REFLECT HISTORY CHANGES OF THE FAMOUS HISTORICAL BUILDING VIA AR TECHNOLOGY

By

Beh Jia Jing

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR INFORMATION SYSTEMS (HONOURS) INFORMATION SYSTEMS ENGINEERING

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2024

UNIVERSITI TUNKU ABDUL RAHMAN

REPORT STATUS DECLARATION FORM

Title: REFLECT_HISTORY_CHANGES_OF_THE_FAMOUS_HISTORICAL_BUILDING_VIA_AR_TECHNOLOGY

Academic Session: JAN_2024

I BEH_JIA_JING

declare that I allow this Final Year Project Report to be kept in
Universiti Tunku Abdul Rahman Library subject to the regulations as follows:

1. The dissertation is a property of the Library.
2. The Library is allowed to make copies of this dissertation for academic purposes.

Verified by,

(Author's signature)

(Supervisor's signature)

Address:
No.30 Jalan Taman Suria Permai.
Taman Suria Permai, 34000,
Taiping, Perak.

Ts. Dr Saw Seow Hui
Supervisor's name

Date: 25/04/2024

Date: 25/04/2024

FACULTY/INSTITUTE* OF INFORMATION AND COMMUNICATION TECHNOLOGY

UNIVERSITI TUNKU ABDUL RAHMAN

Date: ____25/4/2024_____

SUBMISSION OF FINAL YEAR PROJECT /DISSERTATION/THESIS

It is hereby certified that _____***BEH JIA JING***_____ (ID No: __***21ACB01879)*** has completed this final year project/ dissertation/ thesis* entitled "___***REFLECT HISTORY CHANGES OF THE FAMOUS HISTORICAL BUILDING VIA AR TECHNOLOGY***___" under the supervision of _____Ts. Dr Saw Seow Hui_____ (Supervisor) from the Department of ____Computer Science_____, Faculty/Institute* of __Information and Communication Technology_____, and Dr. Zurida Binti Ishak (Co-Supervisor) * from the Department of ____Information Systems__, Faculty/Institute* of Information and Communication Technology.

I understand that University will upload softcopy of my final year project / dissertation/ thesis* in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

_____

(Beh Jia Jing)

*Delete whichever not applicable

DECLARATION OF ORIGINALITY

I declare that this report entitled "**REFLECT HISTORY CHANGES OF THE FAMOUS HISTORICAL BUILDING VIA AR TECHNOLOGY**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : 

Name : Beh Jia Jing

Date : 8 February 2024

ACKNOWLEDGEMENTS

First and foremost, I would like to express my sincere thanks and appreciation to my supervisors, Ts. Saw Seow Hui, who has given me this bright opportunity to participate in this project under the topic of Historical Building Mobile Application. This is my first-time experience in learning the AR-related technologies, and I feel thankful for the guidance, advice, and different ideas that I gained from Ts. Saw in helping my project development. Other than the technical support, Ts. Saw Seow Hui also provide the support from the mental health to pass through those stressful moments during FYP period. A million thanks my supervisor.

Getting through my dissertation required more than academic support, I have many people to thank for who have accompany my journey for the past few trimesters. Sincerely thanks to my buddies Tan Kean Hon, Lew Wei Yi, and Ang Wei Di for provided me a lot of mental support. Besides, Tan Kean Hon have given me lots of advice whether in technical skills or non-technical approach in completing this project.

Besides, I must say thanks to my parents and my family for their love, support, and continuous encouragement throughout the course. Last but not least, I truly appreciate all that have helped me whether directly or indirectly to have this project done. Thank you.

ABSTRACT

The historical building is important treasure to our nation. The project address critical issues of historical building preservation in Malaysia. Understanding the reasons behind the current situation regarding historical buildings preservation become extremely important. According to the study, it shows most of the precious historical buildings in Malaysia is not getting adequate treatment which eventually leads to their demolition. To solve this problem, this project intent to reconstruct the demolished historical buildings using 3D model integrated with Augmented Reality (AR) while preserving the related information and store to provide an opportunity to the public in accessing and utilizing the knowledge. In order to develop a more integrated application, a review and analysis of past and existing applications is conducted, then based on the analysis of their weaknesses and strengths help us to strengthen our application. The development process is adopting the RAD methodology to enable a flexible development process. Additionally, the conduction of questionnaire also helps us to understand better the user requirements. The application is separate into different module to develop, which consists of AR Module, Building Module, Authentication Module, Map Integration Module, Bookmark Module, and Profile Module. Various software and technology are assisting the development of the application, such as the Visual Studio 2022, Blender, Unity, Vuforia SDK, Firebase and so on. The project visualizing the requirements in several stages, including user flow, storyboard, use case diagram, and so on. Finally, the application is being developed and evaluated on its effectiveness and functionality. The success of this project can bring a lot of benefits to the preservation of Malaysia's historical treasures, allows it to pass generation by generation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AR	Augmented Reality
ARCHEOGUIDE	Augmented Reality-based Cultural Heritage On-site GUIDE
IST	Industrial Service Technology
MU	Mobile Unit
DGPS	Differential GPS
GIS	Geographic Information System
VR	Virtual Reality
AI	Artificial Intelligence

CHAPTER 1
Introduction

1.1 Project Background

For each nation, the historical buildings stand as a storyteller that tell the story of past era [1]. Through their linkage to the triumphs, struggles, and aspirations of the past embodies the essence of national identity and fostering a sense of unity and nationalism. These historical buildings that crafted by human and given the physical existence, have an amount of significance to be constructed as 'historic' representation and plays significance roles to link to the past. [2]. Exploration on these historical structures, offers the precious opportunities to the modern people in gaining a deeper understanding of the past, learning, and revealing the artistic expressions and historical context of earlier timeline [3].

Malaysia, a country famous for its cultural diversity and comprised on Malay, Chinese, and Indian communities [4], its historical buildings hold a particular unique significance. These buildings witness the growth of the nation, therefore they possess rich historical value of multiculturalism that is part of the Malaysia's history. Subsequently, the architecture design, cultural elements, and historical values of these buildings blend different influences, demonstrating the interplay of various ethnicities and traditions [3]. These structures are poignant reminders of our shared past, with every brick and beam resonating with a narrative of unity and diversity.

In the modern times, technological advancements have brought some new transformative experiences into our daily lives, none more fascinating than Augmented Reality (AR). Conceptualized as early as 1997 by Ronald Azuma, AR is capable to transcends the restriction of hardware capabilities, while brings the real and virtual items within a single real environment [5, 6]. Then Milgram and Kishino further explore on this concept and presenting AR as a dynamic continuum involvement of both reality and virtuality, create a path towards the mixed reality [5, 7]. Beyond merely replace the tangible objects in reality with virtual counterparts, AR

also have the capability to modify the entire environment through device and enrich our sensory perceptions.

Trace back the roots of AR history, starts from Ivan Sutherland groundbreaking work in 1968, where first AR technology is developed and implemented in a head-mounted display system, a precursor to modern AR devices [8]. In following decades, the AR technology is growing at a speed visible to the naked eye due to the contribution of different visionary inventors that involves in the evolution of AR, including Myron Krueger, Ronald Azuma, and Bruce Thomas [6].

Today, the fusion of AR with various technologies shapes the derivatives of multiple types of AR, with each distinct characteristics and applications. From maker-based AR, markerless AR, project-based AR, superimposition-based AR, location-based AR, and outlining AR, these variants have found their footing across diverse domains and fields, spanning manufacturing, education, healthcare, marketing, and fashion [9]. The evolution of AR has made it no longer limited to any specific hardware and has been driven by the ubiquity of mobile devices. Notably, the phenomenon The phenomenal application like Pokémon go have foster the acceptance of AR into public consciousness. In fact, the popularity of mobile AR active user has increased year by year [10] (Refers to Figure 1.1.1).

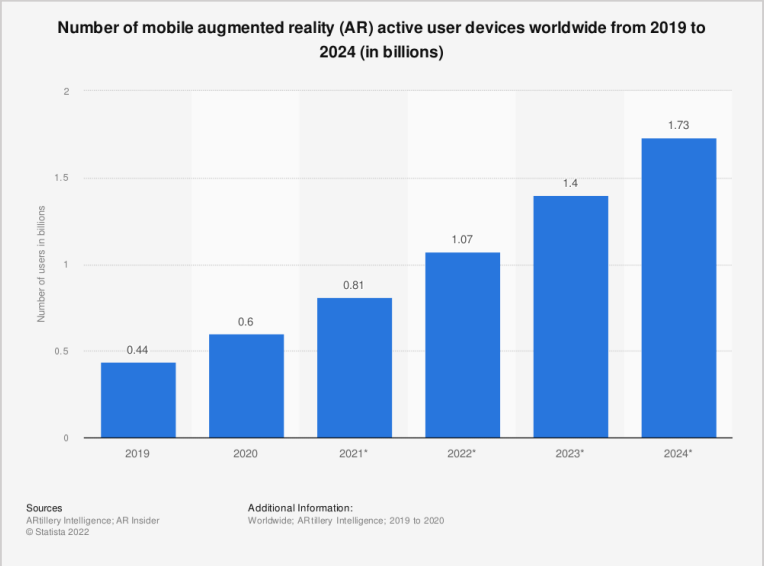


Figure 1.1.1: Number of AR Active User Devices

In the juncture of heritage and technological advancement. The intersection of AR technology and Malaysia's architecture heritage open a new path in historical conservation. This new path not only utilize the transformative power or AR in providing users the gateway to Malaysia's historic buildings, but also to contribute to the restoration and conservation of these architectural treasures under the slogan 'preserve, protect, and interpret' [11, 12].

1.2 Problem Statement and Motivation

The historical buildings hold a lot of immense cultural and iconic value, yet still facing the problem of **demolition of historical building due to lacks protection by government bodies.** The reservation of historical buildings requires a lot of effort. These invaluable structures, symbols of the nation's heritage, find themselves under the constant threat due to potential challenges arising during the conservation work from environment, human, organization, technical, and financial factors [13]. Despite the existence of National Heritage Act, 2005 (Act No.645), enacted under the purpose of providing any safeguard measures to these heritages [14], it has never stopped the continues demolition and sabotage occurrence of significance heritage sites in Malaysia. For example, the demolition of the 101-year-old Sri Muneswarar Kaliamman Hindu temple during 2013, was demolished by Kuala Lumpur City Hall (DBKL) to make an 8-feet walkway after the temple authorities lost in a long negotiation with DBKL [15]. And the 150-year-old Wong Ah Fook mansion that originally belongs to Wong Ah Fook was bulldozed secretly on 30 April 2014by commercial developers before it was declared as a historical site [16]. Even the 115-year-old Pudu Jail, a famous correctional and detention facility built in stages by the British colonial government in the late 1800s and once held the record of the longest mural in the world demolished in December 2012 to ease the congested Kuala Lumpur traffic [17]. Issues such as economy pressure, third party influence, confusing laws, and so on the reason why state actor and builder can always have the nationalistic and economic as excuses to destroy or fail to preserve these precious historical architectures rather than provide protection to the cultural nationalism [2]. This dissonance is what fuels the urgency of the project. The motivation of this project is to apply the AR technology to recreate and document these historical

buildings and conduct a proper documentation, so their value can be preserved properly.

The heritage conservation is essential to increase the life span of these buildings, but it also **brings up the problem of changing in historical buildings appearance**. To conduct a proper conservation of historical buildings, not only need to consider on how to make modification on distinguish new additions to the original structure while keep the fabric as much as possible, but it also needs to serve the purpose on bringing out the characteristic of existing building [13]. The design and materials are the most authentic criterion to represent the identity of historical buildings. The architecture style and construction techniques of these historical heritage contained evidence of forgotten knowledge, ideas, and their golden era, which makes them have important value [18]. Through the conservation process, the historical buildings may suffer alterations over time including changing of materials and design like the color schemes, lead to the forgotten of their original appearance. Figure 1.1.2 and 1.1.3 illustrates the changes of the Ihsaniah Iskandariah Mosque located at Kampung Kuala Dal before and after the reconstruction. Hence, by applying the AR technology, we able to reproduce the historical buildings in different time period, allowing the observation of changes these buildings have undergone, fostering a deeper connection with their evolution.

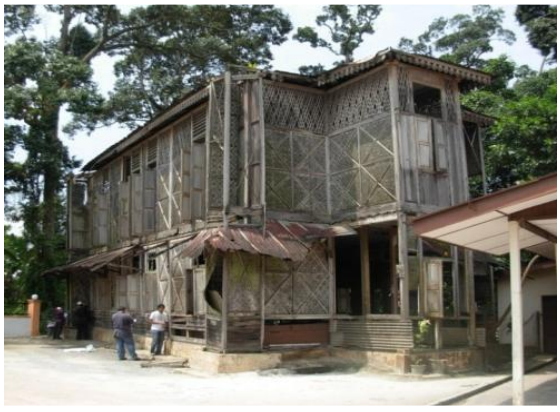


Figure 1.1.2: Ihsaniah Iskandariah Mosque before conservation (2009)

Figure 1.1.3: Ihsaniah Iskandariah Mosque after conservation (2009)

Furthermore, the challenge of heritage conservation is exacerbated by the **neglection on the repairment process and environmental factors such as air pollution,**

which accelerates the deterioration of heritage sites. The ravages of time and external uncertainties can cause the degradation of historical buildings [19, 20]. As stated in survey research by Kamal et.al, Malaysia has a rich legacy of historical sites and there are nearly 39,000 historic sites built only between 1800 and 1948 (Refers to Table 1.1.1). These huge number of "pre-war buildings" is impossible to maintain in a regular basis, which cause the losing value and decay [21]. The Federated Malay States Survey Department building, once an important place to produce detailed surveys of British Malaya and the Straits Settlements that was built in 1910, faced the collapse of the spire on one of its domes in 2018. Although the building is registered as national heritage and put under National Heritage Act 2005, poor management has left the buildings in disrepair [22]. In result, neither the tourist or local people be able to visit these historic buildings due to under permanently maintenance status or being destroyed, nor they are able to take the picture of it. The project seeks to utilize the AR technology to enable the interaction between user and 3d models of these historical buildings through different angles. The interaction process not only increases the awareness about preservation, but also encourages virtual exploration when on-site visits are unfeasible due to maintenance or destruction, even taking the picture of it.

Table 1.1.1: The Distribution of Pre-War Urban Buildings in Malaysia

No	States	No of Historical Buildings	Percentage of Historical Buildings
1	Penang	5,057	24.30%
2	Perak	3,351	16.10%
3	Johore	2,323	11.20%
4	Malacca	2,177	10.50%
5	Kuala Lumpur	1,763	8.40%
6	Kedah	1,282	6.12%
7	Selangor	1,166	5.60%
8	Sarawak	1,010	4.90%
9	Negeri Sembilan	999	4.80%
10	Pahang	831	4.00%
11	Terengganu	420	2.00%
12	Kelantan	373	1.80%
13	Perlis	25	0.10%
14	Sabah	10	0.05%
	Total	**20,787**	**100.0%**

Source: Idid (1995).

As the time passed, **the profound historical significance of architecture heritage gradually fades from public view**. Decrease of interaction and connection between the society and historical building resulted in a gradual erosion of cultural

understanding and appreciation. From the study conducted by Ummu Liyana Halim et al, they found that the local community of George Town only have moderate levels of awareness towards the preservation of heritage buildings [23]. There are still some spaces for improvement as historical buildings have huge value even for educational purposes, and the cultural of architecture heritage should passed from one generation to another. Although Malaysia a multicultural country, it still challenging for people to experience when visit these places due to the communication gaps and language barriers. They may be struggling when try to understand the background story of historical buildings. Through the augmented reality historical building system, we able to fill the connection gap by with immersive AR experiences and reconnect them to the history, sparking interest and appreciation for architectural heritage. This is also helpful to increase the user interest and awareness of the cultural and educational significance of the heritage.

1.3 Research Objectives

The project goal is to produce an augmented reality (AR) system for mobile applications to provide immersive experiences, in-depth exploration, and engagement of historical buildings to the users. There are 3 objectives for this project.

1. **To develop a mobile application with the AR technology implemented to reconstruct the various appearance of historical buildings**

   This objective is to create a user-friendly mobile application with the employment of AR technology to provide users with captivating immersive experience of historical buildings. It ensures the individuals who not familiar with AR technology also able to experience historical buildings from different eras and leave a memorable moments after using the application. By combining the 3D models, historical information, and AR functionality, the application can reconstruct the visual appearance of these buildings. Each building's evolution over various renovation periods can be display and show to the users based on how detailed the availability of the information, allowing them to make compare and contrast.

2. **To preserve and document historical buildings**

   This objective is to preserve the collected information within a digital space. Compared to traditional paper-based documentation, digital storage is more secure and have permanent life-span to store the data. The application not only focus on the AR capabilities, but the application can contribute to the educational and cultural by allowing the accessibility of these historical literature records to both current and future generations to access, fostering a deeper understanding of the architectural legacy.

3. **To provide high accessibility and interact with historical buildings**

   This objective emphasizes on increasing interest and interaction with historical buildings. The digital platform is easier to attract modern people, inspiring them to explore historical heritages. The Pokémon Go [24] is one of the cases that seen in a successful and phenomena to use the AR technology to engage the people in participating outdoor activities. Indirectly, it shows what AR-based applications is capable of. The application aims to designed to resonate with the potential target users and providing multi-language. It ensures that users from different regions are able to understand and appreciate the context of historical buildings including building background, architecture style and significance of these heritage structures.

1.4 Project Scope and Direction

The project plan is to develop an historical building related AR application. The mobile application development techniques and 3D modelling is used to building this project. The target audiences of the project including novice users like newcomers, citizens, and tourists. Therefore, the development concept is focus on the creation of a user-friendly and welcoming platform. The final project is inclined to provide a seamless experience for user to gain insights into historical building structure and fostering familiarity with their historical significance through the implementation of AR technology. This application is designed to cater to individuals with the interest of AR technology and people who love the historical architecture, thereby offering benefits to both segments.

This project comprises six modules: the AR Module, Building Module, Authentication Module, Map Integration Module, Bookmark Module, and Profile Module. The AR Module serves as the core of the application, it allows the users to visualize the 3D model within an AR environment. This module allow the projection of 3D models to real-world surroundings if the suitable plane surface is detected. Users can choose various 3D models corresponding to different historical buildings and choose different variations to represent diverse timelines. The user experience can be enhanced by interaction functionalities that allow them to resize the models with either enlarge or shrink it, and the rotating functions that enable them to have a different perspective of building in same location. Once the model is positioned, users can explore it from different angles by walking around and get a close-up view of it. They can also capture the image and share it on social media.

Besides that, the Building Module played the role of providing the details information about the historical buildings. Starting from the listed state, the users need to select a building of interest, prompting the system to display a list of available historical buildings. After choosing a specific building, the system retrieves data from the database and presents comprehensive information such as the building's name, historical context, architectural details, images, and so on. This module ensures that users can gain a deep understanding of the historical buildings' significance. For convenience and interaction, the user can bookmark the selected building, or share make the comment to express their feelings towards it. Then the user can access their bookmark in the bookmark module.

The security and interaction are facilitated by the Authentication and Profile Module to ensure the user have a safe environment in engage in experiencing the application. We allow the user to experience the application in either authenticated user or as a guest, which increases the flexibility. The user can perform the changing of username, email, and password through profile module. Consider the access to wider user, the profile module also provides multi-language support, increase the accessibility, and enable more user to appreciate the cultural significance of historical buildings through proper understanding.

The Map Integration Module Visualizes the locations of historic buildings through geographical data, allowing users to see where they are located. Users can also access their own location data in real-time updates and identify the distance between them and selected historical buildings through a navigation line on the map.

The overall aim of this project is to create a mobile application that foster curiosity and appreciation for Malaysia's architectural heritage. Through these modules, the application offers a whole new experience to the user and allowing them to virtually step into the past and uncover the stories behind these historical treasures.

1.5 Contributions

The project aims to make significant contributions to the fields of augmented reality, historical information preservation, and user engagement. First and foremost, the augmented is one the latest technology that allows the user to enjoy immersive experiences in interaction with the virtual world. The combination of 3D modeling, real-time interaction, and historical data allow the application to tailored and blend these together to introduce an innovative way for people to go on a new journey of exploring old historical buildings with new technologies.

Besides that, the project contributes by digitizing and preserving valuable information historical buildings. The long past of the time makes the preservation of the historical buildings more important, we can capture the historical backgrounds, architectural details, and other information in digital form through this project to ensures that the knowledge and essence of these buildings are able to conserve for future generations.

Other than that, the project designs the interface in a user-oriented way and high accessibility able to attract a wider audience to try out the application. Increasing of the user accessibility can allow the promotion to the exploration of historical buildings and receive high appreciation from them to these unique and old architectural buildings.

With the proper preservation of the historical content and the features of interactive AR experiences, contributes it's to the enrichment of education and cultural values. Not only it is a platform that offers the user with the opportunity to interactive with historical buildings, but also encourages the exploration and curiosity spirit from the future generations to eager to know this knowledge.

In short, the projects contribute to facilitating the connection between the community and the historical buildings with the help of technology. Reaching into virtual environment for a digitally and modernly way of experience the past.

1.6 Report Organization

The details of this research are shown in the following chapters. Chapters 2 delves into a comprehensive literature review, examining existing applications in the field to analyse their mechanisms, strengths, and weaknesses. In Chapter 3, the proposed system methodology will be presented, detailing the chosen system development life cycle. This chapter also outlines functional requirements, database design, system design diagrams like user flows, storyboards, wireframes, ERDs, use-case diagrams, activity diagrams, and system architecture diagrams. Following this, Chapter 4 showcases the preliminary work accomplished during FYP1, focusing on system design, including system block diagrams, module specifications, and the development of 3D building models. Moving forward, Chapter 5 discusses the system implementation phase, covering hardware and software setups, configuration details, system operation procedures, and addressing implementation challenges. Then, Chapter 6 shows the system evaluation and discussion, conducting thorough testing and assessing performance metrics to conclude the project with a comprehensive summary and remarks. Lastly, chapter 7 will be the final chapter and delves into the discussion, novelty of the project, future work, and concludes with a summary.

CHAPTER 2
Literature Reviews

To understand the concept and ideas to generate a more comprehensive AR historical building application, the five related applications and articles are reviewed and analyzed, which includes ARCHEOGUIDE project, West Java AR application, Cinema "Sever" restoration filter, Hong Kong Heritage Conservation Education Mobile Application, and London History AR These five applications are mainly utilize the AR functionalities to perform functions that similar with this project. Each application's will be studies to verify its strengths and weaknesses from the implementation and functionality aspects.

2.1. Review on Similar Application

2.1.1 Review on ARCHEOGUIDE project

Introduction

The ARCHEOGUIDE project that developed by Vassilios Vlahakis et al in 2001 [25-26] represents a significant advancement in the field of AR applied to heritage and archaeology. It is an IST project that focuses on enhancing experiences and archaeological research of cultural site visitors. The project aims to create an innovative Augmented Reality (AR) system that overlay virtual reconstruction, historical context, and multimedia content onto ruined real-world archaeological sites and historical buildings through art visualization technology and mobile computing. The flow of information satisfies both professional and recreational users through user profiles from archaeological research, education, multimedia publishing, and cultural tourism. This approach offered the potential to link the modern technology with the cultural heritage, providing visitors and researchers opportunities to explore it in a unique way.

The ARCHEOGUIDE project has features of muti-model user interfaces and personalization. The architecture of the system is using the client-server architecture, with three main components: the Site Information Server, the Mobile Units, and the

Communication Infrastructure. The Site Information Server as a central hub, consists of the Authoring Tool, the GIS Authoring Tool, and Data Manager (DBMS) which is built on Oracle 8. It houses multimedia relational database that collect the essential information such as audio-visual resources and textual information. The database has a query function to retrieve data based on different attributes. The stored data content is accessible by the mobile unit according to the preferences, position, and selected tour of the user.

The second component is the Mobile Units, developed using C++ programming language. These units implement three different MU, including laptop, pen-PC, and palmtop computer. The special AR Head-Mounted Display is requiring for the site visitors use in conjunction with the mobiles units to augment the 3D model. Equipped with a DGPS, the MU devices can collect the user location data precisely, it is a crucial step to determine user's position and orientation. The utilization of the phase-correlation image registration technique enables the calibrated image retrieved from the system with the live video captured by the user's heading camera. As result, the 3D VRML model that adapted the rotations, translations, and scaling of the reconstructed ruins can be generated and rendered on top of the live video image.

The Communication Infrastructure of ARCHEOGUIDE has two wireless networks. The first network establishes communication between the Mobile Units and the Site Information , enable the data transfer of audio-visual content between these components. The second network is a point-to-point wireless link to connect signals from DGPS reference station to the Mobile Units' DGPS receives, ensuring accurate positioning.

Figure 2.1.1 illustrates the natural view from the tourist's viewpoint while Figure 2.1.2 illustrates the reconstructed ruins in an augmented 3D model that view from AR glasses.

Figure 2.1.1: The Original Image of Temple of Zeus, Olympia

Figure 2.1.2: The Augmented Image of Temple of Zeus, Olympia

Strengths

The system utilizes the Olympia, Greece ‘s cultural material on an archaeological site and superimposing virtual reconstructions, successfully generate the 3D models of the ancient site. This visual augmentation with new technology enhanced the visitor experience to get a deeper understanding of historical context. The multimedia content, historical information within the AR experience enhance the visitor’s curiosity, leads to the increase of education impact. The project emphasis on the preservation of the historical sites and buildings, while promoting awareness, engagement, and appreciation among the visitors.

The system introduces some interesting features. During the visual content download phase, the application provides navigate assistance to help in identify user current location and orientation. Next, the audio commentary includes as extra element and presents though specialized augmented reality interface to enhance the connection of user with their surroundings. The system’s design also extends to the backend, with a simple interface for updating the latest research and relevant content in the field. Notably, the GIS Authoring Tool further enhances the system's performance, offering greater flexibility through basic graphical operations such as zooming in or out, and distance measurement.

Weakness

The study is conducted before the population of mobile, resulting in the selection of disparate MUs such as laptops, pen-PC, and palmtop computers. This approach led to verifying performance levels and lack of consistency among devices, and potentially affects the overall user experience. The use of different devices introduced complexities and disparities in the capabilities of each MU. For example, the lightest version Compaq iPAQ Colour Pocket PC lacked DGPS receiver, preventing users from viewing their orientation and position.

The user evaluation also faced some challenges, particularly among elderly and southern European users. The elderly first reported that they felt uneasy and discomfort when approaching the system for the first time. Next, some elderly and southern European users complained about the limited language selection, which posed a barrier for users, particularly those whose languages were not supported. The project is open mainly for Europeans, there are only English and Greek language was supported.

This project funded by European Union is extremely resources intensive and costly in terms of the resource's usage and development. The limited number of various hardware such as MU devices and AR Head-Mounted Display, is heavily restrict the number of users to use it at the same time and. Not only that, using multiple equipment at same time can be troublesome and complex in getting a good experience. Another limitation is the project only providing in-site experiences, which cause the problems of unable to accommodate current environments.

Recommendation

The limitations of this project can be resolved by developing a mobile application. The sifting to mobile applications can solve the problem of varied Mobile Units and improve user consistency. The conversion of application increase the user accessibility to the AR functionality through their own smartphones or tablets at

anytime and anywhere. Which increase the portability and standardizes the user experiences in engage with 3D models, historical context, and corresponding multimedia content. The application with the extra language added ensure users from various region can access the historical information in their preferred language.

2.1.2 Review on Mobile-based Augmented Reality in West Java

Introduction

Syahbanlar Rofiah et al. have developed a mobile AR learning media, which aims to facilitate the utility of technology in delivering learning media for historical buildings through AR and VR demonstrations [27]. The application not only involves the creation of models for historical buildings but also integrates pre-existing and free applications to augment the learning experience. For instance, Google Street View and a VR-based YouTube channel has incorporated into the application to enrich the learning content related to historical buildings in West Java, Indonesia.

The software used for developing the AR-related prototype were Vuforia, Unity, and Blender. Vuforia is a software for developing AR technology that has the features to do image recognition and developed image recognition. Several hardware components were applied to ensure the system architecture work properly. First, the camera is used to ensure efficient capture of every frame of the tracker. Second, the Image Converter responsible for converting camera formats into formats detected by tracking and Open GL. Third, a computer vision algorithm designed to detect and track real-world objects through the video camera.

The procedure of the system includes two parts. Initially, the user selects the building model from the building menu interface on their smartphone. The menu displays four selections: AR Camera, Museum Information, Building Information, and Temple Information, presented in the Indonesian language (Refers to Figure 2.1.3). The interaction between objects and learning media primarily placed within the AR Camera Page. Each of the information pages will display the corresponding famous historical site in Java.

In the subsequent phase, another smartphone equipped with the AR application is employed. Users need to navigate from main application page to AR camera menu (Refers to Figure 2.1.4). Through the capturing and tracking process, carried out with

a second smartphone, the application generates the appropriate 3D model of the selected historical building (Refers to Figure 2.1.5). This interactive approach fosters a deeper understanding of West Java's cultural heritage.

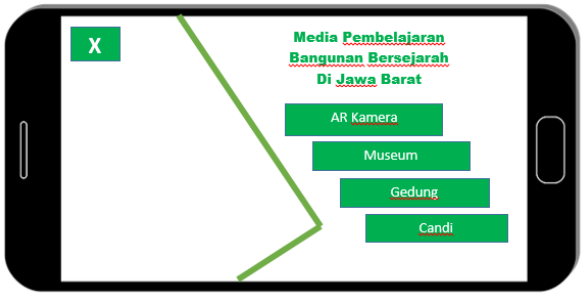


Figure 2.1.3: User Interface of Historic Buildings in West Java

Figure 2.1.4: Main Application Page Interface

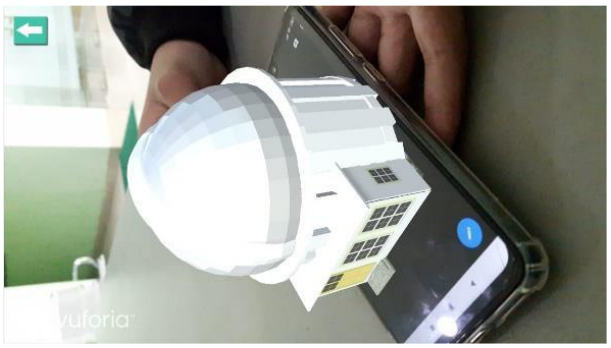


Figure 2.1.5: Generated Boscha building in Bandung, West Java

Strength

Because of the difference in sizes and scales expectation, compared to [25-26], the project implement marker-based AR instead of superimposition AR technologies. The image recognition AR, also known as marker-based AR is suitable and align with the project's core objectives to create a full-scale 3D Model of the mini historical

building in front of the developer, teacher, and others. This approach allows the movement and display of the model from various angles where the 3D model display at fixed location above of the marker.

Next, the interface design of the application main page has a simple navigation design that is friendly for individuals new to AR experiences. Other than display of the AR object, the provision of addition links further enriches user's experience. For instance, Google Street link are provided for each particular historic building, enabling users to access the 3D locations and view geographical context. Similarly, a VR link from YouTube Channel are provided to view 3D interior view of historical buildings.

Weakness

The biggest weakness of the project is the application of marker-based AR with simple display function. It introduce the limitations in terms of scale and size and may potentially restricting the scope of historical structures those on a larger scale. Although the application serves the purpose of delivering learning media, but it only involves the simple information of historical buildings other than display the AR 3D model. Furthermore, the application also suffers from not having much language option to the users. The user that does not understand the Indonesian language will face the problem of not understand the historical context behind each museum and each historical building.

Recommendation

Some of the features can be updated to reach the expectation of the user. While providing a more details information of historical building to enrich the overall content, the users can choose to view the multimedia information such as image and video. Besides that, the function such as scaling and rotating can increase the interaction between the user with application. Lastly, update of the language-translation function can help non-local users and enables of 3D model adjustment function.

2.1.3 Review on Restoration of the Cinema "Sever"

Introduction

The work conducted by E M Tomilina et al. [28] uses AR to recreate the facade of culturally significant heritage architecture, cinema "Sever". The implementation consists of a few research activities,

including bibliographic research, on-site investigations, retrospective analysis of the territory and the object, and the development of a 3D model of the object. Different from [27], they export their AR creation on a digital platform (Instagram) and amplifying the reach and accessibility of the restored architectural marvel.

The "E.K. Plotnikova's city estate in Arkhangelsk Cinema" 1903-1915, was select as the target subject of research for the cultural heritage of regional significance. They apply the superimposition AR through the Spark AR Studio. This approach involved selecting two distinct image references points as the target to superimpose the 3D virtual object on it. Figure 2.1.6 and 2.1.7 illustrates the photo-fixing point 1 and photo-fixing point 2:

Figure 2.1.6: Main façade of the cinema "Server" – fixing point I

Figure 2.1.7: Main façade of the cinema "Server" – fixing point II

In addition to the utilization of Spark AR Studio for AR implementation, other tools were used to assist the creation of this AR experience. Autodesk AutoCAD and Autodesk 3ds Max Design 2009 were created a drawing of the main texture in the form of 2D curves, which were then imported into a 3D modelling software to create

a realistic 3D model of the cinema. To enhance the authenticity of the model, Adobe Photoshop was used to superimpose the relevant parts of the modelled object's appearance. The post-processing phase later applied to Spark AR Studio as a filter effect.

Figure 2.1.8 and 2.1.9 illustrates the outcomes of applying the product of the work, overlay 3D model of the backyard power plant, and the cinema "Sever".

Figure 2.1.8: The augmented image of backyard power plant, 1908-1913

Figure 2.1.9: The augmented image of the cinema "Sever", 1951

Strength

The application of marker-based AR has a huge advantage compared to markerless AR. They choose the launch the augmented 3D model on Instagram as a filter, the publicity of the filter easy to attract the local visitor in trying the new technology, and marker-based were perfect for first-time AR users. Compared with markerless AR, marker-based AR has the advantages of having higher accuracy and lower production cost [28]. For example, the scale of the augmented model will adjust automatically based on the distance of the camera from the building.

Weakness

While the application of filter the superimposition AR gives several advantages, there are also some disadvantages in the case of this filter project. Unlike [25-27], the reliance on physical markers necessitates a direct line of sight between the user's device and the markers themselves. This limitation can restrict the flexibility and mobility of AR experiences, since the user need to travel to corresponding locations where marker is placed to make an interaction.

The selection of this project as a filter has the potential functionality being constraint. Filter with the auto detection and scale adjust autonomy lacks more advanced features support beyond basic scaling adjustments, it limits the users have more interaction and customization their experience with the AR content. Additionally, filter's emphasis on leisure and casual engagement, it lacks the depth of historical context and description of any information about this cinema "Sever". Although it does contribute to the filter's characteristic of simplicity and accessibility, but the potential information reservation is not possible. Thus, the users cannot increase their understanding and appreciation of the presented historical building.

Recommendation

Instead of using the filter to deploy the AR functionality to attract the people in increasing the accessibility, it would be more recommended to have a dedicated AR application. The application not only can house the augmented 3D model of the cinema "Sever" while also incorporating with historical information of the building. Besides, the addition of interaction features can allow the user to customize their interactions through exploring in different angles through the camera moving with the combination of scaling and rotating or view the changes of the building in different time periods. To attract the user in visiting this place, the address or other related information also can attach to the application.

2.1.4 Review on Hong Kong heritage conservation education application

Introduction

Lap Kei Lee et al. introduces an intelligent mobile application for heritage conservation education in Hong Kong [29]. The application is focus on providing a comprehensive tour guide. Thus, it has implemented different technologies to enhance the functionality. The developers map the locations of heritages to allow the visualization where the heritages is located. This approach allows the large-scale coverage of heritages in Hong Kong. The location coordinates and associated heritage information, including images and descriptions from the server.

On the client side, there are a few components. The integration of heritage map with Google maps facilitates the retrieval of heritage coordinates, enabling the display of pin markers on the corresponding geographical locations. (Refers to Figure 2.1.10, Figure 2.1.11). After user's selection on a heritage location, the application navigates to the corresponding heritage information page. Here, user can access the textual descriptions and visual representations of the heritage (Refers to Figure 2.1.12).

Figure 2.1.10: Heritage Map (default)

Figure 2.1.11: Heritage Map (selected marker)

Figure 2.1.12: Heritage Information Page (default)

Moreover, the application incorporates AR cameras and AI recognition components to offer users novel and engaging experiences. This technology adds a layer of interactivity, enabling the users to delve deeper into the cultural significance of the heritage sites through immersive exploration.

Strength

In comparison to previous [25-26] and [28], the Hong Kong heritage conservation education mobile application adopt a simplified yet effective methodology to achieve similar effect. The application focus on enabling the users to understand the transformations and evolution of the heritage. The developers identify the precise locations and viewpoints where historical photos were captured and take a present-day view of the historical photograph at the same location., create a side-by-side comparison on the heritage information page (Refers to Figure 2.1.13). They can either slide left or right to view the past and present visuals. Besides that, the heritage information page have a voice guidance feature provided, enhancing the auditory experience for users. It also serves as alternative mode of engagement.

Figure 2.1.13: Heritage Map (photo of pass and present)

Figure 2.1.14: AR camera (matched result)

Figure 2.1.15: AI recognition Page (search result)

The application utilize the AR cameras, provide an augmented reality experience that overlays historical and heritage image onto the device. This augmented historical image can be overlay with the camera's view, allowing users to blend it with their real-world environment and ascertain how the past view corresponds with the present (Refers to Figure 2.1.14).

On the other hand, the AI technology further enhances the user experience by enabling them to upload a photo from device, then the system will employ AI to identify shared elements between the uploaded image and historical photographs. This feature provides users with insight into the development and changes that have occurred over time, thereby fostering a deeper understanding of the heritage's evolution (Refers to Figure 2.1.15).

Weakness

While the Hong Kong heritage conservation education mobile application have their own creativity in promoting the heritage to the public, there are still some limitations. One of it is the utilization of AR technology to present historical images alongside current views within the camera view. This approach only allows the user to get a rough view of the past historical buildings and heritage sites due to several reasons.

First, the effectiveness of this approach relies heavily on the availability of historical photographs capturing the heritage during different moment. There will be potential problems where such images are lacking or inaccessible, the application is unable to provide users with a comprehensive visual representation of the site's historical significance.

Secondly, the presentation of historical images in 2D format onto the camera view may hinder the depth of interaction between users and the heritage sites. This could potentially decrease the attractiveness of user experience and engagement.

Furthermore, the application's current design lacks support for multiple languages, a limitation shared with the system discussed in [24]. This language constraint is crucial from the tourism aspect where the tourists and visitors can only have limited understanding and accessibility. In short, although the application successfully offering informative approach to heritage conservation and promoting it, but the way they handle the AR historical images showcasing and language limitations can restrict them from deliver experience for users.

Recommendation

To enhance the application's engagement and interactivity, a more robust AR implementation could be explored. The transformation of 2D display to 3D model-based would provide users with a more immersive and lifelike experience of the past historical buildings and heritage sites. This approach could involve the creation of virtual reconstructions based on historical data, enabling users to explore and interact with detailed 3D models within the application. For example, the visitor can move around the historical building and have "zoom in" or "zoom out" function to have a better picture of the whole heritage.

To address the issue of lacking historical images for some heritage sites, the application could collaborate with user-generated content. By encouraging users to contribute historical photographs, the application could expand its database and ensure a more comprehensive representation of historical buildings even when official historical images are unavailable.

Furthermore, to broaden the application's accessibility, the implementation of multilingual support is recommended. Offering content in multiple languages would enable a wider range of users, such as tourists, to engage with the educational material and fully appreciate Hong Kong's rich cultural heritage.

2.1.5 Review on London History AR

Introduction

The London History AR app [30], developed by Octagon Studio offers a journey through time by merging historical content with modern technology. Centered around London city around London city's rich heritage, the application leverages AR to transport users to different eras digitally, allowing the exploration and appreciation of historical evolution of the city. The integration of London historical data and city maps creates an immersive experience that connect the past and present. The figure 2.1.16 shows the marker used in this application to display the AR content, providing users a tangible connection to London's history.

Figure 2.1.16: London Marker

The London History AR application creates different path for user to access the history of London. The user can select to either view the specific historical details, or they can access immerse themselves in a timeline mode that spans from year 190 to the present day. This timeline modes overlays comprehensive historical information, including the 3D models (Figure 2.1.17), detailed 2D art (Figure 2.1.18), videos, and 360-degree panoramas onto the augmented map.

Figure 2.1.17: 3D model of old Saint Paul's Cathedral in 1300

Figure 2.1.18: 2D Map and King portrait during 1666

Strength

The development of the London History AR application involved detail attention to historical accuracy and detail. Through the incorporation of various media elements, ranging from audio, animation, 2D items to 3D items, enhances the educational value of the application. By providing users with a multi-sensory experience, the app ensures that historical information of London is both engaging and information.

The application's flexibility in one of its strengths. Users can navigate through the interactive timeline, prompting relevant content to augment onto the London maker. This content can include introductions to King or Queen, the exploration of iconic buildings during specific eras. The inclusion of little pin icon facilitates efficient selection, enabling user to quickly identify and select specific buildings. Furthermore, the availability of 360-degree panoramas enhances the immersive nature of the experience, granting users an insight into the historical structures.

Weakness

The application does possess some weakness. The reliance on markers as the primary interface for accessing augmented content may limit the user experience. Users need to have another medium to get the access to marker such as print it out or another device like phone or pc to display the marker, which would limit the user experience for those who unable to reach the condition. Additionally, the application's focus on London's history confines its scope to a specific geographic area, potentially excluding users who are interested in exploring historical content from other regions.

Recommendation

To address the weaknesses and enhance the functionality of the application, there are a few functions can be considered. First, introduce the expansion that introduces historical content from other places. This can achieve through the collaboration with other historical experts and institutions from corresponding places.

Besides that, the application can either allow the user to generate their own marker or transform to markerless AR. With the capability to generate their own marker, can foster engagement, customization, and personalization while lower the barrier to access AR mode. On the other hand, the markerless AR does not require any of the marker, instead it just detect the plane and display AR content to the user.

2.2 Comparison between similar applications

Table 2.2.1: Comparison of reviewed AR application in literature review

Function	AR application					
	ARCHEOGUIDE	**West Java AR**	**Restoration of Cinema "Sever"**	**Hong Kong Heritage App**	**London History AR**	**HB Project (My Project)**
AR Implementation	✓	✓	✓ (Filter-based)	✓	✓	✓
3D Model Display	✓	✓	×	×	✓	✓
Historical Information	✓	✓	×	✓	✓	✓
Timeline Mode	×	×	×	×	✓	✓
Multiple Language Support	×	×	×	×	×	✓
Personalization	×	×	×	×	×	✓
Interaction Feature (Scaling, Rotating, etc.)	×	×	×	✓	✓	✓
Model scale adjust autonomy	✓	✓	✓	×	×	✓
360-Degree Panoramas	×	×	×	×	✓	×
Location tracking	✓	×	×	✓	×	✓
Characteristic						
Applied as	Application	Application	Instagram filter	Application	Application	Application
AR Type	Superimposition	Marker-based	Superimposition	Markerless	Marker-based AR	Markerless
Display size of the model	Fixed	Fixed	Fixed	Fixed	Flexible	Flexible

CHAPTER 3
System Methodology/Approach

3.1 System Development Life Cycle

Development approach plays an important role in developing a good application. Fail to proper planning with the development process can cause issues such as bad development schedule and consuming development process, eventually result in poor quality software. In this project, the SDLC model is selected to ensure cost effective and time efficient process to process the build a high-quality application. The SDLC not only can minimize the potential risk during the development process but ensure a consistent and systematic management framework for every stage of the software development process. Based on Aziz [31], there are difference software development lifecycle models, including waterfall model, RAD model, spiral model, V-shaped SDLC model, Agile model and so on. The project will focus on comparing the 3 major categories of methodologies.

3.1.1 Structured Design Methodology

Structured Design Methodology, often referred to as the waterfall methodology, is one the classical software for software development. It regarded as basic foundation for all models for controlling process of software development [31]. The phases include planning, analysis, design, implementation, and system creation. This methodology follows a straightforward and linear approach where each phase depends on the completion of the previous one. The non iterative feature of this methodology makes the returning to the previous phase is too costly. The proper planning and documentation are crucial to minimize potential changes throughout the project lifetime to ensure the project is well-defined, well understood and maintain no changing requirements over the project lifetime. These factors resulted in each phase take a long time to develop before entering the next phase including getting approval from relevant personnel. Therefore, it is suitable for projects which is complex, and require high duration, budget, and manpower.

3.1.2 Rapid Application Development

On the other hand, the RAD models is focus on faster development environments. It has two methodologies fall under this category, which are phased development and prototyping [32]. They allow flexibility and changes at any phases in response to new requirements. For phased development, it break the development process of overall system into a series of versions that are developed sequentially. The most important requirement will be added to the first version of the system and will continue refine and add new ideas to it phases after phases until the system is complete. For prototyping, it also split into several steps. In the business modelling state, the focus in on collecting broad requirements through collaboration between clients and developers. A preliminary prototype is created during the prototype phase to give a rough presentation to the client, any feedback from the client will shapes the future requirements. The actual development will only begin after the finish of the prototype phase. It is suitable for the user who has well-defined and stable requirements from the beginning of the projects [33].

3.1.3 Agile Development

The Agile Development module follows an iterative and incremental approach. There are a few methodologies fall under this category, which are extreme programming and scrum [32]. From the overall agile development process, each of the module development is organized into time-boxed iterations called sprints. The developer first needs to communicate with the stakeholders to determine the sprint goals and select user stories for each sprint backlog. The team members works on design, development, testing, integration process based on user stories on each sprint cycle. At the end of each sprint, outcomes are delivered for stakeholders review and feedback. This iterative development and continuous improvement process ensure the final product quality. Although it focus on speedy development process, but some of the system's potential functionality have the risk to be sacrifice. It is designed to handle the projects with evolving or unclear requirements [33].

3.1.4 Selecting the Methodology

Waterfall development models, RAD development models, and Agile development models each have various characteristic and functionality on the process of delivering the final product to the customer. Table 3.1.1 from [34] list out the major differences between them.

Table 3.1.1 Development Models Comparison

RAD	Waterfall	Agile
Builds a functional, working model of the application in the fastest possible	Emphasizes intensive planning and follows through on set objectives	Builds the app by breaking down large objectives into smaller 'sprints'
Perfect for projects that require the shortest time to complete	Projects are thoroughly planned, and execution is typically time-consuming	Helps develop projects in periodical milestones or 'sprints'
Can adjust to changing requirements	Does not allow for changes once planning is done	Can quite easily adjust to changes even at later stages
Involves clients throughout the development cycle	Only involve clients during the planning stage	Involves clients throughout the development
Prioritizes functionality over aspects of UI/UX	Considers all aspects of the app before deployment	UI/UX takes as much priority as functionality

There are a few factors need to be taken into consideration before making the decision of selecting the best methodology. First and foremost, the project is focus on creating an historical building AR application. It is relatively small project to develop and should adopt a methodology that accommodate flexibility and evolution. The Agile approach allowing us to iterate and adapt as needed to ensure that the final product align with our objectives and vision. Unlike waterfall methodology, where its limit by sequential phases to make further modifications if everything is set, the Agile approach can allow the refinement of the requirement and fine-tune every element until it becomes ideal.

Although both RAD and Agile both believe in iterative approach and customer-centric approach, the Agile is more emphasis on user involvement and feedback then RAD approach to accommodate any evolving or uncertainty requirements in the future. Considering the visual and interactive nature of an AR application, it is important for refining user experiences and interactions [33].

Based on above considerations, the agile development methodology is selected.

3.1.5 Methodology Implementation

For this project, the Agile model from [32] is introduced (Figure 3.1.1) due to its characteristic on quick iterations and customer centric approach to develop software applications. It consists of five stages, which are planning, analysis, design, and implementation phase.

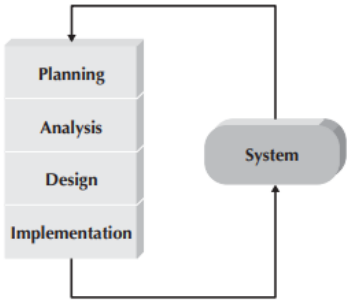


Figure 3.1.1: Agile Methodology Diagram

Here's a brief overview of the implementation of RAD in every phase for this project:

Planning Phase

During the Planning Phase, project objectives, scope, and requirements are defined after conducting through research on project background and problem statement.

Analysis Phases

The Analysis Phase will start after finalizing the planning phase. This phase will focus on determine the user requirements or confirming core functions for implementation. This starts with gathering preliminary requirements through a questionnaire, which mainly focus on university student as the target audience. The existing applications and related articles will be reviewed to benchmark and extract useful functionality to incorporate into the project.

Design Phase

The Design Phase focuses on creating a clear picture of user interactions with the software. Various diagrams will be used to visualize these interactions. The

application's interface will also be designed. The feedback will be collected from relevant personnel to refine the design and ensure alignment with their needs and expectations.

Development Phase

The core of the project lies in Development Phase. Based on the gathered requirements and the diagrams, the functionality will be separate into different modules and start the development. Each iteration will involve making the modifications, adding new features, and addressing any changes in design or requirements.

3.2 Functional Requirements

The survey is conducted to examine the factors that cause respondents to have less engagement with the historical buildings. By understanding these causes, it benefits in develop solutions to improve their interest and engagement. There are total of 27 questions to gain the opinion of respondents. The questionnaire is created through the Google Form and distributed to the public with target audience of university students. In total 32 respondents participated in the survey.

3.2.1 Demographic Information

The basic information of respondents is collected, including the age, gender, highest education level, university name, and living state.

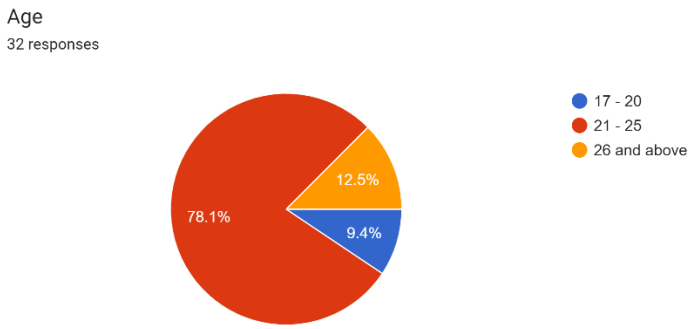


Figure 3.2.1: Age Pie Chart

In Figure 3.2.1, the majority respondents focus on age group of 21-25 years old with 78.1%. A smaller portion, with 12.5% allocation are 26 years old and above. While 9.4% of the respondents belong to 17-20 years old group.

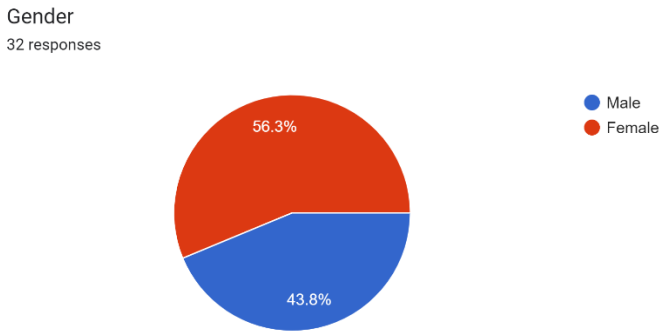


Figure 3.2.2: Gender Pie Chart

As shown in figure 3.2.2, 56.3% of the respondents are female and 43.8% of the respondents are male. It is quite balance in gender distribution of respondents.

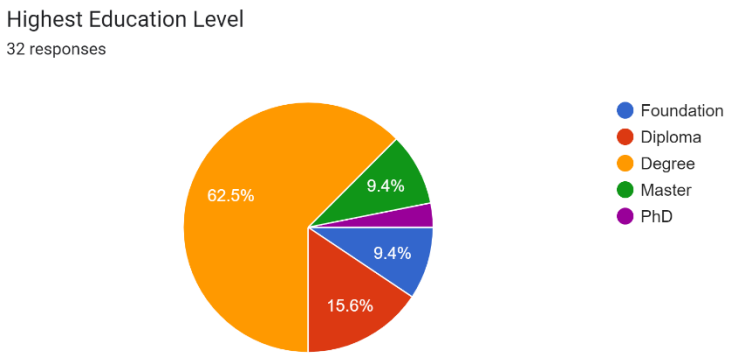


Figure 3.2.3: Highest Education Level Pie Chart

As shown in figure 3.2.3, we able to collect 62.5% of degree students, 15.6% of diploma students, 9.4% for both master and foundation students, and 3.1% of PhD students. It shows only the highest education level's responses are collected and ensure the alignment with our target audience

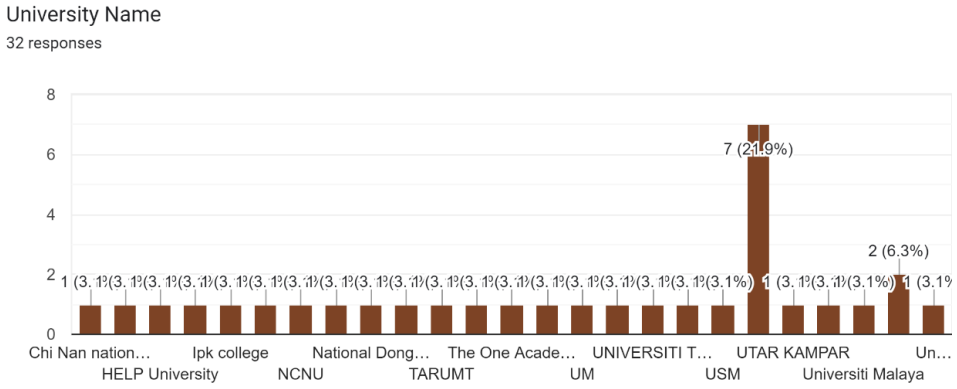


Figure 3.2.4: University Name Bar Chart

As shown in figure 3.2.4, the respondents come from diverse university with the highest percentages 34.4% of participants from UTAR. Next are participants from NCNU, TOA, and UM with 6.2% for each. Following 3.1% for HELP University, Heriot-Watt University, Monash University, National Taipei University of Technology, NDHU, TARUMT, UKM, UNIMAS, UTM, UPM, USM, University of Glasgow, Clazroom College, IPK College, and New Era University College.

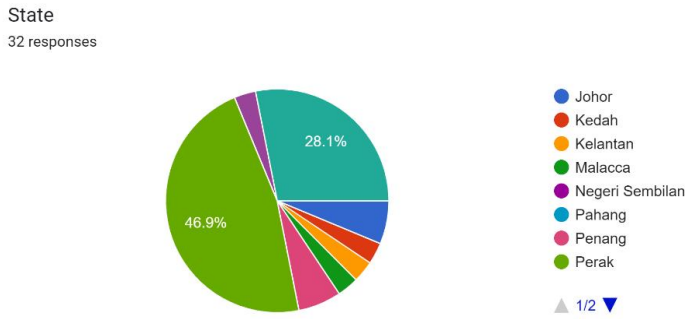


Figure 3.2.5: State Pie Chart

As shown in Figure 3.2.5, the collected responses from 8 different states. The Perak and Selangor occupy the majority, which are 46.9% and 28.1%. Follow by Johor and Penang for 6.3%, Malacca, Kelantan, Kedah, and Sarawak for 3.1%. It shows all the participants are from Malaysia.

3.2.2 Results Analysis

The question 1 to 10 gain understanding of respondents' habits and basic background. Question 11 to 14 examines their knowledge on historical building. Next, 15 to collect their opinions on the significancy. Lastly, question 22 to 27 will explore their understanding of any existing technology integration with historical buildings.

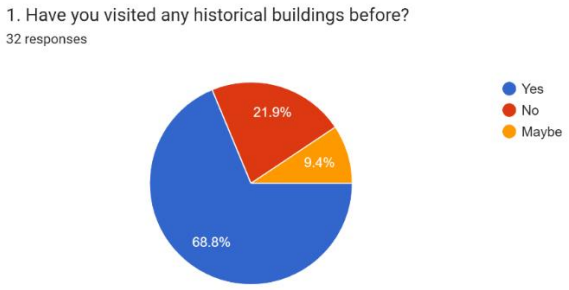


Figure 3.2.6: Visitation Experience Pie Chart

The first question intents to know participants' experience in visiting historical buildings. Results show 68.8% of participants have visited the historical buildings before, while 21.9% have not, 9.4% are uncertain whether they have visited such buildings. This indicates that a significant portion of participants have engaged with

historical sites, potentially have interest in cultural or historical experiences discovered among them.

Figure 3.2.7: Visited Building Answer

In second question, various answers were provided by the participant in providing the building names. After analyzing the building list, the A Famosa is the most visited historic building despite the historical sites not located in their own state. Several participants had explored multiple historical buildings spanning across various states, such as Melaka, Kuala Lumpur, and Penang, which further proves their interest in historical exploration. However, there were also respondents who only visited exclusively to historical buildings in their hometown. The reason may be due to limitations and challenges they faced to get opportunities in visiting foreign state.

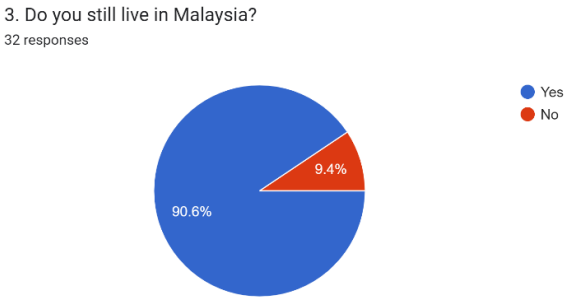


Figure 3.2.8: Living Status Pie Chart

The third question focuses on the current living status of respondents. A significant majority of respondents comprising 90.6% currently resides in Malaysia, while remaining 9.4% are living in foreign countries. This shows that there are some

respondents may face geographical obstacles when they want to visit historical buildings in Malaysia.

Figure 3.2.9: Local Historical Building Answer

Next question analyzes the familiarity of participants with historical buildings located in their hometowns. The responses reveal that the majority of respondents possess certain levels of knowledge of local historical sites. This finding shows there are certain awareness and familiarity from respondents with historical buildings in their respective regions.

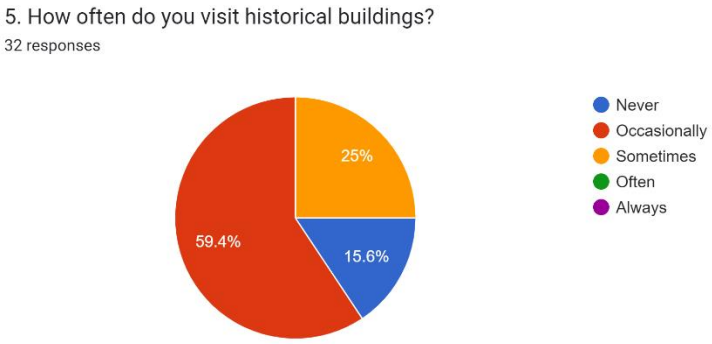


Figure 3.2.10: Visitation Frequency Pie Chart

The fifth question explore the frequency of participants in visiting to historical buildings. The results indicate that a significant majority, 59.4% of respondents have a habit of visiting historical buildings occasionally. Additionally, 25% of participants sometimes participate in such visit, while 15.6% have never visited historical buildings. It shows there are low but substantial interest from surveyed population to engage in historical site exploration.

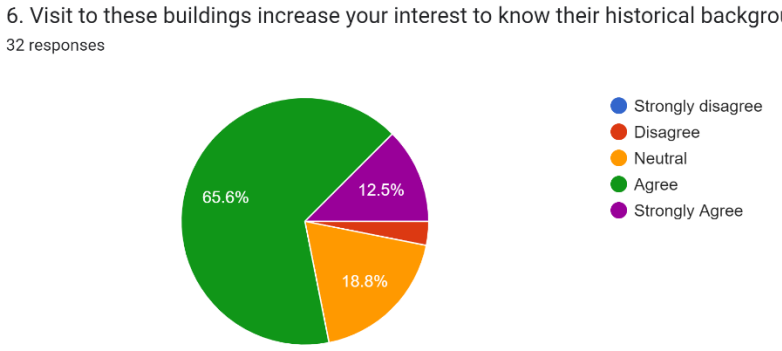


Figure 3.2.11: Interest Increase Opinion Pie Chart

In sixth question, we gathered respondents' opinions after visiting the historical sites. A total of 78.1% of participants expressed positive opinions about the statement, with 65.6% falling into 'Agree' category and 12.5% in 'Strongly Agree' category. There are 18.8% remain neutral in their response. Although a single respondent who doesn't have any visiting experience disagreed with the statement, but it further highlights the potential impact of historical site visitation to foster a greater appreciation and understanding of history and cultural.

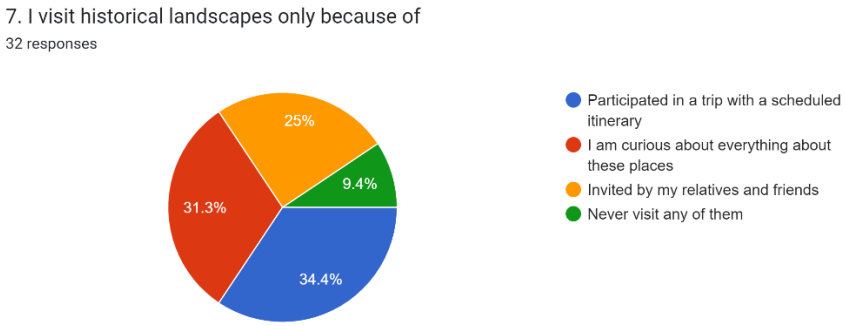


Figure 3.2.12: Reason on Visitation Pie Chart

In seventh question, we gathered the motivation behind participants' visits to historical buildings. Among their experiences, 34.4% had participated in related trips, while 31.3% expressed their interest in related historical building exploration. And remaining 25% indicated that they had been invited by their friends and family for the visitation. It shows the significance of social connections, where the role of interpersonal relationships assists in shaping historical site visits.

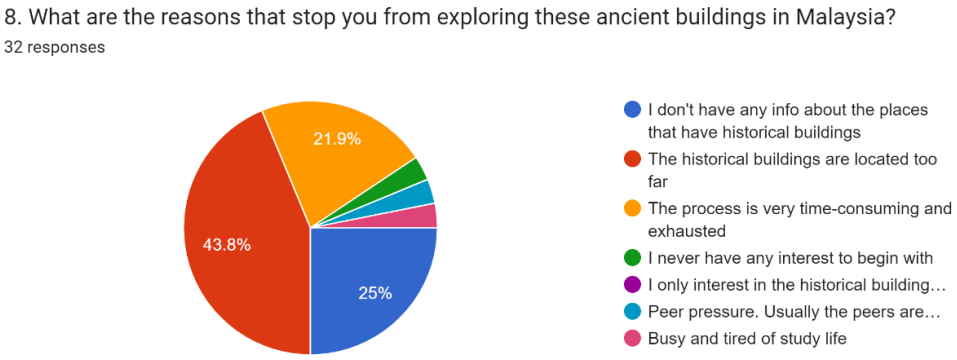


Figure 3.2.13: Obstacles in Visit Historical Building Pie Chart

The eighth question investigate the potential obstacles faced by participants to visit historical buildings. The majority of responses can group into 3 categories, 43.8% of them reflected the historical buildings are located too far from their residence place, 21.8% emphasis that they don't have sources to access related info even they have interest in visiting them. Another 21.9% expressed concerns of the whole exploration process is time-consuming and exhausted. The solution to hinder these problems can be the key solution to promoting cultural and historical exploration.

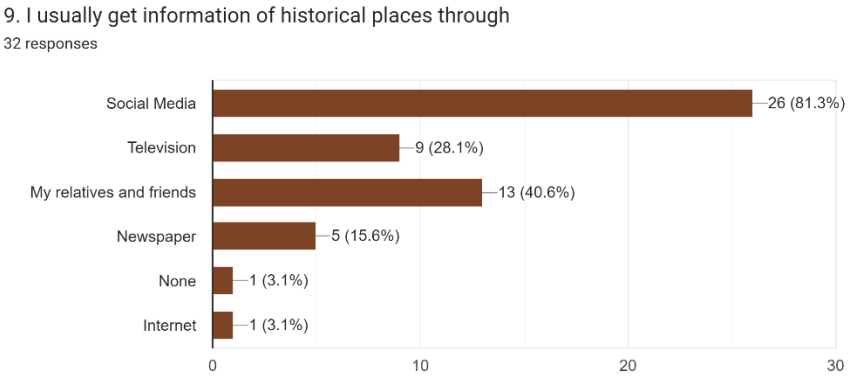


Figure 3.2.14: Info Resources Bar Chart

The nineth question we inquired about the platforms usually they rely on to get related information. A majority of 81.3% respondents states they rely on social media as primary source, and 40.6% get from their friends and family. And another 28.1% from television. It shows the influence of new technology to advertising historical information. Besides that, it further proves the important of social connections in assist in spreading awareness about historical buildings to the public.

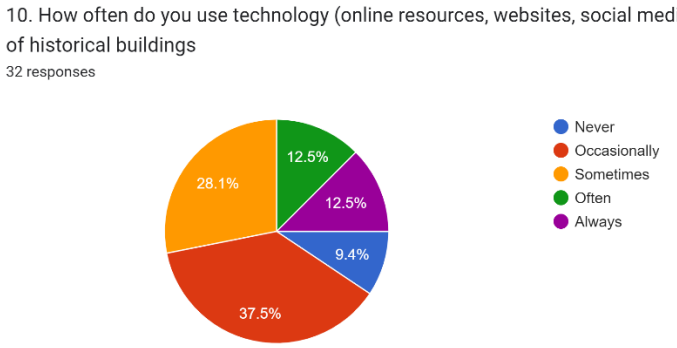


Figure 3.2.15: Frequency of Using Technology to Access Information Pie Chart

In the tenth question, the respondents' frequencies in using technology to access related information is accessed. The largest portion 37.5% respondents occasionally spend time searching for related information using technology. 28.1% of participants sometimes engage in searching, there are 12.5% for each 'Often' and 'Always' categories. And a small percentage of 9.4% reported they don't search for any of it. The assessment of engagement levels with technology shows the potential of technology.

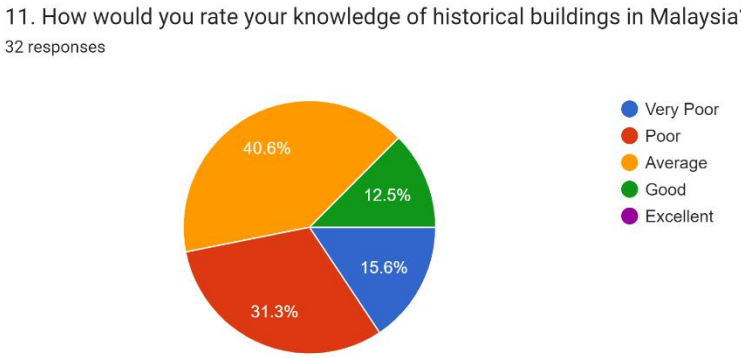


Figure 3.2.16: Historical Buildings Understanding Pie Chart

Start from question 11, we examine the respondents understanding of historical building in Malaysia. Most of the respondents with 87.5% in overall have reflects that they have average or below average understanding of historical building, where 40.6% for 'Average', 31.3% for 'Poor', and 15.6% for 'Very Poor'. The question 12 to 14 which select some historical buildings in Malaysia to test out their knowledge.

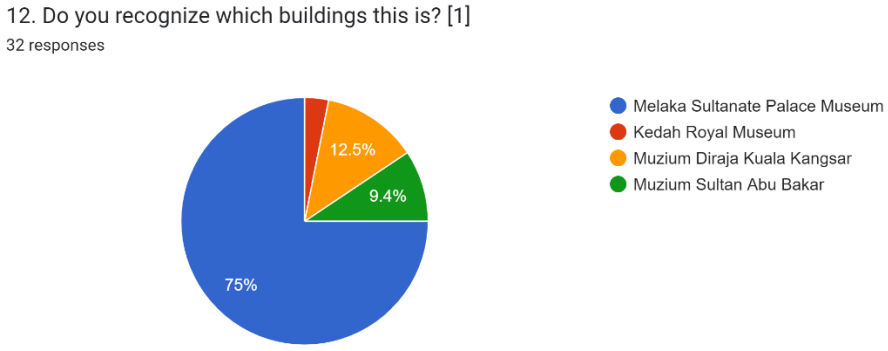


Figure 3.2.17: Melaka Sultanate Palace Museum Recognition Pie Chart

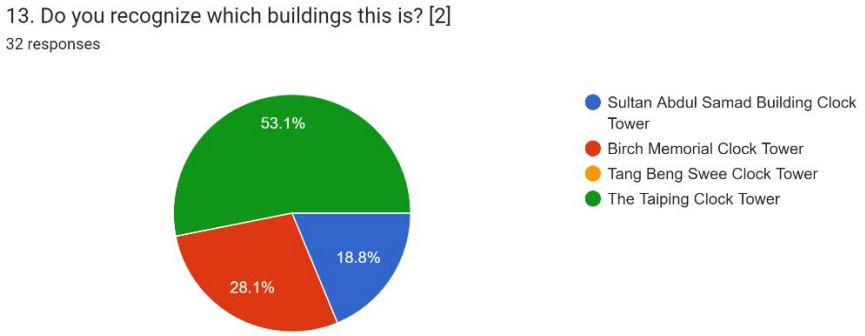


Figure 3.2.18: The Taiping Clock Tower Recognition Pie Chart

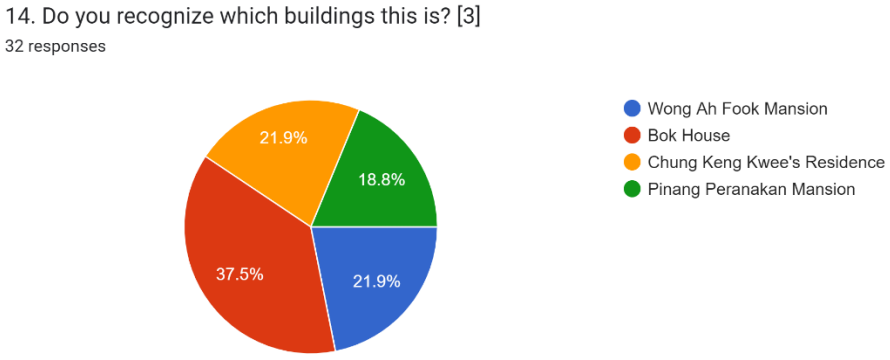


Figure 3.2.19: Bok House Recognition Pie Chart

The first building, Melaka Sultanate Palace Museum is a historical building located in Melaka and known for its unique design and high recognition. In result, achieved a total of 75% correctness among respondents. This indicates that majority of them have an average understanding of famous historical buildings like this.

Next selected building is the Taiping Clock Tower, although part of Malaysia's historic buildings, it is not very famous compared to Melaka Sultanate Palace Museum. In results, it only gained a correctness rate of 53.1%. While this demonstrates recognition, it also suggests that there is space for improvement for respondents' awareness of less famous historical buildings.

Last selected building is the Bok House located in Kuala Lumpur. Despite its historic significance to the growth of Malaysia, the mansion was demolished in 2006 due to new building development issues [35]. In result, it only gets 37.5% recognition correct from respondents. This shows the people are not familiar with the past historical buildings and also highlight the importance of prioritizing the solution to educate public about lesser-known historical buildings and their historical significance.

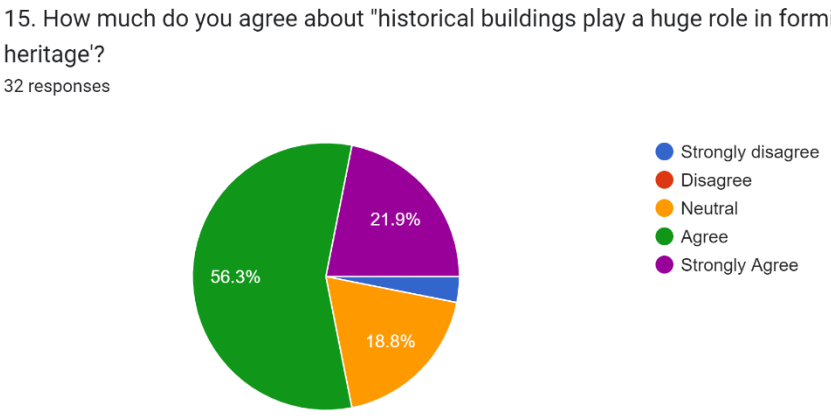


Figure 3.2.20: Opinion of Historical Buildings' Significance Pie Chart

From question fifteenth, majority of the respondents agreed and have positive view on the role of historical buildings in forming our cultural heritage. Which consists of 78.2% positive responses in total with 56.3% of 'Agree' and 21.9% of 'Strongly Agree'. This shows the highly recognition and awareness of public about the significance of historical buildings.

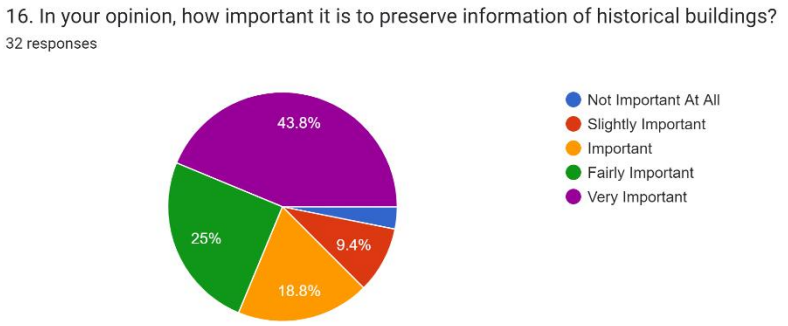


Figure 3.2.21: Significance of Historical Preservation Pie Chart

The question sixteenth queries respondents on their opinions regarding the significance of historical buildings' information preservation. While 9.4% of them indicated that the statement only 'Slightly Important', the majority of them of total 87.6% expressed on the importance of this preservation. It shows our project value in proper preservation of historical buildings.

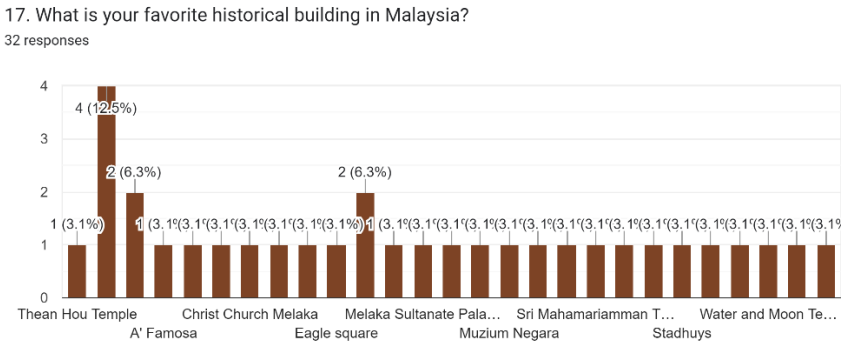


Figure 3.2.22: Favorite Historical Building bar chart

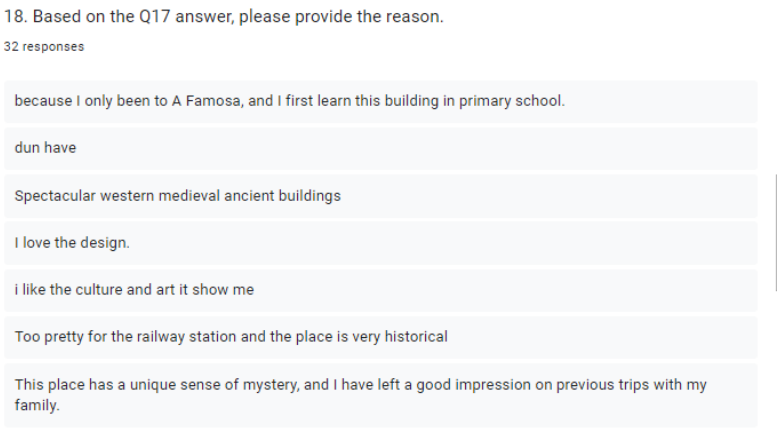


Figure 3.2.23: Reason on Choosing Selected Historical Building For Q17

In question seventeenth, we collect the participants' favorite historical building. Among the answer they provided, the A Famosa building is the top choice, which selected by 25% of respondents. This finding shows that strong correlations between the favorite historical building selection and the historical buildings visited by participants. Through the reason they provided in question eighteenth, further evidence that by gaining a deep understanding of historical buildings, can significantly improve their interest and influence their choice of favorite historical buildings through creating some memorable experiences.

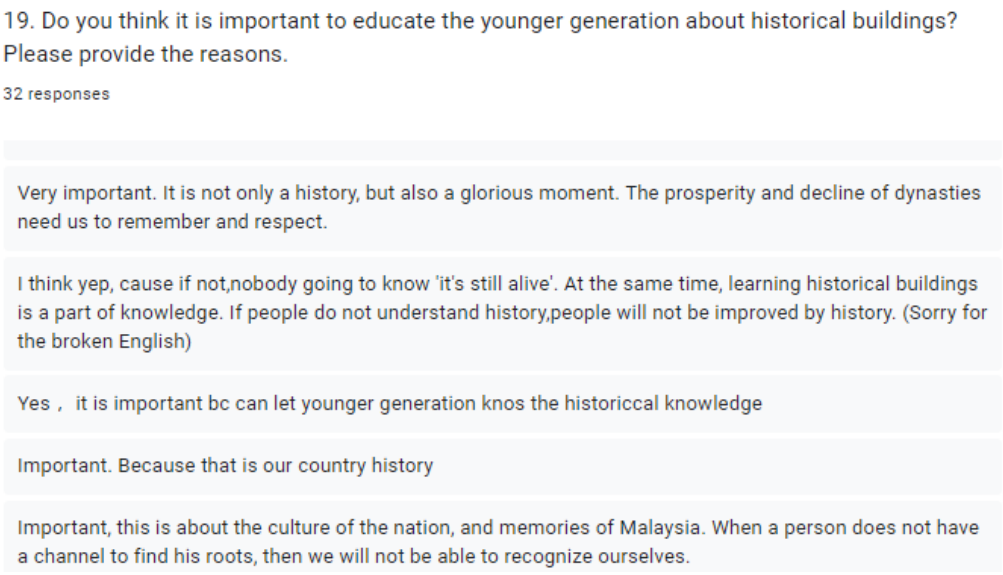


Figure 3.2.24: Opinion of historical building education value to next generation

This question analyzes the participant opinion on the importance of historical buildings education. Without a doubt, all of them agreed and found it necessary to educate corresponding knowledge to the younger generations. It shows them feel the preservation of Malaysia history also part of our responsibility towards our country and should ensure it passed on from generation to generation and not forgotten. Which further increase the value and importance of our project in preserving the historical information.

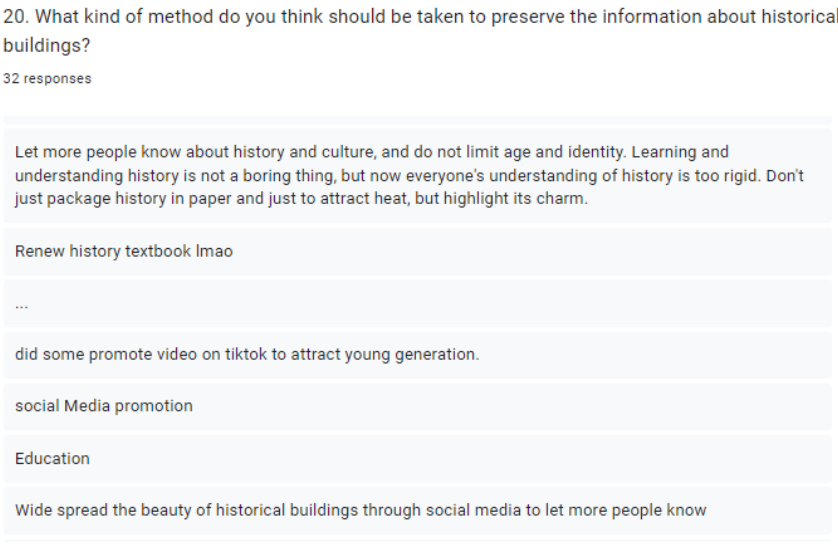


Figure 3.2.25: Method for information preservation

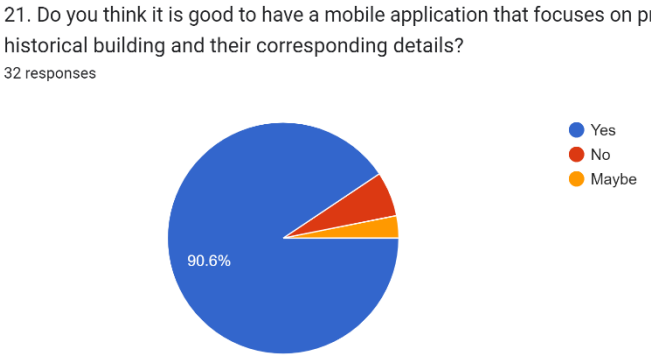


Figure 3.2.26: Mobile Application Development Opinion Pie Chart

In question twentieth, respondents shared their opinions on proper methods to preserve historical information of buildings. Although different ideas were proposed, we able to grasp the common general idea they provided, which is to increase the accessibility to the information through easier platform such as social media, information channels and so on. This is aligned with our project's objective to develop a historical building application with high accessibility.

Furthermore, a total of 90.6% of respondents expressed positive agreement with the idea of developing a mobile application to address this need in twenty-first question. This represents an indirectly confirmation from respondent regarding their acceptance to have an application for historical building.

Start from question 22, we will analyze the respondent understanding of AR technology.

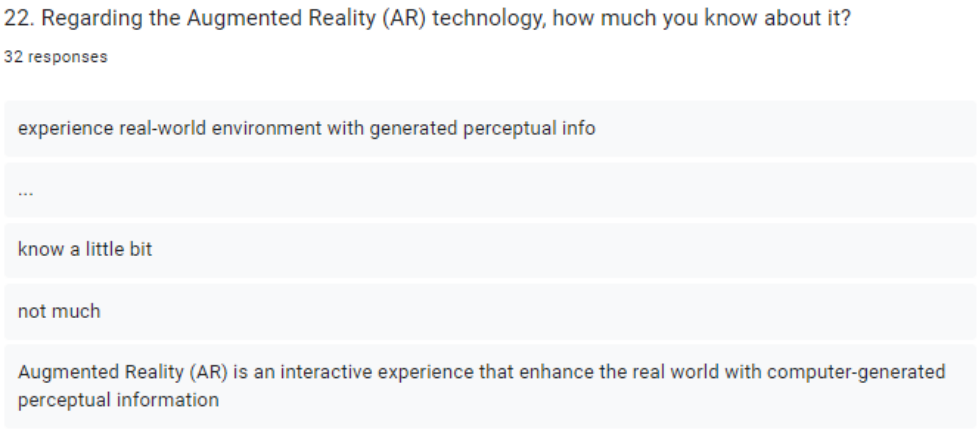


Figure 3.2.27: Awareness of AR technology

Through question twenty-second, we able to get an insight into respondents' familiarity with AR technology. The results show that only minority of participants were able to provide a briefly explanation of what AR is commonly used for. The majority of them have limited knowledge with AR.

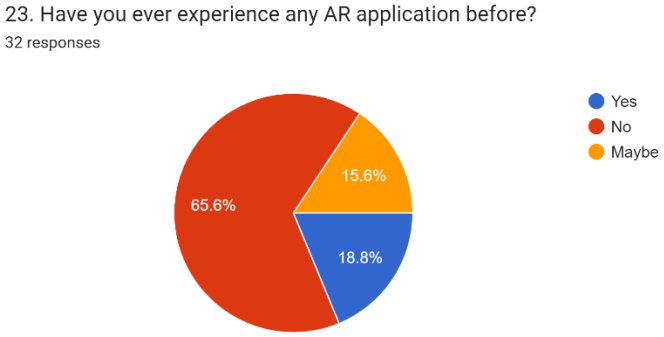


Figure 3.2.28: Respondent AR experience

In question twenty third, it shows that only a small percentage, 18.8% of participants were confident that they have prior experience with AR before. While a larger proportion with 65.6% stated that they had not used any AR applications previously. It shows that the AR technology is new to most of them if it applies to the application and the awareness-building will be extremely important.

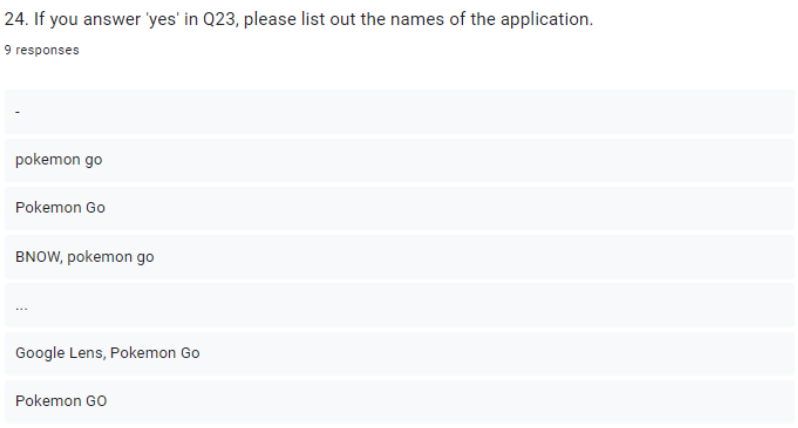


Figure 3.2.29: Experienced Application Names

Among the respondents who indicated that they have experience in using AR during question twenty-third, most of them mentioned the AR application was Pokémon Go, a well-known game under Pokémon franchise with AR application applied [24]. Other than that, the application such as BNOW and Google Lens also mentioned as AR application they have used before.

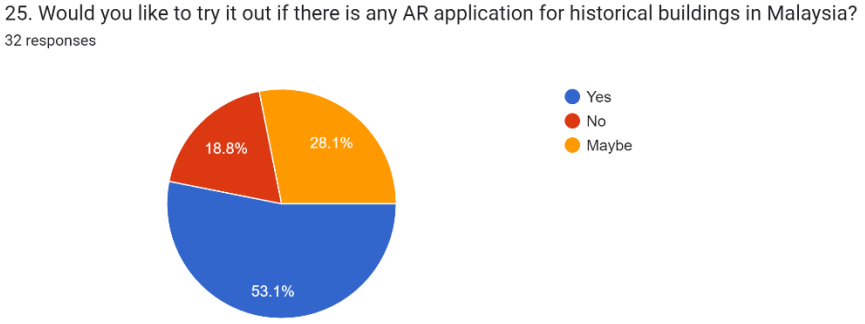


Figure 3.2.30: Opinion on trying AR application for historical building

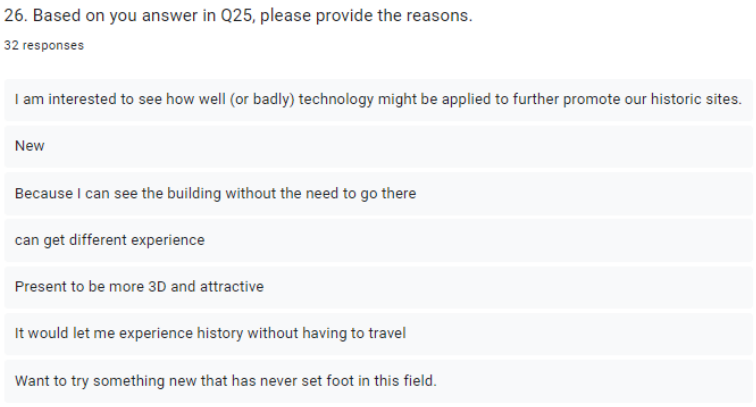


Figure 3.2.31: Reasons to try the application for historical building

Despite majority of respondents stated that they lacked experience in using the AR applications according to the responses in question twenty-third. But approximately 53.1% of respondents were willing to try if there is an AR application designed for Malaysia historical buildings exploration. The reasons from their responses in question twenty sixth, include curiosity, desire to get different experience, and found it interesting. It shows that the AR functionality is significant in provide brand new experiences to the user who don't have prior experience while providing them display of 3D model in real world to them.

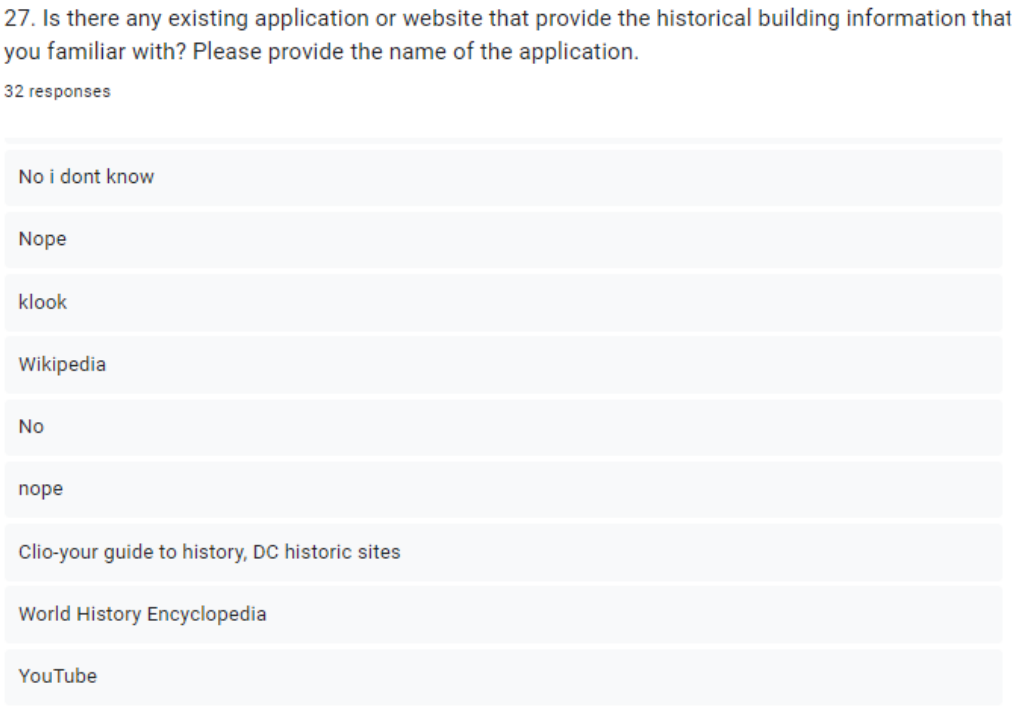


Figure 3.2.32: Application or website that provides related information

Lastly, the question queries the respondents about existing applications or websites they are familiar with for accessing historical building information. The mentioned resources include Tripadvisor, Klook, Wikipedia, Clio, YouTube, DC historic sites, and World History Encyclopedia. However, these sources are not exclusively focused on Malaysia's historical buildings. Consequently, they may encounter difficulties in searching any related information about historical buildings that they haven't experienced yet or may found interesting.

3.3 User Requirements

Table 3.3.1 User requirements

No.	As a	I want to	So that
1	User	view historical buildings in AR 3D models	I can explore and visualize the appearance of historical buildings in different areas.
2	User	resizing and rotating AR 3D models to make interaction	I can view the historical buildings from various angles and perspectives.
3	User	relocate and remove AR 3D model	I can place it at the place I more prefer in the real life
4	User	access information about historical buildings with comprehensive description	I can learn more about the historical context, architectural details, and significance of each building.
5	User	share the image I took from the application to my social media	I can engage with others and promote awareness about Malaysia's architectural heritage.
6	User	bookmark historical buildings	I can save my favorite buildings and revisit them later.
7	User	comment on selected historical building	I can express my feeling and tells the beauty of it to others.
8	User	rate selected historical building	I can provide my opinion how I feel about it.
9	User	view other users' review	I can have a look on how other people look about this historical building.
10	User	experience the application in the languages I more familiar with	I can understand the context and appreciate the cultural significance of historical buildings.
11	User	identify the locations of historical buildings on a map	I can locate nearby historical buildings and plans visits when I am free.
12	User	search for the locations of	I can know which one is the

		specific historical buildings	historical building I am finding
13	User	access real-time location updates and navigation features	I can easily navigate to selected historical buildings and explore it.
14	User	using the application without login	I can experience the AR right away.
15	User	login into the application	I can have set up my own personalization.
16	User	reset password	I can change a new password in case I forgot my previous one.
17	User	view my profile	I can check my profile picture, username, and other related info.
18	User	change my information in profile	I can update my old profile picture and user name.
19	User	keep in login status	I can directly start using it if I login in last time.

3.4 Database Design

3.4.1 Business Rule

Each user saves zero to many bookmarks.

Each bookmark belongs to one and only one user.

Each user makes zero to many reviews.

Each review from one and only one user.

Each bookmark store one and only one building.

Each building can be store in zero to many bookmarks.

Each review belongs to one and only one building.

Each building consists of zero to many reviews.

Each building consists of zero to many medias.

Each media belongs to one and only one building.

Each building has zero to many buildings model.

Each building model for one and only one building.

Each state possesses one to many buildings

Each building included in one and only one state.

3.4.2 Entity Relationship Diagram

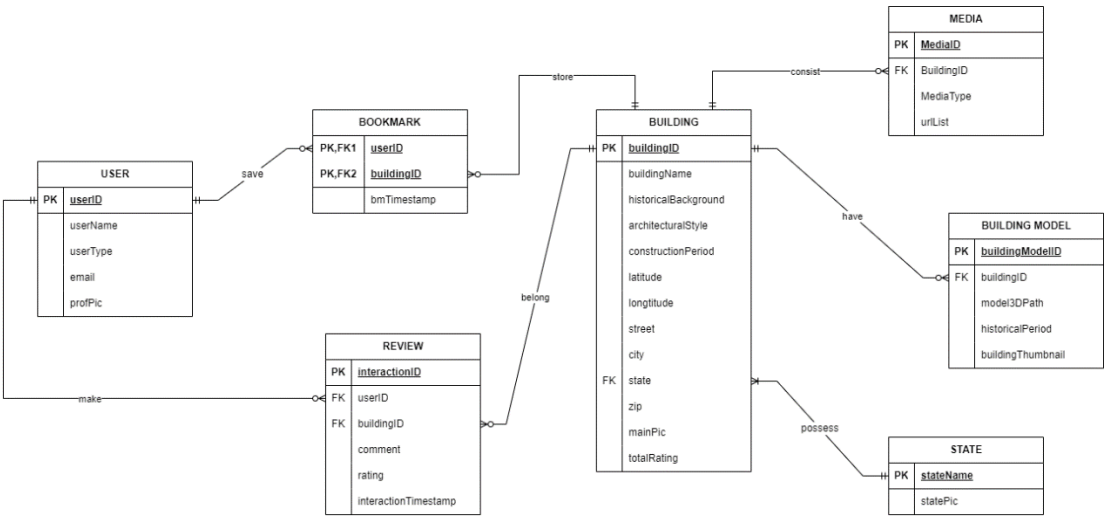


Figure 3.4.1: Entity Relationship Diagram of HB Application

The entity relationship diagram in Figure 3.4.1 shows the structure of the database storage. Despite the project implemented Firebase, which is a NoSQL database, but a proper organization better demonstrates the relationship between different entity. The user entity stores the information of every registered user. It can get indirect connection with the building entity through bookmark entity and review entity. The bookmark entity will store the data of timestamp when user store any building they interested into the bookmark, while the review entity will record the feedback of user regarding the building, which includes rating and comment. Next, the building entity store all the information of corresponding building, including historical background, address, construction Period, and so on. The multimedia data of building such as picture or video will store in the media entity and building model for AR display store in building model entity. Lastly, all the Malaysia state data keep in the state entity.

3.5 System Design Diagram

3.5.1 System Architecture Diagram

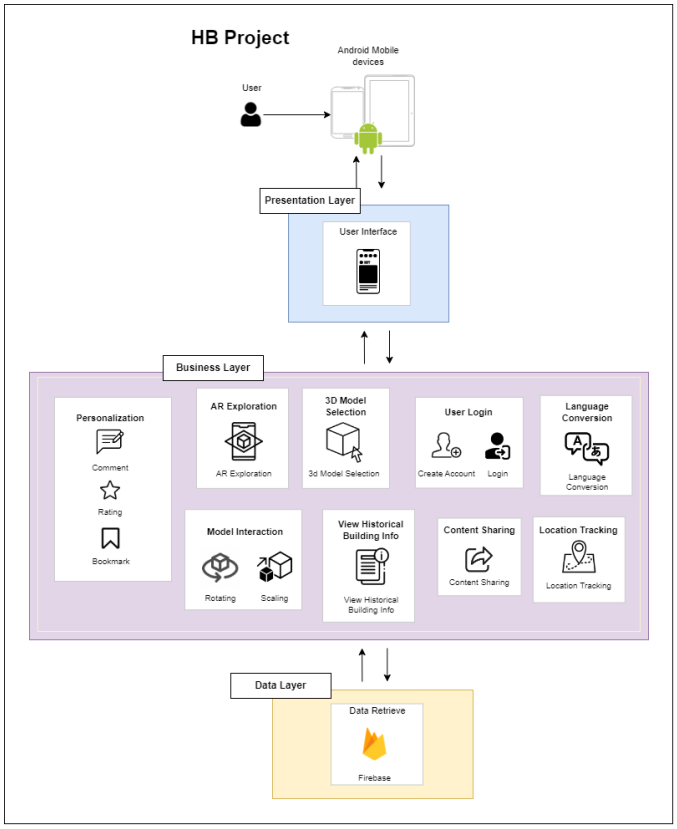


Figure 3.5.1: System Architecture Diagram

As shown in Figure 3.5.1, this project applies three-layer architecture to develop the mobile application. It is a common design pattern for most of the mobile applications and categories all component into three different layers, which are Presentation Layer, Business Layer, and Data Layer. Presentation Layer plays the role of UI components management, it handles the visualization of the interface. It allows the users to get the communication with the application. Next, the Business Layer responsible for back-end logic management. It executes the request from users, perform corresponding business logic and rules, and enable the communication between presentation layer and data layer. Finally, the Data Layer responsible for managing the data storage interaction. It interacts with Firebase to get and store the data needed by the application. All the data will send through the business layer. In short, it provides a reliable and clean structure arrangement between the communication of the model. For our project, we utilize the C# programming language to performing all the activities in these three layers.

3.5.2 System Network Diagram

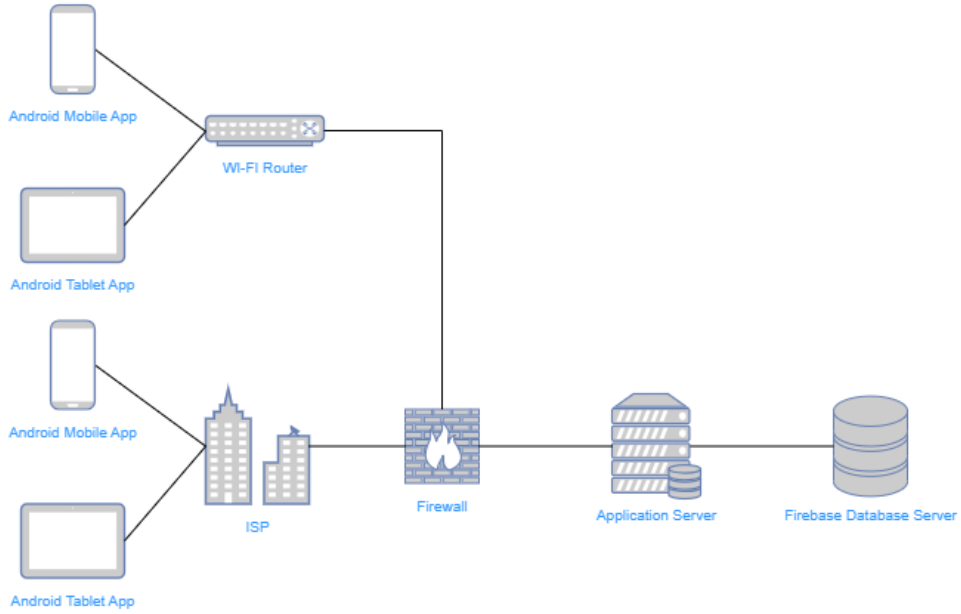


Figure 3.5.2 System Network Diagram

Based on the system network diagram from Figure 3.5.2, user can access the application via either an Android mobile app or tablet app. As the application requires network connectivity, access can be going through the Wi-Fi router or Internet Service Provider (ISP). Upon logging into the application, users can remotely or locally access information about historical buildings. They can view 3D models in AR mode, allowing for detailed exploration. Interactions such as rotation, relocation, and resizing can be performed to examine buildings closely. Users can capture images of the models and save them on their devices or share it with others through sharing button. Besides, they can bookmark buildings they find interesting for future access. Users can also express their opinion by commenting on historical buildings they are interested in and providing ratings. If they wish to locate a specific building, they can utilize the map feature within the app. Any actions involving data retrieval or updates will interact with the Firebase database server.

3.5.3 Use-Case Diagram

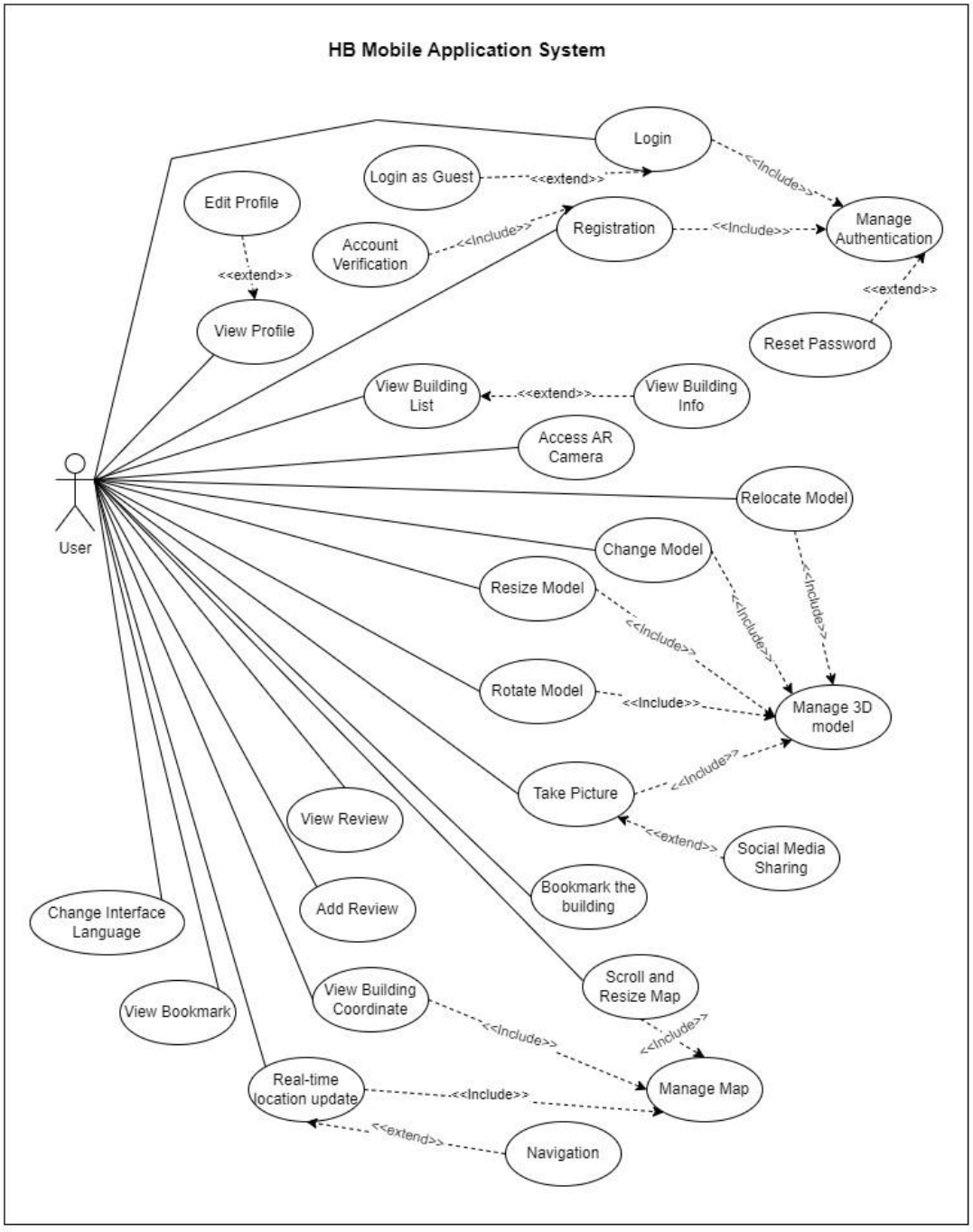


Figure 3.5.3: HB Mobile Application System Use Case Diagram

The Figure 3.5.3 illustrates the use case diagram to show the potential functions actor, specifically normal users, able to perform through the HB mobile application.

Users can login to the application, granting them the permission to access their profile, bookmarks, and past reviews. If a user does not have an account, they have

the option to either create a new account or enter the application as a visitor. Once logged in, users can visit the historical building information through proper navigation from the state list. Within the building info page, user can view the historical building information and leave comments or ratings regarding the historical building and save it to their favorites if interested. Then, they can utilize the AR camera to experience the integration of pre-created building 3D models into the real world, enabling them to perform various interactions, such as rotating, scaling, relocate, photo captures, and switching models. After capturing a blended 3D model picture with the real world, users can choose to delete it, save it, or share it on social media. Furthermore, users have the ability to change their interface language for better interpretation.

Moreover, users can also access the map feature to locate historical buildings. Upon selecting a historical building, the map provides navigation from the user's current location to the selected building, with real-time location updates. Users can resize or scroll the map to find desired markers and also utilize the search bar for location searches. These functions contribute to enhancing the user experience while using the application.

3.5.4 Use Case Description

Manage Authentication Use Case

Table 3.5.1: Manage Authentication Use Case Description

Use Case Name: Manage Authentication	ID: 1	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to start using the application		
Brief Description: This use case describes how using interact with the authentication when using the app.		
Trigger: Users enter the application. Type: External		
Relationships: Association: User Include: Registration, Login use case Extend: Reset Password use case Generalization:		
Normal Flow of Events: 1. The user loads the login page 2. If the user doesn't have account and want to have their own account Execute Registration use case. If the user wants to login. Execute Login use case. If the user has an account but forgot the password the S-1: Reset Password subflow is performed.		
SubFlows: S-1: Reset Password 1. The 'Forgot Password?' button is pressed 2. The system pops out Reset Password box 3. The user enters the email. 4. The user press 'YES' button 5. The system displays the message indicates successful sent the password reset email to user's inbox. 6. Repeat step 1-5 until user finish the password reset.		
Alternate/Exceptional Flows : S-1, 4a1: The system displays the message "An error occurred. Please try again later."		

Register Use Case

Table 3.5.2: Register Use Case Description

Use Case Name: Register	ID: 2	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to create a new account		
Brief Description: This use case describes how user can register and create an authenticated user account.		
Trigger: User presses the user creation button. Type: External		
Relationships: Association: User Include: Manage Authentication use case Extend: Generalization:		
Normal Flow of Events: 1. The user clicks 'New User? Create an account' button 2. The system navigates to register page 3. The user chooses to continue register process. If the user wants to continue register. the S-1: Register subflow is performed If the user doesn't want to continue register. the S-2: Back to main menu subflow is performed		
SubFlows: S-1: Register 1. The user enters the sign-up page. 2. The user enters the name, email, password, and confirm password. 3. The user press 'Sign Up' button. 4. The system begins validating the user info. 5. The system navigates to verification reminder page. 6. The system displays the message indicates successful sent the verification email to user's inbox. 7. The user press 'Login' button 8. The system navigates back to login page. S-2: Back to main menu 9. The user clicks the 'Already have an account? Login' button 10. The system navigates back to login page.		
Alternate/Exceptional Flows : S-1, 3a1: The user didn't enter name. The system displays the message . "User name is empty". S-1, 3b1: The user didn't enter email. The system displays the message . "Email field is empty". S-1, 3c1: The user didn't enter password.		

The system displays the message . “Password is missing”.

S-1, 3d1: The user didn’t enter confirm password or confirm password does not match with password.

The system displays the message . “Password do not match”.

S-1, 3e1: The user enters incorrect format email.

The system displays the message . “Invalid Email”.

Login Use Case

Table 3.5.3 Login Use Case Description

Use Case Name: Login	ID: 3	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to login into the application		
Brief Description: This use case describes how user can login into the application.		
Trigger: User presses the LOGIN button. Type: External		
Relationships: Association: User Include: Manage Authentication use case Extend: Generalization:		
Normal Flow of Events: 1. The user enters login page 2. The user chooses which login method to enter the application. If the user wants to have authentication login. the S-1: Login subflow is performed If the user wants to login as a guest. the S-2: Login as Guest subflow is performed		
SubFlows: S-1: Login 1. The user enters the username and password. 2. The user clicks the 'Login' button 3. The system begins validating the user's username and password. 4. The user exists, entering the main page. S-2: Login as Guest 5. The user press 'Login as Guest' 6. The system navigates into main page.		
Alternate/Exceptional Flows : S1, 2a1: The user didn't enter email. The system displays the message . "Email field is empty" and intercept the login process S1, 2b1: The user didn't enter password. The system displays the message . "Password is missing" and intercept the login process S1, 2c1: The user enters incorrect format email. The system displays the message . "Invalid Email" and intercept the login process S1, 2d1: The user does not exist. The system displays the message . "The user not found" and intercept the login process		

View Building Info Use Case

Table 3.5.4: View Building Info Use Case Description

Use Case Name: View Building Info	ID: 4	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to view the detail introduction to historical building.		
Brief Description: This use case describes how the user can view the historical building information.		
Trigger: Users enter the main page. Type: External		
Relationships: Association: User Include: Extend: View Building List use case Generalization:		
Normal Flow of Events: 1. The user enters the main page 2. The system displays the state list. 3. The user selects one of the states under the list. 4. The system displays the available buildings under that list. 5. The user selects one of the buildings under the list. 6. Enter the page with the selected historical building information displayed.		
Alternate/Exceptional Flows : 3a1: The system displays empty when there isn't any building fall under that state.		

Add Review Use Case

Table 3.5.5: Add Review Use Case Description

Use Case Name: Add Review	ID: 5	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to express their feeling regarding the selected historical building.		
Brief Description: This use case describes how the user can review the historical building.		
Trigger: Users enter the main page. Type: External		
Relationships: Association: User Include: Extend: Generalization:		
Normal Flow of Events: 1. The user enters the building information page. 2. The system displays the information for historical building 3. The user scrolls to the bottom of the page. 4. The user finds the input field for the comment section. 5. The user enters the text and give the rating between 0 to 5 stars. 6. The user clicks the 'SUBMIT' button. 7. The system record down the user comment and rating, generate a new record under the review section. 8. Repeat step 3-7 until user don't want to create new review anymore.		
Alternate/Exceptional Flows : 5a1: The system replaces empty text to "No Comment" when user submit.		

Manage 3D Model Use Case

Table 3.5.6: Manage 3D Model Use Case Description

Use Case Name: Manage 3D Model	ID: 6	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to explore the AR functionality of the application.		
Brief Description: This use case describes how the interact with 3D model in AR mode.		
Trigger: User presses the AR Camera button. Type: External		
Relationships: Association: User Include: Change Model, Resize Model, Rotate Model, Take Picture, Relocate Model use case Extend: Generalization:		
Normal Flow of Events: 1. The user clicks the 'AR Camera' button. 2. The system loads the AR page. 3. The system display reminder panel. 4. The user clicks 'OK' to start the interaction with the page. 5. The system search for the plane to place 3d object. 6. The user touches the screen. 7. The system displays the 3D model on the detect plane. 8. If the user wants to perform scaling function. Execute Resize Model use case. If the user wants to perform rotating function. Execute Rotate Model use case. If the user wants to change the display model. Execute Change Model use case. If the user wants to capture the picture of 3D model in AR mode. Execute Take Picture use case. If the user wants to relocate the model in another place Execute Relocate Model use case. 9. The user click 'Remove' button to remove the model from screen. 10. Repeat step 6-9 for AR environment interaction.		
Alternate/Exceptional Flows : 8a1: The system can't find the 3D Model for the corresponding historical building, nothing will be displayed.		

Take Picture Use Case

Table 3.5.7: Take Picture Use Case Description

Use Case Name: Take Picture	ID: 7	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to capture the image of 3D model blended with the real time environment		
Brief Description: This use case describes what user can do after capture the image.		
Trigger: User presses the Camera icon. Type: External		
Relationships: Association: User Include: Social Media Sharing use case Extend: Generalization:		
Normal Flow of Events: 1. The user enters AR page. 2. The user clicks the Camera icon. 3. The system captures the image of 3D model blended with the mobile's camera. 4. The system displays the preview image of captured result. 5. The user chooses what he wants to do with the image. If the user wants to save the image. the S-1: Save subflow is performed If the user wants to discard the captured image. the S-2: Discard subflow is performed If the user wants to share the captured image to public. the S-3:Share subflow is performed 6. Repeat step 2-5 for AR environment interaction.		
SubFlows: S-1: Save 1. User clicks the Save icon 2. The system saves the image exit the preview mode. S-2: Discard 1. User clicks the Trash icon. 2. The system exits the preview mode without saving the image. S-3: Share subflow 1. User clicks the Share icon 2. The system exits the preview mode without saving the image. 3. The system display sharing bar for user to choose where they want to share the image. 4. Execute Social Media Sharing use case.		
Alternate/Exceptional Flows :		

Manage Map Use Case

Table 3.5.8: Manage Map Use Case Description

Use Case Name: Manage Map	ID: 8	Importance Level : High
Primary Actor: User	Use Case Type: Detail, Essential	
Stakeholders and Interests: User – want to check the historical building's location.		
Brief Description: This use case describes what user can do in searching for their desired historical building.		
Trigger: User enters the map page. Type: External		
Relationships: Association: User Include: Scroll and Resize, View Building Coordinate use case. Extend: Generalization:		
Normal Flow of Events: 1. The user enters map page. 2. The system loads the map and place the markers for mine and historical building's location. 3. The user chooses which method to search the desired historical building. If the user wants to search through manually the S-1: Manual Search subflow is performed. If the user wants to search through search bar. the S-2: Search Bar Search subflow is performed. 4. The user clicks on the historical building they found. 5. The system displays the summary info of the building and draw line from current location to there. 6. Repeat step 3-5 until user don't want to search for any historical building's location.		
SubFlows: S-1: Manual Search subflow 1. Users resize the map to locate the location of historical building. 2. Users enlarge the map and scroll to that historical building. S-2: Search Bar Search 1. User clicks the search bar. 2. User searches the historical building through input the building name. 3. System filters out the building name that match the search result. 4. User clicks the building name at the search bar. 5. System locates the historical building and navigate to that location.		
Alternate/Exceptional Flows : S-2, 3a1: The system display nothing if none of the historical building match the user input.		

3.5.5 Activity Diagram

Manage Authentication Activity Diagram

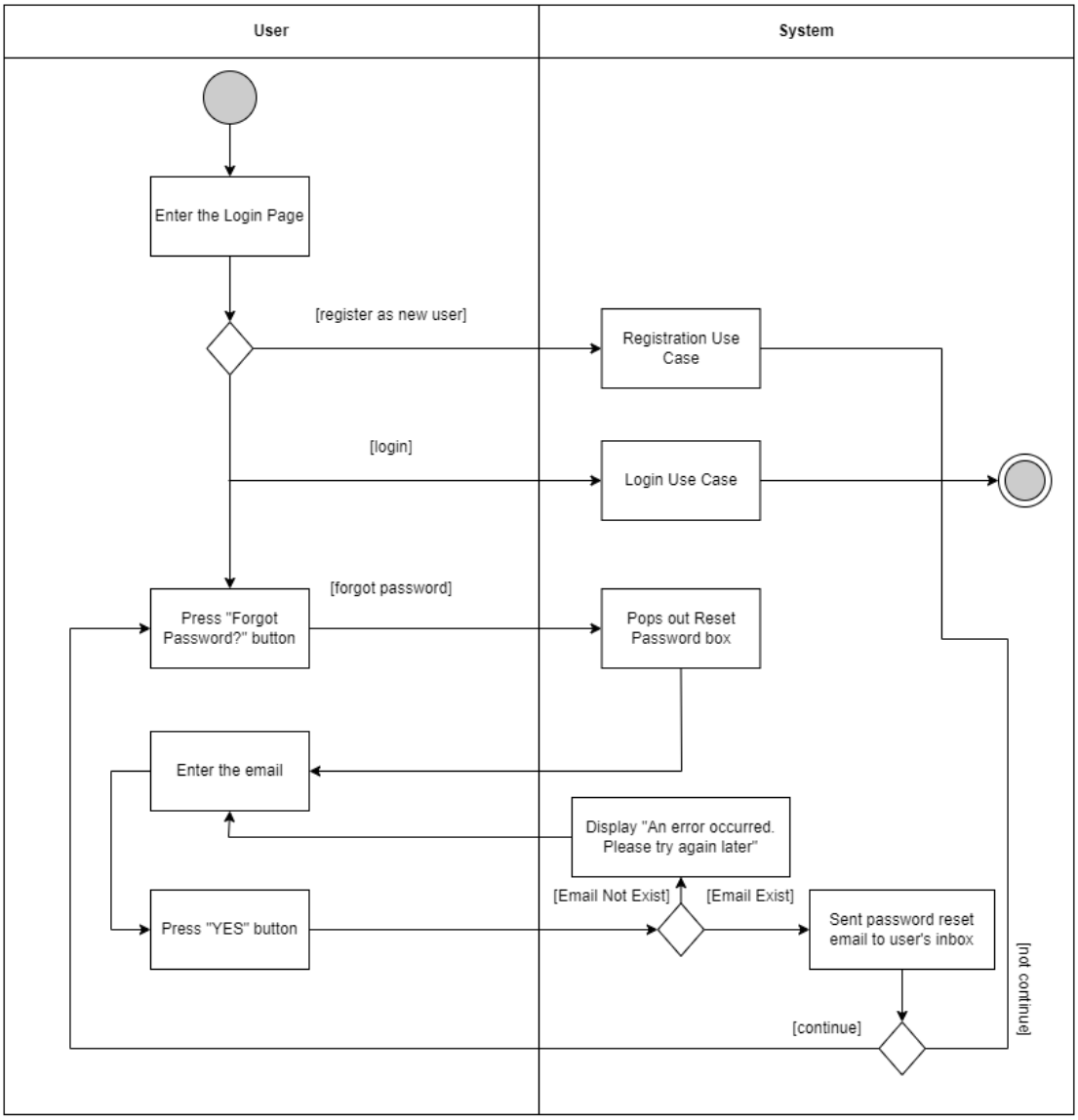


Figure 3.5.4: Manage Authentication Activity Diagram

Register Activity Diagram

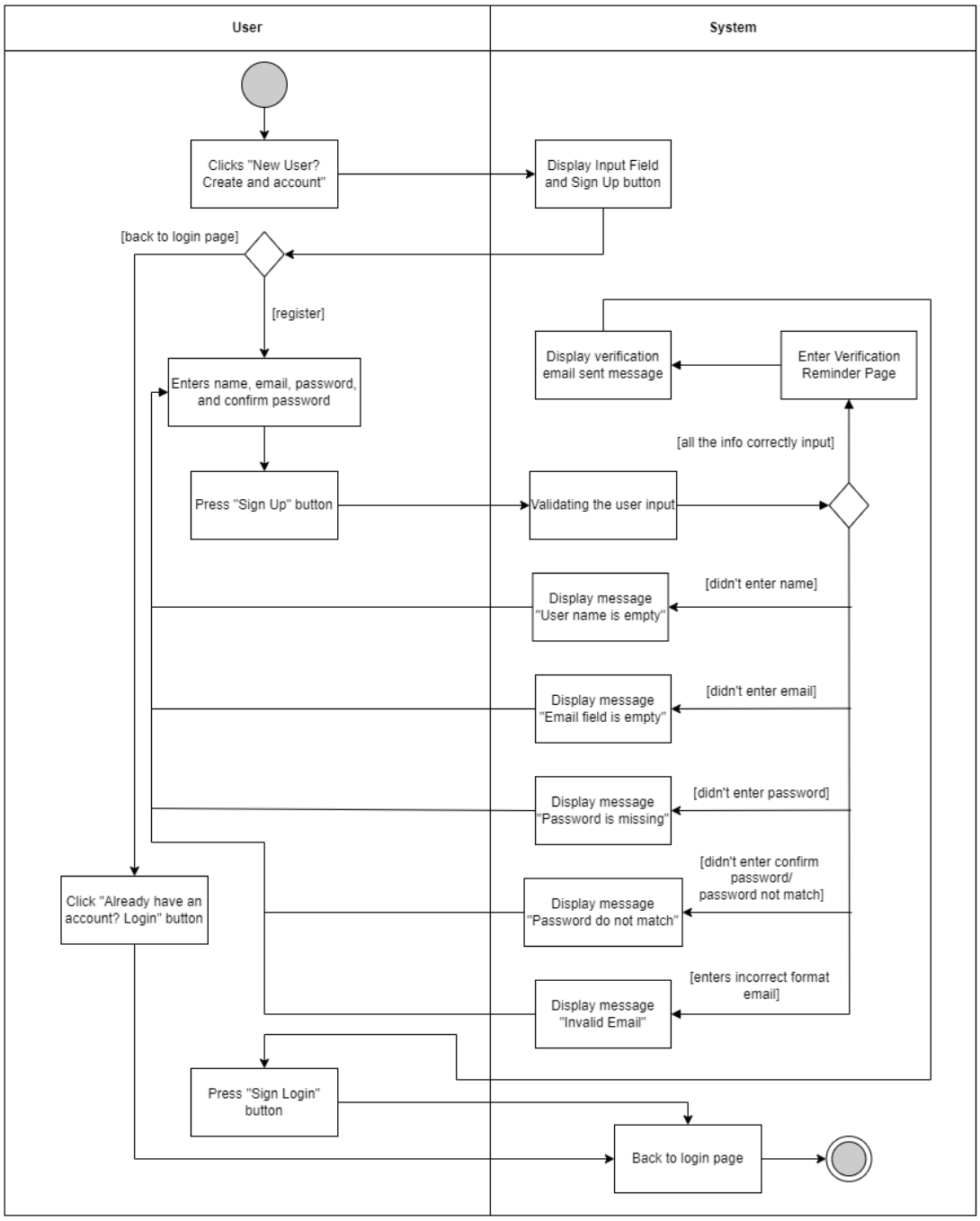


Figure 3.5.5: Register Activity Diagram

Login Activity Diagram

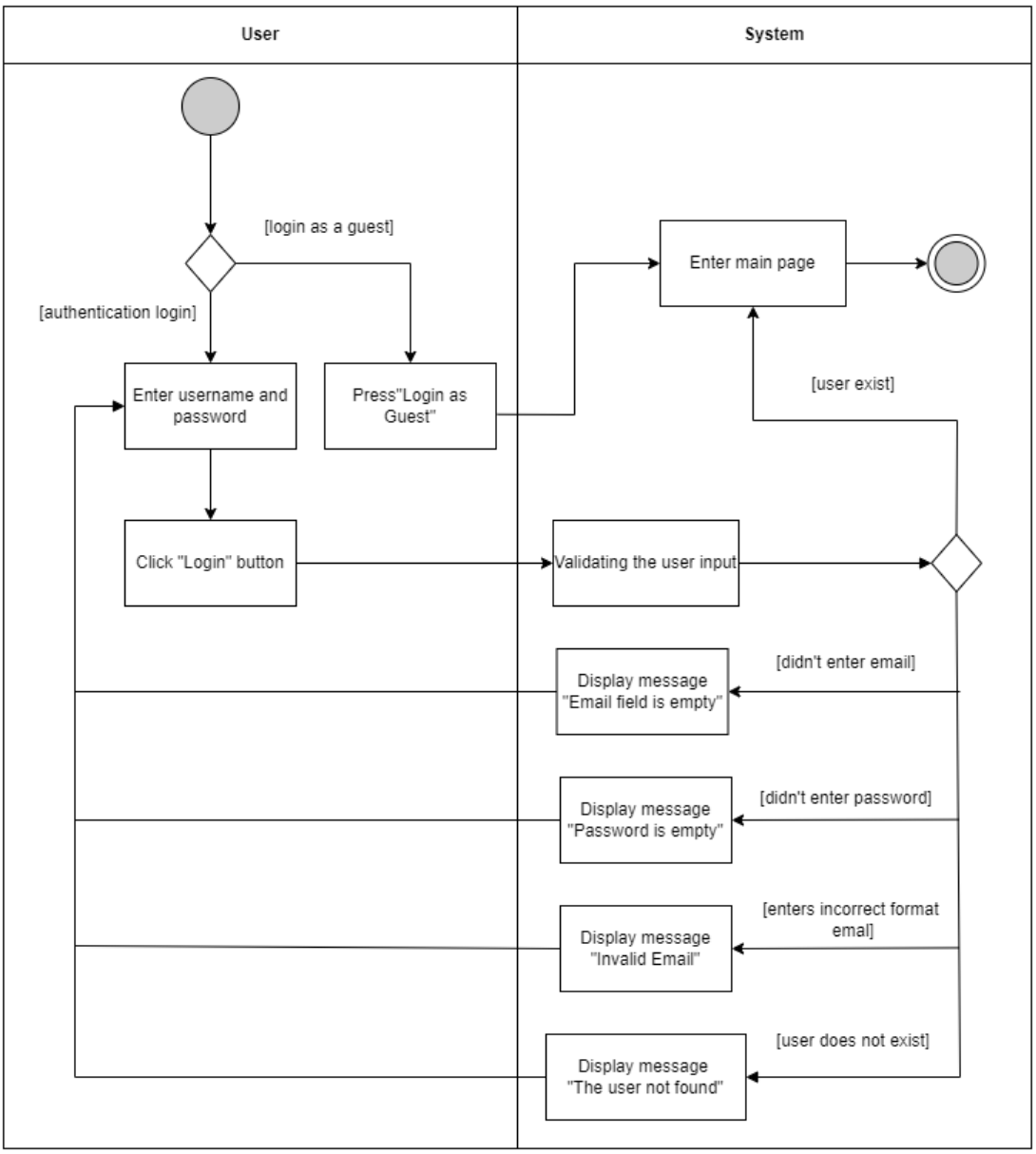


Figure 3.5.6: Login Activity Diagram

View Building Info Activity Diagram

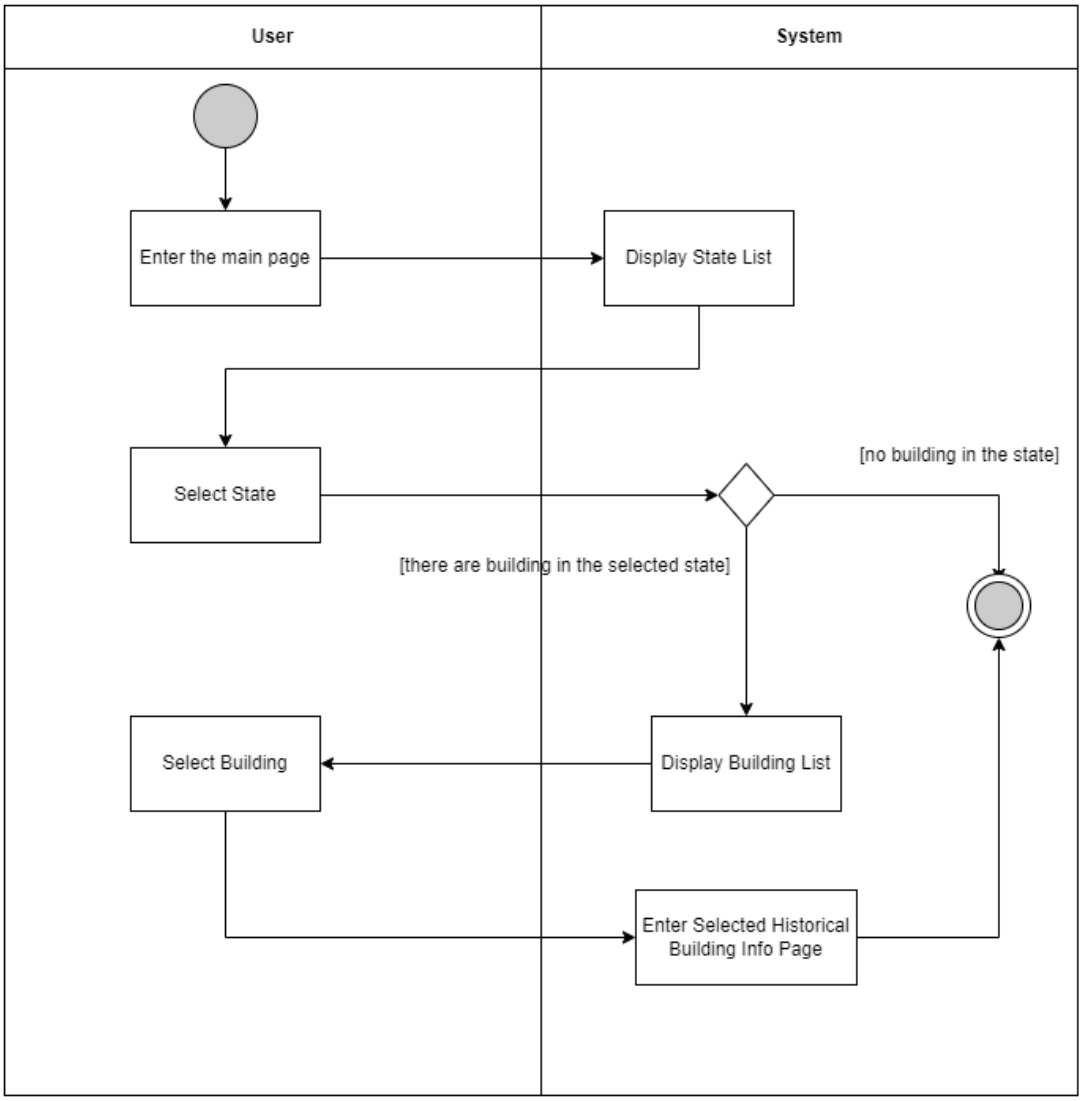


Figure 3.5.7: View Building Info Activity Diagram

Add Review Activity Diagram

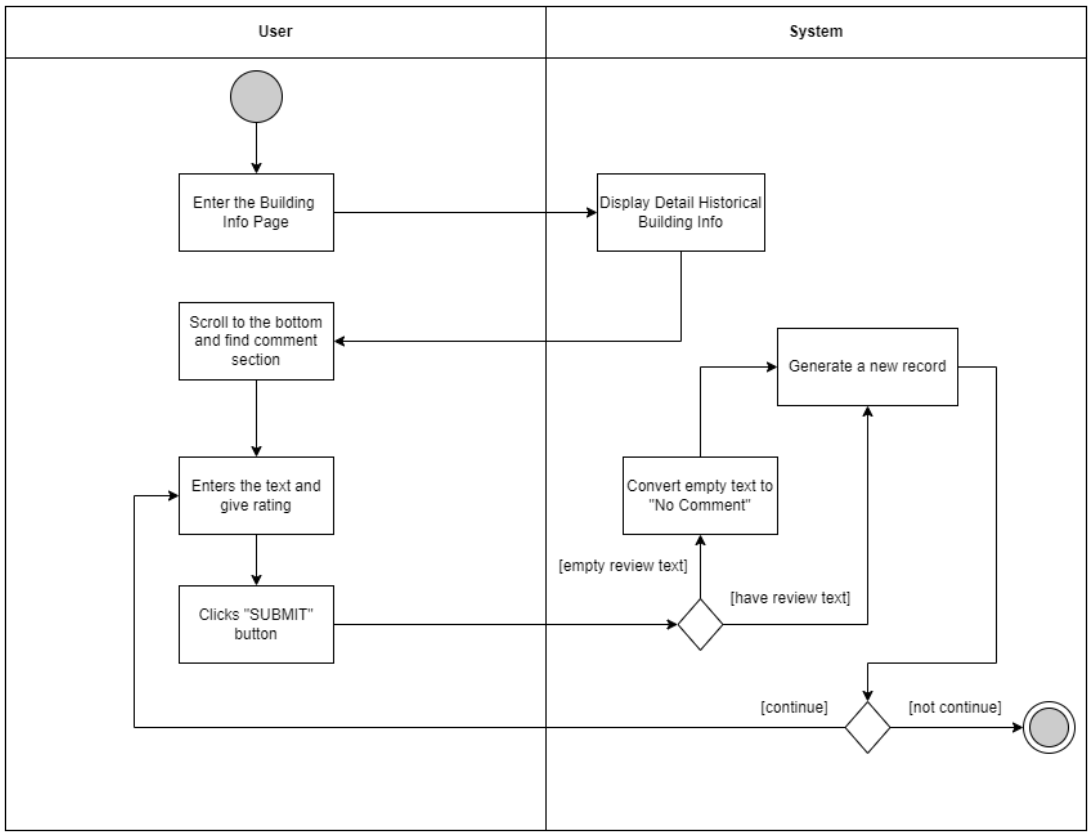


Figure 3.5.8: Add Review Activity Diagram

Manage 3D Model Activity Diagram

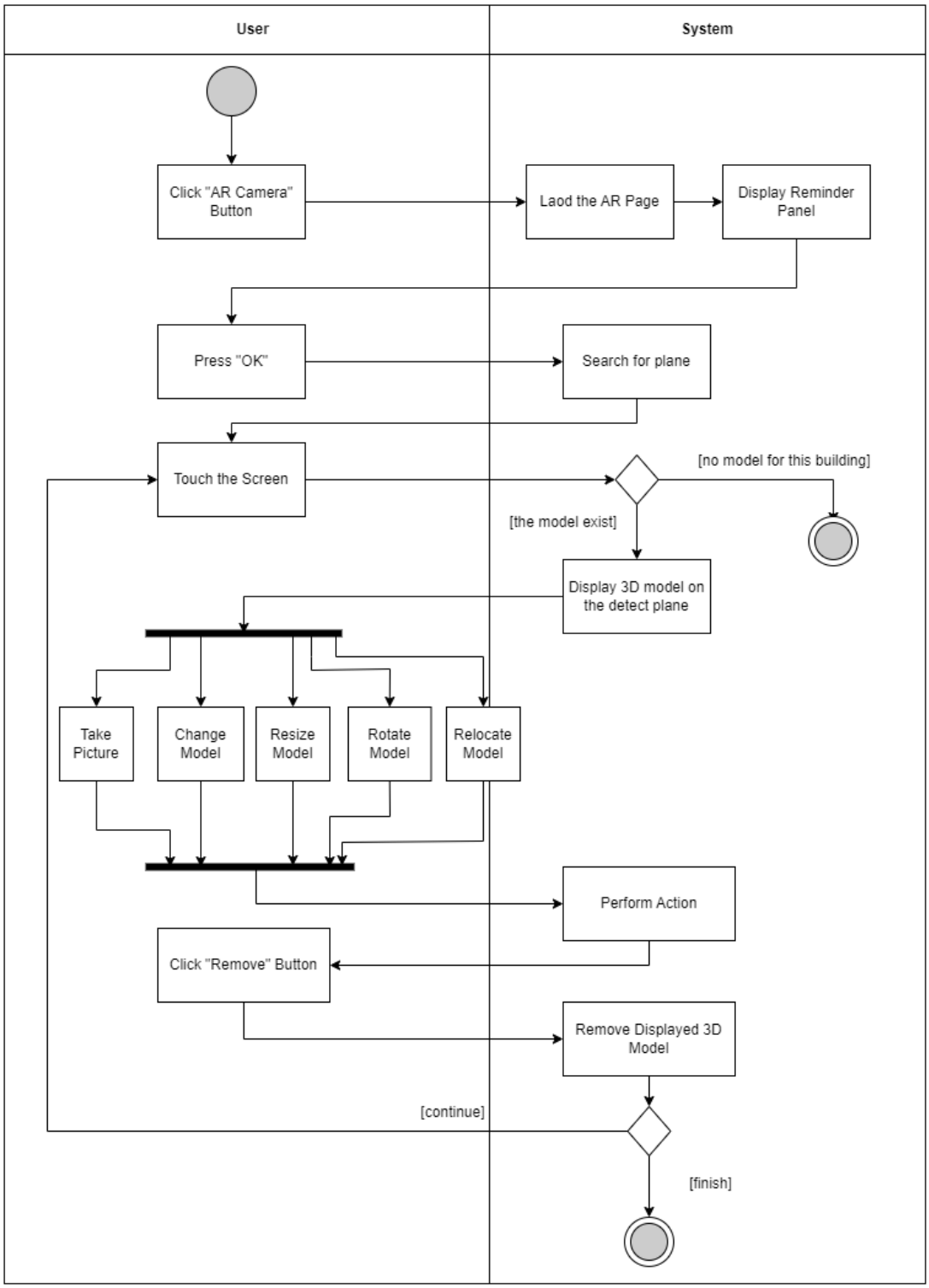


Figure 3.5.9: Manage 3D Model Activity Diagram

Take Picture Activity Diagram

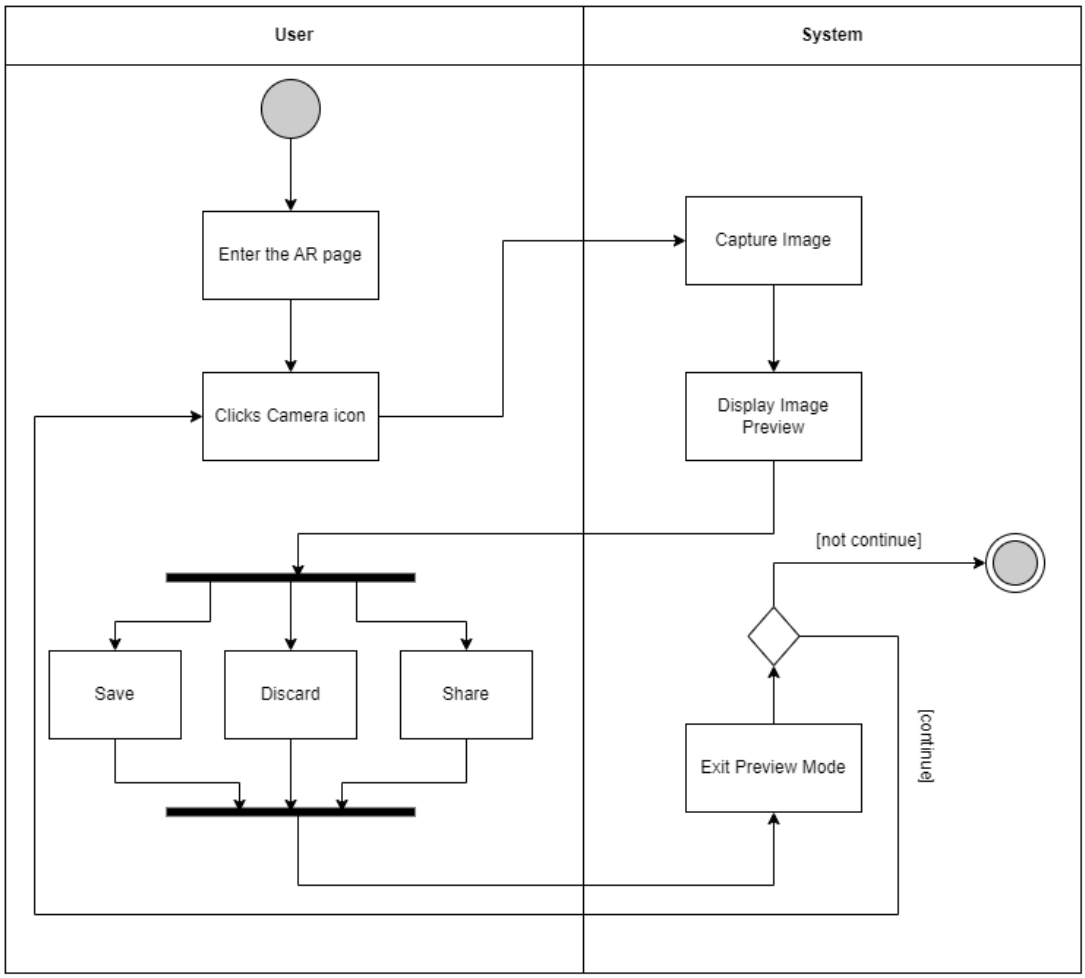


Figure 3.5.10: Take Picture Activity Diagram

Manage Map Activity Diagram

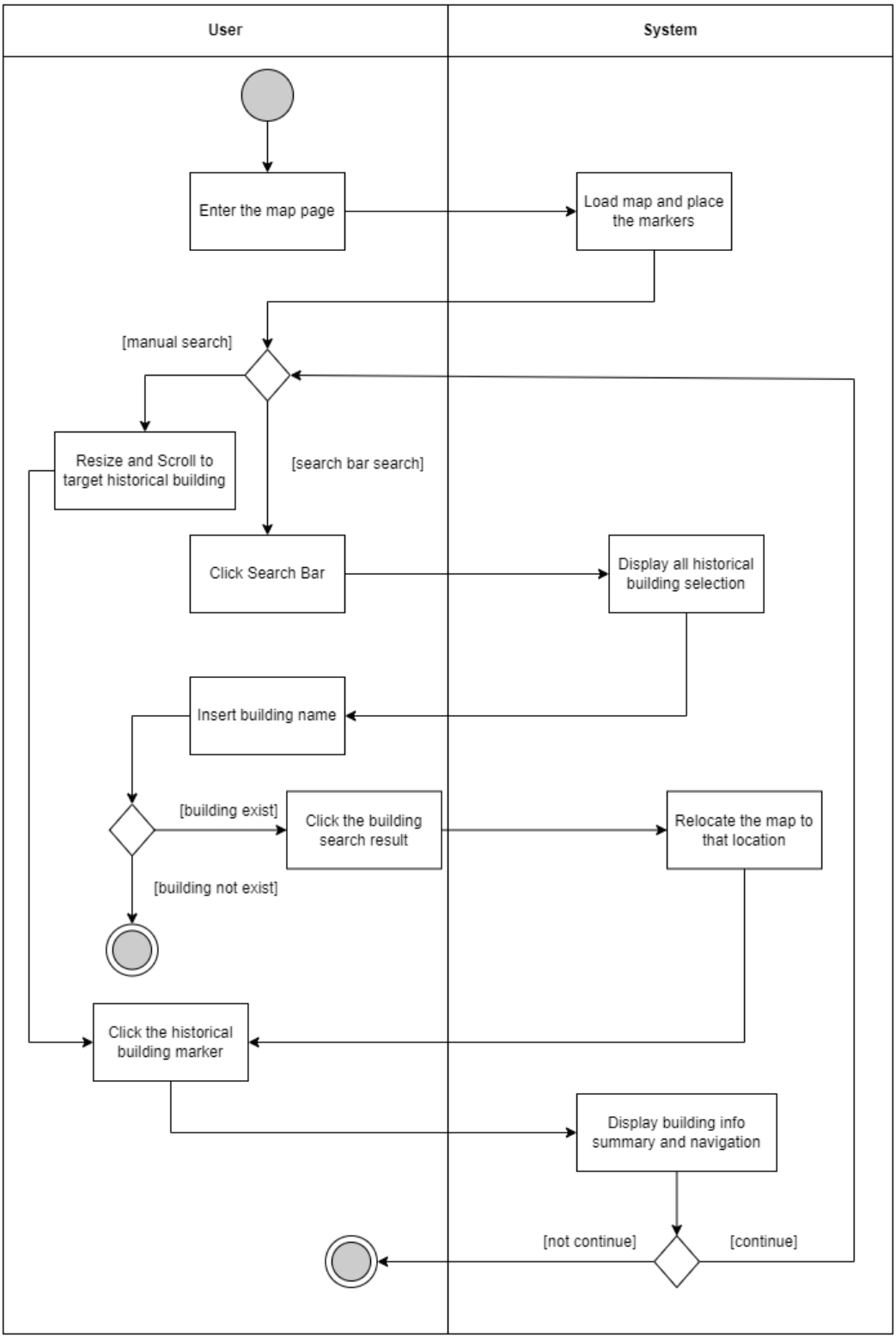


Figure 3.5.11: Manage Map Activity Diagram

3.6 Project Timeline

3.6.1 FYP 1 Timeline

Project 1 was started on 19th June 2023 and ended on 7th September 2023, with duration of 12 weeks. The first 6 weeks of the project focused on requirements definition and collection. The next 6 weeks of the project focused on developing the prototype for this project. Start from weeks 2, the process of report writing, and refinement is working simultaneously with the project development process. The report submitted on 7th September 2023.

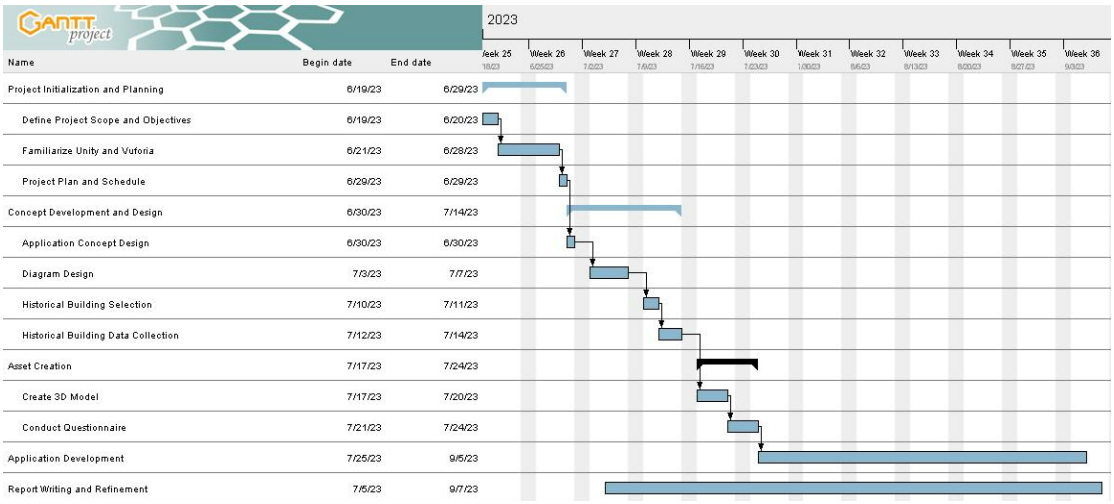


Figure 3.6.1: Timeline of FYP1

3.6.2 FYP2 Timeline

Project 2 was started on 29th February 2024 and ended on 26th April 2024, with duration of 13 weeks. The report submitted on 26th April 2024.

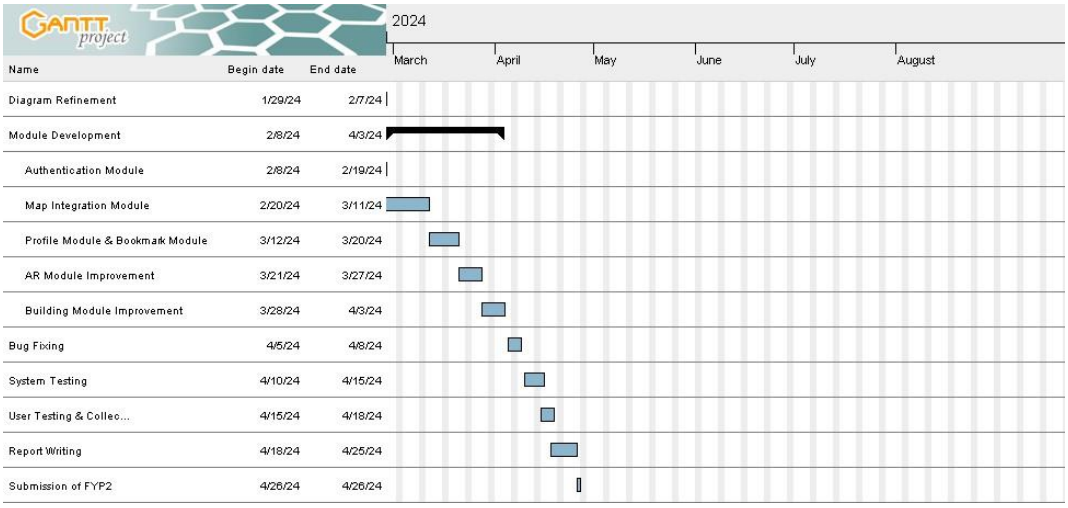


Figure 3.6.2: Timeline of FYP2

CHAPTER 4

System Design

4.1 System Design

4.1.1 System Block Diagram

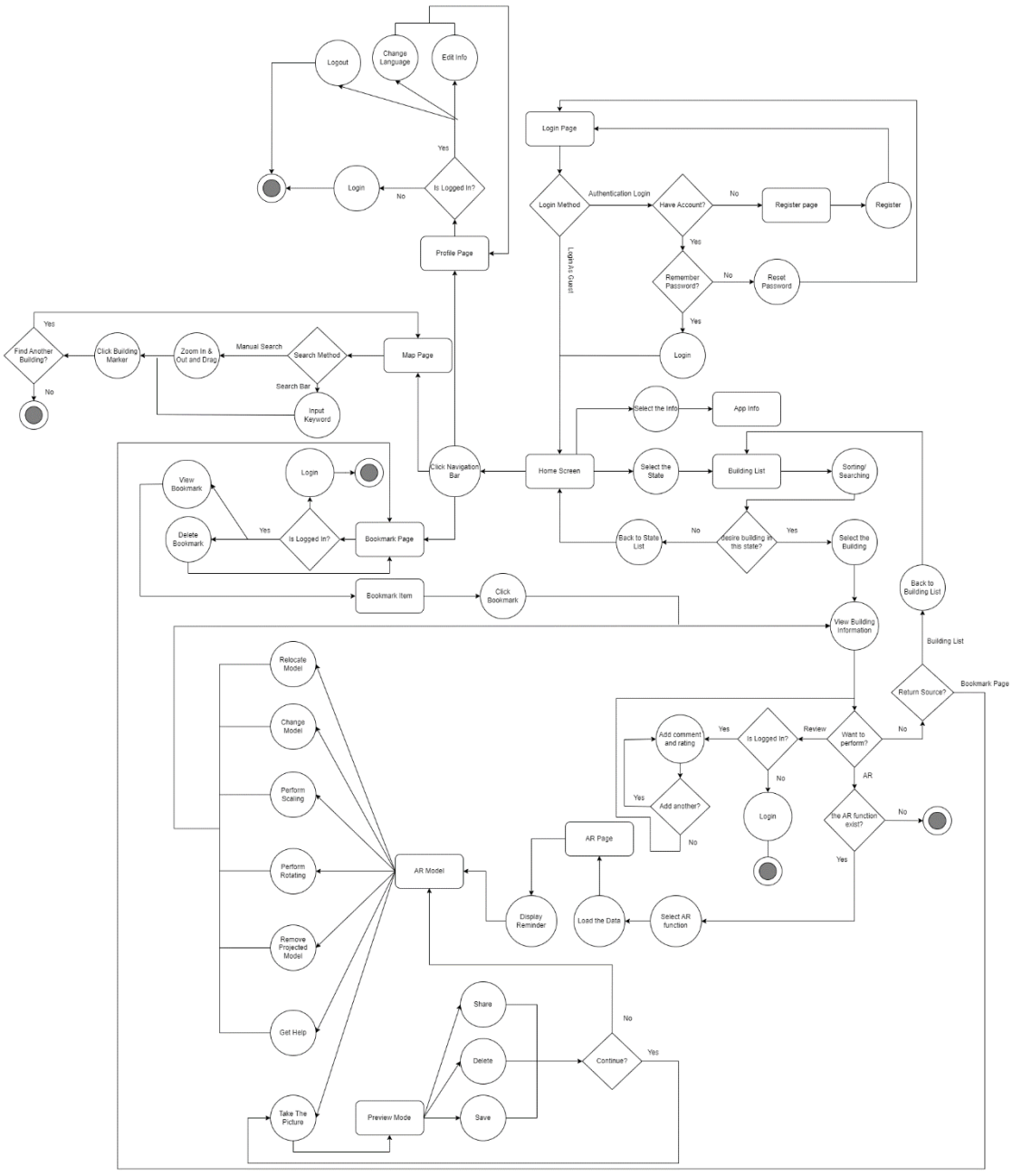


Figure 4.1.1: User Flow of HB Application

Figure 4.1.1 illustrates the user flow for the entire project, shows the sequence of steps from the login page to various subpage within the application.

The flow begins with the login page, where users have the option to either create an account or enter as a guest. If users choose authentication, they can start from registration if they do not have an existing account. After authentication, users enter the main page, which features a hierarchical structure for selecting historical buildings. This involves selecting a state and then choosing a specific historical building to display. Once a building is selected, users can access detailed information including background information, ratings, comments, and more. The user can choose to add a new comment or proceed to the AR page for an immersive experience with historical building models, seamlessly navigating to the AR module which offers various functionality to enhance exploration. From the main page, users can also navigate to other pages such as the bookmark page, map page, and profile page. The bookmark page provides direct access to favorite historical buildings, while the map page allows graphical searching of historical building locations for better understanding. Lastly, the profile page enables users to modify personal information and preferences. The overall design incorporates a smooth navigation design with the options to navigate back and forth between the pages.

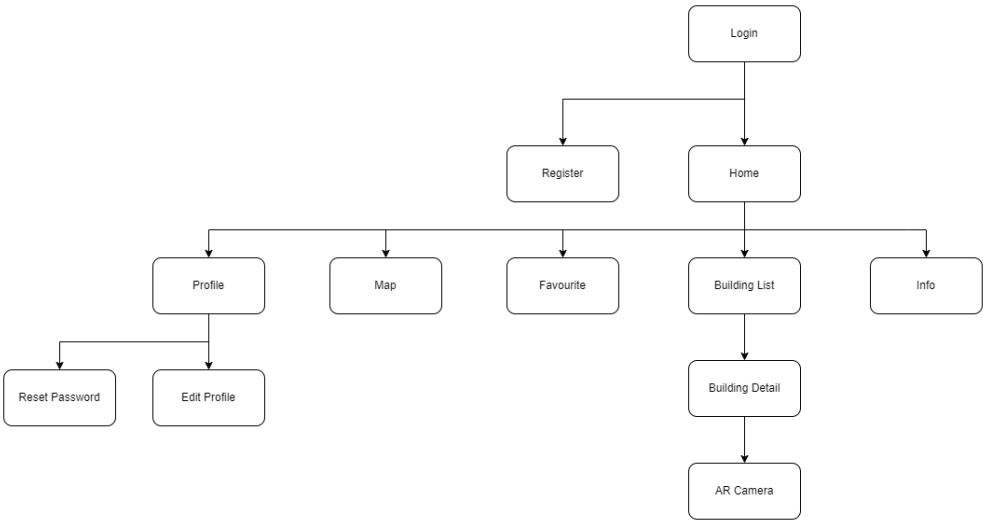


Figure 4.1.2:Site Map of HB Application

Figure 4.1.2 shows the overall navigation of HB Application through site map. From the login page, user can access to register and home page. Then, user can get a directly access to info page, building list from home page. And the navigation bar provides the navigation across main page, favorite page, map page, and profile page.

4.1.2 Storyboard

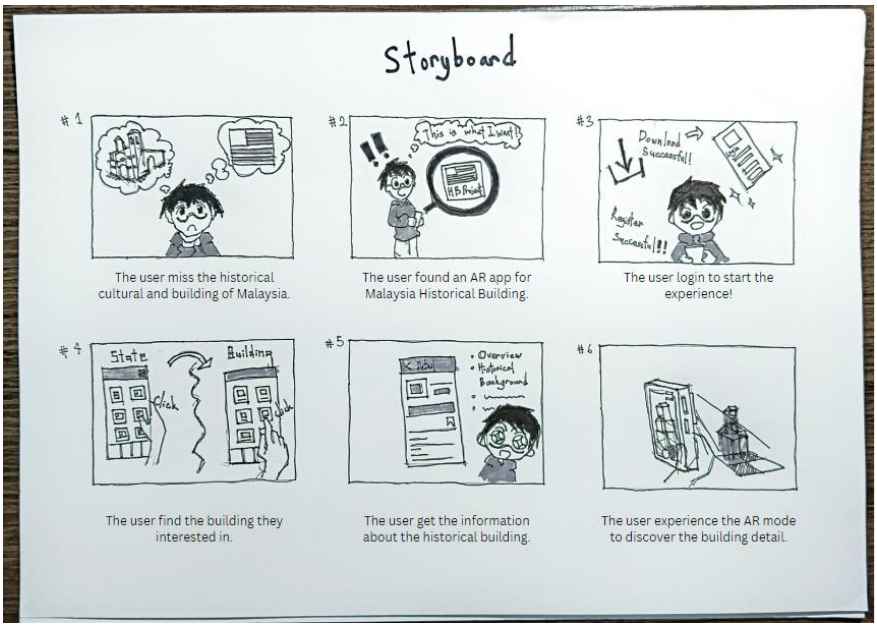


Figure 4.1.3: Storyboard Part I of HB Application

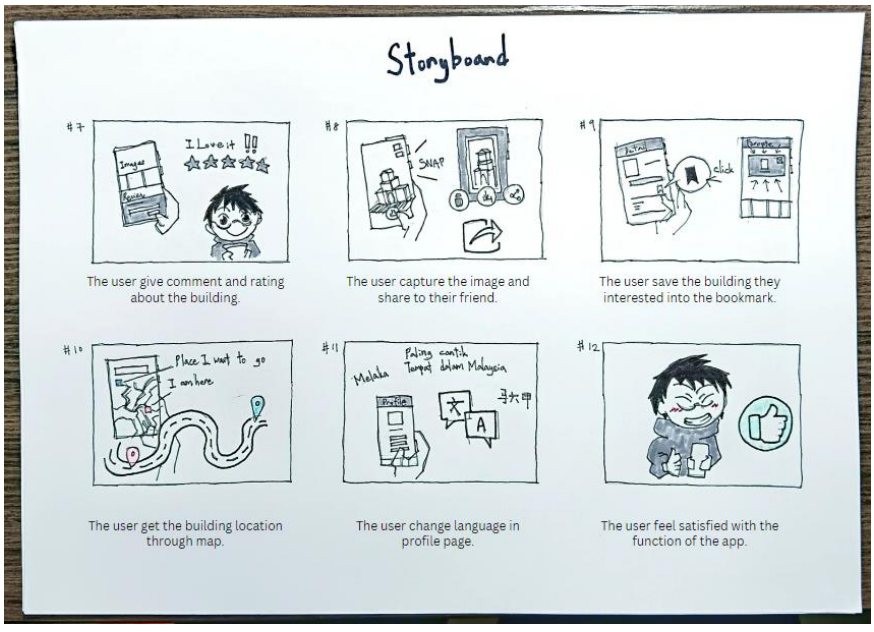


Figure 4.1.4: Storyboard Part II of HB Application

In Part I (Figure 4.1.3) of the storyboard, the user finds themselves unable to physically visit Malaysia's historical buildings due to being in a remote location or facing other inconveniences. They express a desire to experience these buildings in some way. Throughout the process from Part I to Part II (Figure 4.1.4), the user able to utilize the application we developed to solve the problem. Overall, the storyboard demonstrates how the application addresses the user's need to experience Malaysia's historical buildings remotely or in situations where physical visits are note feasible.

4.1.3 Wireframes

Login UI

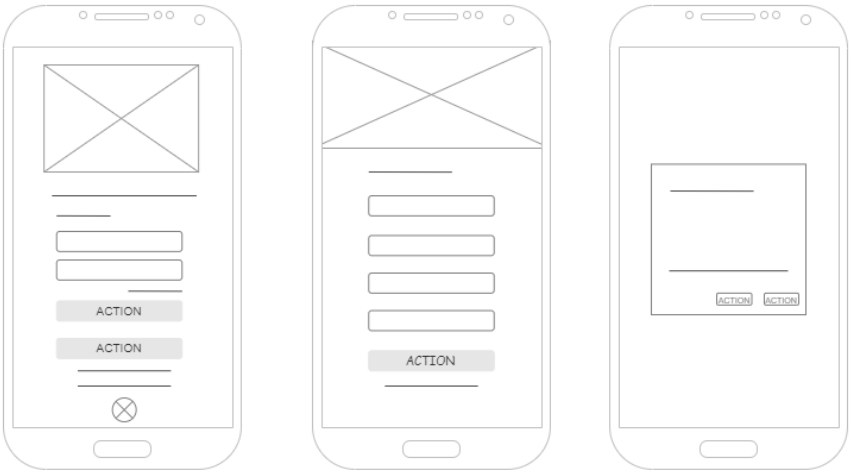


Figure 4.1.5: Login Page , Registration Page, Reset Password

Building UI

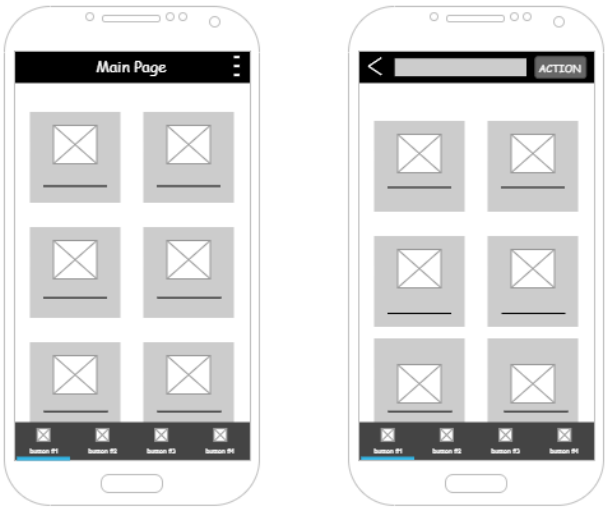


Figure 4.1.6: State List Page (Main Page), Building List Page

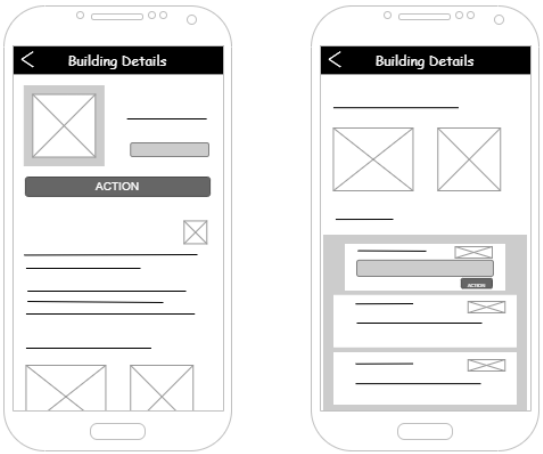


Figure 4.1.7: Building Detail Page

Info UI

Figure 4.1.8: Info Page

AR UI

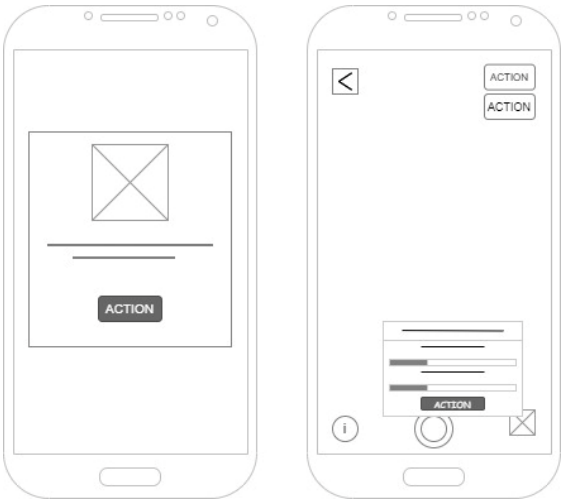


Figure .4.1.9: Reminder Page, AR Page (model interaction button)

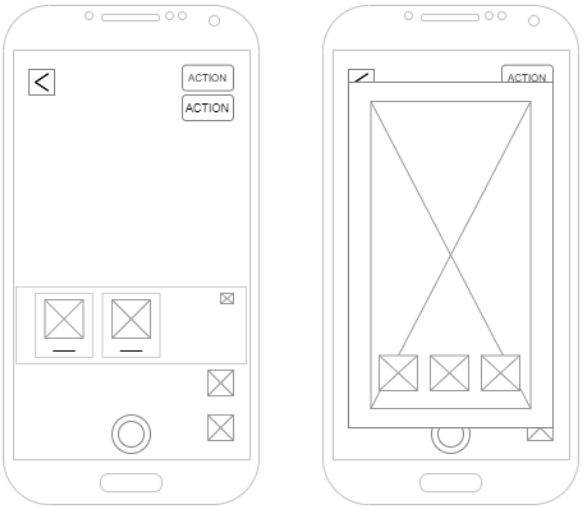


Figure 4.1.10 AR Page (building selection button), Image Capture Page

Favorite UI

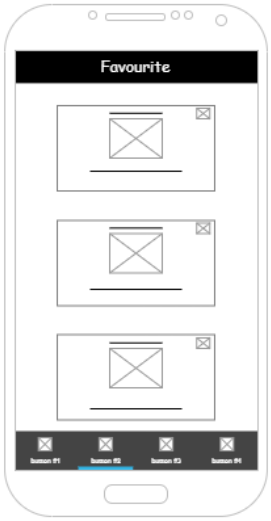


Figure 4.1.11: Favorite Page

Map UI

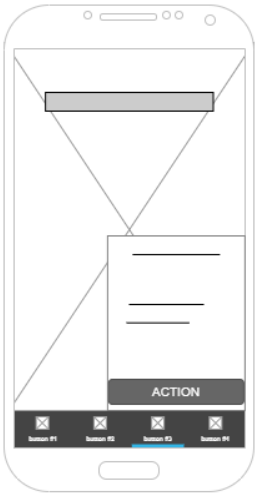


Figure 4.1.12: Map Page

Profile UI

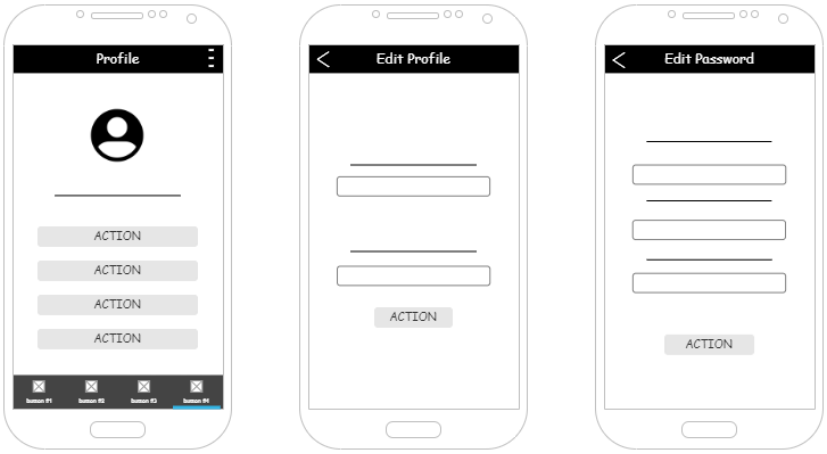


Figure 4.1.13: Profile Page, Edit Profile Page, Edit Password Page

4.1.4 Prototype low fidelity

The prototype low fidelity provides a better picture of the overall basic design of the application and illustrates the navigation to perform a seamless communication between different UI elements.

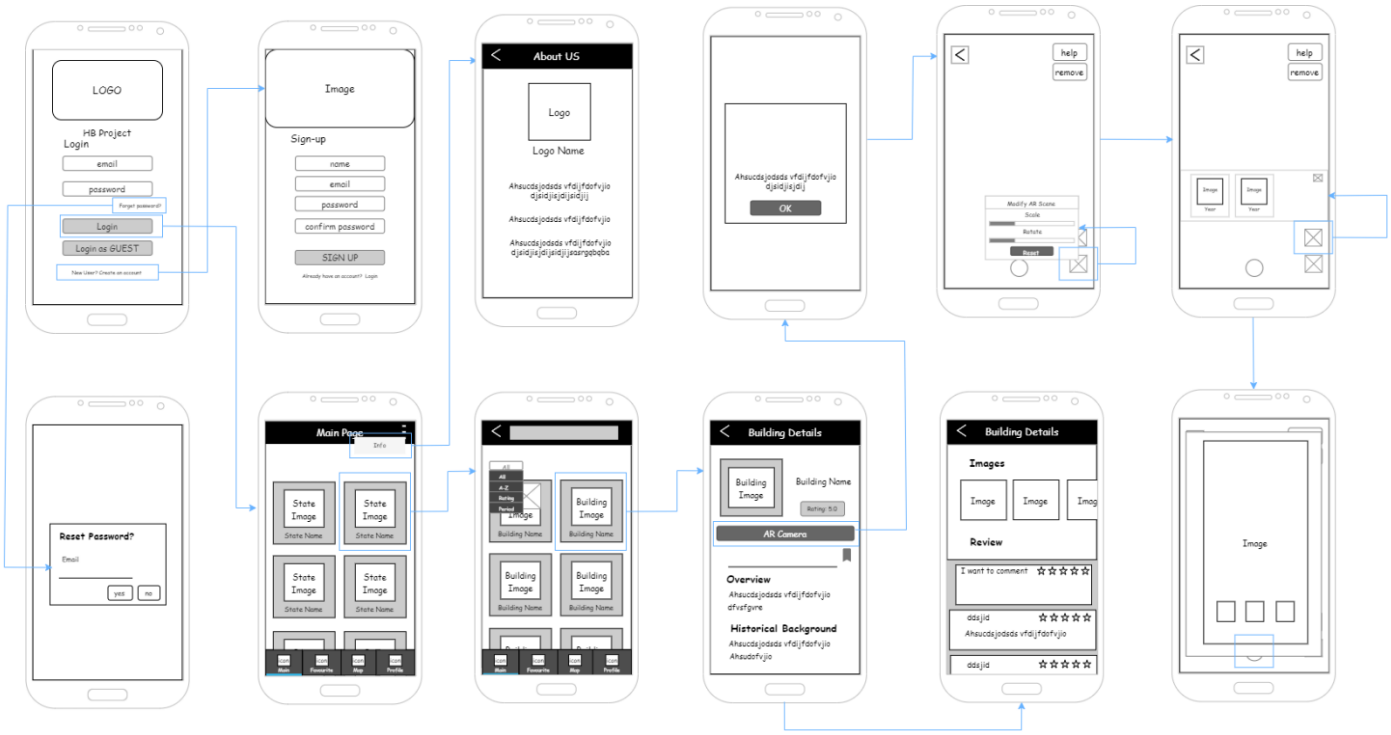


Figure 4.1.14: Prototype low fidelity of HB project I

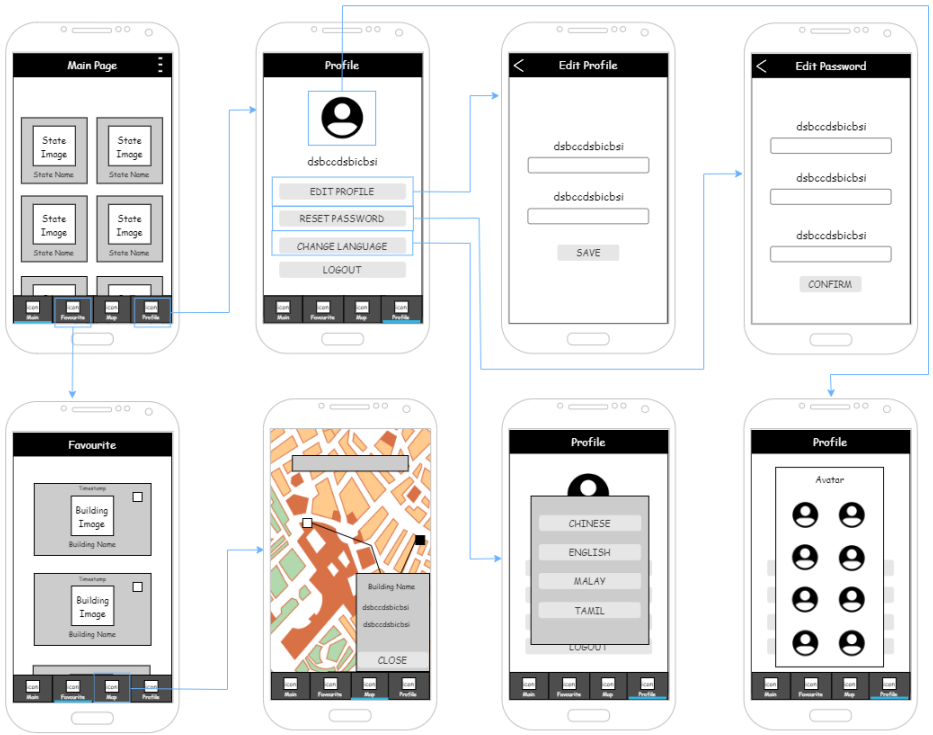


Figure 4.1.15: Prototype low fidelity of HB project II

4.2 System Modules Specifications

4.2.1 Authentication Module

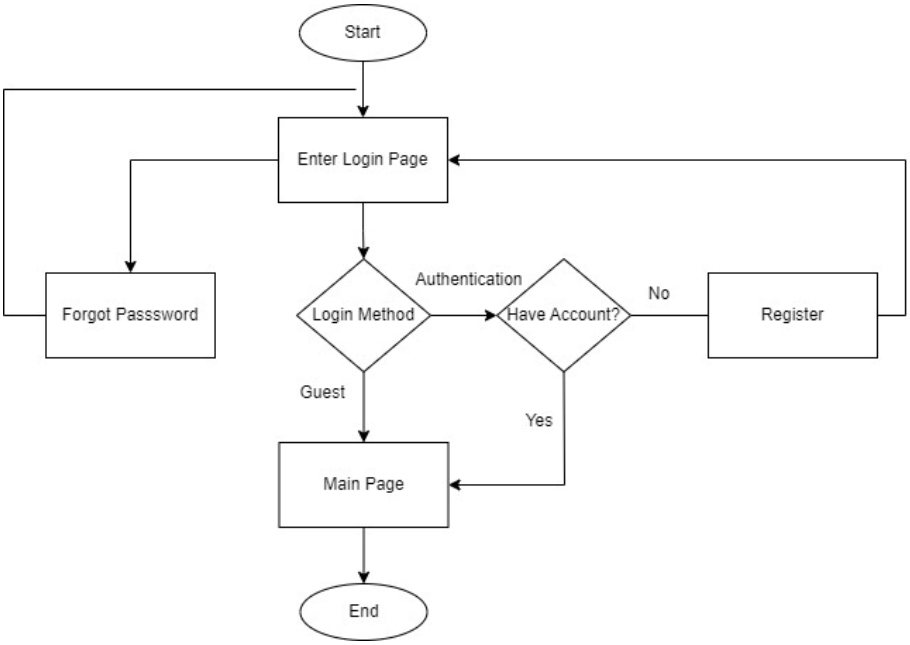


Figure 4.2.1: Flowchart of Authentication Module

In Figure 4.2.1, the flowchart shows the process included in the authentication module of our application, which offers two login methods: guest mode or authentication login. The user will be navigated to the login after launching the application where they can perform several actions such as logging in, registering for an account, or initiating a password reset if they've forgotten their password. In the case of guest login, users can immediately access the application but won't be able to experience the personalized experience provided to the authentication user. However, for authentication login, users must first create an account by clicking "New User? Create an account" and providing the required information for registration. If a user forgets their password, they can initiate the password reset process by clicking "Forgot password?" and entering the email address that will receive the password reset email. When user either have login in either guest or authenticated user, the application will keep the user in login status, so they won't have to go through the login page every time. Our application currently only supports one role, which is the user role.

```
if (name == "")
{
    nameErrorText.text = "User Name is empty";
    nameErrorText.gameObject.SetActive(true);
    yield break;
}
else if (email == "")
{
    emailErrorText.text = "Email field is empty";
    emailErrorText.gameObject.SetActive(true);
    yield break;
}
else if (password == "")
{
    passwordErrorText.text = "Password is empty";
    passwordErrorText.gameObject.SetActive(true);
    yield break;
}
else if (confirmPassword == "")
{
    confirmPasswordErrorText.text = "Confirm Password is empty";
    confirmPasswordErrorText.gameObject.SetActive(true);
    yield break;
}
else if (password != confirmPassword)
{
    passwordErrorText.text = "Passwords do not match";
    confirmPasswordErrorText.text = "Passwords do not match";
    passwordErrorText.gameObject.SetActive(true);
    confirmPasswordErrorText.gameObject.SetActive(true);
    yield break;
}
else
{
    var registerTask = auth.CreateUserWithEmailAndPasswordAsync(email, password);

    yield return new WaitUntil(() => registerTask.IsCompleted);
```

Figure 4.2.2: Registration Function

The code snippet in Figure 4.2.2 is responsible for validating user input during the registration process to ensure that the required information, including username, email address, and password, is provided accurately. To ensure consistency and accuracy in sensitive password, it includes a check for confirming the password and confirm password.

```
public void AddUserToDatabase(string name, string email)
{
    try
    {
        if (databaseReference == null)
        {
            Debug.LogError("Database reference is not initialized.");
            return;
        }

        UserEntity newUserEntity = new UserEntity(email, user.UserId, "7", name, "1");
        string json = JsonUtility.ToJson(newUserEntity);

        databaseReference.Child("USER").Child(user.UserId).SetRawJsonValueAsync(json)
            .ContinueWith(task =>
            {
                if (task.IsFaulted)
                {
                    Debug.LogError($"Failed to create new record: {task.Exception}");
                }
                else
                {
                    Debug.Log("New record created successfully");
                }
            });
        Debug.Log("User added to database successfully.");
    }
```

Figure 4.2.3: User Record Creation Function

A new record of user will be created in the Realtime Database during the creation of new firebase authentication, this help to ensure the consistency of user authentication in Firebase's authentication with other user info such as profile picture, user type, and so on.

```
private IEnumerator SendEmailForVerificationAsync()
{
    if (user != null)
    {
        var sendEmailTask = user.SendEmailVerificationAsync();

        yield return new WaitUntil(() => sendEmailTask.IsCompleted);
```

Figure 4.2.4: Email Verification Function

The verification process will conduct through email verification. Once all the information is correct, a verification email will be sent to the user to complete registration.

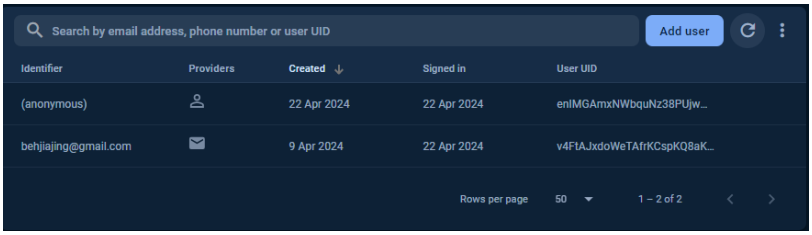


Figure 4.2.5: Firebase Authentication

Successful authentication creation will be recorded in the firebase authentication.

```
{
    // If no errors, continue with successful login process
    user = auth.CurrentUser;

    if (user.IsEmailVerified)
    {
        Debug.LogFormat("{0} You Are Successfully Logged In", user.DisplayName);
        References.userName = user.DisplayName;
        References.userUID = user.UserId;

        SetLoginMethod(LoginMethod.CurrentUser);
        UnityEngine.SceneManagement.SceneManager.LoadScene("mainUI");
    }
    else
    {
        Debug.LogFormat("{0} Please verify your email", user.DisplayName);
        SendEmailForVerification();
    }
}
```

Figure 4.2.6: Authentication Login Function

During the authentication login process, similar checks are performed on the email address and password correctness. If the user successfully logs in, the username and user ID are stored to enable references across different scenes within the application (Figure 4.2.6). Then, the application will load into the main page.

```
1 Reference
private IEnumerator AnonymousLoginAsync()
{
    var anonymousLoginTask = auth.SignInAnonymouslyAsync();

    yield return new WaitUntil(() => anonymousLoginTask.IsCompleted);

    if (anonymousLoginTask.Exception != null)
    {
        // Handle anonymous authentication errors
        Debug.LogError(anonymousLoginTask.Exception);
    }
    else
    {
        // Anonymous login successful
        user = auth.CurrentUser;
        References.userName = "Guest";

        Debug.Log("Anonymous login successful");

        SetLoginMethod(LoginMethod.Anonymous);
        UnityEngine.SceneManagement.SceneManager.LoadScene("mainUI");
    }
}
```

Figure 4.2.7: Anonymous Login Function

Login as Guest will be login in with the anonymous user. The username and login method will be set up for the references across different scenes. Then, the application will load into the main page.

```
private void AutoLogin()
{
    if (!dependenciesChecked)
    {
        Debug.LogWarning("Dependencies check is still running. Skipping auto-login.");
        return;
    }

    if (user != null && (user.IsEmailVerified || user.IsAnonymous))
    {
        if (user.IsEmailVerified || user.IsAnonymous)
        {
            References.userName = user.DisplayName;
            References.userUID = user.UserId;
            UnityEngine.SceneManagement.SceneManager.LoadScene("mainUI");
        }
        else
        {
            SendEmailForVerification();
        }
    }
```

Figure 4.2.8: Auto Login Function

When the application launches, it will check if there is a user already authenticated, through email/password, anonymous login. If there is an authenticated user, the application can proceed with that user's session without requiring them to log in again. At the same time, the application will retrieve the latest user information from Firebase Authentication when detecting authenticated user. Then, the application will load into the main page.

```
public void ResetPassword()
{
    string email = resetPasswordField.text;

    TextMeshProUGUI errorText = loginUIManager.instance.resetPasswordPanel.transform.Find("background").Find("Err
    errorText.text = "";

    auth.SendPasswordResetEmailAsync(email).ContinueWithOnMainThread(task =>
    {
        if (task.IsCanceled)
        {
            Debug.LogError("Password reset email was cancelled");
            return;
        }

        if (task.IsFaulted)
        {
            errorText.text = "An error occurred. Please try again later.";
            errorText.gameObject.SetActive(true);

            Debug.LogError("Password reset email encountered an error: " + task.Exception);
            return;
        }

        loginUIManager.instance.ShowVerificationResponse(true, resetPasswordField.text, null, "resetPassword");
```

Figure 4.2.9: Forgot Password Function

In figure 4.2.9, will check if the email user input if it is valid, then only send a password reset email to their inbox for further procedure in completing the password reset.

4.2.2 Building Module

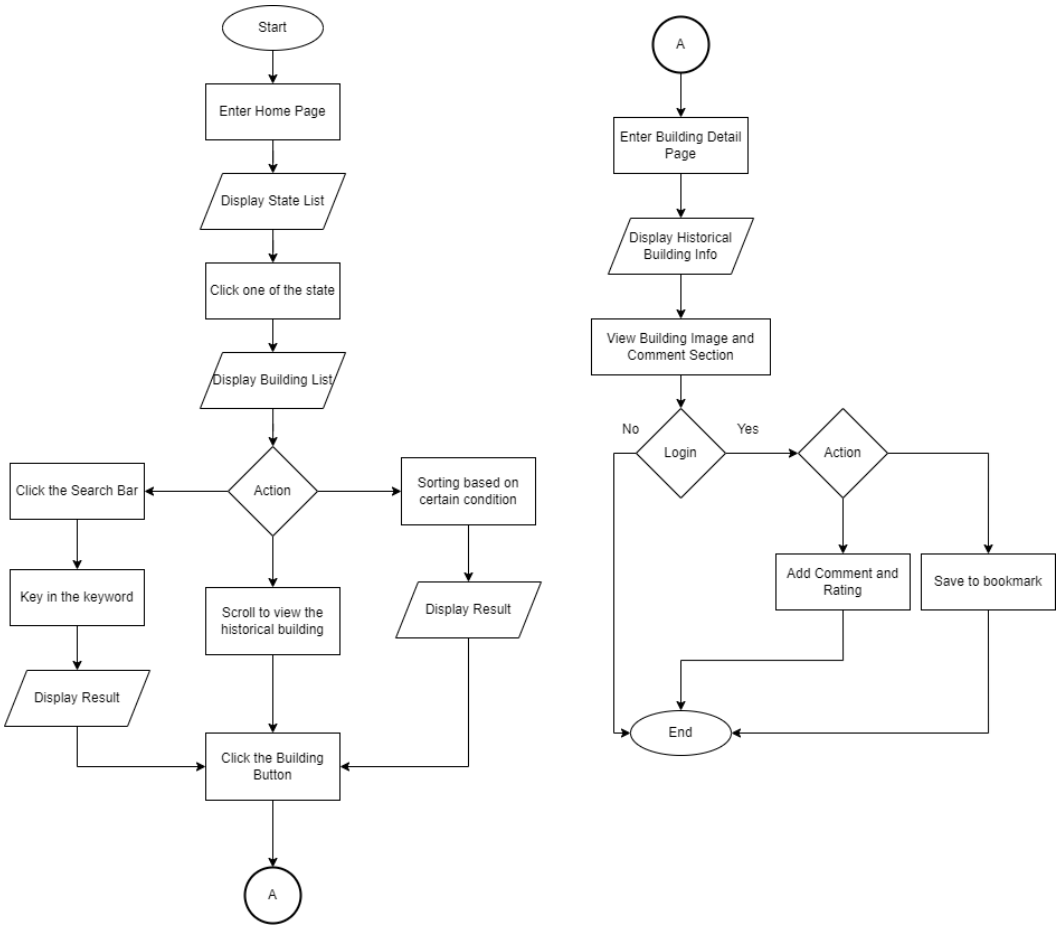


Figure 4.2.10: Flowchart of Building Module

Figure 4.2.10 shows the flowchart for the building module, which covers the process from main page to the building info page. After the user completes the authentication process, they are directed to the main page. Here, all the states in Malaysia are loaded and displayed on the screen, allowing users to search for historical buildings in their desired state. Different search methods are provided to offer flexibility in obtaining results, including searching by name, using the search bar, and sorting options. Upon selecting a specific building, the user is directed to the building info page where the detail of it will be listed out. User can then view the details such as the address, construction period, background information, and more. In addition to historical information, users can also access past images of the building, view comments and rating provided by other users. If they want, user can contribute their own reviews, to share their experiences and feelings to the community in fostering the engagement with the historical buildings featured in the application.

```
2 references
public void onStateButtonClick(string stateName)
{

    // Hide the state panel and show the building panel
    statePanel.SetActive(false);
    returnButton.SetActive(true);
    buildingPanel.SetActive(true);

    // Filter buildings for the selected state
    buildingsInState = buildingList.FindAll(building => building.state.Equals(stateName));
    filteredBuildings.AddRange(buildingsInState);
    generateBuildingButtons(buildingsInState);
}
```

Figure 4.2.11: State Button Click Function

In Figure 4.2.11, the function attached to every state button after retrieval is designed to respond to user interaction. When a user clicks on a state button, the function filters out buildings associated with the selected state and generates buttons accordingly.

```
1 reference
public void onBuildingButtonClick(string buildingID, string scene)
{
    // Get the selected building
    BuildingEntity building = buildingsInState.FirstOrDefault(b => b.buildingID.Equals(buildingID));

    string buildingJson = JsonUtility.ToJson(building);

    // Store to PlayerPrefs
    PlayerPrefs.SetString("currentBuilding", buildingJson);
    PlayerPrefs.SetString("previousScene", scene);
    SceneManager.LoadScene("buildingInfoUI");
}
```

Figure 4.2.12: Building Button Click Function

Similarly, in Figure 4.2.12, each button generated for buildings within a state performs a similar function. When a user selects a building button, the function filters the buildings based on the selected state and directs the user to the building info page for detailed information about the selected building.

```
0 references
public void Search()
{
    string searchText = searchBar.GetComponent<TMP_InputField>().text.ToLower();

    if (!string.IsNullOrEmpty(searchText))
    {
        searchBar.transform.Find("close button").gameObject.SetActive(true);

        filteredBuildings.Clear();

        foreach (BuildingEntity building in buildingsInState)
        {
            if (building.buildingName.ToLower().Contains(searchText))
            {
                filteredBuildings.Add(building);
            }
        }

        ClearBuildingButtons();
        generateBuildingButtons(filteredBuildings);
```

Figure 4.2.13: Search Function

Is it important to notice that the game objects are arranged dynamically, which means that any changes in the search criteria will require rebuilding the buttons accordingly. In Figure 4.2.13, the search function is designed for filter the buttons by checking for input alphabets contained within the building names.

```
public void SortByAscending(string category)
{
    switch (category)
    {
        case "all":
            filteredBuildings.Sort((a, b) => string.Compare(a.buildingID, b.buildingID));
            break;
        case "name":
            filteredBuildings.Sort((a, b) => string.Compare(a.buildingName, b.buildingName));
            break;
        case "rating":
            filteredBuildings.Sort((a, b) => a.totalRating.CompareTo(b.totalRating));
            break;
        case "year":
            filteredBuildings.Sort((a, b) => a.constructionPeriod.CompareTo(b.constructionPeriod));
            break;
        default:
            filteredBuildings.Sort((a, b) => string.Compare(a.buildingName, b.buildingName));
            break;
    }
    ClearBuildingButtons();
    generateBuildingButtons(filteredBuildings);
}
```

Figure 4.2.14: Sorting Function

In Figure 4.2.14, users are provided with the functionality to sort historical buildings in ascending order based on different criteria such as name order, rating, or construction year. Each sorting option triggers rebuilding of buttons to dynamically rearrange the displayed buildings according to the selected sorting criteria.

```
firebaseAuthManager.LoginMethod loginMethod = firebaseAuthManager.GetLoginMethod();

switch (loginMethod)
{
    case firebaseAuthManager.LoginMethod.CurrentUser:
        CheckBookmark();
        break;
    case firebaseAuthManager.LoginMethod.Anonymous:
        BlackBookmark.SetActive(false);
        WhiteBookmark.SetActive(false);
        content.transform.Find("Review Scroll View").Find("Content").Find("myOpinion").gameObject.SetActive(false);
        break;
    case firebaseAuthManager.LoginMethod.None:
        Debug.LogError("cannot identify Login Method");
        break;
}
```

Figure 4.2.15: Login Method Check in Building Info Panel

After entering the building detail page, will first check user's login method (Figure 4.2.15). If login as guest, the bookmark button will be hide. Only the authenticated user is able to interact with it.

```
public void OnBookmarkClick()
{
    if (_isBookmarked)
    {
        if (currentBookmark != null)
        {
            dataManager.instance.RemoveFavouriteFromDatabase(currentBookmark.key, userUID);
            BlackBookmark.SetActive(false);
            WhiteBookmark.SetActive(true);
            _isBookmarked = false;
        }
    }
    else if (_isBookmarked == false)
    {
        dataManager.instance.AddFavouriteToDatabase(building.buildingID, userUID);
        BlackBookmark.SetActive(true);
        WhiteBookmark.SetActive(false);
        _isBookmarked = true;
    }
```

Figure 4.2.16: Bookmark Function

As shown in figure 4.2.16, the bookmark button will cover the operation of both add and remove the bookmark from user's favourite list. After the button is click, the update to firebase will be execute in real time.

```
GameObject imageObject = Instantiate(imagePrefab, contentArea);

Transform childImage = imageObject.transform.Find("Image");
if (childImage != null)
{
    Image image = childImage.GetComponent<Image>();
    StartCoroutine(uiHelpers.LoadImage(imageUrl, image));

    imageObject.GetComponent<Button>().onClick.AddListener(() =>
    {
        StartCoroutine(uiHelpers.LoadImage(imageUrl, enlargedImageView));
        enlargedImageView.preserveAspect = true;
        enlargeCanves.SetActive(true);
    });
}
```

Figure 4.2.17: Building Image Load Function

In Figure 4.2.17, the image load function retrieves images from the database based on the selected building. When a user clicks on an image, the function triggers the enlarge function, allowing the user to view the specific image in a larger size, facilitating a closer examination.

```
public void OnSubmitButtonClick()
{
    string reviewText = contentArea.Find("myOpinion").Find("InputField").GetComponent<TMP_InputField>().text;
    if (reviewText == null || reviewText == "")
    {
        reviewText = "No comment";
    }
    dataManager.instance.SubmitReview(building.buildingID, reviewText, References.userUID, References.userName, rating, curReviewList.Count);
    UpdateReview();
}

1 reference
public void UpdateReview()
{
    dataManager.reviewList.Clear();
    dataManager.instance.RetrieveReviews();
```

Figure 4.2.18: Comment Submit Function

When a comment submit, the function ensures a smooth user experience by updating empty text to “No comment” for clarity and immediately updating the review to the Firebase database upon submission. To ensure users can view the update in real time, the function retrieves the latest data again from Firebase after update.

```
private float CalculateNewTotalRating(string buildingID, int newRating, int reviewCount)
{
    // Find the building in the buildingList
    BuildingEntity building = buildingList.Find(b => b.buildingID == buildingID);

    if (building != null)
    {
        float newTotalRating = ((building.totalRating * (reviewCount - 1)) + newRating) / reviewCount;
        newTotalRating = Mathf.Clamp(newTotalRating, 0f, 5f);
        return newTotalRating;
    }
```

Figure 4.2.19: Rating Calculation Function

Figure 4.2.19 shows the total rating calculation function, which is executed when submitting a comment since rating will also submit at the same time. This function calculates the total rating by considering the current total rating, the number of total reviews, and the new rating provided by the user. It ensures the accuracy of rating system after every update.

4.2.3 AR Module

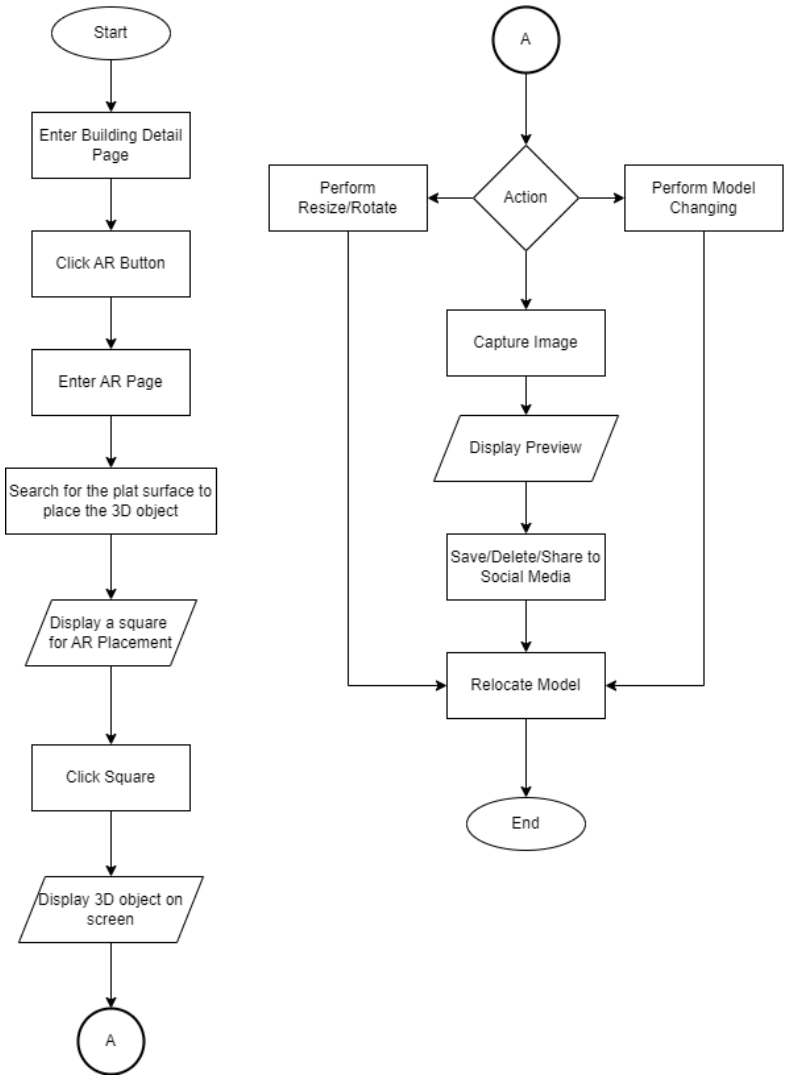


Figure 4.2.20: Flowchart of AR Module

Figure 4.2.20 shows the flowchart of AR Module. It continues from the building module and begins with the user entering the AR page from the building info page. Once on the AR page, the user can utilize their mobile device's camera to search for a flat floor surface. When the application detects a suitable surface, it displays a square to notify the user that it is ready to place the 3D model. After placing the 3D model, users can interact with it in different ways, including rotating, scaling, changing models, and relocating the model within the augmented reality environment. Other than that, the user have the option to capture the image of the AR scene. After capturing the image, a preview will be displayed, allowing them to choose whether add it to their gallery, discard it, or share it on social media platforms.

```
private void LoadingBuildingModels(string buildingID)
{
    // Filter model for the selected building
    buildingModels = dataManager.buildingModelList.FindAll(model => model.buildingID.Equals(buildingID));

    LoadAndActivateModel(buildingModels[0].buildingModelID);
    generateModelButtons();
}
```

Figure 4.2.21: Building Model Load Function

After retrieving all the building models of the selected building, the application sets the first building model to be active. This ensures that users directly experience the oldest historical building model when they enter the AR environment (Figure 4.2.21).

```
public void ScaleModel()
{
    if (currentModel != null)
    {
        float minScale = 0.005f;
        float maxScale = 1.0f;

        float clampedValue = Mathf.Clamp(scaleSlider.value, minScale, maxScale);

        currentModel.transform.localScale = Vector3.one * clampedValue;
    }
}
```

Figure 4.2.22: Scaling Function

In Figure 4.2.22, the scaling function controls the scale of the 3D object within the AR environment. A threshold has been set up to ensure the 3D model is displayed at a correct size between the minimum and maximum scale.

```
public void RotateModel()
{
    if (currentModel != null)
    {
        float rotationChange = (rotationSlider.value - previousSliderValue) * 360.0f;
        previousSliderValue = rotationSlider.value;

        if (rotationChange > 0.0f)
        {
            // Rotate to the right
            totalRotation += rotationChange;
        }
        else
        {
            // Rotate to the left
            totalRotation -= Mathf.Abs(rotationChange);
        }
        currentModel.transform.rotation = Quaternion.Euler(0.0f, totalRotation, 0.0f);
    }
}
```

Figure 4.2.23: Rotate Function

In Figure 4.2.23, the rotate function allows the user to interact with the 3D model by rotating it within the AR environment. The function calculates the rotation based on changes in the value of a slider control. Depending on the increasing or decreasing of slider value, the function will then determine whether to rotate the 3D model to the left or right.

```
private IEnumerator TakeScreenshotAndSave()
{
    takingScreenshot = true;

    // Set the target Render Texture for the AR camera
    arCamera.targetTexture = arRenderTexture;
    arCamera.Render();

    yield return new WaitForEndOfFrame();

    screenshotTexture = new Texture2D(arRenderTexture.width, arRenderTexture.height, TextureFormat.ARGB32, false, true);
    RenderTexture.active = arRenderTexture;
    screenshotTexture.ReadPixels(new Rect(0, 0, arRenderTexture.width, arRenderTexture.height), 0, 0);

    Color[] pixels = screenshotTexture.GetPixels();
    for (int p = 0; p < pixels.Length; p++)
    {
        pixels[p] = pixels[p].gamma;
    }
    screenshotTexture.SetPixels(pixels);
    screenshotTexture.Apply();

    previewImage.texture = screenshotTexture;
    previewCanves.SetActive(true);
```

Figure 4.2.24: Image Capture Function

After user captures an image in the AR environment, the target texture is set to only capture the AR camera's view. This ensures that only content displayed in the AR camera's view is captured. As shows in Figure 4.2.24, the gamma correction is applied to the captured pixels to ensure the image match the real-world lighting conditions. Then a preview image will be displayed for user to view the captured image before taking any further action.

```
public void Save()
{
    // Save the image to Gallery/Photos

    string name = string.Format("{0}_Capture{1}_{2}.png", Application.productName, "{0}", System.DateTime.Now.ToString("yyyy-MM-dd_HH-mm-ss"));
    NativeGallery.SaveImageToGallery(screenshotTexture, Application.productName + " Captures", name);

    previewCanves.SetActive(false);
    ActionCleanup();
}
```

Figure 4.2.25: Save Function

In Figure 4.2.25, the save function utilizes the Unity Native Gallery Plugin to save the captured image. The image is saved with the naming format "application name_Capture_data time.png" and is stored in a folder named "HBProject Captures".

```
public void Share()
{
    string tempFilePath = Path.Combine(Application.temporaryCachePath, "temp.png");
    File.WriteAllBytes(tempFilePath, screenshotTexture.EncodeToPNG());

    // Create a NativeShare object and add the image file
    new NativeShare()
        .AddFile(tempFilePath)
        .SetSubject("Check out this AR capture!")
        .SetText("Hey, I captured this AR scene using " + Application.productName + ". Check it out!")
        .Share();
```

Figure 4.2.26: Share Function

In Figure 4.2.26, the share function utilizes the Unity Native Share Plugin. A temporary image is saved in the temporary cache path, and users able to share it to different social media platforms along with an embedded text message.

4.2.4 Bookmark Module

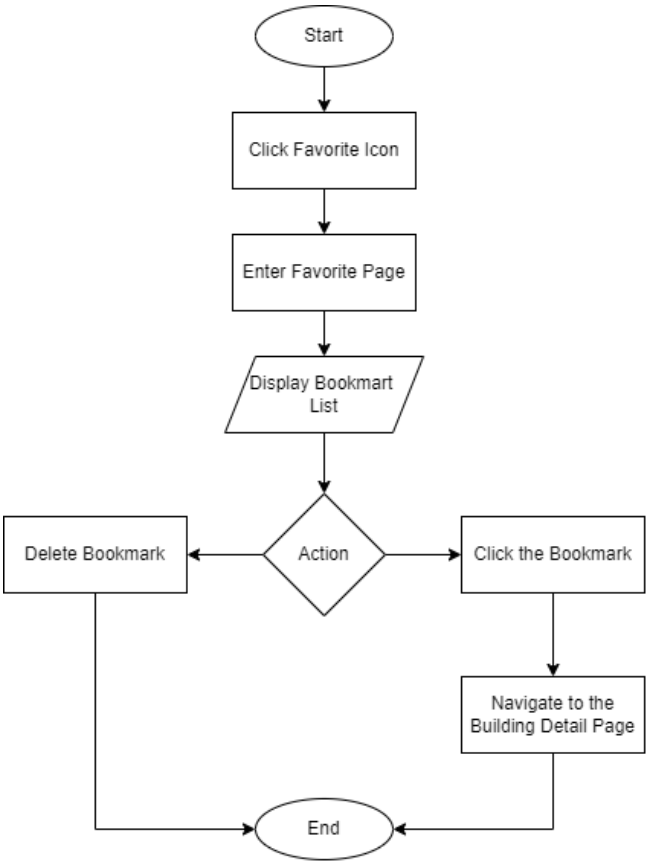


Figure 4.2.27: Flowchart of Bookmark Module

Figure 4.2.27 shows the flowchart of Bookmark Module. While the adding of bookmark already included in the building module, the bookmark module responsible for the management of bookmark. The user able to perform the delete of bookmarks or click the bookmark to get a direct access to the selected building's detail page.

```
public void OnFavouriteButtonClick(string buildingID, string scene)
{
    // Get the selected building
    BuildingEntity building = dataManager.favoriteList.FirstOrDefault(b => b.buildingID.Equals(buildingID));

    string buildingJson = JsonUtility.ToJson(building);

    // Store to PlayerPrefs
    PlayerPrefs.SetString("currentBuilding", buildingJson);
    PlayerPrefs.SetString("previousScene", scene);
    SceneManager.LoadScene("buildingInfoUI");
}
```

Figure 4.2.28: Favourite Button Click Function

In Figure 4.2.28, the on click function for the button performs similar to the Figure 4.2.12. Where it will navigate the user to get a direct access to the building detail page but will set the access source differently to make sure the page will return back to where it comes from.

4.2.5 Map Integration Module

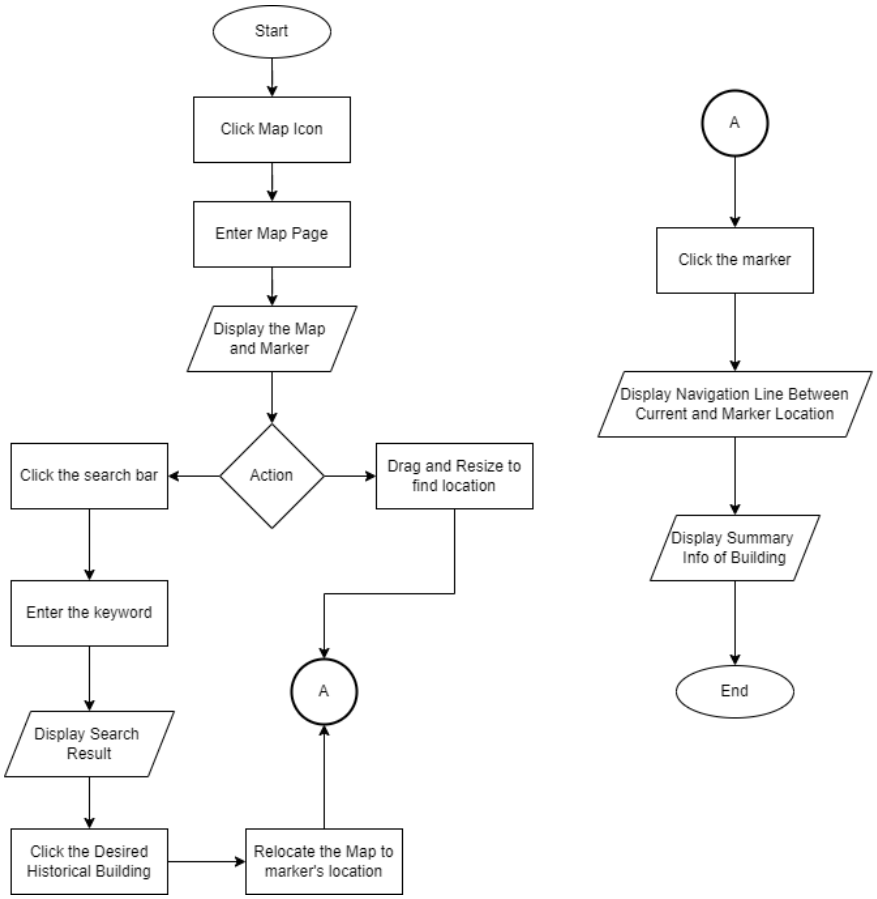


Figure 4.2.29: Flowchart of Map Integration Module

Figure 4.2.29 shows the flowchart of Map Integration Module. After entering the Map Page, the map and markers are loaded, allowing users to identify their current location. Users can search for historical buildings location either manually by dragging or resizing the map, or by utilizing the search bar based on the building name. The map center on the marker location after user click the search result. When user clicks on the found marker, the distance and line between the current and marker locations are displayed, along with a summary of building information. Moreover, the application can update the user's real-time location, enhancing the overall navigation experience while using the map.

```
private void GenerateBuildingMarker(Vector2d coordinate, BuildingEntity building)
{
    GameObject marker = Instantiate(_blueMarkerPrefab);
    marker.name = building.buildingName;

    // convert the geographic coordinate to world position
    marker.transform.localPosition = map.GeoToWorldPosition(coordinate, true);
    marker.transform.localScale = new Vector3(_spawnScale, _spawnScale, _spawnScale);
    marker.transform.SetParent(coordinateContainer.transform);

    blueMarkerHandler markerScript = marker.AddComponent<blueMarkerHandler>();
    markerScript.buildingName = building.buildingName;
    markerScript._blueMarkerCoordinate = coordinate;


    _spawnedObjects.Add(marker);
}
```

Figure 4.2.30: Historical Building Marker Generation Function

In Figure 4.2.30, the function will generate markers for all historical buildings. Utilizing the Mapbox SDK for mapping, it will convert the geographic coordinates of each building to world position to accurately position them on the map.

```
1 reference
private void GenerateCurrentPositionMarker()
{
    _RedMarker = Instantiate(_redMarkerPrefab);
    _RedMarker.name = "Current Position";

    // Initial value
    _RedMarker.transform.localPosition = Vector3.zero;
    _RedMarker.transform.localScale = new Vector3(_spawnScale, _spawnScale, _spawnScale);
    _RedMarker.transform.SetParent(coordinateContainer.transform);

    _spawnedObjects.Add(_RedMarker);

    // Subscribe to the location update event to continuously update the red marker's position
    activeLocationProvider.OnLocationUpdated += UpdateRedMarkerPosition;
}

2 references
private void UpdateRedMarkerPosition(Location location)
{
    Vector2d coordinates = location.LatitudeLongitude;
```

Figure 4.2.31: Current Position Marker Generation and Update Function

As shown in Figure 4.2.31, the function responsible for generation of user's current position marker separately. It will continuously update it to reflect any changes in the user's coordinates, reflect the user latest location in real-time.

```
Unity Message | 0 references
public void Update()
{
    int count = _locations.Count;
    for (int i = 0; i < count; i++)
    {
        var spawnedObject = _spawnedObjects[i];
        var location = _locations[i];
        spawnedObject.transform.localPosition = map.GeoToWorldPosition(location, true);
        spawnedObject.transform.localScale = new Vector3(_spawnScale, _spawnScale, _spawnScale);
    }
}
```

Figure 4.2.32: Update of all location markers

In Figure 4.2.32, will constantly update the location of all location markers, including historical buildings and the current position marker. This update will ensure that all markers remain stable positioned on the map, especially when user performs thee dragging and scrolling.

```
2 references
private void OnLocationUpdated(Location location)
{
    map.SetCenterLatitudeLongitude(location.LatitudeLongitude);

    // unsubscribing from the event once get the first update
    activeLocationProvider.OnLocationUpdated -= OnLocationUpdated;
}
```

Figure 4.2.33: Initial Center Coordinate Load

When first load the map, user's current position will be set as the center. Function in Figure 4.2.33 constantly updated location of user when they first enter the map page.

```
if (Input.touchCount == 1 && searchBarController.isSearching == false)
{
    Touch touch = Input.GetTouch(0);

    if (touch.phase == TouchPhase.Began)
    {
        lastTouchPosition = touch.position;
        lastSwipeDirection = SwipeDirection.None;
    }
    else if (touch.phase == TouchPhase.Moved)
    {
        Vector2 touchDelta = touch.position - lastTouchPosition;

        if (touchDelta.magnitude >= swipeThreshold)
        {
            SwipeDirection swipeDirection = GetSwipeDirection(touchDelta);
            if (swipeDirection != SwipeDirection.None)
            {
                if (lastSwipeDirection != SwipeDirection.None && swipeDirection != lastSwipeDirection)
                {
                    // Execute the second swipe instruction here
                    if (swipeDirection == SwipeDirection.LeftToRight)
                    {
                        // Handle right-to-left swipe action
                        MoveMap(new Vector2d(0, adjustedMoveSpeed * Time.deltaTime));
                    }
                    else if (swipeDirection == SwipeDirection.RightToLeft)
                    {
                        // Handle left-to-right swipe action
                        MoveMap(new Vector2d(0, -adjustedMoveSpeed * Time.deltaTime));
                    }
                    else if (swipeDirection == SwipeDirection.UpToDown)
                    {
                        // Handle top-to-bottom swipe action
                        MoveMap(new Vector2d(-adjustedMoveSpeed * Time.deltaTime, 0));
                    }
                    else if (swipeDirection == SwipeDirection.DownToUp)
                    {
                        // Handle bottom-to-top swipe action
                        MoveMap(new Vector2d(adjustedMoveSpeed * Time.deltaTime, 0));
                    }
                    // Update the last swipe direction
                    lastSwipeDirection = swipeDirection;
                }
                else
                {
```

Figure 4.2.34: Scrolling Function

In Figure 4.2.34, is the scrolling function for moving around the map. It captures single touch input from the user and calculates the swipe direction to update the map. The function also consider the changes in swipe direction within a single touch action.

```
1 reference
private SwipeDirection GetSwipeDirection(Vector2 touchDelta)
{
    float angle = Mathf.Atan2(touchDelta.y, touchDelta.x) * Mathf.Rad2Deg;

    if (angle < 0)
    {
        angle += 360;
    }

    if (angle > 45 && angle <= 135)
    {
        return SwipeDirection.UpToDown;
    }
    else if (angle > 135 && angle <= 225)
    {
        return SwipeDirection.RightToLeft;
    }
    else if (angle > 225 && angle <= 315)
    {
        return SwipeDirection.DownToUp;
    }
    else
    {
        return SwipeDirection.LeftToRight;
    }
}
```

Figure 4.2.35: Swipe Direction Calculation

Figure 4.2.35 is the function to identify the swipe direction based on the angle between the positive x-axis and the point in the counterclockwise direction.

```
private void MoveMap(Vector2d offset)
{
    // Calculate the new center position
    Vector2d newCenter = map.CenterLatitudeLongitude + offset;

    // Clamp the new center position within the boundaries
    double clampedLatitude = Mathf.Clamp((float)newCenter.x, minLatitude, maxLatitude);
    double clampedLongitude = Mathf.Clamp((float)newCenter.y, minLongitude, maxLongitude);
    newCenter = new Vector2d(clampedLatitude, clampedLongitude);
    // Set the new center position
    map.UpdateMap(newCenter);
}
```

Figure 4.2.36: Move Map Function

When user move around the map, the function in Figure 4.2.36 will restricts user movement within specific latitude and longitude coordinates. This ensures that users can only navigate within the bounds of Malaysia.

```
else if (Input.touchCount == 2 && searchBarController.isSearching == false)
{
    Touch touch0 = Input.GetTouch(0);
    Touch touch1 = Input.GetTouch(1);

    if (touch0.phase == TouchPhase.Began || touch1.phase == TouchPhase.Began)
    {
        initialTouchDistance = (touch0.position - touch1.position).magnitude;
    }

    if (touch0.phase == TouchPhase.Moved || touch1.phase == TouchPhase.Moved)
    {
        float currentTouchDistance = (touch0.position - touch1.position).magnitude;
        float zoomDelta = initialTouchDistance - currentTouchDistance;

        if (Mathf.Abs(zoomDelta) > minZoomDelta)
        {
            float zoomAmount = zoomDelta * zoomSpeed * -1;
            float newZoomLevel = map.Zoom + zoomAmount;
            newZoomLevel = Mathf.Clamp(newZoomLevel, minZoomLevel, maxZoomLevel);
            Vector3 touchPosition = (touch0.position + touch1.position) * 0.5f;

            touchPosition.z = Camera.main.transform.localPosition.y;

            // Convert the adjusted touch position to world position
            Vector3 worldPosition = Camera.main.ScreenToWorldPoint(touchPosition);

            // Convert the world position to map coordinates
            Vector2d center = map.WorldToGeoPosition(worldPosition);
            if (newZoomLevel != 10)
            {
                StartCoroutine(ZoomAfterDelay(0.1f, newZoomLevel, center));
            }
```

Figure 4.2.37: Zooming Function

In Figure 4.2.37, is the zooming function to resize the map. It captures two touches from the user and calculates the change in distance between them to update the zoom value. Min and max zoom levels are set to provide a better map viewing experience.

```
public void LoadRoute(Vector2d redMarkerCoordinates, Vector2d blueMarkerCoordinates)
{
    _coordinates1 = redMarkerCoordinates;
    _coordinates2 = blueMarkerCoordinates;

    var redMarkerPosition = map.GeoToWorldPosition(_coordinates1, true);
    var blueMarkerPosition = map.GeoToWorldPosition(_coordinates2, true);

    waypoint1.transform.position = redMarkerPosition;
    waypoint2.transform.position = blueMarkerPosition;

    DirectionsFactory directionsFactory = FindObjectOfType<DirectionsFactory>();
    if (directionsFactory != null)
    {
        Transform[] waypoints = new Transform[2];
        waypoints[0] = waypoint1.transform;
        waypoints[1] = waypoint2.transform;

        directionsFactory.SetWaypoints(waypoints);
        directionsFactory.Query();
    }
```

Figure 4.2.38: Load Route Function

Figure 4.2.38 is the function for loading the route between the user's location and destination location. It generates the route by converting the coordinates of both locations to world position, allows and accurate representation of the route between two points on the map.

4.2.6 Profile Module

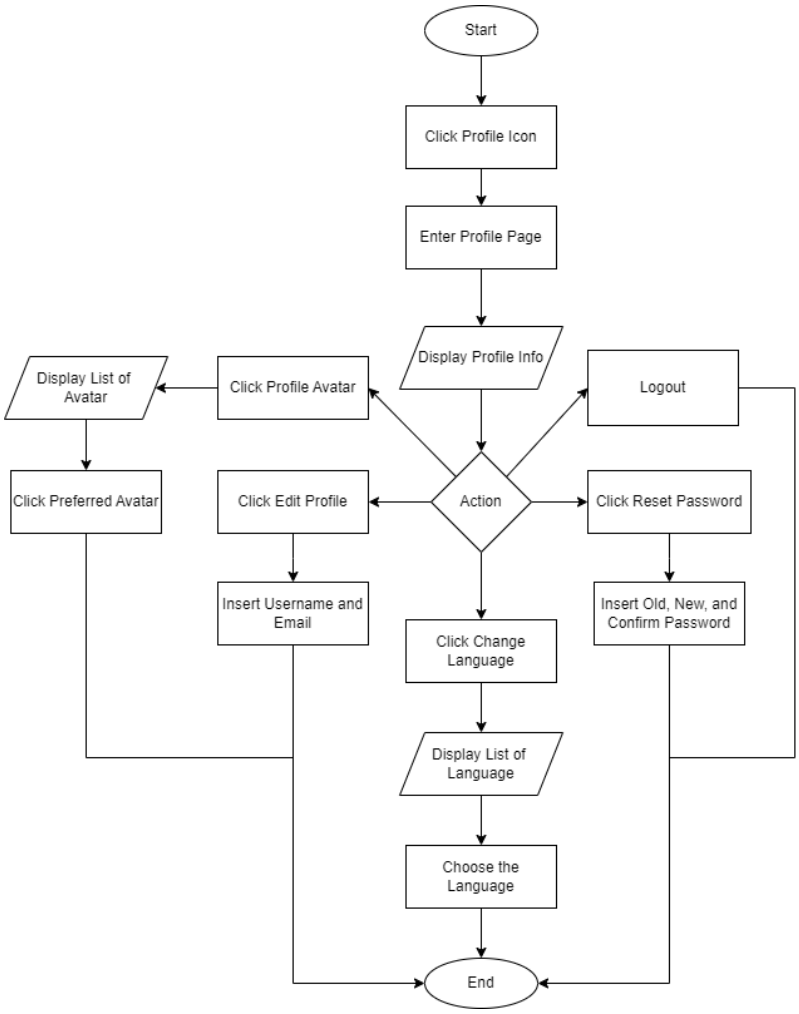


Figure 4.2.39: Flowchart of Profile Module

Figure 4.2.39 shows the flowchart of Profile Module. This module is responsible for the management of user profile information, account security, and personalization options within the application. Users is able to update their profile info such as profile avatar, username, email, and password. Additionally, users can customize the language of the entire user interface to suit their preferences, enhancing accessibility and usability. Lastly, the user can change log out of the application.

```
2 references
private void UpdateProfilePicture(string selection)
{
    string path = "Avatar/" + selection;

    Sprite newAvatar = Resources.Load<Sprite>(path);

    if (newAvatar != null)
    {
        // If the sprite is successfully loaded, update the profile picture
        profileImage.sprite = newAvatar;
    }
```

Figure 4.2.40: Change Avatar Function

The avatar icon will be saved in the project folder instead of firebase. When the user enters the profile page, the function loads the avatar based on user's selection that stored in firebase.

```
if (user.DisplayName != newUsernameField.text)
{
    if (string.IsNullOrEmpty(newUsernameField.text))
    {
        usernameErrorText.text = "Username is empty";
        usernameErrorText.gameObject.SetActive(true);
        return;
    }

    dataManager.instance.UpdateProfileUsername(newUsernameField.text);
    References.userName = newUsernameField.text;
    username.text = newUsernameField.text;

    UserProfile profile = new UserProfile { DisplayName = newUsernameField.text};
    user.UpdateUserProfileAsync(profile).ContinueWithOnMainThread(task =>
    {
        if (task.IsCanceled || task.IsFaulted)
        {
            usernameErrorText.text = "Username update failed.";
        }
    });
}
```

Figure 4.2.41: Edit Username Function

As shown in Figure 4.2.41, when user wants to update their username, it will first check the validity of new username. It then perform the updates to both the record in the Realtime database and Firebase authentication.

```
// Re-authenticate the uesr first for security
var credential = EmailAuthProvider.GetCredential(user.Email, oldPasswordChangeField.text);

user.ReauthenticateAndRetrieveDataAsync(credential).ContinueWithOnMainThread(task =>
{
    if (task.IsCanceled || task.IsFaulted)
    {
        oldPasswordErrorText.text = "Re-authentication failed";
        oldPasswordErrorText.gameObject.SetActive(true);
        return;
    }

    // Re-authentication successful, now update the password
    user.UpdatePasswordAsync(newPasswordChangeField.text).ContinueWithOnMainThread(task =>
    {
```

Figure 4.2.42: Reset Password Function

In Figure 4.2.42, shows the reset password function. Due to the sensitivity of password, this function includes multiple layers of checks. It first verifies if the user has correctly entered the new password by comparing it with the confirmation password. Then, it checks if the user knows the old password of the account before proceeding with the update.

Figure 4.2.43: Available Language Selection

```
public void ChangeLanguage(int localeID)
{
    if (localeActive == true)
        return;
    StartCoroutine(SetLocale(localeID));
}

1 reference
IEnumerator SetLocale(int _localeID)
{
    localeActive = true;
    yield return LocalizationSettings.InitializationOperation;
    LocalizationSettings.SelectedLocale = LocalizationSettings.AvailableLocales.Locales[_localeID];
    PlayerPrefs.SetInt("LocaleKey", _localeID);
    localeActive = false;
    OpenProfilePanel();
}
```

Figure 4.2.44: Change Language Function

As shown in Figure 4.2.43, the locales has been set up to provide offers for 4 language options, which is Simplified Chinese, English, Malay, and Tamil. After calling the function in Figure 4.2.44, the application changes the language based on the localization table language selection order.

```
public void Logout()
{
    auth.SignOut();
}
```

Figure 4.2.45: Logout Function

Figure 4.2.45 is the logout function. It allows authenticated users to log out the application. If they want to login again, will need to enter from login page again.

4.3 Development of 3D Building Model

During the development of our historical buildings AR project, creating 3D models is essential to showcase the AR functionality effectively. Blender was chosen as our primary software for 3D model development due to its wide range of advanced technologies to support the development process, including texturing and lighting capabilities. With Blender, we can create highly detailed and realistic 3D models that accurately represent historical buildings.

To begin, different references images of the buildings was gathered from public sources. These images will serve as the references during the 3D modelling process. Figure 4.3.1 and Figure 4.3.2 shows the different versions of Taiping Clock Tower, which will be our reference points for changing in building's appearance over time.

Figure 4.3.1: Taiping Clock Tower in 1881

Figure 4.3.2: Taiping Clock Tower in 1900

Then, we continue the development in the blender. First, we start with the modelling phase, aiming to resembles the original building as closely as possible. This involves the shaping of 3D geometry. After that, we apply textures to the model to enhance its realism. Finally, lighting is added to make the entire scene more realistic. By following these steps, we able to create our 3D model properly.

CHAPTER 5

System Implementation

5.1 Hardware Setup

The hardware component used for this project shown in Table 5.1.1 and Table 5.1.2.

Table 5.1.1: Specifications of Laptop

Description	Specifications
Model	Acer Nitro AN515-56
Processor	11th Gen Intel® Core (TM) i5-11300H @ 3.10GHz 3.11GHz
Operating System	64-bit OS Windows 10
Graphic	NVIDIA GeForce GTX 1650
Memory	16GB RAM
Storage	475 GB Solid State Drive

Table 5.1.2: Specifications of Smartphone

Description	Specifications
Model	Vivo Y36 5G
Processor	2.2 GHz Dimensity 6020 Octa-core
Operating System	Funtouch 13 Global, Android 13
Graphic	Mali-G57 MC2
Memory	16GB RAM
Storage	256 GB
Internet Connectivity	Yes
Front Camera	1.6 MP, f/2.5, (wide)
Back Camera	50 MP, f/1.8, (wide), PDAF 2MP, f/2.4, (depth)
Resolution	1080 × 2388 pixels

5.2 Software Setup

The software involved in this project are Visual Studio 2022, Blender, Unity, Draw .io, and Gantt Project. Next, the involve technologies include Vuforia SDK, ARCore SDK, Firebase, Mapbox and the C# programming language. These software and technologies are selected due to compatibility with the development of the project.

Figure 5.2.1: Visual Studio 2022

Figure 5.2.2: Blender

The Visual Studio 2022 (Figure 5.2.1) is the selected software for coding in C#. It facilitates the interaction between user and system through custom-defined functions. Next, the Blender software (Figure 5.2.2) plays the role of 3D models creation for historical buildings. These models will be export to the Unity after modelling process.

Figure 5.2.3: Unity

Figure 5.2.4: Vuforia

Figure 5.2.5: ARCore

The Unity (Figure 5.2.3) as the core platform for the development of this project, it integrates diverse technologies into a unified system, including Vuforia, C# script, and 3D model to perform the AR function. The Vuforia (Figure 5.2.4) enhanced the application's AR functionality with the provided AR camera features for precise plan detection, enable the placement of 3D models within real world environment. Furthermore, the ARCore SDK (Figure 5.2.5) supports the mobile to enhance AR experiences.

Figure 5.2.6: Firebase

Figure 5.2.7: Mapbox

Different technologies in Firebase (Figure 5.2.6) was utilized for storing the data and authentication. The firebase authentication manage the authenticated and anonymous user. The real time database Firebase ensures a consistent storage, retrieval, and updating of the data in providing a real-time interaction within the application. The Firebase storage stores the image that will be used for graphical display. Mapbox SDK (Figure 5.2.7) will be used to insert an embedded map for user to search for historical building's location. These selected software and technologies contribute to a dynamic historical building AR application.

Figure 5.2.8: Draw.io

Figure 5.2.9: Gantt Project

The draw.io (Figure 5.2.8) responsible for visualizing the diagram design for this project including user flow, site map, wireframes, prototype low fidelity, ERD, use-case diagram, activity diagram, and so on, offering a comprehensive blueprint for the project's structure. To effectively manage project scheduling and timelines, Gantt Project (Figure 5.2.9) is used to create Gantt charts for efficient project management.

5.3 Setting and Configuration

To use the application, there are specific requirements and configurations that need to be meet. Initially, the basic requirement for the mobile device was Android 8.0 'Oreo' (API Level 26). However, with the implementation of the Native Gallery, the minimum requirement has been increased to Android 10.0 (API Level 29). Besides, for users to experience the AR module's functionality, ARCore support is necessary. Several requirements needs to be checked to ensure that the mobile device supports AR functionality. Firstly, the device must originally ship with the Google Play Store. Secondly, the device should be running Android 7.0 or newer. Furthermore, AR required applications must declare a minimum SDK Version of 24 (API Level 24). Figure 5.3.1 listed out some devices that fulfil these requirements.

Samsung	Galaxy A3 (2017)	Requires Android 8.0 or later ARCore always runs with auto focus mode enabled on the rear facing camera Supports multiple GPU texture resolutions - 1080p, 720p, 480p
Samsung	Galaxy A5 (2017)	Supports multiple GPU texture resolutions - 1440x1080, 960x720, 480p
Samsung	Galaxy A6 (2018)	
Samsung	Galaxy A7 (2017)	Some models only support OpenGL ES 3.0 and earlier
Samsung	Galaxy A7 (2018)	Some models only support OpenGL ES 3.0 and earlier Requires Android 9.0 or later
Samsung	Galaxy A8	
Samsung	Galaxy A8+ (2018)	
Samsung	Galaxy A13 5G	
Samsung	Galaxy A14 5G	
Samsung	Galaxy A20	
Samsung	Galaxy A20s	
Samsung	Galaxy A20e	
Samsung	Galaxy A22	
Samsung	Galaxy A22 5G	

Figure 5.3.1: Portion of Supported Devices

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.unity3d.player"
    xmlns:tools="http://schemas.android.com/tools">

  <!-- Permissions -->
  <uses-permission android:name="android.permission.ACCESS_FINE_LOCATION" />
  <uses-permission android:name="android.permission.CAMERA" />
  <uses-permission android:name="android.permission.INTERNET" />
  <uses-permission android:name="android.permission.WRITE_EXTERNAL_STORAGE" />
  <uses-permission android:name="android.permission.READ_EXTERNAL_STORAGE" />

  <application
      android:requestLegacyExternalStorage="true">

    <!-- Main Activity -->
    <activity android:name="com.unity3d.player.UnityPlayerActivity"
        android:theme="@style/UnityThemeSelector">
      <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />
      </intent-filter>
      <meta-data android:name="unityplayer.UnityActivity" android:value="true" />
    </activity>

  </application>
```

Figure 5.3.2: Android Manifest

In Figure 5.3.2, we have set up the permissions in Android Manifest that will be required for fully experience of the application. The internet connection is necessary for task such as login, Firebase data retrieval, and updates. Location permission is required for the map module, especially for real-time functionality. Then, camera and storage permissions are also important for the AR experience and image saving functionality.

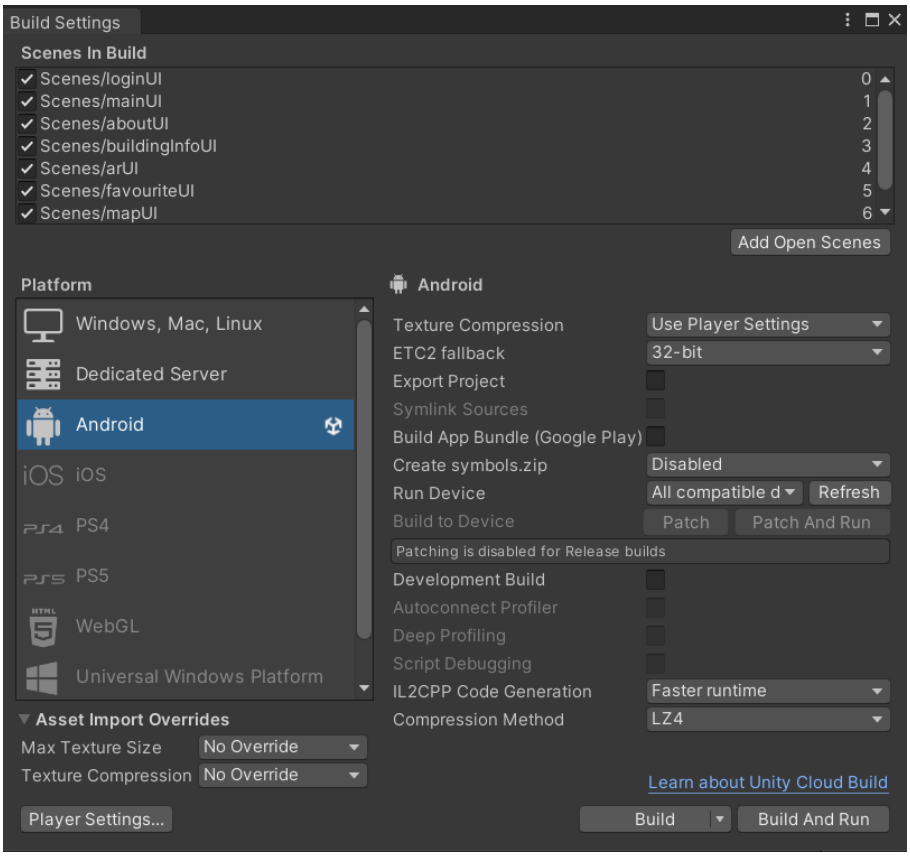


Figure 5.3.3: Build Settings

From the developer's side, the scenes need to be organized in the correct sequence and select Android as the target platform before building the application. This ensure that the generated build file is in the APK format and will launch from the login user interface right after the installation on an Android device. Once everything been setup properly, the application is able to be use normally in Android mobile devices.

5.4 System Operation

Figure 5.4.1 shows the splash screen that welcome users when launching the application. After the splash screen, user is directed to the login page. In Figure 5.4.2, two login method are provided, which are authenticated login and anonymous login. Authenticated login requires users to key in the email address and password into the login page's input field.

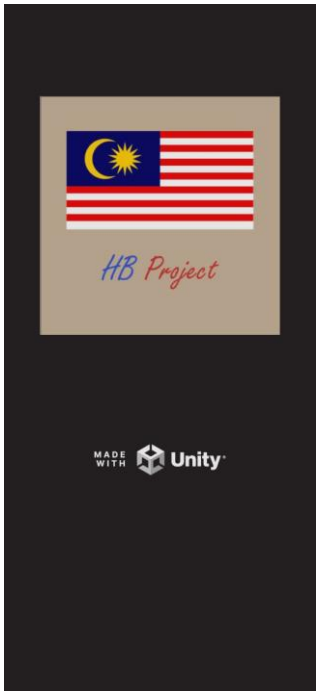


Figure 5.4.1: Splash Screen

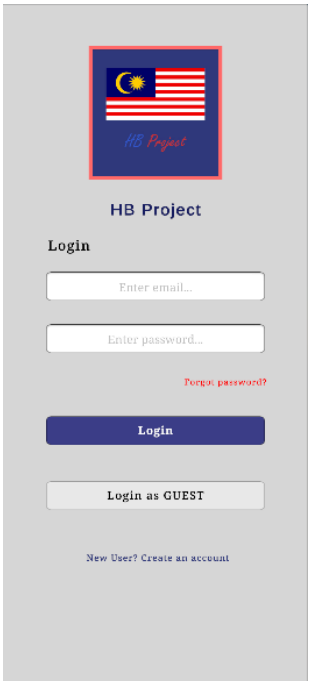


Figure 5.4.2: Login Page

The authenticated login must have an account created before they can proceed with the login. User clicks the "New User? Create an account" to filling out the required information, including name, email, password, and confirm password to start the account creation. A panel is displayed to notify users to verify their email address to complete the registration process after a successful registration in registration page. After clicking "Login", users are redirected back to the login page. Additionally, the login page includes a "Forgot Password" option for user to reset their password if they forgot. Clicks on it will pop out a reset password window, where users simply need to enter their email address, then a new password reset email will be sent to their inbox. Any further action will be complete there.

Figure 5.4.3: Registration Page

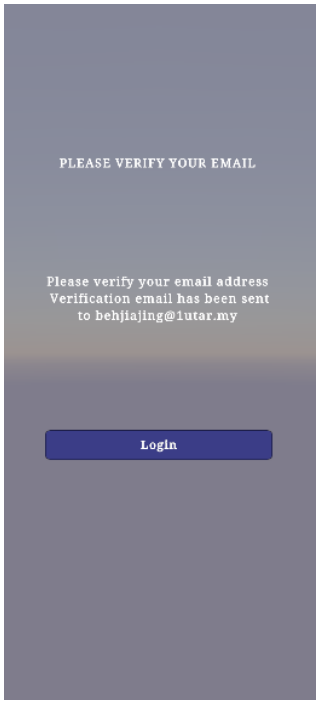


Figure 5.4.4: Email Verification Panel

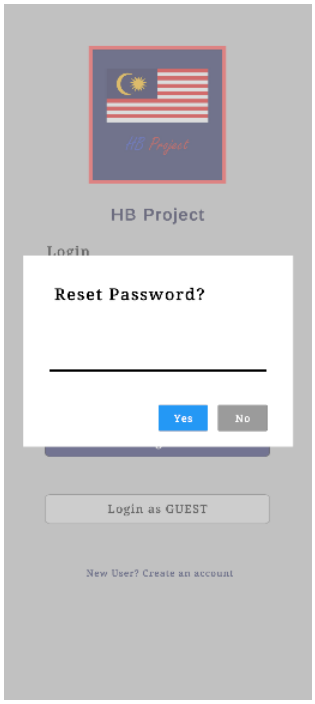


Figure 5.4.5: Reset Password Window

The main page which continues after the login page shown in Figure 5.4.6 and Figure 5.4.7. A little pop out welcome message will be display for around 2 seconds. The application retrieves data for all the states in Malaysia from Firebase and dynamically generate button accordingly. The interfaces have a title bar with an option menu on the right and a navigation bar at the bottom, emphasizing simplicity design.

Figure 5.4.6: Main Page Part I

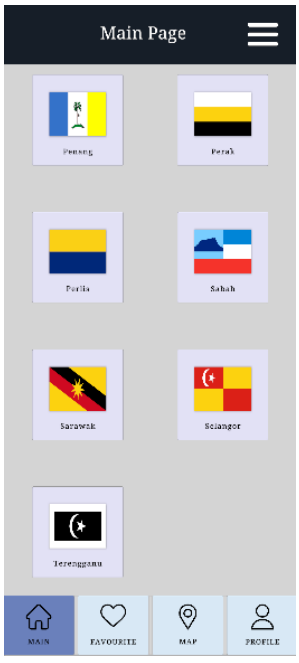


Figure 5.4.7: Main Page Part II

Figure 5.4.8 shows the option menu, which becomes visible when user click the option menu. Clicking the “Info” button navigates users to the About Us Page (Figure 5.4.9). This page solely displays the application’s logo and provides text describe its purpose. User can easily return to the previous page using the back button.

Figure 5.4.8: Option Menu Button

Figure 5.4.9: About Us Page

Next, user can access the building list pages by clicking on the state buttons. In this example, clicking the “Perak” button displays all historical buildings which belong to the Perak state. Figure 5.4.10 and Figure 5.4.11 show the historical buildings listed for the Perak state.

Figure 5.4.10: Perak Building Page II

Figure 5.4.11: Perak Building Page II

In state panel, user is able to perform the search and sorting functions. Figure 5.4.12 shows the outcome after sorting based on the alphabetical order, while Figure 5.4.13 shows the results after conducting a search based on certain keyword.

Figure 5.4.12: Sorting Function

Figure 5.4.13: Searching Function

Once users find a historical building of interest and select it, such as "Taiping Clock Tower" in this example, users are redirected to the building info page (Figure5.4.14). This page introduces in-depth historical details about the building, including its address, architectural style, historical background, construction period, and more. Furthermore, users can view the rating, comments, and images related to the selected building (Figure 5.4.15).

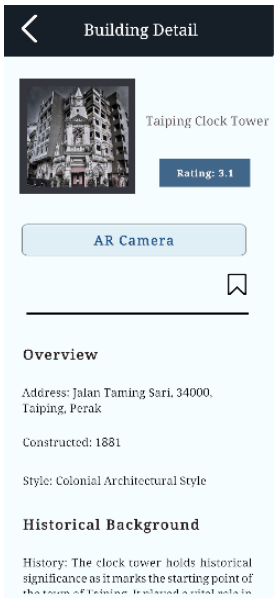


Figure 5.4.14: Building Detail Page I

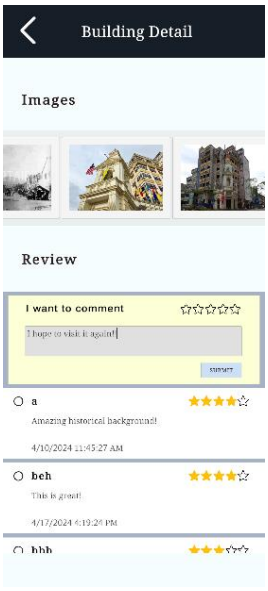


Figure 5.4.15: Building Detail Page II

Figure 5.4.16 shows the enlarge function after user clicks the image. Besides, there's a bookmark button allowing users to save historical buildings of interest into their favourite list. Users can also add comments to share their experiences or express their feelings toward the building (Figure 5.4.17). If user wishes to explore the AR functionality of Taiping Clock Tower, they can easily access it by clicking the 'AR Camera' button. During the transition, a loading screen is displayed to notify the user that the AR pages are still preparing.

Figure 5.4.16: Enlarged Image

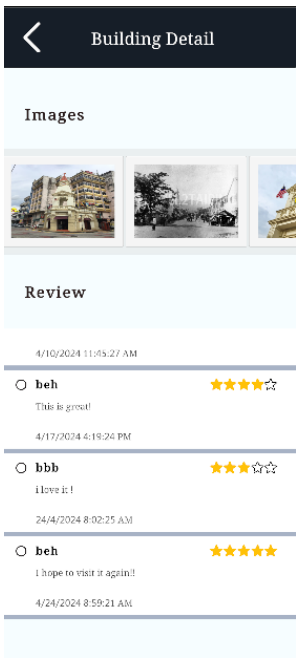


Figure 5.4.17: Updated Comment Section

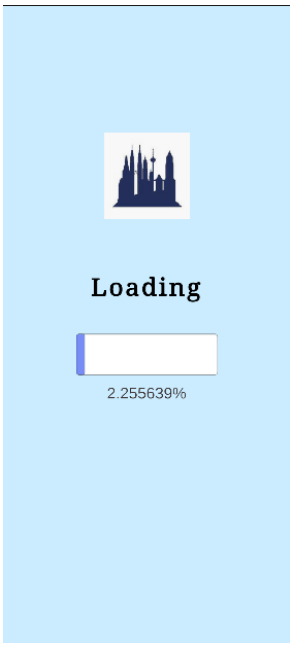


Figure 5.4.18: Start Loading

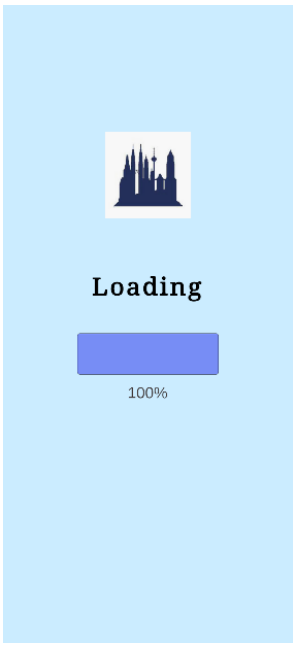


Figure 5.4.19: Finish Loading

Upon the scene loading is complete, a reminder page is displayed to alert users about using AR in a safe environment (Figure 5.4.20). Once users press 'OK', they can begin enjoying the AR experience. To place the 3D model into the real-world environment, users first need to detect a plane. Figure 5.4.21 and Figure 5.4.22 shows the placement of 3D model to the real-world environment.

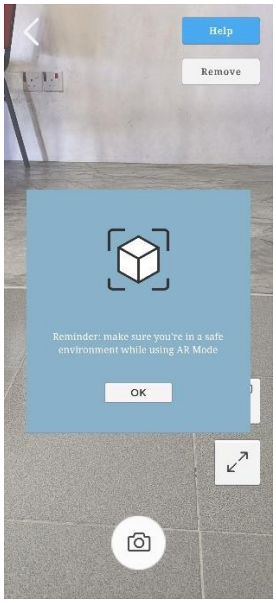


Figure 5.4.20: Reminder Page

Figure 5.4.21: Plane Detection

Figure 5.4.22: 3D Model Placement (1881)

Once the 3D model placement process is completed, users can interact with the model. They can walk around the model to get a clearer view of the building structure or perform scaling and rotating function. Figure 5.4.23 and Figure 5.4.24 demonstrates the results after performing these functions.

Figure 5.4.23: Scale Function

Figure 5.4.24: Rotate After Scale

To view different versions of historical buildings, users can select another button to change the appearance of the building model. Figure 5.4.25 shows the transition of the Taiping Clock Tower 3D model from 1881 version to 1990 version, displayed through the Vuforia Provided Ground Plane in Figure 5.4.26.

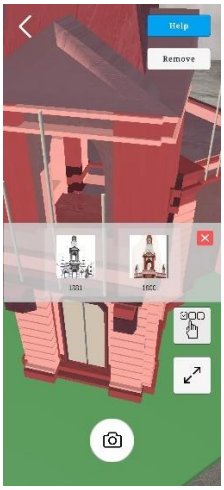


Figure 5.4.25: Taiping Clock Tower Model (1990)

Figure 5.4.26: Vuforia Ground Plane

If user captures an image, they like using the capture button, they have several options to proceed. Figure 5.4.27 shows the preview mode after an image is captured, where user can choose to either discard, save, or share the image. Figure 5.4.28 and Figure 5.4.29 demonstrate the process of sharing the image via WhatsApp, show the seamless integration with social media platforms for easy sharing of captured images.

Figure 5.4.27: Preview Mode

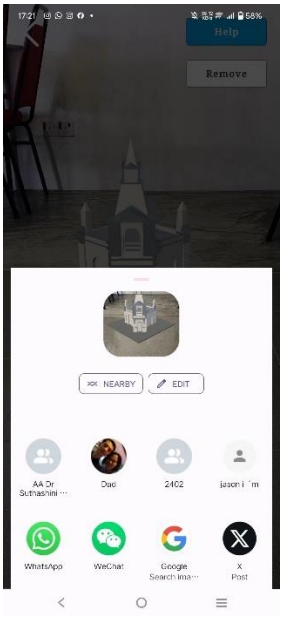


Figure 5.4.28: Sharing Platform Selection

Figure 5.4.29: WhatsApp share Page

Users can bookmark buildings of interest for easy access. Figure 5.4.30 shows the Taiping Clock Tower being bookmarked. They can then access bookmarked buildings directly from favorite page (Figure 5.4.31). If user don't have favorites, the page will be display as shown in Figure 5.4.32.

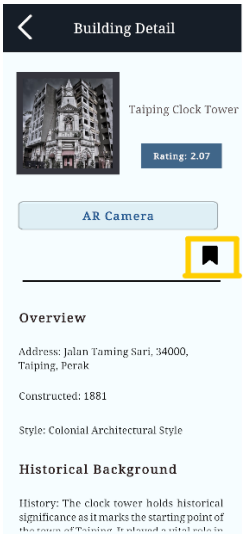


Figure 5.4.30: Bookmark Button

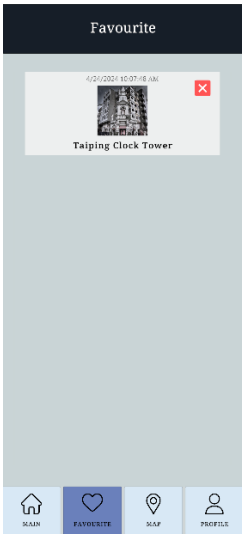


Figure 5.4.31: Favorite Page

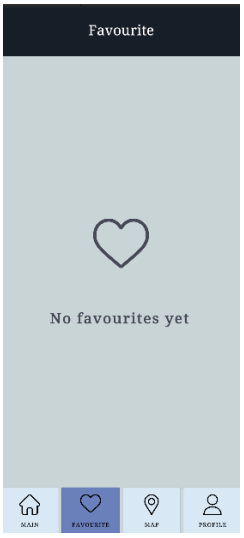


Figure 5.4.32: No Favorite

Next is the map page, when first entering, the current location and historical building locations will be loaded (Figure 5.4.33). User can use the search bar to target specific historical buildings they want. Figure 5.4.34 displays the result after user search for the Taiping Clock Tower. After clicking it, users will see a navigation from their current location to the target location, along with a summary of building info. User can scroll or resize the map to get a full picture of the entire route (Figure 5.4.35).

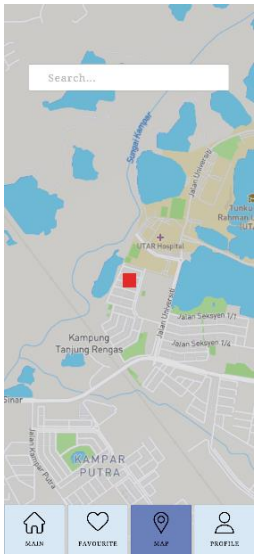


Figure 5.4.33: Map Page

Figure 5.4.34: Search Result

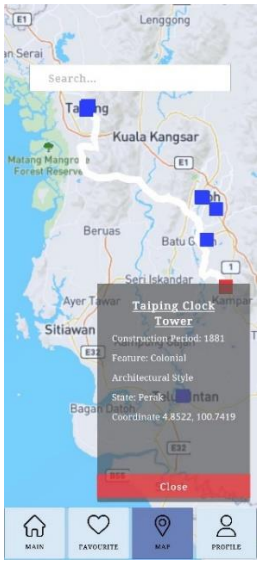


Figure 5.4.35: Navigation

Figure 5.4.36 shows the profile page, where user can manger their settings. In our application, user can customize their avatar instead of updating their profile picture. Figure 5.4.37 and Figure 5.4.38 shows the avatar selection and changes process.

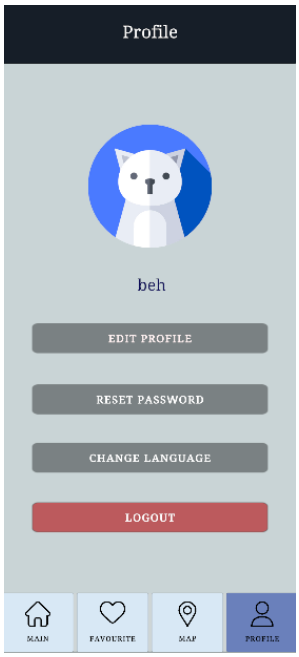


Figure 5.4.36: Profile Page

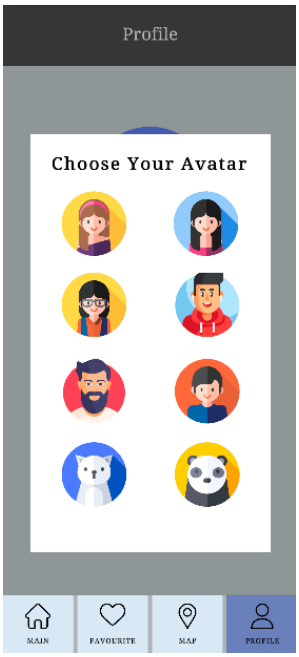


Figure 5.4.37: Avatar Selection

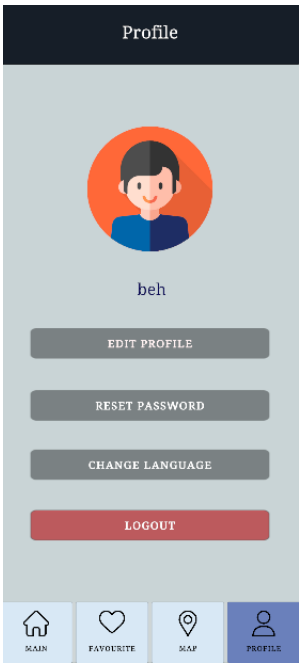


Figure 5.4.38: Updated Avatar

The user can also edit their personal information through the profile page. They have the option to edit either their profile or reset their password. Figure 5.4.39 displays the edit profile page, while Figure 5.4.40 shows the edit password page.

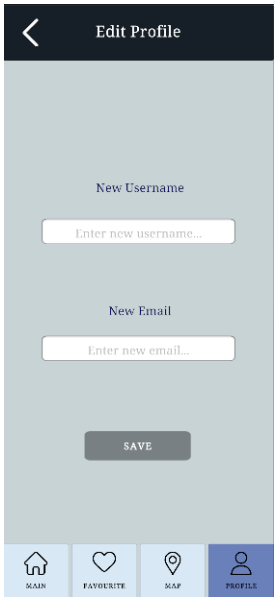


Figure 5.4.39: Edit Profile Page

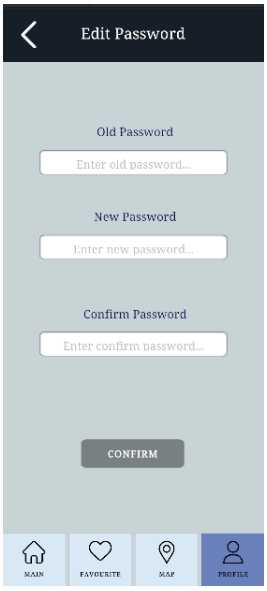


Figure 5.4.40: Edit Password Page

Figure 5.4.41: Change Language Window

To cater the users who may not be proficient in English, we offer language selection options, including Chinese, Malay, and Tamil, in addition to English (Figure 5.4.41). Figure 5.4.42, 5.4.43, and 5.4.44 shows the interface after switching to respective language. The logout function allows user to securely log out of their accounts.

Figure 5.4.42: Chinese Interface

Figure 5.4.43: Malay Interface

Figure 5.4.44: Tamil Interface

For guest users, who do not have authenticated accounts, some features are limited. For example, in the building detail page (Figure 5.4.45), the bookmark button is unavailable, and they cannot add comments (Figure 5.4.46). Guest user also does not have access to a favorite list (Figure 5.4.47). Their profile page is simplified, offering only language change and switch account options (Figure 5.4.48).

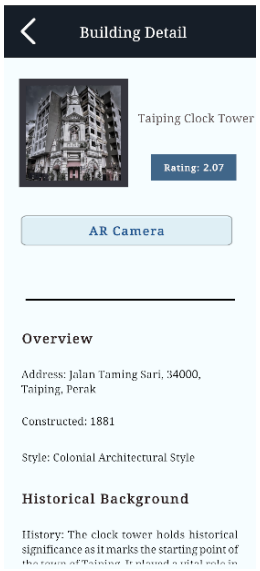


Figure 5.4.45: Guest Building Detail I

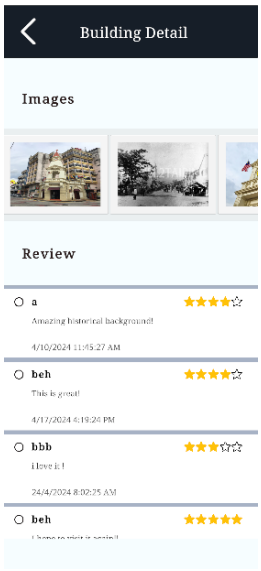


Figure 5.4.46: Guest Building Detail II

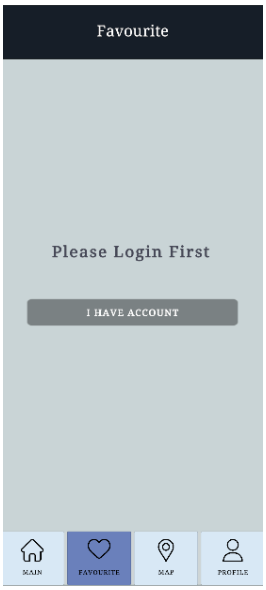


Figure 5.4.47: Guest Favorite Page

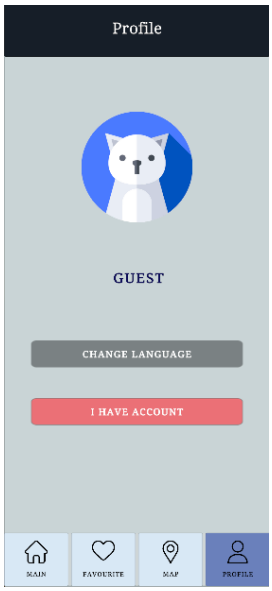


Figure 5.4.48: Guest Profile Page

5.5 Concluding Remark

The current project is developed using the Acer Nitro laptop with Microsoft Windows 10 and 64-bit OS Windows 10. The mobile used to test out the prototype and final version of the application is Vivo Y36 5G. The development of the project involved various tools and platforms, including Visual Studio 2022, Blender, Unity, Firebase, and Mapbox SDK. These were utilized to create an engaging user interface and integrate essential functionalities. C# scripting in Unity was then employed for implementing application features, while Firebase Realtime Database, Firebase Storage and Firebase authentication were utilized for data storage and user authentication. Furthermore, the Blender was using for the development of historical building's 3D model which will become the model to display in the AR mode.

Across the development process, the requirement for Android API requirements have been evolving from Android 8.0 'Oreo' to Android 10.0, necessitated by the implementation of the Native Gallery. Additionally, support for ARCore required a minimum SDK version of 24 (API Level 24) to ensure AR functionality. Configurations were made before building the project to optimize the user experience. This included setting permissions in the Android Manifest and organizing scene builds to ensure smooth navigation from the login page.

All the system operation has been shown in this chapter. The application consists of various modules, starting from the login module offering authenticated and anonymous login options. Authenticated users can register and reset passwords. The main interface allows user to search for historical buildings by name, with sorting and searching functionalities available for convenience. Users can also view detailed building information, leave comments, and access AR functionalities for immersive experiences. Bookmarking, map navigation, and change language features enhance user engagement and exploration. For guest user, they cannot bookmark or make comment, but can experience anything other than that. The project mainly focuses on provide a novel experience for users to interact with historical buildings through AR technology, with a focus on simplicity and user-friendly design. The interface has been designed in a way that make the interaction process more smoothy, ensuring users can easily adapt to the application's features.

CHAPTER 6

System Evaluation and Discussion

6.1 System Testing and Performance Metrics

Table 6.1.1 Test Case for Authentication Module

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Empty Name Sign Up	Name: NULL Email: behjiajing@1utar.my Password: 123456 Confirm Password: 123456	Display “User Name is empty” and failed to Sign Up	Display “User Name is empty” and stop the Sign Up	Pass
2	Empty Email Sign Up	Name: BEH Email: NULL Password: 123456 Confirm Password: 123456	Display “Email field is empty” and failed to Sign Up	Display “Email field is empty” and stop the to Sign Up	Pass
3	Invalid Email Sign Up	Name: BEH Email: behjiajing Password: 123456 Confirm Password: 123456	Display “Invalid Email” and failed to Sign Up	Display “Invalid Email” and stop the Sign Up	Pass

4	Existing Email Sign Up	Name: BEH Email: behjiajing@gmail.com Password: 123456 Confirm Password: 123456	Display “Email already in use” and failed to Sign Up	Display “Email already in use” and stop the Sign Up	Pass
5	Empty Password Sign Up	Name: BEH Email: behjiajing@1utar.my Password: NULL Confirm Password: 123456	Display “Password is empty” and failed to Sign Up	Display “Password is empty” and stop the Sign Up	Pass
6	Invalid Password Sign Up	Name: BEH Email: behjiajing@1utar.my Password: 1 Confirm Password: 123456	Display “Weak Password” and failed to Sign Up	Display “Weak Password” and stop the Sign Up	Pass
7	Empty Confirm Password Sign Up	Name: BEH Email: behjiajing@1utar.my Password: 123456 Confirm Password: NULL	Display “Confirm Password is empty” and failed to Sign Up	Display “Confirm Password is empty” and stop the Sign Up	Pass
9	Unmatched Password Sign Up	Name: BEH Email: behjiajing@1utar.my Password: 123456 Confirm Password: 654321	Display “Passwords do not match” and failed to Sign Up	Display “Passwords do not match” and stop the Sign Up	Pass
8	Valid Sign-Up Details Sign Up	Name: BEH Email: behjiajing@1utar.my	Display panel to notify user for complete the registration	Switch to the email verification email to remind	Pass

		Password: 123456 Confirm Password: 123456	through verification email	the user	
9	Empty Email Login	Email: NULL Password: 123456	Display “Email field is empty” and failed to Login	Display “Email field is empty” and stop the Login	Pass
10	Invalid Email Login	Email: behjiajing Password: 123456	Display “Invalid Email” and failed to Login	Display “Invalid Email” and stop the Login	Pass
11	Empty Password Login	Email: behjiajing@1utar.my Password: NULL	Display “Password is missing” and failed to Login	Display “Password is missing” and stop the Login	Pass
12	Incorrect Password Login	Email: behjiajing@1utar.my Password: 77777	Display “Password is missing or incorrect” and failed to Login	Display “Password is missing or incorrect” and stop the Login	Pass
13	Valid Login Credentials Login	Email: behjiajing@1utar.my Password: 123456	Enter the login page as authenticated user	Successful login	Pass
14	Empty or Invalid Email Password Reset.	Email: behjiajing	Display “An error occurred. Please try again later” and failed the reset password	Display “An error occurred. Please try again later” and stop the process	Pass
15	Valid Email Password Reset	Email: behjiajing@1utar.my	Display panel for reset password in email inbox	Navigate to the panel to notify continue reset and follow the instruction in inbox email	Pass
16	Guest Login		Enter the login page as anonymous user	Successful login as Guest	Pass

Table 6.1.2 Test Case for Navigation

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Main Menu Navigation	Click “MAIN” button	Enter Main Page	Successful enter Main Page	Pass
2	Favorite Navigation	Click “FAVOURITE” button	Enter Favorite Page	Successful enter Favorite Page	Pass
3	Map Navigation	Click “MAP” button	Enter Map Page	Successful enter Map Page	Pass
4	Profile Navigation	Click “PROFILE” button	Enter Profile Page	Successful enter Profile Page	Pass

Table 6.1.3 Test Case for Building Module

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	View State List	Click “MAIN” button	Display all states in Malaysia	Button of 13 States in Malaysia successful display	Pass
2	View About Us Page	Click “Info” button through option menu	Enter About Us Page	Successful enter About Us Page and display the description	Pass
3	View Building List	Click Perak state button	Display all building in Malaysia	Button of all Perak building successfully generated	Pass
4	Building List Search Function	Keywords: Taiping	Display all the building with “Taiping” in their names	Successful display all the historical building with “Taiping” in their names	Pass

5	Building List Alphabetical Sorting Function	Sort By: A-Z	The sorting working fine and display the building name in alphabetical order	Successful display the result with alphabetical order	Pass
6	Building List Rating Sorting Function	Sort By: Rating	The sorting working fine and display the building start with the highest rating	Successful display the result with descending rating order	Pass
7	Building List Period Sorting Function	Sort By: Period	The sorting working find and display the building start with the earliest construction period	Successful display the result with ascending period	Pass
8	Building List Search and Sorting Function	Keywords: Taiping Sort By: Rating	Filter out the building with "Taiping" in their name and order by highest rating	Successful get the filtered building sort in descending rating order	Pass
9	Building Info Display	Click "Taiping Clock Tower" button	Enter the Taiping Clock Tower Building Detail Page	Successful go into the page and view info such as rating, historical background, images, and review	Pass
10	Building Image Enlarge	Click one of the images in "Images" section	Display the enlarged building image	Successful load the enlarge building image	Pass
11	Authenticated User Bookmark	Building: Taiping Clock Tower (Bookmark)	Bookmark button in Black Color indicates bookmarked	Display the Black bookmark button, click it become white	Pass
12	Authenticated User Haven't Bookmark	Building: Istana Besar (Haven't Bookmark)	Bookmark button in White indicates haven't bookmark	Display the White bookmark button, click it become black	Pass

13	Guest Bookmark	Building: Kellie's Castle	No bookmark button shows	No bookmark button shows	Pass
14	Add Review	Building: Kellie's Castle Rating: 4.0 Comment: "This is very British style!"	A new record of comment added and update the total review.	Total rating update to 4. A new comment with current username is added.	Pass
15	Guest Review	Building: Taiping Clock Tower	Can only view other users' review.	Cannot make review but can view other reviews.	Pass

Table 6.1.4 Test Case for Bookmark Module

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Authenticated User Bookmark Display	Click "FAVOURITE" button	Display all the bookmarks users have save before	Successful display the Istana Besar bookmark saved just not and also other bookmark with the timestamp recorded	Pass
2	Bookmark Delete	Click delete button on "Kellie's Castle" bookmark	Kellie's Castle bookmark remove from the list	Removed Kellie's Castle bookmark from Favorite List	Pass
3	Bookmark Click	Click "The Taiping Market" bookmark	Enter The Taiping Market detail page	Successful display the detail of The Taiping Market building	Pass
4	Guest Bookmark Page	Click "FAVOURITE" button	Display text "Please Login First" and a button for user to proceed to login page	No bookmark can be display since they cannot save, display the message and button	Pass

Table 6.1.5 Test Case for AR Module

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Loading Screen Display	Click "AR Button" button	Start the loading to the AR page	Successful loads the Screen	Pass
2	Reminder Display	Finish loads the Loading Screen	After finish load the Loading Screen, will have a reminder window pop out	Success pop out reminder window with instruction attached	Pass
3	Plane Detection	Moves the camera to find robust plane	Display a square indicator shows that plane is being detected	Successful detect the plane and display the square indicator	Pass
4	3D Model display	Building: Taiping Clock Tower Click on the indicator	Show the Taiping Clock Tower oldest historical building model on the screen through camera	Successful project the 1881 Taiping Clock Tower 3D model to the screen	Pass
5	Switch Model	Building: Taiping Clock Tower Click another building button	Change the Taiping Clock Tower from 1881 to 1990 version	Successful display the Taiping Clock Tower of 1990 version	Pass
6	Scaling Function	Adjust the scale	Scroll the scale scroller and change the size of the model	Model size become bigger when scroll to right, become smaller when scroll to left	Pass
7	Rotate Function	Adjust the rotate value	Scroll the rotate scroller and change the orientation of the model	Model point to right when scroll to the right, point to left when scroll to the left	Pass

8	Reset scale and rotate	Click “reset” button	Reset the scale and rotation of the model to default value	The model’s scale and rotation return back to original	Pass
9	Remove Function	Click the “REMOVE” button	The building model will disappear from the screen	The Taiping Clock Tower being remove from the screen	Pass
10	Relocate Function	Click on another plane with indicator shows	Current building model on previous plane with disappear and appear on new location	Successful relocate the 3d model to a new location and remain only one building	Pass
11	Preview Panel	Click capture button	Display an image which user captured just now	Successful capture the image and wait for further instruction	Pass
12	Delete Captured Picture	Click trash icon	Return back to AR page without saving the image	Back to the AR page, no image found in the gallery	Pass
13	Add Captured Picture	Click save icon	Return back to AR page with the image save to the mobile gallery	Successful save the image and continue back to the AR page	Pass
14	Share Captured Picture	Click share icon	Pop out a window for user to choose which platform they want to share the image	Successful get the sharing window and choose one of it to send the image	Pass

Table 6.1.6 Test Case for Map Integration Module

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Load the map	Click "MAP" button	Load the map from Mapbox	Successful display the map	Pass
2	Drag the map	Move the map with one gesture	The map moves to the right when user swipe to the right, move to the left when user swipe to the left	Successful move the map based on the direction the user swipe to with same zoom value	Pass
3	Zooming the map	Zoom the map with two gestures	The map zooms in when user move out the fingers, the map zoom out when user put in the fingers	Successful zooming the map for both zoom in and zoom out	Pass
4	Search the historical building location	Keywords: Kellie Clicks on the search bar and select the building	Relocate the map view to the Kellie's Castle as center point	The map center moves from my current position to the Kellie's Castle coordinate	Pass
5	Display navigation line and summary info	Clicks on the Kellie's Castle marker	Draw a line from current position to the selected building and show a summary page	Successful display the navigation line from here to the Kellie's Castle with the summary of the building info	Pass

Table 6.1.7 Test Case for Profile Module

Test Case	Test Case Description	Test Data	Expected Result	Actual Result	Pass/Fail
1	Change Avatar	Click Avatar	Display Avatar Selection	Successful update the avatar after select one of it	Pass
2	Empty Name Edit Profile	Name: NULL	Display “Username is empty” and failed to Edit Profile	Display “Username is empty” and stop the Edit Profile	Pass
3	Valid Name Edit Profile	Name: Beh	Update the username and return to the Profile Page	Successful show the latest updated username in Profile Page	Pass
4	Empty Old Password Edit Password	Old Password: NULL New Password: 111111 Confirm New Password: 111111	Display “Password Field is empty” and failed to Edit Password	Display “Password Field is empty” and stop the Edit Password	Pass
5	Incorrect Old Password Edit Password	Old Password: 777777 New Password: 111111 Confirm New Password: 111111	Display “Authentication Failed”” and failed the Edit Password	Display “Authentication Failed”” and stop the Edit Password	Pass
6	Empty New Password Edit Password	Old Password: 123456 New Password: NULL Confirm New Password: 111111	Display “Password Field is empty” and failed to Edit Passwords	Display “Password Field is empty” and stop the Edit Password	Pass

7	Invalid New Password Edit Password	Old Password: 123456 New Password: 1 Confirm New Password: 111111	Display “Password format incorrect”, “Confirm Password format incorrect” and failed to Edit Passwords	Display “Password format incorrect”, “Confirm Password format incorrect” and stop the Edit Password	Pass
8	Empty Confirm Password Edit Password	Old Password: 123456 New Password: 111111 Confirm New Password: NULL	Display “Confirm Password Field is empty” and failed to Edit Passwords	Display “Confirm Password Field is empty” and stop the Edit Password	Pass
9	Unmatched Password Edit Password	Old Password: 123456 New Password: 111111 Confirm New Password: 7777777	Display “Password do not match” and stop the Edit Password	Display “Password do not match” and stop the Edit Password	Pass
10	Valid Password Edit Password	Old Password: 123456 New Password: 111111 Confirm New Password: 111111	Password being updated	Display message and successful update the password	Pass
11	Change to Chinese Language	Language: Chinese Select “CHANGE LANGUAGE”	Entire application interface changes to Chinese Language	The interface successfully changes to Chinese UI	Pass
12	Change to Malay Language	Language: Malay Select “CHANGE LANGUAGE”	Entire application interface changes to Malay Language	The interface successfully changes to Malay UI	Pass

13	Change to Tamil Language	Language: Tamil Select “CHANGE LANGUAGE”	Entire application interface changes to Tamil Language	The interface successfully changes to Tamil UI	Pass
14	Logout	Click the “LOGOUT”	Logout of the current account	Return back to Login Page to choose login method again	Pass
15	Guest User Profile Page	Click “PROFILE” button	Only have “CHANGE LANGUAGE” and “I HAVE ACCOUNT” button	Only can either change language or login	Pass

6.2 System Testing and Performance Metrics

The system testing and performance metrics for the project were conducted through quantitative usability testing with university users as participants. There are a total of 25 users participated in the testing, providing valuable feedback on the application's reliability and user experience.

Based on the survey data in Appendix B, the majority of users rated the application as good to excellent, indicating satisfaction with its usability. However, some users faced bad experiences, it may be due to the issue on AR plane detection where if the plane is not robust may need to take some time to detect. Regarding the guest mode feature, most users expressed a positive response, stating it would provide a faster and easier start to using the application. The testing application still don't have enough data to compare to the existing website, some users felt that the application lacked comprehensive information on historical buildings, the majority found the available information sufficient.

Although not all users were rejected to leave comments and ratings, they valued and appreciated the presence of these features to aid in their future travel planning. Despite the application is new to them, most user viewed it as a reliable source of travel information, indicating confidence in its usability and functionality. User particularly appeals to the existing of AR, the AR technology's immersive experience and features like bookmarking and map navigation beneficial for exploring historical sites. However, still have small portions of users encountered difficulties with navigation. Feedback on personalized options, such as avatar customization and language selection, was positive, shows the user satisfaction with these features. Suggestions from participants regarding the future enhancements will be the improvement on the 3D models interaction and expanding the database of historical places and corresponding information.

Overall, the feedback from users indicated high satisfaction with the application, which proves its reliability and usability.

6.3 Project Challenges

Throughout the project development, several challenges and issues has been raised, primarily comes from the adoption of new technologies. When first kick start of the project, there was a lack of familiarity with AR platforms, which we requires to conduct extensive research to identify the most suitable development platform. Ultimately, Unity was chosen for its versatility in implementing both AR features and mobile application development. To build up the knowledge and understanding how it works, tutorials on online platforms were sought to acquire the practical skills for integrating AR functionalities into the Unity environment.

Another significant challenge will be the selection of historical building for 3D model creation. Building accurate, real-world-sized models is complex and requires spending a lot of time, especially the time to learn the Blender, which is a sophisticated 3D model tool. I then start the first building model creation with Taiping Clock Tower, a historical building from my hometown and I more familiar with. Importing these models later into Unity also posed additional hinders, but luckily, we able to overcome the issue by using the glTFast (Graphics Library Transmission Format) and import it in glTF format for integration.

The next issues will be the implementation of mapping functionality. Initially I start with the API of Google Maps, but later discover the limitations of API does align with the functionality I wish to implement in the project. Transitioning to the Mapbox SDK offered a grater flexibility and functionality, then I only able to continue working on it. Moreover, integrating of additional plugins like Native Share and Native Gallery also cause some challenges to the project, where it require us to adjust the Android version when want to facilitate successful APK builds. Although these challenges cause some delay in project development, but luckily the problem is able to solve and provided a valuable learning experience for us.

6.4 Objective Evaluation

1. **Development of a mobile application with AR technology**

   The mobile application successfully integrates AR technology, enable the users to experience it in AR environments. While user not familiar with the historical buildings, different appearances of the buildings is able to be shown and interaction with the historical buildings can build more memorable memories despite haven't experience it before.

2. **Preservation and documentation of historical buildings.**

   The application has properly collected the correct data and present it in an interesting way for users to view, contributing to their preservation and documentation. The user also able to get the view of historical buildings' coordinate visually through map for them to know where it located.

3. **High accessibility and interaction**

   The availability of different login can increase the usage selection, whether they want to have more customize or easier access method. Then through reviews, AR image sharing, bookmarking, and language customization, the application enhances user interaction and accessibility, ensuring a rich user experience.

Based on the verification with the project objectives in Chapter 1, we able to successfully achieve all of the objectives.

6.5 Concluding Remark

In this chapter, thorough testing on the application system was performed to ensure the correct functioning of each module. Testing was conducted from the perspectives of two roles, which are authenticated user and anonymous user. Different modules was covered for the testing, such as Authentication module, Building module, AR module, Bookmark module, Map Integration module, and Profile module. Detail and complete test cases were setup for guarantee the performance and quality of each module, make sure it works as expected.

Following the completion of system testing step, we proceed to the practical testing with actual users. There are 25 users join as participants for the application testing. Quantitative usability testing was applied to collect their feedback through survey after using and interact with the application for data analysis purpose. Overall, user expressed positive feedback after using the application, especially satisfy with the incorporation of AR technology. However, some of them suggest potential improvements, including the addition of more detailed content and more 3D models to enrich the user experience.

Other than that, several challenges faced along the development of the application has been listed. These challenges included navigating the unfamiliar terrain of AR technology at the beginning of the development phase, difficulty in creating the 3D models and incorporates it into the Unity., the consideration for the update of minimum android version due to the implementation of new functionality, and the map selection to continue the development of map module. Due to the development requirement, the decision has been making switching from the Google Maps API to the Mapbox SDK. Each of these challenges requires a long time to study and figures out how to solve the problem. But in the end, everything is able to be solve and works well.

CHAPTER 7
Conclusion and Recommendation

7.1 Discussion

Augmented Reality technology continues to evolve and remains a trend in the novel technology of application development even in 2024. Various industries have begun the utilization of AR to enhance their operation and bring convenience to themselves. Despite this, Malaysia still has yet to discover the potential of historical application that able to serve for both data preservation and AR technology combination to create engaging experience for users. This is where I get the idea of the creation of HB Project, which aimed at preserving Malaysia's heritage assets while tapping into emerging trends to attract younger audience.

The HB Project has seen to be quite success, where it addresses the challenge of local visitation limitations while offering diverse functionalities to keep users engaged. The inclusion of a map feature facilitates navigation to historical buildings, while the creation of 3D models enables users to view and interact with detailed representations of these structures in augmented reality environments. Quantitative testing results even proved users' satisfaction with the AR functionality, highlighting the potential of AR to stimulate users in Malaysia's rich heritage landscape and foster deeper engagement.

7.2 Novelty of the Project

Historical heritage holds significant important for a country, serving as a testament to its rich cultural and architectural legacy. However, factors such as the aftermath of the MCO, geographical distance, and the unfortune occurrence of demolitions or repair works often hinder people from visiting these invaluable sites. To solve the problem, the proposed application aims to serve as a comprehensive hub for historical building data, catering to individuals seeking travel experiences enriched with historical insights.

The project has focus on integration of AR technology, offering users the ability experience historical sites anytime, anywhere. Through AR, users can engage with historical buildings in a dynamic and interactive manner. Functions such as scrolling, rotating, and model selection further improve the user engagement and exploration to the architectural evolution of these buildings, providing a deeper understanding of their historical significance. Moreover, the image capture function enables users to capture and share their AR experiences with friends and peers, thereby extending the influence and reach of the application within the Malaysian community.

In consideration of the diverse user base and requirements, the application tends to cater to different peoples, offering flexibility in usage. Tour guides for example, they can utilize the guest login feature to introduce the application to their passengers, providing them with a unique and memorable way to learn about historical buildings during tours. Besides, regular users have the option to login as authenticated or anonymous users based on their preferences, ensuring a personalized experience and flexibility tailored to their needs.

Furthermore, the inclusion of a map feature not only assists users in locating historical buildings but also serves as a GPS navigation tool during actual visits. Given that some historical buildings may not be accurately represented on platforms like Google Maps, the application offers an exclusive built-in map with real-time tracking capabilities, addressing the limitations of existing mapping services and enhancing the overall user experience. Overall, the proposed application successfully bridge the connection between individuals and historical heritage using AR technology.

7.3 Future Work

Current application have done the basic requirement to algin with the project objectives, there are still some recommendations for the future development of the project.

1. **Expansion of Historical Data and the 3D models**

   Increasing the number of historical buildings in the database and other detail info such as the operation time and status will be helpful for the users. Besides, enhancing the level of detail in the 3D models will provide users with a more comprehensive experience. Collaborating with local expert can further ensure the correctness of the historical data accuracy.

2. **Improvements in AR Functionality**

   Implementing features such as virtual guided tours with story telling elements and interactive quizzes will enrich the AR experience. This will make the application more engaging and educational for users interested in exploring historical sites.

3. **Enhanced Personalization and Community Engagement**

   Allowing users to post images or videos, participate in discussions, and share their experiences with others can foster a sense of community within the application easier compared to current rating and comment sections. This will encourage user engagement in sharing their experiences.

4. **Gaming Elements Implementation**

   Introducing gamification elements can also be a way to attract the people in using the application in a relax yet educational way. One of the examples is the treasure hunt AR games based on historical sites, can make the exploration process more enjoyable and interactive. Gamified experiences will appeal to a wider audience and encourage repeat usage of the application.

5. **Admin Role Implementation**

   Adding an admin role will make sure the flow of updating and managing data within the application. So, no need to add the data through firebase because admin can easily add new historical buildings data, update information, or perform any action directly through the application interface.

7.4 Conclusion

The project gaining a deep understanding of current historical buildings situation in Malaysia. After the study, we identify the problem and challenges faced during the historical building conservation such as unproper protection by government bodies, changing in historical buildings appearance, air pollution issues, and the gradually decrease in the connection between public and historical heritage. The project objectives are aimed to solve these problems through the generation of AR mobile applications to enables the construction of historical buildings model to real world environments and give a proper documentation of related historical backgrounds information, which will eventually benefit the public through high accessibility and provide the interaction with these precious treasures.

The project defines six modules after performing the literature review to create a better application, which are AR Module, Building Module, Authentication Module, Map Integration Module, Bookmark Module, and Profile Module. The application is developed through the Agile Development method, we first have conducted the survey to collect functional requirements, followed by the creation of various diagram such as system architecture diagram, use case diagram, activity diagram, wireframe, and so on. These diagrams served the purpose of designing how each component will looks like and built the interconnections between components. Then only start the development process based on the predefined project timeline.

In result, we successfully to complete the project on schedule. The entire testing, consists of both system performance testing and quantitative usability testing, was conducted to ensure performance, and gather authentic user feedback. Additionally, discussions were held to ensure alignment with defined objectives and propose potential growth spaces for future development.

REFERENCES

[1] "The importance of preserving and promoting historic buildings," Norwalk Tomorrow, August 30, 2019. [Online] Available: https://tomorrow.norwalkct.org/news/importance-preserving-promoting-historic-buildings/ [Accessed Sep. 7, 2023].

[2] M. Thatcher, "Introduction: The state and historic buildings: preserving 'the national past,'", January 2018. [Online] Available: https://www.researchgate.net/publication/322104824_Introduction_The_state_and_historic_buildings_preserving_'the_national_past' [Accessed Sep. 7, 2023].

[3] A. Welengoda, "7 reasons it's important to undertake historical building restoration," SCE, [Online] Available: https://www.stonecleaningexperts.co.uk/blog/reasons-historical-building-restoration/ [Accessed Sep. 7, 2023].

[4] S. Chaneac, "14 interesting facts about Malaysia," Nomadic Boys, June 12, 2023. [Online] Available: https://nomadicboys.com/interesting-facts-about-malaysia/#:~:text=Malaysia%20is%20famous%20for%20being [Accessed Sep. 7, 2023].

[5] A. O. Alkhamisi and M. M. Monowar, "Rise of augmented reality: Current and future application areas," October 12, 2013. [Online] Available: https://www.researchgate.net/publication/276494825_Rise_of_Augmented_Reality_Current_and_Future_Application_Areas/fulltext/5ac91a670f7e9bcd519749db/Rise-of-Augmented-Reality-Current-and-Future-Application-Areas.pdf [Accessed Sep. 7, 2023].

[6] J. K. Ford and T. H. Höllerer, "Augmented reality and the future of virtual workspaces," January 2008, [Online] Available: https://www.researchgate.net/publication/289618555_Augmented_reality_and_the_future_of_virtual_workspaces [Accessed Sep. 7, 2023].

[7] S. C. Y. Yuen, G. Y. yune yong, and Erik Johnson, Augmented reality: An overview and five directions for AR in education, 2011, [Online] Available: https://aquila.usm.edu/cgi/viewcontent.cgi?article=1022&context=jetde [Accessed Sep. 7, 2023].

[8] A. Javornik, “The mainstreaming of augmented reality: A brief history,” Harvard Business Review, October 4, 2023, [Online] Available: https://hbr.org/2016/10/the-mainstreaming-of-augmented-reality-a-brief-history [Accessed Sep. 7, 2023].

[9] Y. E. Filali and S. -ddine Krit, “Augmented Reality types and popular use cases - scitepress.org,” [Online] Available: https://www.scitepress.org/Papers/2018/97763/97763.pdf [Accessed Sep. 7, 2023].

[10] T. Alsop, “Global Mobile Augmented Reality (AR) user devices 2024,” Statista, [Online] Available: https://www.statista.com/statistics/1098630/global-mobile-augmented-reality-ar-users/ [Accessed Sep. 7, 2023].

[11] A. K. Azmin, M. H. Kassim, F. Abdullah, and A. N. Zafirah Sanusi, “ARCHITECTURAL HERITAGE RESTORATION OF RUMAH DATUK SETIA VIA MOBILE AUGMENTED REALITY RESTORATION,” View of architectural heritage restoration of Rumah Datuk Setia via mobile augmented reality restoration, 2017, [Online] Available: https://planningmalaysia.org/index.php/pmj/article/view/229/209 [Accessed Sep. 7, 2023].

[12] Z. Noh, M. S. Sunar, and Z. Pan, “A review on augmented reality for Virtual Heritage System,” SpringerLink, 2009, [Online] Available: https://link.springer.com/chapter/10.1007/978-3-642-03364-3_7 [Accessed Sep. 7, 2023].

[13] N. Z. M. Azizi, A. A. Razak, M. A. M. Din, and N. M. Nasir, “Recurring issues in historic building conservation,” Procedia - Social and Behavioral Sciences, 23 June 2016, [Online] Available: https://www.sciencedirect.com/science/article/pii/S1877042816302944?ref=pdf_download&fr=RR-2&rr=7f4c5f54efc43fd1 [Accessed Sep. 7, 2023].

[14] National Heritage Act, 2005 (act no. 645)., [Online] Available: https://www.ecolex.org/details/legislation/national-heritage-act-2005-act-no-645-lex-faoc130377/ [Accessed Sep. 7, 2023].

[15] T. Avineshwaran, “DBKL demolishes part of 101-year-old Hindu Temple, mic’s T. Mohan, PKR’s Jayathas detained,” The Star, 01 September 2013,

[Online] Available: https://www.thestar.com.my/News/Nation/2013/09/01/DBKL-demolishes-101-year-old-Hindu-temple/ [Accessed Sep. 7, 2023].

[16] C. M. Mei, "150-year-old Wong Ah Fook Mansion in Johor Bahru secretly demolished - says," Says, 05 May 2014, [Online] Available: https://says.com/my/news/150-year-old-wong-ah-fook-mansion-in-johor-bahru-secretly-demolished [Accessed Sep. 7, 2023].

[17] S. Selan, "7 facts about pudu jail that's often left out of history books," TheSmartLocal Malaysia - Travel, Lifestyle, Culture & Language Guide, 29 April 2022, [Online] Available: https://thesmartlocal.my/pudu-jail-facts/ [Accessed Sep. 7, 2023].

[18] S. N. Harun, "Heritage Building Conservation in Malaysia: Experience and challenges," Procedia Engineering, 2011, [Online] Available: https://www.sciencedirect.com/science/article/pii/S1877705811029468?ref=pdf_download&fr=RR-2&rr=7f4fc72afafeab5c [Accessed Sep. 7, 2023].

[19] "Air pollution puts cultural heritage at risk," UNECE, Mar 13, 2015, [Online] Available: https://unece.org/environment/news/air-pollution-puts-cultural-heritage-risk [Accessed Sep. 7, 2023].

[20] "Five reasons why we need historical building restoration," Concrete Renovations, Sep 28, 2019, [Online] Available: https://www.concreterenovations.co.uk/news/five-reasons-why-we-need-historical-building-restoration/ [Accessed Sep. 7, 2023].

[21] K. S. Kamal, A. W. Lilawati, and A. G. B. Ahmad, Pilot survey on the conservation of historical buildings in Malaysia, Jan 2008, [Online] Available: https://www.researchgate.net/publication/46445620_Pilot_Survey_On_The_Conservation_Of_Historical_Buildings_In_Malaysia [Accessed Sep. 7, 2023].

[22] S. B. M, "Historical buildings in sad state of disrepair," The Star, Mar 27, 2017, [Online] Available: https://www.thestar.com.my/metro/community/2017/03/27/historical-buildings-in-sad-state-of-disrepair [Accessed Sep. 7, 2023].

[23] U. L. Halim and N. Tambi, Awareness of Community on the Conservation of Heritage Buildings in George Town, Penang, 2021, [Online] Available: https://www.researchgate.net/publication/351639594_AWARENESS_OF_CO

MMUNITY_ON_THE_CONSERVATION_OF_HERITAGE_BUILDINGS_IN_GEORGE_TOWN_PENANG [Accessed Sep. 7, 2023].

[24] Pokémon go, https://pokemongolive.com/?hl=en [Accessed Sep. 7, 2023]

[25] V. Vlahakis, N. Ioannidis, J. Karigiannis, M. Tsotros, M. Gounaris, L. Almeida, D. Stricker, T. Gleue, I. T. Christou, and R. Carlucci, "Archeoguide: first results of an augmented reality, mobile computing system in cultural heritage sites," Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage - VAST '01, 2001.

[26] D. Stricker, A. Pagani, and M. Zoellner, "In-situ visualization for cultural heritage sites using novel Augmented Reality Technologies," Virtual Archaeology Review, vol. 1, no. 2, p. 37, 2010.

[27] S. Rofiah, D. Sukma, R. T. Handayanto, H. Herlawati, S. Solikin, and D. Setiyadi, "Mobile-based augmented reality for historic- building lessons in West Java," 2019 Fourth International Conference on Informatics and Computing (ICIC), 2019.

[28] E. M. Tomilina, E. V. Gontar, and M. A. Frolova, "The use of augmented reality technology in the reconstruction of a lost Cultural Heritage Site," IOP Conference Series: Materials Science and Engineering, vol. 945, no. 1, p. 012065, 2020.

[29] L. L. Kei, C. K. Tai, C. C. Man, L. P. Yu, T. S. Wing, and W. N. In, "An Intelligent Augmented Reality Mobile Application for Heritage Conservation Education," 2021. [Online]. Available: http://ceur-ws.org/Vol-3080/1.pdf. [Accessed Sep. 7, 2023]

[30] "London history Ar," Octagon Studio, https://octagon.studio/portfolio/london-history-ar/ [Accessed Sep. 7, 2023].

[31] A. Aziz, A brief comparison of SDLC Models, April 2012, [Online] Available: https://www.researchgate.net/publication/271834029_Brief_comparison_of_SDLC_models [Accessed Sep. 7, 2023].

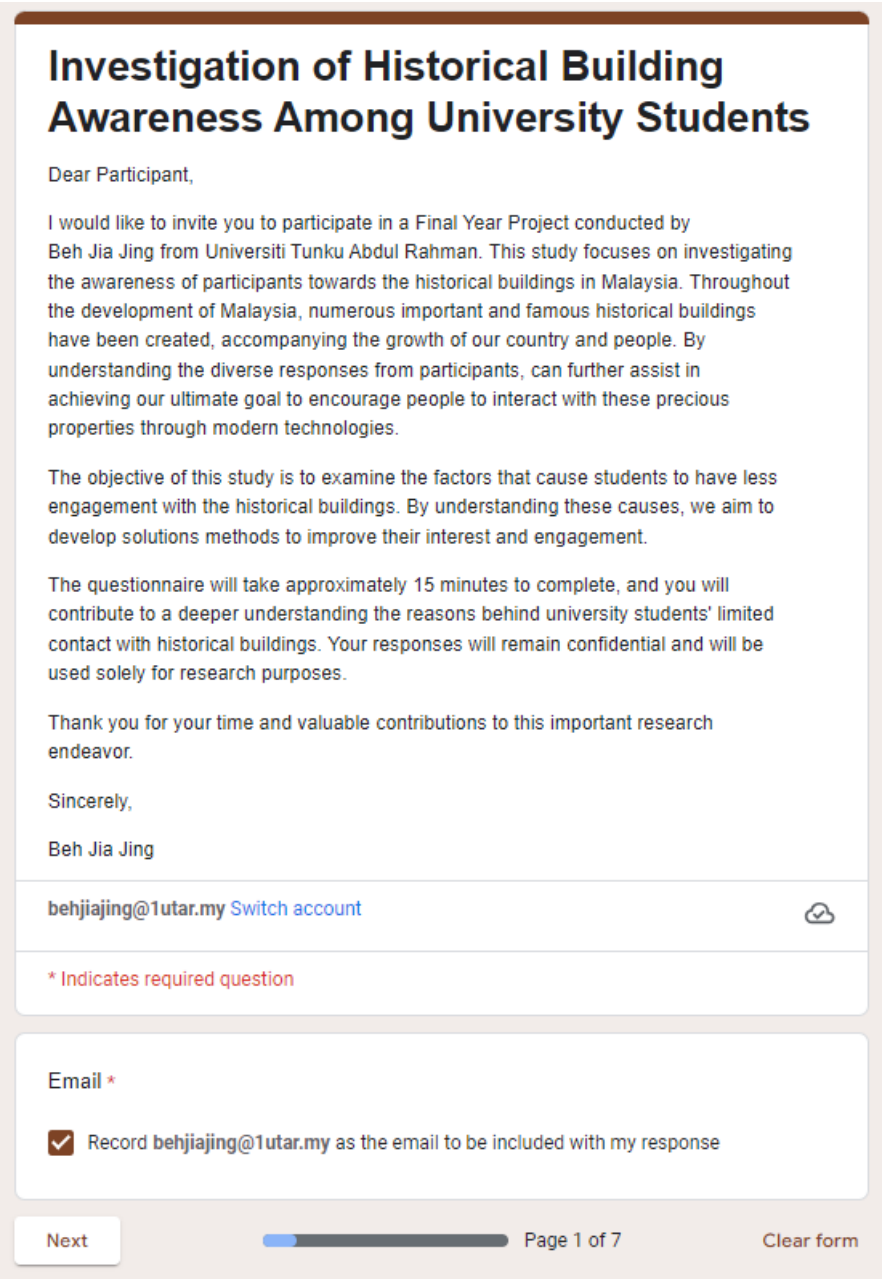
[32] A. Dennis, B.H. Wixom, and D. Tegarden, Systems Analysis & Design: An Object-Oriented Approach With UML, 6th ed. Hoboken, NJ : Wiley, 2021

[33] L. Quick, “Rad Vs Agile: Which one is right for you?,” KnowledgeHut, Sep 5 2023, [Online] Available: https://www.knowledgehut.com/blog/agile/rad-vs-agile [Accessed Sep. 7, 2023].

[34] Person, “Rapid application development (RAD): Definition, Steps & Full Guide,” Kissflow, Aug 17, 2023, [Online] Available: https://kissflow.com/application-development/rad/rapid-application-development/ [Accessed Sep. 7, 2023].

[35] Bibliobibuli, “The tragic end of Bok House,” The Tragic End of Bok House, Dec 22, 2006, [Online] Available: http://thebookaholic.blogspot.com/2006/12/tragic-end-of-bok-house.html [Accessed Sep. 7, 2023].

Appendix A: Functional Requirements Investigation



Investigation of Historical Building Awareness Among University Students

Dear Participant,

I would like to invite you to participate in a Final Year Project conducted by Beh Jia Jing from Universiti Tunku Abdul Rahman. This study focuses on investigating the awareness of participants towards the historical buildings in Malaysia. Throughout the development of Malaysia, numerous important and famous historical buildings have been created, accompanying the growth of our country and people. By understanding the diverse responses from participants, can further assist in achieving our ultimate goal to encourage people to interact with these precious properties through modern technologies.

The objective of this study is to examine the factors that cause students to have less engagement with the historical buildings. By understanding these causes, we aim to develop solutions methods to improve their interest and engagement.

The questionnaire will take approximately 15 minutes to complete, and you will contribute to a deeper understanding the reasons behind university students' limited contact with historical buildings. Your responses will remain confidential and will be used solely for research purposes.

Thank you for your time and valuable contributions to this important research endeavor.

Sincerely,

Beh Jia Jing

behjiajing@1utar.my Switch account

* Indicates required question

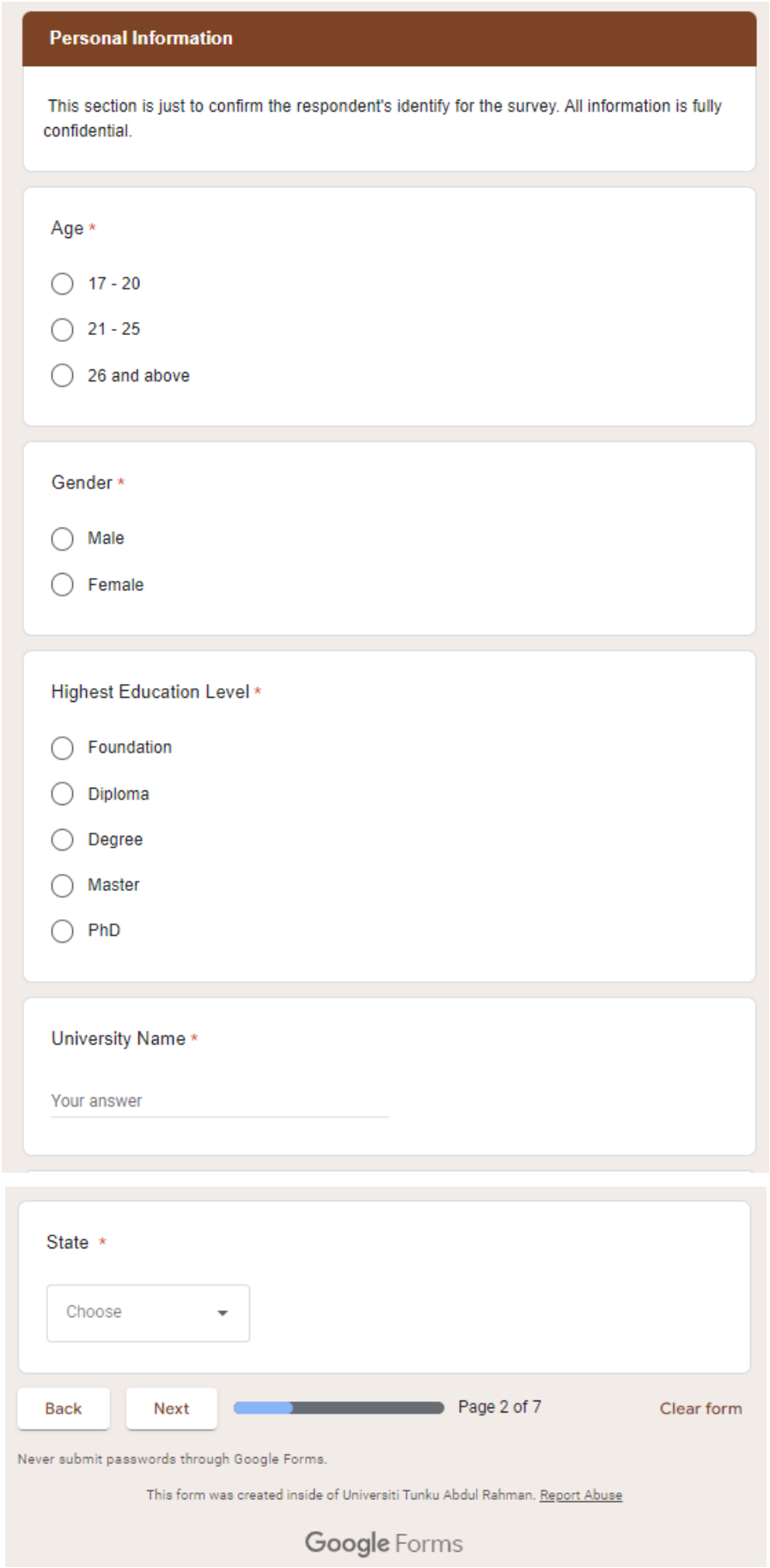
Email *

Record behjiajing@1utar.my as the email to be included with my response

Next

Page 1 of 7

Clear form



Personal Information

This section is just to confirm the respondent's identify for the survey. All information is fully confidential.

Age *

- 17 - 20
- 21 - 25
- 26 and above

Gender *

- Male
- Female

Highest Education Level *

- Foundation
- Diploma
- Degree
- Master
- PhD

University Name *

Your answer

State *

Choose

Back Next Page 2 of 7 Clear form

Never submit passwords through Google Forms.

This form was created inside of Universiti Tunku Abdul Rahman. Report Abuse

Google Forms

Understanding of Habits and Basic Background

Historical Buildings refers to buildings that are considered to have a particular historical or architectural significance. (FastBuildSupplies, 2022)

1. Have you visited any historical buildings before? *

- ◯ Yes
- ◯ No
- ◯ Maybe

2. If you answer 'Yes' in Q1, please list out the name of the buildings you remember. (Format: Building1, Building 2, …)

Your answer

3. Do you still live in Malaysia? *

- ◯ Yes
- ◯ No
- ◯ Other: _____

4. Based on the state you live, please list out the local historical buildings that you know. (Format: Building1, Building 2, …) *

Your answer

5. How often do you visit historical buildings? *

- ◯ Never

5. How often do you visit historical buildings? *

- ◯ Never
- ◯ Occasionally
- ◯ Sometimes
- ◯ Often
- ◯ Always

6. Visit to these buildings increase your interest to know their historical background. *

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

7. I visit historical landscapes only because of *

- ◯ Participated in a trip with a scheduled itinerary
- ◯ I am curious about everything about these places
- ◯ Invited by my relatives and friends
- ◯ Never visit any of them
- ◯ Other: _____

8. What are the reasons that stop you from exploring these ancient buildings in Malaysia? *

- ◯ I don't have any info about the places that have historical buildings
- ◯ The historical buildings are located too far
- ◯ The process is very time-consuming and exhausted
- ◯ I never have any interest to begin with
- ◯ I only interest in the historical buildings outside of Malaysia
- ◯ Other: _____

9. I usually get information of historical places through *

- ☐ Social Media
- ☐ Television
- ☐ My relatives and friends
- ☐ Newspaper
- ☐ None
- ☐ Other: _____

10. How often do you use technology (online resources, websites, social media) to get information of historical buildings *

- Never
- Occasionally
- Sometimes
- Often
- Always

Back Next Page 3 of 7 Clear form

Never submit passwords through Google Forms.

Understanding of Historical Building Knowledge

The following questions will list out some of the historical building in Malaysia.

11. How would you rate your knowledge of historical buildings in Malaysia? *

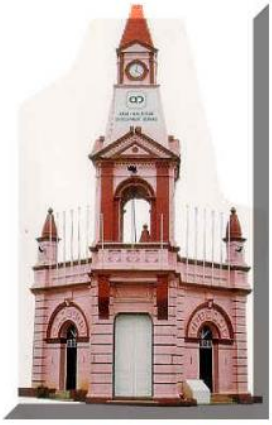
- Very Poor
- Poor
- Average
- Good
- Excellent

12. Do you recognize which buildings this is? [1] *

- Melaka Sultanate Palace Museum
- Kedah Royal Museum
- Muzium Diraja Kuala Kangsar

- ◯ Melaka Sultanate Palace Museum
- ◯ Kedah Royal Museum
- ◯ Muzium Diraja Kuala Kangsar
- ◯ Muzium Sultan Abu Bakar

13. Do you recognize which buildings this is? [2] *

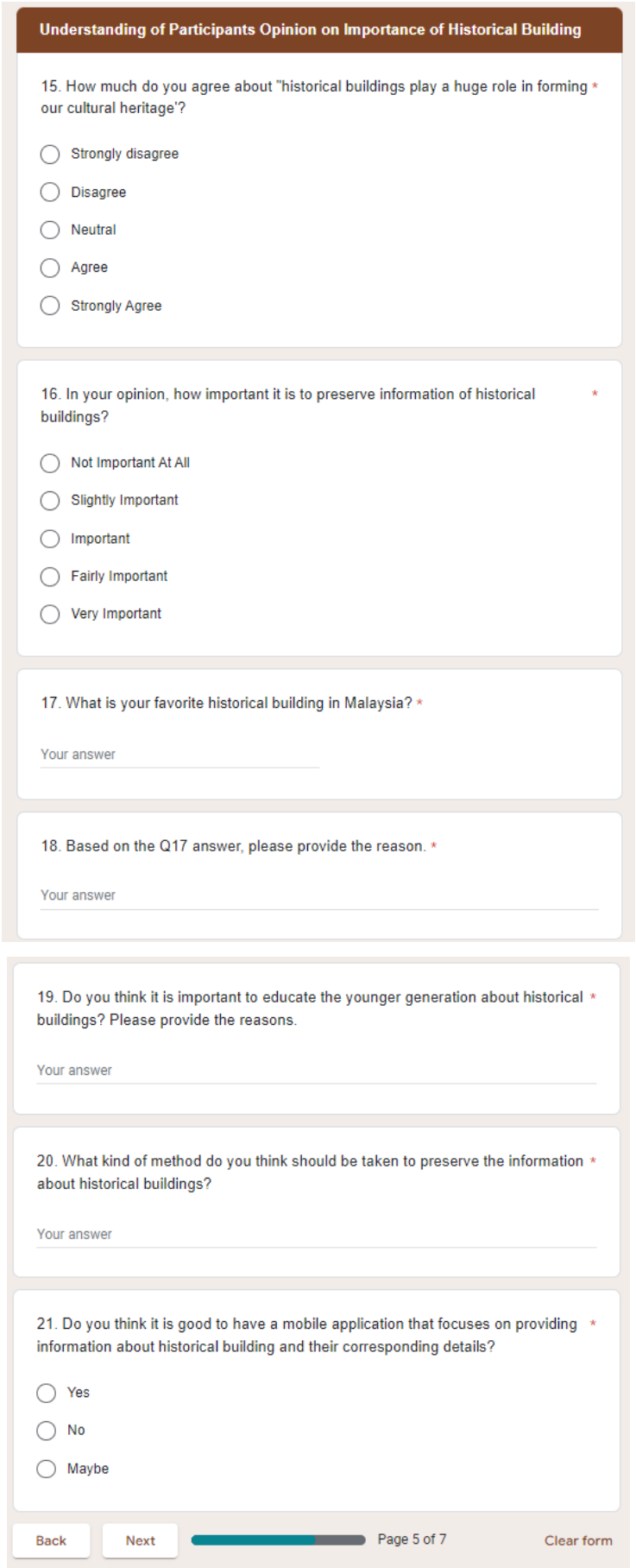


- ◯ Sultan Abdul Samad Building Clock Tower
- ◯ Birch Memorial Clock Tower
- ◯ Tang Beng Swee Clock Tower
- ◯ The Taiping Clock Tower

14. Do you recognize which buildings this is? [3] *

- ◯ Wong Ah Fook Mansion
- ◯ Bok House
- ◯ Chung Keng Kwee's Residence
- ◯ Pinang Peranakan Mansion

Back Next Page 4 of 7 Clear form



Understanding of Participants Opinion on Importance of Historical Building

15. How much do you agree about "historical buildings play a huge role in forming our cultural heritage'? *

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

16. In your opinion, how important it is to preserve information of historical buildings? *

- ◯ Not Important At All
- ◯ Slightly Important
- ◯ Important
- ◯ Fairly Important
- ◯ Very Important

17. What is your favorite historical building in Malaysia? *

Your answer

18. Based on the Q17 answer, please provide the reason. *

Your answer

19. Do you think it is important to educate the younger generation about historical buildings? Please provide the reasons. *

Your answer

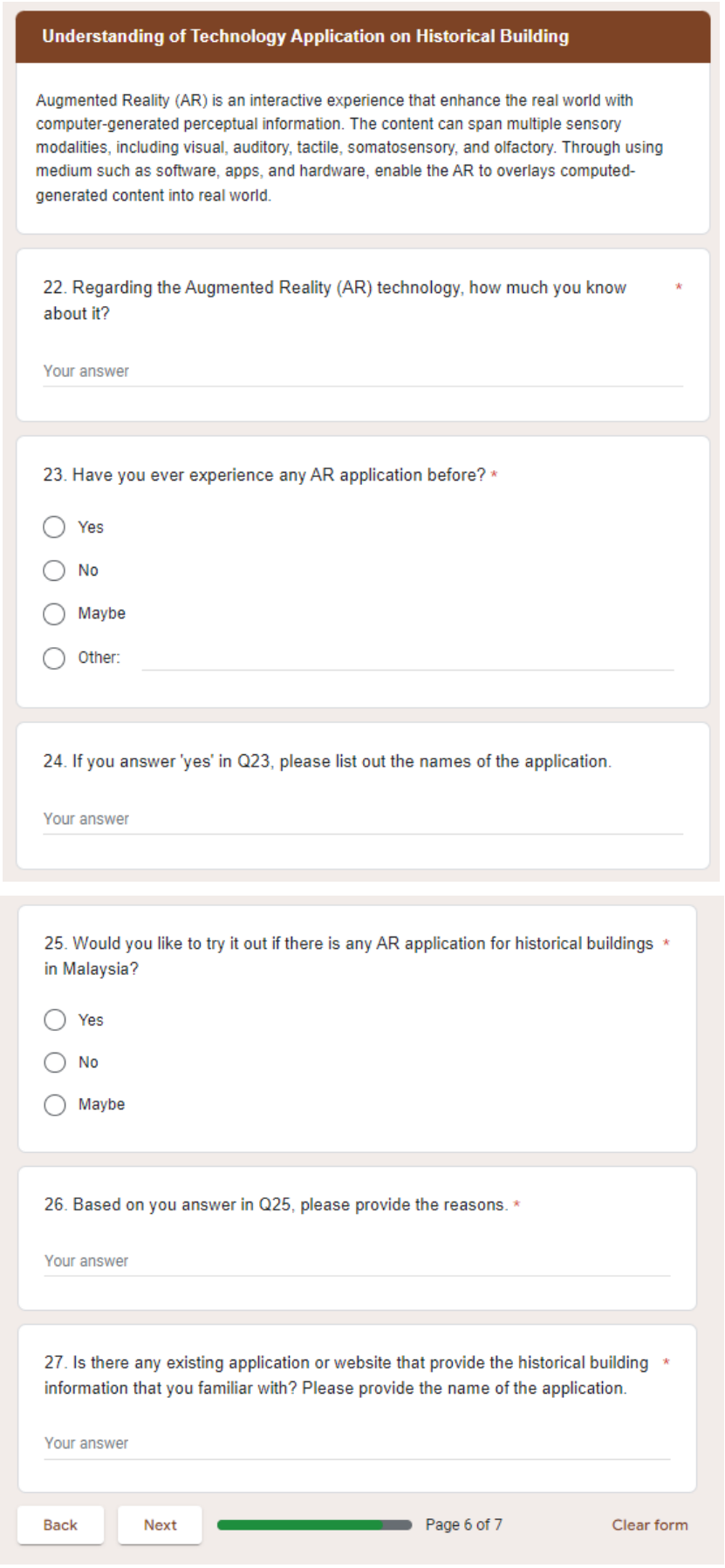
20. What kind of method do you think should be taken to preserve the information about historical buildings? *

Your answer

21. Do you think it is good to have a mobile application that focuses on providing information about historical building and their corresponding details? *

- ◯ Yes
- ◯ No
- ◯ Maybe

Back Next Page 5 of 7 Clear form



Understanding of Technology Application on Historical Building

Augmented Reality (AR) is an interactive experience that enhance the real world with computer-generated perceptual information. The content can span multiple sensory modalities, including visual, auditory, tactile, somatosensory, and olfactory. Through using medium such as software, apps, and hardware, enable the AR to overlays computed-generated content into real world.

22. Regarding the Augmented Reality (AR) technology, how much you know about it? *

Your answer

23. Have you ever experience any AR application before? *

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Other:

24. If you answer 'yes' in Q23, please list out the names of the application.

Your answer

25. Would you like to try it out if there is any AR application for historical buildings in Malaysia? *

- ◯ Yes
- ◯ No
- ◯ Maybe

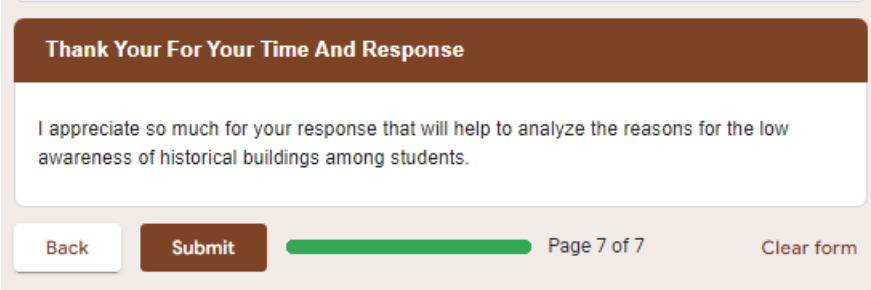
26. Based on you answer in Q25, please provide the reasons. *

Your answer

27. Is there any existing application or website that provide the historical building information that you familiar with? Please provide the name of the application. *

Your answer

Back Next Page 6 of 7 Clear form


Thank Your For Your Time And Response
I appreciate so much for your response that will help to analyze the reasons for the low awareness of historical buildings among students.
Back
Submit
Page 7 of 7
Clear form

Appendix B: Survey Questionnaire

HB Project Survey Among University Students

Dear Participant,

I would like to invite you to participate in a Final Year Project conducted by Beh Jia Jing from Universiti Tunku Abdul Rahman. This study aims to gather feedback from participants who have experienced the HB project. Your response is crucial in evaluating the performance of our application.

The questionnaire will take approximately 5-10 minutes to complete. Your responses will remain confidential and will be used solely for research purposes.

Thank you for your time and valuable contributions to this important research endeavor.

Sincerely,

Beh Jia Jing

behjiajing@1utar.my Switch account

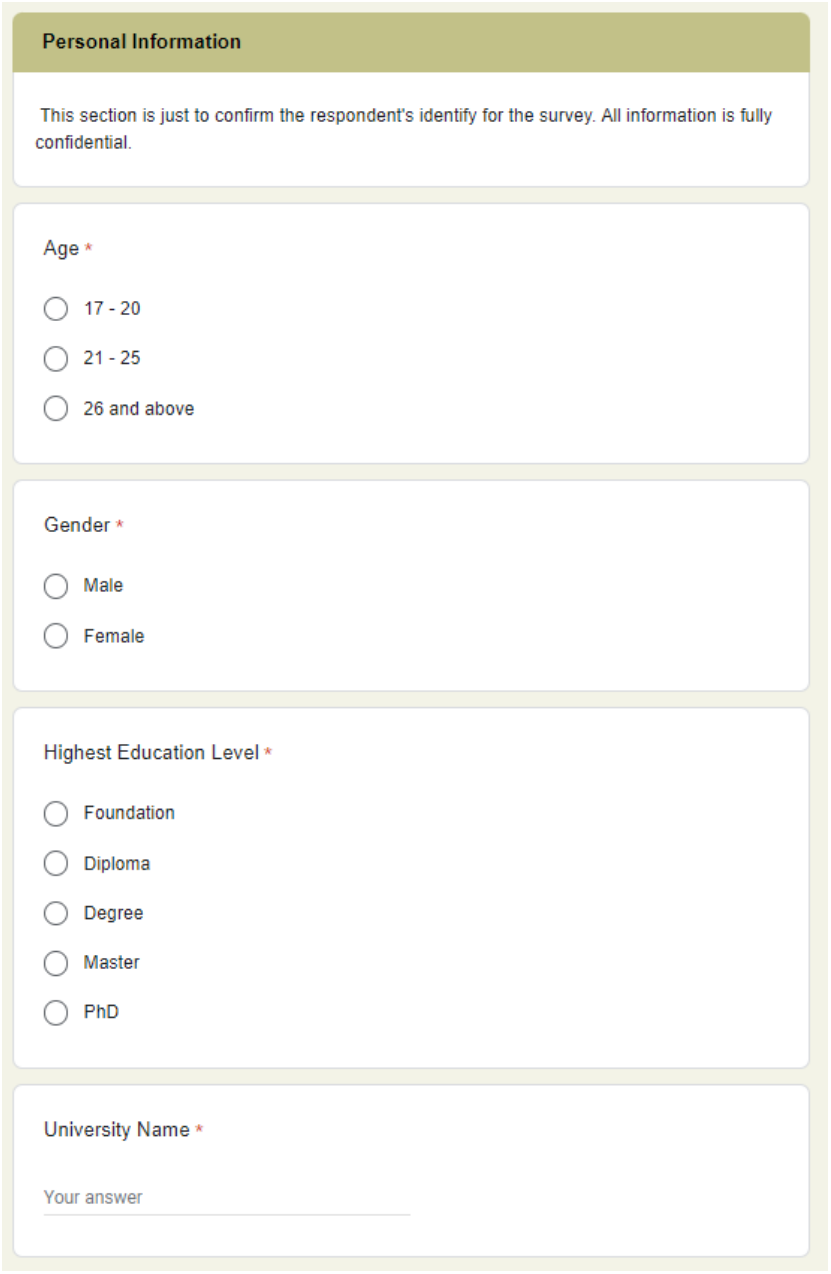
* Indicates required question

Email *

Record **behjiajing@1utar.my** as the email to be included with my response

Next Page 1 of 4 Clear form

Never submit passwords through Google Forms.



Personal Information

This section is just to confirm the respondent's identify for the survey. All information is fully confidential.

Age *

- ○ 17 - 20
- ○ 21 - 25
- ○ 26 and above

Gender *

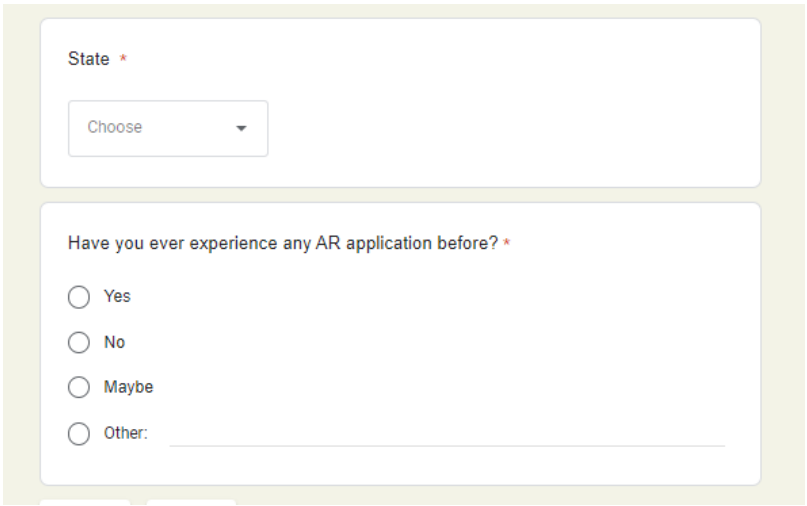
- ○ Male
- ○ Female

Highest Education Level *

- ○ Foundation
- ○ Diploma
- ○ Degree
- ○ Master
- ○ PhD

University Name *

Your answer



State *

Choose

Have you ever experience any AR application before? *

- ○ Yes
- ○ No
- ○ Maybe
- ○ Other:

Participants Data Collection

1. How would you rate our application after using it? *

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

2. Do you think it is convenience to have the option to login as a Guest? *

- ◯ Yes
- ◯ No
- ◯ Other: _____

3. How satisfied are you with the ease of finding the historical building you desired? *

	1	2	3	4	5	
Very Dissatisfied	◯	◯	◯	◯	◯	Very satisfied

4. Did you find the information provided about historical buildings comprehensive and informative? *

	1	2	3	4	5	
Not comprehensive	◯	◯	◯	◯	◯	Very Comprehensive

5. Did you enjoy giving comments and ratings to historical buildings? *

	1	2	3	4	5	
Not enjoyable at all	◯	◯	◯	◯	◯	Very enjoyable

6. Did you find the rating of historical buildings to be a reliable reference for you to decide to visit them? *

	1	2	3	4	5	
Not reliable	○	○	○	○	○	Very reliable

7. Do you consider this application a reliable source when searching for new places to travel? *

	1	2	3	4	5	
Not reliable	○	○	○	○	○	Very reliable

8. How satisfied are you with the AR functionality of our project? *

	1	2	3	4	5	
Very Dissatisfied	○	○	○	○	○	Very satisfied

9. Did you enjoy interacting with the buildings in the AR environment? *

	1	2	3	4	5	
Not enjoyable	○	○	○	○	○	Very enjoyable

10. Do you find bookmark feature convenience for faster navigation? *

	1	2	3	4	5	
Not convenient	○	○	○	○	○	Very convenient

11. How helpful do you think the map integration feature is for locating historical buildings?

	1	2	3	4	5	
Not helpful	○	○	○	○	○	Very helpful

12. Were you able to easily navigate to the desired historical buildings using the map functionality? *

	1	2	3	4	5	
Not easy	○	○	○	○	○	Very easy

13. How satisfied are you with the customization options available in the profile module? *

	1	2	3	4	5	
Very Dissatisfied	○	○	○	○	○	Very satisfied

14. Did you encounter any difficulties while using the application? *

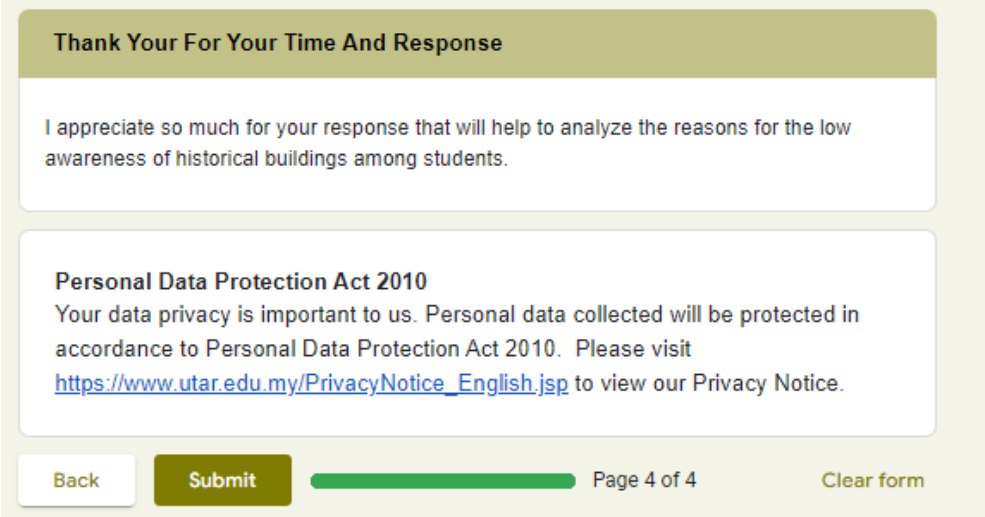
- ○ Yes
- ○ No
- ○ Other: _____

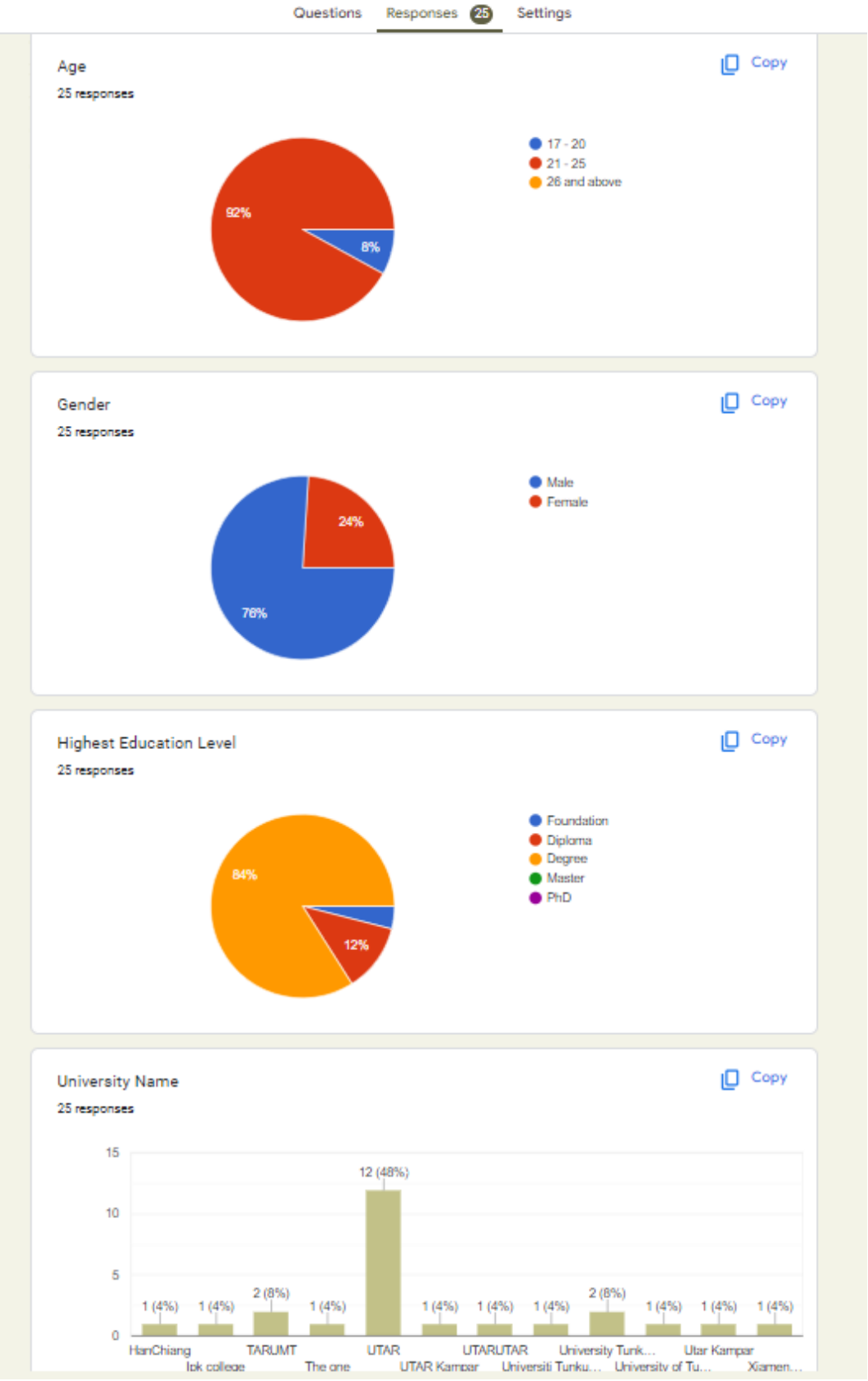
15. If yes, please specify the difficulties you faced

Your answer

16. Would you recommend any features to improve our application?

Your answer

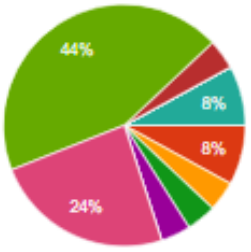

Thank Your For Your Time And Response
I appreciate so much for your response that will help to analyze the reasons for the low awareness of historical buildings among students.
Personal Data Protection Act 2010
Your data privacy is important to us. Personal data collected will be protected in accordance to Personal Data Protection Act 2010. Please visit https://www.utar.edu.my/PrivacyNotice_English.jsp to view our Privacy Notice.
Back
Submit
Page 4 of 4
Clear form


Questions
Responses 25
Settings
Age
25 responses
Copy
17 - 20
21 - 25
26 and above
92%
8%
Gender
25 responses
Copy
Male
Female
24%
76%
Highest Education Level
25 responses
Copy
Foundation
Diploma
Degree
Master
PhD
84%
12%
University Name
25 responses
Copy
15
10
5
0
12 (48%)
2 (8%)
2 (8%)
1 (4%)
HanChiang
Ipk college
TARUMT
The one
UTAR
UTAR Kampar
UTARUTAR
Universiti Tunku...
University Tunk...
University of Tu...
Utar Kampar
Xiamen...

State

25 responses

Copy

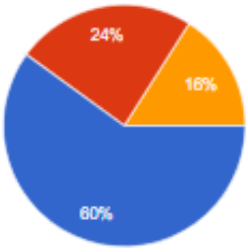


Johor
Kedah
Kelantan
Malacca
Negeri Sembilan
Pahang
Penang
Perak
1/2

Have you ever experience any AR application before?

25 responses

Copy



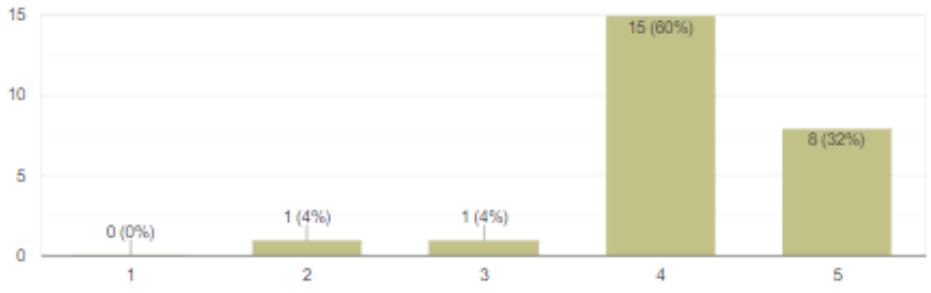
Yes
No
Maybe

Participants Data Collection

1. How would you rate our application after using it?

25 responses

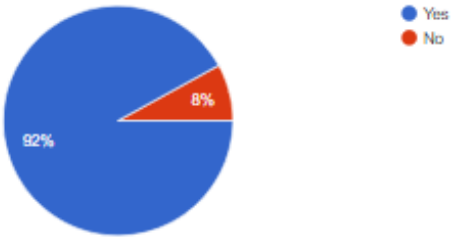
Copy



2. Do you think it is convenience to have the option to login as a Guest?

Copy

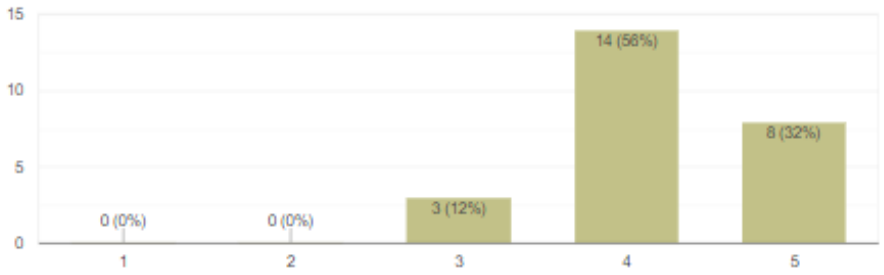
25 responses



3. How satisfied are you with the ease of finding the historical building you desired?

Copy

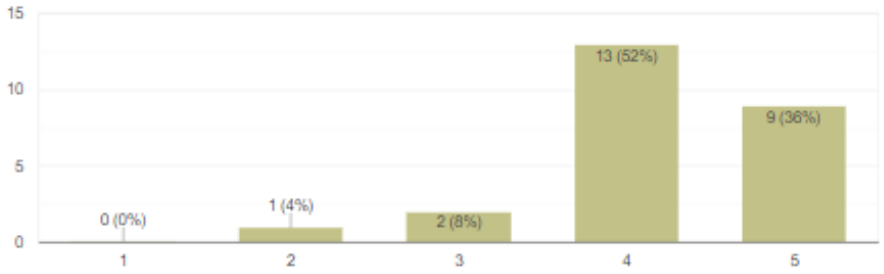
25 responses



4. Did you find the information provided about historical buildings comprehensive and informative?

Copy

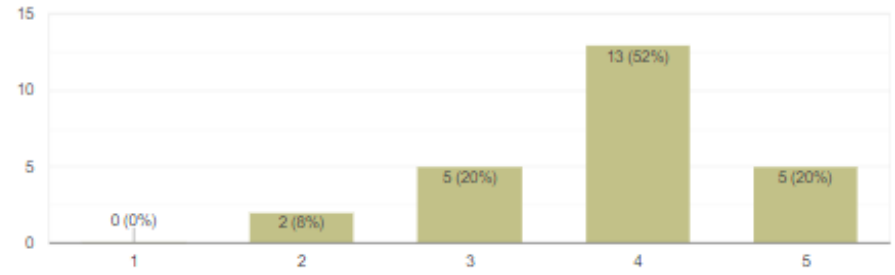
25 responses



5. Did you enjoy giving comments and ratings to historical buildings?

Copy

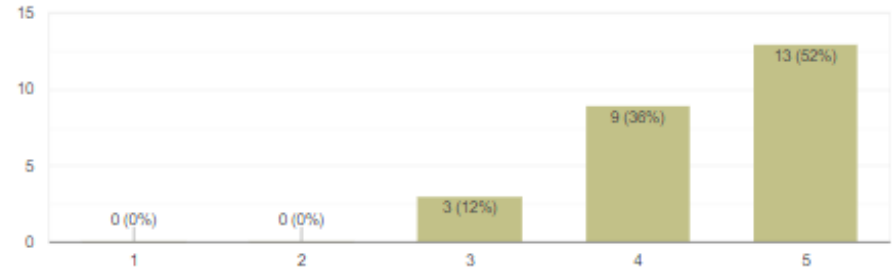
25 responses



6. Did you find the rating of historical buildings to be a reliable reference for you to decide to visit them?

Copy

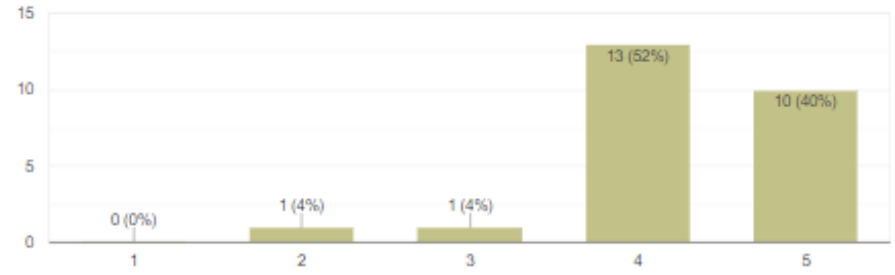
25 responses



7. Do you consider this application a reliable source when searching for new places to travel?

Copy

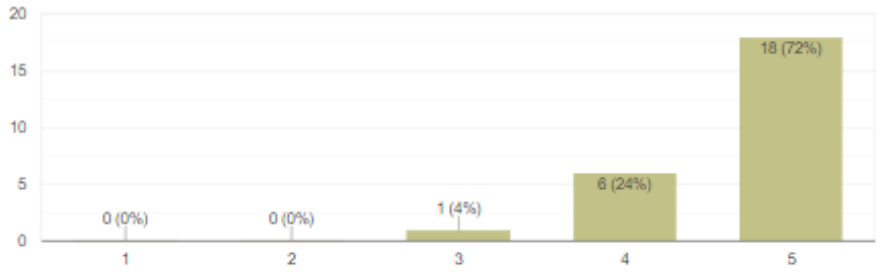
25 responses



8. How satisfied are you with the AR functionality of our project?

Copy

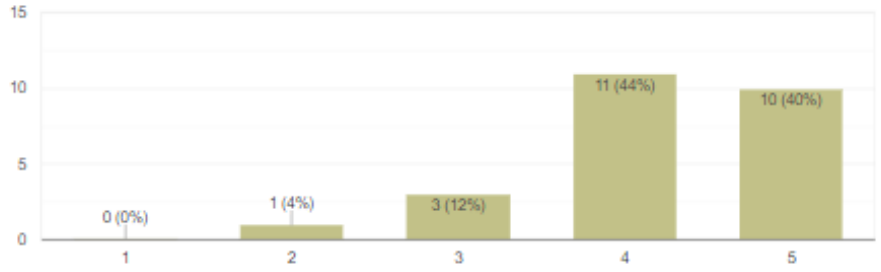
25 responses



9. Did you enjoy interacting with the buildings in the AR environment?

Copy

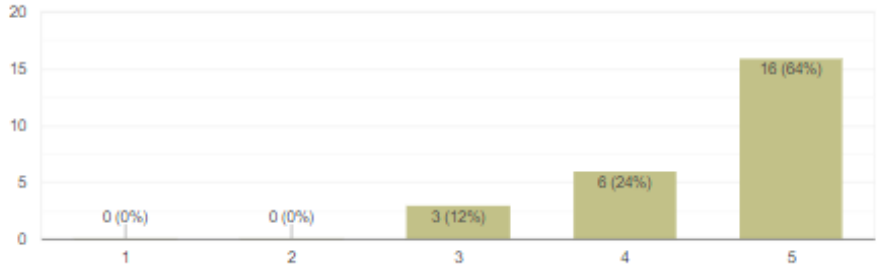
25 responses



10. Do you find bookmark feature convenience for faster navigation?

Copy

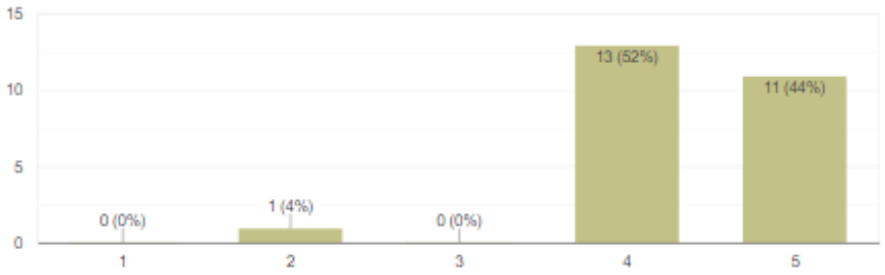
25 responses



11. How helpful do you think the map integration feature is for locating historical buildings?

Copy

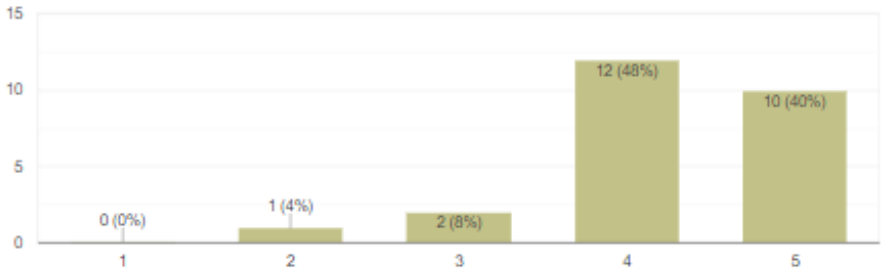
25 responses



12. Were you able to easily navigate to the desired historical buildings using the map functionality?

Copy

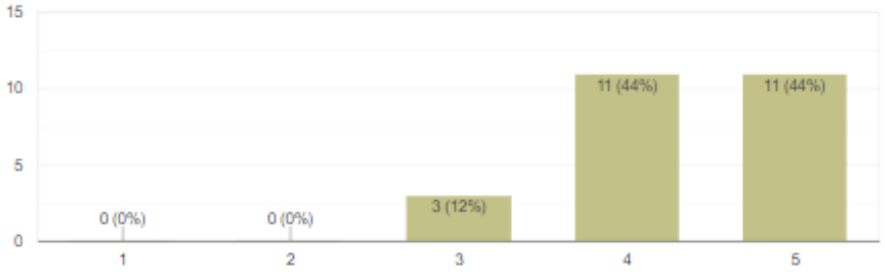
25 responses



13. How satisfied are you with the customization options available in the profile module?

Copy

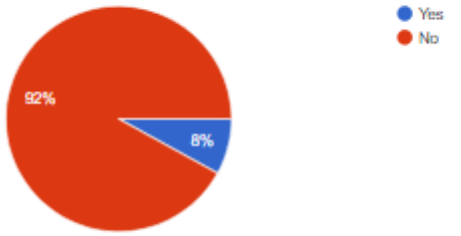
25 responses



14. Did you encounter any difficulties while using the application?

Copy

25 responses



15. If yes, please specify the difficulties you faced

4 responses

- It is difficult for the camera to detect the plane when I try to place it on the table
- No faced any difficulties
- -
- It takes quite a long time to detect the plane then only can place the building model on AR camera

16. Would you recommend any features to improve our application?

11 responses

- No
- Easy to use is important
- Very good
- I hope to have more interaction with the 3d model
- So far not now
- Provide route navigation from current location to the historical building
- Very good not need improve
- no
- Make it more detailed

Thank Your For Your Time And Response

Personal Data Protection Act 2010

Your data privacy is important to us. Personal data collected will be protected in accordance to Personal Data Protection Act 2010. Please visit

Appendix C: Biweekly Report

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 1-2**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- Getting myself familiarized with what have done in FYP1 and IIPSPW
- Finish the improvement on the diagram such as system network diagram, use case diagram, storyboard, wireframes, and so on

2. WORK TO BE DONE

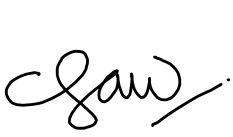
- Barely start the development of the authentication module

3. PROBLEMS ENCOUNTERED

- Database structure arrangement for the user collection to integrate with the Firebase authentication

4. SELF EVALUATION OF THE PROGRESS

- Starting to pick up what have left in the FYP1, will be continue on the development



Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 3-4**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- Finish the development of authentication module, two type of user login method has been set up

2. WORK TO BE DONE

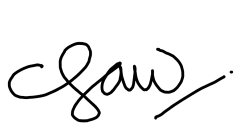
- Map Integration Module
- Localization Module

3. PROBLEMS ENCOUNTERED

- The display message of the authentication error when user enter invalid data cannot shown for the invalid password

4. SELF EVALUATION OF THE PROGRESS

- Make a quite good process on finish up the initial version of authentication module.



Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 5-6**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- Finish the Map integration Module

2. WORK TO BE DONE

- Profile Module & Bookmark Module

3. PROBLEMS ENCOUNTERED

- Face the issues of not able to implement the navigation, but able to solve it at the end through changing to using the Mapbox SDK from Google API

4. SELF EVALUATION OF THE PROGRESS

- Just come back from the Chinese New Year, will continue the development of the module that is important with objective alignment

Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 7-8**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- Profile Module
- Bookmark Module
- Improvement of Building Module

2. WORK TO BE DONE

- Building Module Improvement

3. PROBLEMS ENCOUNTERED

- The localization requires manual input the translation, which takes some time to update the data.
- Although finish the Building Module and Bookmark Module, but still have some execution logic error, will be solve later

4. SELF EVALUATION OF THE PROGRESS

- Able to finish most of the module, will continue the remaining next week

Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 9-10**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- Bug Fixing
- Improvement of Building Module

2. WORK TO BE DONE

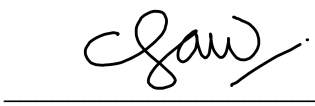
- System Testing
- User Testing & Survey Feedback
- Report Writing

3. PROBLEMS ENCOUNTERED

- Most of the faced problem able to solve within these two weeks, will conduct the system testing to have a throughout check on the functionality.

4. SELF EVALUATION OF THE PROGRESS

- The coding part already finish, need to work on the report part for the remaining time.



Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 11-12**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- System Testing
- User Testing & Survey Feedback
-

2. WORK TO BE DONE

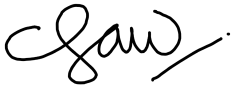
- Report Writing

3. PROBLEMS ENCOUNTERED

- The user testing requires a lot of actual users to test, it takes some time to complete, which make the report writing time shorten.

4. SELF EVALUATION OF THE PROGRESS

- Still have report writing to do.



Supervisor's signature

Student's signature

FINAL YEAR PROJECT BIWEEKLY REPORT

(Project II)

Trimester, Year: S3, Y3	**Study week no.: 13**
Student Name & ID: Beh Jia Jing 21ACB01879	
Supervisor: Ts Saw Seow Hui	
Project Title: Reflect History Changes of the Famous Historical Building via AR Technology	

1. WORK DONE

- Report Writing
-

2. WORK TO BE DONE

- Everything done

3. PROBLEMS ENCOUNTERED

- Only spent time on report, nothing much problem encountered

4. SELF EVALUATION OF THE PROGRESS

- Able to finish everything according to the timeline.

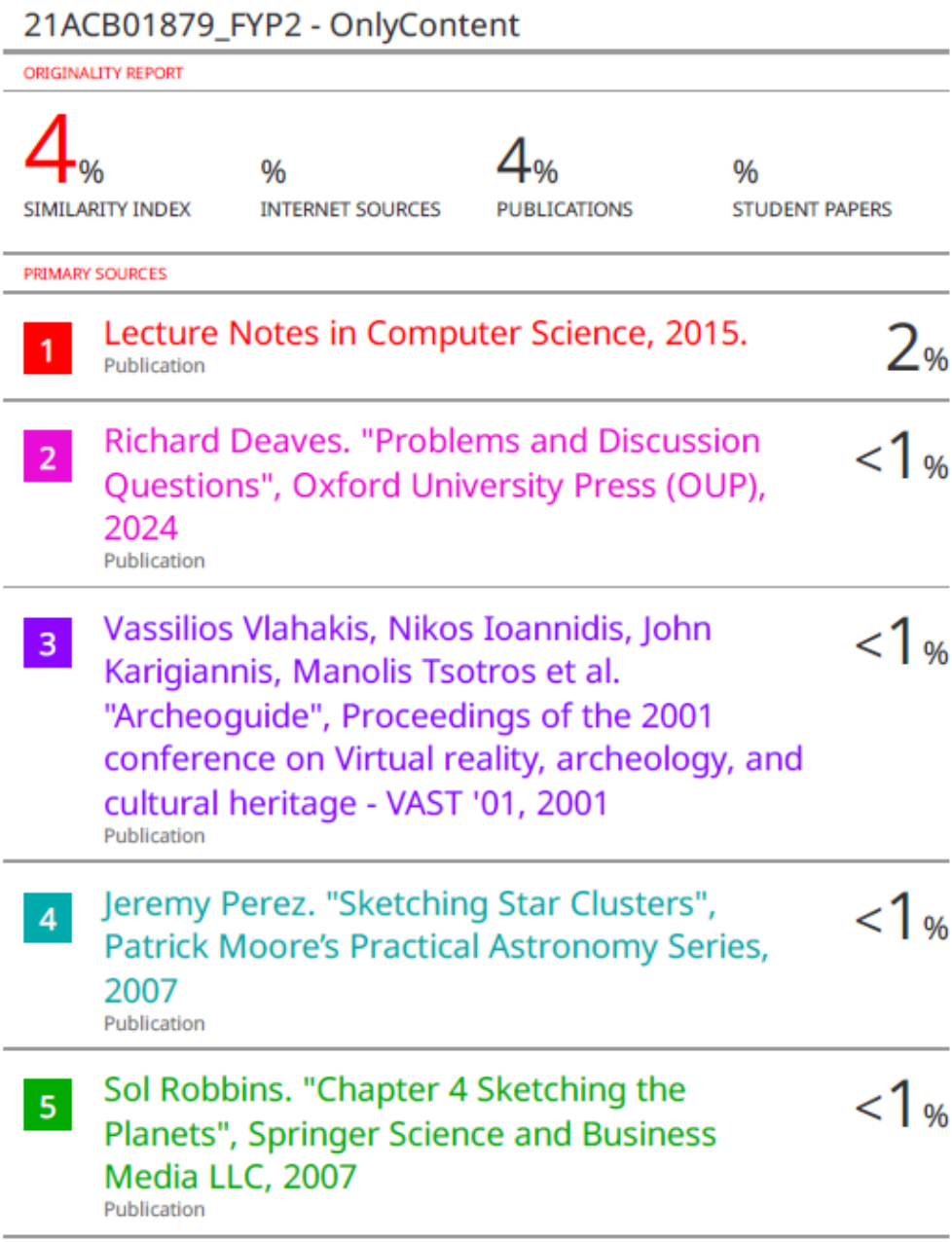
Supervisor's signature

Student's signature

POSTER


Reflect History Changes of the Famous Historical Building via AR Technology
HB Project
Introduction
Create an mobile application that utilizes AR technology to provide immersive experiences and in depth exploration of historical buildings to the users
Project Objective
1. Reconstruct Appearance of Historical Building through 3D Model
2. Perserve Historical Building Info
3. Provide High Accessibility and Interaction with Historical Buildings
Project Scope
1. Interact with 3D model in AR Environment
2. Acessess Selected Building Information
3. Building coordinate tracking
4. Language Conversion
Result
Software/Techologies
Programming Language
Developed By : Beh Jia Jing
Supervised By : Ts.Saw Seow Hui
FINAL YEAR PROJECT
UNIVERSITY TUNKU ABDUL RAHMAN
FACULTY OF INFORMATION COMMUNICATION TECHNOLOGY

PLAGIARISM CHECK RESULT



21ACB01879_FYP2 - OnlyContent

ORIGINALITY REPORT

4%	%	4%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

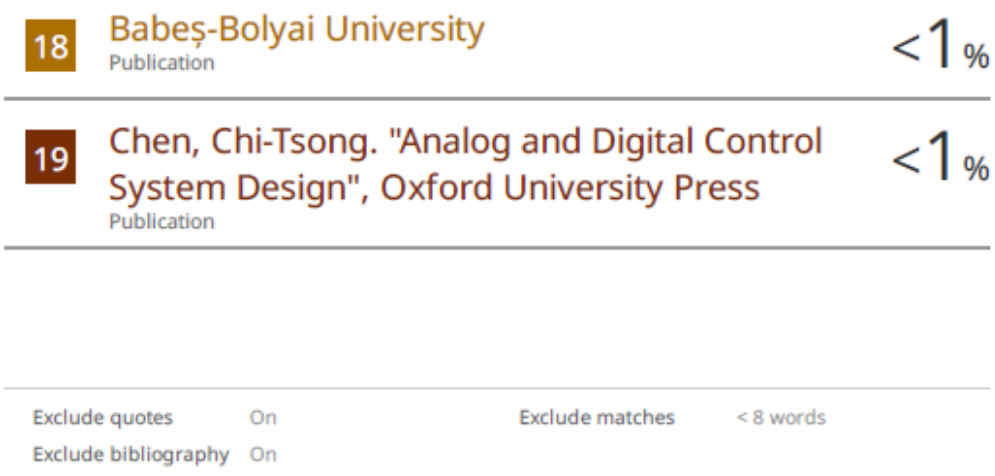
PRIMARY SOURCES

1	Lecture Notes in Computer Science, 2015. Publication	2%
2	Richard Deaves. "Problems and Discussion Questions", Oxford University Press (OUP), 2024 Publication	<1%
3	Vassilios Vlahakis, Nikos Ioannidis, John Karigiannis, Manolis Tsotros et al. "Archeoguide", Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage - VAST '01, 2001 Publication	<1%
4	Jeremy Perez. "Sketching Star Clusters", Patrick Moore's Practical Astronomy Series, 2007 Publication	<1%
5	Sol Robbins. "Chapter 4 Sketching the Planets", Springer Science and Business Media LLC, 2007 Publication	<1%

6	"Ontology in the AEC Industry", American Society of Civil Engineers (ASCE), 2015 Publication	<1 %
7	Lucio Tommaso De Paolis, Carola Gatto, Laura Corchia, Valerio De Luca. "Usability, user experience and mental workload in a mobile Augmented Reality application for digital storytelling in cultural heritage", Virtual Reality, 2022 Publication	<1 %
8	Rohit Rastogi, Devendra Kumar Chaturvedi, Mayank Gupta. "chapter 20 Mental Health Through Biofeedback Is Important to Analyze", IGI Global, 2021 Publication	<1 %
9	Huilian Zhang. "Design and Application of College and University Entrepreneurship Platform Based on MVC Architecture", Procedia Computer Science, 2023 Publication	<1 %
10	Fendi Aji Purnomo, Dewi Maharani Setyaningsih, Gravilian Megarifera Liset, Rike Aqila Nurfi et al. "Implementation of Vue Js and Laravel on Monitoring Battery Management System", Applied Mechanics and Materials, 2024 Publication	<1 %

11	"Intelligent Computing Technology and Automation", IOS Press, 2024 Publication	<1 %
12	Frank Süli. "New product development", Elsevier BV, 2019 Publication	<1 %
13	Nemanja Kaplanović. "Information system to support the operation of the car park", Vojnotehnicki glasnik, 2024 Publication	<1 %
14	Nguyen T. Binh, Pham D. Tinh, Nguyen H. Chien. "BKiosk System - A Solution for Context-specific Services Supporting Contextualization Stage of E-government systems", 2022 6th International Conference on E-Commerce, E-Business and E-Government, 2022 Publication	<1 %
15	"Audible Empire", Walter de Gruyter GmbH, 2016 Publication	<1 %
16	"Modern Heterogeneous Oxidation Catalysis", Wiley, 2009 Publication	<1 %
17	"Quantum Mechanics", Mathematica® for Theoretical Physics, 2005 Publication	<1 %

PLAGIARISM CHECK RESULT



Universiti Tunku Abdul Rahman			
Form Title: Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1of 1

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Beh Jia Jing
ID Number(s)	210ACB1879
Programme / Course	Information System (Honors) Information System Engineering
Title of Final Year Project	Reflect History Changes of the Famous Historical Building Via AR Technology

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceed the limits approved by UTAR)**
Overall similarity index: 4 % **Similarity by source** Internet Sources: 0 % Publications: 4 % Student Papers: 0 %	The percentage meets the requirement.
Number of individual sources listed of more than 3% similarity: 0	N/A.
Parameters of originality required, and limits approved by UTAR are as Follows: **(i) Overall similarity index is 20% and below, and** **(ii) Matching of individual sources listed must be less than 3% each, and** **(iii) Matching texts in continuous block must not exceed 8 words** ***Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.***	

Note: Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor

Name: Ts Dr Saw Seow Hui

Date: 25/4/2024

Signature of Co-Supervisor

Name: _____

Date: _____

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

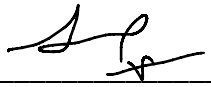
CHECKLIST FOR FYP2 THESIS SUBMISSION

Student Id	21ACB01879
Student Name	Beh Jia Jing
Supervisor Name	Ts. Dr. Saw Seow Hui

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
√	Title Page
√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
N/A	List of Symbols (if applicable)
√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report.



_____

(Signature of Student)

Date:25th April 2024