PERSONALIZED POINT OF INTEREST IN LOCATION BASED AUGMENTED REALITY TOURISM APPLICATION

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ABSTRAK

Dalam tahun-tahun kebelakangan ini, dengan perkembangan pesat pelancongan dan permintaan yang tinggi untuk perjalanan, orang ramai memberi lebih banyak perhatian kepada pengalaman dan kecekapan perjalanan. Di beberapa destinasi pelancongan terkenal, pelancong sering menangguhkan perjalanan mereka kerana mereka tidak biasa dengan kawasan tempatan. Ini kerana jumlah pelancong yang terlalu ramai dan kerajaan tempatan tidak dapat menyediakan perkhidmatan bimbingan pelancong kepada semua orang terutama pengunjung kali pertama. Semasa musim kemuncak pelancong, kebanyakan hotel dan restoran tempatan penuh sesak, dan pelancong perlu mencari penginapan dan makanan di tempat yang tidak dikenali, yang mengurangkan kecekapan dan pengalaman perjalanan mereka. Oleh itu, pelancong memerlukan aplikasi mudah alih untuk membantu mereka mengelakkan kesukaran semasa perjalanan. Objektif projek ini adalah untuk membangunkan aplikasi Pelancongan AR (PutrajayAR) Berasaskan Lokasi Peribadi yang membimbing pelancong untuk mengelakkan pengalaman yang menyusahkan dan memberikan cadangan menarik kepada pelancong. Metodologi yang digunakan dalam projek ini ialah model air terjun yang membahagikan projek kepada lima fasa, fasa 4 memfokuskan pada ujian sistem dan pengesahan fungsi, dan saya akan menggunakan ujian kotak hitam untuk menguji aplikasi ini. Hasil yang dijangkakan ialah pengguna berpuas hati dengan aplikasi ini dan apl itu

meningkatkan pengalaman dan kecekapan perjalanan pelancong. Kesimpulannya, apl PutrajayayAR akan meningkatkan pengalaman dan kecekapan perjalanan pelawat melalui teknologi AR dan pengesyoran yang diperibadikan.

Kata kunci: Realiti Tambahan Berasaskan Lokasi(LBAR), Pemperibadian, Aplikasi Pelancongan

ABSTRACT

In recent years, with the rapid development of tourism and high demand of traveling, people are paying more and more attention to travel experience and efficiency. In some famous tourist destinations, tourists often delay their trips because they are unfamiliar with the local area. This is because there are too many tourists and the local government cannot provide tourist guidance services to everyone, especially first-time visitors. During the peak tourist season, most local hotels and restaurants are overcrowded, and tourists need to find accommodation and food in unfamiliar places, which reduces their travel efficiency and experience. Therefore, tourists need a mobile app to help them avoid difficulties during travel. The objective of this project is to develop an Personalized Location-based AR Tourism(PutrajayAR) app that guides tourists to avoid inconvenient experiences and provides interesting suggestions to tourists. The methodology used in this project is a waterfall model which divides the project into five phases, phase 4 focus on the system testing and function verification, and I will use black-box testing to test this application. The expected result should be that users are satisfied with this app and the app improve tourist travel experience and efficiency. In conclusion, the PutrajayAR app will enhance visitors' travel experience and efficiency through AR technology and personalized recommendations.

Keywords: Location-Based Augmented Reality(LBAR), Personalization, Tourism Application

1.0 INTRODUCTION

Location-based AR(LBAR) is a technology that stands for a markerless, position-based, and geo-based Augmented Reality. It relies on GPS, accelerometer, digital compass, and other technologies to identify a device's location and position with high accuracy (Saxena, P. 2015). Most modern mobile devices have the required

sensors, so this powerful technology is available for every mobile owner, use of IoT in automotive industry has also become popular these days.

As global tourism grows, people are increasingly eager to travel internationally, and AR technology has made an objective contribution to the growth of tourism. From interactive maps and personalised recommendations to remote assistants and translation apps, the potential for AR usage in tourism is boundless. The virtual tourism market alone is set to grow at a compound annual growth rate (CAGR) of 30.2% between 2023 and 2028, to reach a valuation of $23.5 billion (Cranmer, E. E., tom Dieck, M. C., & Fountoulaki, P. 2020). Based on the existing AR technology, LBAR will bring people a more convenient and personalized travel experience.

LBAR technology is popular for its usability and personalization. However, to develop an LBAR application for tourism, especially to enhance the users travel experience, there are still some problem to be considered at the beginning.

Visual clutter concerns designers of user interfaces and information visualizations, disorganized display items can cause crowding, masking, decreased recognition performance due to occlusion, greater difficulty at both segmenting a scene and performing visual search (Rosenholtz, R., Li, Y., & Nakano, L. 2007). Augmented reality is seeing a rapid expansion into several domains due to the proliferation of more accessible and powerful hardware. While augmented reality user interfaces (AR UIs) allow the presentation of information atop the real world, this extra visual data potentially comes at a cost of increasing the visual clutter of the users'field of view, which can increase visual search time, error rates, and have an overall negative effect on performance (Flittner, J. G. 2023). It can be seen that while AR technology is becoming increasingly colorful, visual clutter has become a new problem that needs to be considered.

In addition, non-personalized POIs can cause negative experience to users. Point of Interest (POI) is an important component of common AR tourism software, the

distances between two POIs of an AR tour trajectory through which users should pass to visit AR contents, need to be filled using the personalized AR contents to reduce the discontinuity experience (Shakeri, M., Park, H., Jeon, I., Sadeghi-Niaraki, A., & Woo, W. 2023). It can be seen that establishing a personalized POI system is extremely important for AR and especially location-based AR software.

The project aims to develop a personalized location-based AR tourism app (PutrajayAR) that recommends attractions based on user travel preferences (e.g. interested POI categories, tourist type, budget) and device settings (e.g. time, date, weather). Users are able to the view the opening time, opening days, consumption budget and detailed information of attractions. The app also provides an AR view of the surrounding environment and 3D annotations for each POI, enhancing the tourism experience through real-time, personalized recommendations.

2.0 LITERATURE REVIEW

2.1 Background of The Study

The PutrajayAR application is operated on the Android platform by using Augmented Reality technology and smart phones. Compared to other operating systems, this application is Android-oriented, according to Ruqiya's survey (Ruqiya, R., 2020), among 60 participants, most people prefer Android than IOS, for operating system convenience, 90% would prefer Android system performance compatibility while only 10% choose IOS. This proves that Android users are more numerous and Android-oriented applications are more popular.

2.2 Location Based Augmented Reality

Location-Based AR seeks to smoothly link the physical location coordinate with data processing environments that make a user can see POI (Point of Interest) annotation of the particular landmark in a real environment (Paucher, R., & Turk, M., 2010). Implementing this technology for navigation can greatly improve user action to

reduce the travel time especially when the apps designed for pedestrian usage. Figure 2.1 shows an example of location-based AR for navigation.

Figure 2.1 location-based AR for navigation

Source: Brata, K. C., & Liang, D. (2019)

Various devices can be used to apply the concept of location-based AR, such as mobile phones, special AR glasses, tablets and so on. These devices will function as the output device and will display the information inside forms of videos, pictures, animations and 3D models that need to be used. Location based Augmented Reality is divided into two types, namely Indoor LBAR and Outdoor LBAR.

i. Indoor Location-based Augmented Reality

Indoor LBAR uses AR technology within enclosed spaces like malls, airports, museums, and other indoor environments where GPS signals may be unreliable. The users' devices detect nearby Wi-Fi access points (Curran, K., 2011) or communicate with nearby Bluetooth (Qiu, C., & Mutka, M. W., 2018) devices to approximate their locations, making up for the instability of GPS signals indoors.

ii. Outdoor Location-based Augmented Reality

Outdoor AR usually relies on GPS and geolocation technology. According to Blanco's research (Blanco, J. L., 2009), normal GPS provides approximate location with a standard accuracy of about 3 meters outdoors, differential GPS can even support higher positioning accuracy, which is sufficient for many applications. PokemonGo

(Mäyrä, F., 2017) is a very vivid example, it is an AR-based mobile tourism game developed by Niantic that combines a virtual game world with real-world maps, encouraging players to explore their surroundings to interact with virtual characters. Players use the app to walk around their local environment to find and catch Pokémon, which are often positioned near real-world landmarks, historical sites, and popular locations. This encourages users to visit and learn about new places in their area or while traveling. Important locations in the game, called PokéStops and Gyms, are often set at notable points of interest, such as statues, parks, monuments, and public art installations. Visiting these spots lets players collect in-game items or participate in Pokémon battles. Figure 2.2 shows a demo of Pokémon Go.

Figure 2.2 Pokémon Go.

Source: Althoff, T. (2016)

Depending on the player's geographic location, different Pokémon or special events like city events or community days will appear in the game, which will also make the player's experience different depending on the location, forming a unique gaming journey. In this scenario, we can find not only the features of location-based augmented reality bring users wonderful experience, personalization also satisfy them better.

2.3 Personalized Recommendation

A Personalized Application is a software solution designed to adapt to individual user preferences, behaviors, and needs, offering tailored experiences. Personalized recommendations based on user behavior and preferences can make the app feel more tailored and relevant to individual users. By utilizing data analytics and machine learning, applications can deliver content and features that resonate with users, enhancing their overall satisfaction and engagement (Deon, L., & Jackson, D., 2024).

i. Personalized Recommendation enhances user satisfaction

According to Li's study (Li, P., 2020), different users might have different preferences towards the same recommendation, and even the same user might have different opinions towards the same recommendations on different sessions. Therefore, personalized and session-based recommender systems constitute important tools for providing satisfying recommendations. For further research, he built models and incorporate personalized and session-based information into the model design, specifically, these models take user behavior sequences into account to learn user behavior patterns and the shift of user preferences from one transaction to another. This study proved that a personalized recommendation system enhance user satisfaction efficiently.

ii. Personalized Recommendation improves user engagement

Personalized Recommendation also contributes much to the user engagement. In Yang's survey (Yang, X., Zhang, L., & Feng, Z., 2024), they analyzed the survey data from the 496 participants, and the results provided support for the hypothetical model, revealing that tourists' attitudes toward the personal recommendation tourism(PRT) system and content were relatively positive. In the questionnaires' data indicator, the mean values of PTR attitude were 5.810, 5.569, and 5.724; the mean values of technology trust were 5.661, 5.827, and 5.589. All of the result presented a positive level, which supports the evidence of a positive relationship between user engagement

and personalization.

2.4 Tourism Application

As society has become networked, and networks have become ubiquitous through the use of mobile telephones, societal practices are undergoing a radical transformation, none more so than in the domain of travel. The rapid uptake of mobile technology has enabled people to negotiate their day to day mobility with increasing fluidity (Ling, 2004) providing scope for adhoc decision making on the go based on networked connectivity between people.

Tourism application can also improve the culture exchange, when people travel, they are constantly exposed to new cultures and spread their own culture and knowledge to others. Cultural tourism is an important carrier of traditional culture; its cultural memory generated through contact with tourists will dominate the behavioral decision-making of tourists and have an impact on the intention of tourists to revisit (Lai, S., 2021). With the development of tourism applications, it will be more convenient for people to start a international travel, different cultures are also being spread all over the world.

2.5 Existing Location-Based AR Tourism APP

Table 2.1: LBAR Apps Comparison Table

Application	AR City Guide	Horizon Explorer AR	World Around Me
Device	Smart Phone, AR Glasses	Smart Phone	Smart Phone
Language	English	English	English
Main Function	AR City Navigation. Recommend nearby landmarks based on the distance between user device and places.	Wild Terrain and Village Exploration based on user GPS detection. Calculation on the	AR City Navigation. Filter places based on user selected categories.

		distance between users and each POI.	
Technology	● Location-based AR, ● Visual Positioning System, ● Simultaneous Localization and Mapping, ● Real-time Location System, ● GPS, ● Geographic Information System ● Distance Calculation	● Location-based AR, ● GPS, ● Geographic Information System, ● Distance Calculation	● Location-based AR, ● Real-time Location System, ● Simultaneous Localization and Mapping, ● Categorized POI,
POI Filter Types	Based on Distance Based on User needs	Based on Distance	Based on User needs
Personalized Recommendation	Based on Distance	None	None

As a result of the study of existing location-based AR tourism applications, there are functions and elements that need to be included in PutrajayAR application to improve the user satisfaction. For example, the application must be equipped with location-based AR technology and have POIs in AR views to provide users with vivid visual experience and interactions. Additionally, it's necessary to include POI filters which support users to view POIs based on their current needs and avoid visual clutters.

However, while the above features are commonly found in most AR tourism applications, they often lack true personalization, offering generic functions that fail to fully align with individual user preferences. Therefore, PutrajayAR aims to provide personalized POI recommendations based on users' travel preferences and their device settings like time and weather. This approach helps simplify exploration and makes travel more convenient and engaging for tourists.

3.0 METHODOLOHY

The methodology used in this project is a waterfall model which divides the project into five phases, including Requirement Analysis, System Design, Software Implementation, Testing as well as System Maintenance shown in Figure 3.1. The waterfall model requires detailed documentation to be completed at each phase, which helps ensure clarity of requirements, design, and implementation, and provides guidance for subsequent phases. Each phase of this model has clear goals and outputs to facilitate management and monitoring of project progress.

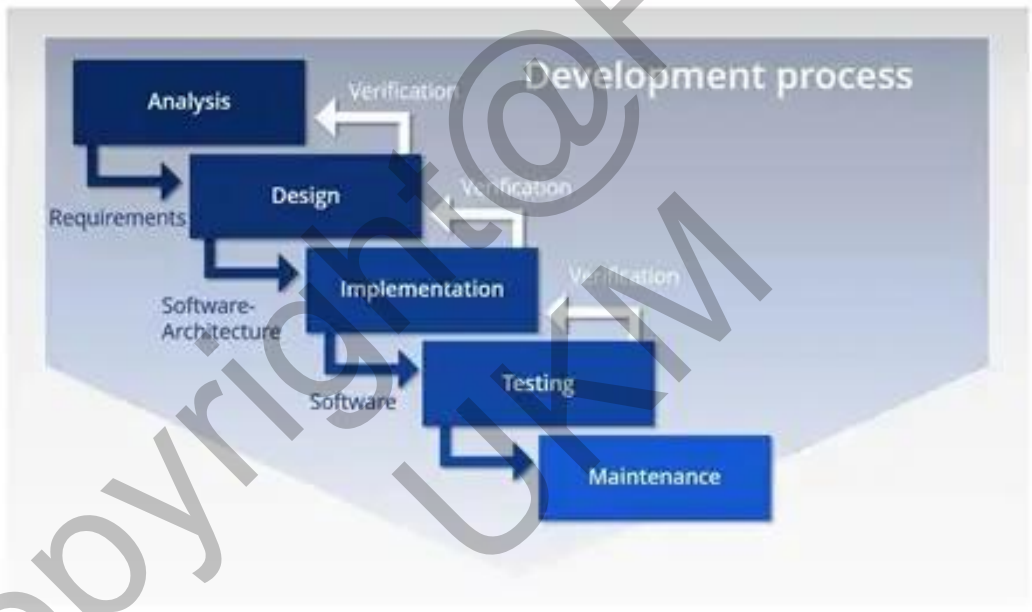

Figure 3.1 Waterfall Model Process

i. Requirement Analysis

In application or system development, understanding user requirements is crucial to meeting expected specifications. To gather these needs, techniques such as interviews and observation of existing applications will be employed. In this phase, the functional requirements and non- functional requirements to develop the application will be specified.

These requirements serve as the foundation for the system design and development process. Functional requirements will detail the specific features and capabilities the application must provide, such as user authentication, real-time POI display, and personalized recommendations. Meanwhile, non-functional requirements will outline performance standards, security protocols, usability expectations, and platform compatibility to ensure the system operates efficiently and meets user expectations. By clearly defining these aspects early in the development lifecycle, the project team can align their efforts with user needs and technical feasibility, minimizing the risk of costly revisions later on.

ii. System Design

Following the requirement analysis phase, the system design stage focuses on translating these requirements into a comprehensive blueprint for development. This includes the system architecture design, database design, user interface design, algorithm design and interaction flows. Tools such as UML diagrams may be used to visualize and validate the planned structure before actual implementation begins. At the end of this phase, all the completed design will be compiled into a specific document, the software design specification.

iii. Implementation

During the implementation phase, the PutrajayAR application will be developed based on the software design specification. This includes writing the code for system components, integrating APIs (such as location services, weather, and the Firebase database), and ensuring that both front-end and back-end modules function correctly and meet specifications.

iv. Testing

The testing will be divided in to two parts, the functionality testing and usability testing. Functionality testing focuses on verifying that all features and components of the application work according to the specified requirements. This includes testing

modules such as user registration and login, non-personalized AR funtions, personalized POI recommendation function, and interaction with external services like Firebase and weather API.

On the other hand, usability testing evaluates an app's overall satisfaction, persuasive design, and personalization by collecting user feedback on the app. Participants will be divided into two groups with a balanced distribution of gender and age. One group will test the app's personalized functions, while the other will interact with the non-personalized version. After completing specific tasks, both groups will provide feedback through surveys or interviews. This feedback will be analyzed to assess user satisfaction, the effectiveness of persuasive design, and overall user experience. By comparing the responses from both groups, the study aims to determine user preferences and attitudes toward personalization as well as its feasibility within the application. This comparison will help identify whether personalized features significantly enhance user satisfaction and engagement compared to non-personalized ones.

v. Maintenance

The maintenance phase begins after the system has been deployed. It involves ongoing monitoring, user support, and updates to fix issues, enhance performance, or introduce new features based on user feedback. Regular maintenance ensures the application remains secure, efficient, and relevant in a continuously evolving technological environment.

4.0 RESULTS

4.1 Application Development

A variety of software and modules were utilized in the development of the PutrajayAR application, including Unity 2022.3.55f1, Visual Studio 2022, the Firebase SDK. The primary development platform was Unity 3D, which offers robust

features for designing user interfaces, creating both 2D and 3D objects, and building augmented reality (AR) environments with ease. The application's core functionalities were programmed using the C# (C-Sharp) language through Visual Studio, enabling efficient scripting and seamless integration with Unity.

In addition, the application integrates the Firebase SDK to build the database. These SDKs include Firebase Authentication for user registration and login, Firebase Storage for uploading and retrieving user avatar images, Firebase Realtime Database for storing and accessing real-time Point of Interest (POI) data, and Firebase Firestore for managing and querying user information efficiently.

Furthermore, to support cross-platform development and integration with specific tool chains, additional modules such as Open JDK and Android SDK & NDK Tools were installed. These are not core functions of the Unity Editor but are essential for building Android applications. Open JDK provides the Java environment required for running Gradle build scripts and packaging APK or AAB files, while the Android SDK offers necessary APIs and packaging tools. The NDK enables Unity to use IL2CPP to convert C# scripts into native C++ code, enhancing performance and compatibility.

Figure 4.1 to Figure 4.11 is the user interface of the PutrajayAR application. Figure 4.1 is the Login interface of the application, users need to fill in their email and password to log in to the application. Once they filled the input fields, they can click "Login" button to login. If a user has not registered before, they may choose to click the "Sign Up" button to initiate the account creation process.

Figure 4.1 Login Interface

Figure 4.2 is the User Register interface of the application, when new users want to create an account, they are required to provide a username, email address, and password to complete the registration process. After filling in all the required input fields, they can click the "Sign Up" button to finalize their account registration.

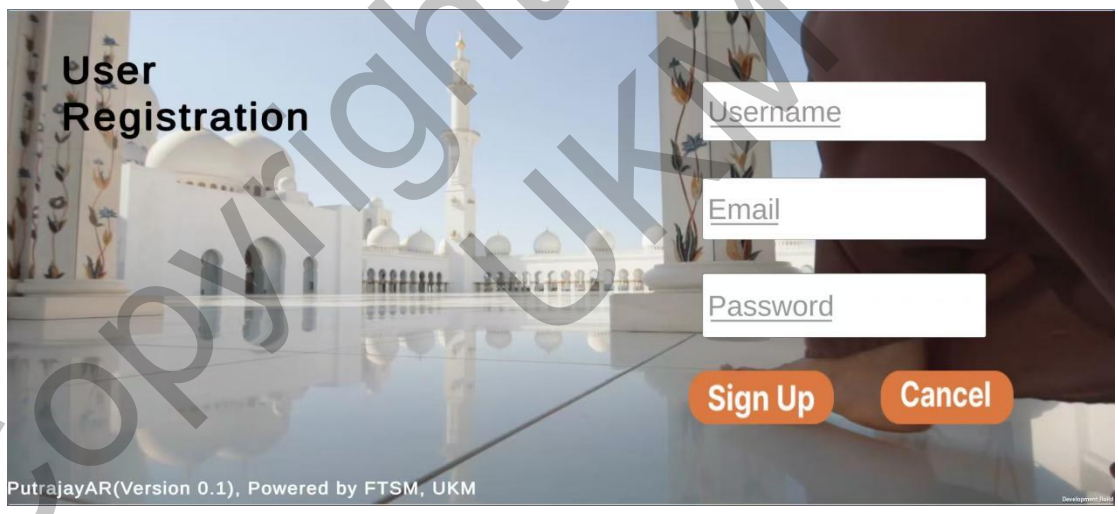

Figure 4.2 User Register Interface

Figure 4.3 is the Homepage interface of the application, users can click the Avatar on the left-top of the screen to open user profile, they can also click the “AD Discovery” or “AR Recommendation” button to open camera and enter the AR environment.

Figure 4.3 Homepage Interface

Figure 4.4 shows the User Profile interface, which displays detailed user information such as User ID, registration time, and email address. Users can update their profile details, including avatar image, username, phone number, and country, by clicking the "Save" button. Alternatively, users can discard any changes by clicking the "Reset" button.

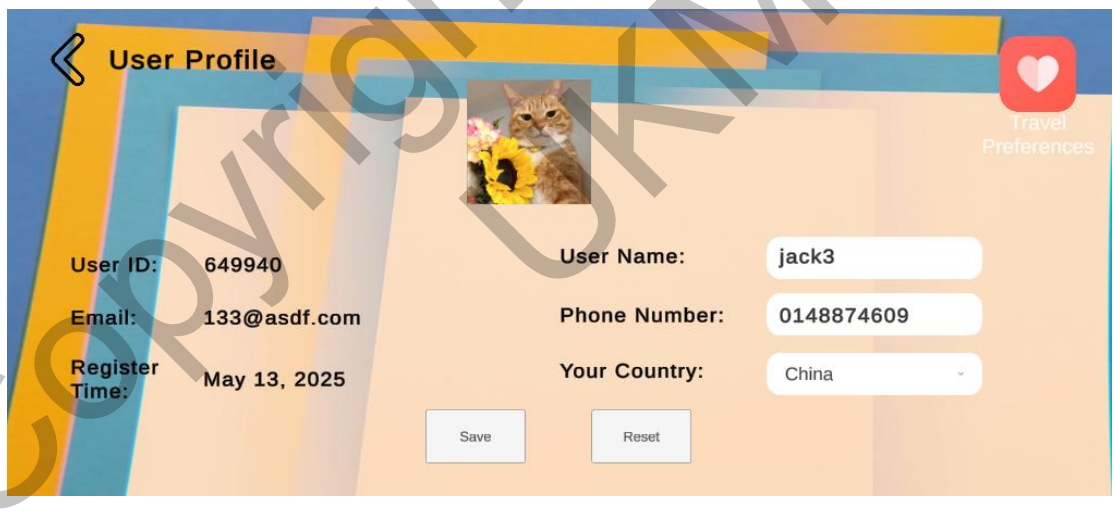

Figure 4.4 User Profile Interface

Figure 4.5 displays the Travel Preference interface, where users can select their tourist type, estimated budget, and preferred travel destinations. The preferences specified by users serve as the basis for generating personalized recommendations in the AR Recommendation interface.

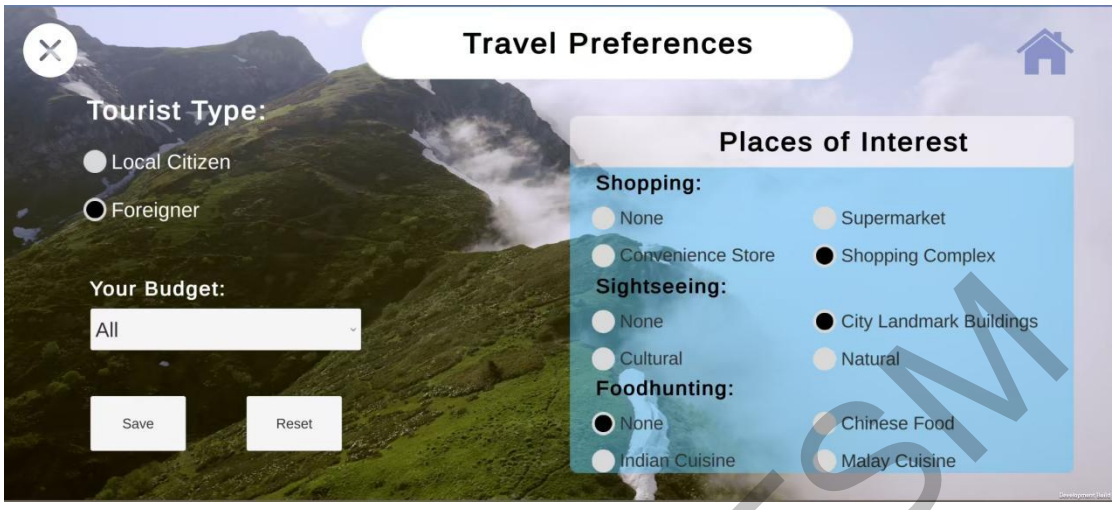

Figure 4.5 The Travel Preference Interface

Figure 4.6 is the AR Discovery interface, which supports users to open camera and scan surroundings to get POI annotations, Figure 4.7 and Figure 4.8 shows the POI Filtering function of this interface, to avoid the visual clutter, they can click the POI category button on the top side or the distance slider on the left side. For example, the value of distance slider in Figure 4.6 is 1711 meters but it's increased to 4148 meters in Figure 4.7, so the amount of POI annotations in the AR environment also increase. The POI filter which should be "All" in Figure 4.7, while the Sightseeing button is clicked, , the POI filter is changed to "Sightseeing", and the screen only display the POI annotations matched with sightseeing category, as shown in Figure 4.8.

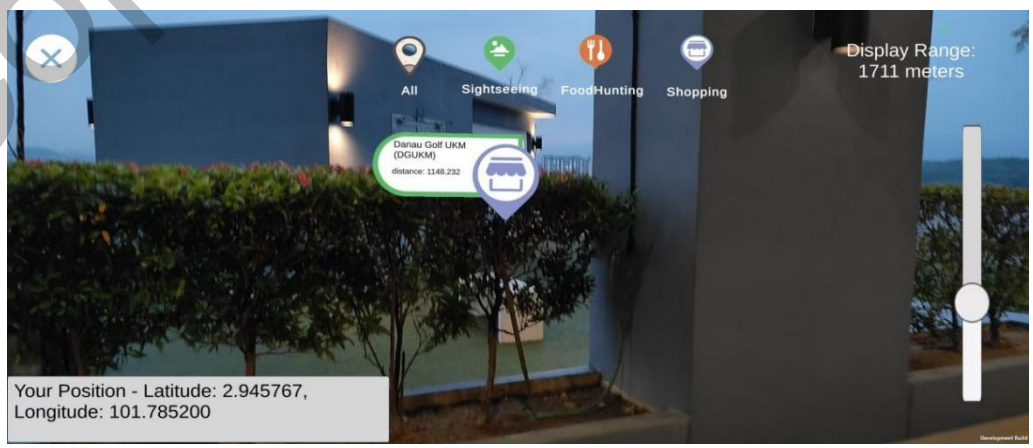

Figure 4.6 AR Discovery Interface

Figure 4.7 AR Discovery Interface - increase the distance range

Figure 4.8 AR Discovery Interface - click sightseeing button

Figure 4.9 presents the AR Recommendation interface of the application. In this interface, users can activate the camera to detect and filter Point of Interest (POI) annotations. Compared to the AR Discovery interface, the AR Recommendation interface offers a cleaner and more user-centric experience, as it displays only the POIs that align with the user's travel preferences. POIs that fall outside the user's specified interests are excluded from the view to minimize visual clutter and enhance relevance.

For instance, based on the travel preferences shown in Figure 4.5, where the user selected "Shopping Complex" for shopping, "City Landmark Buildings" for sightseeing, "Foreigner" as the tourist type, and "All" as the estimated budget, only POI annotations that match these specified categories will be displayed in the AR

Recommendation interface. This ensures that the user receives personalized and relevant recommendations aligned with their individual travel interests and criteria.

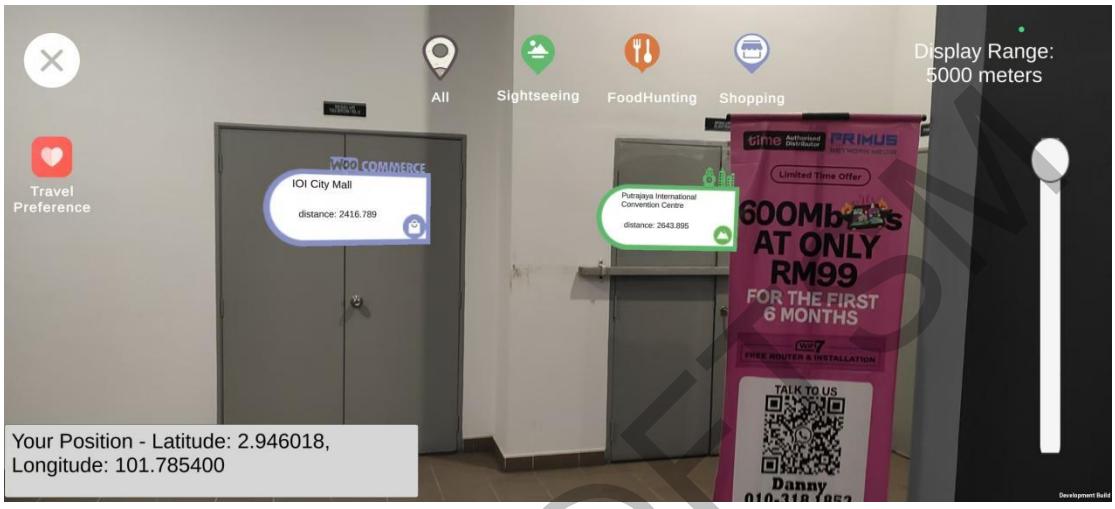

Figure 4.9 AR Recommendation Interface

Users have the option to update their travel preferences by clicking the "Travel Preference" button within this interface. This feature allows users to conveniently modify their preferences and receive more relevant POI recommendations in real time. As illustrated in Figure 4.10, this functionality enhances the personalization and usability of the AR experience.

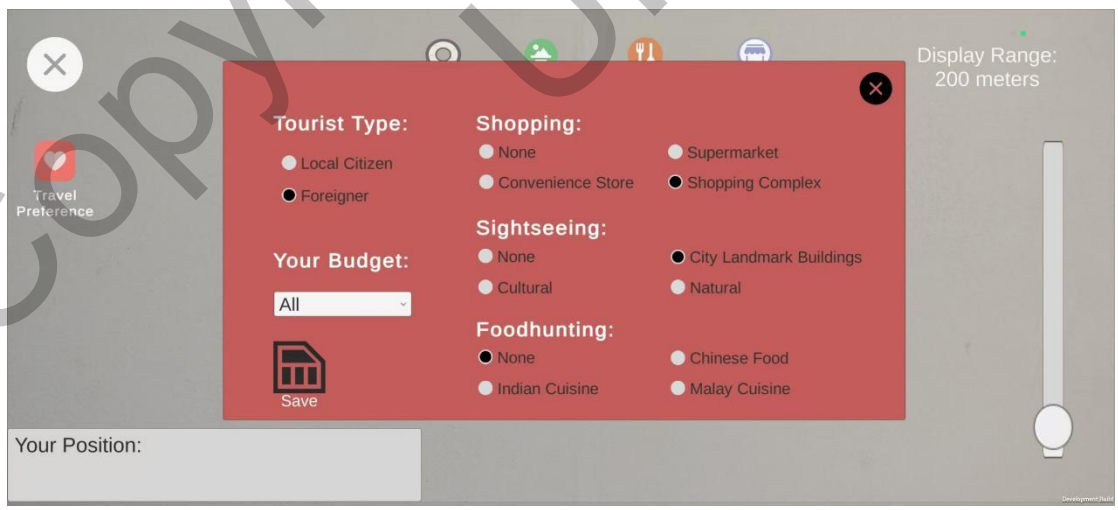

Figure 4.10 AR Recommendation Interface

When users tap on any POI annotation within either the AR Discovery or AR Recommendation interface, the application navigates to the POI Detail interface, as

illustrated in Figure 4.11. This interface presents comprehensive information about the selected point of interest, including its name, detailed description, operating days and hours, associated tourist type, and estimated budget. This detailed view enhances user decision-making by offering contextual and practical insights into each POI, thereby supporting more informed and personalized travel planning.

Figure 4.11 POI Detail Interface

4.2 Application Evaluation

The evaluation procedure of PutrajayAR application is performed ensuring that all features such as buttons, distance sliders, POI annotations, and AR environments work properly and meet users' requirements. The functional testing was conducted to identify errors and ensure the program functions as intended. Usability testing was also conducted to test the app's user satisfaction, persuasive design, and personalization by inviting tourists to experience the app in Putrajaya city.

i. Functional Testing

Functional testing is a phase dedicated to identifying problems and detecting errors in the PutrajayAR application. It targets all nine features listed in Table 4.1 and was conducted using the black-box testing method, which aims to validate the functionality of a software application by providing appropriate inputs and checking the outputs against the expected results based on functional requirements. Black-box testing was chosen for its efficiency in quickly developing test cases, allowing bugs to

be identified and addressed promptly.

Table 4.1 Test Log

Test Item ID	Test Items	Test Type	Method	Pass/Fail
F001	User Registration	Function	Manual	Pass
F002	User Login	Function	Manual	Pass
F003	Homepage	Function	Manual	Pass
F004	User Profile	Function	Manual	Pass
F005	Travel Preference	Function	Manual	Pass
F006	AR Discovery	Function	Manual	Pass
F007	AR Recommendation	Function	Manual	Pass
F008	POI Detail	Function	Manual	Pass
F009	Logout	Function	Manual	Pass

Before functional testing of the application is conducted, the PutrajayAR application is first installed on an Android smartphone. Each user is required to create an account and log in to the system. Test Items F001 and F002 focus on verifying the basic user registration and login processes. During registration, a new user must provide a username, an unregistered email address, and a password between 6 to 8 characters. For login, users must enter a registered email along with the correct matching password to access the system.

F003 focus on verifying the correct display of the Homepage. After the user successfully logs in, the application will redirect to the Homepage, which will display the AR Discussion and AR Recommendation buttons, the user avatar, and the current location's weather.

In F004 and F005, the system will display the user details like their personal information and travel preferences, when user clicks the user avatar in Homepage, a

navigation bar would be displayed with two buttons named “User Profile” and “Travel Preference”. In the “User Profile” interface, some information including user id, user name, email, phone number, register time and country will be shown. In the “Travel Preference” interface, the application would present the users’ tourist type, preferred travel budget and categories of interests. The testing primarily focuses on verifying successful data access, display, and updates.

F006 and F007 mainly test the AR functions of the application, in the AR Discovery interface, the system displays an AR environment with POI annotations within specific distance, users can click the POI category buttons or slide the distance slider to filter POIs. Compared to AR Discovery, AR Recommendation introduces a personalized recommendation feature. This function suggests POIs that users are likely to be interested in, based on their travel preferences, current weather conditions, and the operating hours of each POI. The testing of these two interfaces is conducted to ensure that all intended functionalities are properly implemented, all interface components function correctly, and no errors occur during execution.

In Test Item F008, when users tap on any POI annotation within the AR environment, the application redirects them to a POI Detail interface displaying information about the selected location. This includes the POI's name, detailed description, opening hours, estimated budget, recommended tourist type, and related images. The testing primarily focuses on verifying successful data access and information display.

Test Item F009 focuses on verifying the logout functionality when a user attempts to switch accounts. When the user clicks the “Logout” button in the homepage navigation bar, the application redirects them to the login interface. All test items were executed successfully with a 0% incident rate, indicating that all tests passed without any errors.

ii. Usability Testing

Usability testing is a process that involves final testing carried out by users within a specified time to ensure that the software or system being developed can be operated and functions according to the user's needs before the application is released in the real environment. Usability testing is an important process for achieving development objectives. This is because, the application development objectives will be achieved if the product produced meets the user's criteria.

The usability testing is divided into three sections to obtain user feedback on three key aspects of the application: user satisfaction, persuasive design, and personalization. Selected questions from the USE (Usefulness, Satisfaction, and Ease of Use) questionnaire, as shown in Figures 4.12, will be utilized to test the users' overall satisfaction to this app. Besides, several questions adapted from other software usability studies will be employed to assess the app's persuasive design (Lehto, T., Oinas-Kukkonen, H., & Drozd, F., 2012). In addition, two open-ended questions will be used to collect participants' feedback on the application's personalization features.

Acronym	Instrument	Reference	Institution	Example
QUIS	Questionnaire for User Interface Satisfaction	Chin *et al*, 1988	Maryland	27 questions
PUEU	Perceived Usefulness and Ease of Use	Davis, 1989	IBM	12 questions
NAU	Nielsen's Attributes of Usability	Nielsen, 1993	Bellcore	5 attributes
NHE	Nielsen's Heuristic Evaluation	Nielsen, 1993	Bellcore	10 heuristics
CSUQ	Computer System Usability Questionnaire	Lewis, 1995	IBM	19 questions
ASQ	After Scenario Questionnaire	Lewis, 1995	IBM	3 questions
PHUE	Practical Heuristics for Usability Evaluation	Perlman, 1997	OSU	13 heuristics
PUTQ	Purdue Usability Testing Questionnaire	Lin *et al*, 1997	Purdue	100 questions
USE	USE Questionnaire	Lund, 2001	Sapient	30 questions

Figure 4.12 Test questionnaires for Usability

Source: Perlman, G., (2009)

The method used to obtain data is through Google Forms. Both the Google Form and the APK file were shared with participants. After installing and running the application on their smartphones, participants were asked to complete the form to

provide their feedback.

To evaluate the usability of PutrajayAR app, the testing was conducted in Putrajaya city, Malaysia, and 40 tourists from different countries or other states of Malaysia were invited to join this testing. Of the 40 participants, 19 were female and 21 were male, aged between 20 to 30 years. The usability test started with a brief introduction of the app's features to the participants. The purpose and method of the usability test process of this app were explained to all the respondents. Table 4.2 presents the distribution of the participants by age and gender.

Table 4.21 A table of respondent demographics

Age	**Gender**		**Amount**	**Percentage**
	Male	Female		
22	8	2	10	25%
24	2	4	6	15%
26	8	7	15	37.5%
27	2	4	6	15%
29	1	2	3	7.5%
Amount	21	19		
Percentage	52.5%	47.5%		

The 40 participants were divided into two groups with similar age, gender, and technology familiarity distributions. Group A tested the non-personalized functions of PutrajayAR, while Group B tested the personalized functions. By evaluating and comparing the usability of these two types of functions, we obtained user feedback on the usability of individual features as well as the app as a whole.

The test data was interpreted based on two principles. For feedback related to user satisfaction and persuasive design, the interpretation was based on Mohd Majid

Konting's book, Interpretation of Mean Level, which provides a scale for evaluating usability levels (Mohd Majid K., 2000). The interpretation criteria are illustrated in Figure 4.13. Besides, Qualitative Content Analysis method was used to evaluate the app's personalization, In the responses to the open-ended questions, frequently mentioned keywords were identified and considered as key indicators of users' perceptions and expectations regarding personalization (Selvi, A. F.,2019).

Stage Interpretation	Mean Range
Low	1.00 - 2.33
Medium	2.34 - 3.67
High	3.68 - 5.00
Source: Mohd Majid K (2000)	

Figure 4.13 Interpretation of Mean Levels

Source: Mohd Majid K., (2000)

The testing of user satisfaction was conducted to evaluate user perceptions and experiences across four key aspects: usefulness, satisfaction, ease of use, and ease of learning. Table 4.3 presents the mean scores and for each section of the testing. In this test, the average scores for all aspects were above 3.68 on a 5-point Likert scale, indicating that users strongly agreed with the positive statements about the PutrajayAR app. For each section, the mean scores recorded for the personalized functions are notably higher than those for the non-personalized functions. Based on these findings, it can be concluded that users demonstrated a high level of overall satisfaction with the app and showed a clear preference for its personalized features.

Table 4.3 Mean values of the testing questions about user satisfaction

Construct	**Non-Personalized**		**Personalized**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Usefulness	3.59	0.61	4.38	0.64
Satisfaction	3.95	0.53	4.17	0.47
Ease of Use	4.21	0.49	4.46	0.39
Ease of Learning	4.22	0.48	4.50	0.40

The testing of persuasive design was conducted to evaluate how well PutrajayAR helps users achieve their goals, interact with them, and persuade them across three key aspects: primary task support, dialogue support and perceived persuasiveness. Table 4.4 presents the mean scores for each section of the testing. The primary task aspect achieved an average score of around 3.68 on a 5-point Likert scale, with the remaining two aspects attaining mean scores that exceeded this value, indicating that users kindly agreed with the positive statements about the PutrajayAR app. For each section, the mean scores recorded for the personalized functions are notably higher than those for the non-personalized functions. Based on these findings, it can be concluded that users gave a relatively high overall evaluation of the app's persuasive design and and demonstrated a distinct preference for its personalized functionalities.

Table 4.4 Mean values of the testing questions about persuasive design

Construct	**Non-Personalized**		**Personalized**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Primary Task Support	3.59	0.61	4.38	0.64
Dialogue Support	3.95	0.53	4.17	0.47
Perceived Persuasiveness	4.21	0.49	4.46	0.39

Additionally, 2 open-end questions ,as shown in Table 4.5, are used to test the persuasive design of the personalization of PutrajayAR, all the responds of the 2 questions are displayed from Figure 4.14 to Figure 4.18. Qualitative Content Analysis was used to analyze open-end question data. For the open-ended question “Any suggestions for improving the app’s features or personalization?” Analysis of user responses revealed that the term “recommendations” appeared most frequently (4 times), followed by “region-based” (2 times), “local” (2 times), and “events” (2 times). These keywords highlight the key areas where users believe improvements are necessary. Users generally suggested enhancing the personalization features of the app by focusing on more accurate recommendations, region-specific content, and greater control over customization options.

For the open-ended question “How did the personalized recommendations influence your decision-making?”, the analysis revealed that the word “recommendations” appeared most frequently (2 times), along with “influenced” (2 times) and “confidence” (2 times). These keywords indicate that the personalized recommendations generally helped users make quicker and more confident decisions, by filtering down choices and providing relevant suggestions. However, a few respondents reported minimal impact, mentioning that they either ignored the recommendations or found them only moderately useful.

Table 4.5 Open-end questions for personalization

Question		**High Frequency Words**	**Amount**
No.1	Any suggestions for improving the app’s features or personalization?	Recommendations	4
		Include	2
		Region-based	2
		Local	2
		Events	2

No.2	How did the personalized recommendations influence your decision-making?	Recommendations Influenced Confidence	2 2 2

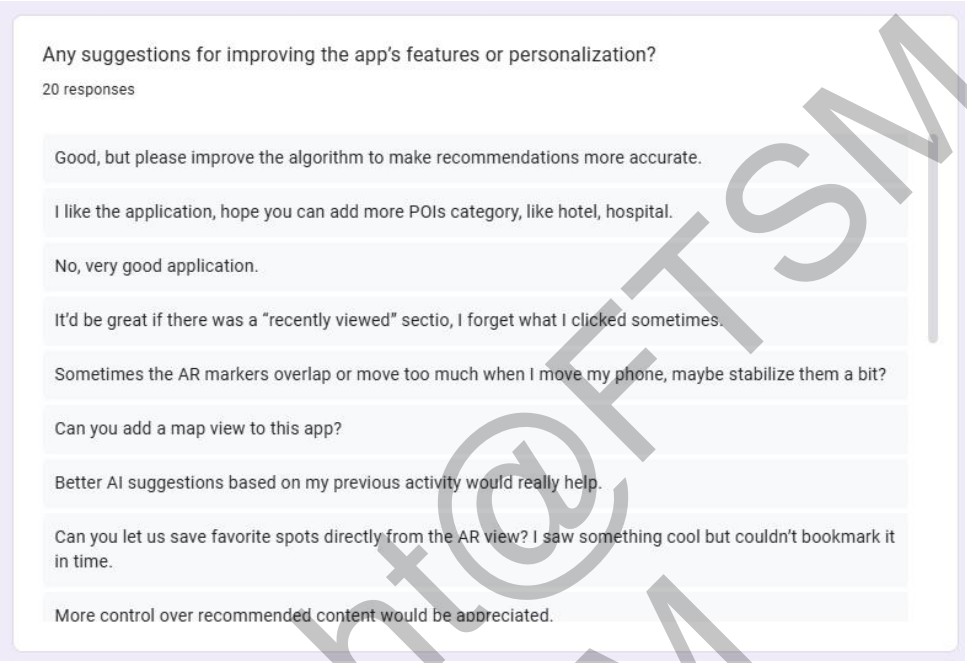

Figure 4.14 Responds of Question 1

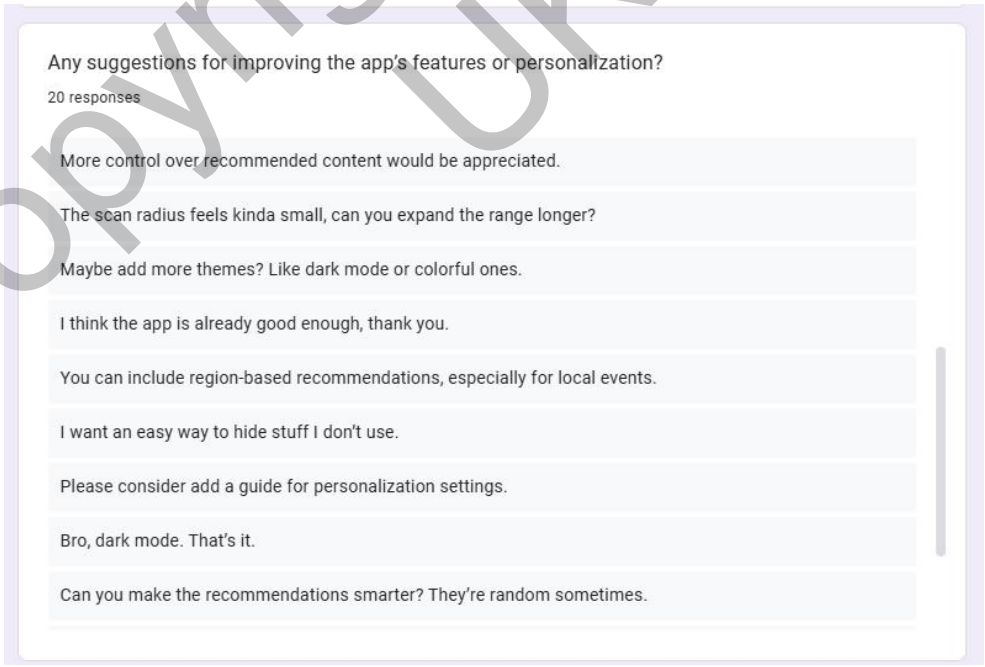

Figure 4.15 Responds of Question 1

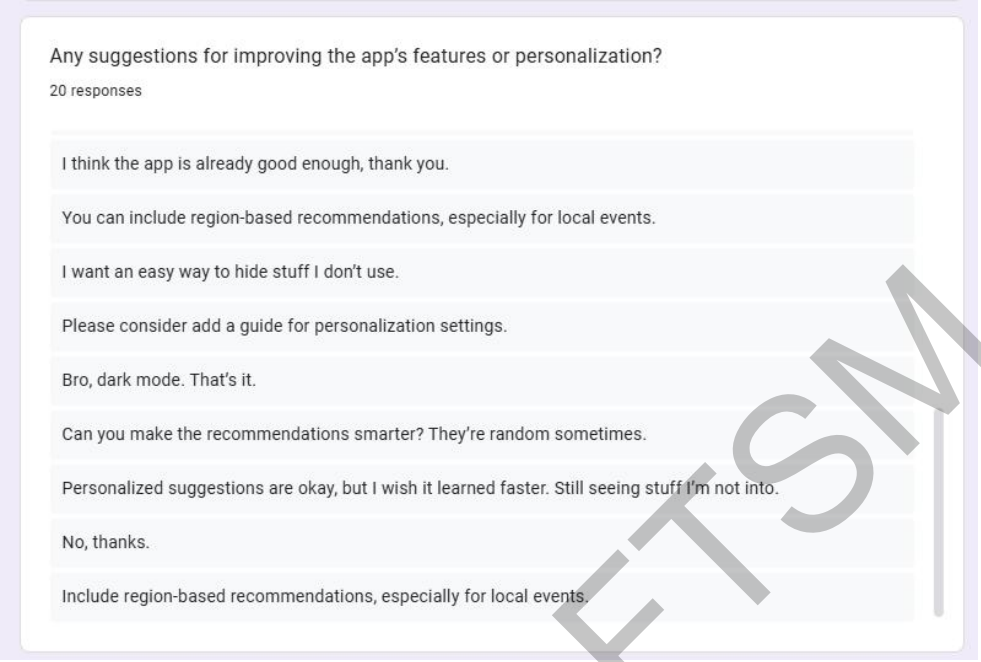

Figure 4.16 Responds of Question 1

Figure 4.17 Responds of Question 2

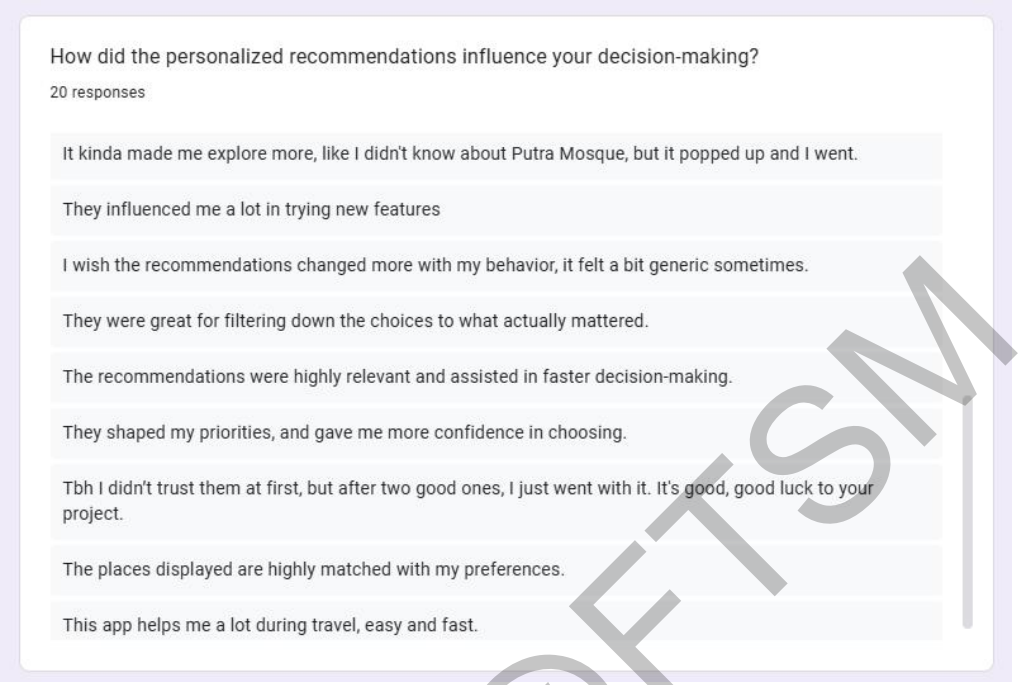

Figure 4.18 Responds of Question 2

The test results indicate that the PutrajayAR application exhibits strong functional stability and positive user acceptance, providing a solid foundation for future optimization and feature enhancements. Participants of this test expressed their love and satisfaction with the app and hoped that the app could enrich its content and improve its detailed recommendation functions.

5.0 CONCLUSION

PutrajayAR is a personalized, location-based augmented reality (AR) tourism application designed to enhance the travel experience for tourists. It enables users to scan their surroundings and view 3D points of interest (POIs) tailored to their needs, as well as receive recommendations based on their travel preferences through AR technology.

The project offers several notable advantages. Testing revealed that the application successfully captured tourists' attention, significantly enhanced their travel experience, and encouraged them to develop the habit of using PutrajayAR to

explore their surroundings. Many test participants also gave feedback that the design of the application is very interesting and suitable for most people, and the personalized settings greatly reduced the time to find the target POI.

However, the application does have some limitations. Currently, it only supports English, and its coverage is restricted to Putrajaya and a few nearby cities. In addition, according to the feedback from the respondents, the content of the application is also relatively limited, with suggestions to include more POI categories to enrich the experience and prevent users from losing interest over time. But these problems can be solved in subsequent development and maintenance

To enhance the overall quality of the application, several suggestions for future improvements have been identified. Firstly, incorporating additional language versions into the app design, such as Malay and Chinese, would further broaden its appeal and attract a more diverse user base. Secondly, expanding the range of POI categories would enrich the application's content and provide users with a more comprehensive tourism experience. Furthermore, certain aspects of the application could be refined in terms of quality and functionality, for instance, optimizing the loading efficiency of POI annotations and mitigating visual clutter caused by overlapping POIs would significantly enhance usability and user satisfaction.

6.0 APPRECIATION

With heartfelt gratitude and deep respect for the pursuit of knowledge, I sincerely thank everyone who contributed to the successful completion of this project documentation. I am especially grateful to my supervisor, Dr. Rimaniza Zainal Abidin, for her invaluable guidance, insightful advice, and continuous encouragement throughout the development of the PutrajayAR Application project. My sincere appreciation also goes to all lecturers and staff of the Faculty of Information Science and Technology (FTSM) for their dedicated teaching and unwavering support, which have greatly shaped my academic journey.

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