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Development of Augmented reality-based object recognition mobile application with Vuforia

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Abstract

Augmented Reality (AR) applications based on object recognition are the focus of interest for many researchers. AR technique incorporates an intelligent display, 3d registration, virtual and reality conjunction, and tracking via handheld or wearable devices, allowing the virtual information to be completely anchored with the users' actual scene, thus improving the perceived view.This paper utilizes Unity 3D gaming software to develop an AR application to recognize and track physical objects using the functionality of the Vuforia engine. It can place animation and text.To measure object recognition performance, experiments were conducted at different distances and several settings of light intensity of the object. The results indicated that Vuforia could recognize objects excellently in several settings, with a success rate of 85.9%. The recognition success rate is strongly impacted by the intensity of the light and object size and the number of feature points of the objects.the result also shows that the objects cannot be detected in dark lighting

Keyword: Augmented reality;Vuforia; object recognition; Unity 3d

1- Introduction

Human cognitive processing is a continuous activity. It is also an essential component of individuals. As a result, research that facilitates computers to conduct recognition tasks using visual information has attracted attention and has been the focus of studies in recent years[1]. In addition, invention and creativeness started to arise in diverse fields, especially in technology, which became the primary motive for creating and developing different types of systems that enable solving challenges in life[2].

Augmented reality (AR) is a promising technology that aims to integrate virtual information with the real world[3]. The types of multimedia include 3d CAD models, 2d graphics, audio, video, or simple text.Virtual information is superimposed on the physical world in the same space and real-time, viewed by individuals.

Object recognition technology is a crucial element for AR since combining these two technologies helped solve various problems. They were implemented successfully in different fields, such as the manufacturing field, to assist workers in performing maintenance, repair, and assembly tasks [4]. Furthermore, education and training also employ AR with object recognition, as AR is considered one of the leading technologies used to enhance learning and education.

Vuforia is a Software Development Kit that allows the developers to design and create AR applications for mobile devices. It recognizes and captures images, surfaces, or physical 3d objects in real-time by employing advanced computer vision technology. Then it enables developers to place virtual information through the device camera and calculate its position according to the lens[5].

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2- Related Work

Several studies have performed studies associated with detection by having diverse testing objects and procedures. According to the research[6] , the study is performed to implement AR application for visually impaired people who could not distinguish the difference between medicine and drugs and cannot count the number of pills available in the package, The mobile application was developed with Unity 3D engine and Vuforia SDK. Then the application was tested with 20 users where they provide positive feedback regarding the functionality, effectiveness, and user acceptance.
Another study presented in [7], proposed AR systemin working environment for human-robot collaboration to assist worker in assembly tasks. The study conducted a simple case study that includes of a camera, a robot, a monitor and car engine parts to assembly. The detection process is achieved using computer vision libraries OpenCV with Unity engine. The results of the case study highlight the usability of the AR system

A study investigated the effectiveness of AR in enhancing driver awareness to limit the fatal car accidents. The study implemented two object recognition methods, called Viola-Jones and YOLO, to determine which is the most effective method Head mounted display (HoloLens) [8].

Another study proposed an AR application based on mobile device that aims to help autistic children in learning and with the simple user interface eliminate the need of parental supervision. The application was created using Vuforia SDK to detect action figures and images [9].

Another study [10], that combine the AR technology with object recognition techniques to design and develop a collaborative AR systemoperatesin tablet device that help in completing tasks in management and maintenance. The proposed system is based on two parts AR and VR where the workers can share the view of tasks with the control unit. The system provides an authoring tool where the workers can highlight and write notes about the required tasks. The system was implemented using Vuforia SDK.

3- Applications development with Unity 3D & Vuforia SDK

The study's primary goal is to design and develop AR applications with Vuforia SDK and measure the effectiveness of object recognition based on the light intensity, the number of feature points, and distance

2.1. Vuforia

Vuforia is a popular AR software development kit (SKD) for handheld devices that allows the development of AR applications. It employs advanced computer vision techniques to detect and track marks by analyzing the camera's target features.

Vuforia object recognition can recognize complex 3D objects. The real object must include several characteristics to ensure successful recognition, such as rigid, opaque, and containing few moving components to perform correctly. The object's texture should not have any reflective surfaces and should not be shiny.

The following factors influence the Vuforia's performance in recognizing physical objects:

• Lighting settings

• object size

• Camera angle

• Object features points

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Furthermore, to ensure proper object recognition, it is essential to scan every physical object with the Vuforia Object Scanner application to save the information of each physical object in an object data file.

Consequently, the factors mentioned above need to be established before using Vuforia Object Scanner, such as the number of features points captured during the scanned process, and the scanning process should be performed in moderate and diffuse lighting and placing the object on top of the image map as shown in the figure where the target object is located in the center of the Cartesian chart.

2.2. Target Model Making

Vuforia needs the physical objects with a measurement of 1000mm; hence, the objects' sizes must be at least 10 mm × 10 mm × 10 mm. The objects used in this research were car toy, and lotion container. Figure 1.shows the target objects. Target modeling was accomplished utilizing the Vuforia object scanner (VOS) version 9.0.12 with a galaxy A22 smartphone. The smartphone includes a rear camera with a 4224 x 3136 *pixels* resolution. Feature points were collected in excellent light condition (200 lux). In addition, the scanning process should be conducted on all sides of the physical objects. Figure 2.illustrates a feature captured on a 3D object with the detected features labeled green points.

Figure 1. sample objects used in this study: on the left is a car toy; on the right is a lotion container

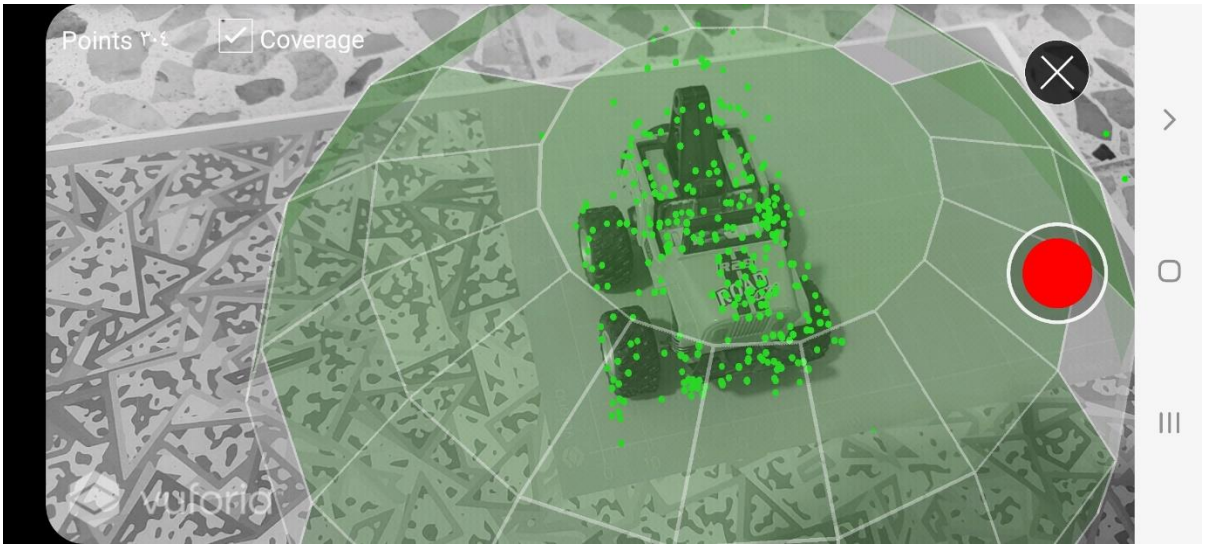

Figure 2. Scanning feature point of a 3d object

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2.3. Unity 3D engine

Unity software is a cross-platform development tool created by Unity Technologies that enables developers to develop 2D and 3D games based on mobile devices, computers, and consoles. The programming languages supported by Unity are C# and C++. The logic for choosing Unity to create and implement the AR application over other software was the extendibility and simplicity of the unity software. The usage of the Vuforia library is simple, it is easy to debug, and the application deployment for the testing objective is straightforward. In addition, Unity 3D provides the features of adding sunlight, water, wind, sky box, fog, other physical materials, audio, and animation to the virtual scene. Also, it supports the release on different platforms, like Windows, iOS, and Android.

2.4. Application Implementation

A. Environment establishment:

1- Download and install the Unity 3D engine

2- Import Vuforia SDK within Unity

B. Create the object database:

1- Create a license key from the developer portal of the Vuforia website and copy it to the unity engine.

2- Click the option Add Database on the Target Manager tab. Hence the creation of the database is completed.

3- Add model targets to the database by uploading the object files previously created using the Vuforia object scanner.

4- Download the database as a Unity package file.

Figure 3. Shows the steps of database creation.

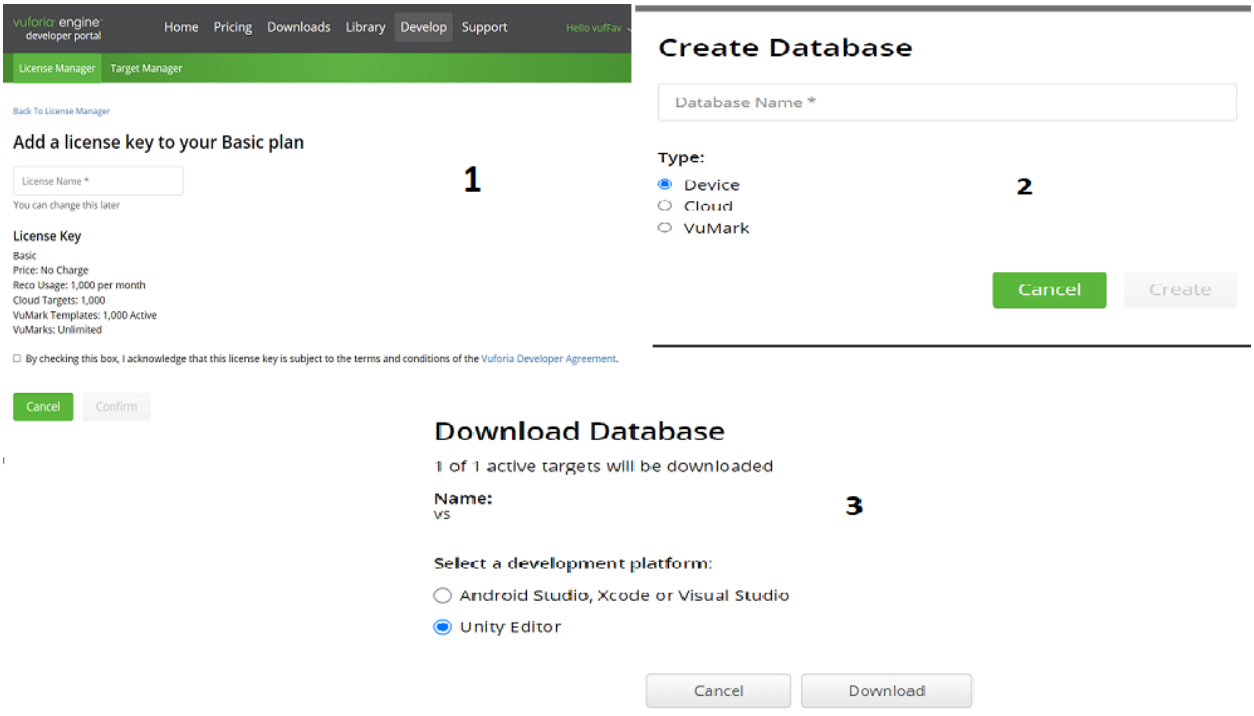

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Figure 3. Steps to create database in Vuforia portal website

C. Application creation and development:
   1- Create a new project in Unity.
   2- After importing, the Vuforia Plugins will appear in the Asset directory. Then in the Hierarchy view, delete the Main Camera component and select the AR Camera and 3d object from the Vuforia list option to the scene.
   3- Click AR Camera in the Hierarchy window to see the Inspector window. Then select Open Vuforia Configuration in the Inspector window and add the App License Key.
   4- Click the 3d object component in Hierarchy to display the inspector window. Select the database in the Target Behavior and select the imported Unity package file. Select the3d object component again and select the object in the import file.
   5- Add the virtual content related to each object in the scene and set the parameter settings associated with each object.

Figure 4. Shows the steps of the development.

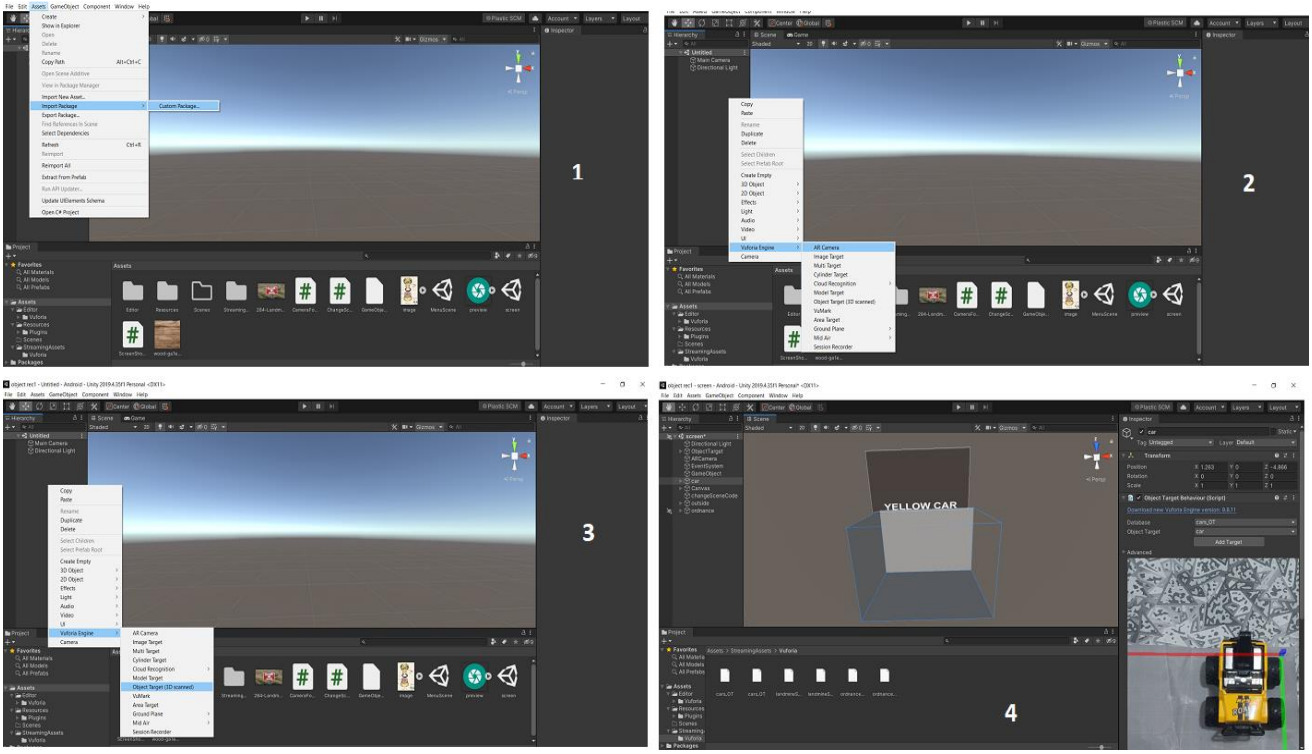

Figure 4. steps to develop the AR application

4- RESULT AND DISCUSSION

The result is conducted using the test of the black-box method. The test helps specify the functions' practicality of the application. Black box testing is accomplished by testing every action in the application. From the outcomes of the black-box test, it can be noticed in Table 1 and table 2, that all of the elements utilized in this research, wherein the light, distance, and partly obscuring the objects, are considered to evaluate the detection process.Table1 and table 2 shows the object name and the number of feature points captured during the scanning process

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Object name	Feature point	Factor	Result
Toy car	304	± 10 cm	Detected
		± 30 cm	Detected
		± 40 cm	Not Detected
		5 lux	Not Detected
		± 15 lux	Detected
		± 400 lux	Detected
		Not covered	Detected
		Covered by 20%	Detected
		Covered by 50%	Not Detected

Table 1. test result for 3d object (car)

Object name	Feature point	Factor	Result
lotion Container	335	± 10 cm	Detected
		± 30 cm	Detected
		± 40 cm	Detected
		5 lux	Not Detected
		± 15 lux	Detected
		± 400 lux	Detected
		Not covered	Detected
		Covered by 20%	Not Detected
		Covered by 50%	Not Detected

Table 2. test result for 3d object (lotion container)

In the testing process regarding light intensity, the toy car can be detected in good and moderate lighting ranging from (15- to 400) lux. However, the toy car cannot be detected in a lighting environment equal to 5 lux. Furthermore, testing the distance between the car toys and the camera has three categories: a distance of ± 10cm, ± 30cm, and ± 40 cm. In the first two measure types, car toys can be adequately recognized. In addition, the car toy can be detected even when the object is covered by 25%. However, the detection fails when the car is covered by 50%.Figure 5, shows the result of object detection in different setting.

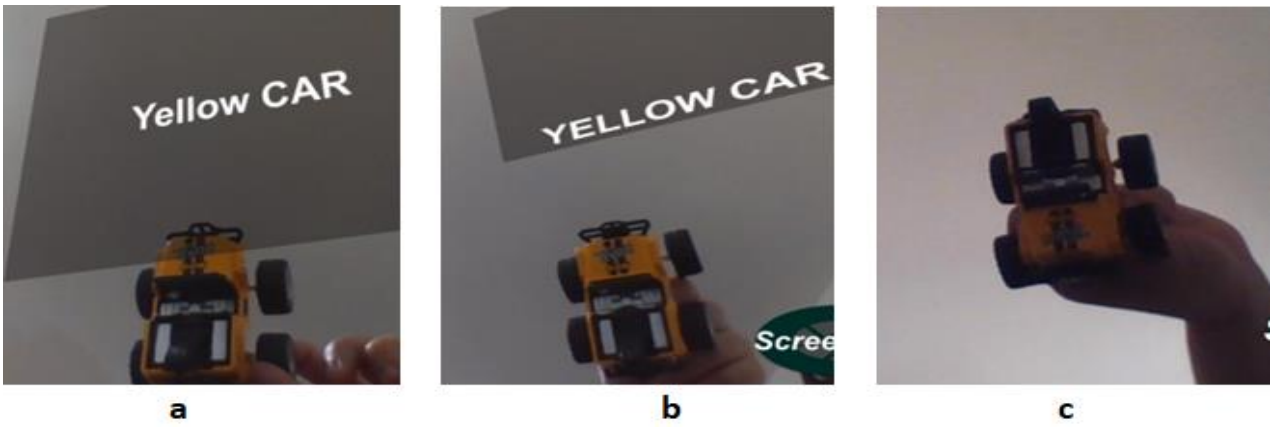

Figure 5. test result for the car, a: object detected in 100 lux and 10 cm, b: object detected in 200 lux and 30 cm, c: object not detected in 15 lux.

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In the testing process of the container object, the detection outcomes demonstrate better results than the detection car result even though the feature points of both objects are similar; however, the size of the objects affects the detection outcomes since the toy car is smaller than the containers.Hence, regarding the lighting detection, the container can be detected in low to good lighting that ranges from (5- to 400) lux. Similarly, testing the distance between the container and the camera also demonstrates excellent results by detecting the container from all the specified distances ranging from (10 - to 40) cm. Additionally, the containers can be detected even when the object is covered by 25%. However, the detection fails when the car is covered by 50%. Figure 6. shows the result of object detection in different settings.

Figure 6. Figure 5. test result for the lotion container, a: object detected in 100 lux and 10 cm, b: object detected in 200 lux and 30 cm, c: object detected in 15 lux.

The analysis results of the testing procedure indicate that object detection is nearly successful with several factors. Except in the case of detection in dark light, intensity cannot be determined. In the dark, the pattern received by the camera will be less efficient, resulting in errors in the matching procedure or the object not being detected, as demon stated in the conducted study. This type of detection failure occurs because recognizing patterns is the most crucial aspect of in the recognition process

5- Conclusion

This paper highlights the development of AR-based object recognition with Unity 3D and Vuforia. In this context, the virtual information of the scene is created using Unity 3D. The Vuforia engine can recognize and track feature points and simulate the corresponding virtual information according to the object position.

The most effective facets in the recognition success rate are the detected features and light intensity setting. The experiment results demonstrated that the light intensity of room, distance, and feature points of an object impacts the recognition success rate. In addition, the recognition success rate is also affected by the size of the target object. Failure of detection is related to low light settings and can be eliminated by creating several target samples with several light intensity variations; however, this makes the size of the database larger.

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