Augmented Reality Using Real Objects Tracking Development

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Abstract

Augmented reality applications in tourism usually use images as markers, such as brochures or information boards. However, it is still ineffective because users cannot interact directly with real objects. This study aims to create applications that are more interesting and interactive which can be used by interacting directly with real objects. This research is located in Taman Ayun Temple, one of the tourism objects that are world cultural heritage in Bali. The application is designed with the real objects tracking augmented reality method using the Wikitude Android SDK platform. The application is built in Indonesian and English. The test results show that the percentage of the recognition of 40 objects from various directions is more than 80%, from a distance of 10 to 40 meters is more than 70%, from a good and moderate lighting condition is more than 80% and recognize similar objects as a different object.

Keywords: Augmented reality, object tracking, android, wikitude

Introduction

The existence of temples in Bali apart from the spiritual aspect, has developed into a historical heritage and has become a tourist attraction due to the beautiful architecture of the building (Somantri 2016). One of the temples which is a world cultural heritage in Bali is Taman Ayun Temple. Taman Ayun Temple is a representative temple for the Mengwi people who want to pray to big temples, just come to this Taman Ayun Temple. Apart from being a place of prayer, Taman Ayun Temple is also part of the world cultural heritage (Ardika & Subadra 2018; Widiarta 2016).

Based on observations, the information from the buildings at Taman Ayun Temple is still not fully delivered. Through this problem, technology can be a solution. One of the technologies that is widely used in the tourism sector and has the potential to be a solution to this problem is augmented reality. Augmented reality is a technology that makes it possible to display virtual objects or digital objects in the real world (Zlatanova 2002).

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Several studies that apply augmented reality (AR) technology in the tourism sector are also used as a reference in developing this research. One of them is research on mobile applications that implement augmented reality at Purbalingga District. This study works by detecting images on brochure media as markers and displaying information related to Purbalingga District (Tahyudin et al. 2015). Another research is the augmented reality application in the museum that displays information in text and video using two dimension (2D) images as markers. In addition, the application also uses a location map image as a marker to display location points and can be used via a desktop or smartphone (Yudiantikaet al. 2013). The next research is an augmented reality mobile application for Historic Sites in Tainan. This application uses the AR game as an educational medium as long as visitors are at Chihan Tower by using 3 objects as checkpoints (Hu & Tsai 2016). The three studies previously mentioned use the camera function in displaying augmented reality objects. The constraints experienced in maximizing system performance come from the direction and scanning distance as well as the lighting conditions.

This study aims to provide a different experience in the use of augmented reality technology. This study creates an augmented reality application that can be used when the user is directly at Taman Ayun Temple. The marker used is a real object or building that is inside Taman Ayun Temple. The application is built in two languages, Indonesian and English so that it can be used by both domestic and foreign tourists. It displays information in the form of text as well as audio using text-to-speech technology accompanied by Balinese background music. Through this application, we hope that information about Taman Ayun Temple can be delivered in a more interesting and interactive way. Visitors who come to Taman Ayun Temple can be more comfortable and independent in obtaining information regarding each of the objects in the Taman Ayun Temple.

Literature Review

Augmented Reality

Ronald Azuma, an expert of Augmented Reality in 1997 defined Augmented Reality as a system that has the characteristics of using real and virtual environments, running interactively in real time, and integrating in three dimensions (3D). Furthermore, Azuma wrote that in simple terms AR can be defined as a real environment that is added with virtual objects. Merging of real and virtual objects is possible with suitable display technology, interactivity is possible through certain input devices (Azuma 1997).

Augmented Reality is different from Virtual Reality (VR), where a computer generates an entire virtual living environment, while AR only generates augmented objects to complement the real world for users to interact with (Cawood & Fiala 2008). The resulting object is not limited to graphic objects such as 3D models, but also includes other sensory input, such as sound and text, which can be felt by human senses (Krevelen & Poelman 2010).

- *Marker-Based Augmented Reality*

   Marker based AR is AR which uses markers or object markers that have a pattern that will be read through the camera (Hirzer 2008). The computer will recognize the position and orientation of the marker and create a virtual world at points (0,0,0) and 3 axes X, Y, and Z (Cheng et al. 2017).

- *Marker-less Augmented Reality*

   Marker-less AR is AR which does not use a marker to display digital elements. Marker-less AR takes advantage of device position, direction, and location (Cheng et al. 2017).

Wikitude SDK

Wikitude SDK is an Augmented Reality Software Development Kit (SDK) for mobile devices with android and ios operating systems. Wikitude SDK is a product created by Wikitude GmbH which is located in Salzburg, Austria. Wikitude was founded in 2008 Wikitude GmbH initially focused on developing location-based Augmented Reality with the Wikitude Browser product. However, since 2011 Wikitude GmbH has begun to see a promising market potential in the field of Augmented Reality technology development, thus starting to create technology development with markers, 3D object

rendering, three-dimensional object recognition, two-dimensional and three-dimensional tracking, face recognition, and sensor control. Early 2013, Wikitude released version 1.0.0 of the Software Development Kit (SDK) which is intended for developers to develop augmented reality applications with the help of functions in the library.
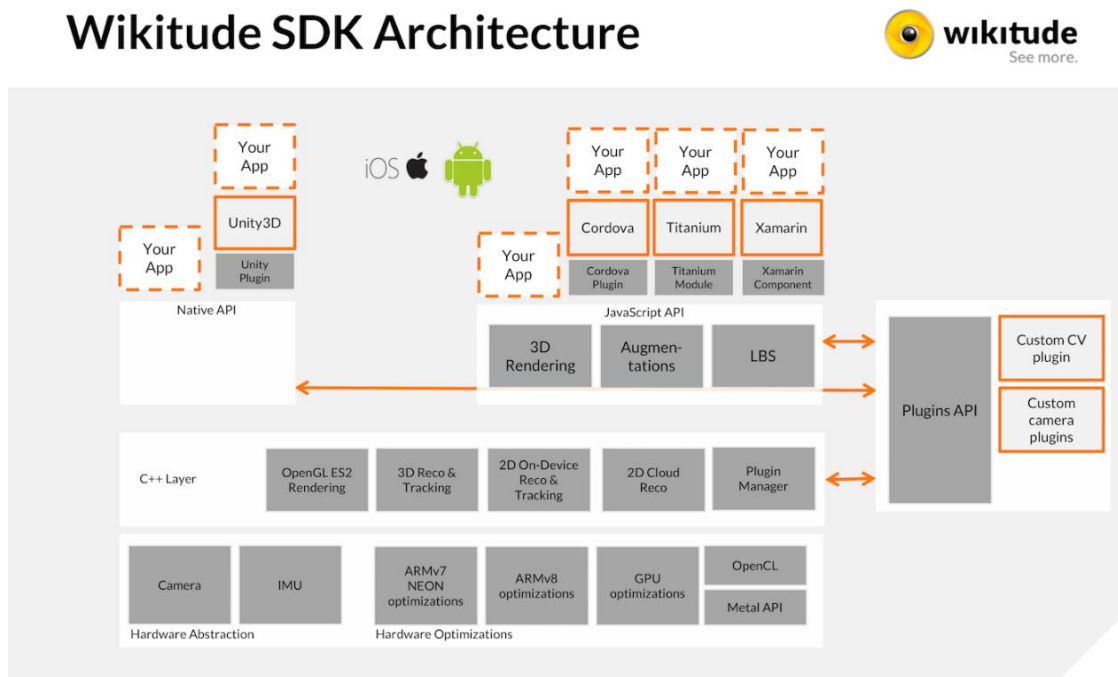

Figure 1. Wikitude SDK Architecture

Figure 1 shows the architecture of the Wikitude SDK. Wikitude SDK is divided into three layers, namely the Computer Vision Engine layer, which is the main engine of the Wikitude SDK, the API layer that connects the main engine with the application or platform you want to build, and the application layer (Wikitude 2020).

Wikitude Studio Editor

Wikitude Studio Editor is designed to optimize Wikitude SDK projects and minimize effort when creating target image collections (.wtc) and target object collections (.wto). Wikitude Studio Editor is a drag & drop tool that allows you to add, delete, edit, and organize target images, objects, and scenes more efficiently (Wikitude 2020).

Wikitude Scene & Object Tracking

This feature is based on the Wikitude SLAM (Simultaneous Localization and Mapping) engine which is used throughout the SDK for any kind of environmental tracking. Scene & Object Tracking makes it possible to detect predefined objects and entire scenes. In order to target that object, it is necessary to create a pre-recorded map of the object which will then be used to trigger the AR experience. The workflow for creating a simple target object is to collect the images of the object or scene, then convert the image into the Wikitude Object Target Collection (.wto) using the Studio Editor, then only need to import the .wto file in the AR application project (Wikitude 2020).

Methodology

Schematic of System Development

Schematic of System Development is the stages in the application development process. The stages are carried out sequentially starting from the data collection stage until the application is ready for use.
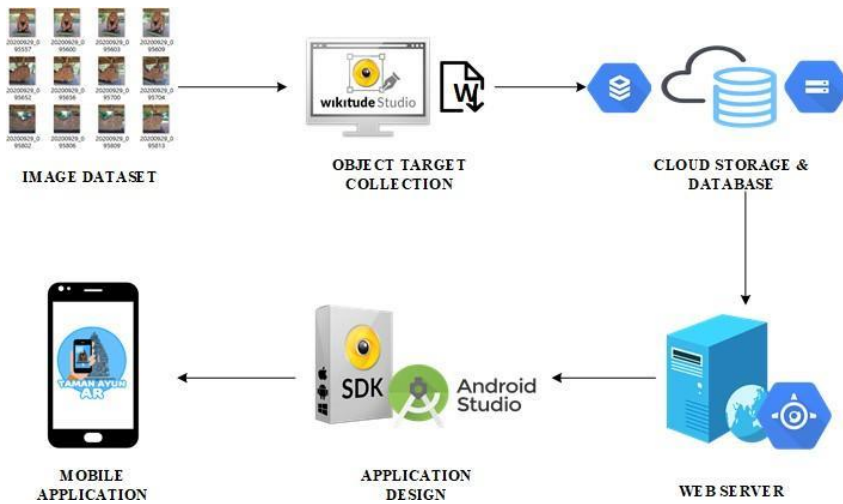
Figure 2. Schematic of System Development

Figure 2 is the System Development Scheme applied in this study. It begins with the process of collecting data on object images dataset, creating WTO files in the Wikitude Studio Editor. Furthermore, the dynamic AR design process is carried out by creating an object database and followed by the development of the server web page. After that, the process of creating an AR application with Android Studio was carried out using the Wikitude SDK platform.

System Overview

System overview is a flow that describes how the system works (see Figure 3). It also describes the function of each component and the relationship between one component and others in this application.
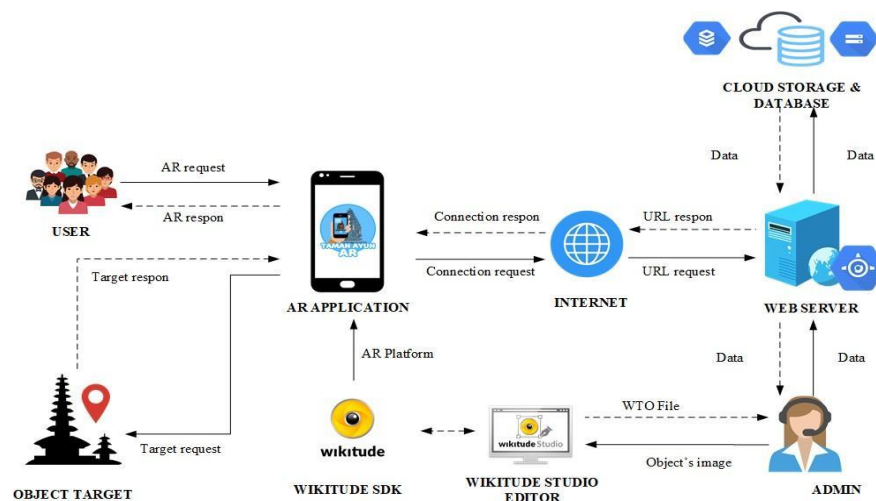

Figure 3. System Overview

First, the smartphone must be installed with the application, then make sure that smartphone was connected to the internet before running the application. The application requests and receives data from the database via web server in JSON format. The administrators can manage data (input, update, delete) and WTO files on the database server. Data that has been stored in the database is used as a trigger in displaying the information.

Application Flow

The Application Flow describes the work steps of the application. It describes the steps from the first time the application is run until it shows the information of the related objects.
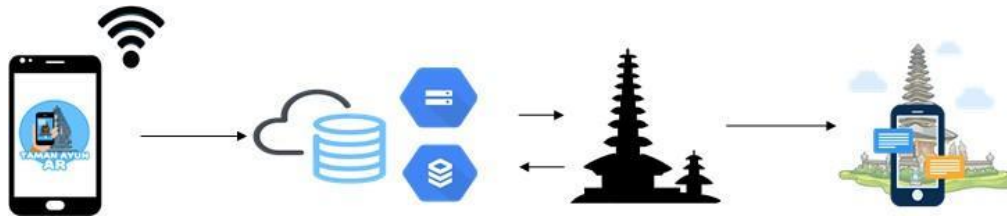

Figure 4. Application Flow

Figure 4 is a schematic explaining the application flow in this study. First of all, smartphones must be installed with the application and connected to the internet. When the application runs, it will display the AR Camera and automatically request data from the server database and storage. The loaded WTO file then matched with the object scanned by the user. If it matches, it will display the information related to the object.

Image Dataset

Each object must be registered in the Object Target Collection (WTO file) before it can be scanned. The object target is created by uploading images of objects which are taken from various points of view to produce a model for recognition. Furthermore, the system is trained to recognize objects based on features or points stored in the WTO file. Uploaded images cannot be more than 50 images and each image cannot be more than 8MP.
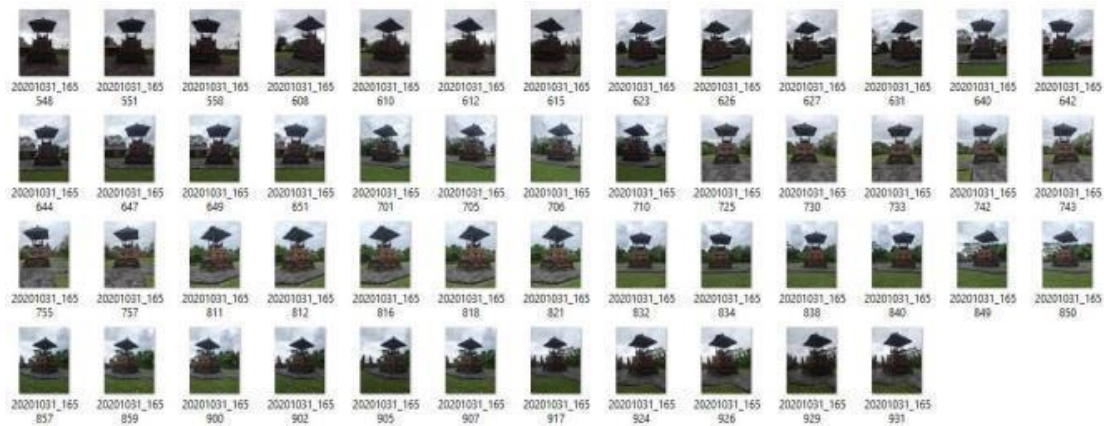

Figure 5. Image Dataset

Figure 5 is an example of an image dataset of one of the objects in Taman Ayun Temple. This research uses a total image dataset of 40 objects and each object consists of a variety of 24 to 50 images. The objects that have been registered in the WTO file must also be listed on the web server to be stored in the database system. The variable used in matching data on the WTO file and on the database is the object's name. When the real object is scanned, the matching object's name in the WTO file will be used to retrieve data from the database to display as object information.

Result

Augmented Reality Testing from Various Directions

Augmented reality testing from various directions aims to find out whether the augmented reality function can run well if the angle of shooting or scanning objects from various directions. Testing was carried out on 40 objects and scanning from 8 directions north, northeast, east, southeast, south, southwest, west, and northwest or in other words surround the object.

Table 1. Various Directions Test Results

Tested Items	Recognized	Percentage
North	33	82.5%
Northeast	32	80%
East	38	95%
Southeast	34	85%
South	40	100%
Southwest	33	82.5%
West	37	92.5%
Northwest	35	87.5%

Table 1 is the test results of scanning objects from various directions against 40 objects at Taman Ayun Temple. The success rate for each direction is more than 80%. Some objects that cannot be scanned from various directions are affected by the object's location, where it is not possible for the user to scan the object from that direction.

Figure 6. Testing from Various Directions

Figure 6 shows testing the object named Bale Pangubengan scanned from various directions. The Augmented Reality technology applied can run well through the direction of scanning objects north, northeast, east, southeast, south, southwest, west, and northwest. It can be concluded that the application is able to recognize objects through scanning objects from various directions or points of view. This test shows that the synchronization between Augmented Reality technology, the model created in the WTO file, and the camera is running well so that the information that can be displayed from the scanned object from various directions.

Augmented Reality Testing from Various Distances

Augmented reality testing from various distances aims to determine whether the augmented reality function can work well if object scanning is carried out from various retrieval distances. Testing was

carried out on 40 objects by scanning the object from 6 scan points as far as 5 meters, 10 meters, 20 meters, 30 meters, 40 meters and 50 meters.

Table 2 is the test results of scanning objects from 6 points distance against 40 objects at Taman Ayun Temple. The success rate for 10 to 40 meters is more than 70%. It can be concluded that the best distance to use when scanning the object is as far as 10 meters to 40 meters depending on the size of the object. Objects that are successfully scanned at 5 meters are small objects or not buildings, such as statues, masks, or other historical objects.

Table 2. Various Distances Test Results

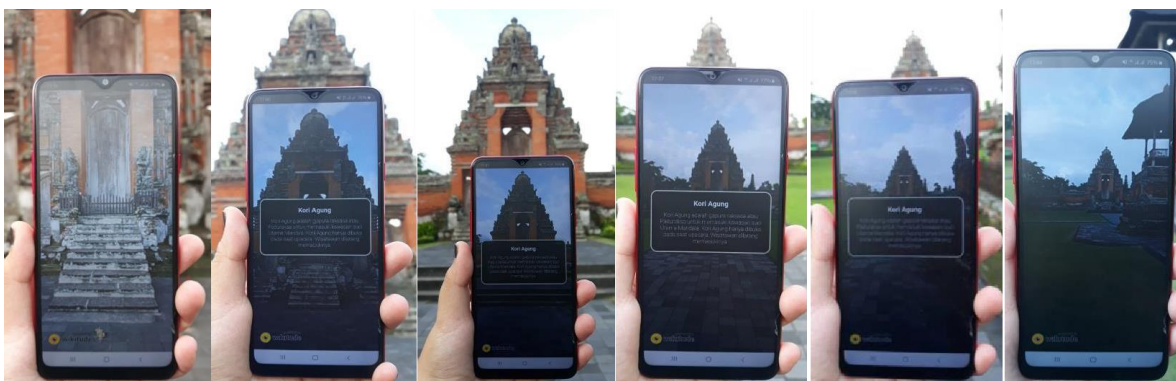| Tested Items	Recognized	Percentage
5 meters	4	10%
10 meters	40	100%
20 meters	38	95%
30 meters	38	95%
40 meters	29	72.5%
50 meters	0	0%

Figure 7. Testing from Various Distances

Figure 7 shows testing the object named Kori Agung scanned from various distances in sequence from the leftmost image to the rightmost image, which are 5 meters, 10 meters, 20 meters, 30 meters, 40 meters, and 50 meters. Based on the results of testing, the Augmented Reality technology applied has accuracy or can detect objects up to less than 50 meters. However, this distance cannot be used as a benchmark for all objects because the size of the objects is different. The size of the object is directly proportional to the distance that can be used in object scanning. The best recommendation for scanning an object is where the entire object appears to fill the smartphone screen, is not cut off and is not too small or scanned with other objects.

Augmented Reality Testing of Various Lighting

Augmented reality testing from various lighting aims to determine whether the augmented reality function can run well when scanning objects in good lighting conditions and less lighting conditions. Testing was carried out on 40 objects by scanning objects in good and less lighting conditions.

The test results on Table 3 shows that the augmented reality technology applied can only detect objects with good and moderate lighting conditions. The success rate for good and moderate lighting conditions is more than 80%. Scanning objects with good lighting causes objects to be captured perfectly and easily recognized. Scanning an object with moderate lighting causes the object to be captured but requires

several attempts at recognition. Scanning objects with less or minimal lighting causes objects to be invisible and unrecognizable so they cannot be recognized. Scanning objects with lighting that is too bright or when the sun is too bright causes the object to appear backward to the light so that the object becomes dark (backlight) and cannot be recognized.

Table 3. Various Lighting Test Results

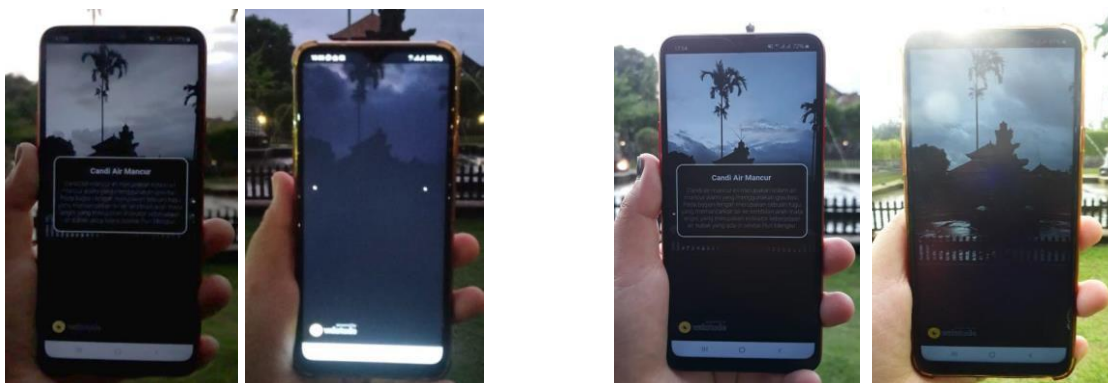| Tested Items	Recognized	Percentage
Good lighting	40	100%
Moderate lighting	33	82.5%
Less lighting	0	0%
Over lighting	0	0%

Figure 8. Testing from Various Lighting

Figure 8 shows testing the object named Candi Air Mancur scanned in the various lighting conditions. This proves that lighting has a very important thing in maximizing application functionality. The recommendation for the right time to use the application is when the object is scanned in the morning when the sun is not too bright, during the day when the sun is not too bright until late in the afternoon, where the lighting is still sufficient to be able to detect objects properly. Meanwhile, not recommended times for application use are when the sun is too bright and at night.

Augmented Reality Testing with Similar Object

Augmented reality testing with similar objects aims to determine whether the augmented reality function can be executed properly by scanning objects on objects that are similar but different. The objects being tested are Meru Tumpang 11 Sakenan and Meru Tumpang 11 Gunung Agung.

Figure 9. Object's Image

Figure 9 shows the original appearance of Meru Tumpang 11 Sakenan and Meru Tumpang 11 Mount Agung. These objects have an 11 overlapping building architecture so they both look the same. These objects scanned to find out whether the system can recognize the two objects as different objects or not.

Figure 10. Recognition Result

The test results in Figure 10 shows that the augmented reality technology applied can detect similar objects as different objects. However, the experiment must be repeated in several scanning positions of the object to obtain appropriate recognition results.

Discussion

This application has several advantages, such as: (1) The application is made based on mobile and can be accessed using the internet network so that processing and delivery of information can be done quickly and easily. (2) The application can be used directly to the real objects so that the user experience is more real, interesting, and interactive. (3) The application does not require other intermediate media as markers, such as brochures, books, or catalogs. (4) The application is equipped with narrative audio and Balinese gamelan background music, so that the sense of hearing is also involved in the user experience. (5) Data manipulation can be done by an admin via a web server. Apart from the advantages that have been mentioned, this application also has several drawbacks. The drawbacks of the application, such as: (1) Users must have good internet access because the augmented reality feature runs through the internet. (2) Users must have a good smartphone camera to maximize the real objects tracking function. (3) The application can only run on the Android platform.

Conclusion

The design of the application based on Android uses the Wikitude platform. Administrators can manage data from a web server so that users must be connected to the internet before starting the application to process data requests. The application is built in two languages, Indonesian and English. The name and description of the recognized object is displayed in text and audio so the user can possibly read and hear the information at the same time.

The system success rate in recognizing 40 objects from various directions reaches more than 80%. The recognition of objects from a distance of 10 to 40 meters achieves a success percentage of more than 70%. While testing of good and moderate lighting conditions has a success percentage of more than 80%. The system can recognize similar objects as different objects.

This application makes it possible for tourists to have a more interesting and interactive travel experience. This research leads to a smart-based tourism industry, where tourists no longer only know the tourism industry through technology but travel directly with the interference of technology in it. This research is still far from perfect, so it is hoped that in the future some developments can be made to perfect it. Developments that can be made include system improvements to allow displaying more than one object at a time, development of an integrated system between tourist attractions and tour and travel services such as information and online booking of hotels, restaurants, transportation rentals, online souvenir shops, etc. It is hoped that in the future this can be a development towards the tourism industry 4.0.

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