Marker-Based Mobile Augmented Reality for Application of Visualization in Product Packaging

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Abstract - Mobile Augmented Reality has emerged as the most popular and most convenient form of Augmented Reality [AR], especially because mobile devices are enhanced with more sensors, powerful embedded cameras and increased processing power and features. It combines the intelligent display, registration tracking, virtual and reality convergence, and human-computer interactions through portable devices or intelligent terminals. This paper introduces an Android application that can help everyone with application of visualization in product packaging. The idea is to allow the user to view the virtual object in the real world using image targets. This application was developed using following technologies: Vuforia AR, SolidWorks for 3D modeling and Unity3D. The Vuforia AR Extension for Unity enables vision detection and tracking functionality within Unity and allows developers to create AR applications. Unity3D is a cross-platform which comes with an integrated 3D game engine. It can superpose the virtual onto reality and realizes human-computer interaction. SolidWorks software was used for design of a 3D model.

I. INTRODUCTION

As computers increase in power and decrease in size, new mobile, wearable, and widespread computing applications are rapidly becoming feasible, providing people access to online resources always and everywhere. This new flexibility provides new kind of applications that exploit the person's surrounding context. Augmented Reality (AR) can be defined as ability to deal with new information immediately direct or indirect therefore influence the physical real-world environment that can be enhanced/augmented by adding virtual computer-generated information to it [1][2]. Basically, AR generates user selected images, videos, 3D objects and information into the real environment which can be viewed through the camera of the devices. AR application are classified into two types: the marker based that uses camera and visible indication to serve as a target, while markerless deals with mobiles global positioning system and compass from the positioning information. Most markers are black and white, although they can be colored, but contrast between colors can be properly recognized by a camera. Simple AR markers are consisted of one or more basic shapes made up of black squares on white background [3]. Mobile AR applies this concept in truly mobile settings, thereby combining several technologies: global tracking technologies, wireless communication, location-based computing (LBC) and services (LBS) and wearable computing. By considering the definitions from various researchers [4] [5] [6], can be determined that mobile AR: combines real and virtual objects in a real environment, is interactive in real time, registers and aligns real and virtual objects with each other, and runs and/or displays the augmented view on a mobile device. This allows the 3D virtual object to be fully rendered and superimposed on the captured scene, so a user can see it from each side. One of the widely used approaches in the development of AR mobile applications is the use of visual markers. Visual markers used in AR applications allow users to "animate" information associated with markers. Applications that use markers allow user to read information about a specific object or its location using mobile devices. There are many software available in the market to ease application process. The paper is the presentation of application development using new version of Unity3D which comes with Vuforia plugin. The main objective of Vuforia is to move the augmented applications into the Reality using the camera of mobile devices. This software uses the capability of Computer Vision Technology to recognize and track individual coordinates of images. The application can be deployed directly to mobile device for Android platform.

II. RELATED WORKS

The number of applications utilizing mobile AR is increasing continuously and the outcomes are clear in many domains. This section concerns a summary about prior researches that exploit the mobile AR applications. Reference [7] researches the application of Unity3D the integrated game development tool of multiple platforms and employs the mobile device augmentation of the real application software development kit developed by Qualcomm. A mobile AR application to support musical learning of children is presented in [8]. The application works by verifying whether sequences of musical notes of the melody are

correctly colored in a printed pentagram (target). Reference [9] describes AR and Unity3D, how it applies to learning and training and the potential impact on the future of education. The idea is to allow the user to view the virtual object in the real world using an Object based AR system. A concept of using the technology of AR in education field is proposed in [10]. The users will be able to visually interpret the conceptual diagrams, 3D models, videos, etc. related to the concepts in the book content via an Android application supported by the Android smart phones. This is developed using a game engine called Unity3D, with Vuforia Software Development Kit (SDK) for Unity. Reference [11] describes the procedure to develop an AR application with Unity3D and Vuforia SDK and publish it to a smartphone for the localization of critical tissues or organs that cannot be seen easily by the naked eye during surgery. An interesting way to guide students to use such kits by introducing AR as an interactive user manual, thereby increase students' interest and ease learning and reduce work load of laboratory instructors is proposed in [12]. They have developed the application for the laboratory work of an entire course of Analog and Digital Communications in Unity3D using Vuforia AR SDK. In [13] an objective to develop an AR platform for inspection and maintenance to assist technician and evaluate the effectiveness of implementing AR compared to traditional manual sheets inspection that are currently being used is presented. They used CATIA software for design 3D under hood area parts and Vuforia Unity3D for AR application development. Reference [14] discusses the development of "ARCampusGo" which is a Mobile AR based application intended to improvise the visuals rendered to the user. The informational and navigational requirements are sufficed with the help of Unity3D platform and Vuforia Cloud Services.

III. Example Tools for AR Development-Vuforia and Unity3D

Vuforia is an advanced AR building engine that provides an intuitive platform for creating AR applications for Android and iOS platforms. Vuforia features broad functionality and compatibility with other tools. Since many AR applications include the appearance of virtual 3D objects over the real world, building such applications requires a 3D design tool where such objects called 3D models can be created. The top of the rating of such tools is occupied by Unity3D, a powerful game engine allowing building 2D and 3D scenes, games and simulations. Vuforia and Unity3D have been used together to create AR applications. Unity3D offers built-in support of Vuforia allowing creating AR projects easier.

AR can be developed using Vuforia and Unity3D so that Vuforia provides the printable image targets that will trigger the appearance of 3D objects created in Unity3D, or specify the object that the application should recognize to produce AR content. Common uses of Image Targets include recognizing and augmenting printed media and product packaging for marketing campaigns, gaming, and visualizing products in the environment where the product was intended to be used. Vuforia account and a Unity ID are required when creating a project [15]. Vuforia also requires each application to have a unique license key. The license key can be created by logging in to the Vuforia Developer Portal [16], where a unique key will be generated, "Fig. 1". This completes the configuration of project. If all components have been installed correctly, the video feed from web camera will be played.

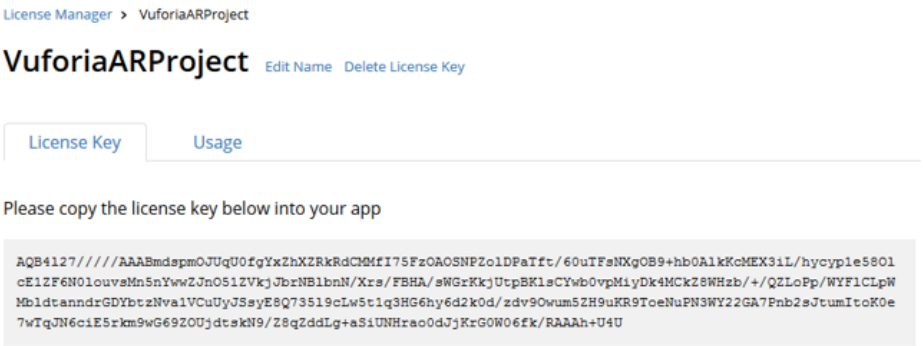

Figure 1. License key by logging in to the Vuforia Developer Portal

IV. The Process of AR development with Vuforia and Unity3D Tools

This section briefly describes the process to use Vuforia and Unity3D to develop Android AR.

Configuring image targets

To build AR applications, it is necessary to activate the AR camera using GameObject→Vuforia Engine→AR Camera. Image targets trigger the appearance of virtual objects in an AR app. The corresponding target should be specified so that the application recognizes it. Vuforia Developer Portal and Target Manager page are implemented to set up the image targets. Add Database button is used to proceed to the Create Database page where target image database can be set up, while Add target button, "Fig. 2" to find and select the target images. Vuforia supports four types of targets – Single Image, Cuboid, Cylinder, and 3D Object (we choose Single Image target). Vuforia adds the star rating that shows how easy it will be for the camera to recognize image. Aim for

5 stars. Database can be used in Unity3D after downloading and selecting Unity Editor as the development platform.

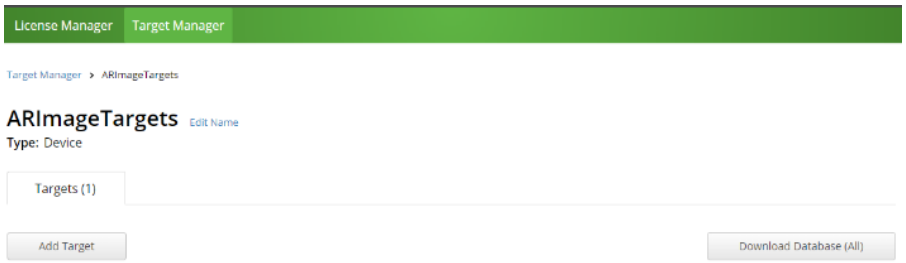

Figure 2. Target button to find and select the target images

Adding image targets and 3D objects

Image Targets represent images that Vuforia Engine can detect and track. Unlike traditional fiducial markers, data matrix codes, and QR codes, Image Targets do not need special black and white regions or codes to be recognized. The Engine detects and tracks the features that are naturally found in the image itself by comparing these natural features against a known target resource database. Once the Image Target is detected, Vuforia Engine will track the image as long as it is at least partially in the camera's field of view.

Image targets can be created with the Vuforia Target Manager using JPG or PNG images in RGB or grayscale. The size of the input images must 2 MB or less. Features extracted from these images are stored in a database, which can then be downloaded and packaged together with the application. The database can then be used by Vuforia Engine for runtime comparisons. To add an Image Target to the Scene, it should be selected with Vuforia→ Image from the menu GameObject. The image target appears on your Hierarchy screen and can be used to connect to the 3D object. Then the type of object that would like to appear in your AR application needs to be selected, "Fig. 3".

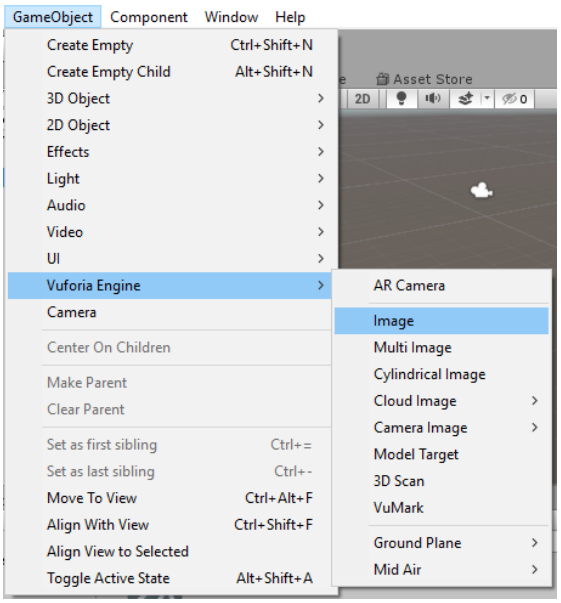

Figure 3. Adding image targets

Digital content to augment target can be added by simply adding assets as children of the target in the scene hierarchy, "Fig. 4". Parenting content with a target object automatically sets up the necessary rendering and physics behaviors. It is used Asset→Import New Asset for this purpose. Unity can work with 3D models of any shape that can be created with modeling software. There are also number of primitive object types that can be created directly within Unity. Unity can read .fbx, .dae (Collada), .3ds, .dxf, and .obj files. Exported files from 3D modeling software in generic formats can be imported and edited by a wide variety of different software. Model files can contain a variety of data, such as character and terrain Meshes, Animation Rigs and Clips, as well as Materials and Textures. In this case 3D model is created using SolidWorks software and imported as fbx file.

Vuforia Engine provides a simulator in the Game view that can be activated by pressing the Play button. This feature can be used to evaluate and rapidly prototype scene(s) without having to deploy to a device.

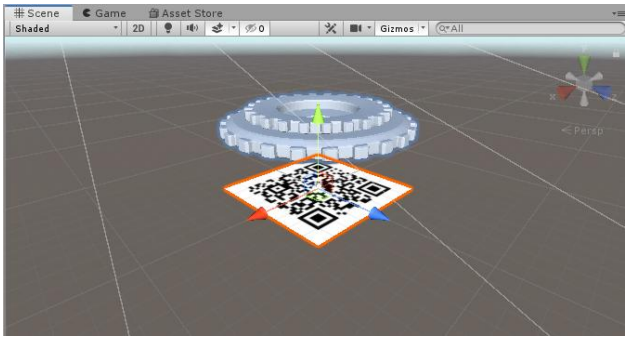

Figure 4. Adding image targets and 3D objects

Building the Application

After developing the application in Unity, it is necessary to choose File →Build Settings, switch platform to Android, and then click Build to export the application as an APK file. This APK file can then be installed on an Android phone, "Fig. 5".

Figure 5. AR model imposed over image target

V. USING MOBILE AR IN PRODUCT PACKAGING

In order to use installed APK file on an Android phone it is necessary to print image target and place it on the package. This allows the user to visualize the 3D model in the real world using image target without opening the package, "Fig. 6". Respectively, the companies that produce the model can use it as a 3D model for creating application in Vuforia and Unity3D and thus provide three-dimensional visualization using mobile phone.

Figure 6. Mobile AR for visualization in product packaging

VI. CONCLUSION

This paper emphasizes the creation of interactive mobile AR application for Android mobile devices intended for visualization in product packaging. It uses Unity3D technology and Vuforia as an AR SDK. Based on this, the three-dimensional model created by SolidWorks of scene is simulated by the means of Unity3D. The Vuforia engine using computer vision technology detects and tracks identification features and fabricates corresponding 3D model in accordance with the relative position and attitude information of identifiers on the visual plane. The real-time synchronization satisfies the users in the real world and enables to feel the virtual space, thus strengthening the space and interaction. Vuforia supports four types of targets – Single Image, Cuboid, Cylinder, and 3D Object (we choose Single Image target). Vuforia also has a built-in star rating that it gives to markers. Our marker scored 5 stars out of 5. If rating is less than 5 stars, it may be harder for the camera to track it. In the future our intended work includes application of visualization in assembly packaging with built-in animations.

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