Design an inexpensive augmented reality platform for the customized application

Ma Quanjin*[1,2], M.R.M.Rejab[1,2], M.S.Idris[1], M.H.Abdullah[1]

*Correspondence

neromaquanjin@gmail.com

[1] Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
[2] School of Mechanical Engineering, Ningxia University, 750021 Yinchuan, China

ABSTRACT

Augmented reality (AR) technology is an emerging method to advance real world (RW) environment or user experience, which is mixed virtual and real reality. It is generally used to support image formation concepts, which is enhanced using relevant equipment. However, the relevant equipment is high-cost, portable, and limited software or hardware equipment, which reduces its potential application areas. Therefore, the aim of this paper is to design an inexpensive platform to determine the customized application using augmented reality technology, which is based on open-source software and hardware equipment. It is used to advance the targeted platform with several render effects. In addition, three virtual models are selected and applied animation function on its platform, which is controlled using external device such as keyboard and mouse. It is successful, sufficient and inexpensive device to meet the demands in various applications with external control device.

INTRODUCTION

Augmented reality (AR) has been a hot topic in software technology development in recent years, which attentions the latest release of products with virtual reality and mixed reality such as Google glass, 0glass Danny, Microsoft HoloLens. Augmented reality is an advanced technology that works on computer vision based recognition algorithms to augment sound, video, graphics and other sensors based on inputs real world objects using the camera device [1]. It is a sufficient and simple method to render effect real world information and present it in an interactive way so that virtual elements could become part of the real world. Augmented reality shows superimpose information in your field of view and can take it into a new world where the real and virtual worlds are tightly combined, which is not limited to desktop or mobile devices [2].

A simple augmented reality case is that a user captures the image of a real-world object, and the underlying platform detects a marker, which triggers it to add a virtual object on top of the real-world image and displays on camera screen or computer display screen. It is typically performed in real time and in semantic context with environmental elements, which can serve to aid and enhance individual's knowledge and understanding of what is going on around them [3]. With the advanced AR technology

support, the information about the surrounding real world of the user makes interactively and digitally manipulable [4]. Supplementary information about the environment and its objects is overlaid on the real world. It also brings out the components of the digital world into user perceived real world. The first functional AR 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 Labs in 1992 [1], which was the first commercial augmented reality experiences took place in gaming and environment areas, as shown in Figure 1. Augmented reality can also transform world of education, where content may be accessed by scanning or viewing an image using portable device with different advanced software. It enhances one's current perception of reality, whereas in contrast, virtual reality replaces the real world with a simulated one, which properly provides high quality 2D and 3D augmented reality environment [5-7].

Augmented reality is mainly consisted with hardware and software equipment. Basic hardware components are involved processor, display, sensors and several input devices. Figure 2 shows the brief flowchart hardware of basic hardware section in augmented reality. Modern mobile computing devices such as mobile phone and tablet computers, which contain these elements and provide the camera and MEMS sensors like accelerometer, GPS, and solid state compass [3]. Software components is derived real world coordinates, which is independent from the camera or camera image and it is generally used to video and 3D model tracking. The relevant software have been rapidly emerged and developed like SDKs. Several of the well-known AR SDKs are provided by Vuforia, ARToolKit, Catchoom, CraftAR, Wikitude SDK, Blippar, Meta and ARLab [9-12]. The brief flowchart of software section of augmented reality is presented in Figure 3.

Various applications are used augmented reality technology, which refers to optical projection systems, monitors, hand held devices, and display systems worn on the user body [4]. It has been applied in many fields such as advertising and marketing, architecture and construction [13, 14], environment [15], medical [16], military [17, 18], travel [19] etc. It is briefly shown in Figure 4, which presents its application in education, traveling, language and engineering areas.

Based on technology develops, there are two other realities have been emerged and developed in recent years. Augmented reality (AR) refers to various scopes that the computer generates several elements such as image, text, video and users' perception the real world [24-26]. Virtual reality (VR) refers to immersive multimedia or computer-simulated reality, which simulates a physical condition in the real or virtual world [27]. Mixed reality (MR) refers to hybrid reality such as Magic Leap, which is the merging of real and virtual worlds to produce a series of new environments and visualizations in real time [28]. Visual comparison analysis between virtual reality, augmented reality and mixed reality are illustrated in Figure 5, which shows its characteristics. User's experience interaction analysis is compared between virtual reality, augmented reality and mixed reality, as shown in Figure 6.

METHODOLOGY

Software Section

Unity software is a cross-platform game engine, which is developed by Unity technologies [12] [30]. It is primarily used to develop simulations and video game environment for mobile device, control panel and computer. It is also a notable game engine that can support 2D and 3D graphics imaging technique [31]. Vuforia developer portal is support application, which provides Unity extension package and target manager [32]. In this technical paper, Unity 5.2.5 version, Vuforia developer portal and Unity editor are used to perform its purposes, which are downloaded model render effect, virtual model and several animation controllers. Vuforia developer portal is used to create and manage targeted image, which can be downloaded from database and import in Unity software, as shown in Figure 7.

Hardware Section

Hardware section is used to design a portable and inexpensive device, which achieves customized purpose using augmented reality. The hardware equipment is briefly shown in Figure 8, which involves targeted platform, rotation showcase, HD720p web camera, USB connector and device support. The platform was designed as targeted image using manual rotation, which is presented in Figure 9. It is significant attention is that targeted single image should have a high augmentable rating from target

manager of vuforia developer portal. The distance between the platform and camera view should be adjusted in order to obtain a clear and stable augmented reality experience.

Design Procedure

Flowchart of this project is presented in Figure 10, which depends on hardware and software equipment. Targeted image and 3D real model are provided, which is operated and downloaded from vuforia developer portal. Hardware and software equipment is prepared accordingly, and relevant assets are added in Unity software. The several control setting and program codes are set and written, which is used to provided render effects and 3D model animation. Augmented reality with different effects could be shown in "Play Mode" of Unity software interface, and targeted image visualization is presented in Unity software. The overall augmented reality process of this project is illustrated in Figure 11, which briefly highlights its components and functions in details.

There are three typical effects using augmented reality, which are render effect, animations with rotation and motion modes, character model motion using external device like keyboard and mouse. The selected render effects are added from the Asset store from Unity software. 3D models are selected like Lamborghini car model and Zombie model, which are used animation mode to obtain its function. Related setting parameters are exhibited in Figure 12, which show its basic setting values in details. Chan character model is aimed to perform its designed animation function, which is controlled can be controlled by keyboard and mouse click. The design flowchart of controller animator is shown in Figure 13, which provides its action schematics.

RESULTS AND DISCUSSION

The first method is to add the render effect on the real character model to advance its environment condition. In Unity software, AR camera and image target components should be imported, and selected render effects could be imported from Unity asset stores. Render effect can be optimized according to targeted real model, which refers to color, size and its position. Two yellow render effects are placed at the two hands of real model. One red render effect is placed in front of the real model body, and one blue render effect is put around the feet to add specific effect. One yellow render effect is enlarged its size to cover the whole body of real model. Images with different views have been summarized and compared in Figure 14, which highlights its augmented reality function. It makes the real Gouku model likes energy effect protection cover, which enhances its customers' emotion.

In order to achieve the render effect on virtual 3D model with several animation functions, AR camera, targeted image, Lamborghini car model, zombie model and render effects could be imported in Unity content. Lamborghini car model and zombine model are freely downloaded from TF3DM website and colored in Unity software [13]. Each 3D model is set in Animator with Controller, which is not selected Root Motion. Render effects can be put in each model bottom side, which enhances its real effect environment. In applied augmented reality interface, the Lamborghini car model is rotated with surrounding render effects, and zombie model walks forward with a blue render effect around the feet. Figure 15 presents images of render effects with two virtual 3D models.

In order to control the animation of the virtual model using external device, the AR camera, targeted image and virtual character should be firstly imported in Unity software interface. It needs to create the animation folder with animator controller named play controller, which programs several animation control steps, as shown in Figure 13. Play controller script program code is provided in appendices. Therefore, the virtual 3D model can be controlled by keyboard number button, space and shift button and mouse click. Figure 16 shows images of animation function with virtual character model. Five typical actions have been shown in Figure 16 c, which highlights its function using augmented reality.

Figure 1 The first AR system with virtual fixtures at U. S. Air Force's Armstrong Laboratory [8]
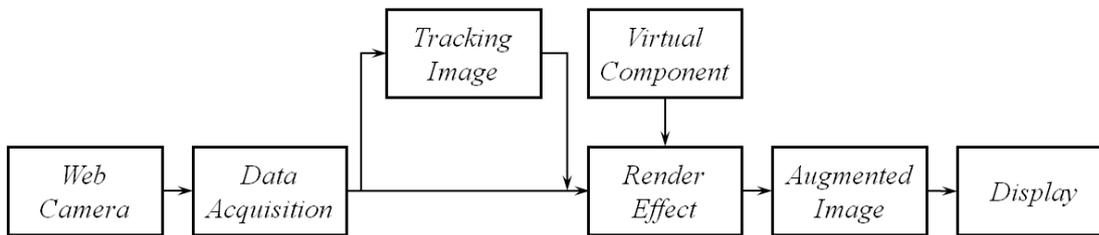

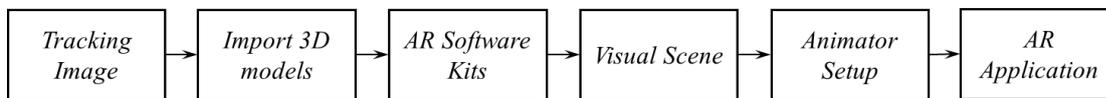**Figure 2** The brief flowchart of hardware section in augmented reality technology

Figure 3 The brief flowchart of software section in augmented reality technology

Figure 4 Typical applications using augmented reality technology: (a) education [20]; (b) auxiliary tool [21]; (c) language translation [22]; (d) manufacturing assembling [23]
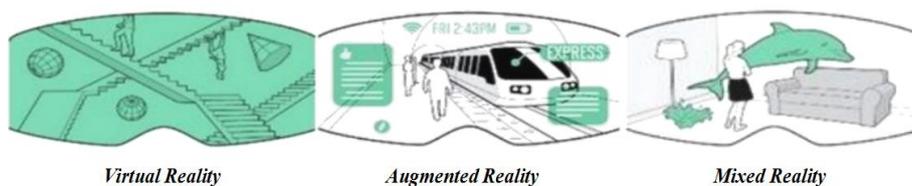

Figure 5 Visualization comparison between virtual reality, augmented reality and mixed reality [10]

Type	VR	AR	MR
User can aware about real world	×	√	√
User can interact with real & virtual world in real-time	×	√	√
User can interact real & virtual contents in real-time	×	×	√

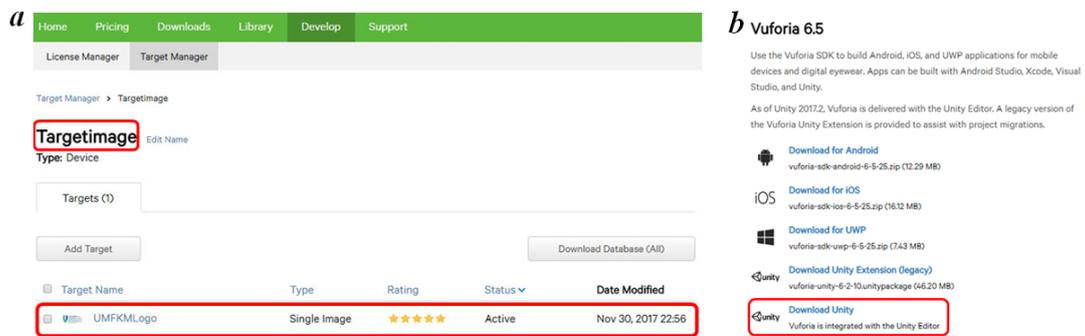**Figure 6** User's experience interaction comparison between virtual reality, augmented reality and mixed reality [22]

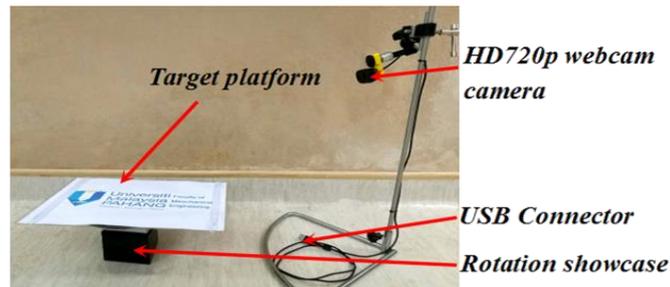**Figure 7** Vuforia developer portal setup: (a) image targeted download; (b) Unity editor packages

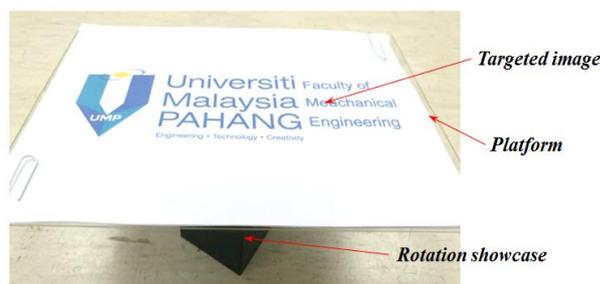**Figure 8** Experimental setup with hardware section

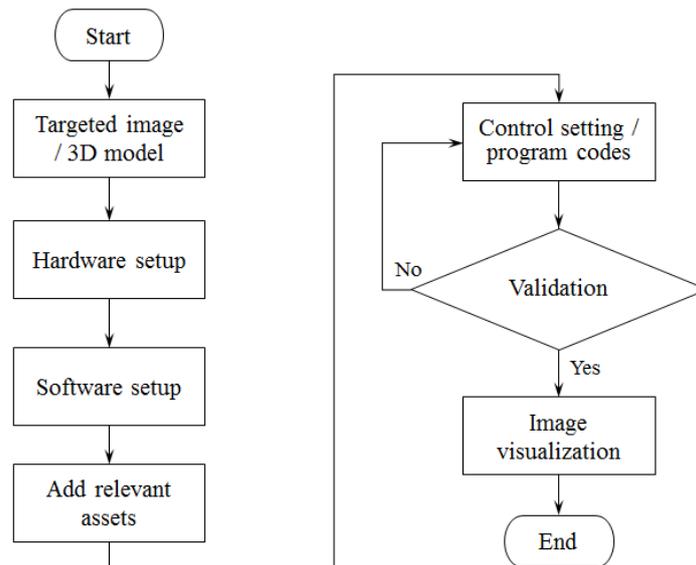Figure **9** Platform device with its targeted image

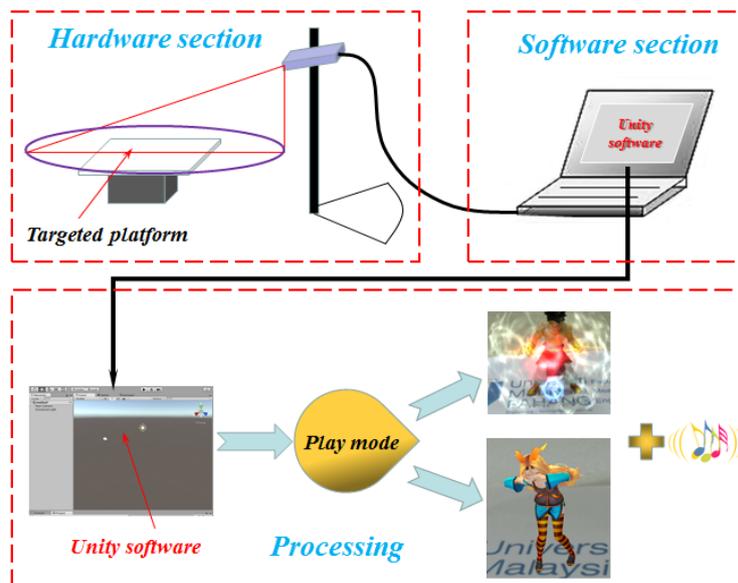**Figure 10** The simplified flowchart of this project methodology

Figure 11 The open-source platform used augmented reality technology
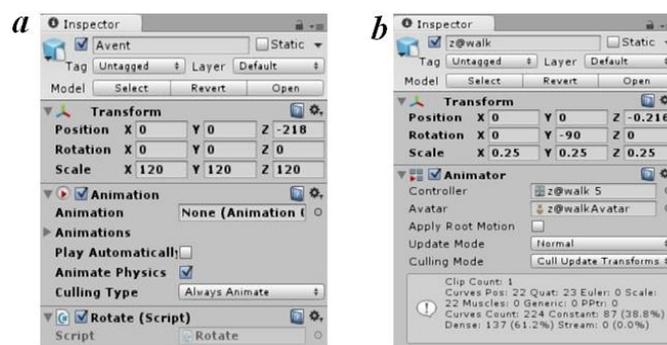

Figure 12 Parameters setting of animation function: (a) Lamborghini car model; (b) zombie model
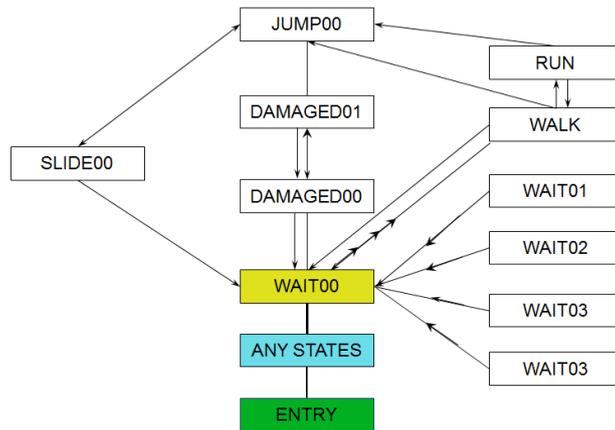
Figure 13 The design flowchart of controller animator (Notes: WAIT, RUN, WALK, SLIDE, JUMP and DAMAGE are the different character's actions)
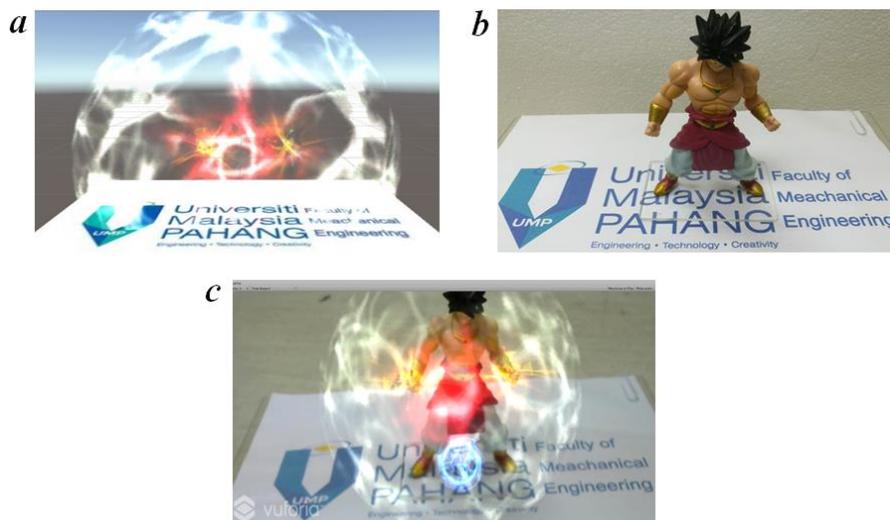

Figure 14 Images of render effects with real character model: (a) Unity software interface; (b) real condition; (c) applied augmented reality interface in Unity software
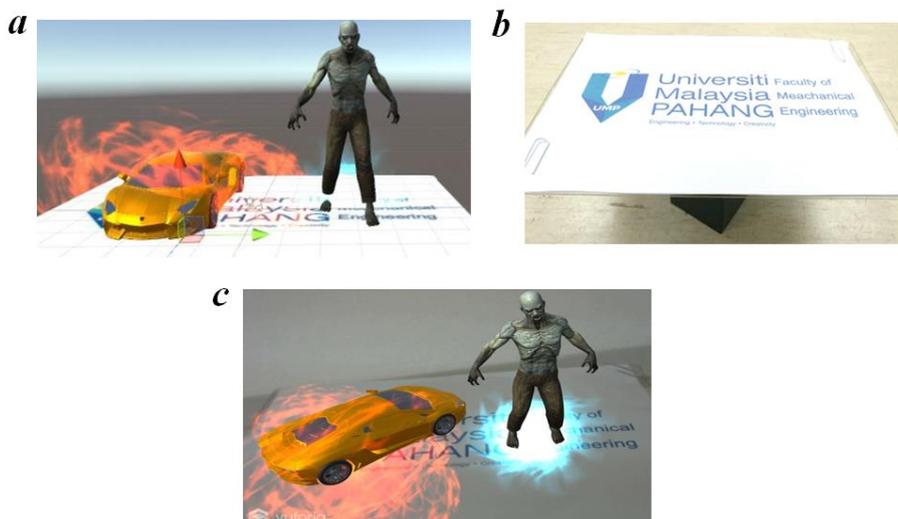

Figure 15 Images of render effects with two virtual 3D models: (a) Unity software interface; (b) real condition; (c) applied augmented reality interface in Unity software
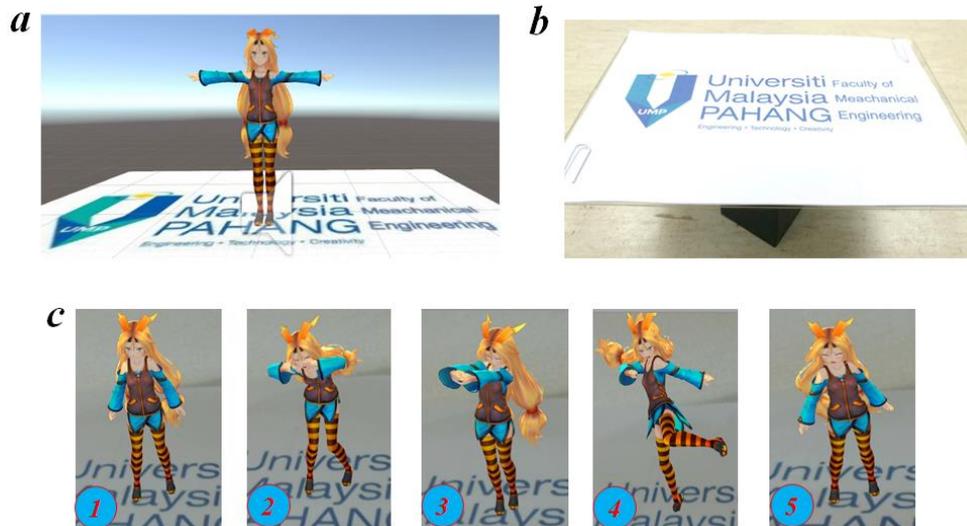
Figure 16 Images of animation function with virtual character model: (a) Unity software interface; (b) real condition; (c) applied augmented reality interface in Unity software with five actions

CONCLUSION

Augmented reality (AR) technology has been successfully applied and developed using inexpensive equipment and open-source software. The inexpensive equipment with portable platform is used to advance augmented reality with customized purpose. There are three methods used in this project, which highlights its application. The first method is to create augmented reality environment with render effects on a real 3D model. The second method is to design virtual models with several render effects on targeted image platform. The third method is to design an augmented reality character model controlled using keyboard and mouse click. Unity software & vuforia developer portal software are open-source and powerful software tools to service toward a high quality augmented reality technology. It is highlighted that augmented reality could have large potential applications in later several years.

Nomenclatures

AR: Augmented reality
VR: Virtual reality
MR: Mixed reality
RW: Real world
HUD: Head-up display
SDK: Software development kit
QR: Quick response
2D: 2 dimension
3D: 3 dimension
MEMS: Micro-electromechanical systems
GPS: Global position systems
TF3DM: Free 3D model

Nomenclatures

Appendices: Controller Code
```
using UnityEngine;
using System.Collections;
public class play controller: MonoBehaviour {
        public Animator Animat;
        public Rigidbody Characterrun;
        private float inputH;
```

```
private float inputV;
private bool run;
// Use this for initialization
void Start ()
{
        Animat = GetComponent<Animator>();
        Characterrun = GetComponent<Rigidbody>();
        run = false;
}
// Update is called once per frame
void Update ()
{
        if(Input.GetKeyDown("1"))
        {
                Animat.Play("WAIT01",-1,0f);
        }
        if(Input.GetKeyDown("2"))
        {
                Animat.Play("WAIT02",-1,0f);
        }
        if(Input.GetKeyDown("3"))
        {
                Animat.Play("WAIT03",-1,0f);
        }
        if(Input.GetKeyDown("4"))
        {
                Animat.Play("WAIT04",-1,0f);
        }
        if(Input.GetMouseButtonDown(0))
        {
                int n = Random.Range(0,2);
                if(n == 0)
                {
                        Animat.Play ("DAMAGED00",-1,0f);
                }
                else
                {
                        Animat.Play ("DAMAGED01",-1,0f);
                }
        }
        if(Input.GetKey(KeyCode.LeftShift))
        {
                run = true;
        }
        else
        {
                run = false;
        }
        if(Input.GetKey(KeyCode.Space))
        {
                Animat.SetBool("jump",true);
        }
        else
        {
                Animat.SetBool("jump", false);
        }
        inputH = Input.GetAxis ("Horizontal");
        inputV = Input.GetAxis ("Vertical");
        Animat.SetFloat("inputH",inputH);
```

```
        Animat.SetFloat("inputV",inputV);
        Animat.SetBool ("run",run);
        float moveX = inputH*20f*Time.deltaTime;
        float moveZ = inputV*50f*Time.deltaTime;
        if(moveZ <= 0f)
        {
                moveX = 0f;
        }
        else if(run)
        {
                moveX*=3f;
                moveZ*=3f;
        }
        Characterrun.velocity = new Vector3(moveX,0f,moveZ);
    }
}
```

ACKNOWLEDGEMENT

REFERENCES

[1]   Y. Boger, M. Machlin, and Y. Korakin, "Apparatus, systems and methods for providing motion tracking using a personal viewing device," ed: Google Patents, 2018.

[2]   Z. Lai, Y. C. Hu, Y. Cui, L. Sun, N. Dai, and H.-S. Lee, "Furion: Engineering high-quality immersive virtual reality on today's mobile devices," *IEEE Transactions on Mobile Computing,* 2019.

[3]   J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," *Future generation computer systems,* vol. 29, no. 7, pp. 1645-1660, 2013.

[4]   S. G. Dacko, "Enabling smart retail settings via mobile augmented reality shopping apps," *Technological Forecasting and Social Change,* vol. 124, pp. 243-256, 2017.

[5]   D. Parsons, "The future of mobile learning and implications for education and training," *Increasing Access,* vol. 217, 2014.

[6]   M. K. Bekele, R. Pierdicca, E. Frontoni, E. S. Malinverni, and J. Gain, "A survey of augmented, virtual, and mixed reality for cultural heritage," *Journal on Computing and Cultural Heritage (JOCCH),* vol. 11, no. 2, p. 7, 2018.

[7]   W. R. Sherman and A. B. Craig, *Understanding virtual reality: Interface, application, and design*. Morgan Kaufmann, 2018.

[8]   L. B. Rosenberg, "The Use of Virtual Fixtures as Perceptual Overlays to Enhance Operator Performance in Remote Environments," Stanford Univ Ca Center for Design Research1992.

[9]   M. Awad, J. El Haddad, E. Khneisser, T. Mahmoud, E. Yaacoub, and M. Malli, "Intelligent eye: A mobile application for assisting blind people," in *2018 IEEE Middle East and North Africa Communications Conference (MENACOMM)*, 2018, pp. 1-6: IEEE.

[10] V. Kushnir, B. Koman, and R. Shuvar, "Development a Software with Augmented Reality Using Unreal Engine 4."

[11] J. Glover, *Unity 2018 Augmented Reality Projects: Build four immersive and fun AR applications using ARKit, ARCore, and Vuforia*. Packt Publishing Ltd, 2018.

[12] D. A. Vyas and D. Bhatt, "Augmented Reality (AR) Applications: A survey on Current Trends, Challenges, & Future Scope," *International Journal of Advanced Research in Computer Science,* vol. 8, no. 5, 2017.

[13] J. Wang, X. Wang, W. Shou, and B. Xu, "Integrating BIM and augmented reality for interactive architectural visualisation," *Construction Innovation,* vol. 14, no. 4, pp. 453-476, 2014.

[14] F. P. Rahimian, R. Ibrahim, J. Wang, X. Wang, W. Shou, and B. Xu, "Integrating BIM and augmented reality for interactive architectural visualisation," *Construction Innovation,* 2014.

[15] T.-C. Huang, C.-C. Chen, and Y.-W. Chou, "Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment," *Computers & Education,* vol. 96, pp. 72-82, 2016.

[16] C. Kamphuis, E. Barsom, M. Schijven, and N. Christoph, "Augmented reality in medical education?," *Perspectives on medical education,* vol. 3, no. 4, pp. 300-311, 2014.

[17] M. A. Livingston *et al.*, "Military applications of augmented reality," in *Handbook of augmented reality*: Springer, 2011, pp. 671-706.

[18] J. LaViola, B. Williamson, C. Brooks, S. Veazanchin, R. Sottilare, and P. Garrity, "Using augmented reality to tutor military tasks in the wild," in *Proceedings of the Interservice/Industry Training Simulation & Education Conference, Orlando, Florida*, 2015.

[19] P. Kourouthanassis, C. Boletsis, C. Bardaki, and D. Chasanidou, "Tourists responses to mobile augmented reality travel guides: The role of emotions on adoption behavior," *Pervasive and Mobile Computing,* vol. 18, pp. 71-87, 2015.

[20] G. Woods, in *Augmented Reality in Education*, ed, 2018.

[21] J. Graham. (2010). *Five Ways Augmented Reality Is Making Your Life More*. Available: https://www.shareable.net/five-ways-augmented-reality-is-making-your-life-more/

[22] M. Kroll, "Augmented Reality - A New Tool for Extension," 2016, Available: https://learn.extension.org/events/2816.

[23] [23] *how-to-build-augmented-reality-applications-for-industrial-iot*. Available: https://www.pcmag.com/feature/355732/how-to-build-augmented-reality-apps-for-the-industrial-iot

[24] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre, "Recent advances in augmented reality," *IEEE computer graphics and applications,* vol. 21, no. 6, pp. 34-47, 2001.

[25] S. C.-Y. Yuen, G. Yaoyuneyong, and E. Johnson, "Augmented reality: An overview and five directions for AR in education," *Journal of Educational Technology Development and Exchange (JETDE),* vol. 4, no. 1, p. 11, 2011.

[26] E. Olshannikova, A. Ometov, Y. Koucheryavy, and T. Olsson, "Visualizing Big Data with augmented and virtual reality: challenges and research agenda," *Journal of Big Data,* vol. 2, no. 1, p. 22, 2015.

[27] S. Mandal, "Brief introduction of virtual reality & its challenges," *International Journal of Scientific & Engineering Research,* vol. 4, no. 4, pp. 304-309, 2013.

[28] C. Stapleton, E. Smith, and C. E. Hughes, "The art of nurturing citizen scientists through mixed reality," in *Fourth IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'05)*, 2005, pp. 2-11: IEEE.

[29] R.-A. Călin, "Virtual Reality, Augmented Reality and Mixed Reality–Trends in Pedagogy," *Social Sciences and Education Research Review,* vol. 5, no. 1, pp. 169-179, 2018.

[30] J. Jerald, P. Giokaris, D. Woodall, A. Hartbolt, A. Chandak, and S. Kuntz, "Developing virtual reality applications with Unity," in *2014 IEEE Virtual Reality (VR)*, 2014, pp. 1-3: IEEE.

[31] U. Technologies. (2005). *Unity*. Available: https://unity.com/

[32] (2017). *Vuforia Developer Portal*. Available: https://developer.vuforia.com/