Development of an Educational Augmented Reality Application

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Abstract - The aim of this paper is to explain the application of augmented reality technology in various domains, particularly in development of educational applications. Firstly, the principles of the augmented reality are explained and the manner of its usages in a broad spectrum of fields, such as medicine, education, entertainment, game, sport, architecture and tourism. We have compared most commonly used technologies and tools for development of augmented reality applications. Unity is a part of the advanced computer graphics technologies that improve contemporary computerized life with ordinarily used games and various mobile applications. Unity is employing to develop 2D and 3D applications and to deploy them on different platforms. We have created an educational discovery-based augmented reality application by using Unity.

Keywords: computer graphics, augmented reality, programming languages and technologies, software development.

I. INTRODUCTION

With the recent scientific and technological advances, people can even modify the real world around them. This is possible by using augmented and virtual reality technology. The augmented reality comes from the idea of mixing the virtual reality and the real world. Augmented and virtual reality tools and techniques create another enriched reality that has the same key features as the real world. Differently from virtual reality that immerses users in synthetic computer-generated environment, augmented reality combines real environment with virtual objects enriched with augmented components by using computer graphics. Augmented reality enriches information that existed in reality with information available in the digital devices [18]. Augmented reality allows the user to see the real word with synthetic objects superimposed or merged with real environment, thus bridging the gap between real and virtual world [14] [15]. This augmented reality feature makes smartphones to be very suitable platform for augmented reality applications.

Very famous examples of using augmented reality are the TV sport shows, where virtual (non-real) elements are added to the real pictures or scenes.

With the advance of the augmented reality, smart phones and tablets with their high performance processors, cameras and touch screens play a crucial role. All these components significantly increase the opportunities for using augmented reality technology in various areas such as: medicine, marketing, sport, sales, entertainment, education, tourism, architecture and construction, military, manufacturing etc. For instance, in the domain of architecture, when a project for a new building is designed, the synthetic final building at the desired place can be seen by using augmented reality techniques. Moreover, when walking through the streets using augmented reality applications, it is possible to see how the buildings looked like hundreds years ago or how they will look like in the future after several years.

Advances in information and communication technologies enable their application in educational from teaching staff and students. Pupils and students in their ordinarily life use numerous multimedia contents provided by the Internet, 3D movies and videogames [14].

Augmented reality has shown a great potential for application in education aiming to improve the effectiveness and quality of the teaching and learning process, especially in visualizing abstract concepts [12]. Augmented reality helps students to develop their visualization skills.

Augmented reality is used in discovery-based learning for recognizing places, persons or things and in preparing interactive course materials [15].

Among many existing learning approaches, digital game-based learning is very promising approach [17]. Many learning and teaching activities by using augmented reality can be simplified, more cost-effective and less time demanding.

Augmented reality in education leads to improvement of learning achievement and enhancement of learning motivation and spatial ability, thus avoiding teacher's repeating explanations [13] [14]. The authors in [21] [22] [23] has surveyed using augmented reality in different educational applications.

Nowadays, the big industrial leaders, such as Google, Apple, Microsoft, Facebook are already working on new augmented reality devices.

The remainder of the paper is structured as follows. A survey of software tools for development of augmented reality is given in Section II. The subsequent section describes the main features of Unity, while Section IV depicts developed educational augmented reality

application using Unity. The last section provides concluding remarks and direction for further work.

II. SURVEY OF SOFTWARE DEVELOMPMENT TOOLS FOR AUGMENTED REALITY APPLICATIONS

It was widely considered that the augmented reality technology is used only in games and entertainment. The focus of this paper is put on application of augmented reality in education for application development.

Augmented reality applications are categorized in two types:

- marker-based augmented reality applications and

- location-based augmented reality applications.

Marker-based applications use markers, which are previously defined, to trigger the presenting augmented reality objects in the original scenes. Most markers are black and white, although they can be colored, but contrast between colors should be accurately recognized by a camera. Simple augmented reality markers are consisted of one or more basic forms made up of black squares on white background [19], while the advanced augmented reality applications can recognize 3D markers and real-world objects.

Location-based augmented reality applications use GPS (Global Positioning System), accelerometers, or compass information to show objects in the original scene or environment.

When choosing the software for development of augmented reality applications, the following features should be taken into account: costs, supported platforms, image recognition and tracking, unity support, OpenSceneGraph support and GPS [1]. To choose most appropriate software for application development, we have compared mainly used augmented reality software.

A. Vuforia

Vuforia is one of the best and most commonly used software for creating augmented reality applications [2], which has wide range of usages such as objects recognition including pictures. It accepts and recognizes text up to 100 000 words, creates its own unique marks (VuMarks) that are better than the typical QR. By using the tool Smart Terrain, it is possible to design a 3D map of any location, the static pictures are transformed in a video that can be played on any surfaces using Unity plugins and cloud and local storages.

B. ARToolKit

ARToolKit is an open source library for creating augmented reality applications. It is a free, cross-platform that offers large sets of tracking tools. Its supportive properties and purposes can be described as: Unity3D and OpenSceneGraph, single and dual camera, augmented reality application based on location with GPS and design AR applications in real time. ARToolKit supports smart glasses as well as many programming languages.

C. Google ARCore

Google ARCore is a software development kit designed from Google, which is very popular worldwide and useful among users. It is one of the best tools for designing augmented reality applications that works with Java, OpenGL, Unity and Unreal [2] [3] [4]. It has many different useful tools aimed for:

- Motion tracking. With ARCore, the position and orientation of the device using of camera and the location positions can be calculated. This enables easily putting any virtual object to the exact location.

- Environmental understanding. Google ARCore can recognize horizontal terrain, which helps to put virtual objects on tables or floors. This tool is also suitable for motion tracking.

- Light estimation. This feature enables the light balance of the surrounding and background by the lights of the virtual objects. This feature is very advantageous for developers to design very realistic scenes.

Some of ARCore supported devices are: Google Pixel, Pixel XL, Pixel 2, Pixel 2 XL, Samsung Galaxy S7-S8+, Samsung A5-A8, Samsung Note8, Asus Zenfone AR, Huawei P20 and OnePlus 5.

D. Apple ARKit

Apple has created its own augmented reality software development kit for iOS11 [2]. Apple's augmented reality iOS SDK (Software Development Kit) features are:

- Visual Inertial Odometry. This feature allows environment tracking precisely without any further calibration.

- Robust face tracking feature, for adding effects on the face or design expressions of the faces of 3D characters.

- Tracking of the quantity of the surrounding area lighting to add necessarily lighting to the virtual objects.

- Apple ARKit can recognize horizontal terrain, such as tables and floor and to detect vertical and irregular shaped objects.

- Recognizing 2D objects that can be altered by users.

- Integration with Unity and Unreal Engine.

This is the list of supported devices: iPhone 6s and 6s Plus, iPhone 7 and 7 Plus, iPhone SE, iPad Pro (9.7, 10.5 or 12.9), iPad (2017), iPhone 8 and 8 Plus and iPhone X.

E. MAXST

MAXST has two SDKs that developers can use: 2D SDK for image tracking and 3D SDK for environment recognition [1]. Here is the list of the 3D SDK features:

- MAXST Visual Simultaneous Localization and Mapping, used for tracking and mapping of the

environments. When the environment is tracked, the map is automatically expanded beyond the first view, as well as the move of the camera.

• Files created using Visual Simultaneous Localization and Mapping can be stored to render 3D objects. Also, those objects can be enriched by AR features.

• Scanning of QR codes and barcodes is enabled.

• It is possible to extend image tracking and Multi-target tracking. With this feature, you can track a target for a very long distance, or as long as it is on the reach of the camera's view.

• It provides tracking of digital object placing them in association with the plane.

This tool supports integration of Unity plugin and it works on Android, iOS, Mac OS and Windows operating systems.

F. Wikitude

Wikitude is a technology provider, used mainly for creation of mobile augmented reality applications. Recently, Wikitude has launched their SDK 7, which supports simultaneously localization and mapping [1]. These are the key features provided by Wikitude:

• 3D recognition and tracking.

• Image recognition and tracking.

• Cloud recognition - ability to work with huge amount of targets, which are hosted on the cloud.

• Providing location-based services.

• Integration with smart glasses.

• Integration with external plugins, such as Unity.

Its SDK supports: Android, iOS and Smart Glasses.

III. USING UNITY TO IMPLEMENT AUGMENTED REALITY APPLICATIONS

Unity is a multi-platform tool for creation of augmented reality applications and games. It was first developed by Unity Technologies in 2005. Since 2018, Unity has upgraded supporting more than 25 platforms. This tool can be used to develop 2D and 3D games, virtual and augmented reality applications, to make simulations. Unity is used in numerous branches, such as in film industry, automobile industry, architecture and engineering, entertainment, medicine and education.

Among many available software for augmented reality application, Unity is chosen because it is most cost-effective, flexible and sustainable solution for application development [16].

Unity is a part of the advanced technologies that improve contemporary computerized life with ordinarily used game and various mobile applications. Unity is employing to develop 2D and 3D applications and to

deploy them on different platforms. Unity is a cross-platform game engine that is supported on many different devices, such as mobile devices, augmented and virtual reality devices, desktop, web and console [10]. Developed games and applications can be used on different operating systems and platforms such as Windows, Android, Windows Phone, Tizen, iOS, Windows Store Apps, Mac, Linux/Steam OS, WebGL, PlayStation4, PlayStation Vita, Xbox One, Wii U, Nintendo 3DS, Oculus Rift, GoogleCardboard, Steam VR, PlayStation VR, Gear VR, Microsoft Hololens, Daydream, Android TV, Samsung SMART TV, tvOS, Nintendo Switch, Fire OS and Facebook Gameroom [7].

Description of the Unity features and tools is given as follows.

A. Well-ordered user interface

Unity has simple and easy-to-use design and user interface, shown on Fig. 1. The best feature of the program is fast and easy creation of the desired games or applications. Its basic function is collecting external scripts and contents. This allows fast and simple editing of the tools, products and documents.

Figure 1. Unity user interface.

B. Powerful graphics

Unity has very big and adjusted DirectX and OpenGL graphics that provides work in high resolution. This engine is sophisticated, modern and allows using very different designs.

C. Importing models

Unity allows importing models from the best 3D software tools such as Maya, Cinema4D, 3D MaxStudio, Cheeta3D, Moddo, Lightwave, Blender and SketchUp. Unity can read .fbx, .dae (Collada), .3ds, .dxf, .obj and .skp files.

D. Shadows

This tool, in Unity is simple, easy to use and adjustable, as shown on Fig. 2.

E. Network

Network system is connected with HTTP server, in order to connect to PHP. Collecting photos that could be used in 3D user interface is performed easily. Some new Unity models allow using Asset Store, for downloading objects that can imported simply into the project simply.
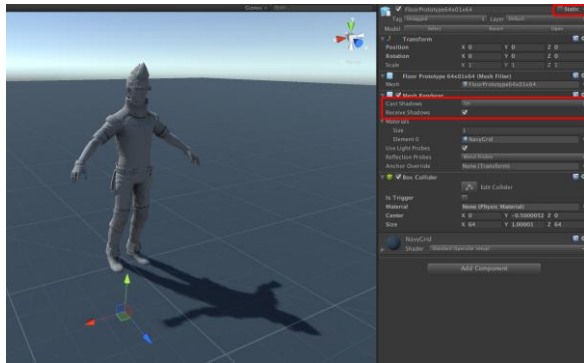
Figure 2. Shadows in Unity.

F. Video and audio

Combining the 3D graphical design with video and audio plays an important role in the producing of high quality applications. There is an option for using different audio formats (e.g. AIFF, WAV, MP3, Ogg) and video formats (MP4).

G. Scripting process

This is a complex process. The good side is the fact that there is an option to use different programming languages (e.g. C#, JavaScript and Boo). Unity automatically imports the MonoDevelop software that allows creating or modifications of the scripts.

H. Documentation

Nowadays, there are many available documents, studies and works, which can be very supportive during learning Unity.

IV. DESCRIPTION OF CREATED EDUCATIONAL AUGMENTED REALITY APPLICATION

Among many existing learning approaches, digital game-based learning is very promising approach and it leads to improvement of learning achievement and enhancement of learning motivation, thus avoiding teacher's repeating explanations. Van Eck states that this learning approach is effective because learning takes place within a meaningful context and the subject is directly related to the environment in which students learn. As such, the knowledge gained is applied and practiced within that context [20].

The educational application is created by using Unity for Android platform. This platform was chosen because it is very suitable to develop augmented reality applications. The functionality of the augmented reality is demonstrated by using mobile phone camera. To create an application, beside Unity as a basic tool, another tool for easier development of augmented reality applications is required. In our case, we have chosen Google ARCore.

The main idea of this augmented reality application is for a certain image to be recognized by the mobile phone and then a 3D model to be shown on top of that images. For that purpose, the part of the tool Google ARCore, named AugmentedImages will be used. This feature enables designing of augmented reality applications, which can respond to the 2D images, such as posters and

product boxes. First, a set of reference marker images are initially added, which later will be recognized, when targeted with the camera of the mobile phone.

To use Google ARCore, this tool has to be downloaded and then imported to the Unity project.

Adding the images to the project is simply done by dragging them in the appropriate folder with images, as shown on Fig. 3. Therefore, the images are selected, and a database of images is created. This image database needs to be set as an image source in the configuration folder.
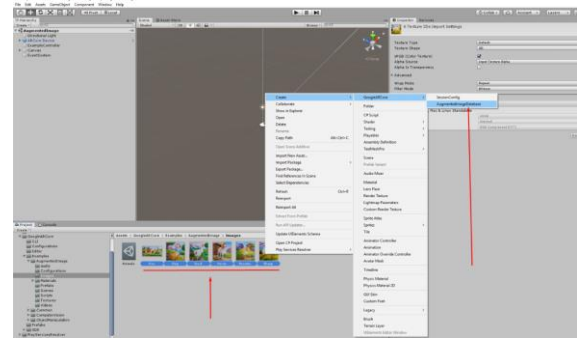

Figure 3. Adding images in Unity.

The 3D models used in this application are downloaded from https://poly.google.com. This is a Google folder of 3D models, which can be used to create several different applications, as shown on Fig. 4. Its interface is very useful and easy-to-use.
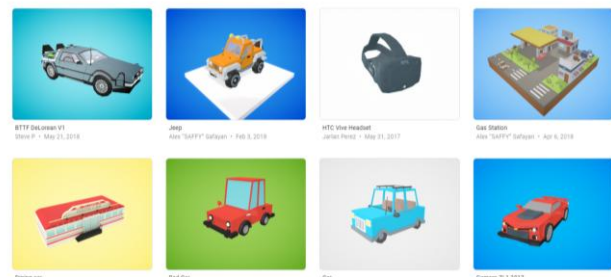

Figure 4. The folder of 3D models on poly.google.com.

With the simple downloading and dragging of the models in the appropriate folder in Unity, they become available for further using in the project. The next step is creating the scene, where selected models will be shown, after their successfully recognition from the device, as shown in Fig.5.

The adequate audio file is added to the previously created scene. The sounds will be played when the right model will be shown on the scene.

To connect all previous parts, and make them as one scenario, a short C# script in C# has to be written. This script enables adequate showing and hiding of the learning subject, depending on recognized image in the real world. For that purpose, the scene is connected to a

corresponding script. In that script, all elements (e. g. models and sounds) as objects are added, in order to perform action on them, through the adequate code. The script is consisted of two parts. The references to the used objects and performed action are located in the first part. The update methods, which Unity uses to create a new frame on the screen of the device are in the second part [11].

Figure 5. Adding 3D models in Unity.

The adequate audio file is added to the previously created scene. The sounds will be played when the right model will be shown on the scene.

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The control script code is quite simple and understandable. Its purpose is to check which image is recognized and based on that, to show the adequate model in the scene. Initially, all models are hidden, and all the sounds are muted. When an image is recognized, a model for that image's index is shown and the adequate sound is played.

The next script is for getting the information about the recognized image, from another script, initially added by Google ARCore. This script checks on every frame, if on the device's screen any of the reference images is shown, and whether the application is running. If any of the images from the database is recognized, the control script is activated and the appropriate image variable is placed on the found image [4] [11].

Fig. 6 and Fig. 7 show a part of developed augmented reality application, when different models are used: a car and an animal, respectively.

Figure 6. Showing the functionality of the created application - a car.

Figure 7. Showing the functionality of the created application - an animal (horse).

V. CONCLUSION AND FURTHER WORK

The technology of augmented reality is opening new opportunities for development numerous applications that will be used on daily base in many areas of the contemporary life. The intention of created application is to help the pupils at school in their everyday classes to learn more information about animals and things that they usually encounter [5].

This application and the augmented reality technology will be very useful in the process of educating young students and pupils at school. The application and the technology of augmented reality will improve the quality of the teaching materials through fun and interactive learning. In the future, every school should have augmented reality equipment and to use augmented and virtual reality tools to create teaching materials. This can be achieved by supplying the schools with suitable devices such as smartphones, tablets and glasses [5] [9].

In the near future, more efforts should be made toward development of wide range of applications in the field of education and their usability, because augmented reality offers great opportunities to support learning and teaching process.

As further work, we will extend this educational application to cover more teaching contents and to put appropriate score points to measure learning achievement results and to validate this digital game-based learning application.

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