

Research Article

Simulation of a Project Area by Using Virtual Reality

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Abstract: Simulation of a construction project area not even travelling there is an innovative idea to have real perception about that area with the innovation of cutting-edge technology of Oculus Rift. Visceral experience inside the imagery is also a new perception of being physically present in a non-physical world by using an Oculus Rift. Virtual simulation on any images and videos provide completely preoccupied environment for the purpose of having real perceptions without being present at that place. Oculus Rift, which is a virtual reality headset, is capable of maintaining six degrees of freedom of rotational and positional tracking to realize the real test of presence in the imagery sphere. Google street view, personal street view and Google Map enable accessing of any location on the earth and virtual reality can create the real perception without moving to the location. Therefore, this study is aimed to work out a cost effective and time efficient model of experiencing virtual site perception of reality without moving to that place. The technique of imagery analysis by using immersive visualization at any locations is implemented in the study. It is an analytical technique for making a comparison among different probable project suitability in a location. In this study, it is also developed a technique of identifying the most suitable location for a particular project by wearing head mounted display integrated with street view, satellite view and bird's view. In the process, images are introduced by dragging and dropping from the extra features of Unity Engine software into the artificial world representing the reality of Oculus Rift.

Keywords: Simulation, imagery analysis, suitable project location, Oculus Rift, visceral experience, perception, image.

INTRODUCTION

Oculus Rift built with state-of-art technology offers 3D immersive visualization facility implementing different features of Unity Engine and other supporting software. Virtual Reality is a perception of being physically present in a non-physical i.e. computer-simulated virtual environment that can simulate physical presence in places of the real world or imagined worlds [1]. Oculus Rift is a virtual reality headset that allows head movement to feel as reality on the digital world (Fig. 1). The Oculus Rift carries facility for viewing any build scene with six degrees of freedom in rotation and position. The field of view (FOV) of the Oculus Rift (DK2) is 110 degrees whereas a human field of view 180-degree without rotation of eyes which produces some kinds of simulation sickness. The DK2 has minimal latency [2] that creates no time difference between input and output synchronization rates in the head movements in which the actual panes of vision can be navigated [3].

In recent years, rifts have been taken much attention to the research, education and business

communities, which are involved to make this device more users friendly [2]. This opportunity makes the doors open for researchers and engineers to simulate different projected areas free of cost, implies in advanced studies to make students professional in the field and creates vast areas of study implementing practical application of theoretical knowledge acquired during the studies and providing practical knowledge as real life experiences to the trainee [4].

Unity engine, a three-dimensional (3D) image processing software, is the best fitted software integrating with Oculus Rift [5] among all other similar types of software like Blender, Unreal Engine, 3ds Max, Cry Engine, Autodesk Maya. In addition, Oculus Rift has its own software development kit (SDK) implementing Unity Engine and Unreal Engine. The package of Unity 4 Integration and Unreal 4 Integration used to integrate desirable images with Oculus Rift [1], it is a distinguished software for its multiple-platforms based on different operating systems like Windows, iOS, Windows phone 8, OS X, Xbox 360, Android and few others (Fig. 2). As the availability of different

versions of Unity Engine, now it is easy to choose the most compatible version in addition to other supporting

software and unity assets.

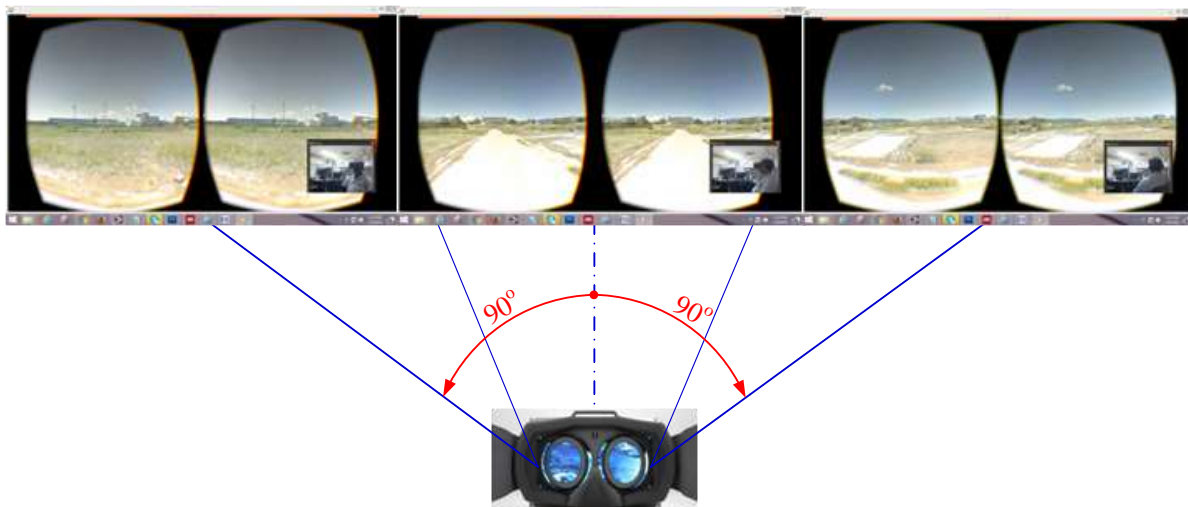


Fig. 1: Head mounted display of Oculus Rift demonstrating 180° angle of view

There are distinguished advantages of using immersive media like Oculus Rift simulating projected buildings and structures on self-created street views, Google street views, Satellite views and bird's views and executing aptness studies of the project to the existing street views in combination with surrounding buildings and structures. For street views which are not permitted to access in Google engine, self-created street views need to be generated with the help of mobile application identified as "Photo Sphere". Besides of generating projected area for imaging with Oculus Rift, Unity is a cross-platform game engine developed by Unity Technologies providing supports to generating images inserting from different map engines and recorded hazardous videos of natural disaster. These images with the help of Oculus Rift, people can have real life experiences which will help them increase their awareness and prepare them for upcoming major disasters resulting from natural phenomenon of the earth.

Google provides services known as Google Street View, Google Maps and Google Earth which maps the streets and locations of places all around the world. Among them Google Street View is an integrated function programming platform capable of

generating panoramic view of a location. It allows users to move in all horizontal directions but has few limitations in vertical movements [3]. These limitations can be avoided by linking Photo Sphere apps to Google street view and it can be generate even more immersive, 360 degrees views than Google street views does. Thus, users can access to any location of Google street view when it is combined with self-created street view. In addition, bird's view of any places can also be integrated with them to view in Oculus Rift head mounted display [6-8].

A new version of Oculus Rift is available from March 2016; it is the improved version of DK2 [9]. The first version of head mounted display (DK1) was released in late 2012. It has limitations in screen resolution, pixel payout, OLED, Latency, Low Persistence, Refresh rate, Positional tracking from those of DK2. The Rift Development Kit 2 (DK2) was released exclusively for research purposes in March 2014. It consists of two lenses for minimizing of eye restrains with high screen resolution of 1920 x 1080 pixels and can able to show the different images in different eyes with viewing optics which allow a 110 degree.

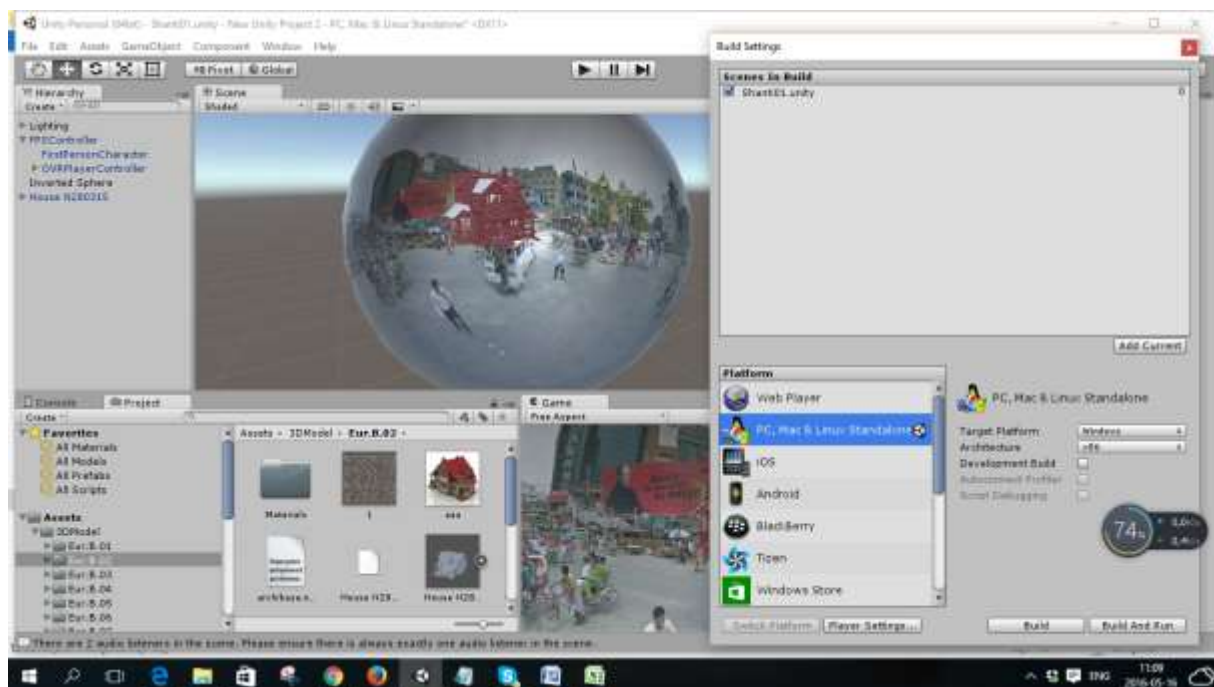
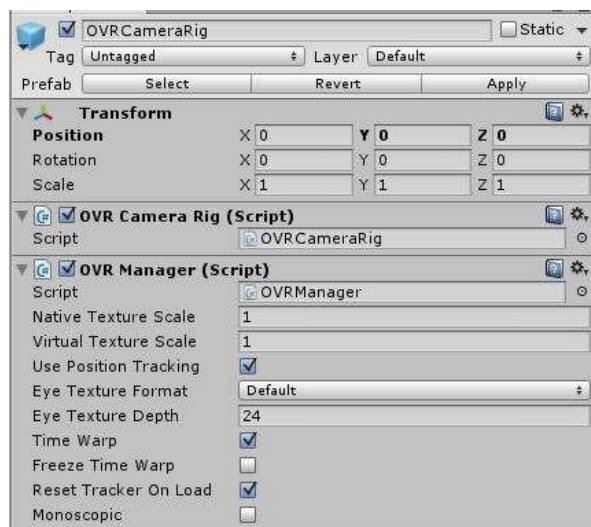


Fig-2: Web-based multi-purpose programming platform of Unity Engine to create executable scenes of project areas

Angle of field of view. In addition to the optics, the head mounted display also contains gyroscope, accelerometer and magnetometer to track

the angle of user’s head and rotational speed at which user rotates his head [10].



(a) OVR Camera Rig



(b) FPS Controller

Fig-3: Web based platforms to insert and generate executive scene

Oculus configuration utility gives the integration facility with other software and it has also calibration options to set user dependable values of interpupillary distance, character height for minimizing the simulation sickness.

Unity is also a cross-platform game engine developed by Unity Technologies which facilitates with different features for generating 3D immersive scene integrating with Oculus Rift. Different types of version with standard assets are available in the web based platform. Unity Engine and Oculus Runtime

for Windows system do not depend on each other during the installation process. All versions of Unity Engine are not compatible with other supporting software and unity assets. Unity Engine of version 5.1.3p3 which is compatible with Infinity Code and other supporting software after few modifications of with C# script is selected for the study. During the installation of Unity Engine, users also have alternatives of downloading and installing the standard assets.

The Unity engine itself has a three dimensional environment for making the immersive executive scene by using some Unity Assets which are available in Oculus Rift. Using C# programming environment script, author has made inverted sphere is created 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. First Person Controller is an essential feature of Unity Engine to insert inside an intended scene using head mounted display. Relative differential geometrical configuration is identified for each eye depending on their locations by forming an interactive scale of devastation superimposing one to another. These all virtual reality techniques bring things in so real life feeling that it could be used as an excellent educational tool to have learners' virtual professional life experiences [4].

People have a natural instinct of moving around to know about their life and the places where they live, but their wishes do not come frequently in reality because of few feasible reasons, such as, family bonding and liability, high cost of traveling and lengthy time to make the travel [3]. To overcome those limitations, Oculus Rift, a device of innovative technology, has emerged. Using this technology, 3D images of any particular area of Google map, Google street view and Google Earth can be integrated to Oculus Rift. Oculus Rift integrating with a head mounted display is capable of tracking and/or moving into the locations and navigating 360-degree horizontally and 290-degree vertically [3]. This environment can be excellent source of visceral experiences of making practical observation and gaining real life knowledge.

Santos and Sampaio [16] emphasized with clarification that by adding time factor and 3D model can be improved into 4D model implementing virtual reality in it. 4D environment modeling makes human interaction possible with the model. In construction management, time factor with the 3D virtual model is capable of making immersive visualization of construction work evolution. It helps engineers to make efficient and effective planning of works. The virtual model combining with the conventional architectural

and structural design images generates additional advantages of visualizing virtually the process of construction works like site preparation, structural erection and project management and maintenance using Oculus Rift. Virtual reality model can also assist to visualize construction errors before starting the constructional works which can help to reduce the construction period and cost.

Considering those point of views, it is essential that consumer usable applications and gaming user utilities are produced at the beginning of the study. So, different application (programming) utilities are developed for the operating system of Oculus Rift in order to simulate the images of whole process of a project virtually. In this stage, different methodologies are implemented for viewing the map inside the 3D environment of Oculus Rift. To improve the application of operating system based environment of Oculus Rift, several forms of utilities, such as, stereoscopy, head tracking, immersion in virtual reality and UDK virtual reality environment are considered. Two types of map displaying methods are chosen for emerging and manipulating of map.

The main motivation of this research is to develop immersive visualization environment of a suitable area inserting different imagery implementing virtual reality. Taking real perception about the position, suitable location and aesthetical view, it is made an artificial world identified as Inverted Sphere into the Unity Engine and imported two lenses camera (**Fig. 3a**) with First Person Controller (**Fig. 3b**) in it to move into the projected location by using head mounted display of Oculus Rift. Relative differential of geometrical configuration is identified for each eye depending on their locations by forming an interactive scale of devastation superimposing one eye to another creating reality views. Moving and switching from one scene to another using programming logic is performed for comparing between pre and post construction projected areas to track out the aptness of applying virtual reality for immersive visualization.

TECHNICAL SPECIFICATIONS

Oculus Rift is an innovative form of technology to have visceral experiences not travelling to the site. Version of DK2 (**Fig. 4**) which has low latency and high resolution with appropriate field of view, is considered for this study. The infrared sensor in **Fig. 5** connecting to Oculus Rift gains rotational and positional tracking ability when Development Kit 2 (DK2) acts as a head mounted display. Integration of Oculus Rift with executive scene, Oculus Runtime for windows of version 0.6.0.1 is used and Unity 4 Integration of version 0.4.4-beta is imported for using the OVR Camera Rig inside the inverted sphere. Unity

Engine of version 5.1.3p2 is used for producing

executive scene.



Fig. 4. Oculus Rift Development Kit 2



Fig. 1. Oculus external positional tracking camera with infrared sensor

METHODOLOGY

To integrate any scene with Oculus Rift, Unity Engine with other utility software represents the most efficient application tool comparing to two other approaches of making dds image implementing xml file following Oculus World Demo project [5] and making panorama image imported by Live View Rift and Kolor Eyes. The basic features, which are integrated with virtual reality kit of Unity Engine are open to for generating executive scene. The two lenses camera OVR Camera Rig for making depth of illusion and First Person Controller for inserting desired scenes are

essential for making functional of the head mounted display. To assess the suitability of a project of a particular location, Google Street View, Google Earth, Real World Terrain Assets and World Composer Assets are used for generating virtually integrated scene. Inverted sphere is created using C+ to simulate images as virtual reality and JavaScript to insert the scene into head mounted display of Oculus Rift. The flow chart shown in Fig. 6 describes the process of modification of Unity Assets and added new features inside the Unity engine for the purpose of making more perception about any area.

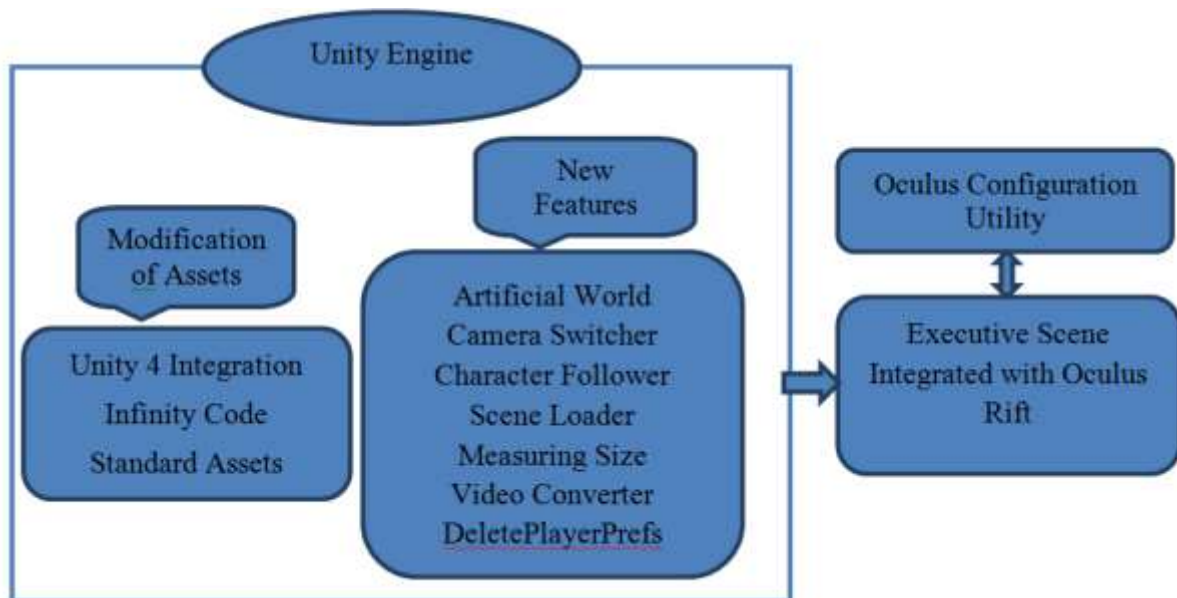


Fig-6: Steps of processing executive scene using Unity Engine

Besides furnishing with different features to form Oculus integrated scene, Unity Engine is capable of developing identified function features using JavaScript and C+ languages. This study proposes few special programming tools to make executable scenes fitted to existing areas using head mounted display

inside the Unity Engine. Initially, it is made an artificial world based on the sphere of Unity Engine which has an option to set user desired size of the artificial world for moving freely inside implementing the following programming code:

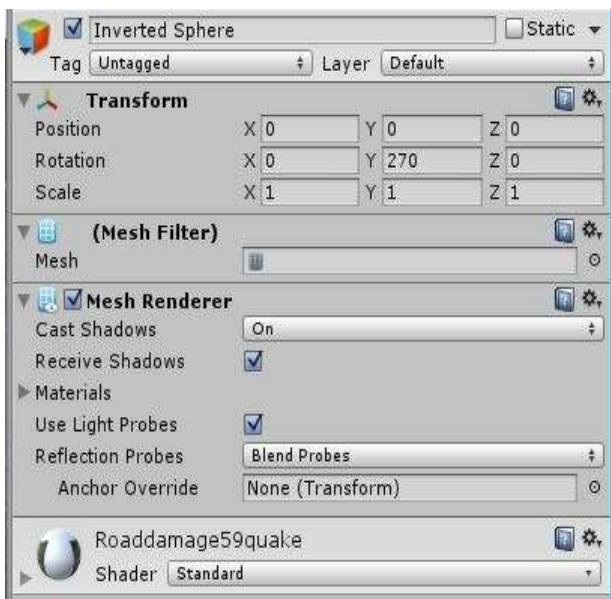
```
private void CreateInvertedSphere(float size) {
    GameObject go = GameObject.CreatePrimitive(PrimitiveType.Sphere);
    MeshFilter mf = go.GetComponent<MeshFilter>();
    Mesh mesh = mf.sharedMesh;

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

Adding this code to the *Editor* of Unity Engine, desired features can be found under the Game Object. Those features are used to create an artificial world identified as inverted sphere where a user can move freely inside the sphere by mounting Oculus display on user’s head and import the additional window for inserting the necessary data after making inverted sphere (Fig. 7).

For the purpose of making perfect perception of pre and post-construction project area, the post-construction project area scene can be switched in the same place and direction (Fig. 8) of pre-construction area by using the following JavaScript code predefined on the script of Unity engine:

```
if (Input.GetKeyDown(KeyCode.V))
    if (!iscamera2) {
        iscamera2 = true;
        camera2.SetActive(true);
    }
```



(a) Window to input desired values



(b) Creating features resulted in an inverted sphere

Fig-7: Platform to create Inverted Sphere from imported features

Figure 8 shows rotation of inside scene before setting up of the projected area; then, the projected scene is switched in the same location and direction of pre-construction area by pressing keyboard button V.

Proposed C+ programming logic to switch one a scene into the other one and move a person virtually inside the scene not changing the position of camera before and after the construction (Fig. 9) is encoded below:

```
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);
}
```

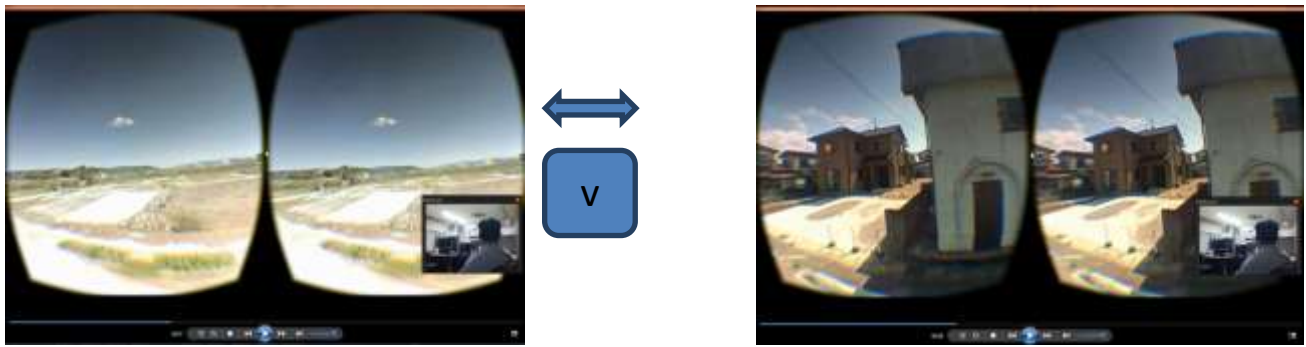


Fig-8: Process of inside rotation of post-construction scene in the same location and direction of the pre-construction area

In the Unity Engine, there is no default unit of measuring scale to adjust imported to the existed scene.

The following programming logic is predefined to make this function:

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

Thus, the above code is used to adjust the sizes of all imported objects inside the Unity Engine and produce perfect sizes of the project area by readjusting

scale of each objects, camera character height and inverted sphere which gives the real perception about the project as a whole (Fig. 8).

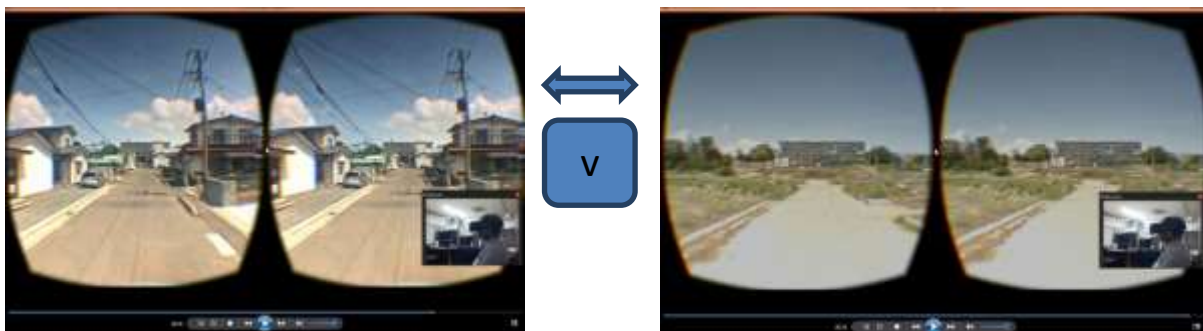


Fig-9: Participant's interaction with the virtual project area in order to visit the pre- and post-construction areas

Unity Engine takes the last JavaScript dialog as default command; the following programming dialog is prepared in case of avoiding the last command:

```
Public class AddMenu : EditorWindow{
    [MenuItem("Edit/Reset PlayerPrefs")]
    Public static void DeletPlayerPrefs(){
        PlayerPrefs.DeleteAll();}
}
```

RESULTS AND DISCUSSIONS

3D immersive visualization inside the imagery and video using Oculus Rift creates the mind blowing perceptions of three-dimensional virtual world and it comes up with the more lively experiences than that can have from the media based broadcasting. Broadcasting of media represents front viewing that is watched standing in front of television screen images; on the other hand, visceral experience brings the impression of not only watching but also moving into that sphere and being part of the virtual environment [5]. This is

observed in Fig. 9 implementing prescribed JavaScript dialogs.

To observe the performance of developed JavaScript dialogs a civil engineering project is prepared located in Shantinagar area, Dhaka. An object is prepared for 3D immersive visualization inside this area. Visualization inside the area is made with the help of Google street view and free access of the street views in all directions is made using proposed approach to choose the best location for the proposed project. The

programming scripts developed for this study with the help of built in application software and Oculus Rift transformed successfully a virtual environment of the three-dimensional project area where any person can move into with the perception of reality feeling not being physically present there as shown in Fig. 10.

Proposed project setup inside the existing scene which is imported from Google street view and

produced 3D immersive visualization facilities inside this image with the help of Oculus Rift (Fig. 11) making walking around inside, moving 360-degree and switching a scene to another one to have real perception about this area possible. The proposed programming scripts produce the positive approach of selecting perfect location for a new project. Any 3D project setup into the targeted spherical environment of 360-degree and visiting this virtual.



Fig-10: Simulation of pre-construction project location for 3D immersive visualization inside Shantinagar, Dhaka area



Fig-11: Moving in the inside of 3D immersive view in different directions after proposed project setting up using Oculus Rift

Project with surroundings creates real perception without physically being present at those places. Switching existing scene after setting up the proposed project at the predefined location and in the same direction of existing area is another approach of making the project features and selecting suitable location for a project.

CONCLUSIONS

For the simulation of any location of a project, imagery analysis with Google Street Views and generation of special purpose street views with different formats have been performed which reflects the same geometrical configuration in case of viewing with both eyes together and different geometrical configurations viewing with individual eyes, inside rotations within 360-degree spherically and switch the 3D project image into predefined area scene for the particular location and similar direction of predefined project area and walk in inside the scene with automatic switching to another scene. It is observed that the executive scene of the same geometries in both eyes makes the perception of real feelings with depth of illusions about the area; whereas, different geometries viewing with individual eyes (before and after the project setup) with perfectly superimposed one-another produce realization about the position of previous structures/objects, change geometrical configurations and rescale all objects of the area. In addition, insertion of few external 3D object files into the scene requires adjusting the geometries of the objects to the existing scene creating real perceptions imposed of those objects. Thus, the proposed types of little aids could save both travelling time and cost and offer essential visceral experiences of a virtually created project area using new technology, Oculus Rift.

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