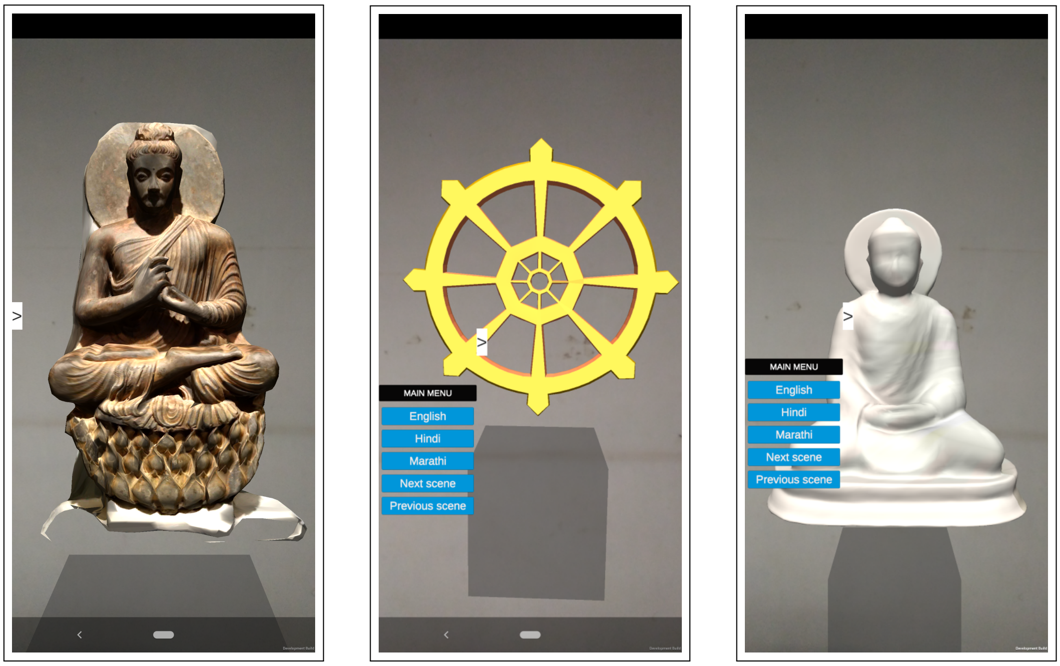

Figure 8.4: Various Monuments and their history displayed

8.2.3 Database

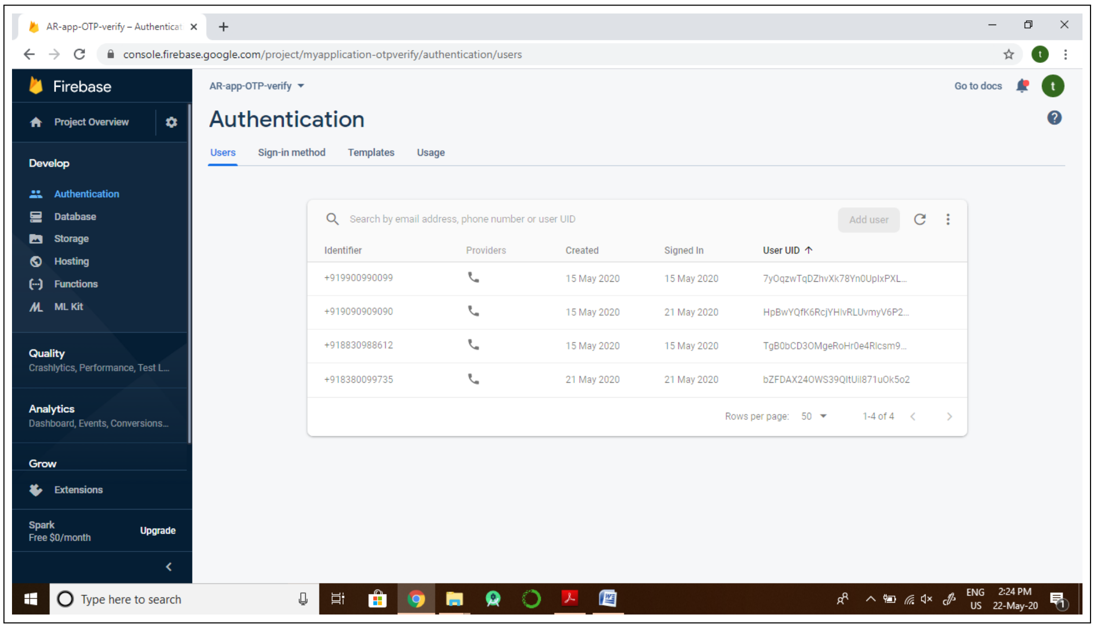

Figure 8.5: Firebase Database

CHAPTER 9

CONCLUSIONS

9.1 CONCLUSION

Hence, to conclude an augmented reality system is being proposed with the purpose of being able to portray the mobile device as a portal to the user through which they are able to see 3D objects related to the historic significance of that monument.
An augmented experience along with an audio playback in three different languages, to spread the usage of the application for all the masses.

9.2 FUTURE WORK

- India is a country with a rich legacy and culture. Currently the application is restricted to fewer number of cities, however in future the application can be enhanced to cover various cities with significant monuments in India.
- Other functionalities that can be pursued in the future are adding, animation, and implementation of image detection and linking the image detected to the web in-order to display the information about the objects being detected in the image.

9.3 APPLICATIONS

- The proposed application is intended to be aimed for the tourism as well as educational genre.
- The proposed application is intended to display information regarding the monuments, initially in limited number of cities, in India.
- It is intended to promote tourism, and spread awareness about interlinking between the various eras the country's heritage has been through.
- The proposed application also covers the educational aspect, as the said application is intended to be used as a medium to provide information for learning, and getting a different look at the history of the monument in an innovative way.

ANNEXURE A

MATHEMATICAL MODEL

System Description:

- Input : Input to the system is live location of the user and operational camera
- Output : The system provides a 3D model of the monument as an output as well as audio narration, information of the monument
- Set Theory Let S be the proposed system, where
  S = {I,O,D,Q,C,E,L,F} , where
  - I (Set of inputs) = {I1,I2} where,
    - I1 = live location
    - I2 = (User details(age,contact details, language,etc.))
  - D: Set of locations and models stored in the database
  - Q: Set of extracted frames from the input video for plane detection
  - C: Content database where the user information is stored
  - E: Information database where the information related to the monument is stored
  - L: Location of the device
  - F(Set of functions) ={F1,F2,F3}
    - F1 : F1(I1,D) $\rightarrow$ Q
      Function which takes the location of user and detects the plane using camera and matches with the one's in the database
    - F2 : F2(I2) $\rightarrow$ (O2)
      Function which takes the user preference of language and provides narration about the history of the monument
    - F3 : F3(D,C,L) $\rightarrow$ (O1)
      Function which renders the image onto the screen of the user device
  - O (Set of outputs) = {O1,O2} where,
    - O1 = 3D rendered image/video as output, which shows the vision of monument in the past
    - O2 = pre-recorded narration, explaining the significance of the place

ANNEXURE B

PAPER PUBLICATION

DETAILS OF PAPER PUBLICATION

International Journal of Innovative Science and Research Technology

- Type : **Research Paper**
- Title : **Historical Insights using Augmented Reality**
- Authors:
    1. Harpal Kaur Dhindsa
    2. Anjali Trimukhe
    3. Rashi Tugaon
    4. V.Rashmi Ramkumar
    5. Prof. Priti Vaidya
- Uploaded by: Harpal Kaur Dhindsa
- Updates: Not yet published

Historical Insights using Augmented Reality

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Nashik-422003, India

***Abstract*— India, a nation steeped in history and tradition, is losing its heritage sites fast. This part of the world has an intriguing and fascinatingly rich and varied heritage that is thousands of years old. Monuments and paintings, are robust tokens of the many characteristics and antiquities that form the joint consciousness and become an absolute part of us. Some forms of menace to heritage monuments can be absence of awareness about the culture, misguidance by people, tampered boards, etc. The project is focused on the importance of using modern technologies in preserving and exploring Cultural Heritage. Specifically, Augmented Reality (AR) can possibly improve the client experience identified with social legacy. Augmented reality is "an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (as a smartphone camera)." The undertaking gives a framework that joins location-based sight and sound retrieval with an enlarged reality on the customer's mobile devices. The system will enable users to query collections of historic multimedia content for perspectives of their current surroundings and overlay them onto their current view using a mobile device. This way, the proposed system offers a virtual window into the past.**

Keywords*— *Augmented Reality; 3D Rendering; History; Android; Computer Graphics

I. INTRODUCTION

Augmented reality (AR) is a shared association of a true domain where, the articles that live in reality are improved by computer created inventive data, at times over different tactile modalities, including picturing, sound, and tangible. AR can be differentiated as a framework that satisfies three essential highlights: a mix of genuine and virtual universes, continuous cooperation, and exact 3D enrollment of virtual and genuine articles. The overlaid tangible data can be useful (for example added substance to the indigenous habitat), or damaging (for example covering of the natural environment). This experience is impeccably joined with the physical world to such an extent that it is seen as a vivid part of the sincere condition. The proposed system aims to bring objects or elements from the history of a monument, onto the display of the mobile phones. To give an experience to users that gives them information about the monument, how it is linked with the heritage of the country, in an augmented tour form.

To develop a mobile tour guide system using augmented reality to guide the tourists with respect to their visit and provide them the visual experience of the history of a particular monument. Enhance the overall tourism experience. Gain meaningful information about the historical sights. Promote tourism in that particular city.

II. RELATED WORK

A. Literature Survey

There is a lot of research done in the field of augmented reality. Especially because it a relatively new and an expanding field, and hence different new methods and techniques have been experimented to achieve set goals. Some of the previously presented methodologies that we have studied are summarized below.

An electronic guide application has been presented for android smartphones and tablets to help users to reach the places of their interest by Athanasios Kountouris and Evangelos Sakkopoulos. Their proposed system with the help of internet technologies help users to reach user preferred locations instead of using a personal guide, a tour guide book or any online website. Their system includes designing software for showing cultural sites, inserting or deleting cultural sites of user interest, study of navigation system using smartphone. The drawbacks of the system proposed are as follows, no proper use of reality navigation to store new POIs at the server-side in order to be able to share them.[1]

Another application that has been implemented is, GoFind for tourists and historians which gives a virtual view in city's past via augmented reality-based user interface. Historic photo collections are important for cityscapes development but are buried in archives. With the proposed system the historic multimedia collection is brought to mobile devices. The system provides the overlay of past and present view. In the system the back-end handles retrieval queries and front-end handles user's interaction. The system has following drawbacks, only a picture will overlay the real-life scene, to show how the place looked in the historic times, but it won't give much information or show any 3D models relative to the site.[2]

Majorly two applications have been implemented for representation of cultural heritage using virtual and augmented reality in Tunisian cultural heritage in the marker based augmented reality field applications. One part of proposed system uses a picture on magazines as markers to superimpose the 3D model of that place. Along with superimposition the system also provides interactive augmented reality for guided tours. The system uses real-time 3D imaging.[3]

Another idea that has been implemented is in interest of, promoting the Taiwan dark tourism through the augmented VR experience. The information about Taiwan's dark tourism destinations was used to build up an augmented virtual reality project for guided tour. GoPro Hero 4 six-camera set, Kolor Autopano Giga and Panotour Pro software, and the web platform Holobuilder were applied in this experiment. Few places were selected to carry out and implement the idea and a tour itinerary was designed for the same. The system has following drawback, external hardware as well as advanced software is required for the development. The drawback of the system is as follows, since this is a VR experience the use of hardware lens is mandatory and AR does not use lens, only a mobile device is required.[6]

There also been a keen interest of the users in a game-based augmented reality applications. One such guidance system for Yuanmingyuan and a time travel game called MAGIC-EYES using Augmented Reality technology. The proposed system by X. Wei, D. Weng, Y. Liu and Y. Wang, can help the tourists immerse themselves in the mystical legend. MAGIC-EYES makes use of plaques, stone tablet, patterns of buildings and geographical location information to identify the user's location, which is then combined with AR-based interactive game to complete the guided tour. The traditional guidance system uses the traditional audio, cartoon and GPS to guide a tourist to reach the designated place and display the historical legend. The system has a drawback of being a game in which you are able to see the computer-generated environment on the mobile phone, and not the real environment. Hence, not being able experience the real-world based augmented reality experience.[9]

In the zone of location-based augmented reality one specific application familiarized, comprised of a transportable visit be able to work with framework consisting augmented data. The application will assist the visitor with finding the precise location additionally the data about the necessary spots and it will likewise give the augmented view so the connection between the vacationer and the spot will be simple. The GPS service is similarly handy for the vacationer to discover the spots without any problem. The visitor will encounter the physical nearness of the location on their cell phones which the user needs to visit. This framework gave a thought for another framework.[8]

Hence, the detailed study in the area of location-based augmented reality applications, and learning from the similar previous work is completed. We were able to get a basis for our tourism augmented reality application.

B. Augmented Reality

Augmented reality (AR) is an intellectual encounter of a genuine situation where the objects that live in reality are enhanced by computer produced perceptual data, once in a while over different tangible modalities, including visual, sound-related, and haptic. AR can be characterized as a framework that satisfies three essential highlights: a mix of genuine and virtual universes, continuous cooperation, and exact 3D enlistment of virtual and genuine articles. The overlaid tangible data can be helpful (for example added substance to the common habitat), or ruinous (for example veiling of the indigenous habitat). This experience is flawlessly intertwined with the physical world to such an extent that it is seen as a vivid part of the genuine condition.

A portion of the uses of AR can be, AR can help in envisioning building ventures. Computer-generated pictures of a structure can be superimposed onto a genuine neighborhood perspective on a property before the physical structure is developed there. AR can likewise be utilized inside a planner's workspace, rendering vivified 3D representations of their 2D drawings. Engineering touring can be improved with AR applications, permitting clients seeing a structure's outside to essentially observe through its dividers, seeing its inside items and format.

With nonstop upgrades to GPS precision, organizations can utilize augmented reality to picture georeferenced models of building destinations, underground structures, links, and funnels utilizing cell phones. Augmented reality is applied to introduce new tasks, to fathom nearby development challenges, and to improve special materials.

AR applied in the visual expressions permits items or spots to trigger aesthetic multidimensional encounters and translations of reality. Augmented reality can help in the movement of visual craftsmanship in exhibition halls by permitting gallery guests to see fine art in displays in a multidimensional route through their telephone screens.

C. SLAM

Simultaneous Localization and Mapping (SLAM) is turning into an inexorably significant subject inside the computer vision network, and is accepting specific enthusiasm from the enlarged and augmented reality ventures. 'SLAM' is certifiably not a specific calculation or a bit of programming, but instead it alludes to the issue of attempting to simultaneously localize (for example discover the position/direction of) some sensor as for its environmental factors, while simultaneously mapping the structure of that condition. This should be possible in various manners, contingent upon the circumstance.

The precondition of recuperating both the camera's position and the guide, when nor are known in the first place, recognizes the SLAM issue from diverse endeavors. For instance, marker-based tracking isn't SLAM, in light of the fact that the marker image (comparable to the guide) is known beforehand. 3D recreation with a fixed camera rig isn't SLAM either, in light of the fact that while the guide (here the model of the item) is being recuperated, the places of the cameras are as of now known. The test in SLAM is to recuperate both camera posture and guide structure while at first knowing not one or the other.

SLAM idea is principally utilized, when the organization condition is ambiguous. In any case, if there should be an occurrence of enlarged reality the space is known in the genuine world, and it must be characterized in the virtual world. Since to show enlarged reality the client's relative situation in nature ought to be known. Subsequently, SLAM isn't the most valuable strategy for the proposed application.

D. AREA (Augmented Reality Engine Application) coordinate system and track notion

It fundamentally comprises of a versatile enlarged reality portion that empowers area based portable expanded reality applications. It comprises of the ECEF facilitate framework. ECEF (abbreviation for earth-centered, earth-fixed), otherwise called ECR (an initialism for earth-centered rotational), is a geographic and Cartesian arrange framework and is now and then known as a "traditional earthbound" framework. It speaks to positions as X, Y, and Z facilitates. The point (0, 0, 0) is characterized as the focal point of mass of Earth, thus the term geocentric directions. The good ways from a given focal point to the focal point of Earth is known as the geocentric span or geocentric separation.

Its axes are lined up with the international reference pole (IRP) and global reference meridian (IRM) that are fixed regarding Earth's surface, subsequently the descriptor earth-fixed. This term can create turmoil, since Earth doesn't pivot about the z-axis (not at all like an inertial framework, for example, ECI), and is along these lines on the other hand called ECR.

The z-axis stretches out through evident north, which doesn't match with the momentary Earth rotational hub. The slight "wobbling" of the rotational pivot is known as polar movement. The x-axis converges the circle of the earth at 0° scope (the equator) and 0° longitude (prime meridian in Greenwich). This implies ECEF turns with the earth, and in this manner directions of a point fixed on the outside of the earth don't change. Change from a WGS84 datum to ECEF can be utilized as a transitional advance in changing over speeds toward the northeast down organize framework.

Due to advancements in hardware and software technologies over time, and availability of better hardware components on selected mobile devices. Components such as gyroscope, accelerometer, magnetometer, GPS, and a camera module of the mobile device can be used in place of using an algorithm serving for the same purpose.

III. PROPOSED METHOD

This document is the summarization of an application based on augmented reality on the android platform. The proposed system is an android application. The application has been developed using the Unity and Android Studio platforms. The said application consists of following features such as, displaying of 3D models on the mobile screen, audio for an explanation as a part of the tour, information in text form for reading purpose, and relative images as well.

The application is built using android, as to give a proper augmented reality experience to the end-user there are certain pre-requisites which include software as well as hardware requirements.

In the case of virtual reality experiences, the end-user requires a special lens or virtual glasses, that the end-user has to mount on their head to be able to experience the virtual objects around them. Whereas, in an augmented reality, the end-user requires a device with a camera as a primary requirement and a display screen onto which the virtual objects will be portrayed. Hence, mobile phone is a pre-requisite to use the various components such as gyroscope, magnetometer, accelerometer, GPS, display screen, and camera. The combined use of these sensors, performing individually or in combinations makes it possible to deliver the augmented reality experience.

The system architecture entails the following main modules:

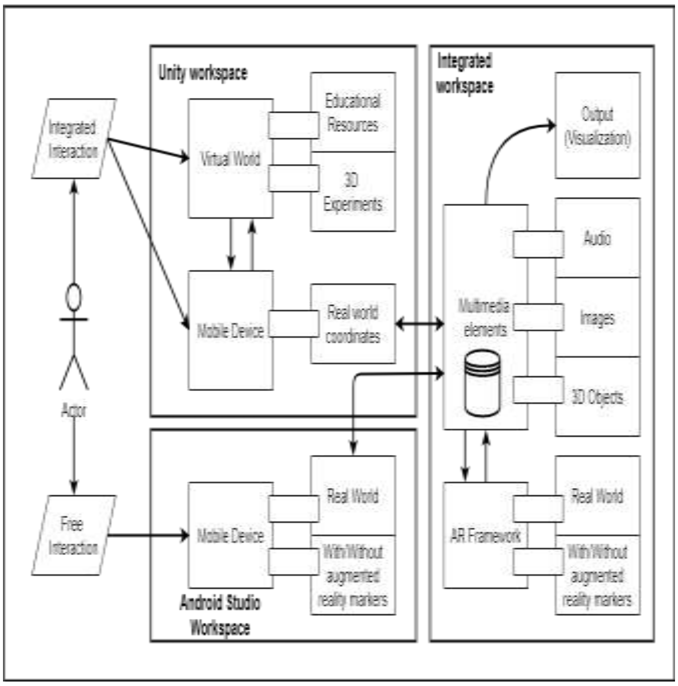

Fig 1: - Proposed System Architecture

A. Unity workspace

The Unity workspace consists of the manipulation of 3D objects (they may also be referred to as 3D models or in Unity terms as assets), plane detection, and the rendering of the 3D objects. The Unity platform is used along with the ARCore SDK, to be able to use the camera, to be able to visualize the 3D models, and to be able to anchor the 3D models at a given location. The Unity workspace also includes adding the audio part of the augmented reality tour.

B. Android Studio workspace

- The user interface part of the proposed system is present in the android studio workspace. The application can only be retrieved by a registered user after being able to login in the application. Hence, the name, phone number, and other user details need to be stored in the database. Once the user has logged in, into the application, they should be able to see information about all the places available in the system. Initially the proposed system consists of three places situated in three different cities in the state of Maharashtra, India. The user should be able to see the monuments of the city they are currently present at.

- Information about the places in text form for reading as well as relative images are available. This module is a small sub-part of the application, in addition to the 3D models and audio.

- The user interface is required to be user friendly, and hence proper instructions are given at every step, so that the user does not have any issues while navigating through the application.
- Augmented experiences require a few permissions from the user's mobile device. It is important that the user feels safe while using the application. In order to enhance security of the developed application an OTP (One Time Password) verification is used in the android studio workspace, to confirm that the user is logging in and not an imposter.

C. Integrated workspace

- The integrated workspace consists of the combination of android studio and unity. The module developed in Unity can be built under the android platform, but to provide the additional features, it is exported into android studio.
- Hence, resulting in an integrated application, with the rendering and visualizing part from Unity, and user interface and security part from android.

  The location service that is required to know the current position of the user is also included in the android module while integrating the Unity module.
- When the application is started, the user will be able to see an option of Augmented tour. The camera will start and user can select and navigate to certain positions in monument's location and 3D model will be rendered in real time based on the location.
- The options to get an audio tour are given in three different languages namely, Hindi, English, and Marathi. The user will be able to listen to the audio as per their convenience.

IV. RESULT

The resulting application consists of the following modules. The first page gives an option to create a new account for the user who is visiting the application for the first time, and a login option for the user who has already created an account.

The user on creating the account has to enter their mobile number for OTP (One Time Password) verification. And on entering the number generated, gets to login. The user then gets to explore the three cities available in the application.

One of the monuments available in the system is, Phalke Samarak in Nashik.

Fig 2a

Fig 2b

Fig 2a depicts the image of the page showing information based on Phalke Samarak. Fig 2b depicts the image of one of the pages that open during the augmented tour, on this page the 3D model of Buddha is displayed, which can be observed alongside audio information, which is available in three languages, namely Hindi, English, and Marathi.

V. CONCLUSION

In this paper, an augmented reality system is being proposed with the purpose of being able to portray the mobile device as a portal to the user through which they are able to see 3D objects related to the historic significance of that monument. An augmented experience along with an audio playback in three different languages, to spread the usage of the application for all the masses. India is a country with rich heritage and culture. Currently the application is restricted to fewer number of cities, however in future the application can be enhanced to cover various cities with significant monuments in India.

ACKNOWLEDGMENT

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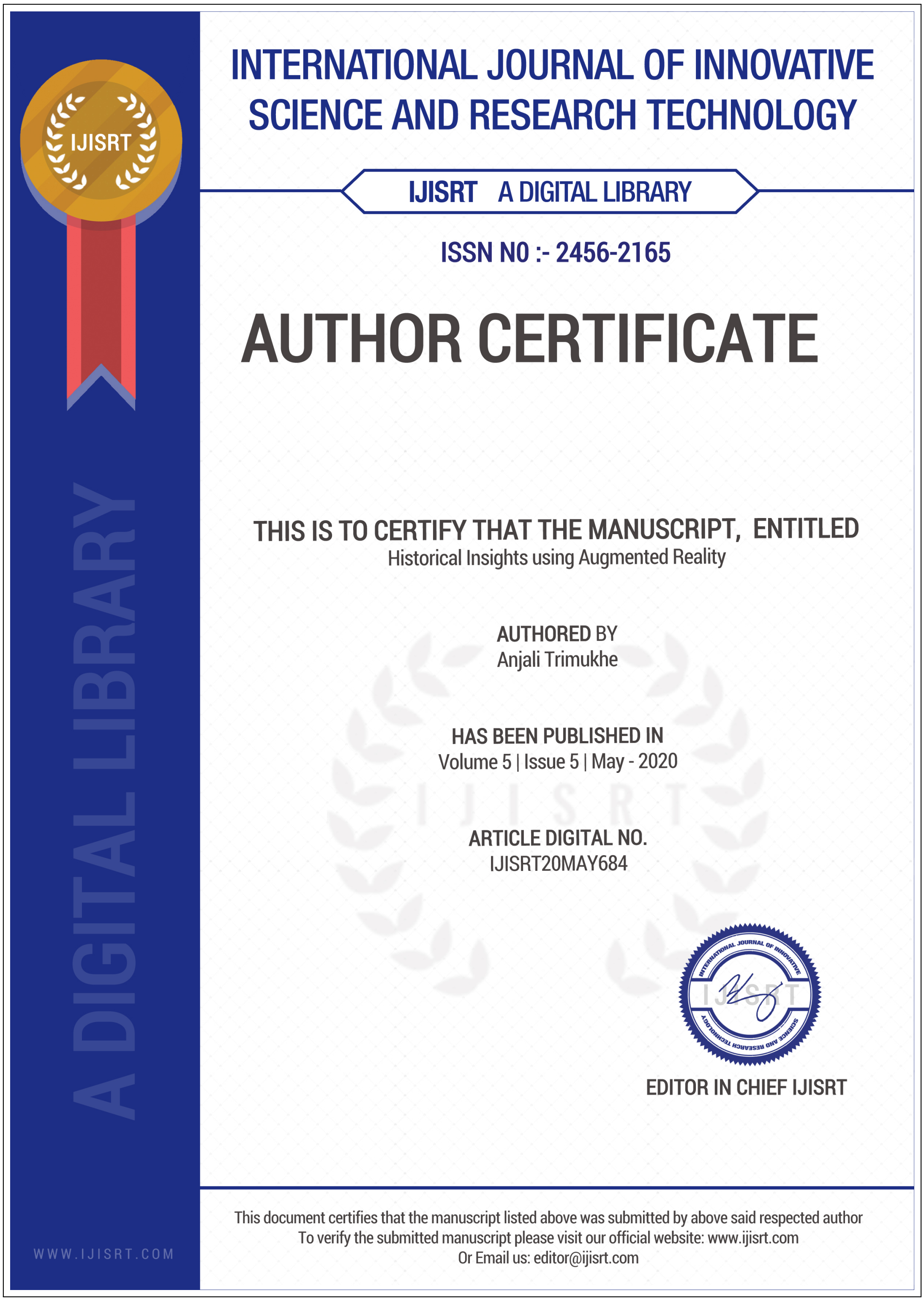
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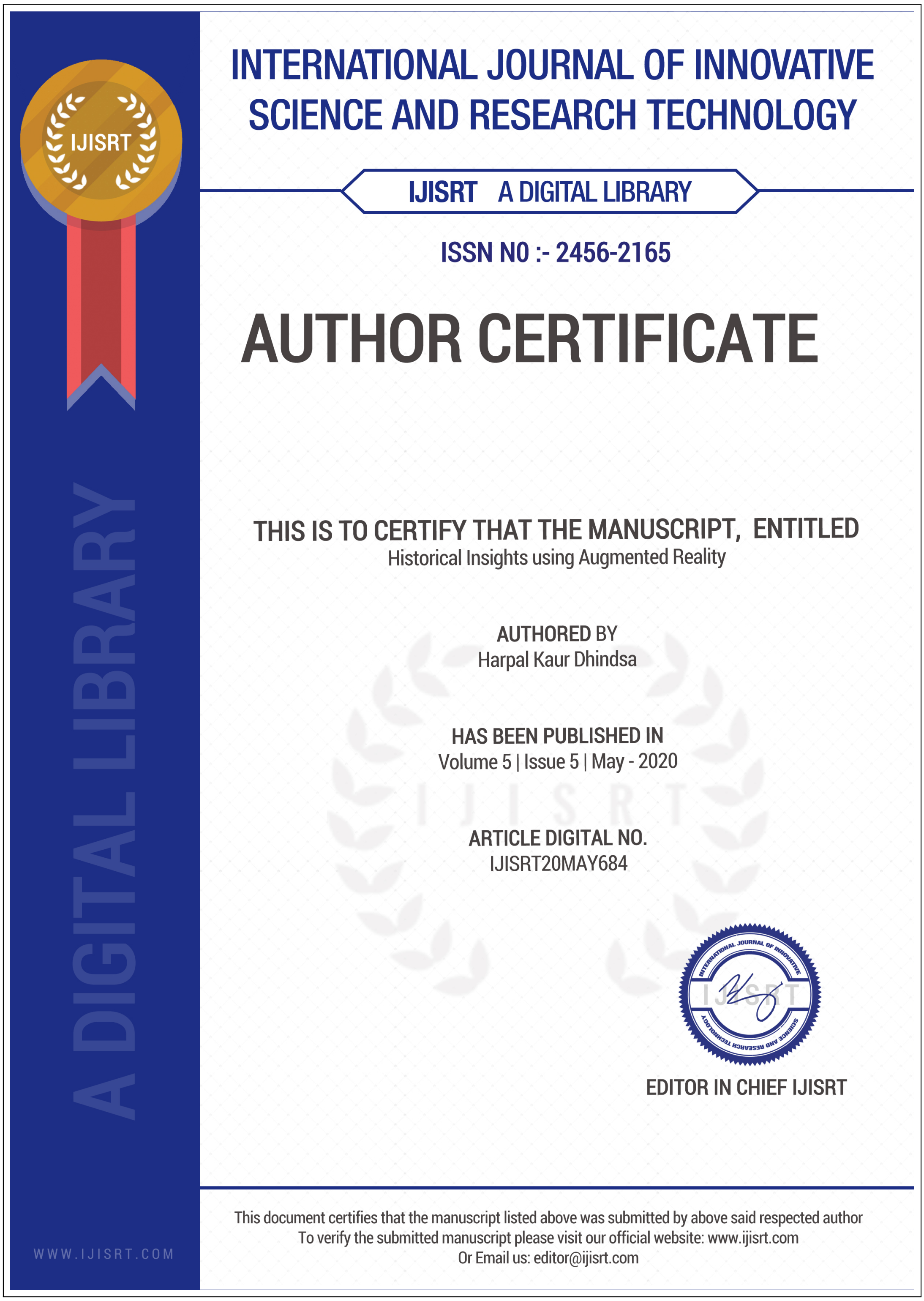
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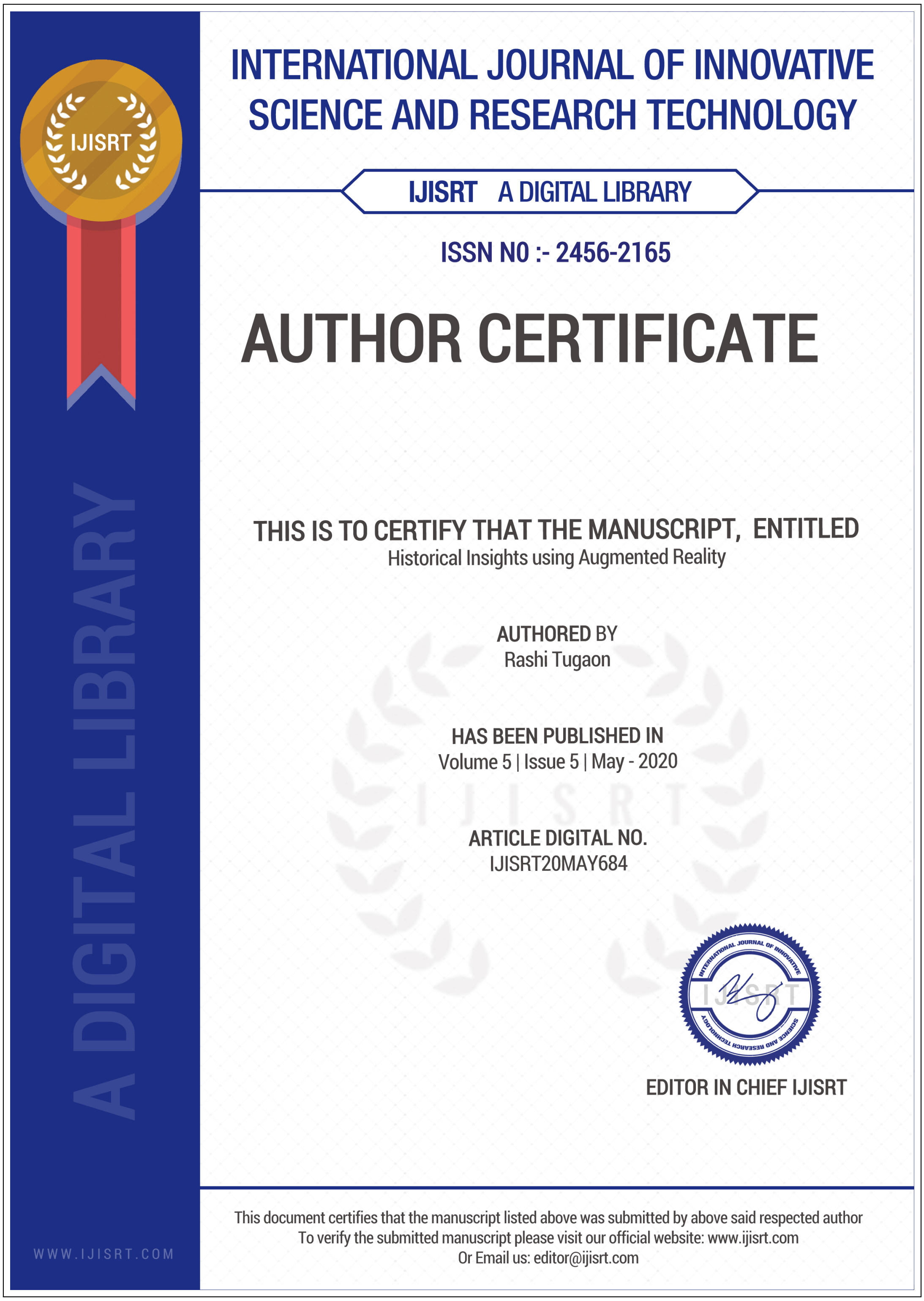

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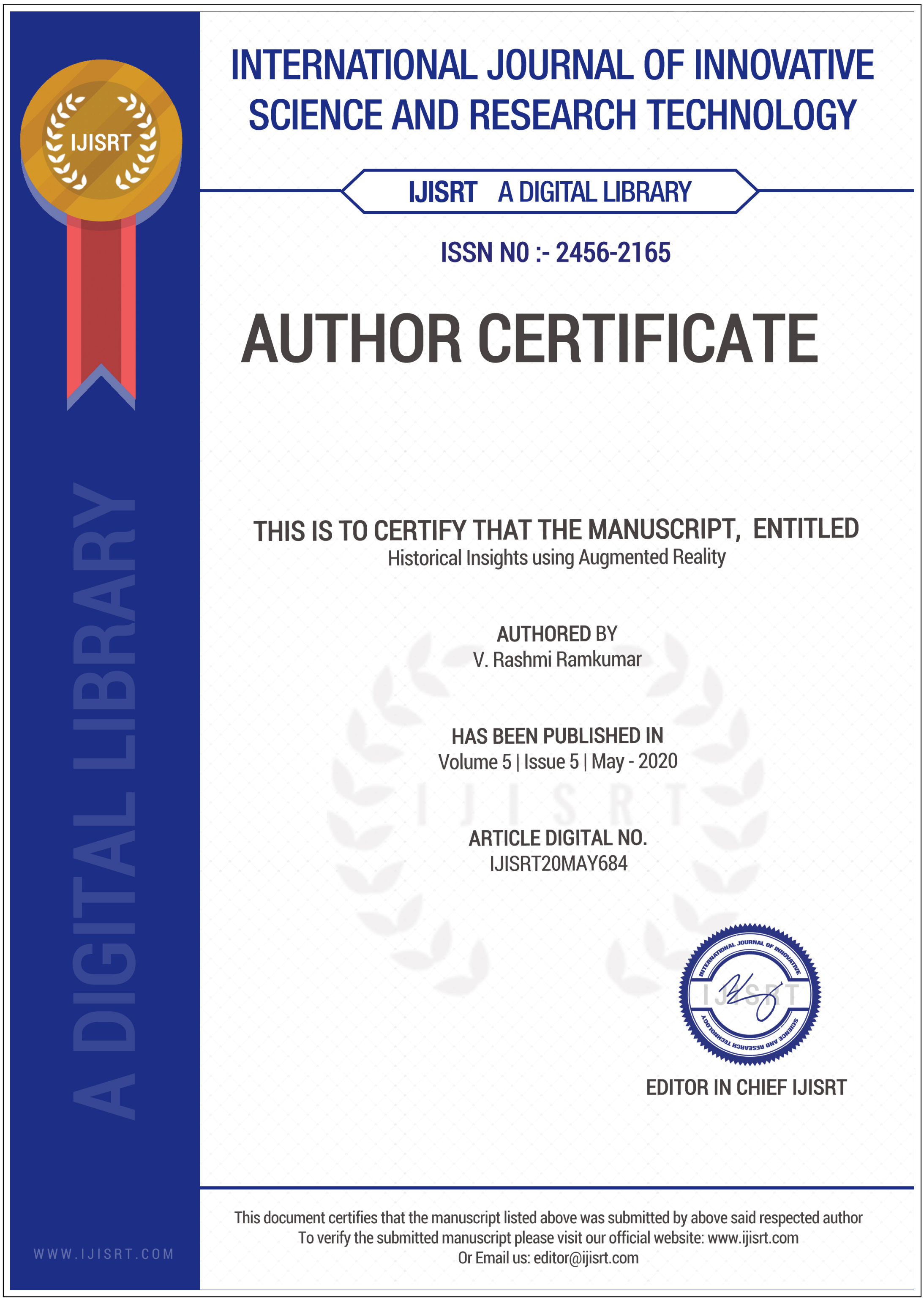

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ANNEXURE C

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Sr. No.	Topic	Plagiarism
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2	Motivation	0%
3	Literature Survey	0%
4	Requirements	0%
5	Analysis Model	0%
6	Project Implementation	0%
7	Testing	0%
8	Result	0%

Table C.1: Topicswise plagiarism in percentage

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3.4) Non-Functional Requirements 3.4.1) Performance Requirements 3.4.1.1) The application is intended to perform smoothly, taking at most 5 seconds to retrieve calls from the database with a decent internet connection. 3.4.1.2) The application is intended to take at most 5 seconds to retrieve calls from the Unity workspace. 3.4.1.3) The number of simultaneous users, initially, should support one or two dozen. 3.4.2) Safety Requirements 3.4.2.1) User is expected to be aware of their surroundings. 3.4.2.2) User is expected to obey posted signs (ex. 'Restricted Area', 'No swimming', 'No Trespassing'). 3.4.3) Security Requirements 3.4.3.1) Users are intended to have credentials for visiting the monument premises, according to the visiting hours given as per the monument authorities. 3.4.4) Software Quality Attributes 3.4.4.1) Application is intended to implement an object-oriented design to be modular in which the modules are flexible for change. 3.4.4.2) Application is intended to be correct as far as the sensor readings are correct. 3.5) System Requirements 3.5.1) Database Requirements 3.5.1.1) Types of information 3.5.1.1.1) Text data 3.5.1.1.2) Audio data 3.5.1.2) Location data 3.5.1.2.1) Longitude 3.5.1.2.2) Latitude 3.5.1.2.3) Address 3.5.1.3) Grid Data 3.5.1.3.1) Mesh data from the previous session, divided into polygons. 3.5.1.3.2) Vertices transformations to be in the plane's centre. 3.5.1.4) Cloud anchor data 3.5.1.5) HTTPS GET / HTTP GET 3.5.1.6) Firebase data 3.5.1.6.1) Access is intended only through methods related to handling OTP (One Time Password) verification. 3.5.1.6.2) Access is intended only through methods related to handling user data. 3.5.1.7) 3D models 3.5.1.7.1) Access is intended only through methods related to handling the monuments. 3.5.1.8) Location 3.5.1.8.1) Access is intended only through methods related to handling the location services. 3.5.1.9) Grid Data 3.5.1.9.1) Access is intended only through methods related to generating the grid. 3.5.1.10) Data entities and their relationships There are no relationships between the different types of data at the moment. 3.5.2) Software Requirements The device that is intended to be launched on, is the Android platform. 3.5.3) Hardware Requirements 3.5.3.1) Android mobile device with operating front-facing camera. 3.5.3.2) Android mobile device with on-board storage. 3.5.3.3) Android mobile device with an on-board operating system. 3.5.3.4) Android mobile device with battery life. 3.5.3.5) Android mobile device with touch screen capabilities. 3.6) Analysis Models: SDLC Model Applied Software Development Life Cycle (SDLC) is a procedure used by the software industry to design, develop, and test high quality software. The SDLC intents to produce high-quality software that sees or surpasses customer expectations, reaches to an accomplishment within times and cost estimates. The Waterfall Model which is also know as linear-sequential life cycle model. In a waterfall model, each phase must be completed before the next phase can begin and the phases cannot be overlapped. By using the waterfall model, requirements are very well documented, clear and fixed. 3.6.1) Waterfall model applied 3.6.1.1) Requirement Gathering and analysis • The information about the monuments needs to be collected, a few monuments and cities are selected • The information about various algorithms to navigate in AR (Augmented Reality) needs to be collected, and an appropriate algorithm is selected • The information about various rendering algorithms needs to be collected, and an appropriate algorithm is selected • The information about the various platforms available for developing 3D models needs to be collected, and an appropriate platform is selected • The information about the various platforms available to build visualization-based applications needs to be collected, and an appropriate platform is selected • The information about various SDKs available for AR needs to be collected, and an appropriate SDK is selected 3.6.1.2) System Design • The user is intended to be notified about the location, hence the Play Services Location is used • The user is intended to only, be able to see the 3D model on the display screen. Hence, ray casting is used • The platforms Autodesk Maya, Blender and Unity are used for creating and editing the 3D models • The Unity platform is used for the 3D model rendering, plane detection, and anchoring of the 3D models at given location • The Android Studio platform is used to develop user interface • The ARCore SDK is selected 3.6.1.3) Implementation • Autodesk Maya, Blender and Unity are used in combination to create, model, give material and texture to the 3D models • The Unity module includes the plane detection, rendering of 3D models, anchoring 3D

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1) Introduction 1.1) Motivation The development of Augmented Reality (AR) technologies is creating new opportunities and challenges for the developers of AR systems. The keen interest by developers in AR applications and the good feedback from the users has led to an expansion in the application genres of AR. One of the applications that has attracted the users most is AR based Tourism and Travel applications. The main motivation behind AR based tourism application is to be able to convey information about the monuments, in an innovative manner to spread awareness about legacy that we have inherited from our ancestors and be able to intellect the philosophies passed onto us. And not let the monuments just be left as mere ruins, visited just for amusement purposes. 1.1.1) Enhance the overall tourism experience. 1.1.2) Gain meaningful information about the historical sights. 1.1.3) Promote tourism in that particular city and ultimately it would help the government in increasing the funds. 1.2) Problem definition and objectives To develop a mobile tour guide system using augmented reality to guide the tourists with respect to their visit and provide them the visual experience of the history of a particular monument. 1.2.1) Objective • To learn rendering methodologies • To learn plane detection algorithm • To learn the art of creating 3D models/ assets • To learn how to detect the geolocation and link it with the 3D models/assets • To learn and follow the proper user interface necessities • To build a mobile tour guide system using augmented reality to guide the tourists and provide them the visual experience. 1.3) Project scope and limitation 1.3.1) Project Scope • The proposed system is intended to take input from the camera module, hence getting a visual of the actual site in front of it, and detect the plane in-order to display the 3D models • The input from camera module is intended to be either in portrait or landscape form. • The proposed system is intended to focus on being able to detect the plane, and display the 3D models according to the anchors placed in the visual environment 1.3.2) Limitations • The plane detection requires to visualize a grid, if the ground or plane in front of the camera, is supposed to be distinguishable. Smooth white planes make plane detection more difficult • Internet connection is required in-order to be able to access the location • Due to obstacles rendering becomes difficult 1.4) Methodologies of Problem Solving To perform plane detection, and to be able to render 3D objects; grid visualizer function is being used. These methodologies make use of the ARCore SDK. 1.4.1) Plane detection function – grid visualizer 1.4.2) Ray Casting function – rendering 1.4.3) Anchor function – to display the 3D models at given location

Sources	Similarity

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4) System Design 4.1) System Architecture The system architecture consists of mainly three modules namely, Unity workspace, Android Studio workspace, and Integrated workspace. Unity module: - The following functionalities are accounted for in the Unity module. A framework is required to place the 3D models in the virtual environment and editing them, and Unity is the framework that has been used for development purposes in this project. The functionality of adding material, and textures to the 3D models is done using Unity. In Unity the scenes are created in the manner of how they will pose in the real-world environment. The placing of the 3D models, giving them direction, and making them adaptive is done using Unity. The audio clip, being a part of the augmented tour is supposed to play alongside the models being displayed, to give a complete experience. Hence, the addition of the audio clips based on the information being conveyed through speech and the model being displayed is synchronized in Unity. The key requirement to be able to render a 3D model is the system being aware of its environment. Hence, for the mobile device's camera to be able to detect the space in front of it, the plane detection algorithm from ARCore is also developed in Unity. Since, the application consists of multiple models to displayed on multiple sites with different locations on the globe. The use of cloud anchors from ARCore is utilized to place these models at a certain location using Unity. Android Studio Module: - The following functionalities are accounted for in the Android Studio module. One of the key requirements of the user interface in the application is that, the application should be easy to access and navigating through the application should be in a flow. The user interface is developed using the Android Studio IDE. The functionality of OTP (One Time Password) verification is developed in the android studio module. The OPT assures the user that, the application is protected. The login process cannot be completed without the OTP verification step. The interface consists of modules of the places available in the system. The information based on the monuments available in the system is displayed. From there the user can select the option to read the information about the monuments or go for the 3D view, which consists of the augmented reality tour of that place. Integrated Module: - The integrated module consists of the functionalities from the combination of the Unity module and the Android Studio module. The augmented reality tour is developed on the Unity platform. The interface is developed in the android environment. Although we can build the Unity module on the android platform, the application built needs to be integrated in android studio for it to be able to run as an android application. Hence, on a button click in android studio, we are able to call the 3D models, audio and the UI built from Unity to the application. 4.2) Mathematical Model System Description: • Input: Input to the system is live location of the user and operational camera • Output: The system provides a 3D model of the monument as an output as well as audio narration, information of the monument • Set Theory Let S be the proposed system, where S = {I, O, D, Q, C, E, L, F}, where -I (Set of inputs) = {I1, I2} where, *I1 = live location *I2 = (User details (age, phone number, language, etc.)) – D: Set of locations and models stored in the database – Q: Set of extracted frames from the input video for plane detection – C: Content database where the user information is stored – E: Information database where the information related to the monument is stored – L: Location of the device – F(Set of functions) ={F1,F2,F3} * F1 : F1(I1,D,L)->Q Function which takes the location of user and detects the plane using camera and matches with the one's in the database * F2 : F2(I2)-> (O2) Function which takes the user preference of language and provides narration about the history of the monument *F3 : F3(D,C,L)-> (O1) Function which renders the image onto the screen of the user device -O (Set of outputs) = {O1, O2} where, *O1 = 3D rendered image/video as output, which shows the vision of monument in the past *O2 = pre-recorded narration, explaining the significance of the place

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3) Software Requirement Specification 3.1) Assumption and Dependencies Augmented Reality is a growing field, and it has come to life due to these advancements in technology. Hence, augmented reality experiences cannot be aimed for all the mobile devices available in the market. There are certain requirements in the versions of the user's mobile software as well as services available on the said software. The following are the assumptions and dependencies of this project: - • Assumption made is; the user is using an android phone • Assumption made is; Android device is assumed to have Android API level 24 or higher to run ARCore • Assumption made is; Android device has a working camera and location sensor • Assumption made is; the user has a stable internet connection to retrieve data from the database • Assumption made is; user's access to the PlayStoreServices API calls is continuously operating • Assumption made is; the user grants permission for the app to use the camera • Assumption made is; the user grants permission to use location data. 3.2) Functional Requirement 3.2.1) The application is intended to run on an Android device. 3.2.2) The application is intended to process permissions upon first launch. 3.2.2.1) The application is intended to prompt for location permissions. 3.2.2.2) The application is intended to prompt for camera permissions. 3.2.3) The application shall provide an interface for credentials. 3.2.3.1) The application is intended to provide OTP (One Time Password) verification step, if incorrect login will not be operational. 3.2.3.2) The application is intended to disable functions that need the credentials if the credentials are incorrect. 3.2.4) The application is intended to provide a module to view the monument's information in text form. 3.2.5) Grid Visualizer function. 3.2.5.1) The grid visualizer function is intended to create the mesh. 3.2.5.2) The grid visualizer function is intended to divide the mesh into polygons. 3.2.5.3) The grid visualizer function is intended to detect the plane. 3.2.6) The application is intended to provide an implementation of PlayServicesLocation. 3.2.7) The location services function is intended to retrieve the device's coordinates. 3.2.8) The caves manager function is intended to place a cloud anchor at given a location. 3.3) External Interface Requirements 3.3.1) User Interfaces 3.3.1.1) The user interface is intended to be prompted with the logo of the application as a welcome upon executing the application. 3.3.1.2) The initial load is intended to request, upon the first launch of the application, permissions that will be specified by the user. 3.3.1.3) Next, the application is intended to instantly gain access to the device's camera, location services, and device storage. 3.3.1.4) Create new user/Login is intended to prompt after the welcome screen. 3.3.1.5) Upon logging in, the main screen is intended to appear with the different modules for all the cities available, along with the various modules for all the monuments available in the application. 3.3.1.6) Upon selecting the Phalke Samarak (for demo purpose) module, a screen is intended to appear with the information in the text form and a 3D view button. 3.3.1.7) Upon selecting the 3D view button, the augmented reality tour is intended to begin. 3.3.1.8) After the tour screen opens, a slide-navigation bar is intended to appear with the options for the audio available in three different languages namely, Hindi, English, and Marathi. And other options to go to the next scene, previous scene, and on the last screen to exit the tour. 3.3.1.9) Once a plane is detected the 3D model is intended to appear at the position it is intended to be anchored at. 3.3.2) Hardware Interfaces 3.3.2.1) Android mobile devices are the supported device types 3.3.2.2) Android mobile devices with a front-facing camera 3.3.2.3) Android mobile devices with a location (GPS) sensor 3.3.2.4) Android mobile devices with a magnetic sensor (required by ARCore) 3.3.2.5) Android mobile devices with a gyroscope sensor (required by ARCore) 3.3.2.3) Android mobile devices with internet access 3.3.3) Software Interfaces 3.3.3.1) Android mobile devices with API level 24 & up

3.3.3.2) Firebase extension 3.3.3.4) Autodesk Maya 3.3.3.5) Blender 3.3.3.5) ARCore SDK 3.3.4) Communication Interfaces 3.3.4.1) HTTP GET 3.3.4.2) HTTPS GET

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2) Literature Survey This section presents a concise note on the existing work carried out in augmented reality, and navigating in real world methodologies. 2.1) Augmented Reality • In 2018, L. Saute, L. Rossetto, and H. Schuldt, presented an application named GoFind for tourists and historians which gives a virtual view in city's past via augmented reality-based user interface. Historic photo collections are important for cityscapes development but are buried in archives. With their proposed system the historic multimedia collection is brought to mobile devices. Their system provides the overlay of past and present view. In their system the back-end handles retrieval queries and front-end handles user's interaction.[2] • In 2018, K. Meriem, M. Makram and I. R. Farah, presented two applications to expose cultural heritage using virtual and augmented reality in Tunisian cultural heritage. One part of their proposed system uses a picture on magazines as markers to superimpose the 3D model of that place. Along with superimposition their system also provides interactive augmented reality for guided tours. Their system uses real-time 3D imaging.[3] • In 2017, S. Chelaramani, V. Muthireddy and C. V. Jawahar, presented a system for interactive story generation, for a casually captured video-clip of a heritage site tour. It leverages the user interaction to improve the relevance of the stories presented to the user. Their system takes the feedback from user for stories related to the current segment of the video and dynamically adjusts the stories taking the interaction into account.[7] • In 2018, Akil. H. Sayyad, and Santosh. A. Shinde, presented an application which consisted of a mobile tour guide system with augmented information. This application helped the tourist to find the accurate location also the information about the required places and it also provided the augmented view so that the interaction between the tourist and the place will be easy. The GPS facility was also available for the tourist to find the places easily. The tourist would experience the physical presence of the location on their mobile phones which user wants to visit.[8] • In 2016, X. Wei, D. Weng, Y. Liu and Y. Wang, presented a game-based guidance system for Yuanmingyuan and a time travel game called MAGIC-EYES using Augmented Reality technology. Their proposed system could help the tourists immerse themselves in the mystical legend. MAGIC-EYES makes use of plaques, stone tablet, patterns of buildings and geographical location information to identify the user's location, which is then combined with AR-based interactive game to complete the guided tour. The traditional guidance system uses the traditional audio, cartoon and GPS to guide a tourist to reach the designated place and display the historical legend.[9] 2.2) Navigation methodologies • In 2018, Athanasios Kountouris, and Evangelos Sakkopoulos, presented an electronic guide application for android smartphones and tablets to help users to reach the places of their interest. Their proposed system with the help of internet technologies helped the users to reach user preferred locations instead of using a personal guide, a tour guide book or any online website. Their system includes designing software for showing cultural sites, inserting or deleting cultural sites of user interest, study of navigation system using smartphone.[1] • In 2018, D. E. Kurniawan, A. Dzikri, M. Suriya, Y. Rokhayati and A. Najmurrokhman, proposed a system which uses augmented reality as a tour guide on Batam island. Their system used marker-based tracking for displaying 3D objects in the tour. Their proposed system is built with the help of software's like Unity and Vuforia. Their system also provided navigation to the tourist attraction along with displaying 3D tourist object that is present on the map.[4] • In 2018, E. Pyshkin, and P. Korobenin, presented a model which provided appropriate multimedia assistance of outdoor travel tours with using geo-positioning for better tour recommendation and playback automation. The system not only had on-demand audio guides but also had a framework which allows tour users and tour creators to indirectly collaborate. The proposed system provides the time and distance required for the tour along with the information about the best and worst visiting period. System also allowed users to create travel diaries and sync it with their Facebook account.[5] • In 2017, S. TsungWu, and B. Lee, presented the idea of promotion that introduced the Taiwan dark tourism through the augmented VR experience. The information about Taiwan's dark tourism destinations was used to build up an augmented virtual reality project for guided tour, GoPro Hero 4 six camera set, Kolor Autopano Giga and Panotour Pro software, and the web platform

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5) Project Plan: 5.1) Project estimate: 5.1.1) Reconciled Estimate 5.1.1.1) Cost Estimate All the resources used for developing the application are open source, and is used on student license. Hence, no software has been used that consists of cost features. 5.1.1.2) Time Estimate The development of the application among four group members, took approximately eight months. 5.1.2) Project Resources 5.1.2.1) Hardware Resources • Processor i5 or higher • Minimum 4 GB RAM • 2.66 GHz or Faster CPU speed • Graphics card DirectX9 or later with WDDM 5.1.2.2) Software Resources • Windows 10 • C# .Net • .Net Visual Studio • Unity • Android Studio • Android SDK • Android NDK • Blender • Autodesk Maya • ARCore SDK 5.2) Risk Management This section discusses risks in the proposed application and the approach to managing them. 5.2.1) Risk Identification • No end-users are enthusiastically committed to the project and system to be built. • End users have unrealistic expectations. • Project requirements are not stable. • No customer has been involved in the definition of requirement. • Software requirements should be matched by the end-user. • Climatic conditions such as, rain, and fog might disrupt the rendering of the application. • Internet access required on the end user's side. • Skills are required for making the 3D model. • Augmented Reality overlays real-time, computer-generated visual, audio, and haptic signals onto a person's natural field of vision, the system should be able to take the load. • Augmented Reality systems have been associated with having security threats from hackers breaching the Augmented Reality system, which could result in privacy invasions as well as digital data and physical security risk. 5.2.2) Risk Analysis ID Risk Description Probability Impact 1 Software requirements should be matched by the end-user Medium Schedule: Low Quality: Low Overall: Medium 2 If there are bad weather conditions Medium Schedule: Low Quality: Medium Overall: Medium 3 If the user does not have internet access Medium Schedule: Low Quality: Medium Overall: Medium 4 If the model does not portray the information aimed for High Schedule: High Quality: High Overall: High 5 If the end user's mobile is not able to take the load of the application Medium Schedule: Low Quality: Medium Overall: Medium 6 Security threats Medium Schedule: Medium Quality: High Overall: High 5.2.3) Overview of Risk Mitigation, Monitoring, Management Risk ID 1 Risk Description Software requirements should be matched by the end-user Category Technology Source Software requirement Specification document Probability Medium Impact Medium Response Accept Strategy Aiming for the software systems that match with the version required Risk Status Identified Risk ID 2 Risk Description If there are bad weather conditions Category Risk associated with climatic factors Source This was identified during primary development and testing Probability Medium Impact Medium Response Mitigate Strategy The mobile phones cannot be operated in bad weather conditions Risk Status Identified Risk ID 3 Risk Description If the user does not have internet access Category Technology Source This was identified during primary development and testing Probability Medium Impact Medium Response Mitigate Strategy Internet connection needed only to access location, even if the location cannot be accessed end-user can still experience the tour Risk Status Identified Risk ID 4 Risk Description If the model does not portray the information aimed for Category Technology Source This was identified during primary development and testing Probability Medium Impact High Response Mitigate Strategy Use of proper combination of information and tools Risk Status Identified Risk ID 5 Risk Description If the end user's mobile is not able to take the load of the application Category Technology Source This was identified during primary development and testing Probability High Impact High Response Accept Strategy Aiming for the software systems that match with the software requirements Risk Status Identified Risk ID 6 Risk Description Security threats

Category Technology Source This was identified during primary development and testing Probability High Impact High Response Accept Strategy Using OTP authentication during registration Risk Status Identified

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Technologies used: • Visual Studio Community 2019: Microsoft Visual Studio is an integrated development environment (IDE) introduced by Microsoft. It is utilized to create PC programs, just as sites, web applications, web administrations and portable applications. It can create both native code as well as override code. Visual Studio underpins 36 distinctive programming dialects and permits the code proof-reader and debugger to help (to shifting degrees) about any programming language, gave a language-explicit assistance exists. Worked in dialects incorporate C, C++, C++/CLI, Visual Basic .NET, C#, F#, JavaScript, TypeScript, XML, XSLT, HTML, and CSS. • Android Studio: Android Studio is the authorized integrated development environment (IDE) aimed for Google's Android operating system. It is built on JetBrains' IntelliJ IDEA software and designed precisely for Android development. It is offered for download on Windows, macOS and Linux based operating systems. It is a used as the primary IDE for native Android application development, a replacement for the Eclipse Android Development Tools (ADT). These are some of the features provided in the current stable version: 1. Gradle-based build support 2. Android-specific refactoring and quick fixes 3. Android Virtual Device (Emulator) to run and debug apps in the Android studio. • Unity: Unity is a cross-platform game engine industrialized by Unity Technologies. As of 2018, the engine had been prolonged to sustain more than 25 platforms. The engine can be utilized for the following purposes, to create three-dimensional, two-dimensional, virtual reality, and augmented reality games, as well as simulations and other experiences. The engine has been embraced by industries outside video gaming, such as film, automotive, architecture, engineering and construction. • Autodesk Maya: Autodesk Maya, generally condensed to just Maya, is a 3D computer graphics application that is available to operate on Windows, macOS and Linux platforms, it provides a special license for educational purposes, presently owned and developed by Autodesk. It is used for the creation of assets for interactive 3D applications (including video games), animated films, TV series, and visual effects. • Blender: Blender is an open-source 3D computer graphics software toolset. It is used to produce animated movies, visual effects, art, 3D printed models, motion graphics, interactive 3D applications, and computer games. Blender provides the following features, 3D modelling, UV unpacking, texturing, raster visuals editing, rigging and paring, fluid and smoke simulation, particle simulation, soft body simulation, and sculpting. Other features such as animating, match moving, rendering, motion graphics, video editing, and compositing, can also be implemented using Blender. 6.3) Algorithm Details 6.3.1) Algorithm 1 Plane detection logic: Procedure: Grid Visualizer Steps: 1. Create a mesh polygon as a list of vectors 2. Create an awake() function with mesh component and mesh renderer component 3. Create an update() function, which will continuously check if the tracking state is tracking as well as detecting the plane, or else the renderer will be disabled. 4. Create an initialize() function, that initializes the detected plane visualizer with a detected plane 5. Update mesh with a list of Vector and plane's centre position 6. Convert the polygon to a mesh with two polygons, inner polygon. Render with 100% opacity and fade out to outer polygon with opacity 0% 7. Fill transparent colour to vertices 0 to 3 8. Add vertex 4 to 7 9. Generate triangle (0, 1, 4), (4, 1, 5), (5, 1, 2), (5, 2, 6), (6, 2, 3), (6, 3, 7), (7, 3, 0), (7, 0, 4) 10. Keep previous frame's mesh polygon to avoid mesh update every frame 6.3.2) Algorithm 2 Procedure: Ray casting 1. Start from the left-most column of the projection plane. 2. Finding the height of the floor that the player is currently standing on. (Call it current_height) 3. Casting a ray and checking intersections as before. 4. If the casted ray hits a floor that has different height than the current_height, then that floor is either raised/sunk. (A raised floor is just a wall.) 5. If it is raised, then it will be visible. Project it, and render it.

(Figure 30 below illustrates the math behind this.) 6. If it is sunk, then we don’t need to project it because it will not be visible. 7. Draw the floor from the point of where the height changes are occurring until the point where the top of the last wall slice is projected onto. (Initially, the top of the last wall slice will become the bottom of the projection plane.) 8. Repeat until the ray is extending pass the limit of the world map. 9. Repeat step 2 to 8 for all subsequent columns.

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7) Software Testing Software testing is a process, to estimate the functionality of a software application with the purpose to detect whether the developed software met the specified requirements or not and to identify the defects to ensure that the product is fault free in order to produce the quality product. Various types of testing have been performed to ensure quality and bug-free working model. 7.1) Types of testing The different types of testing carried out in the development of the project are listed below: • Functional Testing • Unit Testing • Integration Testing • GUI Testing • Back-end Testing • System Testing • Usability Testing 7.2) Test cases and test results Functional Testing Testing performed to check whether the code works as it is expected in terms of the functionality that the code should provide. Example: Function for rendering of models is checked if it correctly renders the model on the user screen. Test Case ID FT-01 Test Case Description Rendering model according to the specified location Input Location of the user Expected Output Model of that particular monument is rendered and visible to the user Actually Output Model of the monument is visible to user Test Status Pass Unit Testing Testing performed to ensure proper functioning of the project module or the smallest functional unit of the project. Example: Module for OTP generation is checked whether it works correctly with proper functionality as an independent unit. Test Case ID UT-01 Test Case Description OTP should be sent to specified recipient on the registered phone number Input Phone number of the user Expected Output OTP should be sent on registered number Actually Output OTP is sent to user on the registered number within seconds Test Status Pass Integration Testing Testing performed when multiple (two or more) project modules are integrated together to check if they work correctly together with expected interaction throughout the module interfaces. Example: The android module (Module-1) is integrated with unity module (Module-2) and testing is performed to ensure that the modules work together with expected functionality. Test Case ID IT-01 Test Case Description Check the working after integration of Module-1 and Module-2 Input Location of the user and access to the device camera Expected Output Location given by user in Module-1 should be accepted as input by Module-2 and Module-2 displays the desired output Actually Output Module-2 accepts input generated by Module-1 and displays the desired output Test Status Pass GUI Testing Testing performed to check the front-end of the project. Example: Testing the different pages for correct display of different monuments and information. Test Case ID GT-01 Test Case Description Check the aesthetics and display of all the buttons, links on all pages Input Checking all the pages Expected Output Pages should be displayed properly Actually Output Pages are displayed properly Test Status Pass Check whether the application displays 3D models on user interface. Test Case ID GT-02 Test Case Description Check whether the application displays 3D models of the requested monument. Input Selection of monument Expected Output Models should be displayed properly Actually Output Models are displayed properly Test Status Pass Check whether the application plays audio as per user request through the interface. Test Case ID GT-03 Test Case Description Check whether the application plays audio as per user request through the interface. Input Selection of audio language Expected Output Audio should be played properly Actually Output Audio is played properly Test Status Pass Back-end Testing Testing performed on the database to check whether the database stores the data of the user by performing various operations. Example: Executing the insert operation of the phone number and check the database whether the number is stored or not Test Case ID BT-01 Test Case Description Insert the number and check the database whether the user is stored or not Input Phone number of the user Expected Output User phone number should be stored in database Actually Output Phone number is stored in database Test Status Pass System Testing Testing performed on the entire system as a whole. Example: Entire system containing all the modules it tested to verify proper functioning. Test Case ID ST-01 Test Case Description Check entire system as a whole after integration Input Details of the user location and monument Expected Output All the modules should execute successfully and of successful display of 3D model should be achieved Actually Output The system works correctly and displays the 3D model of monument Test Status Pass Usability Testing Testing performed on the system to check the

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8) Results 8.1) Outcomes The intended outcomes of the proposed system are: - 8.1.1) An application with easy to understand user interface 8.1.2) An Augmented Reality visual experience through the 3D view function in the application 8.1.3) A tour experience through the audio guidance provided along with the 3D view functionality 8.1.4) To provide security to the user by providing OPT verification 8.1.5) To provide the location of the user by the PlayLoactionServices 8.2) Screen shots 8.2.1 GUI Fig: Cloud Database 9) Conclusion 9.1) Conclusion Hence, to conclude an augmented reality system is being proposed with the purpose of being able to portray the mobile device as a portal to the user through which they are able to see 3D objects related to the historic significance of that monument. An augmented experience along with an audio playback in three different languages, to spread the usage of the application for all the masses. 9.2) Future Scope India is a country with a rich legacy and culture. Currently the application is restricted to fewer number of cities, however in future the application can be enhanced to cover various cities with significant monuments in India. Other functionalities that can be pursued in the future are adding, animation, and implementation of image detection and linking the image detected to the web in-order to display the information about the objects being detected in the image. 9.3) Applications The proposed application is intended to be aimed for the tourism as well as educational genre. The proposed application is intended to display information regarding the monuments, initially in limited number of cities, in India. It is intended to promote tourism, and spread awareness about interlinking between the various eras the country's heritage has been through. The proposed application also covers the educational aspect, as the said application is intended to be used as a medium to provide information for learning, and getting a different look at the history of the monument in an innovative way.

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5.3) Project Schedule 5.3.1) Project Task Set Major tasks in the project stages are: • Task 1: Collecting information about the monuments selected • Task 2: Developing of the 3D model, which in development terms are called as assets; to be rendered o Collecting the various designs for the model o Creating the model on the selective platform o Giving materials and textures to the model • Task 3: Developing plane detection, to be able to detect the plane from the mobile camera. And importing the 3D models in Unity • Task 4: Developing UI (User Interface), and location module in Android Studio • Task 5: Linking of UI and rendering application 5.3.2) Task Network 5.3.3) Timeline Chart 5.4) Team Organization 5.4.1) Team Structure Team members: • Harpal Kaur Dhindsa • Anjali Trimukhe • Rashi Tugaon • V Rashmi Ramkumar Various tasks are divided as follows: • Collecting information about the monuments selected: V. Rashmi Ramkumar, and Anjali Trimukhe • Developing of the 3D model, which in development terms are called as assets; to be rendered: Equally divided as per modules • Unity scripting: Harpal Kaur Dhindsa, and Anjali Trimukhe • UI scripting: Rashi Tugaon, and V. Rashmi Ramkumar • Linking of UI and rendering: Harpal Kaur Dhindsa, and Rashi Tugaon • Documentation: Equally divided as per modules 5.4.2) Management Reporting and Communication • A dedicated project log-book, project log-sheets are maintained to trace the communication of the project work between the team members and project guide. • The project slots available in the semester timetable is utilised for the discussions related to the difficulties faced and progress reports of the project with the project guide. Sr., No:, Date of meeting, Topics Searched, Faculty Approval 1 1st July,2019 Query Resolved Approved 2 8th July,2019 Topics Searched Approved 3 15th July,2019 Topics Discussed Approved 4 22nd July,2019 Abstract shown Approved 5 29th July,2019 Discussion implementation of topic Approved 6 21st September,2019 Presentation 1 Evaluated 7 16th October,2019 Presentation 2 Evaluated Sr., No:, Date of meeting, Topics Searched, Faculty Approval 1 4th April,2020 Presentation 1 Evaluated 2 25th April,2020 Presentation 2 Evaluated 6) Project Implementation 6.1) Overview of Project Modules The system has been developed with a combination of two languages, C# and Java with Android Studio. Both these languages are used for the front-end design implementation and scripting for the rendering of the 3D models. Java is used for database purpose in the back-end. The database primarily consists of data about the user that has to be stored for registration purpose and the information about the monuments to be displayed. C# is used with Unity for scripting the rendering of 3D models as well as the speech rendering, as a part of the tour. Java is used in Android Studio for developing the UI, as well as for providing the location services, and for the database management. 6.2) Tools and Technology used Tools Used: • C#: C# was developed to be a universally useful, multi-worldview programming language encircling powerful composing, lexically scoped, declarative, functional, basic, object-oriented, and component-situated programming disciplines. It is created by Microsoft as a feature of its .NET activity. Mono is the name of the free and open-source project to build up a compiler and runtime for the language. C# is one of the programming dialects intended for the Common Language Infrastructure (CLI). • Java: Java is a broadly useful programming language that is object-oriented, class-based, and intended to have as hardly any execution conditions as could be expected under the circumstances. Java applications are commonly ordered to bytecode that can run on any Java virtual machine (JVM) paying little attention to the fundamental PC design. The grammar of Java is like C and C++, yet it has less low-level offices than both of them. • ARCore SDK: ARCore is a software development kit developed by Google, which allows for augmented reality applications to be built. ARCore uses three crucial technologies to integrate virtual content with the real world as seen through your phone's camera, it allows the developer to advance to six degrees of freedom allows the phone to understand and track its position relative to the world, environmental understanding, and light estimation. • Android SDK: The Android software development kit (SDK) includes an inclusive set of development tools. These contain debugger, libraries, a handset emulator based on QEMU, documentation, sample code, and tutorials. All languages which are not supported by JVM, such as Go, JavaScript, C, C++ or assembly, need the help of JVM language code, that may be abounding by tools, likely with

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