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Building 360-degree VR Video for AquaFlux and Epsilon Research Instruments

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Abstract—The Virtual Reality (VR) technology is being utilised immensely in recent years for the purposes of demonstration and illustration a variety of prototypes and products especially on the world wide web platform. AquaFlux and Epsilon are two advanced research instruments that were developed by a research group at London South Bank University for medical and cosmetic purposes. These two medical tools have now been marketed in more than 200 organisations globally. However, for users to master and understand comprehensively how these two devices operate they often do require an intensive on-site training which is time-consuming, costly and in some cases like the current era of COVID-19 it becomes essential to offer clients the option of remote learning whether they were nationally or internationally based. Thus, the design of a VR environment that can simulate and envision all features and functionalities of AquaFlux and Epsilon is one of the ultimate solutions. 360-degree VR videos are going to empower users with the required knowledge and provide a broad essential feeling of how AquaFlux and Epsilon instruments function.

Keywords—3D modelling, 3D e-learning, Virtual Reality (VR), Web3D, Interactive Learning Environments, Virtual labs, AquaFlux, Epsilon, 3ds Max, Virtual User Manual (VUM), Virtual Learning Environment (VLE), Second Life, Smart Cities

I. INTRODUCTION

This research paper illustrates the importance of using three-dimensional objects designs in representing models online for variety of purposes. The demonstration of 3D contents on the World Wide Web in the current era, especially in the fields of e-commerce, e-learning, Virtual labs, Smart Cities in terms of illustration of features to appliances or devices virtually and generally, for online training objectives has become an essential approach for conveying notions and comprehensively explaining them. Moreover, the global pandemic of COVID-19 has forced many people (individual and establishment level) around the world to adapt the online approach in conducting almost every aspect of human life for different life's sectors e.g. education, health, finance, business, tourism, engineering, government etc. 3D modelling has always been associated with the virtual environments and virtual tools. Through utilising this technology, 3D objects displayed online appear tremendously realistic and has greater impact on any audience [1]. Interactivity it's another vital element in any 3D web application presentation. It allows viewers to experiment realistic feeling while trying out the 3D contents online [2]. Additionally, there are other technologies that are used with 3D contents and virtual environments to add extra

effect and perfection to the realism of the product demonstrated online such as Augmented Reality and Holography [3]. Additionally, the current era of Internet users is prepared to make the move from two-dimensional to three-dimensional online content presentations.

With the popular utilisation of three-dimensional web resources have augmented the need to develop an enhanced three-dimensional service and create a an extremely sophisticated learning environments, like 3D-learning, Virtual Laboratories (V-Labs), Virtual Learning Environment (VLE), Virtual User Manuals (VUM), online 3D-training, 3D medical teaching, smart cities, and the government area. Moreover, all the previously mentioned areas are becoming more popular to be viewed, trained, and conveyed using a suitable 3D approach due to the pandemic and the remote and online work that has dominated most of our lives' sectors. As it became a necessity to view contents online in a very realistic manner to comprehend and completely immersed for easy learning. Virtual Reality environment that uses three-dimensional contents to deliver its notion through the usage of web 2 as a platform mechanism would be as feasible as using an application locally [4]. The notion of VR being incorporated with social media these days is to boost its popularity further. Nevertheless, a Virtualisation Overview VMware report proclaims that “the potential of 3D/VR technology in everyday applications can be fully exploited. Simply if accompanied by the development of efficient and easy to use methods of creation, management, search, and presentation of interactive 3D multimedia content, which could be used by both expert and non-expert users” [5]. On this matter, AquaFlux and Epsilon skin research instruments have been developed by London South Bank University's engineering lab. Moreover, demonstrating all functionalities of these medical tools in a Virtual Reality world would illustrate all their features as being used in the real world. AquaFlux and Epsilon skin research devices as described by Biox (2016) Biox Science of Measurement

“Comparing AquaFlux and Epsilon with other skin medical technologies, they have higher sensitivity, higher repeatability, and most importantly, skin measurement results are independent of the external environment. AquaFlux and Epsilon are described as the new scanning devices for imaging dielectric permittivity (ϵ) that are used for a broad array of soft materials, including plant and animal tissues, liquids, fats, gels, waxes, and powders. Their main feature of electronics and signal processing

converts the sensor's original non-linear signals into refined fine-tuned permittivity scale for imaging attributes such as hydration or recording dynamic processes, for instance, textile wetting or the permeation of liquids through membranes. AquaFlux and Epsilon are used in more than 70 organisations worldwide, and there are hundreds of people using it" [6].

This paper explores the usage of three-dimensional content on the web, and the practical methodology adopted to construct and apply the 360-degree Virtual Reality video of AquaFlux and Epsilon research tools in the Virtual User Manual environment.

II. 3D CONTENTS APPLICATIONS AND RELATED WORK

Since the spread of Web 2.0 in late 2004/5 and there has been an evolution in web-based applications as Web 2.0 supports and allows different activities like team collaborations, communications, social networking. The 3D Immersive Virtual Worlds (3DVW) are one of the important products/applications of Web 2.0, which are computer-generated, virtual, online, graphics, multimedia, and 3D worlds [7]. Three-dimensional objects and contents that are used for online purposes have been around the world of computing and technology since the need for animated 3D-contents. The main reason why such objects are required is because of the real experience it can provide the users with. Therefore, 3D modelling is the essential component and the important aspect in the field of Virtual Reality environments [8]. The development and building of three-dimensional objects can be based on three steps:

- 3D modelling: the process of building a computer model in 3 dimensions.
- Layout and animation: the procedure of inserting animation and producing a scene and attach it to the object.
- Rendering: the procedure of combining other effects to the scene, such as lights, surface type, placing the camera and other qualities [1].

The concept of demonstrating online contents in three-dimensional environment is heavily discussed and immensely put forward to be fully utilised in the areas of engineering, science, and technology. Additionally, immersive education is on the rise especially after the effect of the pandemic and how during it users relied heavily on using the internet as a platform to conduct a variety of things, e-learning, online education, online training. Lately we have noticed several recent opinions emerging in the literature associated with the future of education. As has been commented by Potkonjak, Gardner, Callaghan, Mattila, Guetl, Petrović, Jovanović (2016), "Technological examples most relevant are distance learning, e-learning, virtual laboratories, virtual reality and virtual worlds, avatars, dynamics-based virtual systems. And the overall new concept of *immersive education* that integrates many of these ideas together" [9]. Moreover, with the increase development of 3D educational technologies, it is well-known that learning is utilised effectively in "3D virtual environments". Consequently, it is pointed out that virtual

worlds are applied in all degrees of education, learning and teaching process e.g. the virtual world of Second Life, which is 3D online life simulating as an alternative learning environment to learners [10]. Furthermore, the utilisation of game concept can deliver a fully interactive and immersive experience to learners studying a variety of subject especially medicine and applied sciences [11]. Furthermore, the utilisation of virtual training methods in educating people/users especially in the concept of Smart Cities will improve their quality of life in all areas (public, transportation, home). It will similarly empower people with difficulties, i.e. visually impaired people [16].

III. DEVELOPING, AND IMPLEMENTING 360-DEGREE VR VIDEO FOR AQUAFLUX AND EPSILON

This research project comprises the following stages of design, build and implementation:

- Using 3D modelling software (3D Studio Max) to create and build the 3D animated content of the Virtual User Manual (VUM) system.
- Using 3ds Max modelling software to convert and upgrade the 3D animated scenes of AquaFlux and Epsilon in Action into 360-degree VR video experience.
- Using Adobe Flash CS6 to add all different levels of interactivity, navigational buttons, links, and the process of adding audio clips to assist with the displayed illustrative text

3D creation and modelling are vital processes in any 3D content presentation. The buildings of 3D objects are the main elements of a successful modelling and mapping system. Furthermore, 3D viewing functionalities are proven to be the fundamental concept in nowadays most recent applications. AquaFlux and Epsilon are two state-of-the-art skin measurement instruments. They both have very similar 3D technical modelling approaches. Both devices have a probe, base, and both are used to measure human skin. Thus, the approach adopted in creating the virtual world was similar in both models, and the steps that have been followed using 3ds Max and Adobe Flash CS6 programs were similar too.

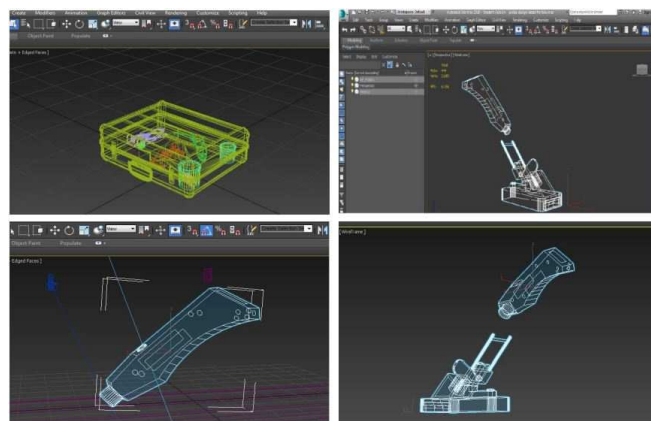


Fig. 1. Few rudimentary screenshots for AquaFlux instrument modelling.

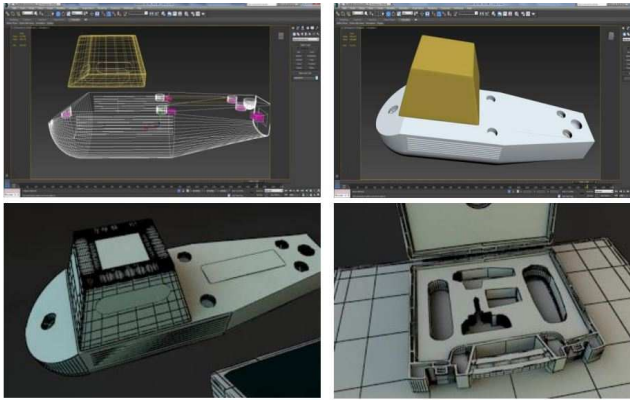


Fig. 2. Few rudimentary screenshots for Epsilon instrument modelling.

A. How Virtual Reality VR is created:

Virtual Reality (VR) is a second world (simulated environment) accessed by various users, and it resembles our world in most of its characteristics depending on what is required from that virtual world to present. VR shared users' interaction is on the rise in the current Internet era. The purpose of this collective, collaborative work is to enable users to experience full VR immersive environment. In addition to the users' shared experiences mentioned previously, users in virtual worlds can be presented by avatars or walkthrough scenes to conduct a variety of activities [12].

There are two methods to create a virtual reality environment:

- a) Using a 360-degree video: This VR approach is going to provide users with 360 degrees of freedom of movement in the virtual world. The user will be placed in the centre of the virtual scene and will have the ability to navigate through it along with rotating and zooming in and out on a variety of objects that the VR scene contains [13]. Additionally, users need to use a head-mounted display unit or an HMD to allow them to experience the virtual walkthrough such as Oculus Rift and HTC Vive used for online purposes in Internet browsers. These VR systems are mostly non-directional videos. Furthermore, this 360 VR experience is becoming ever so popular in the current era since it provides users with a new level of VR immersion and different level of virtual interactivity [14].
- b) Using 3D animation: animating a 3D scene and then applying it in a virtual environment presents an extremely realistic product with a wide range of functions, features and an excellent level of user interaction. 3D content animating is the process of animation using keyframes functionality in 3D modelling software that provides 3D designers with plenty of control of the 3D scene [15]. Thus, this method, in a nutshell, is when all selected objects are built using a 3D modelling software such as 3ds Max, Blender, Maya and many more. The 3D animating approach is more costly as it requires

more tools and software to be involved in the creations, design, and development processes. Besides, it requires the expertise to develop, create, animate, render, and subsequently publish the product online, and for that reason, it is a time-consuming procedure. Another way of creating VR is via using game engine packages such as Unity, which is mainly used for creating and developing games.

B. AquaFlux and Epsilon360-degree VR video creation:

In this process, it is required to use the main and original 3ds Max file created while modelling AquaFlux and Epsilon at the early stages of the 3D modelling process of the VUM system. The same 3D file (3ds Max scene file format) is taken and used to be upgraded into 360-Degree VR video. Like the early stages of 3D modelling, the 3D scene of AquaFlux and Epsilon operating in a clinic is needed to be used in the 360-Degree VR video. This specific 3D file is going through the animation process but this time for the 360 VR video. In 360-degree VR video positioning, a camera point must be created for that animation. A newly physical camera is needed for the 360 scenes, and it must be placed in a suitable position or location. Furthermore, the animation process will begin via using the keyframe animation, as seen in Figures 3. and 4. below. Keyframe animation by default starts at keyframe zero, all the way to 100 frames to work with, and this keyframe scale can be increased to a bigger number of frames as desired from the time configuration menu. Keyframing helps in the process of arranging how the scene is going to be animated (in what order). Making sure to turn the Autokey on, Autokey is a feature that assists in the process of filling all frames in between all the keys that are set during the animation of a 3D object. After that, it is required to enter the camera view to see how objects look like from within the 3D scene. For 360-degree VR video, it is recommended to select view type of spherical panorama override FOV: 360 vertical FOV: 180. Regarding the screen resolution to display a 360 view, the width needs to be set twice 73 the height. The final step is to make sure that the output path of the rendered files is set before the rendering process is initiated.



Fig. 3. The animation process of AquaFlux for the 360-Degree VR video using 3ds Max software.

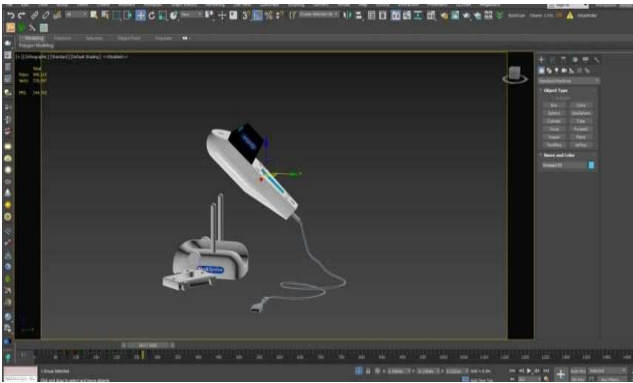


Fig. 4. The animation process of Epsilon for the 360-Degree VR video using 3ds Max software.

Occasionally, some objects animated in 3ds Max starting to move at different speed level (accelerate and decelerate) during their animation. This change of speed can be cleaned and fixed using the curve editor menu. The curve editor menu is used to adjust 3D objects speed during the animation process. When adding materials for the AquaFlux and Epsilon 360-Degree VR video, the material editor has been used instead of the single object colour menu box. The object colour menu box has too few varieties of colours. Additionally, it lacks the availability of real-life material colours, textures, pictures, or custom glow colours. Therefore, using the 3ds Max material editor menu is going to be the perfect feature to achieve that. The 3ds Max material box can be opened by pressing on the M key on the keyboard as seen in the Figure below.



Fig. 5. Using the material editor box for Epsilon 360-degree VR in 3ds Max software.

The process of lighting in AquaFlux and Epsilon 360-degree VR video is essential. In 3ds Max, we have three different types of lights that can be used in a scene Photometric light, Standard light, and Vray light. Not using a suitable type of light in any 3D scene will result in a lifeless, dull scene that has no shadows. Once the designer selects a suitable type of light and the perfect camera viewpoint, he/she can go to the shadow's menu and tick the shadow option, and that would result in a more realistic, lifelike 3D scene. In AquaFlux and Epsilon 360-degree VR video, VRay lights have been applied. VRay plug-in in 3ds Max software comes as a complete package of VRay light,

VRay material, VRay camera and of course VRay renderer. VRay light has a more realistic feel to it with VRay rendering, and it produces a more natural and realistic content. Additionally, VRay light is designed to work very smoothly with VRay materials and the VRay renderer. VRay sun is used when there is no background in the 3D scene as it provides the scene with a brighter background sky colour.

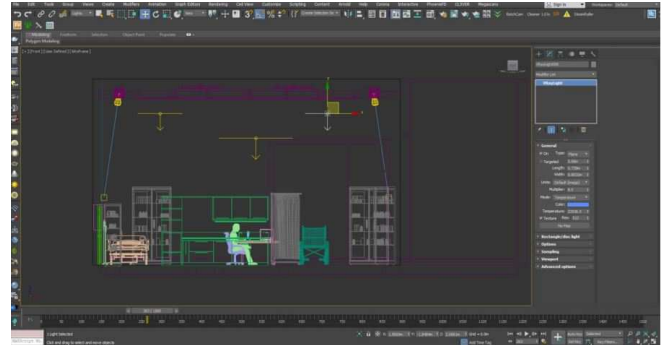


Fig. 6. Applying VRay light setting for Epsilon in 3ds Max.

VRay rendering plug-in is required to render 360-degree video. The most important part before starting to render any 360 videos is setting up and positioning the scene's cameras. Three cameras are used in AquaFlux and Epsilon 360-degree scenes individually. When setting cameras in 360 videos, it is important to rotate the cameras, and they need to be placed in a way that all cameras deployed are focusing on the main objects of the scene. Additionally, it is important to instruct the camera to grab or focus on the targeted object and everything around it. To do that the designer has to open the rendering set up and select VRay then press on the VRay tab. Under the VRay tab, click on the camera option and change the camera default value to spherical. This option will enable the camera to observe everything in the sphere. The Override FOV (Field Of View) value should be changed into 360 degrees. The output size of the rendering setting of the camera must be changed in a way that width is always double the value of the height as it is a 360 view (HDTV 6000x3000 or 4000x2000).

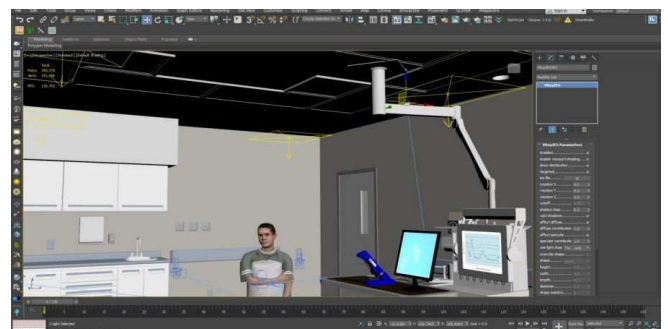


Fig. 7. Camera setting for AquaFlux 360-degree video in 3ds Max.

3D designers of 360-degree videos need more than one camera position with 360 renders, zoom in into the centre of the room. Create a physical camera in the centre of the room. Set the camera view into the viewport. Pan the view to up the camera into eye level. Panorama rendering works

with six different directions or positions (left, right, front, back, up, and down). From that point, the six positions need to be connected into a spherical panorama. Once all camera settings are completed, it is time to begin the process of rendering. Rendering could take a huge amount of time, especially if the designer is rendering for a high quality, slow motion 360-degree video. The rendering of AquaFlux and Epsilon 360-degree video is based on 300 frames a second. Because the machine that has been used is not of high quality regarding the CPU speed and the size of the RAM it took 6 minutes to render one frame. Because it is a 360 V-Ray render that calculates one view of 6000 resolution, high resolution means it is better quality, but more frames to render. Therefore, to render 300 frames for 6 minutes each frame that will be 1800 minutes the total time to render one scene only. Thirty hours rendering time for one complete video. The resolution used in AquaFlux and Epsilon 360-degree video was HDTV type of resolution of the value 1920x1080.

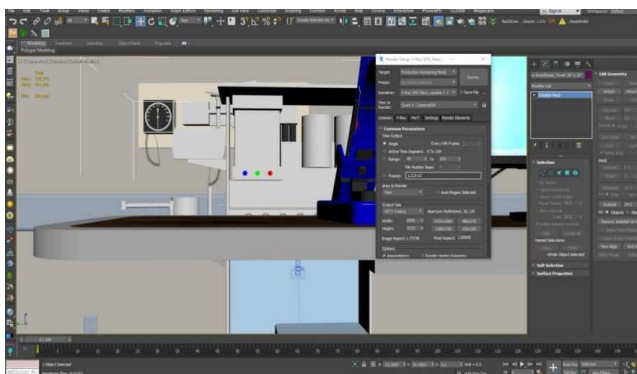


Fig. 8. Rendered settings of AquaFlux 360-degree video in 3ds Max.

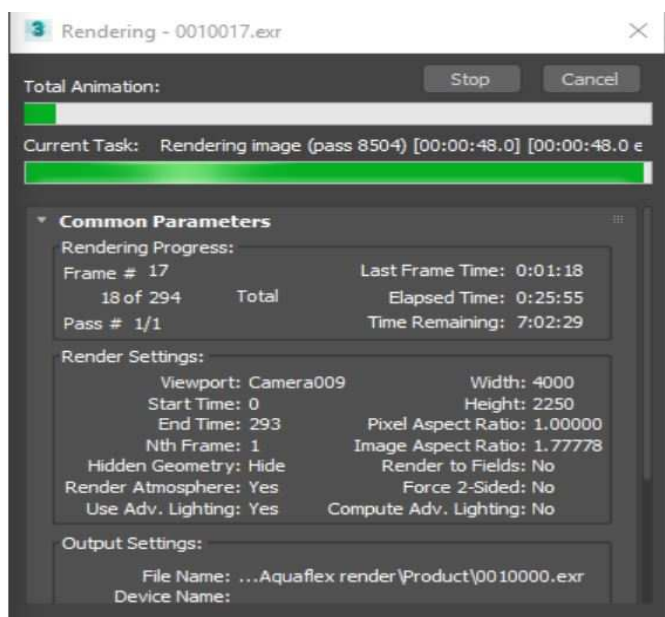


Fig. 9. The progress of the rendering of AquaFlux 360-degree video in 3ds Max.

Once the rendering is complete, the 360-degree video will become ready to play. The output video format is mp4 as it is compatible with most modern-day applications and WebGL support browsers like Microsoft Edge, Chrome, and Firefox. The file will have a script attached to it. This JavaScript file is downloadable from Valiant360 website. The video can be played without the need to download a third-party plug-in like blender or Unity.

C. Evaluating AquaFlux and Epsilon 360-degree VR video experience and in-depth challenges:

To evaluate AquaFlux and Epsilon 360-degree VR video experience (VUM), a usability study was carried out among 12 users from a non-IT background and what follows are the results:

Eighty-three per cent of the participants found that the service provided online was smooth and error free, whereas 17% were neutral. Fifty-eight per cent of the users enjoyed their 360-degree VR video experience, 42% were neutral. Sixty-four per cent were successful in using the VUM while 36% were impartial. Fifty-nine per cent were able to control the VUM, whereas 33% were neutral and 8% had difficulties. Thirty-six per cent thought that the VUM is sufficient and comprehensive, whereas 46% were neutral and 18% disagreed.

As is evident from the above results, AquaFlux and Epsilon 360-degree VR experience has a smooth error-free service; users successfully used the system. However, there is room to improve the system as a sufficient tool to teach users how to use the medical device comprehensively. It is essential to learn how to use the instruments. Therefore, training users on how to use the system virtually is an important aspect. Currently, the VUM system of AquaFlux and Epsilon does contain an audio support feature that will guide any trainee step-by-step beside the virtual tutorial session. However, the challenges to improve the virtual learning experience can be based on the following:

- The lack of full interactivity sessions with the research medical devices during training.
- Technical issues, like not having access to sufficient resources to complete the training.
- Building a comprehensive virtual system that meets the requirements of all types of special needs and disabilities.

IV. CONCLUSION

The objective of the research paper was to introduce a total understanding of an online 3D contents and utilising it in an effective way and not limited to displaying it on a webpage. The main contribution to the field is using an interactive virtual environment to demonstrate the process of using a medical device in conducting a human skin

measurement for medical purposes with the aid of audio feature. The new web-based 3D interactive 360-degree VR video VUM for AquaFlux and Epsilon will replace the old method of illustrating how these medical devices work and what are all their features and functionalities via providing each client with an accessible URL after purchasing the instruments. The web-based virtual system is self-explanatory and easy to use as well as the availability of audio support that guides users step by step throughout the process. Novel holders and futuristic concepts have been introduced to display the capabilities of the new addition and to utilise the marketing process using 3D contents with the interactive virtual world to deliver real novel ideas globally.

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