



A REVIEW ABOUT AUGMENTED REALITY TOOLS AND DEVELOPING A VIRTUAL REALITY APPLICATION BASED ON EDUCATION

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Augmented Reality (AR) is a technology that gained popularity in recent years. It is defined as placement of virtual images over real view in real time. There are a lot of desktop applications which are using Augmented Reality. The rapid development of technology and easily portable mobile devices cause the increasing of the development of the applications on the mobile device. The elevation of the device technology leads to the applications and cause the generating of the new tools. There are a lot of AR Tool Kits. They differ in many ways such as used methods, Programming language, Used Operating Systems, etc. Firstly, a developer must find the most effective tool kits between them. This study is more of a guide to developers to find the best AR tool kit choice. The tool kit was examined under three main headings. The Parameters such as advantages, disadvantages, platform, and programming language were compared. In addition to the information is given about usage of them and a Virtual Reality application has developed which is based on Education.

Keywords: Augmented reality, ARToolKit, Computer vision, Image processing.

Introduction

Augmented reality is basically a snapshot of the real environment with virtual environment applications that are brought together. Basically it can be operated on every device which has a camera display and operation system. Running mode is completed by installing virtual two-dimensional or three-dimensional image on the marker in the real environment (special signs or real object) which is detected by the camera. We can divide them into two AR applications; the applications with marker and without marker (unsigned). Those running with markers need them in real environment. They perform operations based on these markers. On the other hand, those without marker are more complicated. They perform the operations through calculating the deepness of 3D surroundings. There are also other Augment Reality Web Browser applications that are not related to these two categories. In addition to the specifications mentioned above, these systems also use GPS technology. Furthermore there are web browser systems which can be used with 3G sensors. Basically, AR Web Browser's operation logic has the same specifications as usual web browsers. These three different applications will be discussed in depth while Augmented Reality Tool Kits are researched.

Toolkits with Marker

AR Toolkit

ARtoolkit began to be developed in 1999 and is one of the first studies in this area. It constitutes the basis of many AR applications. After the introduction of ARtoolkit, many similar systems have taken place almost with the same characteristics. ARtoolkit runs well on many platforms such as windows, Linux, OSX, Android, and IOS. It basically performs Detecting Marker, Marker's Recognition, Tracking and rendering process. Marker Detection process is performed by using image Detection processing algorithms, such as Threshold, Contour Detection and Edge Detection. The first priority of Marker Detection process is locating a frame with thick black edges [1]. Then comes the Marker Recognition. At this stage, detected phase of the frame in the first stage is focused on. First, frame's interior is turned into a full frame with the rules of normalization [2]. This square is divided into 256 parts determined as 16x16. Each separated part is converted into Gray (0-255) scale as and numbered. A result of numbering process a matrix of 16x16 squares is obtained. This matrix is compared with the stored ones in the memory [3]. At this stage Rotation of the marker and the XYZ position is calculated. Last defined marker in the tracking process is compared first and processing is performed quickly [4]. Render phase are associated with markers of the three -dimensional object and placed in the required position on the screen During insertion of the marker, X, Y , Z plane angular values are calculated, and then positioning the 3 -dimensional object is performed. ARtoolkit can perform operations mentioned above for more than one marker simultaneously. With this feature it allows many interactive applications to be performed in the field of education. For example, many educational materials can be developed on tablet computers and the Smart Boards distributed free of charge related Projects currently carried out in Turkey such as Project Fatih, ARtoolkit is one of the most used tools that can be operated on many platforms and provided with wide range of sources. For those who do work in this area, it could be recommended as a starting point.

ArUco

Aruco is a similar system like ARtoolkit. It has been developed using OpenCV, OpenGL and C + +. Its biggest difference from ARtoolkit is the markers used. The markers used are a 7x7 square matrix form. According to empty and full matrix element values, markers take different values. Values taken are processed through some filters and functions and then realized as a marker recognition process. Placed close more than one, matrixes may behave as a single marker, so that the marker on the screen becomes adequate in terms of recognition. By this aspect it eliminates problems such as the problem of not detecting under more light markers as observed in ARtoolkit devices. Aruco runs on several platforms like Linux, Android. Aruco also includes the JS- Aruco version like Jsartoolkit web browser. JS- Aruco runs on HTML5/JAVASCRIPT or Flash Player[5]. Running on Web browser makes JS- aruco a platform-free environment. Recently, considering the wide use of smart phones and tablet computers, we have had the ability to develop applications running on multiple platforms at once, and this ability would save us from not developing new software for each application and device every time. However, because of speed problems of JS- Aruco, its application capabilities are confined to limited specifications. It is a tool that can be recommended for developers who want to offer Augmented Reality applications on a web-based environment.

Vuforia

Vuforia is a tool that can be used not only in Android but also in IOS operating systems .Unity, Eclipse and Xcode are used as development kits [6]. Unlike many other tools, Vuforia does not rely on a standard marker, instead, it maps the real images and then performs marker recognition process on this map. In Figure 1, there is a mapping process during which a real image is defined as a marker after being recognized by Vuforia. Besides, on the same image, it can be seen that Figure A points out coordinate layout of the marker, the similar of which can be seen on OpenGL.

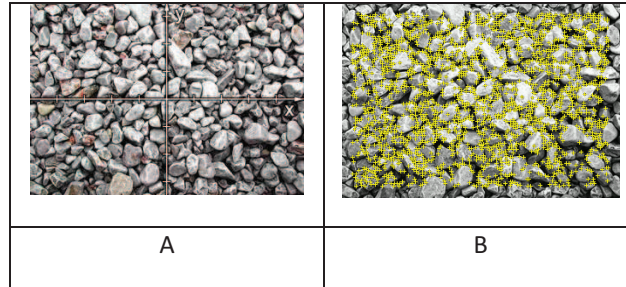


Figure 1 Vuforia Marker [7].

In addition to this feature, thanks to the mapping process marker is not required to be seen by the camera. It is enough for marker to see less than 30 % to be able to recognize. For this feature markers are not affected by the light. Moreover, there is Virtual Button feature in this algorithm. This feature is the use of a part on the marker as a button. Through this feature, when a button on marker is clicked on an event begins processing and the interaction is improved in this way.

Vuforia has a sophisticated background tracking system. As seen in Figure 2, during the marker recognition process, augmented reality is sustained though the images are no longer in the frame of the marker as a result of being recognized beforehand and the process goes on as if the marker is also seen whereas it is not. This feature takes Vuforia a step forward compared with other AR applications.

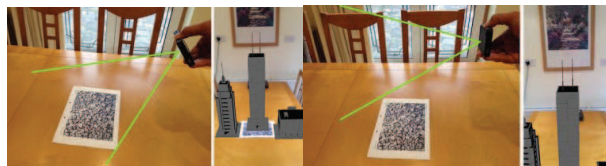


Figure 2 Marker Tracking [8].

Vuforia is a state of the art application in terms of its technical features. In addition to the features stated above, apart from the marker recognition, it can also perform OCR, text reading process. It provides adequate technical features for the developers who want to use one or more of these features.

AR Toolkits Not Using Market

Paralel Tracking and Mapping (PTAM)

It is supported by many platforms such as Windows, Mac OSX, Android, and IOS. This tool is known by a robot called SLAM. PTAM has adequate features for various needs. The most striking feature of this is that it can operate without using a marker. During its operation it specifies a virtual platform (Keyframe-Based) on the image. It performs its action by taking this platform as a reference. PTAM algorithm is formed by VideoSource, Renderer, Controller, Model, Tracker, Relocalizer, Mapper components [9]. The technique deployed by this tool will be the underlying technique of many AR applications in the future. User will be inclined to use applications which utilize other objects nearby as markers rather than using real markers.

Handy AR

Handy AR is a tool which Works with the movement of hand. In this tool, hand is used as a marker instead of a printed symbol. In addition to hand recognition function Handy also has the features of creating a platform on the surface and processing according to this platform [10]. It is similar to PTAM with this feature. The hand can operate differently in both closed and open positions. There is a hand recognition algorithm in Figure 3. Main functions of this algorithm are hand recognition, finger recognition and tracing. If we consider hand as a marker, then the differences between these algorithms with the ones working with markers would be as followed:

1st and 2st steps in figure 3 would be the same in both however 3rd step (Fingertip detection) is skipped, marker tracking and camera pose estimation steps are common in all algorithms. If their functions are taken into consideration all the AR algorithms are basically similar to each other. The main distinction of hand recognition algorithm of Handy AR from other algorithms is its potential to be used in various fields. Especially when it is used with Argon which will be discussed in the next chapter many interactive applications may well be developed.

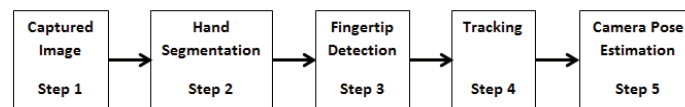


Figure 3 Process Steps [10].

Web Browser AR Toolkits

Argon

ARGON is an application developed as a web browser. ARGON is designed for IOS operating systems. As its working principle, location of your mobile is detected first by GPS. With this procedure, latitudes, longitudes and altitude parameters (KARML-KML AR MARKUP LANGUAGE) are identified [11]. After the GPS detection frequency image (panoramic

Background images) on the server matching with the GPS data are downloaded. Recognition process is done according to the images taken. Recognition process is done with the technique developed by Vuforia [12]. Thus, even only capturing a small part of the image is enough for recognition. Argon can add 2D and 3D graphics into the screen. It uses JavaScript (three.js) based on 3D images [13]. Argon is a tool which can only be used in open fields where GPS is active. Especially when used in open air museums many effective applications may be developed. Through ARGON we can figure out from where does a plane or a car come and go to just by showing it on camera or we can estimate the weather only by handing our camera to the sky. It is a tool which is advisable to the developers who will develop such applications.

Mixare

Mixer is an AR web browser similar to Argon. However, unlike Argon it is also applicable in Android tools. It uses Google's mapping service too. They structurally resemble each other with Argon. The major difference between them is that Mixare is only a two-dimensional and text based application. This application basically designed for social network can Show the locations of your friends with an arrow in your mobile screen [14]. Apart from this, it enables to get information about weather etc. by using GPS and gyroscope of your mobile. Main difference between this tool and the other AR applications mentioned above is that it functions only by using GPS and Gyroscope without processing any other features such as marker detection etc. Camera is only a kind of background tool for this application.

Applying This Model Into Education

This application is developed by using Vuforia for Android systems. It offers further developing with Vuforia Unity3d and Android SDK. The application mentioned here in this study is also developed by using these tools. Unity 3D was used for developing three-dimensional applications whereas Android SDK was used for Virtual Button and Play Back. Our application is a kind of educational application. Image Target, Virtual Button and Video features were used in this application.

This application has three major tasks. A video explaining the structure of a skeleton will be viewed on a marker by clicking on virtual button, if this button is clicked this skeleton will be seen on the screen as 3D.

Developmental Steps

1. Marker and virtual button coordinates were specified. Video and 3D skeleton image were chosen.
2. Eclipse and Vuforia Playback features were added and marker could be brought on the video when it is appeared.
3. 3D AR application was developed by using Unity3D.
4. 3D AR application is provided to be operated when the button is clicked on.

Images to be used as markers were selected. These images were uploaded into the website on '<https://developer.vuforia.com/targetmanager/>' The images uploaded there were later downloaded as "xml" and "dat."

New files were saved into VuforiaSamples\assets folder. The important thing here in this stage is to identify the areas on the image which would be used as button. In order to this, button coordinates must be defined in '<VirtualButton/>' tag within the xml file saved in VuforiaSamples\assets folder. Following these steps, the first stage of this application is finalized. The files formed above are added into the Android based Project.

After the markers and buttons are created, 3D skeleton was obtained readily on the internet. During the use of Unity3D, the directives found on the website of Vuforia are all exactly performed and the 3D Project is exported as .apk

Video will be installed on marker by using Playback feature of Vuforia. These steps should be taken:

1. The marker should be identified
2. An image of video should be selected
3. The video should be specified

Identification of a marker was done in the first stage of the Project. The marker can be found in Figures 4 and 5. The thing that must be done here is to choose the video and its Picture. The video and its image should be saved in VuforiaSamples\assets folder. As the Project will be used as an educational material an instructional video about skeleton is used. Following this step the photo chosen for the video is added into the Project as can be seen in Figure 6.

```
mMovieName[ISKELET] = "iskelet.mp4";
mTextures.add(Texture.loadTextureFromApk("iskelet.png", getAssets()));
```

Upon completion these three stages, it is provided to reach 3D images or videos when they are clicked on.



Figure 4: The marker used for the application.

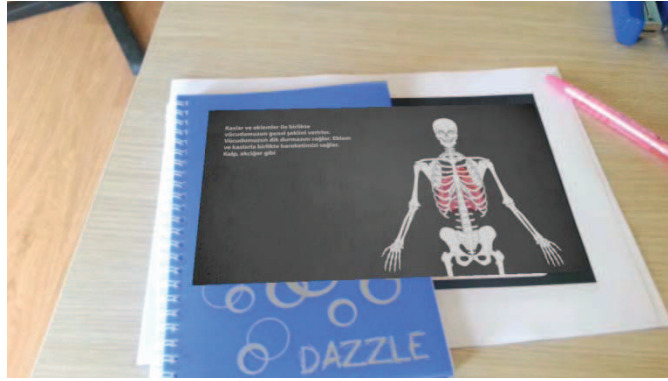


Figure 5 Instructional Video for the application.

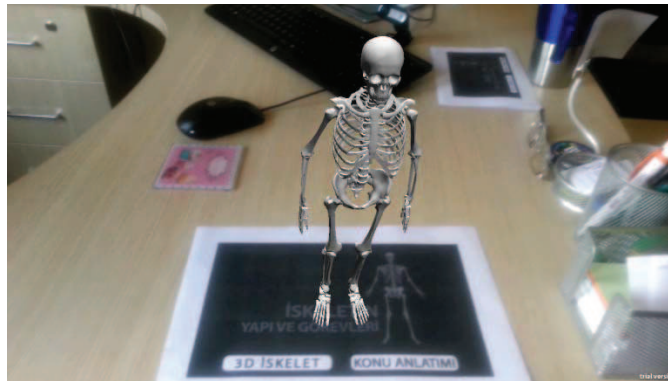


Figure 6 3D Skeleton model for the application.

Results

All the Augmented Reality tools we have analyzed are used for distinctive functions. Each of these tools has their own characteristics. 7 tools are analyzed Under the 3 main topics above. This study deals with the analysis on the applications applicable by these tools and the operation methods of these applications. As a result of this study it is aimed to give some contributory information on selection of the most effective tool in terms of application areas by presenting extensive comparison on the disadvantages and advantages of all. As these tools are open source software, they can be used by any developers without paying anything. However some of these tools require licensing for commercial use. An educational application is carried out here in this study by using Vuforia which is one of these tools. It is observed that this application has improved the quality of instruction.

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