ACTA TECHNICA NAPOCENSIS
Electronics and Telecommunications

ENHANCED INTERACTIVITY IN VIRTUAL TOURS

Catalina MALINCHI, Radu LACATUSU, Aurelia CIUPE, Serban MEZA
Technical University of Cluj-Napoca, Cluj-Napoca, Cluj
G. Barițiu, nr 26-28, 400027, 0264-591689, catalina.malinchi@yahoo.com

Abstract: In the context of immersive environments, interactivity has become a strategy of object manipulation in customized virtual scenes. A new emerging trend has been orientated on the development of integrated solutions, where augmented reality (AR) elements are used for real space representations, specific to the estate industry and intelligent design. The current work presents a gesture-based AR application which uses physical commands to identify and manipulate 3D objects in a 360° virtual tour. A low-cost technical setup has been used for in-lab validation, as an alternative to current VR/AR headsets.

Keywords: *Google Cardboard; virtual tour; explorable panorama; augmented reality; explorable panorama.*

I. INTRODUCTION

Immersive experiences are seeking to challenge the traditional environment through new technologies, tools and software.

The use of Augmented Reality (AR), Virtual Reality (VR) and Mixed Worlds in learning and knowledge - oriented setups has evolved in the past 5 years, from experimental frameworks to application prototypes, thus, the degree of novelty and the value of its potential applicability are still to be challenged specifically for variations of physical locations and communities [1].

Virtual reality is a technology based on a virtual space the user can interact with, and can experience telepresence [2]. Environments are constructed in such a way, that the borderline between the real and the virtual worlds becomes subtle. AR becomes the reality where the virtual world interlocks with the real world, allowing the user to manipulate virtual objects of the real world.

Virtual tours represent a series of panoramic photographs, interactively connected. A technology already matured and widely available on the market, makes field innovations and extensions to be more easily accepted and understood.

A virtual tour is a virtual bridge that connects the user with an indoor or outdoor place that is not accessible to him. Accessible on a phone, laptop or television, virtual tours are a simulation of virtual reality that permits the user to interact and explore the virtual world, rendered through panoramic images. According to the classification of VR devices on the interaction and immersion scales, wearable devices are related to the visual movement and achieve a standard immersion, while providing interaction between device-based and non-engaging device [3]. Five main players (Samsung, Oculus VR, HoloLens, HTC Vive, PlayStation VR) had released headset boxes by 2016, with a range of prices varying from $99 dollars to $3000 [4]. A more in-depth comparison on the physiological effects of the 3D vision through VR headsets compared to the 2D vision highlights 3 major types of associated sickness: motion sickness, simulator sickness, and cybersickness [4]. The Google Cardboard glasses (released to the public in 2014) are a low-cost system that wants to encourage people to develop virtual reality applications. The glasses are made from cardboard and have two 45 mm focal lens, a magnet and two Velcro bands. This low-cost system offers free SDKs (software development kit) to integrate applications to smartphones on Android (Java) OS, IOS OS and Unity 3D Game Engine (C#). [5].

I.1 Problem context and motivation

Through virtual and augmented exploration techniques, ordinary rooms and museums have become de-facto immersive environments in Second Life (SL). The theoretical framework, principles of evaluation as well as the research tools and methods specific to SL have been documented in the SL toolkit [1].

Two of the main implications are to be furtherly considered: 1) The novelty achieved by an immersive experience in designing a room is assessed dependently on its degree of interactivity; where the interaction with the virtual/augmented environment should ease the development of cognitive skills 2) Immersive visualization in virtual worlds involve high-performance setups (wearable devices, processing units), mostly at high costs, while offering little portability or mobility.

I.2 Proposed approach and outline

The proposed solution aims to offer a new way of designing a room interior through gesture-based interaction and to introduce interaction in a rather static virtual tour. Following the principles of the virtual touring, using the low-cost virtual reality headsets (Google Cardboard), an explorable panorama has been used, which offers a virtual view of a laboratory classroom. The interaction is achieved through head movements and hand actions, used to adapt the way in which the user collects and manipulates the 3D objects (chairs and tables) in the scene through control functions assigned to body gestures.

Manuscript received May 14, 2017; revised June 27, 2017

Section II describes the existing solutions in AR/VR environments. The principles behind the current solution are presented in section III. Section IV creates a summary of the limitations found during the development and directions for future development.

II. BACKGROUND AND EVIDENCE

With a high multidisciplinary applicability, AR/VR solutions can be used for visiting museums, buying products from the supermarket, stress relief through physical exercises or other recreational activities such as treasure hunting [6]. Museums become scenes for learning new things and setting up the environment for virtual exploration One de-facto case study in virtual touring used to create immersive experiences is Louvre Museum. [7] In the mining industry, one application [8] is proposed for preparing miners to face accidents in mines. Using a VR device and a pair of intelligent gloves, the miners were transposed into a virtual mine environment. Another current solution proposes the implementation of head tracking algorithms for interactive viewing of panoramic scenery. [9] One virtual reality application identifies in real time the head's current position and points it on an interactive map. The moving inside the virtual tour is done using the mouse and the keyboard. [10]

A solution which includes the software basis of a VR application, using a library as a scene, is presented in [11]. A modular API has been designed as being oriented on interaction identification between the application layer and the device input, allowing a one-point synchronization between interaction techniques and the application itself. This way, moving between environments is facilitated without losing the VR implementation features. A further extension of an AR world is through mixed media, and several case projects have been proposed for cultural heritage exploration, one of which uses a physical projection setup on which the AR is mapped [12]

Virtual reality is also included in commercial solutions. "Samsung Fearless / Launching People" campaign is a virtual tour that combines 3D objects to help people get rid of their fears. The campaign simulates different scenarios like walking on a high bridge or jumping in a pool from a high jumping board; all this to help people get over the fear of heights. [13]

III. GESTURE-BASED INTERACTION IN EXPLORABLE PANORAMAS FOR VR

The current work implements functions of gesture-based interaction for organizing the objects in a classroom, virtually modeled through panoramic rendering and 3D objects, while being delivered as a mobile software application under the Google Cardboard SDK.

A specific motivation in choosing the setup has been to propose a further applicability on the TUCN's (Technical University of Cluj-Napoca) virtual tour and to examine how different categories of people (professors, students and even librarians) might benefit from such enhanced interaction.

III.1 Technical setup

The current prototype has been created using the Unity 3D Game Engine (version 5.3.4) [14] and can been visualized using compatible devices. To simulate the immersive experience, the Google Cardboard kit (version 0.6) [15] has been used. The latest release (January 2016) of the Google Cardboard SDK comes with support for spatial audio. Among the existing VR toolkits or game engines that provide support for VR/AR rendering (Crytek's CryEngine 3, the Unreal Engine 3, Valve Source Engine, Unity 3D) [11], Unity 3D has been preferred due to its integration (supporting functions and libraries) with the Cardboard SDK.

The scope of the proposed solution was to use affordable and portable hardware components, accessible among users in higher education (students, professors, librarians), thus the Google VR headset has been chosen (https://vr.google.com/cardboard/).

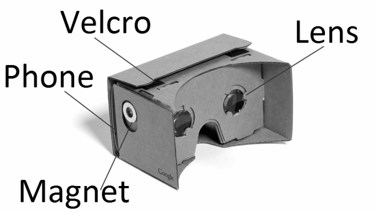


Figure 1. Assembled Google Cardboard setup

III.2 Panoramic-based scene rendering

The scene created with Unity 3D Game Engine uses a 360-degree panoramic image. The spherical panorama has been stitched from image segments obtained through a panoramic-capturing setup (Manfrotto 303SPH QTVR Spherical Panoramic Head, Canon 5D Mark II Camera, Tokina 10-17mm f/3.5-4.5 AT-X 107 DX AF Fisheye Lens). For obtaining a more accurate view of the room and for an immersive experience, a stereoscopic HDR panoramic image has been used. Figure 1 displays the panoramic segments captured for a 0-exposure value which were stitched to create the panorama.

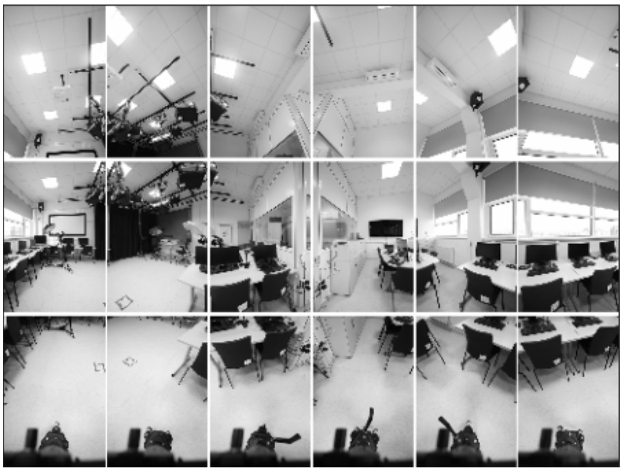


Figure 2. Panoramic segments of the laboratory

A stereoscopic panorama implies the existence of two points of view (2 cameras) at a chosen distance simulating the pupillary distance. Shooting is done synchronous, while rotating the setup around the tripod's axis. Having a different angle on the perspective for the both stitched panoramas, adds depth when visualized with the stereoscopic viewer (Cardboard). Figure 2 presents the setup used to capture the segments for a stereoscopic panorama.

Figure 3. Capturing the images for stereoscopic panorama

The version 0.6 of the Google Cardboard Kit offers the possibility to create the immersive effect by replicating the scene, so only a single panorama image may be used. Afterwards, the image has been displayed on a Sphere (Game Object). Given the fact the sphere is a solid object, a Shader has been associated to make the scene transparent. To show the action inside of the sphere, a camera has been placed (figure 3).

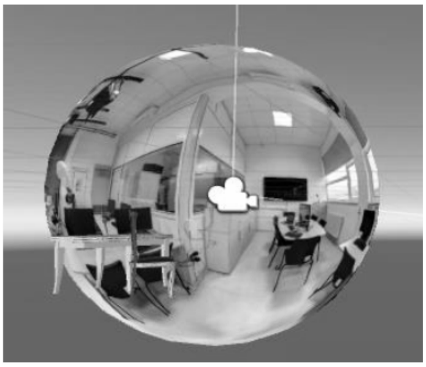


Figure 4. Game Object Sphere from stereoscopic panorama

III.3 Manipulation functions

The interaction with the objects in the scene has been implemented using an active collider (a frame that boxes the object) present on each game object and an interaction Ray defined in the Google Cardboard SDK. The Raycast procedure starts by creating a colored beam having the starting point in the middle of the sphere (figure 4). Because it corresponds with the camera's position, the ray is connected to the camera and the viewer's movements.

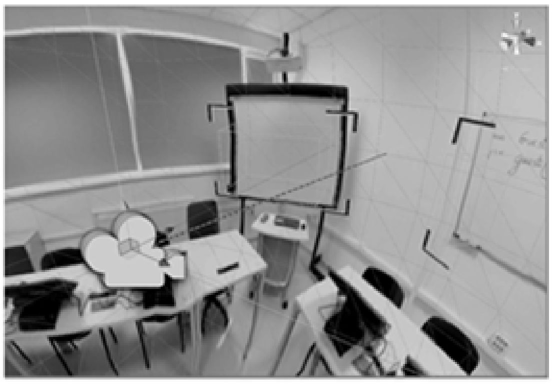
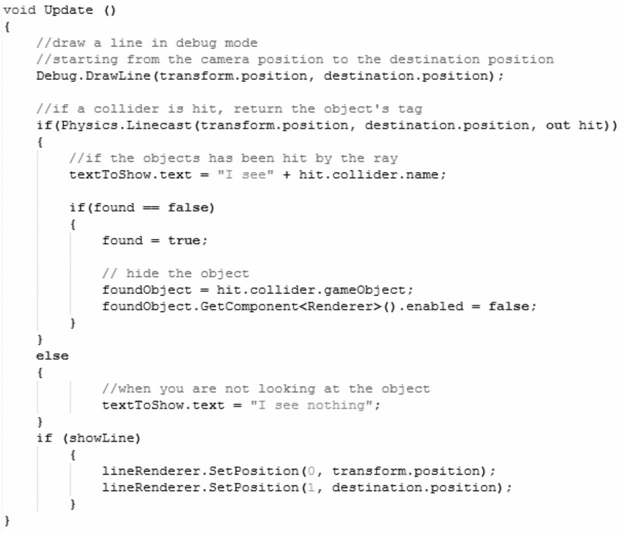


Figure 5. Raycast collision example

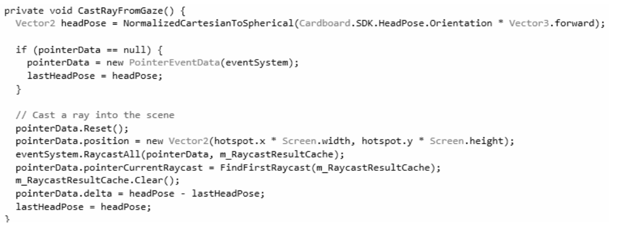
The Raycast can identify any collided objects based on the associated functions (figure 5). If an object is hit by the Raycast, the change can be seen in debug mode and through a text displayed in the view.



```
void Update ()
{
    //draw a line in debug mode
    //starting from the camera position to the destination position
    Debug.DrawLine(transform.position, destination.position);

    //if a collider is hit, return the object's tag
    if(Physics.Linecast(transform.position, destination.position, out hit))
    {
        //if the objects has been hit by the ray
        textToShow.text = "I see" + hit.collider.name;

        if(found == false)
        {
            found = true;

            // hide the object
            foundObject = hit.collider.gameObject;
            foundObject.GetComponent<Renderer>().enabled = false;
        }
    }
    else
    {
            //when you are not looking at the object
            textToShow.text = "I see nothing";
    }
    if (showLine)
        {
            lineRenderer.SetPosition(0, transform.position);
            lineRenderer.SetPosition(1, destination.position);
        }
}
```

Figure 6. Code snippet for Raycast implementation

A newer version for Google Cardboard offers the possibility to generate the Raycast from the prefabs the SDK has. The version 0.6 Raycast (namely "Reticle") identifies the middle of the screen and is made visible through a white marker. Having the ray implemented (figure 6), a "textToShow.text" function is required to identify the collision.



```
private void CastRayFromGaze() {
  Vector2 headPose = NormalizedCartesianToSpherical(Cardboard.SDK.HeadPose.Orientation * Vector3.forward);

  if (pointerData == null) {
    pointerData = new PointerEventData(eventSystem);
    lastHeadPose = headPose;
  }

  // Cast a ray into the scene
  pointerData.Reset();
  pointerData.position = new Vector2(hotspot.x * Screen.width, hotspot.y * Screen.height);
  eventSystem.RaycastAll(pointerData, m_RaycastResultCache);
  pointerData.pointerCurrentRaycast = FindFirstRaycast(m_RaycastResultCache);
  m_RaycastResultCache.Clear();
  pointerData.delta = headPose - lastHeadPose;
  lastHeadPose = headPose;
}
```

Figure 7. Code snippet for Google Cardboard's Raycast implementation

Interaction with the objects in the scene has been implemented using the Google Cardboard SDK. The desired objects have a tag and a collider assigned, allowing them to be identified by the Raycast. If the Raycast encounters an object, the latter switches to a "picked" state, while doing a 3D rotation. All this is visualized by the user through the Cardboard headset. Having the 3D object in the center of the view, the viewer can investigate the sphere (360-degree panoramic image) and can choose a place where the object can be left down.

In the left corner of the view there is an associated text that is connected to the Raycast and will confirm if the object is in the "picked" state or not. If the object is in the "selected" state, then the text will confirm it through the next phrase: "You're looking at <Object's name>". This text changes to the one matching a non-picked state – "There is

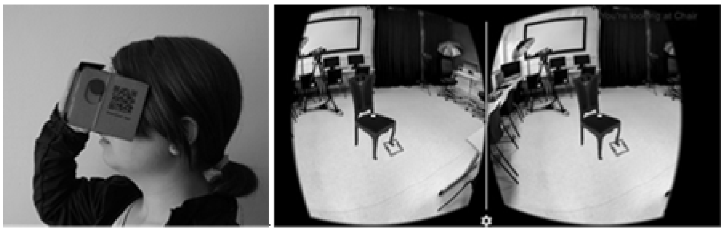


Figure 8. a) Viewer using Google Cardboard VR glasses b) Stereoscopic view of a "picked" 3D object

nothing there". Figure 7.a. displays a user with the Google Cardboard glasses, while Figure 7.b. displays the stereoscopic scene mapped on the Glasses' Lens. Using the mobile device, the user selects a targeted object. The 3D object becomes manipulatable, once the Raycast hits its collider. The collision center (white marker) is marked and the object remains centered, while the user might explore the rest of the scene.

The way the object is controlled has been achieved through three functions (grab, drop and resize), that are associated to the user's behavior. Such functions are the ones that give the scene the immersion effect, thus improving the interaction the user has with the prototype. After the object has been selected and moved all through the scene, it can be let down at a desired place using the Cardboard magnet, which is situated on the left side of the glasses.

If the magnet hasn't been touched, the object remains in its "picked" state, attached to the user's point of view and the 360-degree panoramic image.

When the magnet has been touched, the object has its size scaled down before being placed into the scene. The drop function is linked to the Raycast, so that when the object was placed at a chosen position, the connection between the Raycast and the object disappears until it encounters another object in the scene. The interactive text on the left side of the screen will also show this change – "There is nothing there".

After the disposal (grab, resize, drop) the flow is being reiterated after 3 seconds, so the dropped object can be reassigned a tag and become targetable by the Ray.

IV. CONCLUSION

The proposed application transposes the current emerging trend of virtual touring in a virtual reality environment, generated through a low cost mobile setup that includes a mobile device (smartphone) and the Google Cardboard VR headset. By combining the two concepts it was intended to create an immersive experience.

The way the object is controlled has been achieved through Google Cardboard's functions (grab, drop and resize), that are associated to the user's behavior and physical actions (head movements, Raycast control, magnet control). One of the limitations found during the development of this prototype is multi-action input required either in scene manipulation or navigation.

Other types of interaction that will be considered for future developing are: adding a vocal command for object identification and scene navigation, as well as a virtual menu for choosing what objects should be transposed into the scene.

Scaling the solution to the virtual tour of the TUCN (http://panorama.msal.utcluj.ro) becomes a challenge both in: interaction design and implementation. Correspondingly, such a model is to be used for visualization and presentation of technical laboratories and the associated equipment.

REFERENCES

[1] E. Moschini, "The Second Life Researcher Toolkit -- An Exploration of Inworld Tools, Methods and Approaches for Researching Educational Projects in Second Life", Researching Learning in Virtual Worlds, Springer London, 2010, pp. 31–51, doi: 10.1007/978-1-84996-047-2_3

[2] J. Steuer, "Defining Virtual Reality: Dimensions Determining Telepresence", J. Commun., vol. 42, no. 4, pp. 73–93, 1992.

[3] M. Carrozzino and M. Bergamasco, "Beyond virtual museums: Experiencing immersive virtual reality in real museums", Cultural Heritage, vol. 11, Dec. 2010, pp. 452–458, doi: 10.1016/j.culher.2010.04.001

[4] T. Siriborvornratanakul, "A Study of Virtual Reality Headsets and Physiological Extension Possibilities, Computational Science and Its Applications (ICCSA)", vol. 9787, Jul.2016, pp. 497–508, doi: 10.1007/978-3-319-42108-7_38

[5] "Google Cardboard Manual" [Online]. Available: https://developers.google.com/cardboard/reference

[6] Google Play page of "Treasure Hunt: VR Cardboard" game [Online]. Available: https://play.google.com/store/apps/details?id=com.EagelsStudios.TreasureHunt&hl=ro

[7] "Louvre Museum Virtual Tour" [Online]. Available: https://www.youvisit.com/tour/virtualreality/louvremuseum/80769

[8] E. Van Wyk and R. De Villiers, "Virtual reality training applications for the mining industry", Proc. 6th Int. Conf. Comput. Graph. Virtual Real. Vis. Interact. Africa AFRIGRAPH 09, vol. 1, no. 212, p. 53, 2009.

[9] Y. J. Hong, J. I. Hwang, S. B. Youn, S. C. Ahn, H. G. Kim, and H. Ko, "Interactive panorama video viewer with head tracking algorithms", 2010 3rd Int. Conf. Human-Centric Comput. HumanCom 2010, pp. 3–6, 2010

[10] D. Bradley, A. Brunton, M. Fiala, and G. Roth, "Image-based navigation in real environments using panoramas", HAVE 2005 IEEE Int. Work. Haptic Audio Vis. Environ. their Appl., vol. 2005, no. October, pp. 57–59, 2005

[11] D. Valkov, "Viargo - A Generic Virtual Reality Interaction Library", Workshop Software Engineering and Architectures for Realtime Interactive Systems (SEARIS 05), Mar. 2012, pp. 23–28, doi: 10.1109/SEARIS.2012.6231177.

[12] D. Rossi, E. Petrucci, and A. Olivieri, "Projection-Based City Atlas: An Interactive, Touchless, Virtual Tour of the Urban Fabric of Ascoli Piceno", Int. Conf. Virtual Systems & Multimedia (VSMM), Dec.2014, pp. 310-317, doi: 10.1109/VSMM.2014.7136672

[13] "Samsung Launching People (Fearless) Campaign," 2015. [Online]. Available: http://www.samsung.com/ae/launchingpeople/

[14] "Google Cardboard Manual" [Online]. Available: https://developers.google.com/cardboard/reference

[15] "Unity 3D Game Engine" [Online]. Available: https://unity3d.com/