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WebXR Asset Management in Developing Virtual Reality Learning Media

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ABSTRACT

Extended Reality (XR) is the technology that allows blending virtual and physical worlds using augmented reality (AR) and Virtual Reality (VR) to create a fully immersive experience. While WebXR is a web based XR environment built on a JavaScript framework that enables interactivity of AR and VR devices within the web browser. Contemporarily, educators are demanded to explore the variety of new media in practicing interactive learning, specifically in an academic environment. Arguably, VR has recently been identified as one of the most popular gamification mediums. It can create an environment that is both physically and digitally engaging. This paper reviews, simplifies as well as recommends a better component management system in the VR production pipeline using practice-based research methodology.

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1. INTRODUCTION

Extended reality (XR) is a relative new term that covers virtual reality (VR), augmented reality (AR), and mixed reality (MR) under one umbrella (Marr, 2021). The history of Extended Reality (XR) began when, in 1956, cinematographer Morton Heilig initiated a movie booth that allows viewers to sit in a vibrating chair to experience an immersive experience with color video, 3D with audio, and smells. It is called Sensorama as shown in **Figure 1** the first-ever virtual simulator in the world.

Figure 1. Sensorama machine designed by Morton Heilig *(Source: Beenoculus Blog)*(*Beenoculus Blog*, 2022)

In the 1960s, building from Heilig's idea, the engineers from Philco (Philadelphia Storage Battery Company), the com-

pany which famous for pioneer development in battery, radio, and television, developed the first Headsight for military purposes as shown in **Figure 2**. Although it was not developed for virtual reality, this device allows immersive remote viewing of a dangerous situation (Marr, 2021).

Figure 2. Headsight by Philco's Engineer (1960) ***(Source: The origins of virtual reality),*** (*The Origins of Virtual Reality*, 2022)

The first VR games were developed by a game company SEGA in 1993. However, they went flopped because their product faced many technical development difficulties and created dizziness to the users (Marr, 2021).

In the modern digital era, XR has become a mainstream technology adopted in a broad range of industry from military simulation, entertainment shows, medical training, and educational tools for learning.

The year 2014 was a significant milestone for XR (Marr, 2021). First, famous companies like SONY and Samsung announced that they created their own VR headsets. Meanwhile, Google released a cardboard device, a low-cost cardboard for VR viewers in smartphones. Then in 2016, Microsoft released its HoloLens Headset which created a new level of interactive experienced as shown in **Figure 3**.

The widening of XR applications and technologies on the Internet of Things (IoT) era makes WebXR becoming a platform that resulted XR easily accessible on the web, reducing the need for an expensive VR headset (Fatai, 2021).

Figure 3. Prototype Microsoft Hololens ***(Source: FOSSYBYTES),*** (*FOSSYBYTES*, 2022)

WebXR is a JavaScript Application Programming Interface (API) that democratizes immersive experiences in 2D and 3D web browsers. It means web user behavior will change in the future when they "visit" for travelling to virtual space. Hence, they can spend time in a virtual dimension, no more extended flat presentation of information, and change the meaning of "interactive." (Rodríguez, Peraro, & Abriata, 2021).

Implementing WebXR applications on the web can bring many benefits. For example, in immersive entertainment, VR films and 360 Photography have grown popular in society as can be seen in **Figure 4**. It also opens a new world of possibilities for content creators.

It positions the audience in the middle of the story action, hence bringing new ways of telling the stories (Mattka, 2020).

Figure 4. VR 360 city tour of Paris ***(Source:*** **VR 360 city tour*),*** (*VR 360 City Tour*, 2020)***).***

The education sector also gets benefits from the emergence of XR Technology (Rodríguez, Peraro, & Abriata, 2021).

This sector was looked for as a more entertaining way to teach the students. Educational websites have started to incorporate WebXR-based AR content that students and teachers can run on their devices. For example, if we search queries in Google, we can find a site that can provide a detailed model of the human circulatory system, and then move all around it to inspect its inner structures and organs, much like with the physical models used by medical students as shown in **Figure 5**.

Figure 5. VR application from Human Anatomy Atlas AR app *(Source:* ARPost*),* (*ARPost*, 2021)

EDUCAUSE, a non-profit association and the largest community of technology, academic, industry, and campus leaders advancing higher education through IT, has distributed a report (2020) on XR experience. It shows that XR is a successful innovation. By giving "hands-on" insight, XR provides advanced student commitment with learning materials and developed student interaction with complex issues (Choubey & Ghule, 2021).

In a survey from Perkins Coie LLP and the XR Association (Perkinscoie, 2019), nearly 9 in 10 respondents said that by the year 2025, immersive technologies—including augmented reality, virtual reality, and mixed reality — will be as ubiquitous as mobile devices.

This paper explores the asset management that is used to develop an extended reality (XR) in web XR applications like A-Frame. The topics with a focus on Virtual reality (VR) can be used in the educational sector with the help of which the students can experience the new way of learning more effectively.

The rest of the paper has the following structure: Section 2 elaborates the research methodology and how the supporting graphics assets management gathered from where the authors developed VR interactive learning about US History using web XR application called A-Frame to support the interactive learning; Section 3 presents the results, analysis, and discussion; and lastly Section 4 presents the conclusion of this paper and some recommendations that can be explored in the future especially in relation with WebXR and education.

2. RESEARCH METHODOLOGY

This research was conducted using practice-based research methodology and empirical analysis to evaluate the production simplicity and effectiveness in creating WebXR platform using a programming framework. Primary data were gathered in developing interactive learning media using A-Frame code-based framework on an existent course conducted at Sampoerna University. Despite the advantages, it is crucial to review and recommend a finer pipeline in this article because the current provided documentation is not well-structured and there is an opportunity to reduce information redundancy in its usage.

The workflow when Developing WebXR is similar and adapted to the common 3D Animation and Production Pipeline. 3D Animation Pipeline is a system consisting of people, hardware, and software aligned to work in a specific sequential order to do pre-determined tasks in a pre-determined time frame. This leads to a 3D Animation product or asset

as the final output as can be seen in **Figure 6**.

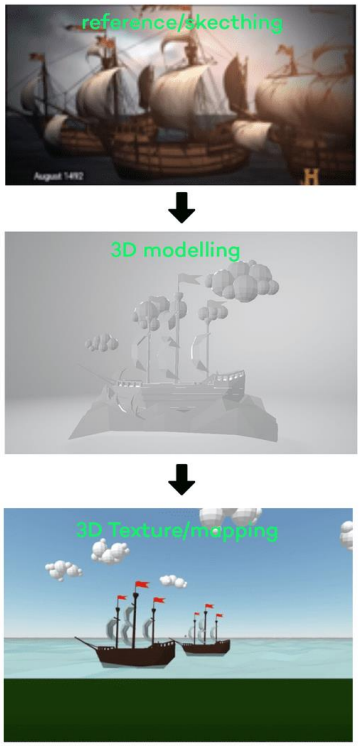

Figure 6. 3D Designing Workflow

Meanwhile, the 3D Animation Production process is where all previous efforts must pay off and transform into action. At this stage, the elements of the 3D Animation will be handed out to the designated designer and animators. Team leaders need to make sure the production timeline, and the quality matches those of the determined plan in the pre-production stage as well as maintaining the best output quality possible. The outcome at this stage determines the entirety of the 3D Animation project. The production stage consists of the following steps:

1. **Sketching/Layouting**

   In this step, design drawing or graphical statement of the overall form of a component or a device, which is usually prepared during the innovative stages of a design.

2. **Modelling**

   Modelling is the process of developing a geometric surface representation of any object in 3D software.

3. **Texturing**

   Texturing is the process of creating and applying textures (colors and surface) to a 3D model.

4. **Animation**

   Animation is the movements of the 3D objects or characters in a scene.

5. **Programming**

   In this step, arrangements and rendering VR objects, environment and behavior are performed by utilizing prepared assets.

2.1. 3D Assets Modeling

Although the methodology is adapted from the 3D Animation pipeline, it is worth noting that some production methods are different, e.g., asset format. A common asset format in WebXR development is FBX. In WebXR, the delivered output is not rendered, it will be rendered when assets are already compiled in the WebXR environment. The suggested format for WebXR is OBJ and/or glTF 2.0. In this article, glTF is chosen due to the ease of 3D assets management because all its components are embedded in a single file. According to Khronos Group ("glTF - Runtime 3D Asset Delivery", 2022), the company that develops glTF format, glTF minimizes the size of 3D assets, and the runtime processing needed to unpack and use them. The glTF defines an extensible, publishing format that streamlines authoring workflows and interactive services by enabling the interoperable use of 3D content for the efficient transmission and loading of 3D scenes and models by engines and applications.

To produce and export glTF 2.0 assets, the 3D application used in the project is Blender 3D as it is recommended by

Khronos Group. As can be seen in **Figure 7**, this is the suggested shading workflow to be able to achieve an ideal glTF format.

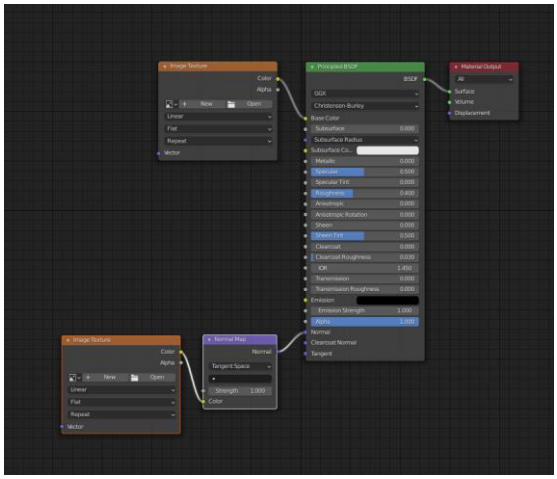

Figure 7. Shading workflow, embedding texture images in one material.

The only external factor that has not been mentioned by Khronos Group is to analyze the face normal of the 3D mesh when modelling assets. If some of the meshes are facing the incorrect normal, parts of the 3D face will not appear in the WebXR environment. Later in the article, the buffer quality and refresh rate of WebXR using glTF2.0 was tested in an online server, and the result is outstanding.

2.2. A-Frame Programming

A-Frame is a web framework for building WebXR experiences. A-Frame is based on top of HTML, making it simple to get started experience as can be seen on **Figure 8**.

But A-Frame is not just a 3D scene graph or a markup language; the core is a powerful entity-component framework that provides a declarative, extensible, and composable structure to Three.js. A-Frame was originally conceived within Mozilla and is now maintained by the co-creators of A-Frame within Supermedium. A-Frame was developed to be an easy yet powerful way to develop WebXR content. As an independent open-source project, A-Frame has grown to be one of the largest VR communities (Marcos, 2022)

```
<a-gltf-model
    src="#cloud"
    position="-3 5 1">
</a-gltf-model>

<a-gltf-model
    src="#cloud"
    position="10 5 -5">
</a-gltf-model>

<a-gltf-model
    src="#cloud"
    position="10 5 15">
</a-gltf-model>

<a-gltf-model
    src="#cloud"
    position="10 5 20">
</a-gltf-model>

<a-gltf-model
    src="#trees"
    position="-10 0.12 10">
</a-gltf-model>

<a-gltf-model
    src="#trees"
    position="-6 0.12 18">
</a-gltf-model>

<a-gltf-model
    src="#trees"
    position="10 0.12 15">
</a-gltf-model>

<a-gltf-model
    src="#trees"
    position="-13 0.12 25">
</a-gltf-model>

<a-gltf-model
    src="#trees"
    position="0 0.12 25"
    rotation="0 90 0">
</a-gltf-model>

<a-gltf-model
    src="#trees"
    position="13 0.12 30">
</a-gltf-model>
```

Figure 8. HTML in WebXR using A-Frame

The experience of programming a WebXR is excellent. The programming logic is clear and direct. Also, there is a clear direction in registering 3D assets and implementing them into a WebXR environment. On the other hand, the experience of duplicating objects in the framework is overly rigid. The length of manually duplicated objects disturbed the programming experience. Alternatively, preparing a glTF

file with multiple objects is currently an acceptable solution, otherwise, when changes are needed, this would affect the production speed. Thus, this article recommends compiling all design assets in Blender 3D and exporting them individually. This workflow was not mentioned in the A-Frame documentation, and it is considered as a new finding and effective method.

2.3. WebXR Typography

Upon developing the project, the issue has already started since the beginning of registering the library script tag. A-Frame is highly modular, thus each component that makes up the entire VR environment is spread across different internet links. Another crucial and problematic library registration is applying typography inside the project. According to Kurbatov (Kurbatov, 2019), fonts are not designed to be in a 3D environment. Many VR designers and developers always work with texts in a virtual environment because it is inevitable. He also pointed out the 10 basic rules of typography in a VR environment, which are:

1. Size
2. Position & Rotation
3. Line Length
4. Typeface
5. Weight
6. Line Height
7. Alignment
8. Color and Contrast
9. Animation
10. Actions

There are 3 types of fonts that can be rendered in the A-Frame framework, they are SDF (built-in), MSDF (converted Google Fonts to JSON) and 3D Geometry (Three.js-based) fonts. It is very useful to have options, but the site where users can obtain the information was not compiled in one place.

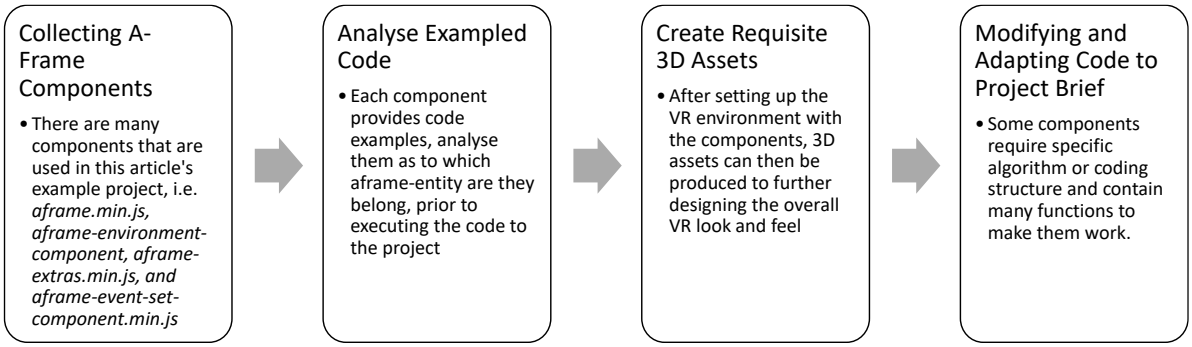

Figure 9. Method working in WebXR

The A-Frame documentation site does not record specific steps to register the modular libraries, the user must select either link and further explore 2 entirely distinct ways of registration and implementation. This article recommends the method shown in **Figure 9** to start using the framework effectively.

3. RESULT AND DISCUSSION

The WebXR project presented in the article aims to create a VR interactive learning platform that simplifies production methods for educators to prepare interactive learning materials, specifically in this project's material is how Christopher Columbus discovered the American continent for the first time .From the beginning of the scene, the students are virtually experiencing the WebXR environment of Christopher Columbus' ships sailed then crossed the American continent As can be seen in **Figure 10**.

In the initial position, the student is presented with a virtual island and introduced to 3D Typography, which explains Christopher Columbus's background history. Continuously, students will explore the island and discover more information on Christopher Columbus's history. The project revolves around user input. These inputs allow the user to interact with the 3D environment. These inputs will come from the touch screen or keyboards and in the orientation and position of the device.

Generally, the interactive media learning project in this article can be viewed as three major components: the front-end, the back end, and the developer tools. The front-end includes the static website files, assets and JavaScript that will be run on the client's browser. This enables the web application to deliver its Augmented Reality experience to the user.

Figure 10. Project scene by scene.

The front-end comprises three components: the static website (HTML, CSS, and basic JavaScript), the Augmented Reality API, and the 3D rendering engine. The static website will be the front page for the web application and how users navigate to the virtual experience. The AR API will handle the communication between the web application and the hardware. When the web application is running on, the 3D rendering engine works. As we can experience in our project, the Virtual Reality experience that we want to deliver through a web browser can be accessed very well on all desktop or mobile devices. The rendering engine that renders the image and passes it back to the AR API to be displayed on the user's display was working well. The main concern for the back end is to make sure the server has enough bandwidth and processing power to serve all its clients and to maintain a server up-time of at least 90%.

4. CONCLUSION

In this article, we have restructured the components published in A-Frame documentation internally and externally to the extent of reducing information redundancy due to the poorly documented framework updates. On the other hand, we have added information on the recommended 3D asset file format that is easy to implement within a web server and gives enough control over the textures and materials that will be used with it. The glTF file format provides file size efficiency yet maintains features that are relevant to the WebXR experience. These 3D asset specifications are not provided specifically within the A-Frame documentation. WebXR can create Virtual experience in developing interactive media learning by typing simple HTML codes accessible for educators, designers, and programmers to implement. However, not all designers and educators are code-literate yet, so designers, programmers, and educators must team up to create and disseminate relevant content for different courses and communities.

Although this article reviews and recommends the technical of WebXR, it is also essential to raise pedagogical questions, for example, how does WebXR help educators deliver guidance and students acquire knowledge from the guidance? What are the features of WebXR experiences that make them pedagogically more effective? How do we organize content for future interactive media learning applications? Researching these questions helps to develop an educational method, especially in this digital era.

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