

## Assess the Scale of Devastation and Preparedness against the Effects of Earthquake by Using Virtual Reality

Abdur Rahman<sup>1\*</sup>, Prof. Hideji Kawakami<sup>2</sup>

<sup>1</sup>Earthquake Disaster Prevention and Mitigation Group, Saitama University, Saitama, Japan

<sup>2</sup>Professor, Earthquake Disaster Prevention and Mitigation Group, Saitama University, Saitama, Japan

### Original Research Article

**\*Corresponding author**

*Abdur Rahman*

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**Abstract:** Visceral experience inside the imagery is a new perception of being physically present in a non-physical world by using new technology as Oculus Rift. Virtual simulation at any images and videos for the purpose of taking practical knowledge without being present in that area which provide preoccupy total environment. Oculus Rift is a virtual reality headset, which provides 6 degrees of freedom rotational and positional tracking to give the real test of presence in the imagery sphere. Imagery analysis by using immersive visualization before and after the earthquake is a technique to measure the scale of devastation without being present at any locations. To move inside the Street view, Satellite view and Bird's view before and after the earthquake with head mounted display makes the exact features of the scale of devastation by using same and different geometry in each eye. By dragging and dropping any objects inside the existing scene and make executive scene which gives the actual features about this object.

**Keywords:** Oculus Rift; Visceral experience; perception; devastation; earthquake; image.

### **INTRODUCTION**

Virtual reality (VR) is a new born technology which creates computer and mobile generated worlds or immersive environments that people can explore as reality by using rift with some software [1]. Virtual Reality addressed as an immersive multimedia as like computer-simulated virtual environment that can simulate physical presence in places in the real world or imagined worlds [2].

Oculus Rift is a virtual reality headset that allows head movement to feel as reality on the digital world (Fig-1). The Oculus Rift gives facility for viewing any build scene with six degrees of freedom rotational and positional. The field of view (FOV) of the Oculus Rift (DK2) is 110 degrees whereas human field of view 180 degrees without rotation of eye which gives some simulation sickness. The DK2 has minimal latency [3] that provides no time difference between input and output synchronization rates in the head

movements, in which we navigate our actual panes of vision [4]. This rift is widely used in the research, education methodology, industry and it will become more users friendly day by day [3]. It will be benefitted for the researcher for making different simulation with free of cost, higher education students making well-prepared for their professional life and expect more courses with practical application of theoretical knowledge acquired during their studies, trainer to give practical knowledge as reality to the trainee [5].

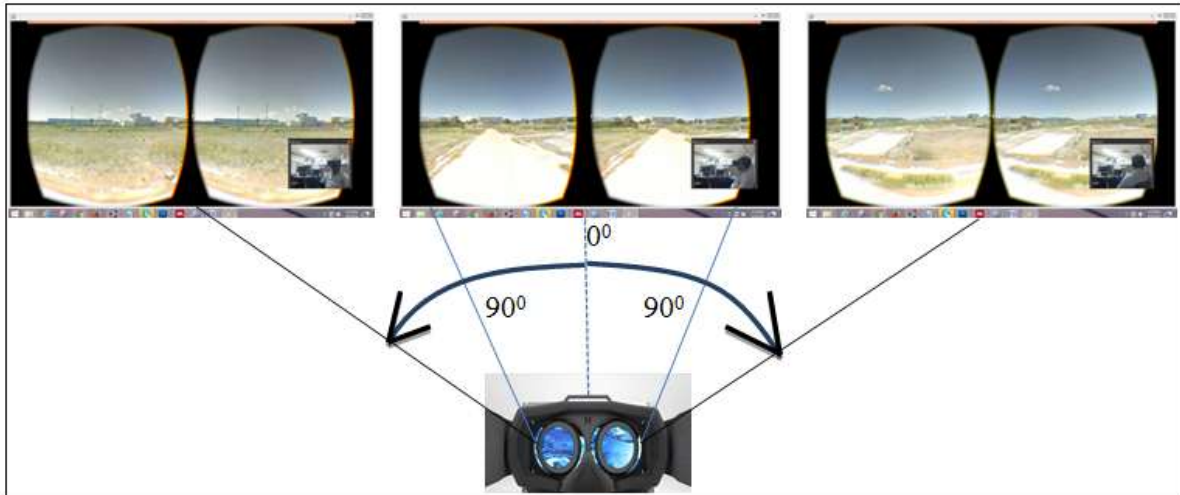


Fig-1: Immersive visualization inside the scene by using head mounted display

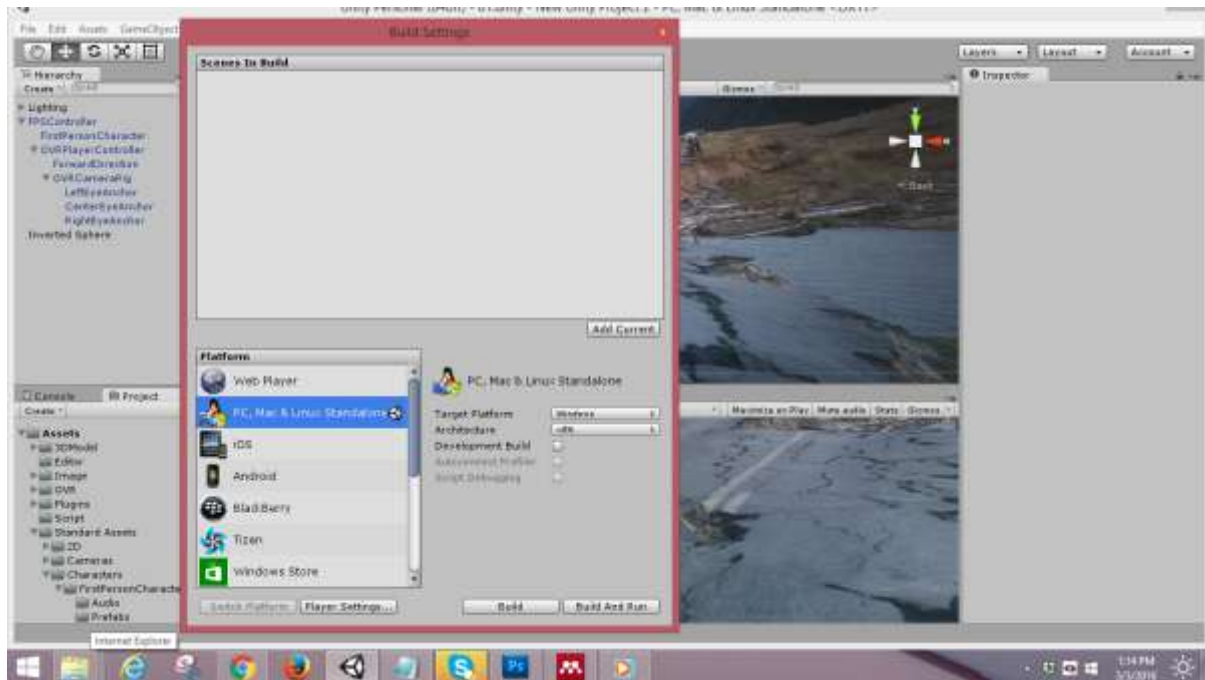


Fig-2: Home page of Unity Engine where shows the multiple platform for developing the executive scene

Among the different 3D engine, the Unity engine is best suited for the integrating with the Oculus Rift [1]. There are different 3D engine available in the website such as Unity engine, Blender, Unreal engine, 3ds Max, Cry Engine, Autodesk Maya etc. but the Oculus rift has software development kit (SDK) for the Unity engine and the Unreal engine. Unity 4 Integration and Unreal engine 4 Integration package is also available for integrating scene with Oculus Rift [2]. Unity engine is notable for its supporting multiple platforms such as Windows, iOS, Windows phone 8, OS X, Xbox 360 and Android etc (Fig-2). Different versions of Unity engine has been released as we can take most compatible version with other supporting software and unity assets. Different versions with necessary features for building scene by using map are free for all.

Imagery and video analysis with street view and people awareness from natural disaster like earthquake, landslides, and tsunami can take undoubtedly advantages with using immersive media as Oculus Rift. Google street view could not give access of all location in the world for that reason to access in any location for simulation of project by making own street view with help of mobile apps as name photo sphere [6-8]. Unity is a cross-platform game engine developed by Unity Technologies which gives support to build a scene by using different map viewing with Oculus Rift [9, 10]. People awareness with viewing previous hazardous due to the natural disaster as reality and can take preparedness for upcoming major adverse event resulting from natural phenomenon of earth [11, 12]

Google provides services known as Google Maps and Google Earth that maps the streets and locations of places all around the world. These services have been integrated with a feature known as Google Street View which shows the panoramic view of a location. Google street view allows users to move in all directions horizontally but few limitations in vertically [4]. By connecting the photo sphere author can be made even more immersive, 360 degrees views as like Google street view. So users can access to any location by the help of Google street view and Own street view. In addition author can also make bird's view of any places which integrated with Oculus rift [13-15].

Any kind of natural disasters may create major adverse effects against human resulting from the natural

processes of Earth. An unpredictable event such as earthquake, tsunami and landslides can create disaster. An adverse event will not raise the level of disaster of human if people awareness about the disaster and possible way to escape themselves from upcoming disaster [16]. Virtual training can make the best path finding way for the mass people to decrease loss of life. Anybody can stand virtually at place of disaster and may achieve visceral experience about the possible vulnerability, loss of life or property damage. By using previous video, photograph of natural disaster to go there virtually but as like reality with the helping of some software and new technology as Oculus Rift for making advanced knowledge, information about possible disaster for escaping themselves.

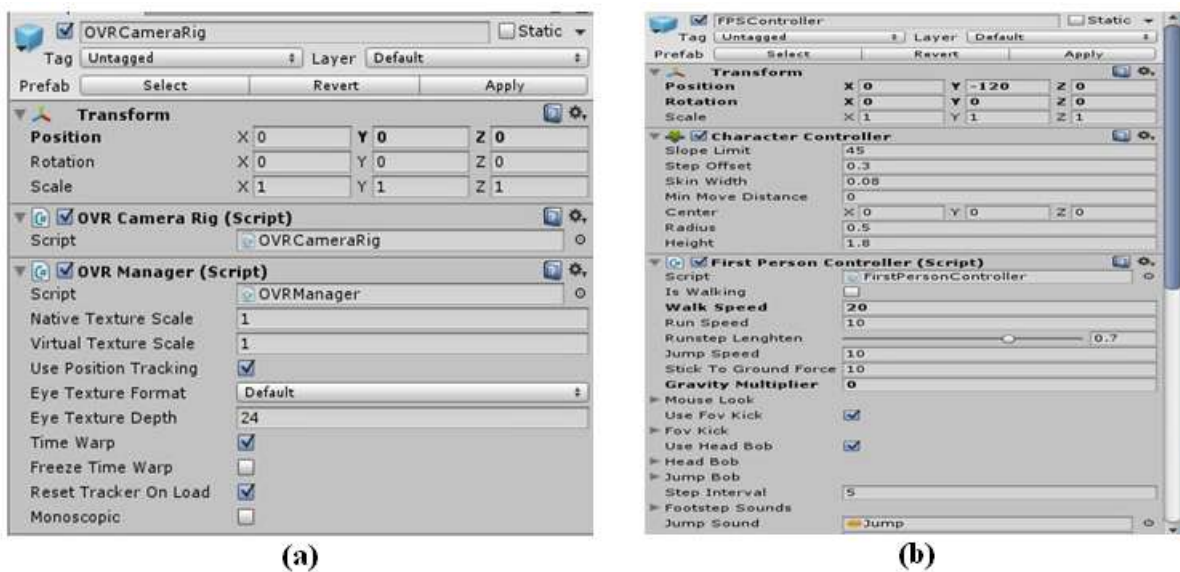


Fig-3: (a) Home page of OVR Camera Rig which supports to make stereo image (b) Home page of FPS Controller that makes the character for moving inside the executive scene

After the effects of earthquake in the 2011 Japan, the existing tsunami protection wall remaining the same but devastation was held inside the Ishinomaki area, Japan [17-20]. Authority has taken a decision to make great sea wall along the coast line for protecting resident people. The resident people have raised their voice against the great sea wall which will make a separation from the ocean and they will feel look like prison. They have a different contradiction about the constructing great sea wall [21, 22]. Immersive visualization in this area after virtually constructing this great sea wall will make the real features about that wall.

The main motivation of this research is that to develop immersive visualization environment of the disaster area by using different imagery to visit that places without wasting time and cost. Purpose of taking real perception about the disaster, author has made artificial world as name inverted sphere inside the Unity engine and imported two lenses camera (Fig-3(a) with

First Person Controller as shown in Fig-3(b) for moving inside that world by using head mounted display. Different geometry in each eye is logic of two cameras for making scale of devastation by perfectly superimposed to each other means before and after the disaster at the same place and same location. Moving and switching from one scene to other scene by using programming logic is another technique for making comparison of before and after the disaster.

**BACKGROUND STUDY AND LITERATURE REVIEW**

The Oculus rift is a virtual reality head mounted display kit which can give the immersive environment. The new version of Oculus Rift will be available after the March 2016, this is the improve version of DK2 [23]. The first version of head mounted display (DK1) was released late 2012. It has different limitations compare with DK2 such as screen resolution, pixel payout, OLED, Latency, Low Persistence, Refresh rate, Positional tracking etc. The

Rift development Kit 2 (DK2) was released March 2014 only for the researcher but not in consumer level. The version of DK2 consist two lenses for the minimization of eye restrains with screen resolution 1920 x 1080 pixels. It can able to show the different image in different eye and viewing optics allows a 110 degree angle of field of view. In addition to the optics, the head mounted display also contains gyroscope, accelerometer and a magnetometer integrated to track the angle the users head is held and rotation speed [24, 3].

Oculus configuration utility gives the integration facility with other software and it has also calibration options to set users desire value such as interpupillary distance, character height for minimizing the simulation sickness.

Unity is a cross-platform game engine developed by Unity Technologies which has different free features for making 3D immersive scene integrating with Oculus Rift. Different types of version with standard assets are available in their website. Unity engine and Oculus Runtime for Windows is not dependable to each other during the installation process. All versions of Unity engine are not compatible with other supporting software and unity assets. For that reason author choose the version as Unity engine 5.1.3p3 which is compatible with Infinity Code and other supporting software after few modifying with C# script. During the installation of Unity engine, users can also download and install the standard assets too.

The Unity engine itself has a three dimensional environment for making the immersive executive scene by using some Unity Assets which is directly integrated with Oculus Rift. By using C# script, author has made inverted sphere for getting virtual world inside the Unity engine. Unity 4 Integration is one of the important Assets for making stereo image with the help of OVR Camera Rig instead of Main Camera of Unity engine. Different geometry in each eye for making perfect scale of devastation by using superimposed to each other. First Person Controller is one of another necessary feature for moving inside the scene by using head mounted display.

Häfner P *et al.*, illuminate that the uses of virtual reality in the teaching methodology for a practical course to be well prepared for their professional life in virtual reality for students. This paper aims to focus on the application of virtual reality in the practical course of Civil engineering field. Simulation of industrial projects virtually which will develop the knowledge of students regarding more practical rather than theoretical courses. Papers also discuss on the application of virtual reality as medicine, automotive, aerospace industries, education and entertainment. In the engineering course, practical as well as theoretical courses is needed more realistic example which have given more emphasis to apply

virtual reality for immersive visualization to improve the practical knowledge [5].

Gierløff H. illustrated that with the introduction of the Oculus Rift in 2012, predicted as a new form of technology which will give the fruitful simulation for the future research, entertainment. Consumer usable application and game development was made successfully before starting their research. They have made different example for virtual simulation by using new technology as Oculus Rift. In this paper, different methodology was taken to choice the methods of display for viewing the map inside 3D environment by using Oculus Rift. To improve the application of Oculus Rift, researcher had been trying into account several theories form such as stereoscopy, head tracking, and immersion in virtual reality and Oculus Rift technology by using UDK virtual reality environment. Two types of map displaying methods have been decided as map emergence and map manipulation. Map manipulation display additional information rather than map emergence method [25].

Dye P. D. and Chawla T. elucidates that people have dream to move in the world but due to some limitations they cannot do it. The main reason is that the family, cost and time to unable move here and there in the world. The Oculus Rift is a new technology to make visceral experience for viewing, visiting any places in the world as per requirement. With help of taking Google map, Google street view and Google Earth, making a scene which integrate with Oculus Rift to travel here and there inside the world. The Oculus Rift is a new device contains head mounted display to track, move inside the scene and can navigate 360 degrees horizontally and 290 degrees vertically [4].

Santos J. and sampaio A. explain that implementation of time factor with three-dimension model which will convert the 4D model and virtual reality makes the possible interaction human with the model. In construction management, they have made the new era as time factor with the 3D virtual modeling that makes the immersive visualization of the construction work evolution. This 4D model makes the positive impression about the decision-maker with the planning strategies. The main agenda is to develop the virtual models include with time factor for the construction management and maintenance. The virtual model over the conventional drawing gives the additional advantages to maintenance and management of construction site due to clear understanding of all supporters by using Oculus Rift. They have made the virtual models include construction procedure, daily activities in the construction site which makes the perfect and errorless work compare with other conventional training. All of possibility of errors can be easily caught before starting the construction work which will save time and cost due to training with virtual reality. By using advance technology such as

mobile to convey the full model project into the project site for clarifying, any doubt about the location or position of each component before starting each and every parts of any project [26].

### TECHNICAL SPECIFICATIONS

Oculus Rift is a new form of technology for taking visceral experience without being present there. Author has used the version of DK2 (Fig-4) which has low latency and high resolution with appropriate field

of view. The infrared sensor (Fig-5) attached with Oculus Rift gives rotational and positional tracking facility when DK2 acts as a head mounted display. For the integration of Oculus Rift with executive scene, the Oculus Runtime for windows (version 0.6.0.1) has used and imported Unity 4 Integration (V 0.4.4-beta) for using the OVR Camera Rig inside the inverted sphere. The version 5.1.3p2 of Unity engine has been used for making executive scene.



Fig-4: Oculus Rift



Fig-5: Infrared Sensor

### METHODOLOGY

For integrating any scene with Oculus Rift, Unity engine with other supporting software, files and folders is the best way among other two approaches such as making dds image with xml file following Oculus World Demo project [27], making panorama image which importing into Live View Rift and Kolor Eyes. The required features of Unity engine are free for all to make executive scene which is directly integrated with virtual reality kit. The two lenses camera for making depth of illusion as OVR Camera Rig, First Person Controller for moving inside the scene are required for making functional of head mounted display inside the executive scene. For taking suitable image for assessing the scale of devastation of any disaster; Google Street View, Google Earth, Real World Terrain Assets and World Composer Assets have used for making virtual integrated scene. Analyzed the images as like reality, have to make inverted sphere by using C#

and JavaScript for moving inside the scene with head mounted display. The following model (Fig-6) describes the part of modification of Unity Assets and added new features inside the Unity engine for the purpose of making more perception about any disaster prone areas.

Unity engine has different features for making Oculus Rift integrated scene but for using author desired purpose, need to make some additional features inside the Unity engine by using JavaScript and C# languages. For the purpose of moving in the same natural world by using head mounted display inside the Unity engine and making executive scene which is directly integrate with Oculus Rift, Firstly have made artificial world based on the sphere of Unity engine which has option to set user desired size for freely moving inside the artificial world following this code:

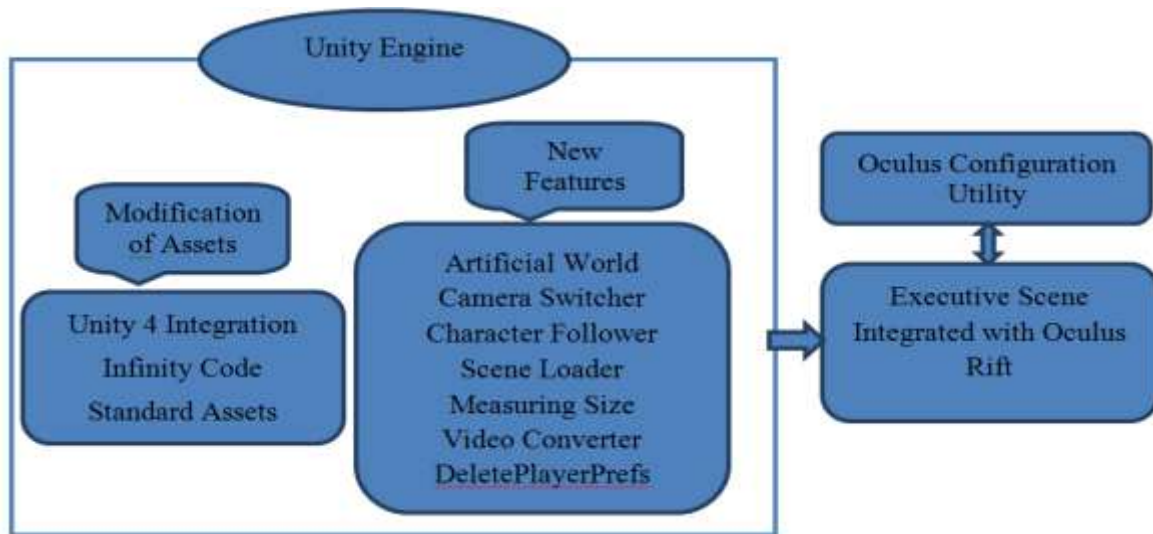


Fig-6: Important steps for making executive scene by using Unity engine

```

Private void CreateInvertedSphere (float size) {
    GameObject go = GameObject. Create Primitive (PrimitiveType.Sphere);
    MeshFilter mf = go.GetComponent<MeshFilter>();
    Mesh mesh = mf.sharedMesh;

    GameObject goNew = new Game Object();
    goNew.name = "Inverted Sphere";
    MeshFilter mfNew = goNew.AddComponent<MeshFilter>();
    mfNew.sharedMesh = new Mesh();
    
```

After adding this code inside the *Editor* of Unity engine, user can get additional features located in the Game Object and can create the artificial world as called inverted sphere where users can freely moving

inside the sphere by using head mounted display. This new features gives the additional window for putting the necessary data after making inverted sphere (Fig-7).

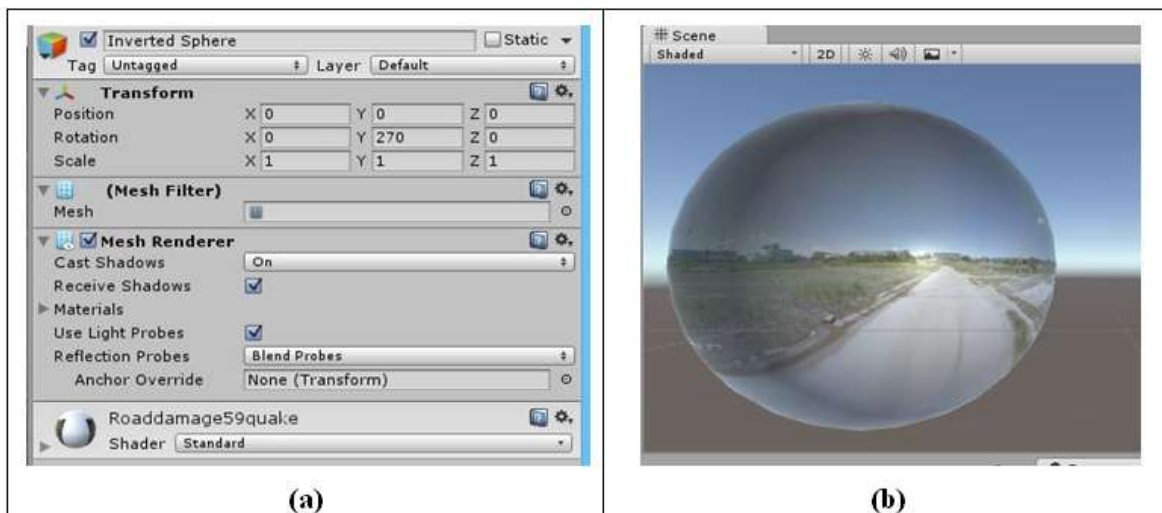


Fig-7: (a) New windows of Inverted Sphere where users can set their desired value, (b) results of the inverted sphere

For the purpose of making perfect scale of devastation of before and after the effects of earthquake, switch before the earthquake to after the

earthquake scene at the same place and same direction (Fig 8) by following this JavaScript code after adding this code inside the script of Unity engine:

```

if (Input. Get Key Down (KeyCode.V))
    if (!iscamera2) {
        iscamera2 = true;
        camera2. Set Active (true);
    }
    
```

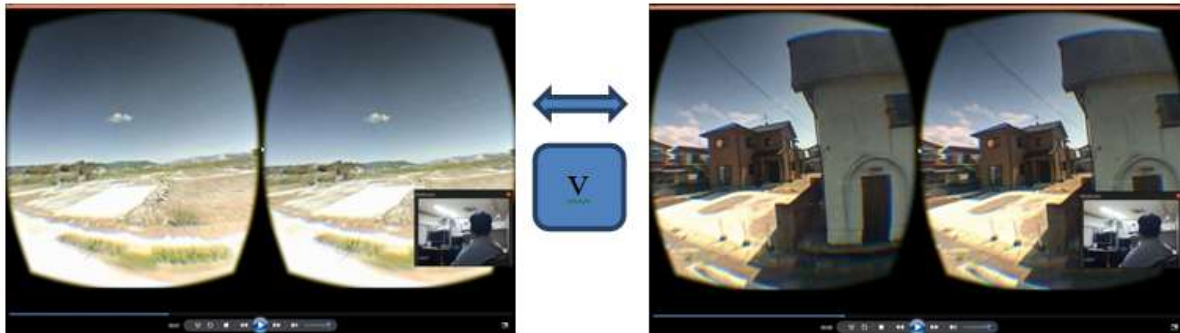


Fig-8: Rotating inside the scene of after the disaster and press keyboard button V to switch after the disaster at same location and same direction

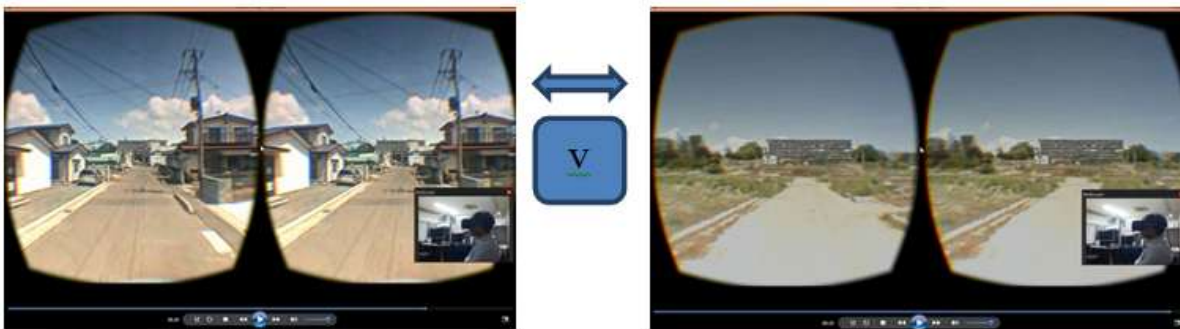


Fig-9: Walking inside the scene of before the disaster and switch after the scene of disaster at the same place and same direction

Switch one scene to other scene and moving inside the scene with following each other means camera position reaming same as before and after the

disaster (Fig-9) using C# programming logic as shown in here:

```

Void Update () {
    transform. position = new Vector3 (transform.position.x, transform.position.y, transform.position.z)
    transform.eulerAngles = new Vector3(0, target.transform.eulerAngles.y, 0);
}
    
```

In the Unity engine, there is no any default unit. For that reason author has made logic to measure

the scale of object for making adjustable to each other as shown in here:

```

Size = GetComponent<MeshRenderer> ().bounds.extents
    
```

By using this above programming logic, users can make the adjustable size of all importing objects inside the Unity engine. Author has used this opportunity to make the great sea wall exactly 14.7meter height and can be made perfect size of camera, character height and inverted sphere which

gives the real perception about this great sea wall among the resident people.

For making the comparison with more than two scenes, author has made logic to load the scene one by one according to this following logic:

```

public class KeyInput: Mono Behaviour {
    void Update (){
        if (Input. GetKey (KeyCode.Keypad1))
            Application. Load Level ("01_2008");
        if (Input.GetKey (KeyCode.Keypad2))
            Application. Load Level ("01_2013");
    }
}
    
```

This logic gives the additional support for choosing suitable object among the different object by importing into the existing scene and changing this scene according to users required with head mounted display.

For making the panorama image of any area, author has taken frequent screenshot of this area and by using photo stitching software has made the required

panorama image with sufficient resolution. To do the perfect superimposed to each other means before and after the disaster, author has taking help from the stereo photo maker software.

In the Unity engine, automatically take previous command as default. To demolish that memory, the following programming logic has made by author:

```
Public class Add Menu : Editor Window{  
    [MenuItem("Edit/Reset Playe rPrefs")]  
    Pulib static void DeletPlayerPrefs (){  
        PlayerPrefs.DeleteAll();  
    }  
}
```

## RESULTS AND DISCUSSIONS

Immersive visualization inside the imagery and video by using a new born technology as Oculus rift creates the mind blowing perceptions from being entirely transported into a virtual three-dimensional world and it can come up with the more practical experience than screen-based media. Screen-based media only provide that you are watching in front of that image or media but visceral experience can give you that not only watching but also visiting inside the image [27]. Different types of virtual assessment can be made by using images during, before and after the natural disaster [28] which is also available in the

internet. Aerial photos of any area also can be given overall visceral experience about the scale of devastation during the earthquake. To acquire the scale of devastation, different types of comparison such as superimposed photos before and after the earthquake, sequential visiting inside the images before and after the earthquake which can be made the actual scale of devastation with considering terrain height and positions with virtual reality. Walking and rotating inside the images of before the earthquake and same position of after the earthquake with virtual reality (HMD) by pressing key board button will give the more realistic measures about the effects of earthquake.



Fig-10: 3D immersive view after the disaster of 2011 earthquake inside the Ishinomaki area, Japan (2012)





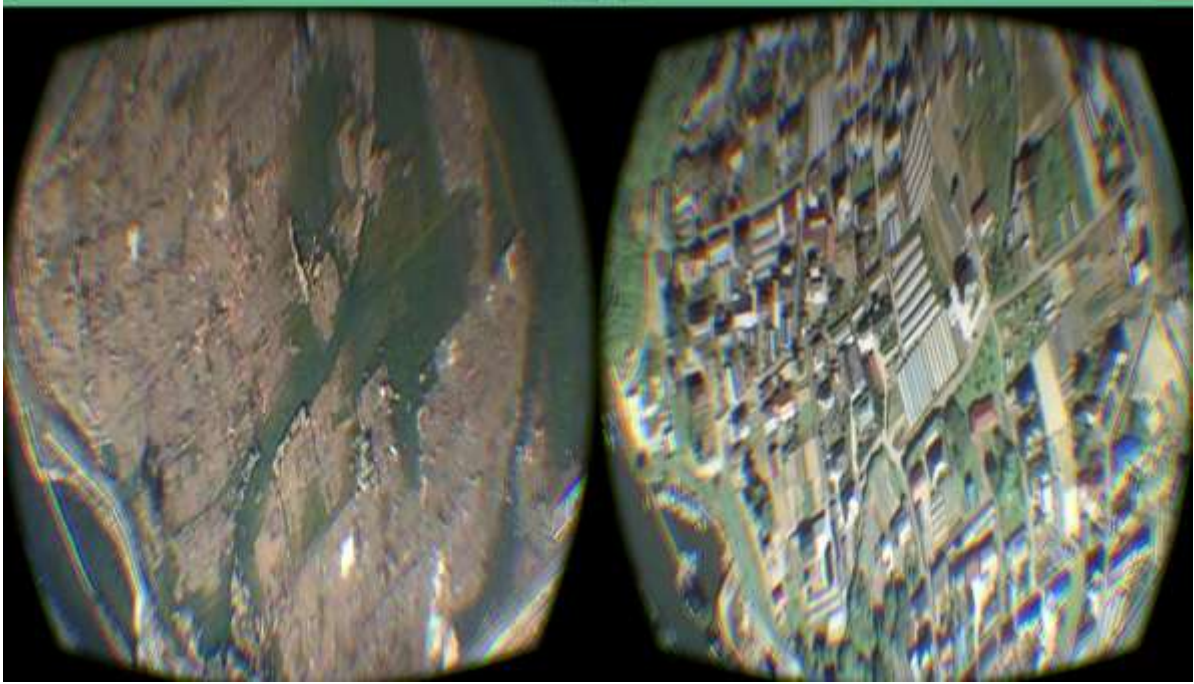
Fig-11: 360 degrees immersive view at different places inside the Ishinomaki area (2012)



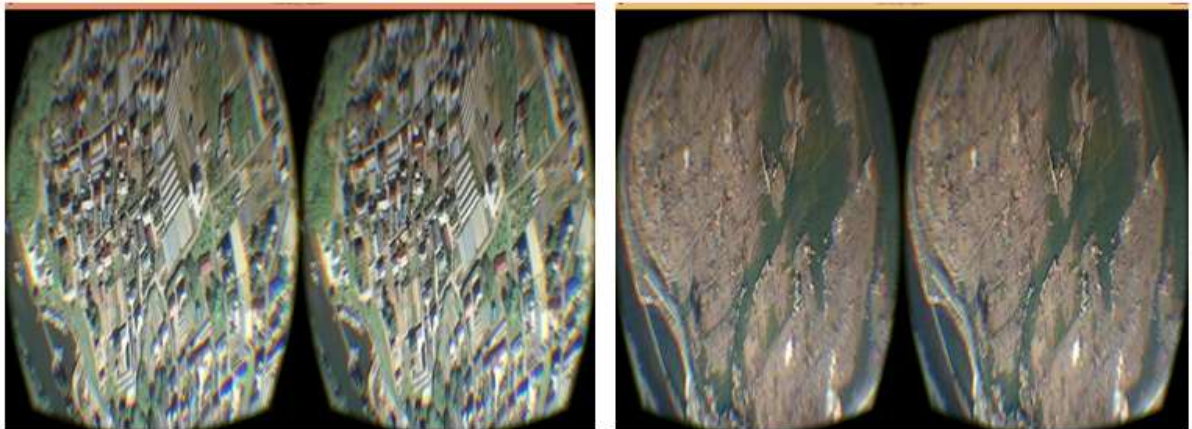
Fig-12: Same geometry in each eye of before and after the disaster and switch to alternate scene at same direction and same point by using head mounted display



Fig-13: Different geometry in each eye with superimposed to each other for making scale of devastation by using head mounted display



**Fig-14: Virtually superimposed to each other of aerial views**



**Fig-15: Virtually move inside the scene and switch from one scene to other scene of aerial views**

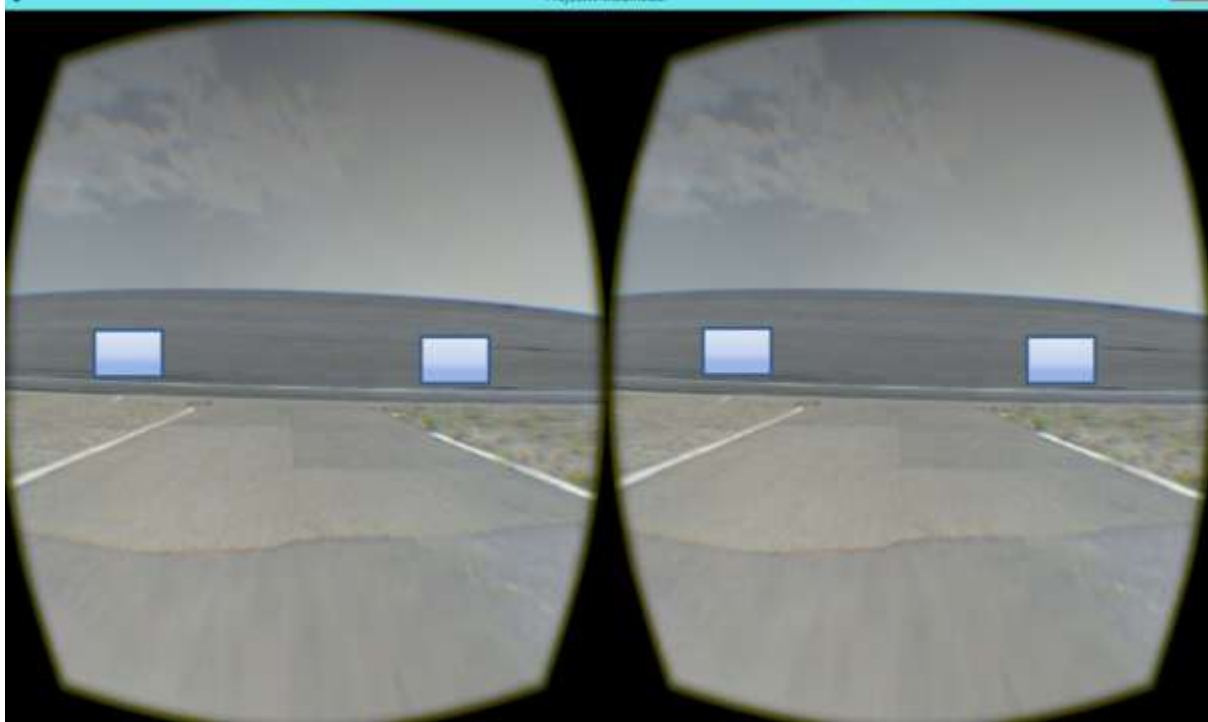


Fig-16: Constructing great sea wall virtually and visit that places for making real perception



Fig-17: Virtually move before and after the disaster scene for making features of existing tsunami protection wall

For preparing against the effects of earthquake, constructing a great wall along the coastline especially in the most tsunami prone areas as Iwate, Miyagi and Fukushima prefectures is a controversial among the resident people [21]. During the 2011 earthquake, tsunami wave made disaster inside the protection wall due to the lower height. For overcome this weakness, authority has taken project to construct around 14.7 meters wall along the coastline. To realize the actual feelings about this controversial issue by constructing this wall along the coastline into the virtual reality which give the visceral experience about this great wall and making a comparison with imagery of before and after the earthquake.

Stereo image analysis is a technique for creating the illusion of depth in an image. Existing stereo image analysis is depending on screen-based

media but virtual three-dimensional world is a new technique for visceral experience with the illusion of depth into the image. Moving inside the stereo image with real feelings by using head mounted display is a perception of being physically present in a non-physical world. Same geometry in each eye gives the sense of depth and stereo into the image and allowing perceptions the location of each object.

The 360 degree executive scene (Fig-10 and Fig-11) by using inverted sphere in the most disaster prone zone as Ishinomaki area, Japan gives the opportunity to move inside the scene with head mounted display. This immersive scene have made by using images just after the two days later from the most devastating earthquake in 2011 for visiting different places under this disaster prone zone.

Simulation of same stereo image in each eye and can be changed to the alternate scene by using keyboard button with the same rotation, walking inside the scene by using Oculus Rift (Fig-12). Same imagery analysis at the same place of before the earthquake in 2008 and after the earthquake in 2013 which will give the additional advantages for comparing and assessing about the disaster in the desired location. Different imagery simulation in each eye with moving inside the scene (Fig-13) by using Oculus Rift, the scale of devastation can be measured easily by using superimposed image with each other and switch alternate scene.

Aerial views simulation (Fig-14) with virtual reality have revealed the scale of devastation of overall areas and different geometry in each eye makes the superimposed of satellite images which make out the comparison of before and after the earthquake imagery. Moving on the Satellite image with Oculus Rift as like bird's makes the overall idea about the area without visiting that places. The imagery analysis of before and after the earthquake (Fig-15) and switch one scene to another with same location and direction by using C# programming logic which make the idea of most devastating prone zone.

Making an additional objects inside the image and assess the people's perceptions about this object by taking visceral experience with head mounted display (Fig-16). To realize the actual impact due to constructing the great wall along the coastline, constructing the same sea walls along the coastline inside the virtual reality and visiting with real imagery by using Oculus Rift. Virtually people can move inside the image with the great sea wall, walking towards the wall, switch before and after the disaster at the same location (Fig-17) and taking real feelings from the very near to sea wall. It is also possible to see from the very far away of this sea wall and making a comparison with the existing sea wall during the effects of earthquake. For minimizing the controversial things as people feels look like prison, author proposed to add some clear glasses in the constructing wall and visiting this scene by using Oculus Rift.

## CONCLUSIONS

For the assessment of scale of devastation during the effects of earthquakes, imagery analysis with different formats has done such as same geometry in each eye, different geometry in each eye, rotate 360 degree inside the scene and switch to other scene at the same place and same rotation, walking inside the scene and directly switch to other scene at the same place same direction. The executive scene of same geometry in each eye makes the real feelings with depth of illusions about the area. Different geometry in each eye (before and after the earthquake) with perfectly superimposed each other gives the realizations about

the position of previous structures and changed the architect of area after the effects of earthquakes.

With adding some external 3D file into the scene and make adjusted with each other that gives the real perceptions without being imposed of this objects. To actual perceptions among the resident people about the sea wall of Japan along the coastline, constructed this sea wall virtually on the existing scene and have made the executive scene to visit and move inside the scene comparing with scene of before earthquake. It makes the real perceptions and minimizes the contradictory points among the resident people.

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