Mobile augmented reality using cloud database for interactive museum guiding system

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Abstract. The use of marker in museum can ruin the aesthetics of a room. In this paper, we will describe ARGuide. ARGuide is a guiding application to help museum visitors, which is implemented on Android smartphone. It uses an unmarked augmented reality method. The application has been developed and tested. The testing is conducted by tracking some objects in a real museum. It shows that ARGuide is able to track different objects at about 63.64% with the tracking speed of between 2-6 seconds. However, ARGuide is not able to work properly if there is either limited or excessive lighting.

Keywords—augmented reality; unmarked, guidance system; museum; tracking

1. Introduction

Museum can be determined as a place to collect historical and memorial objects. Almost half of the museum visitors come to a museum just to see the objects, not to interact with them. In Indonesia, more than half of 275 museums are not yet complete as it has to be, and they need to be revitalized. Moreover, the revitalization is expected to provide more function such as a universal medium for preservation cultural heritage, creative and interactive tools. For this effort, a creative and effective strategy is required.

Normally, the visitor needs a tour guide that will serve and tell some information about museum and all objects. A tour guide also guides the visitor to visit all of rooms of the museum. There will be a problem, when the museum is crowded so that the tour guide could not serve each of visitors.

E-museum is a concept to use electronic devices such as PC desktop, television, smartphone and others in a museum. The use of devices gives more experiences for the visitor by increasing the interactivity and creativity values.

Nowadays, mobile technology has grown rapidly and almost everyone has a smartphone, so it allow us to implement the augmented reality on mobile devices [1]. Research on navigation systems using mobile phone and Augmented Reality (AR) technology has been conducted and introduced at some museums in the world. For example, National Palace Museum in Taiwan has developed a digital navigation system using RFID, and has become a pioneer in digital navigation of museum. With this navigation system, museum visitors can get voice-based information about the objects of the museum through earphones. They reported that the use of the technology can increase the interest of the visitors to come to museum.
American Museum of Natural History Application from the American of Natural History provides guidance service using text and Wi-Fi positioning with indoor AGPS. Using Wi-Fi for positioning with indoor AGPS is a one way of getting the location of visitor accurately.

Vision-based location positioning system and AR for indoor environment allow information service to visitor [2]. This application uses AR marker and displays some 3D objects together with audio information. Through this application, museum visitors can get some information interactively.

The using of marker AR in museum could ruin the aesthetics of room because of marker AR uses a specific image as marker. Unmarked technique could be implemented in museum. Unmarked AR is a technique that uses object or natural image in real world as a marker. In this paper, we propose a museum guidance system. The system is built based on a case study that has been carried out in Museum Sonobudoyo Yogyakarta.

2. Related Work

Augmented Reality is used in military and technological system for the first time [3]. But Augmented Reality (AR) has increased significantly in recent years. Augmented Reality (AR) is a concept of combining the real world with virtual objects created by computer graphics [4]. AR can be implemented in various sectors such as visual information, navigation systems in real world, advertising, military, games, education, and so on. AR is usually implemented in navigation system for the museum visitors.

Navigation systems require information about location. Based on the location, there are two different navigation systems: indoor and outdoor. Research on indoors navigation for museum base on smartphone that consists of location positioning (localization) and content-based augmented reality has been conducted by several researchers. It has proven that it gives more benefits for the museum. For example, the efficiency of mobile guidance system using AR makes usefulness and effectiveness in exhibition at National Museum Korea [5]. This system uses method-tracking algorithm to estimate the accuracy of image adaptively for objects in museum.

3D AR mobile navigation system that supports indoor positioning system has been developed in the campus of Oxford [4]. The system tells about history of Oxford in the past and the future in 3D and based on multimedia that includes the navigation system, the positioning based on RFID, and unmarked AR technology to detect the location of visitors actively. Activity-based instructions method with 3D location is used to get point of the building and success to find that balance between mixture-AR with interface non-AR influenced in indoor navigation of AR technology [6].

Navigation systems may use different identification methods. Approach of tracking to image features without marker can use existing sensors on mobile devices [7]. The determination of location where visitor been is very important in the navigation system type.

Vision-based localization can be used to navigate indoor environment [8]. The system will recognize the location from sequence of images that are taken automatically in a room. To identify a location, we need to make a pre-reconstruction of an image and use a model in a location database which consists of location and path between the rooms. This system is a kind of client-server system. A client which in this case can be a smartphone or other type of mobile device will take a few pictures and send the images to the server to be processed through the network. After the checking process, it will produce the relocation information that will be sent to the client. The determination of location using mobile devices may consist of several stages: feature extraction and description, matching characteristics, determination optionally, removes the outermost points (outliers) and the last pose calculation and smoothness.

Other museum navigation system that employs a robot has also been conducted. In this case the use of the robot is combined with the use of augmented reality technology. The navigation uses interaction with human-robot and location method to find position and orientation [9]. This type of AR museum tour guide robot displays some elements as object virtual 3D, video and audio in the museum.
3. System Model

3.1. System Description

ARGuide is a guidance application for museum visitor. The architecture system of ARGuide can be described in the Figure 1. The application is composed by core component such as: camera, image converter, tracker, database, video render render background, and application code.

In Figure 1, the process is started by taking point camera to the object. The application converts the image into pixel format in order to AR is able to process it. Then it continues to the tracking process to detect the object that has been matched in the cloud database. The results are stored in a state object used by the video background renderer which can be accessed from the application code.

There are three modules in the application codes. They are query of the state object, update of the application logic and render of graphics. Query of the state object processes newly detected targets, markers or updated states of these elements. Update of the application logic is to input new data. Render of graphics is to overlay and show the AR object.

ARGuide guides the museum visitors to get information about objects and location related to the real situation of the museum. Museum Sonobudoyo Yogyakarta has 13 different rooms and 43,235 collections of historical and memorial objects. These objects are registered as image targets in Vuforia Target Manager.

The application is created based on Vuforia SDK and use cloud database systems. There are two types of databases used in the mobile phone: mobile database and cloud database. A mobile database refers to a database embedded on a mobile device. Cloud database refers to computing resources in clouds to provide mobile data services and applications [10]. Mobile Cloud Computing (MCC) defined by [11] is “an emergent mobile cloud paradigm which leverage mobile computing, networking, and cloud computing to study mobile service models, develop mobile cloud infrastructures, platforms, and service applications for mobile clients.”

3.2. Flowchart

Workflow of ARGuide is described in Figure 2.
As shown in Figure 2, this application is started with a welcome screen and a description about the application. After the application is opened, user can choose either to continue or not. If the user chooses not to close the application, the user can take point the camera to an object. If the recognizing process is not success, the application will back to tracking process. If the object is successfully recognized, the information will be displayed. The next step is user can choose either to close the information or not. If the user chooses to close, the application backs to tracking process. Otherwise, the user can choose either to touch button audio or not. Or else, the application will return to display text information. But if the user chooses yes, the application renders the audio information and back to welcome screen.

4. Testing and Result
Testing is conducted using different Android smartphone. The purpose of the testing is to determine capabilities and tracking speed of the application to recognize the objects. For the testing, uses 33 different objects.

1. Testing 1 (T1) is conducted using smartphone Sony Experia Acro S, Android (Jelly Bean 4.1.2), CPU: 1.5 GHz dual-core Scorpion, memory: 1 GB RAM, camera: dual-camera (rear 12 MP + front 1.3 MP).
2. Testing 2 (T2) is conducted using smartphone Lenovo K860, Android (Ice Cream Sandwich v4.0.4), CPU: Quad-core 1.4 GHz Cortex-A9, memory: 1 GB RAM, camera: dual camera (rear 8 MP + front 2 MP). Result of the test can be seen in Table 1.

### Table 1. Result Tracking.

| No | Room                        | Testing 1 |         | Testing 2 |         |
|----|-----------------------------|-----------|---------|-----------|---------|
|    |                             | Success Tracking | Time (s) | Success Tracking | Time (s) |
| 1  | Pendopo                     | 1         | 3       | 1         | 8       |
| 2  | Introduction room           | 1         | 3       | 1         | 7       |
| 3  | Prehistoric room            | 0         | -       | 0         | -       |
| 4  | Islam & Classic room        | 1         | 3       | 1         | 10      |
| 5  | Batik room                  | 2         | 3       | 2         | 7       |
| 6  | Wayang Kulit room           | 0         | -       | 0         | -       |
| 7  | Wayang Golek room           | 3         | 2-5     | 3         | 3-10    |
| 8  | Masking room                | 2         | 4       | 1         | 5       |
| 9  | Central of Java room        | 3         | 2-5     | 2         | 5-7     |
| 10 | Silver room                 | 3         | 3-6     | 3         | 6-9     |
| 11 | Weapon room                 | 2         | 3-4     | 2         | 5-12    |
| 12 | Playing room                | 1         | 5       | 1         | 5       |
| 13 | Bali room                   | 4         | 3-5     | 2         | 7       |

As shown in the Table I, the testing 1, the application has succeeded to recognize 23 objects. This is about 69.70% of the objects. It is also shown that the response time of tracking process is in between 2-6 seconds. In the testing 2, success tracking is about 57.58% or 19 objects can be tracked successfully, with response time between 3-12 seconds. There is significant difference between testing 1 and testing 2, which is approximately 12.12%. It is probably caused by the difference quality of camera and internet connection. Quality of the camera influences quality of image and also tracking process. Based on the observation, when the tracking process has been conducted, the display of picture tracking in testing 2 is not as clear as in testing 1. The result of tracking in testing 2 is a less lighting. It makes the tracking process of testing 2 slower than testing 1. The succeed tracking process can be described in Figure 3.

In Figure 3, ARGuide is able to recognize objects in this museum, except in Prehistoric and Wayang kulit room. It is caused by lighting of the room which is too bright. It makes some noise in image target, so the application could not recognize the feature of the object. The features of the objects are not match with the marker that has been registered in the database.

### 5. Conclusion

The average of succeed tracking of ARGuide application is about 63.64%. This application is an unmarked AR technology using a real object as a marker. There is different result when the application is implemented on different smartphone that have different capability of camera.

Other factors that affect the success of tracking are the quality of processor, internet connection and lighting in the room. This application is not recommended for use in a dark or excessive light environment. The use of sensors to get a real position of the visitors may be considered in the future research.
Figure 3. Visualization of succeed tracking.

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