THE VISUALISATION OF MUHAMMADIYAH MUSEUM USING AUGMENTED AND VIRTUAL REALITY TECHNOLOGY

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Abstract
There is a lot of media for promotion. The brochure is still widely used because of its simple, portable, and easy to carry anywhere. However, in this age of sophistication, the brochure is not effectively used for the millennial generation. Augmented Reality (AR) and Virtual Reality (VR) have been applied to many applications such as education, tourism, advertising, and news reports. With the rapid development of VR and AR technology, there are higher continuously requirements for enhancing brochure media effectiveness. AR and VR provide a potential solution for interaction between person and brochure as new emerging information technology. In this research, AR and VR are used to better educate tourists and visitors about the museum they choose to visit. Muhammadiyah Museum and its historical collection used as an example of applying AR and VR to the brochure as a promoting media. The Multimedia Development Life Cycle (MDLC) method applied to develop AR and VR. AR and VR system was tested by 30 under graduation students with 74.92% of acceptance. This research shows the AR and VR brochure is very feasible successfully sent information about the various kinds of historical collections in museum Muhammadiyah and very helpful as promoting media.

INTRODUCTION

Augmented Reality (AR) and Virtual Reality (VR) has been applied to many applications such as education [1], business [2], medical [3], art [4], and tourism [5]. In Indonesia, AR and VR technology is still rarely used even though any potential objects can be extracted. AR can be used with smartphones and VR with VR-headset, or virtual room can be used as a Human-Computer Interface [6], allowing humans to interact in the world created by computers [7]. In recent research, an increasing role of AR and VR technologies can be observed. A notable example is the ARCO system intended to develop a museum tour in virtually way [8].

The findings of this study [9] highlight the importance of virtual museum that can represent an opportunity to provide access to collectables stored in museums, which is signifies a considerable diverse and unique advantage that can create learning environments rich and help to full integration of the learner in the learning process - that cannot be provided by any other environment. As in [10], discover that the average learning achievement based on the digital museum is higher than the one based on the traditional museum. Advanced virtual technology can combine virtual space with a realistic environment to realize system-human interaction by obtaining surrounding and real-time human data [11].

It needs a method to develop AR and VR as multimedia software. Multimedia Development Life Cycle (MDLC) is the best method for producing a multimedia application. Multimedia software about tourism in West Sumatera [12] has been used in the MDLC method because it has simple software steps. MDLC also used for

developing an application for promoting products [13]. MDLC is the best method for developing AR and VR software. The application of AR carried out in the Bali museum successfully demonstrated its effectiveness [14]. AR application was very useful in understanding info about collections in the museum. Research conducted at the Toba Museum using VR with MDLC as a development method [15] has succeeded in increasing public knowledge about North Sumatra's culture.

The brochure is an appropriate promotional media to convey information due to informative, simple, easy to understand, and easy to carry. The brochure needs to combine with technology to make interactive advertising media as in [16], successfully create a brochure combined with AR that has been used to visualize historical graffiti in the temple of Debod.

Muhammadiyah Museum was built in the 4th campus area of Universitas Ahmad Dahlan Yogyakarta started in 2018 and now in the finalizing step. This museum needs an effective marketing program to drive visitor growth. This study aimed at developing AR and VR software using the MDLC method and testing applied AR and VR technology in the brochure to promote Muhammadiyah Museum.

METHOD AND MATERIALS
Augmented Reality (AR) and Virtual Reality (VR)

AR and VR are not new technologies. The first VR headset was made at the University of Utah during the 1970s by Daniel Vickers. With two screens, the headset offers the client the chance to watch the virtual scene introduced to him by turning his head. Also, the term VR was proposed in the United States during the 1980s by Jaron Lanier. Analyst Thomas Caudell and David Mizell proposed the term AR in 1990 to portray how the head-mounted showcases that circuit testers utilized when gathering confounded wiring saddles worked. The last mechanical furore of AR and VR was during the 1990s. Yet, around then, numerous limitations kept these advancements from being received by the overall population.

VR innovation is an intelligent 3D dynamic scene introduction innovation that uses computer simulation rules to make and experience a virtual world [17]. VR is an innovation that permits us to drench ourselves in a virtual world; this world can be a nonexistent universe or just the generation of this present reality. The experience can be visual, hear-able, and, on occasion, additionally haptic. This inundation is finished utilizing a computer-generated experience headset that puts a stereoscopic 3D show framework before the eyes (on the nose). A few models are furnished with sensors that recognize head following to permit the client to glance around. The pictures are recalculated progressively to synchronize with the bearing of the head or look.

Unlike VR (which prompts absolute inundation in the counterfeit world), AR alludes to a virtual interface, in 2D or 3D, that upgrades (or enlarges) what we see by overlaying extra data (computerized content) onto this present reality. Drenching in the virtual world is not complete because we can generally observe this present reality around us [18]. AR is finding new applications practically day by day. Its capacity to give high client instincts and the overall simplicity of usage has beaten VR, which was one of the most prominent effects of the last part of the 1990s. A multiplication of AR applications can be found on handheld gadgets and cell phones. Moving from marker-based to markerless enlistment and racking, versatile and outside AR is quickly picking up prevalence [19].

A cell phone camera or webcam required in the AR application to catch marker pictures. When a marker is recognized, a 3D item will show up [20]. AR utilizes cameras to perceive the picture of the marker on a progressing premise, procedure and afterwards, creates a virtual communication that shows up in reality to see both the showcase screen and the Head Mounted Display (HMD). The AR framework's primary issue is the exactness in the enrollment of 3D objects, which require the cooperation of virtual items with the genuine condition. The aftereffect of the enlistment object is an objective picture that has explicit keypoint include. Keypoint include that has been produced can be put away in a database and afterwards utilized in a match with a known article by the camera in the AR framework [21].

AR is in front of VR, as there are a few items as of now in the market. VR has its impediments. Regardless of giving entire vivid experience, it hinders the user's communication with the environmental factors. AR gadgets are all the more financially fruitful as they do not disengage individuals from this present reality [22]. AR utilization for museum frameworks past user pleasure, there are numerous components to the utilization of such a framework with more factors to consider [23].

3D Modeling Process

It is important to get information about the object's size and profundity from the outset to demonstrate an item as Museum Muhammadiyah building into a virtual tour. The initial step to turn

the building into a 3D model is to analyze the floor plans. This progression's capacity is utilized to include areas missed by imaging or filtering and for model get together. To change over the floor plans into a 3D model, semantic data, for example, room personalities and interfacing openings, is importantly trailed by dividers expulsion [24].

In different fields of research and applications, there are different demands accordingly [25]. The procedure to pick the correct 3D software to transforms all conditions into 3D also important. We use Blender as 3D modelling software. Utilized as a premise, Blender gives a chance to alteration (presentation of upgrades) from different angles, including the specific inside and outside arrangements. The advancement of inside and outside undertakings utilizing Blender programming is an extraordinary arrangement through which acknowledgement of the planning task gets conceivable, snappy, and proficient [26].

Multimedia Development Life Cycle (MDLC)

Today many museums around the world are aware of the potential advantages of using AR. However, emerging technologies are generally introduced into the museum environment in several stages depending on progressive improvements made by research in the field [27]. Many ubiquitous technologies, such as AR and VR, are continuously being examined in the history learning context. Museums and other heritage institutions, especially, are increasingly augmenting their spaces with highly interactive technologies [28]. Many projects, prototypes, and demonstrators have appeared for almost two decades. In this research, we use MDLC from Luther and have been modified by Sutopo [29], as shown in Figure 1.
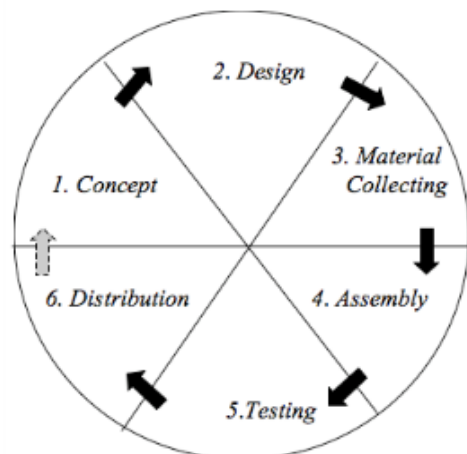
MDLC has structured stages and makes it easier to develop media applications [30] such as AR and VR applications. MDLC consists of six steps [31], namely:

1. Concept determine the concept and purpose of the application
2. Design describing the specifications for hardware and software used to create the Muhammadiyah Museum's AR & VR application.
3. The material collection used to collect data by observation to see the Muhammadiyah Museum's state and the available collections firsthand. Interviews were carried out to the parties involved in the development and to collect objects needed by the system. Literature related to research is also needed.
4. The manufacturing process of produces 3D models uses the specified hardware and software. The brochure was designed using a graphic design application called Adobe Photoshop CS3. The 3D models were created using Blender, as shown in Figure 2.
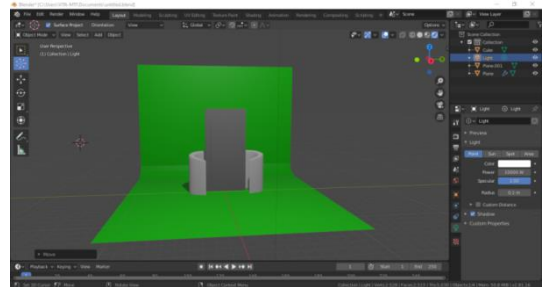

Figure 2. The Creation of Model for AR

For AR, the 3D models are grandfather clock, a badge of the 29th Muhammadiyah Congress, *rubu' al mujayyab*, and fiqh book as shown in Figure 3, Figure 4, Figure 5, and Figure 6.

Figure 1. MDLC Method

Figure 3. 3D Model of Grandfather Clock

Figure 4. 3D Model of Muhammadiyah Badges

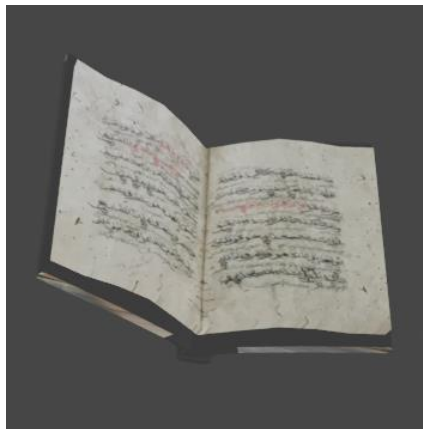Figure 5. 3D Model of Rubu' Al Mujayyab

Figure 6. 3D Model of Fiqh Book

For VR, the 3D model is the Muhammadiyah Museum virtual building. Unity software and vuforia SDK used to build the AR and VR software. The texture, shape, and color of 3D model objects are made to resemble the original shape, but for the volume and height of the 3D model, it is adjusted to the resolution of the smartphone. The installation procedure was written on the front page of the brochure, as shown in Figure 7. The brochure and its contents can be seen in Figure 8.

Figure 7. Front Page

Figure 8. Brochure and Markers

AR application menu display was made simple, as shown in Figure 9. The AR button will direct the user to the AR feature, as shown in Figure 10, and the VR button will direct the user to the VR feature, as shown in Figure 11. In the AR feature, the user only needs to point the smartphone camera to the Muhammadiyah Museum promotion brochure's marker.

Figure 9. AR and VR User Interface

Figure 10. AR Feature

Figure 11. VR Feature

5. Test methods used in this research;
   a. Black Box Test the functionality of the menus in the application.
   b. Compatibility Test to review the capabilities application which is operated on different versions of Android.
   c. Marker test to test the accuracy of camera and marker
   d. Software Usability Scale (SUS) was used to rate specific aspects of the software and related usability experience [32][33].
6. Distribution of approved AR and VR applications then be disseminated to the public via the link.

The second step in this methodology was to clear the definition of roles that will play. Three type roles were defined:
1. Developer – Developer should develop the AR and VR software using the MDLC method and apply AR and VR technology into the Muhammadiyah Museum brochure.
2. Tester – The tester is the person who has the professional skill of their field. Tester's role is to test the system using the Black Box test related to the appearance of application and brochure, clarity of information, color composition, button and menu functionality, animation design, and delay time. There are two testers; the software tester to test AR and

VR software, and Designer to verify the brochure's design.
3. Respondents – 30 undergraduate students were chosen as a respondent to try our final AR and VR software. After they use the AR and VR technology, we interviewed the respondent with SUS [34].

RESULTS AND DISCUSSION

The AR and VR software usability has been tested using a black-box test, as shown in Table 1. The result is 100% work properly.

Table 1. Result of Black Box Test

Testing	Action	Expectation	Result
Display main menu	Loading	The main menu splash screen shows up	✓
AR button	Touch	AR scan feature show up	✓
VR button	Touch	VR interface show up	✓
Exit button	Touch	Application exit	✓
Show 3D objects	Move camera into a marker	3D object show up	✓
Display virtually	VR goggles	display virtually	✓

We use compatibility tests for looking at where the software can be installed. The test is done by installing the AR, and VR application on several Android versions, as shown in Table 2 with the result is 100% running well.

Table 2. Result of Compatibility Test

Device of Android	Version	Result
Samsung Galaxy TAB 3	4.0	Running
Galaxy Note 1	5.1	Running
Oppo F5	7.1	Running

For the best result, the distance between the marker and mobile phone was tested as in [32]. The accuracy of the camera mobile phone and marker accuracy in the museum Muhammadiyah brochure is shown in Table 3.

SUS Testing is done by giving a questionnaire to the user or respondent. In the process of usability testing, researchers use ten questions as below:
1. I think that I would like to use this software frequently.
2. I found the menu and button unnecessarily complex.
3. I think the software was easy to use.

4. I think that I would need the support of a technical person to be able to use this software.
5. I found the various functions of buttons and menus were well integrated.
6. I think there was too much inconsistency in this software.
7. I would imagine that most people would learn to use this software very quickly.
8. This software is very cumbersome to use.
9. I felt very confident using the software.
10. I needed to learn a lot of things before I could get going with this software.

Table 3. Marker Detection

Distance (cm)	Camera tilt angle	Lighting	Result
4	0°	Artificial light, Dark	Success
4	0°	Natural light, cloudy	Success
8	0°	Artificial light, Dark	Success
8	0°	Natural light, cloudy	Success
12	0°	Artificial light, Dark	Success
12	0°	Natural light, cloudy	Success
27	0°	Artificial light, Dark	Success
27	0°	Natural light, cloudy	Success
50	0°	Artificial light, Dark	Success
50	0°	Natural light, cloudy	Success
4	45°	Artificial light, Dark	Success
4	45°	Natural light, cloudy	Success
8	45°	Artificial light, Dark	Success
8	45°	Natural light, cloudy	Success
12	45°	Artificial light, Dark	Success
12	45°	Natural light, cloudy	Success
27	45°	Artificial light, Dark	Success
27	45°	Natural light, cloudy	Success
50	45°	Artificial light, Dark	Success
50	45°	Natural light, cloudy	Success
4	70°	Artificial light, Dark	Success
4	70°	Natural light, cloudy	Success
8	70°	Artificial light, Dark	Success
8	70°	Natural light, cloudy	Success
12	70°	Artificial light, Dark	Success
12	70°	Natural light, cloudy	Success
27	70°	Artificial light, Dark	Success
27	70°	Natural light, cloudy	Success
50	70°	Artificial light, Dark	Success
50	70°	Natural light, cloudy	Success

Table 4. Result of SUS

Question	AVG score
I think that I would like to use this software frequently.	3.63
I found the menu and button unnecessarily complex.	2.10
I thought the software was easy to use.	3.87
I think that I would need the support of a technical person to be able to use this software.	1.50
I found the various functions of buttons and menus were well integrated.	4.00
I thought there was too much inconsistency in this software.	2.17
I would imagine that most people would learn to use this software very quickly.	3.83
This software is very cumbersome to use.	2.13
I felt very confident using the software.	4.17
I needed to learn a lot of things before I could get going with this software.	1.63
FINAL SCORE	**74.92%**

Each question is answered with a SUS-Likert scale by giving points 1 to 5, where scale 1 = very difficult / very not useful / not very much / very not enjoying / very not interested and scale 5 = very easy / very useful / very much very enjoyed / very interested. In addition to giving

points to the respondent's value, a column in every question for the respondent is provided to give reasons or opinions on each question.

Researchers conducted testing on 30 respondents which are 8 females and 22 males. Before filling in the user questionnaire, the respondent must use the AR and VR software, generally for 10 minutes. Table 4 shows the result of the questionnaire given to the respondent. We analyze the data using SUS calculation. The application gets a score of 74.92% means that the application is considered successful and work properly.

CONCLUSION

The use of brochure media by using AR and VR technology to introduce the Muhammadiyah Museum has proven to be successfully implemented in the community. The application was tested by the Black Box Test, Compatibility Test, Marker Detection Test, and SUS with a successful or feasibility rate of 100%, 100%, 100%, and 74.92% respectively. These results indicate that AR and VR application of the Muhammadiyah Museum is very feasible to use, informative, and very helpful in introducing the Muhammadiyah Museum to the public. The Muhammadiyah Museum AR and VR software has properly worked and well running to display 3D objects and their information. The application can be operated on Android with a minimum specification of 2GB RAM and OS Version 4.4 Kitkat.

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