Mars Interactive: Exploring the Potential of WebXR for Managing Online Objective Based Training

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Abstract

The Covid-19 pandemic has resulted in an increased demand for online collaborative tools, one such area which has seen a surge in interest has been in eXtended Reality (XR). Though tools such as Zoom and Skype have existed to simulate the environment of professional meetings there has been an absence of an online alternative to kinaesthetic tasks. Currently virtual reality has seen use in the training of medical students, specifically in the task of surgery, and as a rehabilitation method for those who are dealing with either psychological or physical trauma. These tools however have been limited by both a requirement for external construction of the scenarios and a dependence on offline mediums with local installations. The toolset described in this document aims to alleviate these problems with current training tools by allowing supervisors to construct training scenarios with modifiable parameters to vary the required training tasks. The scenario used for discussing the capabilities of the system is that of a Mars exploration team, used to showcase the flexibility of the toolset.

Declaration

I, Kyle Dick confirm that this work submitted for assessment is my own and is expressed in my own words. Any uses made within it of the works of other authors in any form (e.g., ideas, equations, figures, text, tables, programs) are properly acknowledged at any point of their use. A list of the references employed is included.

Signed: Kyle Dick

Date: DATE OF SUBMISSION.

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1. Introduction

In the present Virtual Reality (VR) has been identified as a desirable solution to the problem of training students for practicing surgery in the medical field with benefits associated with the innate advantages of virtual environments and the improvement to real world abilities [1]. The problem presented with these applications however is the reliance on the systems which they run with VR applications sometimes requiring demanding hardware in order to support the rendering of their 3D assets. The solution proposed within this document is the design for an application which allows for the development of both VR and AR training scenarios that can be accessed within a standard web browser.

The main goal for this solution is to engineer a tool which allows for a training coordinator (referred to in this document as the 'Administrator') the ability to create scenarios using 3D rendered graphics in the virtual space for the purposes of training a user for a specific role. To achieve this goal the solution must aim for the most immersive experience currently attainable as this is the most accurate way of assuring that those interacting with the system can be equipped with the skill set needed for entrance into real world scenarios. In the attempt to engineer the ideal solution a set of objectives were devised to best track the progress towards the main goal. These objectives are as follows:

1. The solution must allow for an administrator to create and manage XR scenarios in which they can invite and train users.
2. The solution must be hosted through the web browser.

Currently the main challenge faced in the field of Virtual Reality (VR) and Augmented Reality (AR) applications is the creation of an interface which would allow for the user to have accurate control over the virtual components. For the implementation of the solution discussed, the API WebXR was chosen as the medium through which the hardware responsible for rendering the 3D virtual components to the user. WebXR is a set of standards developed for the purposes of allowing web applications which render 3D graphics to communicate with a range of hardware devices for the purposes of creating both Virtual Reality (VR) and Augmented Reality (AR) experiences.

2. Background

2.1 Discussion of Extended Reality (XR)

The focus of this project is in allowing for users to create virtual objects in XR and manage scenarios using these virtual objects. These methods require the rendering of 3D objects however the manner that each places the 3D objects in the environment differs when looking at designing either VR or AR scenarios.

2.1.1 Virtual Reality (VR)

VR involves creating a virtual environment through entirely 3D rendered components that is displayed to the user through appropriate hardware, commonly known as visors. Most of these visors are paired with a set of controllers which will communicate with the WebXR API in this solution to interact with the virtual components of the environment. VR has seen a demand within fields in which training scenarios are either too dangerous or expensive to recreate in a real world case. The company VR-Interactive has already presented virtual reality solutions to the demands of industry for VR training tools, one such case being a crude oil burner simulation [2].

2.1.2 Augmented Reality (AR)

AR involves capturing the real world through devices such as the camera of a mobile phone and rendering virtual elements which are able to maintain a consistent position in the environment. These objects can persist within the environment when the camera is not currently pointing in its direction, using the real world surfaces and environment to track the positions of virtual objects. A popular example of this technology being used is the early implementations present within the Nintendo 3DS which used physical cards to initialise the virtual objects in the environment. Since then this technology has progressed such that the virtual objects no longer need any specialised real world objects to initialise the virtual elements, this can be seen in the recent google AR & VR experiments where AR is used to provide directions with google maps [3].

3. Related Literature

Training tools for medical students

Botanical Garden paper

Augmented Reality Paper

4. Requirements Analysis

4.1. Textual Requirements

4.1.1 Requirements Key

This section details the requirements for the system. The following key is used to track the requirements.

ID	Requirement	Priority
FR-U/A/S-No.	Textual description of the requirement.	MoSCoW priority of the requirement

NFR-P/C/R/S/U-No.	Textual description of the requirement.	MoSCoW priority of the requirement

Functional Requirements (FR) are requirements which detail the system functionalities and how the function of the system will help achieve the overall goals. The types of functional requirements this system is concerned with are as follows:

1. User (U) - Requirements related to how the user interacts with the system.
2. Administrator (A) - Requirements related to how the administrator interacts with the system. Requirements which pertain to the User are assumed to include the Administrator also.
3. System (S) - Requirements related to how the system behaves.

Nonfunctional Requirements (NFR) are requirements which detail issues related to the system's capabilities and its constraints. The types of nonfunctional requirements this system is concerned with are as follows:

1. Performance (P) - Requirements related to how the system is able to perform. This includes the ability to deliver a stable frame per second count when serving the graphical components.
2. Compatibility (C) - Requirements related to how well the system is able to perform when varying hardware, browser and the respective versions of both.
3. Reliability (R) - Requirements related to how prone the system is to both minor and critical failure.
4. Security (S) - Requirements related to the security of the system and the protections in place against malicious use. With the main focus of this system based within virtual reality this area will also concern itself with protecting users from malicious imagery being injected into the user's vision.
5. Usability (U) - Requirements related to how easy the user can operate the system and navigate its functions.

Both functional and nonfunctional requirements have been prioritized using the Moscow method. Therefore each requirement has exactly one of the following priorities:

- Must Have (M) - The requirements with the highest level of priority. These requirements are fundamental to the operation of the system.
- Should Have (S) - The requirements which are not as fundamental to the system as the previous category but ideally should be present in the final version of the system.
- Could Have (C) - The requirements which are not important to achieving the goals of the system but would be beneficial to the system.
- Won't Have (W) - The requirements which will not be present within the system. This is either due to them not fitting the scope of the system or being ill suited but still worth noting.

4.1.2 Functional Requirements

ID	Requirement	Priority
FR-S-01	The system must be able to render graphics in 3D	M
FR-S-02	The system should support dynamic lighting	S
FR-S-03	The system must allow for loading of 3D models	M
FR-U-04	The user must be able to walk around a 3D environment	M
FR-S-05	The system must support users moving across a 3D terrain	M
FR-S-06	The system must allow for the virtual environment to be rendered to VR/AR hardware	M
FR-S-07	The system must be hosted online at a static address	M
FR-S-08	The system must allow for multiple users in a single session	M
FR-S-09	The system should allow for multiple sessions	S
FR-S-10	The system must allow for basic lighting	M
FR-U-11	The user should be able to see other players in the environment	S
FR-U-12	The user could be able to create private sessions	C
FR-S-13	The system won’t support an infinite explorable space	W
FR-U-14	The user could be able to communicate to other users	C
FR-U-15	The user must be able to	M

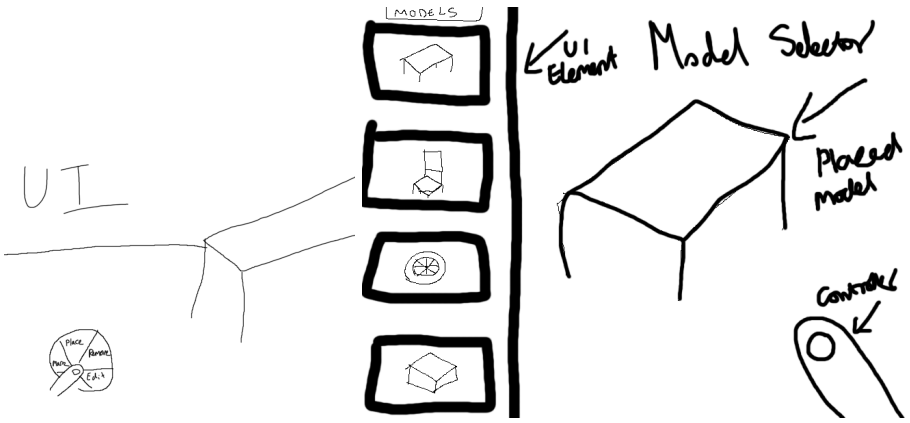
	pick up objects in their environment	

4.1.3 Non-Functional Requirements

ID	Requirement	Priority
NFR-P-01	The system must be able to render the environment while maintaining a stable fps (frames per second) count	M
NFR-S-02	The system must be protected from outside attacks which could affect the images displayed to users	M
NFR-R-03	The system must not suffer critical failures during normal operation	M
NFR-U-04	The system controls should be easily understood by the user	S
NFR-C-05	The system should run on all the popular web browsers	S
NFR-C-06	The system should be able to fall back on the device screen in the absence of the appropriate hardware	S

5. Design

!These sketches are placeholders!



6. Evaluation Strategy

6.1 Requirements Assessment

The main indicator of the progress of the project is the progress made in achieving the requirements laid out earlier within the document. Throughout the project the requirements will be assessed as each milestone of the project is reached.

7. Project Management

7.1. Project Timetable

7.2. Risk Analysis

7.2.1 Risk Classification

To manage the progress of this project efficiently it was important to identify possible risks that could prevent the realisation of the goals laid out earlier in this document. To aid in the identification of the risks the following key was used to classify the associated risks:

- People (P) - Risks which are the result of issues related to those individuals involved in the engineering of solutions.
- Technological (T) - Risks which result from the technology being used to engineer the solutions. This involves the software, hardware and frameworks used.
- Requirement (R) - Risks which result from changes to the requirements of the project. Examples of such being a requirement being dropped from the scope or a requirements priority undergoing a change.
- Estimation (E) - Risks which result from ill estimations of the project timing, capabilities of an individual or understanding of a certain technology.

ID	Risk	Risk Type	Description
R-P1	Textual Title of Risk	People	Textual Description of the Risk
R-T1	Textual Title of Risk	Technology	Textual Description of the Risk
R-R1	Textual Title of Risk	Requirement	Textual Description of the Risk
R-E1	Textual Title of Risk	Estimation	Textual Description of the Risk

7.2.2 Risk Identification

ID	Risk	Risk Type	Description

R-P1	Illness	People	Particularly important due to current events surrounding the Covid-19 pandemic. If an individual falls ill during the implementation of the solutions this could cause contributions to the project to cease temporarily.
R-P2	Conflict of Timing	People	Events within the personal lives of the contributors could cause a temporary cease in addition to the solutions. This could be due to requirements for other courses or personal emergencies.
R-P3	Lack of Experience	People	The technologies involved in the project may be unfamiliar to those involved in engineering the solutions. Time has been taken to familiarise the contributors with the tools however a lack of understanding could cause temporary problems in achieving objectives.
R-T1	Loss of Project Documents	Technology	Currently important documents pertaining to the project are being stored both locally and in multiple online cloud storage services. There is still a risk of some progress being lost even with the protections of version control however. This could range from either minor inconveniences to large setbacks.
R-T2	Service Downtime	Technology	The system currently relies on the services of Github for hosting the project. In the event of downtime with this service progress on the public web will be temporarily slowed.
R-R1	Requirement Changes	Requirements	The system as it is planned currently could undergo changes to its requirements set. This is a possibility in both the early and late stages of the project.
R-E1	Time Estimations	Estimations	The current planned timings for the

			project have a possibility to be found inaccurate. This can be beneficial to the project as areas may require less time to implement than intended however it is equally likely that not enough time is allocated. To counteract this the time given to each task is generous.

7.2.2 Analysis of the Risks

This section includes the analysis of the identified risks associated with the project.
Each requirement was assessed on three main criteria, these being:

1. Probability - The chance of a risk affecting the project at any stage.
    a. Very Unlikely
    b. Unlikely
    c. Possible
    d. Likely
    e. Very Likely
2. Consequence - The resulting impact on the project of this risk, assuming the worst.
    a. Insignificant
    b. Tolerable
    c. Serious
    d. Catastrophic
3. Priority - The importance of monitoring for this risk.
    a. Low
    b. Medium
    c. High

ID	Risk	Probability	Effect	Priority
R-P1	Illness	Possible	Tolerable	Medium
R-P2	Conflict of Timing	Possible	Serious	High
R-P3	Lack of Experience	Unlikely	Serious	Medium
R-T1	Loss of Project Documents	Very Unlikely	Serious	Low
R-T2	Service Downtime	Very Unlikely	Catastrophic	Low

R-R1	Requirement Changes	Likely	Serious	Medium
R-E1	Time Estimations	Possible	Serious	Medium

7.2.2 Risk Planning

7.2.2 Risk Monitoring

7.3 Consideration of Professional, Legal, Ethical and Social Issues

7.3.1 Ethical Issues and Health Concerns

One of the identified risks associated with virtual reality specifically has been the ability it has to induce a form of motion sickness in the user. A study was conducted in an attempt to create an index for levels of motion sickness experienced by those who used virtual reality equipment [4].

7.3.2 Legal Issues

The solution as it will be implemented showcases a demonstration of the system by constructing a replica of the Mars environment. In order for this to be achieved the use of 3D models is required and in the case of any included 3D model the correct copyright must be respected for any assets that were not created by those included in the creation of the solution.

8. References

1. Cooper, N., Millela, F., Cant, I., White, M.D. and Meyer, G. (2021) 'Transfer of training - Virtual reality training with augmented multisensory cues improves user experience during training and task performance in the real world', PloS one, 16(3), pp. e0248225–e0248225. doi:10.1371/journal.pone.0248225.
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3. Google (n.d.). *Augmented Reality* *https://arvr.google.com/ar/*
4. *Kim, H.K., Park, J., Choi, Y. and Choe, M. (2018) 'Virtual reality sickness questionnaire (VRSQ): Motion sickness measurement index in a virtual reality environment', Applied ergonomics, 69, pp. 66–73. doi:10.1016/j.apergo.2017.12.016.*