الجامعة الأمريكية في رأس الخيمة
American University of Ras Al Khaimah

AMERICAN UNIVERSITY OF RAS AL KHAIMAH

SCHOOL OF ENGINEERING

SENIOR DESIGN PROJECT I

VR Lab

Team Members

Omar Irfan Khan	2013000987
Mohammad Eyad Masoud	2013001165

Senior Design Project Advisor
Dr. Abdul Halim Jallad

Department of Computer Science and Engineering

Academic Year
2016-2017

Acknowledgment

Firstly we would like to express our deepest gratitude to our senior design project advisor Dr. Abdul Halim Jallad who guided us and gave his invaluable advice throughout the project. Without his guidance we may have not been able to go down the right path of development and are indebted to him.

Also, this project would not have been initiated/accomplished without the commitment, resiliency and endeavor of each member. Moreover, we would like to acknowledge the diligent senior design project committee for providing us with the project templates and a step by step explanation of how important each phase is.

Furthermore, we would like to thank our parents who supported and encouraged us throughout this project which kept us persevering and patient during this project.

Abstract

Our dependence on the usage of fossil fuels has significantly increased since the gusher age. Middle East is the largest producer of crude oil and United Arab Emirates (UAE) plays a major role in the production of crude oil. Unfortunately, only three universities out of two hundred universities in the UAE teach petroleum engineering at the undergraduate level. Nowadays, we can see various products derived from fossil fuels such as polymers, petrol, natural gas, chemicals (insecticide) and many more. These products would not be available without the practical experience they gained in the laboratories and the workplace. We aim to enhance this hands on involvement by incorporating virtual reality in education. The definition of virtual reality (VR) is derived from both the words ‘virtual’ and ‘reality’. The definition of virtual is near and reality is what we experience as human beings. In technical terms, VR is the terminology used to describe a three-dimensional, computer-generated environment which can be explored and interacted by a person. The person becomes a part of this virtual world or is immersed within this environment and is allowed to perform several actions.

Keywords:

Virtual Reality (VR), Education System, Petroleum Engineering, United Arab Emirates (UAE), Fossil Fuels, Petroleum, Laboratories.

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Executive Summary

Middle East is the largest exporter and producer of crude oil as compared to other regions. Mainly Saudi Arabia and UAE are the main countries which export crude oil. However, UAE has only three universities that offer undergraduate petroleum engineering to students. Therefore, people who want to go in petroleum engineering are usually diverted to other fields either due to the demand capacity of students a university can accommodate for petroleum engineering has been met or for financial reasons. Regardless, the oil industry in UAE are forced to hire foreigners to work instead since the locals do not have enough experience or appropriate training.

In this project, a Virtual Reality (VR) laboratory will be made to tackle this issue head on. We aim to create a system that makes it easy for any academic institution to teach petroleum engineering for undergraduate students since buying laboratory equipment's especially for petroleum engineering is very expensive. Moreover, this will be an inexpensive way to teach students and train them appropriately.

This project will be regulated through two semesters where we need to take into considerations the summer period between spring 2017 and fall 2017. In the first semester we will conduct researches about different parameters such as what standards to follow, what VR headset to use, ethical dilemma and constraints on the system. During the second semester we will start the implementation of laboratory and make incremental deliveries of prototypes until the final design.

During the research phase, we have read, acquired and comprehended information about the requirements and looked for relevant components that could help ease our road in development of the laboratory. Furthermore, we looked at all the possible alternatives and chose the most suitable component that best fits our prototype. In addition, after deciding which component to use we decided to look if the components are locally available.

We established some milestones and decided to implement a VR laboratory that provides undergraduate petroleum engineering students to carry out various experiments such as the Soxhlet extraction.

Our heartiest thanks and deep gratitude is to given to our senior design project coordinator / advisor Dr. Abdul Halim, to the respected senior committee members and to people who have contributed or will contribute to the success of this project.

Keywords: Virtual Reality (VR), Soxhlet extraction, Crude oil, UAE, Petroleum engineering, undergraduate students.

1 Chapter 1: Introduction

1.1 Problem Statement and Purpose

Petroleum engineering is the least available major in the UAE. There are many reasons this major is not being taught in universities and one of the main reason is the accessibility of laboratory equipment. This project aims to tackle this issue by making the equipment available to the students in virtual reality. Thus, eliminating the needs of purchasing expensive laboratory equipment and making any university one step closer to teach this major.

1.2 Background

Virtual reality (VR) had existed since the 1960s but during the 1980s the excitement of VR had died down. Mainly due to the limited amount of computing power and display technology at that time. Up until 2012 an entrepreneur by the name of Palmer Luckey made a VR headset called the Oculus Rift that had solved some of the problems that proved unsolvable back then. In 2016 HTC Vive was released. Since it's a relatively new technology, VR is being amalgamated in gaming, films, construction, sports and museums.

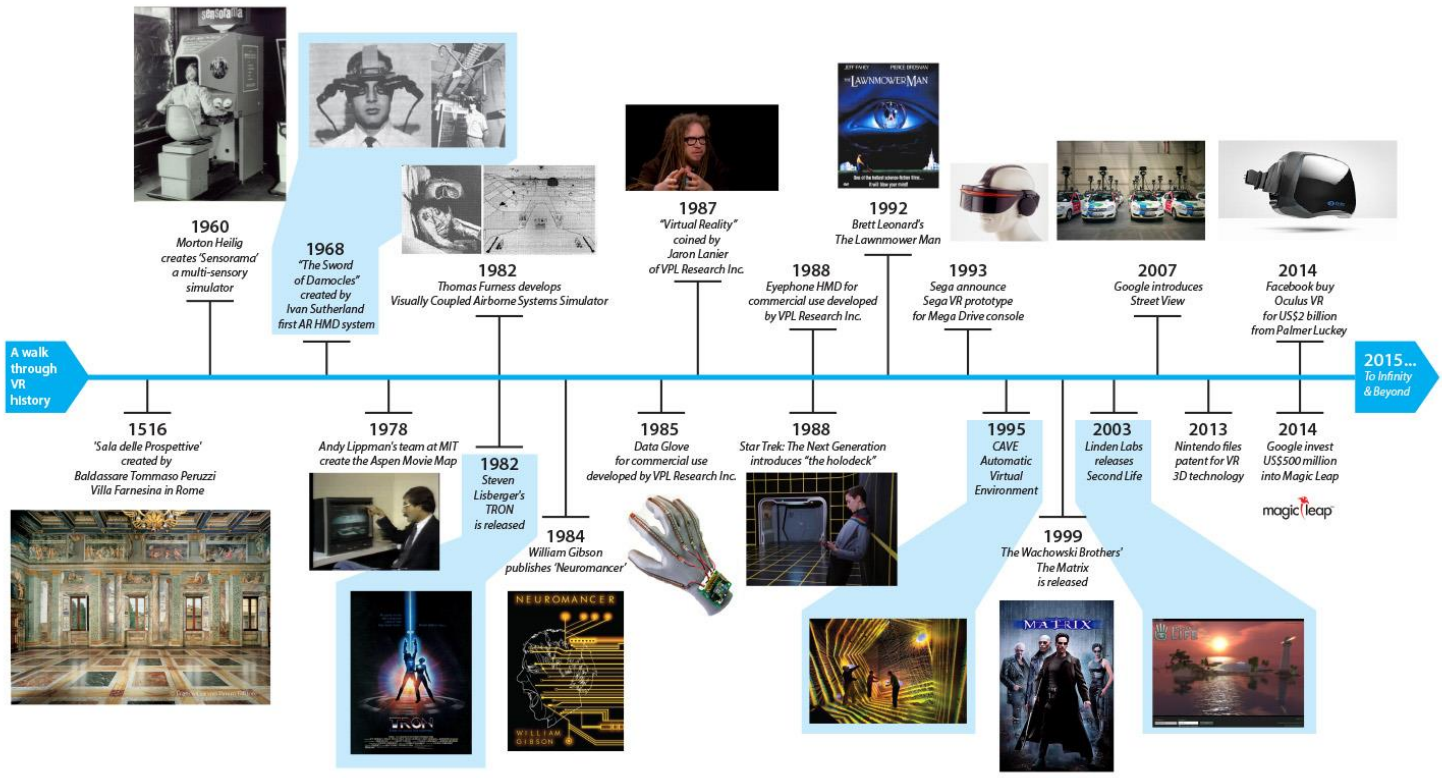


Fig. 1 VR History

1.3 Aims and Objectives

The aim of this project is as follows:

To design and construct a laboratory in VR which provides the user with accessibility to use various apparatus such apparatus such as Steady state gas permeameter and porosimeter (Poroperm) or the soxhlet extraction which is designed to extract a compound which has limited solubility from a solvent. This simulation can be utilized by academic institutions and as well as the industry to train their employees.

Objectives:

- Develop the relevant apparatus for the laboratory so it can mimic and show the desired results if the user was using this equipment in real life.
- Construct various sprites and lightning models to create the perfect atmosphere.
- Maintain the memory and graphics usage to optimal levels.
- Develop rigidbodies and mesh colliders for interacting in the virtual environment.
- Retain a solid 60-75 frame per seconds (FPS) as well as consistently outputs at the desired resolution of the head mounted display (HMD) refresh rate.
- Create a user interface (UI) on one of the controllers so that the user can decide what action to perform.

1.4 Summary of Report Structure

The report is divided up into six sections:

- Chapter one of the report covers the existing problem that has negative effects on academia. Then, stating the purpose of constructing such a system for the problem. Afterwards, discussing the background of the technology we have incorporated in our project followed by the project objectives that need to be satisfied.
- Chapter two provides an overview on how relevant is our project as compared to the research that is being done, to the preferred market and how this project can relate to ethics and environmental issues.
- Chapter three discusses the introductory design of the project in details which consists of the project stipulation, the design process, legal aspects, design constraints, design standards, design alternatives and safety considerations.
- Chapter four comprises of the economic and ethical aspects of our project in terms of the projected price, code of ethics, ethical dilemmas and the relevance to the environment of UAE and the region.
- Chapter five contains the management procedure of how the project has been partitioned into various phases the project has gone through, the estimated required budget, quality and risk management.
- Lastly, chapter six summarizes the deliverables produced along with the plan in senior II. Additionally, the references and appendices are also mentioned here.

2 Chapter 2: Background Literature and Market

2.1 Relevant Literature Research

Since this topic is fairly new the amount of research papers are very limited. VR has been used for education by various organizations such as Gamar, Google Expeditions Pioneer, Program, Unimersiv, Immersive VR education and many more. Immersive VR education claim that students of all ages usually retain 10% of what they read and 30% of what they see. Using VR in education enables students to store more information as more senses are involved in the learning experience [1].

Additionally, one of the applications the organization has created is Lecture VR which allows us to recreate any lecture or record any live lecture to be replayed infinitely [2]. NearPod is another one of these tools that allow teachers to engage students with interactive lessons [3]. Furthermore, Google Expeditions Pioneer Program provides the necessary tools for a teacher to take their students on a field trip to virtually anywhere. It could be to the coral reefs or the surface of Mars in the afternoon [4].

2.2 Target Market and their Need

VR has various applications in real life such as construction, healthcare, sports, films, education, courtrooms, automotive manufacturing, shopping, military, telecommunications, business and many more.

These application provide companies a better solution for their problems and it would provide them with better products, that's why big companies are also our target markets along with academic institutions.

2.3 Potential ethical or environmental issues

When an innovation is made, ethical concerns are always raised with a specific end goal in mind that is to utilize this innovation in a manner that helps human values like freedom, opportunity and life. Some of the potential ethical issues include dependency on the system, vulnerability and inequality.

3 Chapter 3: Preliminary Design

This chapter elaborates more on the design of the project as well as its prototype including specifications, alternatives that could have been used, standards and constraints.

3.1 Design Specifications

Our laboratory will be designed to achieve the required specifications:

1. Allows user to interact with 3D objects in the virtual environment.
2. Provides user with accurate results after performing Soxhlet extraction or Poroperm.
3. Maintains a record of the amount of outputs and tested variables in VR of the following experiment
4. Provides tools to plot a graph of the data and to monitor gas flow, pressure, temperature, solubility and much more.
5. Allows users to walk around the play area and see their limbs moving in real time.

3.2 Design Process

3.2.1 Definition of the problem

To create a laboratory for petroleum students that allow will allow the user to carry out various experiments such as Soxhlet extraction or Poroperm.

3.2.2 Identify Criteria and Constraints

- **Criteria:**
  - The system should provide an easy, intuitive and simple interface to the user.
  - The objects must be fully integrated with the scene and easy to manipulate by the user.
  - The system must produce reliable results, produce relevant sounds of the equipment and can handle user faults.
  - The system should be durable and registers appropriate hand gestures via the lighthouse (camera towers)
  - The system should meet the required standards.
- **Constraints:**

  There are several constraints such as the allotted time period, available budget, delivery of the components, scarce market materials, the space for the play area, and the HMD is tethered to the rig.

3.2.3 Identifying design components

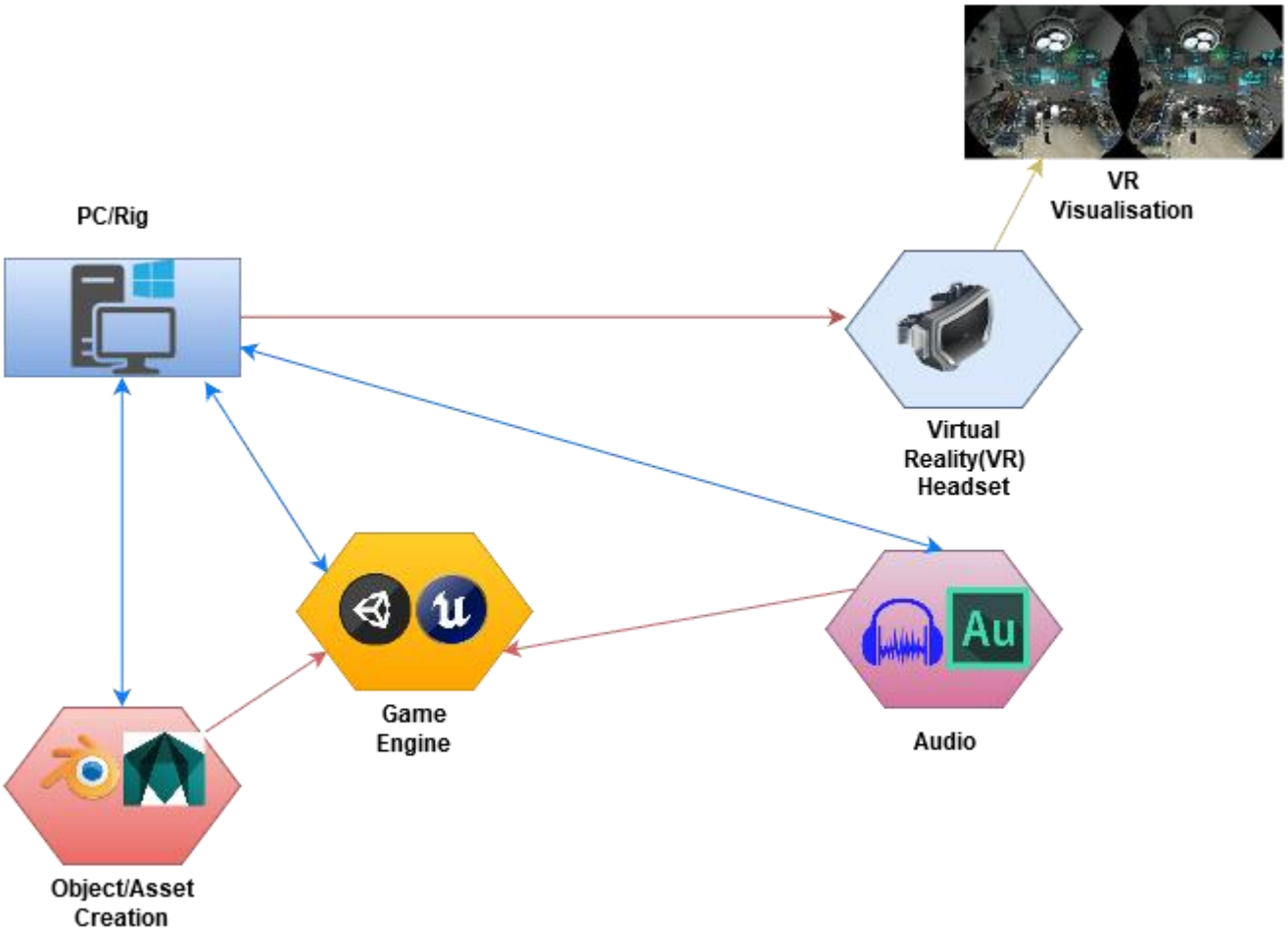


Fig. 2 Block diagram of the system

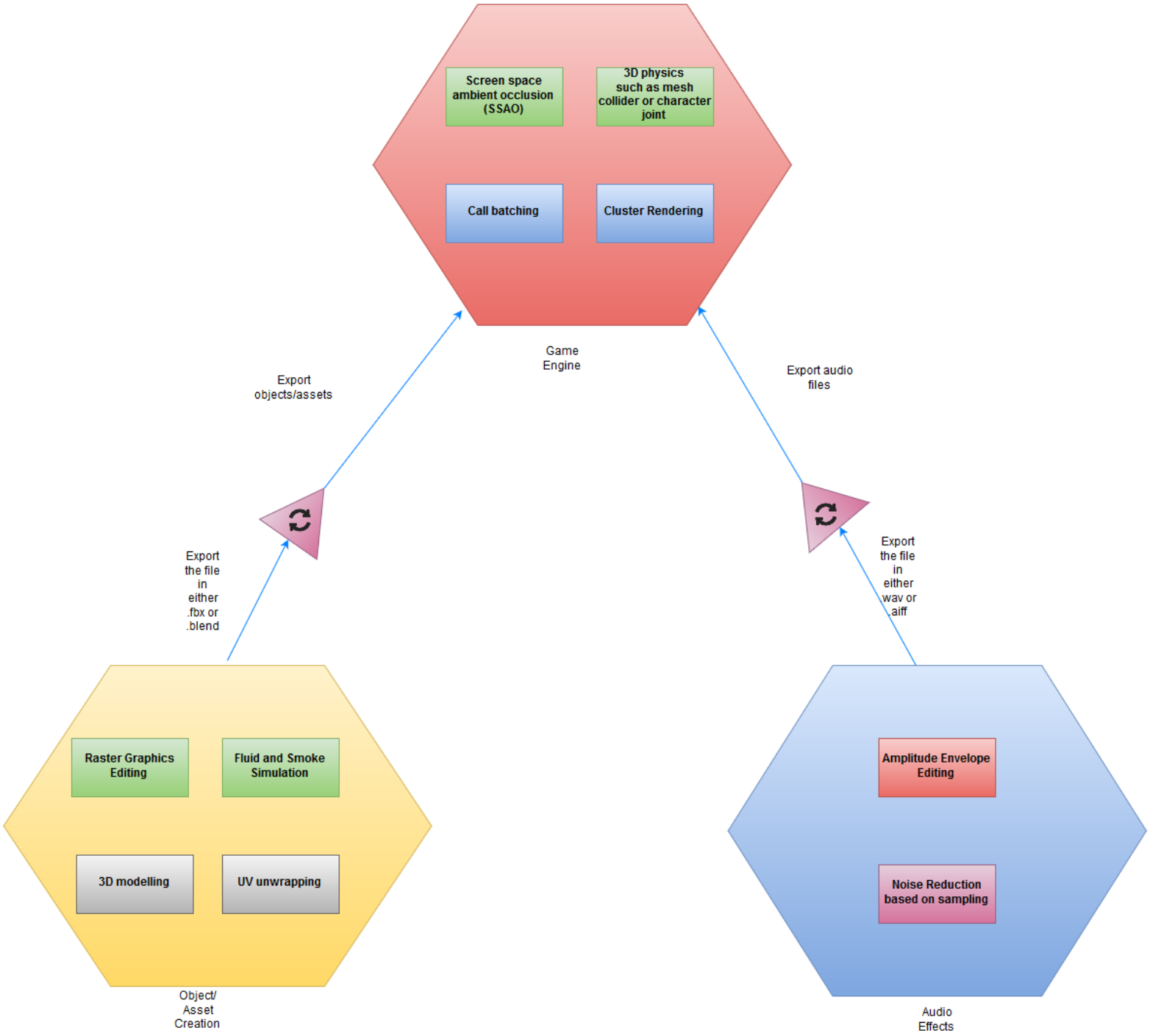


Fig. 3 Diving into details (Block Diagram)

- **PC/Rig:**

  A relevant PC/Rig will be used which is capable of running a VR system.

- **VR Headset:**

  A VR headset such as the HTC Vive or the Oculus Rift will be used.

- **Game Engine:**

  An appropriate game engine will be selected depending on which headset we are going for. Moreover, the game engine will combine the assets and audio into one scenario and optimize the game such that it will run smoothly on VR.

- **Object/Asset Creation:**

  Blender and Maya are the main software's that will be used to create assets and then export the assets to the game engine

- **Audio:**

  Various sound effects will be created to either warn the user or mimic the sounds that are usually made when the experiment is conducted.

3.2.4 Available and alternative solutions

The system relies on five essential constituents which are: VR headset, object/asset creation, game engine, and sound. Based on our research we decided which components meet our design requirements and specifications. Although, there are numerous alternatives for each constituent.

- **VR Headset:**
  - Using different VR headsets such as Oculus Rift, HTC Vive and Playstation VR.
  - Using VR headsets that support mobile devices such as Samsung Gear VR, Google Cardboard and Google Daydream.
- **Object/Asset Creation:**
  - Utilizing software's such as Blender, Maya, Sculptris, ZBrush, Mudbox, 3D Coat, Wing 3D, Equinox 3D, 3D crafter and Modo.
- **Game Engine:**
  - Various game engines such as Unity, CryEngine, CopperCube, Unreal Engine, Amazon Lumberyard and Torque3D.
- **Sound**
  - Software's such as Audacity, Audiowwise, Adobe Audition, Wavosaur and OcenAudio can be used.

3.2.5 Decide a Solution (Selection)

The main competitors though are the Oculus Rift and HTC Vive. Oculus Rift boasts a field of view (FOV) of 110 degrees and refresh rate of 90 Hz just like the Vive and more than that of the PSVR. We decided to go with the Vive since it has more functionality as compared to the rest and provides a comprehensive development environment as compared to Oculus.

Blender and Sculptris are the main contenders that best fit our project unlike the other software's which are paid such as ZBrush, Mudbox, Modo and Maya. Although, Maya and ZBrush are professional tools blender can do most of the things in modelling and animation just like Maya. Therefore, we decided to choose blender.

Unity and Unreal are both great engines to make games in VR. But sadly, unreal is more focused on making the game/application stand out via its graphics and its less user friendly than Unity. We decided to stick with Unity.

For choosing an audio effects software we chose Audacity instead of OcenAudio since we do not have experience in creating audio effects and Audacity is friendlier for beginners and meets exactly with our project objectives and specifications.

3.3 Legal Aspects

Since our design constitutes of mainly software's such as Blender and a few hardware equipment such as the HTC Vive, the design does not necessitate or cause any security or legal breaches to the UAE regulations or to the Middle Eastern region.

3.4 Design Constraints

The HTC Vive has to be tethered to the PC and its cable length is only about 5-6 meters. Moreover, VR headsets are too expensive right now and not many people are willing to spend $2000 on such devices. In addition, people do not always have a big open space available to play in.

On the other hand, blender has unintuitive layers system and a sluggish view port performance with high poly scenes. Rigging is also a bit clunky but doable.

Furthermore, Unity has most of the features locked since you have to pay for it. Also, performance problems may be hard to locate, address and fix since you are usually dealing with black box (no code or very less code is used) and there is no multi-threading.

3.5 Design Standards

To design the laboratory reliably and credibly for other people by specifying what standards are going to be used. The standards that we are going to follow are American Petroleum Institute (API) and American Section of the International Association for Testing Materials (ASTM International). These standards clearly state on how to perform each test and what are the guidelines for each procedure.

3.6 Design Alternatives

- VR Headset

It has been a difficult choice to choose between Oculus Rift or the HTC Vive. Oculus tries to make the setup process as simple as possible but it is rather drawn out since Oculus requires two USB 3.0 ports; one for tracking the camera and another for the headset [5]. Unfortunately, neither of the headsets listed above provide any way of interaction with the virtual world which limits your virtual reality experience to only two senses that is sight and sound. They all have to use a controller. Fortunately, the Vive provides motion controllers to interact with the virtual world while you traverse through it making you use three of your five senses: sight, sound and haptics/touch. Recently Facebook announced Oculus Touch which gives controllers and allows interaction with the environment just like Vive's motion controller does. But it will be released in december 2016.

- Object/Asset Creation

There are various software's to use but the ones that most stand out in the inexpensive category are blender and sculptris. Since blender has more similarities to maya and more robust than sculptris we decided to go with blender.

- Game Engine

The alternatives are Unreal, CryEngine and Torque3D. We decided to go with Unity since it has a more user friendly interface and more simple programming languages to use such as boo which is very similar to python and C#. Although, Unreal supports C++ but unfortunately making a script is a bit more complex in Unreal since you need to create a blueprint first and assign a set of parameters to the variables.

- Sound

There are many software's available but mainly the ones that are free are Audacity, OcenAudio, and Wavosaur. Audiowwise and Adobe Audition are both for professionals and very expensive. Whilst, both software's provide a lot of tools to use unlike Audacity or OcenAudio. But in the end, what matters is the ease of use and Audacity is really easy to use.

3.7 Safety Consideration

Our design does not impede with the safety standards issued both by the petroleum engineering standards and the facility. However, Vive users need to be careful when they move around in the play area since Vive does not indicate if the user is about to hit any object in real life to the user. Moreover, long usage of Vive may cause dizziness or motion sickness in some individuals. The rig may heat up if it is not properly cooled which may cause the video card or any other component to malfunction.

4 Chapter 4: Economical, Ethic and Contemporary Issues

4.1 Preliminary Cost Estimation and Justification

The whole system's hardware will cost about 11000 dirhams (Approx. $3000). Our system comprises of two parts: HTC Vive and a high end PC. The programming will be done from scratch in Unity, it will be written in C# using the Visual Studio (VS) IDE which come as a plugin for Unity.

Component	Cost	Figure
HTC Vive	3800 AED	
High Specification Computer: CPU: Intel Core i5-4590 equivalent or greater Graphic card: NVIDIA GeForce GTX 970 /AMD Radeon RX 480 equivalent or greater Ram: 4GB+ of RAM	7300 AED	

Table 1 Price Estimation

4.2 Relevant Codes of Ethics and Moral Frameworks

This system is like any application, It has some technical issues and need maintenance between time to time, the main failures that could happen is a broken in Glass, also lens should be cleaned frequently,

Moreover, the HDMI cable can get damaged as it is not that durable over the years and for the PC it should be clean from inside because Graphic need to cool properly or overheating may occur.

As undergraduate students of American University of Ras Al Khaimah, and as future engineers of the community, we trust that morals and good acts are what make a specialist enlists the abilities that has been picked up to satisfy the requirements of the group. Hence, amid the execution of this venture, we have the ABET Code of Morals of Designers as our moral structure and standards. Important focuses are:

The Fundamental Principles:

Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by:

1. Using their knowledge and skill for the enhancement of human welfare;
2. Being honest and impartial, and serving with fidelity the public, their employers, and their clients;
3. Striving to increase the competence and prestige of the engineering profession; and,
4. Supporting the professional and technical societies of their disciplines

The Fundamental Canons:

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

4.3 Ethical Dilemmas and Justification of Proposed Solution

Some people may claim that they are placing the companies that provide petroleum engineering laboratory equipment out of business since every experiment is being done in VR. This in turn increases unemployment of those people working at such organizations.

4.4 Relevance to UAE and Region (Social, Cultural and Political)

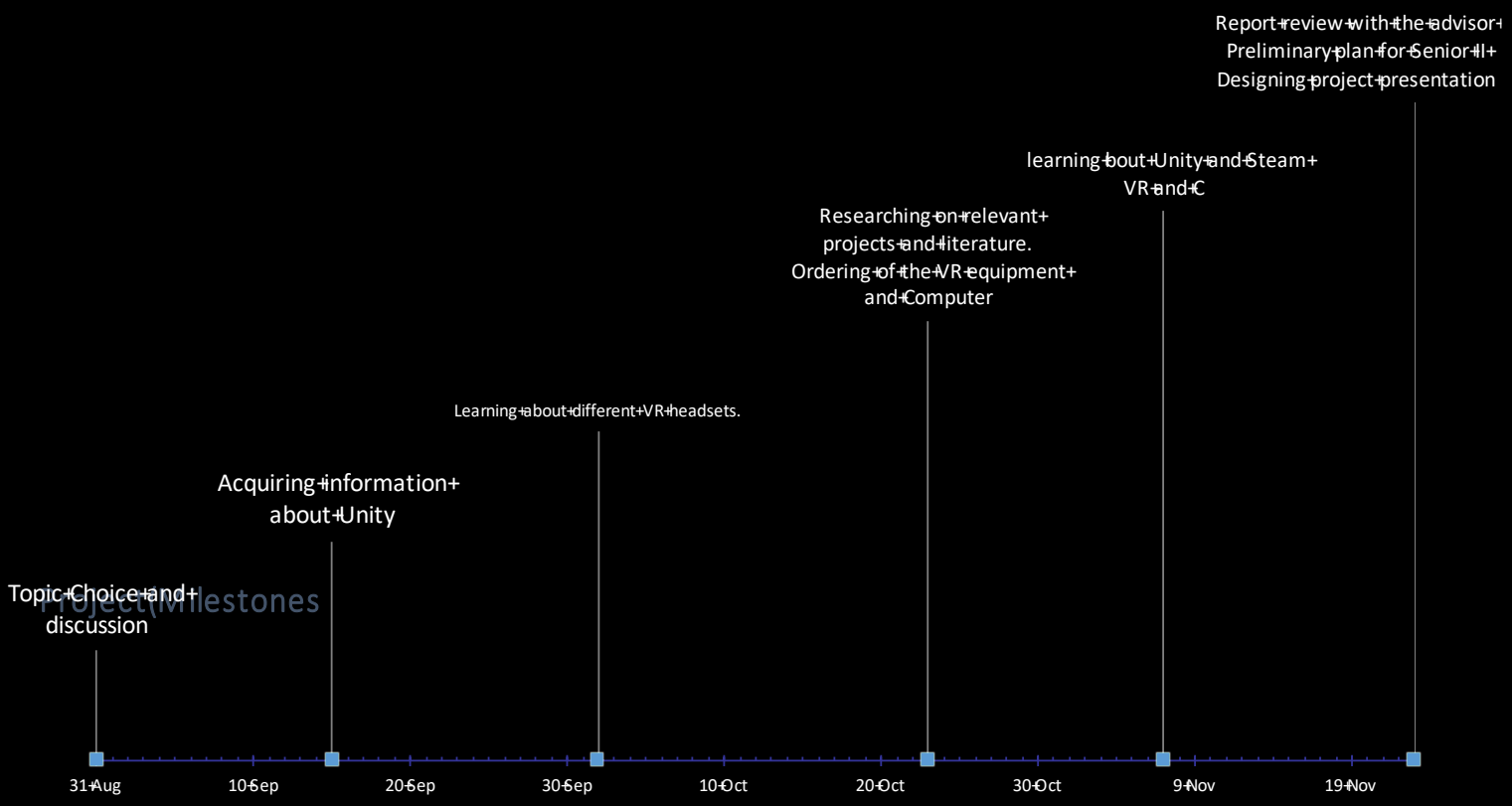
Middle East is the largest oil exporting region in the world. UAE comes behind Saudi Arabia and other regions while exporting oil but it plays a vital role in exporting of oil. Sadly, UAE has scarce institutes that teach petroleum engineering in the undergraduate level. It is mainly due to the fact that the laboratory equipment are really expensive. The acquisition of a PoroPerm apparatus would cost around 500,000 AED. Moreover, a proper laboratory needs to be constructed which abides to the guidelines of both ASTM and API.

5 Chapter 5: Project Management

5.1 Schedule and Time Management

In august of 2016 the scheduling of the project started as the initial step. The scheduling included the time frame agreed upon which contained 6 sessions to maintain our time and keep it well managed. At the end of August, the first session commenced to start the topic choice and brain storm some fresh ideas for our project. The discussion was fruitful with many brilliant ideas, we discussed the possibility of basing our project on VR (Virtual Reality). The discussion led to various methods as to which we will base our Project on, whether it will be in Architecture or Medical or even Industrial Engineering. At the end of our session we decided to continue in the Petroleum Field. Difficulties have been faced at the beginning of the project in order to overcome the learning curve. The minutes of each meeting and what each member of the group should work in were kept weekly. Noting that was really helpful in terms of organizing each member's tasks. Then, the proceedings in these tasks are to be discussed in the next meeting. The minutes of each following meeting were highly noted and discussed in later meetings. The workflow was very successful and our collaboration to succeed in this project was our main concern. The phases of project development are shown in the next page.

Project(Timeline



Date	Milestone	Assigned(To	Meeting
8/31/16	Topic+Choice+and+discussion		1
9/15/16	Acquiring+information+about+Unity		2
10/2/16	Learning+about+different+VR+headsets.		3
#######	Researching+on+relevant+ projects+and+literature. Ordering+of+the+VR+equipment+ and+Computer		4
11/7/16	+learning+bout+Unity+and+Steam+ VR+and+C		5
#######	Report+review+with+the+advisor+ Preliminary+plan+for+Senior+II+ Designing+project+presentation		6

5.2 Resource and Cost Management

The project resources and materials where vital to our plan. We maintained the limited budget by choosing between different types of VR's and Computers. First, the best option that suited our needs for this project while maintain the cost management is the HTC VR and a Desktop Computer (Please see below for the specifications). The cost estimation for the needed resources were successful and well kept within our project budget.

Final Design Component	Cost
HTC Virtual Reality (VR)	3800 AED
PC: Desktop with CPU: Intel Core i5-4590 equivalent or greater Graphic card: NVIDIA GeForce GTX 970 /AMD Radeon RX 480 equivalent or greater Ram: 4GB+ of RAM	7300 AED
Total Price	1100 AED

Table 2 Final Price

5.3 Quality Management

The goal of this project is to meet the needs of the customer/user. The project should be of high standards and should meet with the consumer's expectations. Quality management can be divided into two subsections that are: quality assurance and quality standards.

Firstly, we will make a plan on how to verify quality assurance by listing down all the reliable companies that can provide our constituents in a high quantity for a limited budget.

Secondly, to maintain the quality standards of the project we will purchase only equipment's that are verified and sold from trusted vendors.

5.4 Risk Management

The majority of VR headset manufacturers have set age limits. Samsung's Gear VR and Oculus Rift have a 13+ age rating. While, Sony's PlayStation VR had a 12+ age rating. Although, HTC Vive does not have an age limit written, the developers do warn against allowing children to use the HMD [6]. Also, while using VR people should take care about how they move about in the play area since the VR headset does not warn if you are about to hit a wall or a table.

5.5 Project Procurement

Acquisition of the components are going to be done via online platforms since it is inexpensive. Axiom Telecom is a local online shopping platform that has a reliable and reasonable period of delivery for the requested products, so we decided to choose the HTC Vive. They claim that the delivery period takes from 1 to 2 business weeks and the payment will be on delivery including the delivery charge. The PC has to be either assembled or ordered depending on the budget and time allotted.

5.6 Lessons Learned

Throughout this project we have stumbled at some phases while other phases have been very productive. First and foremost, researching has made us gain information about the current state of the art VR headsets available or being made. Furthermore, it made us realize how VR is a disruptive technology and will change the face of not only industries, but also academic institutions.

In addition, we realized that combining all the elements together in a game engine is easier said than done. Since the object may get some loss during the conversion to import as an asset or worse yet corrupted.

One of the most important things we learnt was that time management and teamwork skills play a vital role during this stage and will significantly increase during the onset of the senior design project. We have learnt how to distribute tasks among team members and how to bounce ideas of each other during brainstorm sessions.

6 Chapter 6: Conclusion and Plan for Senior Design Project II

6.1 Restatement of purpose of Report and Objective

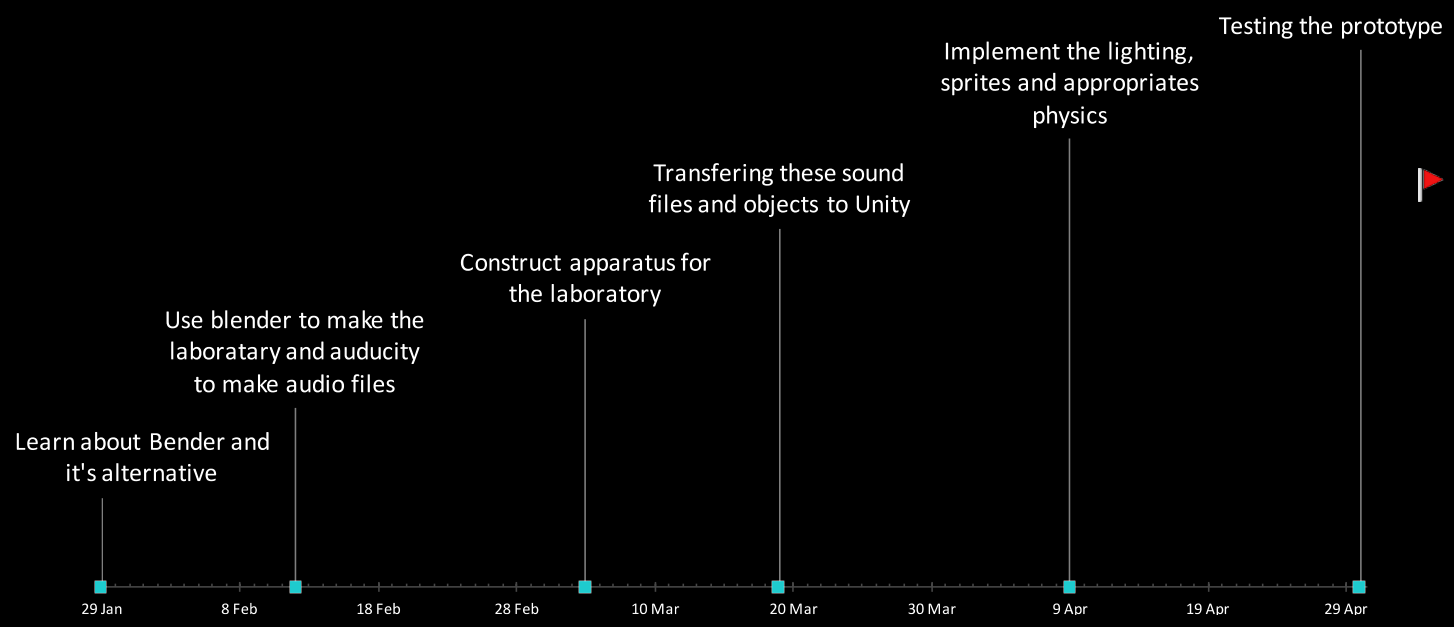
The purpose of the VR lab is to make petroleum engineering more accessible for everyone in the UAE. Most of the students end up doing another field or a related field such as chemical engineering. Moreover, this project aims to improve the way on how petroleum engineering is being taught and make the learning more hands on. Furthermore, this project is feasible since it is affordable and you get the same experience as if you are using the real equipment rather than buying the laboratory equipment. There is a need of such projects in the markets. The system design will consist of the following components:

- HTC Vive + PC.
- Blender, Audacity and Unity.

6.2 Restatement of proposed deliverables

In senior design project II, the implementation of the project will take place. The development phases are shown in the graph below:

Project(Timeline



Project(Milestones

Phases	Milestone	Position
1/29/17	Learn about Bender and it's alternative	1
2/12/17	Use blender to make the laboratary and auducity to make aud	2
3/5/17	Construct apparatus for the laboratory	3
3/19/17	Transfering these sound files and objects to Unity	4
4/9/17	Implement the lighting, sprites and appropriates physics	5
4/30/17	Testing the prototype	6

6.3 Future Work

There are always room for improvements. The project can be improved by adding more equipment's such as a Pressure, Volume and Temperature (PVT) cell which is designed to study the thermodynamic and phase behavior

of black oil and gas condensate samples. Also, we can add a heating, ventilation and air conditioning (HVAC) system so that the laboratory mimics like the real lab and the user will be cautious while experimenting. Moreover, we can add a multiplayer interface where the student can interact with their lab instructor.

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