

AUGMENTED REALITY MOBILE APPLICATION FOR MALAY HERITAGE MUSEUM

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ABSTRACT

Lack of staffs and language barriers are two factors that limit the Malay Heritage Museum UPM staffs to handle visitors especially during peak seasons. Therefore, an augmented reality mobile application is proposed to assist and entertain visitors while touring the museum. In this work, the augmented reality will be imposed at the Malay traditional cloth and textiles section. To develop the proposed application, the methodology used in this work is agile model due to its capability to ensure that the overall process can be done within a time given and also its ability to increase the standard software instantly. Agile model consists of six phases such as requirements, design, development, testing, deployment and review. The experiment was conducted on the same day and three hours were allocated for the respondent because they were having classes. The time required for one respondent to experience the MTRACR is approximately 10 minutes per person. The survey is used as a platform to get feedbacks from users. Based on the survey, it shows that all users were satisfied with the proposed application and they suggested others to use it.

Keywords: Heritage Museum; Augmented Reality; Mobile Application; Malay Traditional Clothing and Textiles

INTRODUCTION

Malay Heritage Museum of Universiti Putra Malaysia (UPM) was established on January 2013 and it is located at the entrance of UPM [14]. The main purpose of the museum is for collecting, conserving and preserving Malay ancient artefacts by documenting and publicly exhibit the items. In addition, it also been used for research purpose. There are four segments in the museum: Malay costumes and textiles, Malay manuscripts, Malay weaponry and arms, and Malay household items.

The staffs provide tour for visitors to visit each segment. The staffs will explain each artefact to the visitors during the tour. Moreover, printed information is provided for the visitors to read the information of the artefacts. But, since the printed information is placed back of the glass wall for safety and to preserve the artefacts, it could limit the view area for visitors for reading. Although, this approach has been implemented since the opening of the museum, but it has led to an issue especially during the peak season. The current number of staffs in the museum is three. Normally, during the peak season, they do not have enough rest and it could lead to stress and unhealthy environment. In addition, the tour for international visitors is conducted in English language. However, there are visitors who are not fluent in English language and this cause the tour to become non-interactive sessions.

Due to these issues, a technology needs to be implemented to solve the problem. One of the solutions is by imposing an augmented reality mobile-based application. Augmented reality application is a well-known technology and with an updated hardware and software, it

become easy to develop [8]. This technology has been embedded in several applications such as Instagram and Snapchat, as a filter, to attract users for entertainment purposes [5]. These advantages have triggered us to propose an augmented reality for Malay Heritage Museum UPM to solve the problem of the staffs and the language barriers. With augmented reality technology, the artefacts could be created in 3D models and visitors could explore the artefacts accordingly to their preferences. They could also obtain information in an entertaining approach about the selected artefacts from the proposed mobile application.

To develop the proposed mobile application for the museum, there are several elements that need to be considered such as lighting. The Malay Heritage Museum of UPM has standardized the range of light dim inside the museum. This is to preserve the quality of the artefacts. The quality of the lighting is dimmer compared to the normal light, and this could affect the detection process of the markers for the augmented reality. Hence, to solve this issue, a high-quality marker is used in the development of the proposed mobile application. The proposed mobile application is focusing on the Malay Costumes and Textiles segment, which is labelled as MTRACR Apps (Malay Traditional Clothing and Textiles Augmented Reality Mobile Application) and it has been developed in Android platform. In this segment, it contains Malay cloth, textiles, accessories, jewellery, wedding, belt, *tengkolok*, decoration royal wedding bed, wedding decoration ceremony and others. For the purpose of interaction and edutainment, virtual button is used, and quiz is provided for the visitors to assess their understanding about the artefacts in the museum.

RELATED WORKS

Augmented Reality has been implemented widely in many fields. In 2013, [2] in his book has explained the advantages and disadvantages of augmented reality. The augmented reality technology can be used in the mobile and portable platform. If it is installed in the mobile, the application can be easily stored and brought to any places due to the size of the current mobile. Whereas, the portable augmented reality, needs the user to bring the special device such as desk-side or a laptop to use the application. This might be suitable for few occasions, but not for visitors in the museum. One of the advantages implementing the augmented reality is because it can be installed in mobile phone or a smartphone, and it is not restricted with the location. Besides, since this technology is literally combining the virtual and real world, hence the development cost is cheap and low. In terms of disadvantages, is in terms of resources in which it is restricted on most devices and that can affect the performance of the augmented reality. Apart from that, the memory also could influence the capability of the application.

TABLE 1. Existing augmented reality mobile application

Application	Description	Advantages
Story of the Forest [15]	Visitors needs to hunt and capture various plants and animals within the drawing using the application.	Users learn things like an animal's habitat and diet, the rarity of the plant or animal found, and general information about the species.
Skin & Bones [16]	This application brings skeletons to life by using augmented reality with 3D tracking.	User increase experiences and exploring more with information (inner lives of animals like bats, giant sea cows, rattlesnakes).
Heroes and Legends [17]	Augmented reality shows hologram of astronaut royalty to life.	User can learn about the astronaut stories with interactive application.
Jinsha Site Museum	The augmented reality was used	The augmented reality could help visitors to

[18]		to assists visitors and researchers to understand the ancient mysteries and artefacts in the museum.	understand the mysteries of the ancient totem. In addition, the augmented reality able to translate the artefacts so that visitors could understand the way of life of past visitors.
England's Cities [19]	Historic	Augmented reality allow user to interact with heritage sites across the country. At each location, there will be virtual guides and information is superimposed on walls and over artefacts.	The user gain experiences in learning with the augmented reality and they understand the pathway in the museum with the help of virtual guides.

Table 1 shows the existing augmented reality application that has been built in a museum environment. Some researchers agree that augmented reality could preserve the history for many years without harm the artefacts [4]. With this technology, museum visitors could understand more on the historical object in the depth view of history element using multi-dimensional view. Furthermore, it could also give an exposure to the user to experience on looking out at historical object with handheld devices such as mobile and tablets. This could increase level of engagement between visitor and the artefacts [7]. Visitors will enhance their experiences when immersing into augmenting scenes by facilitate mental and perceived virtual. Thus, it is proven that augmented reality gives experiences to the visitor. [9] shows that the natural interaction in augmented reality well accepted in cultural heritage environment in museum. Users are happy and enjoys using the augmented reality to interact the 3D model of artefacts from the museum. [11] states that using technology augmented reality protect the cultural heritage in smart cities. A 3D virtual models that interact by multiple user and can interact with each other engage experiences. Furthermore, virtual environment could save the artefacts from being destroyed by visitors as the visitor can learn more in the augmented reality application.

Markers are the key to augmented reality technology. It can be artificial and marker less. There are several ways to make the artificial marker to be interested such as design it on a hard board with interesting image. This key or marker could also affect the performance of the augmented reality mobile application. For instance, [6] presents the limitation of the artificial marker at Casa Batlló Museum, where the placement of the artificial marker could be blocked by visitors whenever the number of visitors is high. To solve this issue, the location of the markers and the distance between the marker and the application are notified to the users. Another issue has been highlighted by [3] which is related to marker tracking that involves visual tracking in an unfamiliar environment. This occurs because the system needs a complete information to calculate the position in real-time. To solve this issue, a bold border is proposed in [3]'s work.

METHODOLOGY

To achieve the objective of this work, agile model is used to ensure the overall process can be done within a time given and can increase the standard software instantly [10]. This model consists of six phases; requirements, design, development, testing, deployment and review as shown in Figure 1.

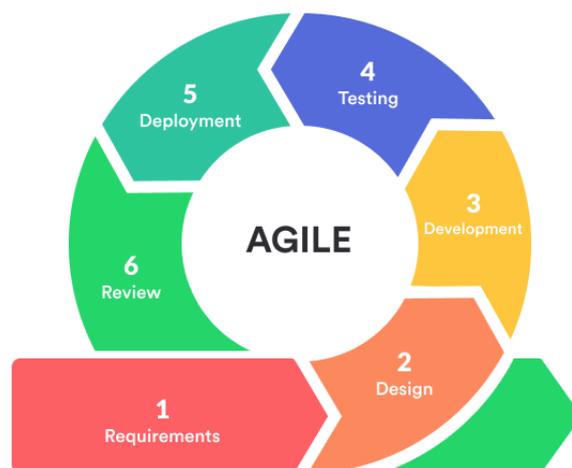


FIGURE 1. Agile Model 6

REQUIREMENTS

In this stage, two approaches were used to gather the important information: survey and interview session. The survey was developed to obtain people’s opinion about their experiences visited museum and their interest in using mobile-based augmented reality. In this survey, 10 questions were distributed to 17 respondents. The respondents were UPM’s students as shown in Table 2. Table 3 shows the list of questions. There are nine objective and one subjective question.

TABLE 2. Respondents Demographics

Age (years old)	20-23
Gender	
Female	12
Male	5
Universiti Putra Malaysia	
Faculty of Computer Science and Information Technology	12
Faculty of Sciences	3
Faculty of Modern Languages and Communications	1
School of Business and Economics	1

TABLE 3. List of questions

No	Questions	Yes	No
1	Have you visited any museum?		
2	Have you visited the Malay Heritage Museum at UPM?		
3	Are you enjoying reading information in text based at museum?		
4	Are you interested in discovering the Malay Clothing and Textiles at museum?		
5	Have you been searching information about the Malay Clothing and Textiles using any medium for instance Google, books or others?		
6	Have you used Augmented Reality Mobile Application for Museum?		
7	Do you think using Augmented Reality Mobile Application for Museum would help increase interest in museum?		
8	Do you think using 3D model in Augmented Reality Application Museum would help increase interest in museum?		
9	Do you prefer the augmented reality application in English Language?		
10	In your opinions, what are the other elements that should be inserted in this Augmented Reality Application?		

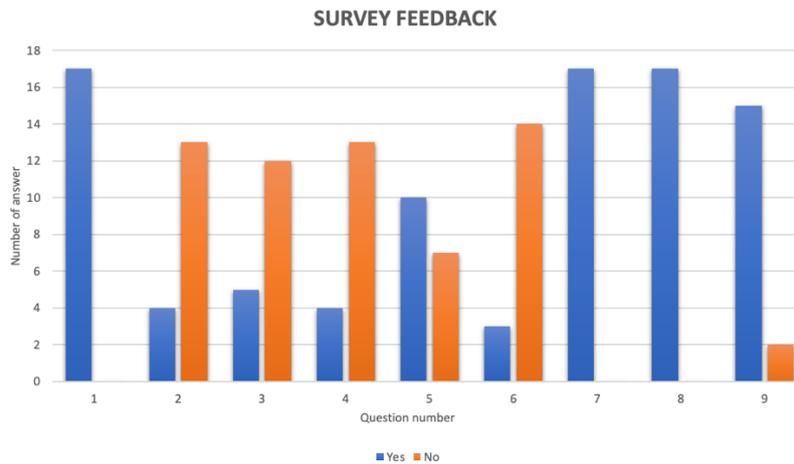


FIGURE 2. Survey feedback

Figure 2 shows the survey feedback. In general, all participants have visited museums. However, only about 24% has visited Malay Heritage Museum UPM. The survey also shows that about 94% of respondents were interested to explore on the Malay Clothing and Textiles in the museum. This shows that, Malay Clothing and Textiles has value and needs to be preserved. This is proved when about 59% is trying to search an information about the Malay Clothing and Textiles. Generally, about 71% of respondents not preferred to use the conventional approach in the museum; the text-based approach in the museum. In fact, all respondents agree that AR-based mobile and the 3D models in AR could increase interests' visitors during touring hours. About 88% of respondents prefer English language for their AR-based mobile to visit museum. Some respondents also suggest having an interactive element as well as animations in the AR-based mobile.

Another parallel approach to obtain more information about the Malay Heritage Museum UPM is by interviewing the museum's staff. During the meeting, the staff has shared the common issues of the museum such as the limited number of staffs. Hence, based on these information and survey's feedback, augmented reality-based mobile is proposed. The scope of this work is decided at this stage as well. The AR-based mobile will be developed for Android users only.

DESIGN

At this stage, the technical part which consists of the software and hardware. The minimum requirements of the hardware and software for the developer and users are shown in Table 4. It is essential to highlight the minimum requirements of the hardware for users to ensure that users or visitors are able to install the application inside their phones.

TABLE 4. Minimum requirements for hardware and software

Descriptions	Hardware		Software	
	Developer	User	Developer	User
Processor	2.0GHz or faster processor			
Memory	1GB or higher	512MB or higher		
Hard Disk/ Storage	15GB of available hard disk space	512MB of available storage		
Resolution	1024 x 768 or higher	720 x 1280 or higher		
Operating			Windows 10 or	Windows 10 or

System Unity	newer 2017.4.2 or newer	newer 2017.4.2 or newer
Augmented Reality Software Blender	Vuforia Engine	Vuforia Engine
Interface design software, Illustrator and Marker	2.5 or newer Adobe Illustrator CS 6	2.5 or newer Adobe Illustrator CS 6
Database	Firestore	Firestore

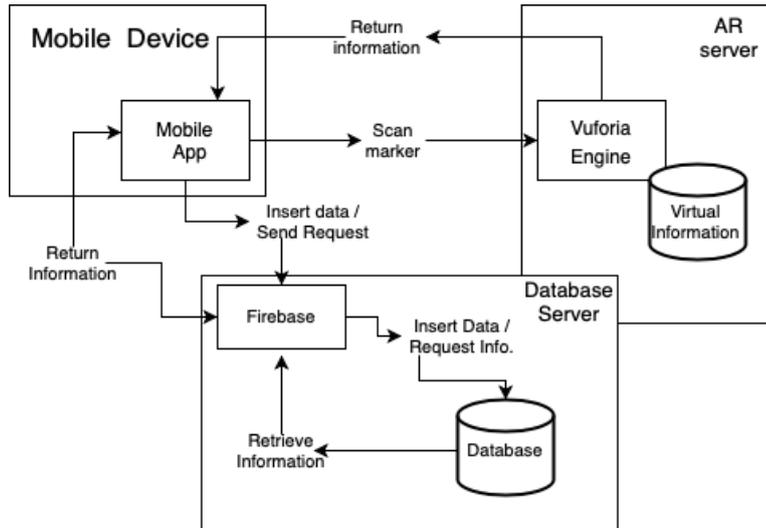


FIGURE 3. System Architecture

TABLE 5. Database Field and Name

Field	Type
username	VARCHAR
score	int

The MTRACR application requires a server to store the database, and in this work the Vuforia engine were used to store virtual information such as 3D models, illustrations, information, animations and virtual buttons and Firestore were used to store and retrieve data in quiz section (Fig. 3). Table 5 shows the field and type of field set in the Firestore and Fig. 4 shows the flowchart for the inserting and retrieving data to/from database. Fig. 5 shows the user interface (UI) of the MTRACR.

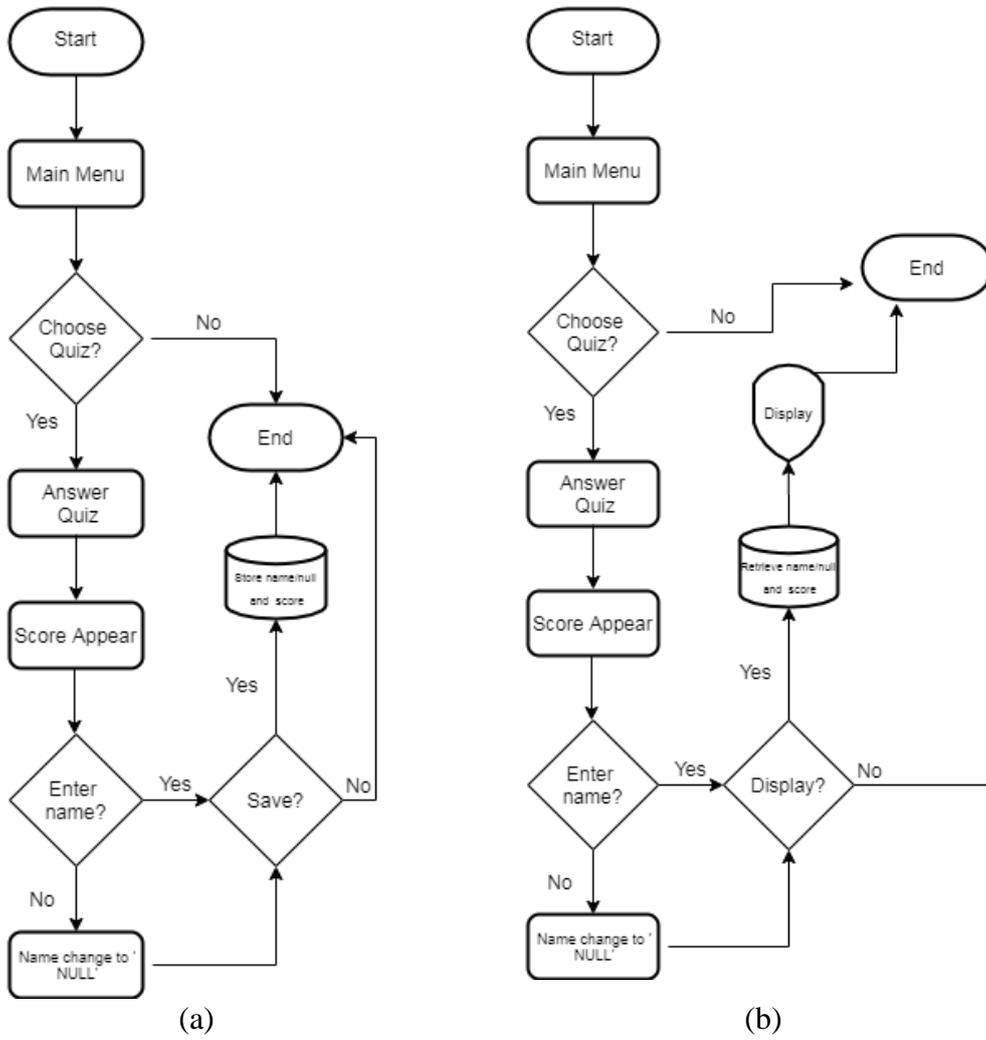
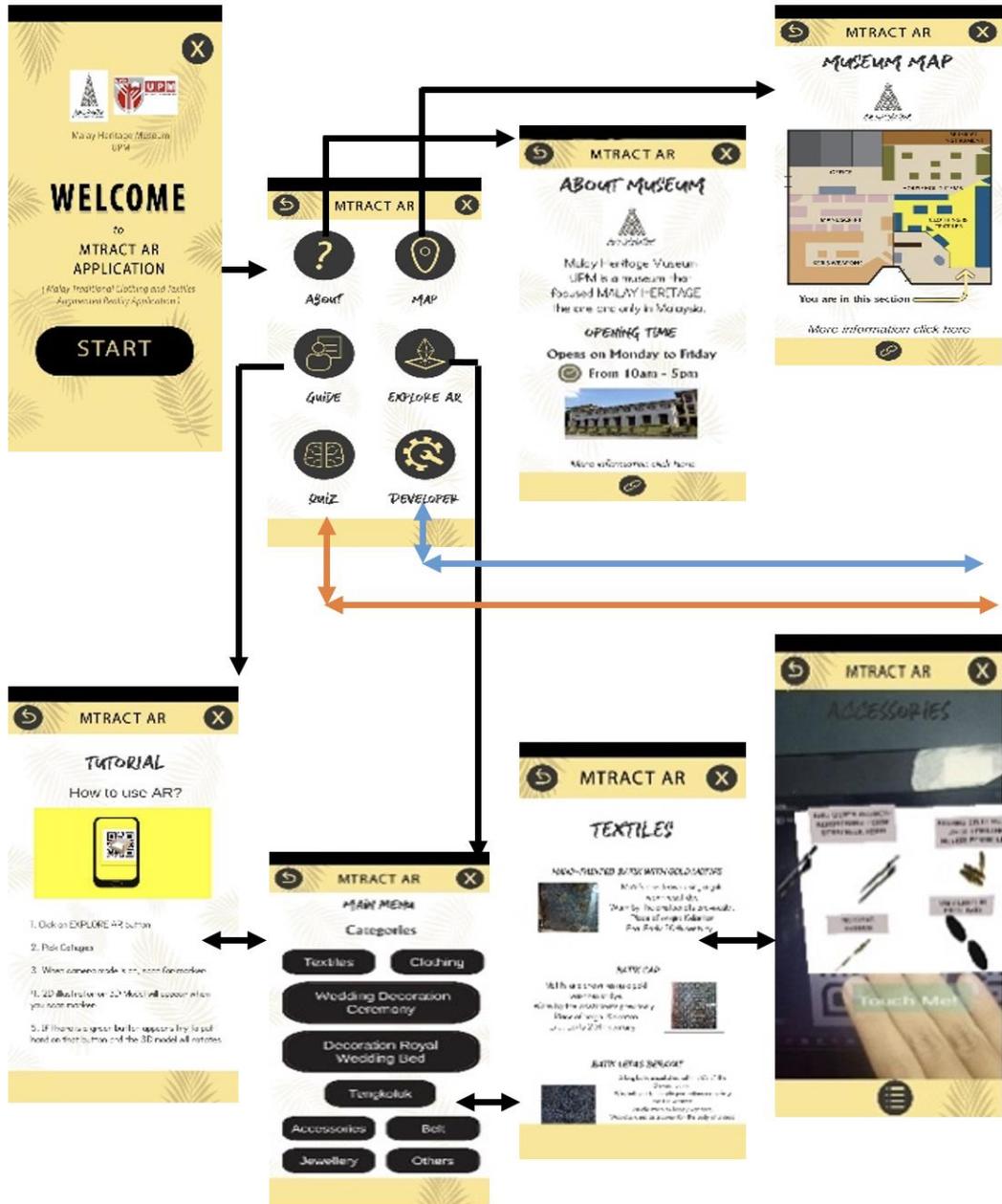


FIGURE 4. Flowchart for : (a) insertion of data to the database from Firebase. (b) retrieve data from the database and to display



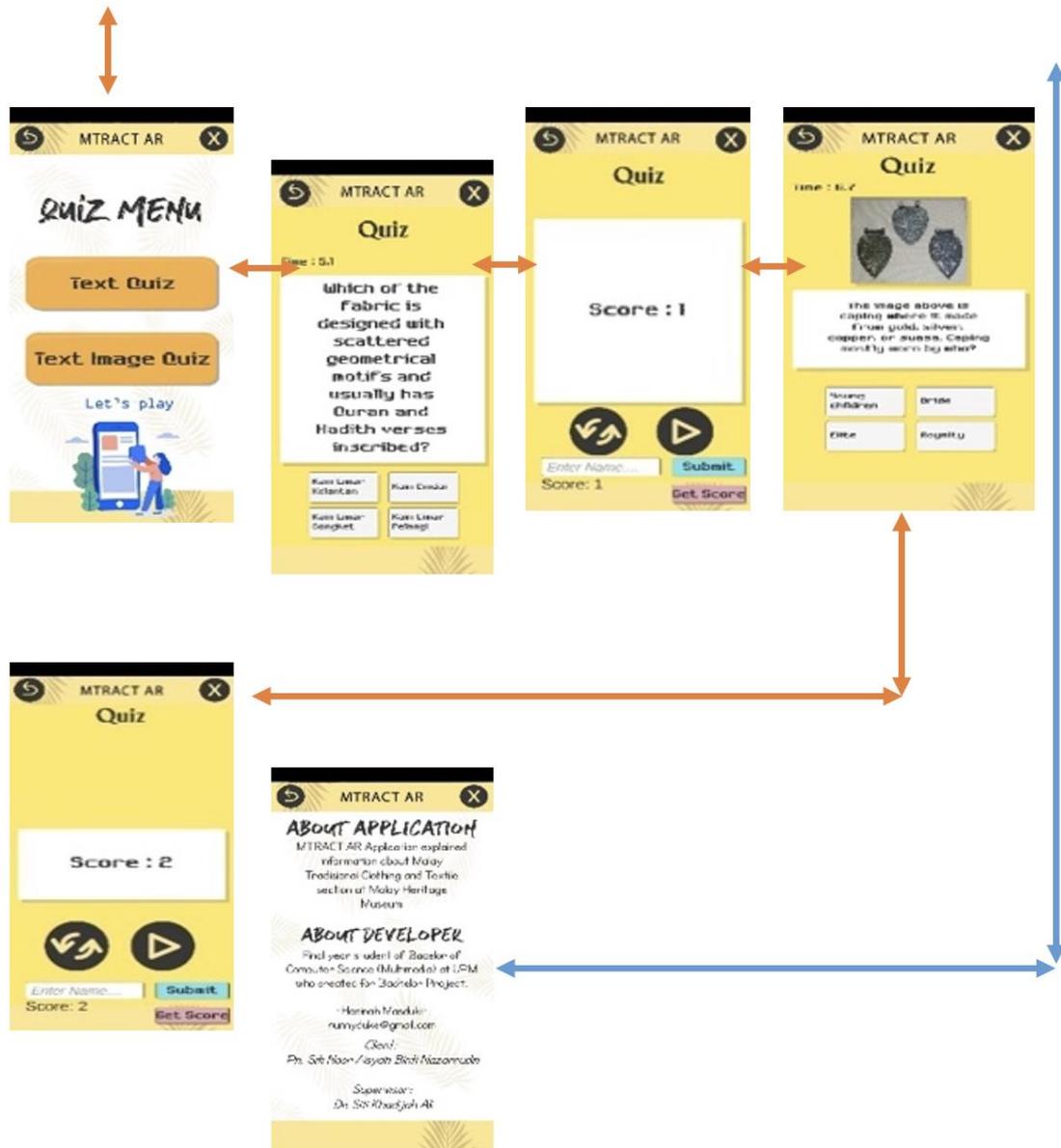


FIGURE 5. User interface (UI) for the MTRACTAR

DEVELOPMENT/ IMPLEMENTATION

As mentioned in previous section, Unity was used to develop the MTRACTAR. The 3D models were modelled by using Blender 2.79 and 2D models were created by using Adobe Illustrator CS6 (Fig. 6(a-c)). Other than 2D and 3D models, animations were included too in the MTRACTAR and Sony Vegas Pro 13.0 was used (Fig. 6(d)). Then, the models and animations were stored in the Vuforia.

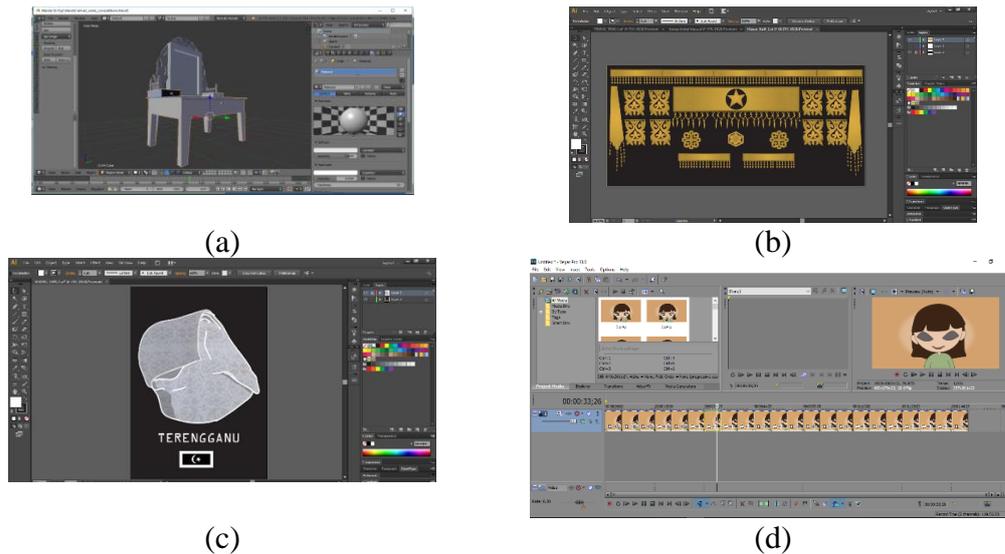


FIGURE 6. (a) 3D model with Blender (b-c) 2D mode with Adobe Illustrator CS6 (c) Animation by the Sony Vegas Pro

TESTING

To ensure the develop AR-based mobile application is working, alpha testing was conducted. To conduct the test, it is essential to ensure that the test environment is similar to Malay Heritage Museum UPM. Three elements were tested in this work: marker detection, virtual button and quiz tests.

In the development of the AR-based mobile application it is important to ensure that the marker is working. After several attempts, the design for the markers were a combination of QR code and the feature as it is requested by Malay Heritage Museum UPM (Fig. 7). Fig. 8 (a-c) show the selection area of detection on the markers. Users need to ensure that these areas need to be scanned so that the 3D/2D models and animations are appeared.

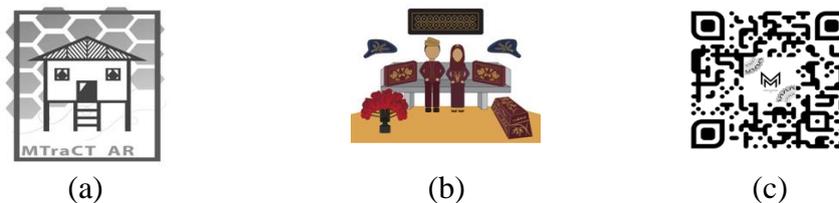
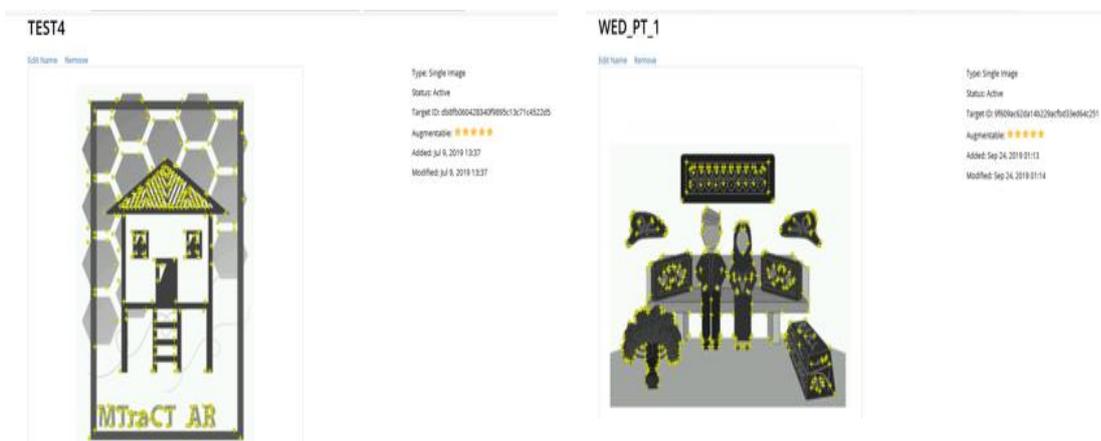


FIGURE 7. Markers. (a) First design (b) Second design (c) Third design (d) Final design



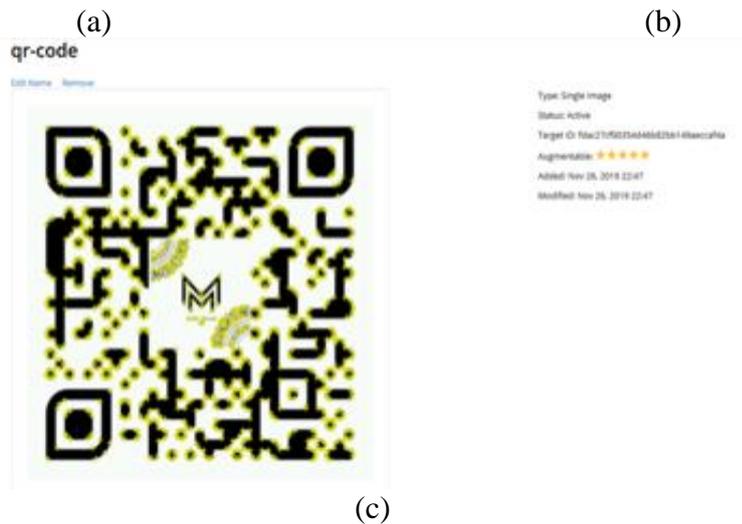


FIGURE 8. Feature detection on markers (a) First design (b) Second design (c) Final design

Virtual button and gestures are two features that is adding up to make the mobile application is entertaining. Hence, it is important to ensure these features is working. To ensure that the virtual button and gestures are working, the placement of button is needed to be on the most feature detection points. In this work, the gesture is used to rotate the 3D models. During the test, it shows that both the virtual button and gesture tests were working.

Another functions that need to be tested is the quiz function. There are two types of quizzes in this proposed application: text and a combination of text and image quiz. The score for both quizzes will be displayed at the end of the quizzes. Both score and names (player) can be displayed and stored in the Firebase database. Users are able to see the marks by using the 'get score' button, and the data will be retrieved from the database and is displayed on the screen. During the alpha test, this function shows that it can run smoothly, and the shown marks are correct and can be displayed correctly.

DEPLOYMENT AND REVIEW

Once the alpha tests were done, the beta tests were implemented. In this test, the overall experience of clients and real users are obtained and evaluated. To obtain those elements, questionnaire was used. The results are displayed in the next section.

RESULTS AND DISCUSSION

In this section, the results of the survey are presented. The beta testing was done at the museum. The demographics for the respondents are shown in Table 6. The experiment was conducted on the same day and three hours were allocated for the respondent because they were having classes. The time required for one respondent to experience the MTRACR is approximately 10 minutes per person.

TABLE 6. Respondents Demographics

Age (years old)	20-23
Gender	
Female	9
Male	4
Universiti Putra Malaysia	

TABLE 7. Questionnaire

No	Question	Percentage (%)			
		Strongly Disagree	Disagree	Agree	Strongly Agree
1	Do you enjoyed using the augmented reality application?			3	10
2	Does the 3D model/2D illustrator appears easily after scanning the marker?			5	8
3	Do you enjoy answering the quizzes?			4	9
4	Do you think answering the quiz with text based is easier than the quiz with image based?		7	6	
5	Do you think answering the quiz with image based is easier than the quiz with text based?			3	10
6	Do you think the 3D model looks real?		1	9	3
7	Do you enjoy using the virtual buttons?			2	11
8	Do you think the application contained enough information the museum that focused on Malay Traditional Costumes and Textures?			6	7
9	Do you enjoyed using mobile application to learn about the museum?			3	10
10	Will you recommend this application to others?			2	11
11	Do you think the interface design and the presentations looks good?			2	11
12	What will you suggest to improve the application in the future?				

Table 7 shows the feedbacks from the respondents. Respondents are required to observe the MTRACR application in terms of excitement or enjoyable moment when they are using the application, to test the functionality of the features such as virtual buttons, 3D models and quizzes. In general, all respondents agree that the application is enjoyable, the 2D/3D models were easy to be appeared, they like to play with the quizzes and virtual buttons and they are willing to recommend the application to other visitors. In terms of quizzes, most users preferred to play with the image-based quizzes. It can be seen in Table 8 as 46% of the users could score with full marks for the combination text and image quiz, but none of the participants could answer correctly for all text-based quiz. Users agree that the combination of text and image quiz is easier, and entertaining compared to the text-based quiz. This could be because the text is longer and respondents need to read the text while standing and looking at the smart phone. With the combination of images, it helps respondents to get a hint to answer and it can speed up the time for the respondents to answer the questions. Overall, all users are satisfy with the MTRACR.

TABLE 8. Respondent score

	Text Quiz	Text Image Quiz
User 1	1/5	User 1 2/5
User 2	0/5	User 2 5/5
User 3	2/5	User 3 4/5

User 4	2/5	User 4	4/5
User 5	1/5	User 5	5/5
User 6	2/5	User 6	5/5
User 7	0/5	User 7	2/5
User 8	2/5	User 8	5/5
User 9	1/5	User 9	4/5
User 10	0/5	User 10	3/5
User 11	2/5	User 11	5/5
User 12	1/5	User 12	4/5
User 13	1/5	User 13	5/5
MEAN	0.2308		0.8154

CONCLUSION

As a conclusion, MTRACR application has been proposed to be used in Malay Heritage Museum UPM. This mobile application has varieties of functions such as augmented reality, virtual buttons and gestures, and games which have been approved to attract more tourists to visit and learn about Malay Heritage Museum UPM. In future, more animations and 3D models should be included. In addition, it would be entertaining to include speech-based quiz. Generally, the MTRACR application has potential to be used by the visitors and students to learn more about the museum.

DECLARATIONS

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