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Implementation of Augmented Reality Technology in Sangiran Museum with Vuforia

F A Purnomo[1], P I Santosa[2], R Hartanto[2], E H Pratisto[1] and A Purbayu[1]

[1]Informatics Engineering Department, Sebelas Maret University,
Jl. Ir. Sutami 36A Surakarta 57126, Indonesia.
[2]Faculty of Engineering, Gadjah Mada University, Yogyakarta

E-mail: fendi_aji@mipa.uns.ac.id

Abstract. Archaeological object is an evidence of life on ancient relics which has a lifespan of millions years ago. The discovery of this ancient object by the Museum Sangiran then is preserved and protected from potential damage. This research will develop Augmented Reality application for the museum that display a virtual information from ancient object on display. The content includes information as text, audio, and animation of 3D model as a representation of the ancient object. This study emphasizes the 3D Markerless recognition process by using Vuforia Augmented Reality (AR) system so that visitor can access the exhibition objects through different viewpoints. Based on the test result, by registering image target with 25o angle interval, 3D markerless keypoint feature can be detected with different viewpoint. The device must meet minimal specifications of Dual Core 1.2 GHz processor, GPU Power VR SG5X, 8 MP auto focus camera and 1 GB of memory to run the application. The average success of the AR application detects object in museum exhibition to 3D Markerless with a single view by 40%, Markerless multiview by 86% (for angle 0° - 180°) and 100% (for angle 0° - 360°). Application detection distance is between 23 cm and up to 540 cm with the response time to detect 3D Markerless has 12 seconds in average.

1. Introduction

Augmented reality (AR) is a technology that combines visual objects or virtual world into the real world to see in real time [1]. Augmented Reality uses cameras to recognize the image of the marker on an ongoing basis, process and then generates a virtual interaction that appears in the real world to see both the display screen and the Head Mounted Display (HMD). The main problem in the AR system is the accuracy in the registration of 3D objects, which require the collaboration of virtual objects with the real environment. The results of the registration object is a target image that has specific keypoint feature. Keypoint feature that have been generated can be stored in a database and then used in a match with a known object by the camera in the AR system.

This research will test the ability of the AR in detecting Markerless which is 3D real objects in museum's showroom with visitor's camera angle position to the exhibition objects approach. Factors affect the Markerless detection process, including distance, angle, lighting, shadows and movement / motion. Device capability in implementing AR also to be considered that the recognition of 3D Markerless can be accessible and virtual information can be displayed next to the object of the exhibition. The purpose of this study is to design a mobile augmented reality application for the

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museum exhibition at the museum with objects as 3D Markerless and measure the ability of mobile devices to recognize 3D Markerless.

In the museum showrooms presentation according to Jing [2], the number of catalog that describe the object information for current exhibition has begun to lag. With the development of technology, visitor ables to choose their own show off objects that he/she want to know the information and the information can be generated virtual ly using visitor's smartphone. However, the interest of visitor to the Museum Sangiran still low, by 2015 only amounted to 314,000 visitors per year and 14% are foreign visitors. It is very unfortunate because Sangiran Museum is one of the best archaeological sites in the world. Research conducted by Ramírez [3] stated that smartphones are the right choice in AR application development for the museum. The device is lightweight making it easy to carry and can be easily manipulated. Research conducted by Ćuković [4] mentioned that the use of ID markers to deliver information in a book is inefficient because it requires additional space and not scalabe. Research conducted by Sari [5] has been successfully collaborate on the use of NFC (Near-Field Communication) and Augmented Reality technology with Vuforia as a guide to the visitor in the museum of Yogyakarta. In that study, the use of NFC as visitor's guide can only be enjoyed limited to smartphones with NFC feature. The accuracy of detected Markerless is 65% of 50 registered Markerless, this is due to Markerless' feature recognition still done at ideal angle that is at an angle of 90 degrees only.

2. Experimental

Research conducted was developed in stages as shown in Figure 1 which includes the tools installation, application development, local testing, real testing. Local testing aims to determine the maximum tilt angle of a detection device in 3D Markerless. Data obtained from local testing will be used in registering the target Markerless 3D image for each AR tilt in recognizing image targets range from 0° up to 360°. The stage of finding minimum angle deviation as shown in Figure 2.

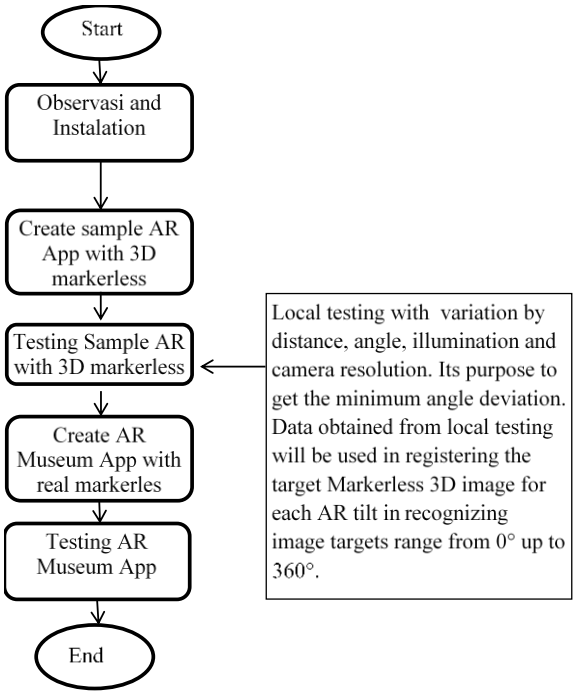


Figure 1. Research stage

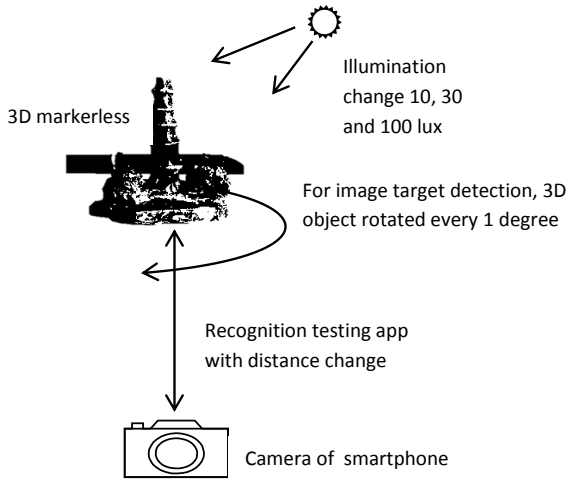


Figure 2. Determining minimum angle deviation for 3D markerless recognition

This study uses Markerless display in the Sangiran Museum. Markerless used in the form of 2D and 3D Markerless with the selection of 3D Markerless for a one-way visitor's perspective with 73 objects, selecting 3D Markerless with a visitor's perspective between 0° - 180° with 7 objects and selection of 3D Markerless with a visitor's perspective between 0° - 360° with 1 object. Each objects are given headlights lighting with intensity varying with the range between 8 Lux to 100 Lux.

Making an AR application for museum that use Vuforia using library which is imagetarget.unitypackage. The process of merging the information with the target image uses Unity. The AR museum applications is tested using various criteria in android smartphone hardware devices. Usefulness test of the application to the the visitor uses a questionnaire with five questions that measure aspects of interest in the application, ease of getting information aspect, the aspect of easy navigation, interactivity aspects of the application, and aspects of application innovation.

3. Result and Discussion

AR applications that have been implemented in Sangiran Museum using 3D Markerless aims to support the preservation of ancient objects on display because they are touchless, in addition the use of Markerless also maintains the initial settings that were neatly without compromising aesthetics of museum showroom space. Content virtual information presented in the form of text information, audio, video and 3D models that provide innovative delivery of information to the visitor. The results display the main menu AR application Sangiran Museum and the information is presented as shown in Figure 3 and Figure 4.

Figure 3. Main menu interface of AR Museum Sangiran

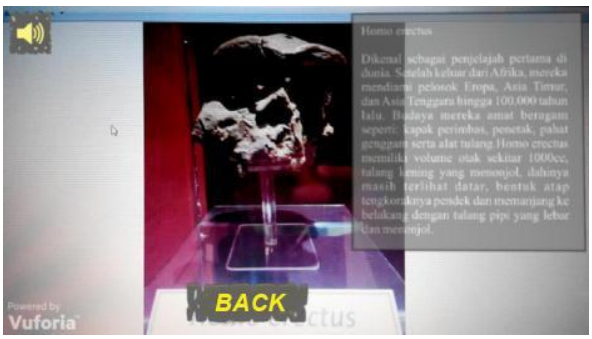


Figure 4. Displayed text information content when 3D markerless is detected by the camera

In detection testing, 3D Markerless keypoint began to be identified either from close range or from the furthest distance and based on tracking testing of the ability to maintain a virtual object that appears stating greater the angle of intersection, the smaller / narrower distance range for the Markerless recognition. However, for the greater the distance of provision of light intensity, the wider the range to maintain the appearance of the virtual object. From the graphical trend relationship between the distance, the angle and the influence of light intensity in the detection and tracking of the target image shown in Figure 5, it can be determined the minimum angle of 3D Markerless can be recognized at an average of 25^{o}.

The successful accuracy of 3D Markerless recognition in the case of the use of images targeted for one-way visitor's perspective is low, this is because some of the weaknesses of the 3D Markerless method, the first weakness is very vulnerable to changes in the position of the object of the exhibition itself. Changes in position can be caused because the object of the exhibition is taken and not returned to the starting position.

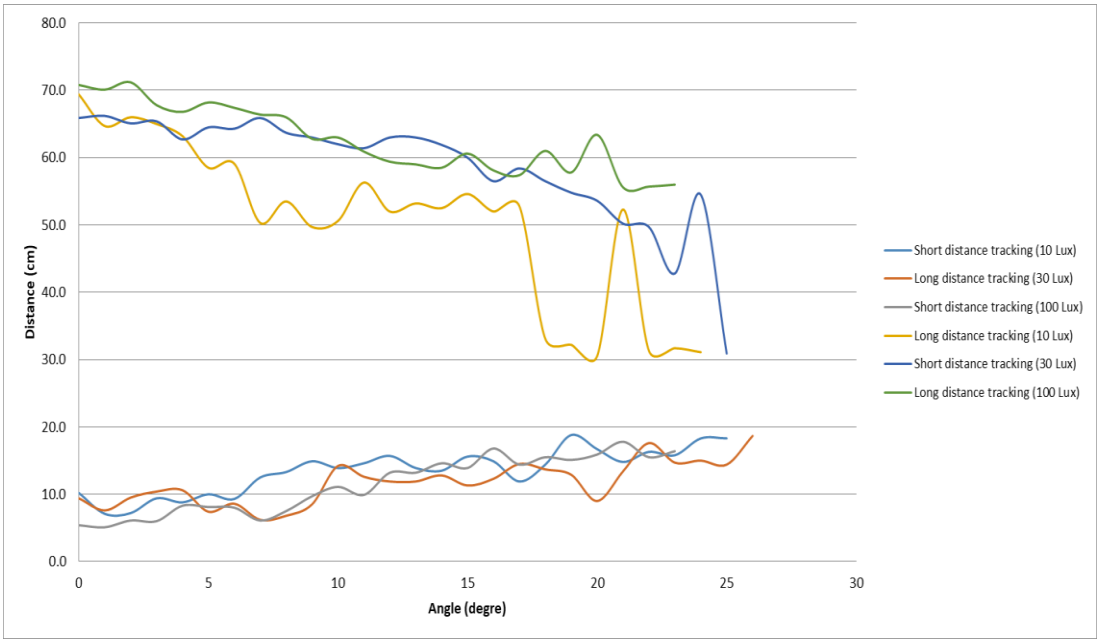


Figure 5. 3D markerless tracking result between detection distance and deviation angle

In early testing, the use of 3D Markerless can be detected when changing the angular position horizontally within the range of 0° up to 25°. The use of 3D Markerless at the initial assumption that the object of the exhibition placed in a glass static and not likely to not be touched or taken is proven wrong. Museum Sangiran Party purge of the exhibition objects, both objects show off, big and small objects showroom located inside a glass cabinet is also cleaned every Monday. As a result, a deep cleaning of the exhibition objects has chance to shift compare to initial position. This makes the target image that has been registered at the beginning of the exhibition objects has decreased the number of objects to show off a number of keypoint that 54.3% did not successfully recognized by AR app museum. In the image registration targets on Vuforia also have to be optimized feature on the exhibition objects that have a rating above the value of 3 or above, which means that the target image is easily recognizable by the AR system.

The second weakness, the use of 3D Markerless very vulnerable to changes in a great light. In a test conducted, the AR is given variation in light intensity changes in the value of 10 Lux, 30 Lux and 100 Lux. This means that the total amount of light incident on the object to show off with such intensity changes, the AR system can still recognize and bring up a virtual information. In the showroom, the lights were on exhibition objects will affect the 3D Markerless recognition if the initial condition when the registered image is different target with the current state of AR application testing museum. Showrooms in Sangiran Museum have been conditioned by both the influence of light from outside the room. The condition can be caused by changes in light intensity in the use of electric lighting showrooms museum. The use of electric lights when they are short-lived, the capacitor and resistor components will experience a reduction in the value and causing the light intensity is about the object of the exhibition will also be reduced. Reduction in the intensity of light that is too large will affect the image recognition system targeted by AR.

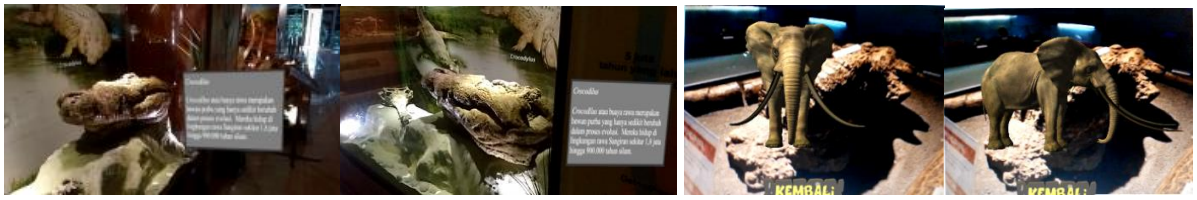
A third disadvantage, the use of 3D Markerless very influential in the shadow covering the object showrooms. In the Sangiran Museum there are many objects that is placed inside the glass so that the object is not marred by the exhibition visitors. Object placement in the glass cupboard in a certain distance will be seen the reflection of light and shadow of show off objects that affect detection of the object keypoint showroom.

As a first solution, an approach that can be done to address the disadvantages of the use of 3D Markerless in this method is the use of 3D objects Markerless is for an object that exactly has not

changed position. Object placement on a permanent position makes the introduction of features more easily recognized by the AR system. In object placement showroom that can only be seen from one point of view only and likely to occur reflection of light by the glass, use Markerless can use name labels on objects such showrooms. This is because the use of 2D Markerless ranges reading corner by the AR system that is greater than the use of 3D Markerless are only in the range of viewpoints 0º-25º to the object show off. The second solution, in the case of the use of electric lights can be replaced with incandescent lamps so that light intensity on the object to show off can be maintained and does not affect too big to a target image on the object to show off.

While testing on 3D objects in the exhibition at the Museum Sangiran carried variation detection position between 0º-180º as shown in Figure 6. Position changed virtual information detection that appears also customized the appearance of perspective so that the information can be easily read by the visitor and equipped with audio dubbing containing a summary description of the object show.

AR application developed also displays 3D objects such as for example the appearance of information on the Ancient elephant bones as Markerless 3D model of Ancient Elephant in the form of 3D models shown include a rotating animation so that visitors can see an ancient elephant in 360º. Elephant virtual 3D model can be shown in Figure 6. Compared to the research conducted by Sari [5] this method is able to detect markerless between angles of 0 degrees to 360 degrees.



(a) (b)

Figure 6. Testing in Sangiran Museum showroom where object can be seen by the visitor from detection position between 0º-180º (a) and detection position between 360º(b)

In Figure 7 is test results of 81 objects exhibition at the Museum Sangiran give AR application museum in the detection of objects showroom for Markerless with a single view of 40%, Markerless with multiview of 86% (for angle 0° - 180°) and 100% (for angle 0° - 360°) with a detection distance of 23 cm up to 540 cm. The response time starts to detect 3D Markerless at average of 12 seconds. From the results of a survey of visitors to the museum, the analysis results in the form of validity and reliability generate Cronbach alpha of 0.97 so that all the questions declared valid and reliable. Respondents to the application of AR Museum Sangiran embodied in five aspects: the interest in applications worth agree-strongly agree 93%, aspects of the ease of getting information valuable agree-strongly agree 97%, aspects of ease of navigation is worth the agreed-strongly agree 100%, aspects of interactivity applications worth agree-strongly agree 94%, and aspects of application innovation worth agree-strongly agree 97%. According to visitor feedback, text is presented in a particular showroom object still looks small and has been offset by the provision of audio content in the delivery of information. In this study also tested the smartphone device hardware specifications variation. The test result indicates that AR museum can be run with the minimum criteria of a device with a hardware specification that is Dual Core 1.2 GHz processor, GPU Power VR SG5X, 8 MP auto focus camera, 1 GB of memory. The greater the performance, the faster its runs the application and detect the 3D Markerless.

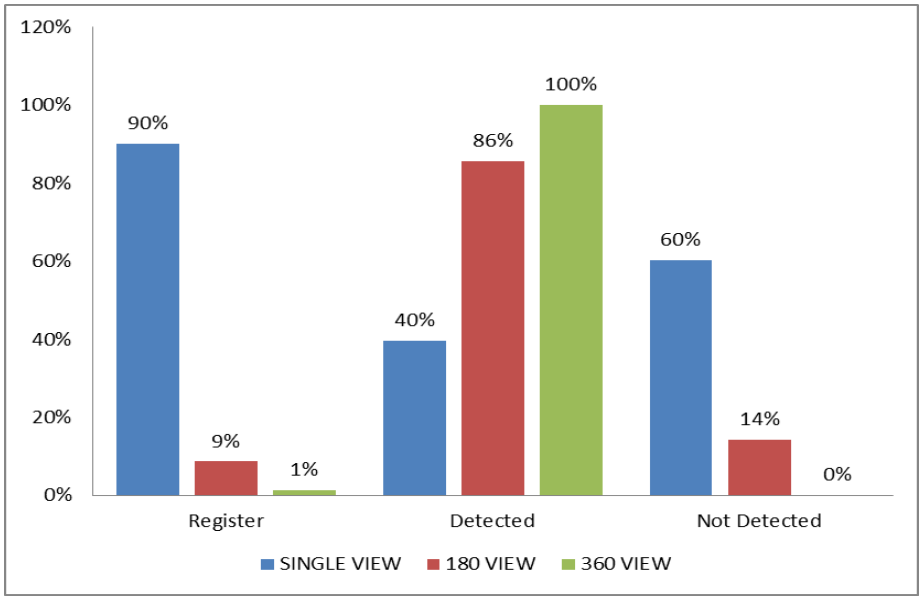


Figure 7. 3D Markerless detection based on visitor's perspective category at Museum Sangiran

4. Conclusions

Interactive application in the Archaeological Museum Sangiran using Android-based Augmented reality and Markerless is an object that is in the showroom Museum has been successfully created and run well. Vuforia ability to detect 3D Markerless has to minimum deviation angle of 25°, which is 0° tilt angle of up to 25°, 3D Markerless is recognizable while outside the those angle range the 3D Markerless is unrecognizable. Extra features of the target image every angle of the hose is capable of displaying virtual information from the different viewpoint horizontally.

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