

# Gamification and Augmented Reality in Education

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## Abstract

This paper shows how to create an animation of a game character for a mobile application with augmented reality. The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world, not as a simple display of data, but through the integration of immersive sensations, which are perceived as natural parts of an environment. The Unity platform, Vuforia SDK and Android OS were used for work. For this work, the Fighting Unity-Chan model was downloaded. This is an animation resource pack that specializes in fighting games. To create a smooth and correct transition between animations, animator was created, in which all animations are shown taking into account the time of their action.

## Keywords

Augmented reality, Unity3D, Vuforia platform, mobile application, gamification, Education, Education Technology.

## 1. Introduction

The advent of technological advances can be used to improve many aspects of everyday life, including education. Augmented reality is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. Augmented reality can be defined as a system that fulfills three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects. The overlaid sensory information can be constructive (i.e. additive to the natural environment), or destructive (i.e. masking of the natural environment). This experience is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, augmented reality alters one's ongoing perception of a real world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one. Augmented reality is related to two largely synonymous terms: mixed reality and computer-mediated reality.

The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world, not as a simple display of data, but through the integration of immersive sensations, which are perceived as natural parts of an environment. The earliest functional augmented reality systems that provided immersive mixed reality experiences for users were invented in the early 1990s, starting with the Virtual Fixtures system developed at the U.S. Air Force's Armstrong Laboratory in 1992. Commercial augmented reality experiences were first introduced in entertainment and gaming businesses. Subsequently, augmented reality applications have spanned commercial industries such as education, communications, medicine, and entertainment. In education, content may be accessed by scanning or viewing an image with a mobile device or by using markerless AR techniques.

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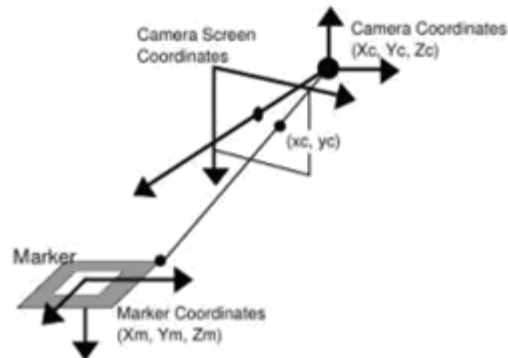
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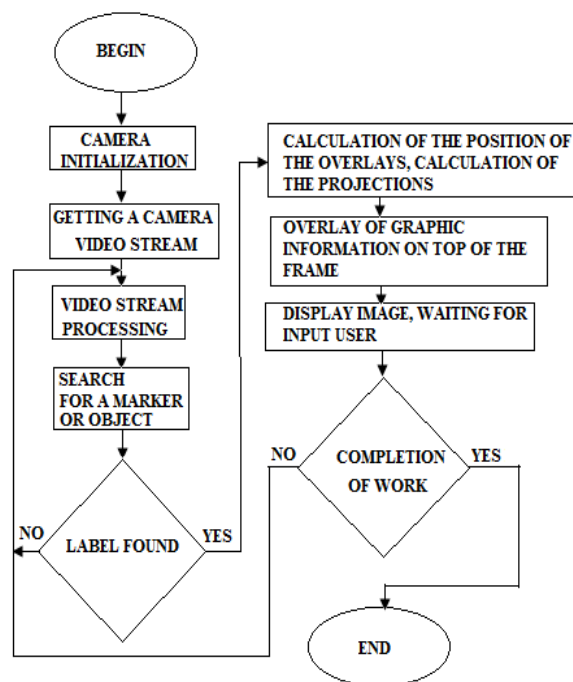
## 2. Technologies and algorithms

The principle of operation of augmented reality systems is to combine a certain virtual object (text, pictures, three-dimensional models, etc.) and a video stream received from the device's camera. The algorithm of complementing reality is based on standard affine transformations in three-dimensional space. Using the definition of the projection of the marker on the observation plane, it is possible to calculate the angles of inclination of the marker relative to the observation plane, which will further distort the generated image of the augmented reality video stream in a similar way. An example of coordinate transformation is presented in Figure 1.



**Figure 1:** The basis of augmented reality technology.

Let us consider in a more detailed way the possible logic scheme of the application of augmented reality. Figure 2 shows a typical operation scheme of such an application.



**Figure 2:** Typical algorithm of the application of augmented reality.

The application starts when the camera is initialized and the video stream is redirected from the device's camera module. Next, it is necessary to analyze the frame of the video stream. The frequency of processing stream frames depends on the capabilities of the user equipment. Processing of each selected frame of the video stream is performed, which allows to prepare it for the next step. Already

on the processed frame, a search for markers (for example, a QR code) is performed or objects are searched using markerless determination methods. If an object has been selected on the frame, its boundaries are calculated using various methods, and the transformation matrix is calculated. A certain virtual object is superimposed on the initial frame of the video stream, which corresponds to the definition at the stage of label search. Thus, globally, we have two problems: searching for a label (object) and calculating where virtual objects are superimposed on the original frame of the video stream.

Marker search algorithms. For augmented reality systems it is very important to make the process of detecting a marker (object) as fast as possible. One of the factors for the qualitative determination of markers is, surprisingly, the marker itself. It must be detectable under any parameters of lighting, colors, camera position and others. The steps of the algorithm are as follows:

1. getting the image.
2. Image processing:
  - a. grayscale translation;
  - b. image binarization (segmentation);
3. Marker definition:
  - a. detection of connected areas (component);
  - b. selection of the contours of the object;
  - c. selection of borders and angles;
  - d. determination of the final position of the marker (coordinate transformation).

Methods for determining the boundaries of the image (segmentation) are often used to highlight individual parts of the image (separating the object and background) and creating a binarized representation. All algorithms for determining the boundaries can be attributed to one of six types based on: the values of the histogram of brightness; on the values of entropy; on clustering; on local thresholds; on pixel correlation; on the attributes.

Contours can be found by one of the algorithms:

- Marr-Hildreth method,
- Canny Boundary Detector,
- Sobel operator,
- the Roberts operator,
- the Prewitt operator,
- Kirsch operator,
- Robinson operator,
- isolation of contours using the LoG method.

Researchers call the methods of Marr-Hildreth, LoG and Canny equally effective. The next step is to find the plane and boundaries of the marker. This can be done by applying the Douglas – Perker algorithm. The idea of this algorithm is to construct approximating curves (curves with fewer points) from the found contours. After the end of this algorithm, we have a set of coordinates at the output. But these coordinates turned out to be exactly perpendicular to the camera, but in reality they are located at a different angle. Since the sides of the marker are coordinate axes, we can calculate the coordinates of the camera relative to its [marker]. Thus, when the camera angle changes, the projection size changes. It remains only to impose a virtual model taking into account the projection matrix on the found area with a marker. All the main considered algorithms are available in the OpenCV library of computer vision algorithms. Final output can be done using OpenGL (interface for outputting three-dimensional and two-dimensional graphics). These two libraries are implemented on all popular platforms: Microsoft Windows, MacOS, Linux, Android, iOS and others.

### **3. Main part**

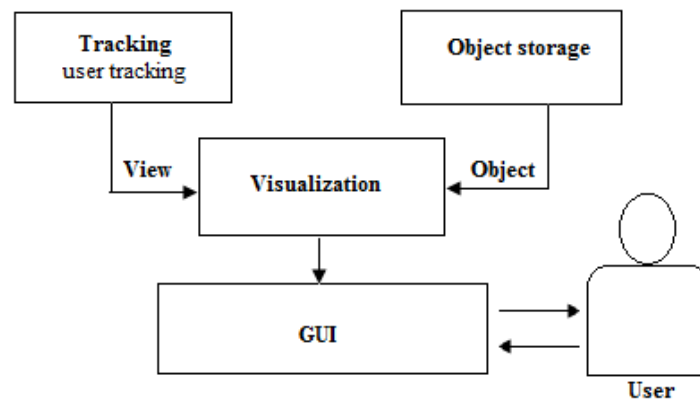
To implement augmented reality technology, two main software components are needed: tracking and visualization. At the moment, researchers and specialists have developed an extensive theoretical and algorithmic base for their implementation in the form of various individual components, as well as in the form of integrated programs and sets of augmented reality development tools. Individual

components include libraries and frameworks of computer vision, three-dimensional graphics engines and other solutions.

The structure of the visualization system by means of augmented reality implies the presence of the following basic components (Figure 3):

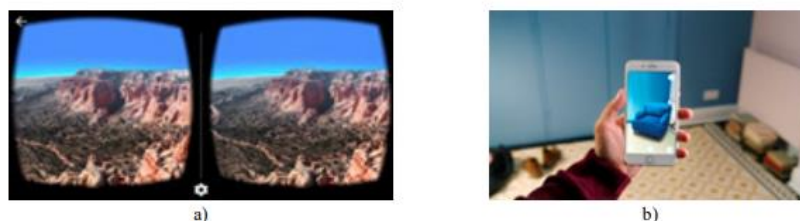
1. Tracking subsystem that provides correct integration of a virtual object into a real environment.
2. Storage of three-dimensional models and other information on objects.
3. Visualization subsystem that provides drawing of objects by means of computer graphics.
4. A graphical interface that provides user interaction.

Virtual and augmented reality (VR and AR) are modern and rapidly developing technologies. Their goal is to expand the physical space of human life objects created with the help of digital devices and programs, and having the nature of the image (Figure 4). Figure 4a shows the image that the user sees through special virtual reality glasses. The image is divided into two separate pictures for each eye and specially distorted to create the illusion of three-dimensional space for the eyes. If a person moves or simply turns his head, the program automatically rearranges the image, which creates a sense of real physical presence.



**Figure 3:** Key elements of augmented reality visualization system.

With the help of controllers (joysticks, etc.), the user can interact with the surrounding objects, for example, he can pick up a stone and throw it from a mountain – the built-in physical model that calculates the flight of the stone, which will further create the illusion of real space. Figure 4b shows an application using augmented reality technology. In this application, you can place images of furniture on the image from the phone's camera, but due to their deformations, the user gets the impression that he sees a real object located in the room. The important thing is that in this case, the reality (room) is complemented by a virtual chair, and the corresponding technology will be called augmented reality. Creation of augmented reality is possible not only with the help of smartphones, but also other technical means, for example, by means of special glasses. In this case, the virtual image is completed on the surface of the lenses of the glasses



**Figure 4:** Examples of virtual technology (a) and augmented reality (b).

Hardware that is used: virtual and augmented reality glasses, controllers, headphones, smartphones and tablets. These devices allow a person to see and hear digital objects (Figure 5). In the near future, to appearance of the gloves with real-time feedback that allow a person to feel digital objects (Figure 6).



**Figure 5:** VR and AR devices: glasses with headphones (a), controllers (b), smartphones and tablets (c).

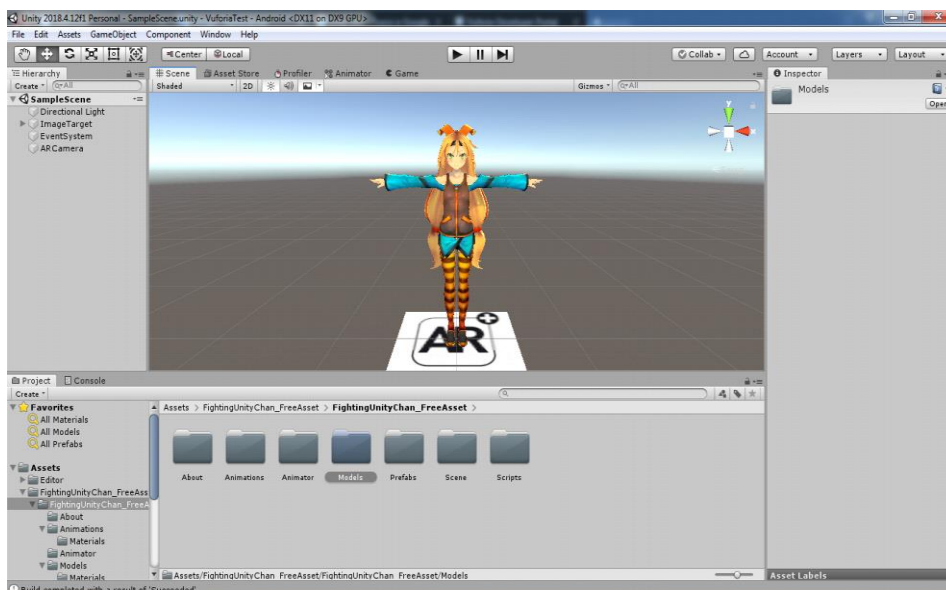
Programs are created, as a rule, on the same platforms on which computer games are developed (Unity, Unreal Engine, etc.), with the help of various tools for developing virtual and augmented reality programs (Steam VR, Google VR, Oculus, Windows Mixed Reality, Google ARCore, Apple ARkit, Google Tango, Vuforia, etc.). Device prototypes and the first uses of the terms VR and AR existed as early as the mid-20th century, but modern terminology was formed in the early 90s. For VR in the work of Jaron Lanier, for AR in the work of authors Caudell, Thomas and Mizell.



**Figure 6:** The glove prototype with real-time feedback.

## 4. Experiment

Vuforia is powered by Unity's cross-platform computer game development environment. For this work, the Fighting Unity-Chan model was downloaded. This is an animation resource pack that specializes in fighting games. This model can be seen in Figure 7.



**Figure 7:** The Fighting Unity-Chan model.

This model is displayed in a specific figure, i.e. if a certain pattern enters the field of view of the camera then a model will be generated on it. This marker drawing is shown in Figure 8. To do this, it was necessary to create an ImageTarget, in which to further adopt our model, as shown in Figure 9.



Figure 8: The picture shown.

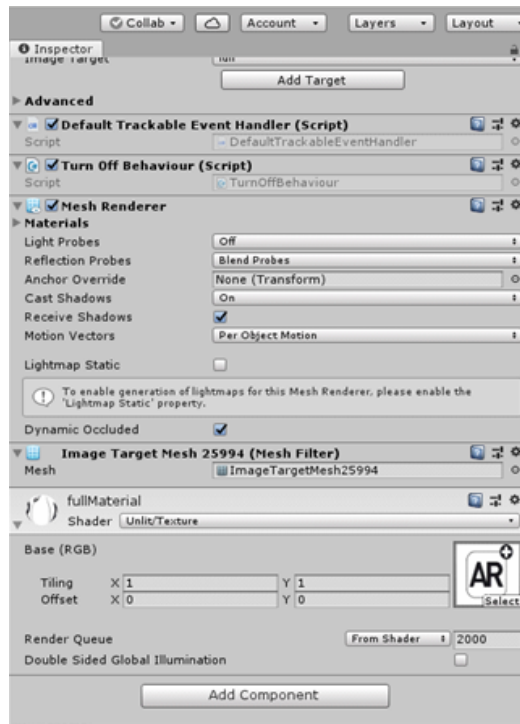


Figure 9: ImageTarget.

There were 10 animations in this package, all of which were displayed in the form of buttons, by clicking on which you could see a specific animation. The buttons were implemented as C# code. The code can be seen in Figure 10. This code shows how a button is created (GUI.Button), it assigns an animation that will work when you click on it, the size of the button and its name (Figure 11).

```
using UnityEngine;
using System.Collections;

[RequireComponent(typeof(Animator))]

public class IdleChanger : MonoBehaviour
{
    private Animator anim;
    private AnimatorStateInfo currentState;
    private AnimatorStateInfo previousState;

    void Start ()
    {
        anim = GetComponent<Animator> ();
        currentState = anim.GetCurrentAnimatorStateInfo (0);
        previousState = currentState;
    }
}
```

Figure 10: C# code for animation start.

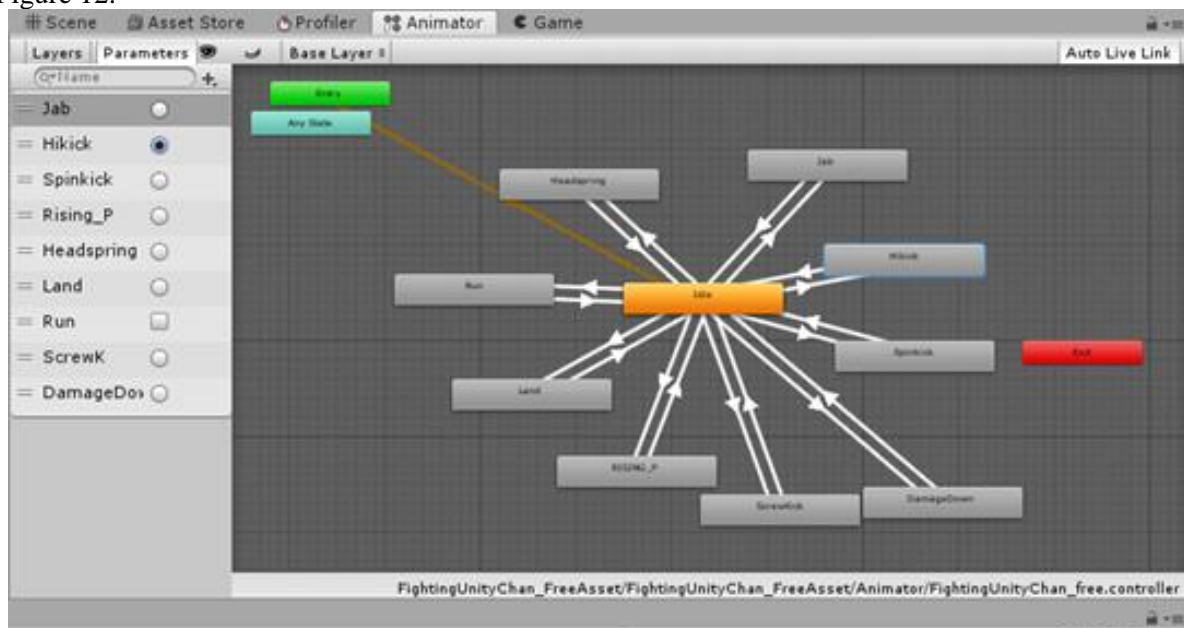
```

void OnGUI()
{
    GUI.Box(new Rect(Screen.width - 400 , 25 ,220 , 520), "");
    if(GUI.Button(new Rect(Screen.width - 390 , 60 ,200, 40), "Jab"))
        anim.SetBool ("Jab", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 110 ,200, 40), "Hikick"))
        anim.SetBool ("Hikick", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 160 ,200, 40), "Spinkick"))
        anim.SetBool ("Spinkick", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 210 ,200, 40), "Rising_P"))
        anim.SetBool ("Rising_P", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 260 ,200, 40), "Headspring"))
        anim.SetBool ("Headspring", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 310 ,200, 40), "Land"))
        anim.SetBool ("Land", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 360 ,200, 40), "ScrewKick"))
        anim.SetBool ("ScrewK", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 410 ,200, 40), "DamageDown"))
        anim.SetBool ("DamageDown", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 460 ,200, 40), "Run"))
        anim.SetBool ("Run", true);
    if(GUI.Button(new Rect(Screen.width - 390 , 510 ,200, 40), "Run_end"))
        anim.SetBool ("Run", false);
}

```

**Figure 11:** C# code shows how a button is created GUI.Button.

To create a smooth and correct transition between animations, animator was created, in which all animations are shown taking into account the time of their action. For example, to switch from a state of rest (Idle) to a state of impact (Hicick) need to spend one second of time. This can be seen in Figure 12.



**Figure 12:** Correct transition between animations.

To run the model on the application, you need to download the apk package on your Android phone and have the marker drawing is shown in Figure 8. Next, the process of working with the model will be shown in Figure 13. The application VuforiaTest.apk can be downloaded from the link: <https://drive.google.com/open?id=1JjjA2SHPsXBDNtOFewbFCfVChE7hsdkK>.

## 5. Conclusion

The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world, not as a simple display of data, but through the integration of immersive sensations, which are perceived as natural parts of an environment. The

gaming industry embraced AR technology. A number of games were developed for prepared indoor environments, such as AR air hockey, Titans of Space, collaborative combat against virtual enemies, and AR-enhanced pool table games. Augmented reality allowed video game players to experience digital game play in a real-world environment. Niantic released the augmented reality mobile game Pokémon Go. Disney has partnered with Lenovo to create the augmented reality game Star Wars: Jedi Challenges that works with a Lenovo Mirage AR headset, a tracking sensor and a Lightsaber controller. Augmented reality gaming is also used to market film and television entertainment properties. In this work an animated character, which can be controlled and played, is created.



**Figure 13:** Process of working with the model.

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