**Project Proposal**

**Motivation and rationale**

Newcastle University possesses a CAVE virtual reality suite, which is both a highly valuable and massively useful piece of equipment. However, its use is presently being disadvantaged by certain features of the current system.

The main problem at the moment is that most users of the suite find it very difficult to operate. This can often lead to problems, rendering the hardware unusable until a technician is available to attempt to resolve these difficulties. In the event of this, it can be particularly awkward to determine the fault given that there are simply so many possible features or elements that could have malfunctioned and consequently this can be a very time-consuming job.

* Many of these issues are caused by the proprietary tracking system that is currently used, as there is the potential for the license files to be lost, at which point they must be retrieved from the server before the system can proceed.
* Likewise, the current system is somewhat complex to develop for as well. This is because it requires stereotypically ‘hardcore’ programming languages to function, meaning that any users with just a general knowledge of programming may not be able to understand their use.
* In the same way testing programs for the system can be particularly tricky as it generally isn’t possible to run the CAVE version of a program elsewhere, meaning that the CAVE itself must be used for testing.

Taking all of this into consideration I believe that the solution is to develop a new system for the suite. By completing this project I will be allowing the suite to be used to its fullest potential and maximising the investment that the University has made in acquiring it.

The overall need that is being addressed by this proposal is the necessity for a single, unified and easy-to-use system. By implementing this it will not only be the commonplace users that will benefit, but also the technicians that overlook its use, as well as developers creating content for the suite. This is because an easier to use system will lead to fewer problems arising and thus fewer cases where a technician is required to restore use of the system. Similarly, a streamlined development pipeline will, in turn, make it easier to develop models and environments for use within the CAVE.

Another motivation for this project is that it will give me the opportunity to develop a system with certain capabilities that are beyond those of the existing one. If it is conceivable for my system to work through a web browser then that will simplify the pipeline even further; developers will require no knowledge of memory allocation or C/C++ in order to create content for the suite.

This is desirable as it will make the technology much more accessible for those who may wish to create something for the suite but simply don’t have the knowledge, resources or time with which to do so. By creating a system capable of working through a web browser I would be giving these users a simpler alternative with which to create their desired content.

This particular project is attractive to me as it will give me a substantial insight into the sector of virtual reality, allow me to develop my understanding of graphics and also give me knowledge and use of several technologies that are paramount for a career related to video games.

**Aim**

Through this project I aim to develop a toolset for the CAVE virtual reality suite, in order to run projects and studies easily

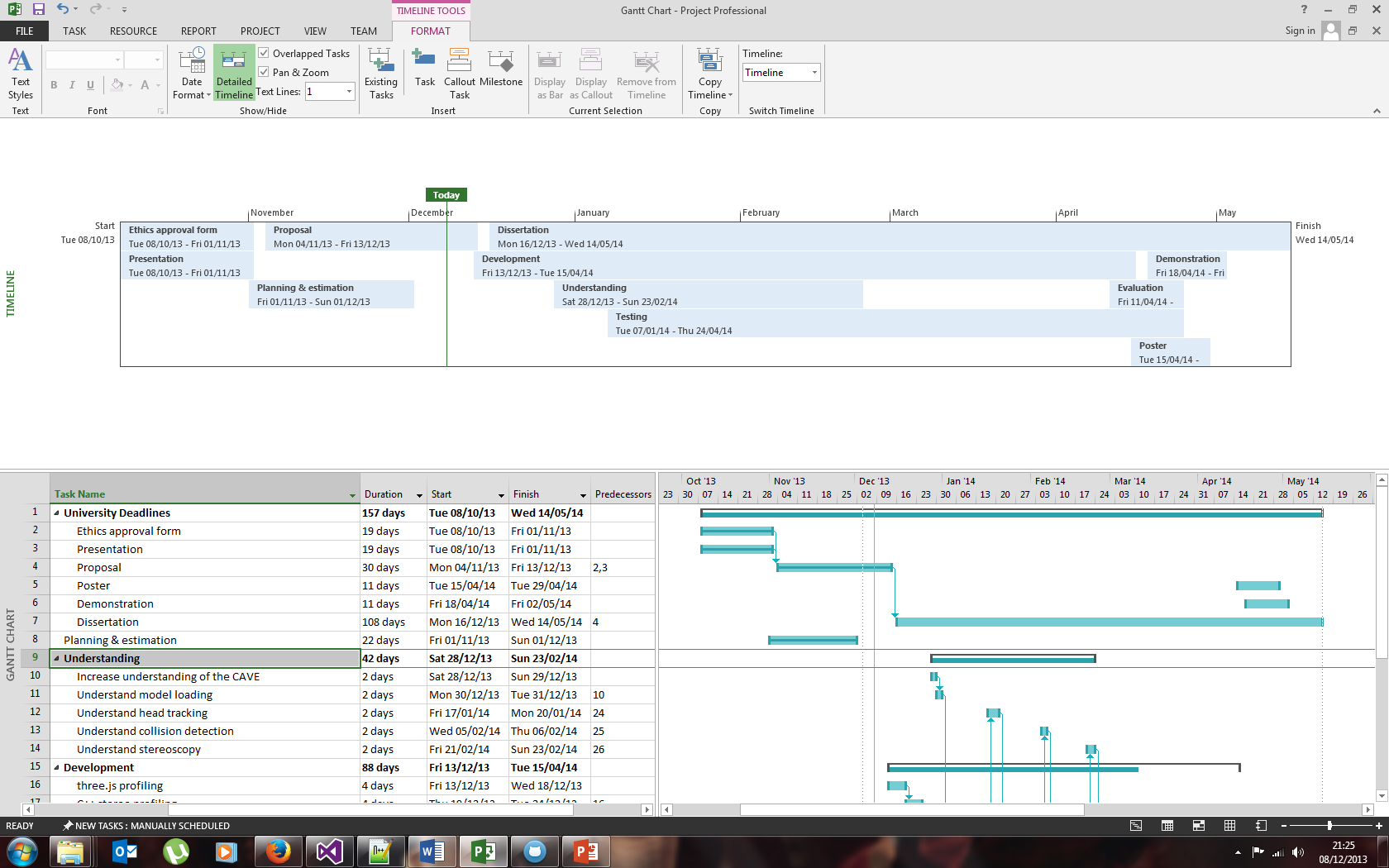
**Objectives**

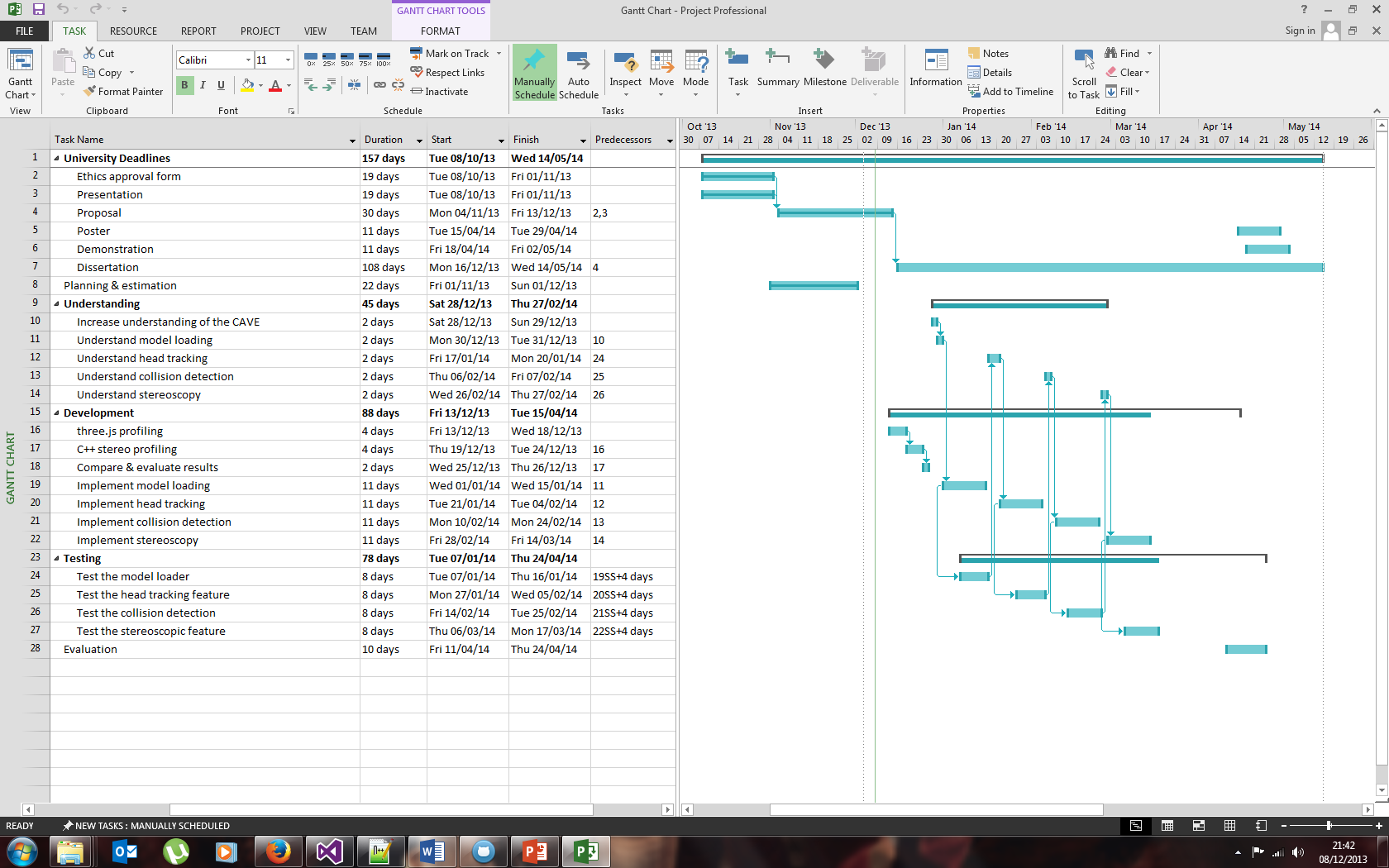
* Create 3D architectural visualizations that can be navigated and explored using the VR suite
* Increase the share-ability of the CAVE through the use of the web and open source technologies
* Develop my toolset as open source so that there is the potential for other users to modify or add to the toolset at a later date
* Integrate head-tracking and collision detection when available in order to provide an immersive experience
* Support the loading of 3D models of various types to ensure that the toolset is widely useable
* Ensure that the system is capable of displaying stereoscopic images so that motion parallax and depth can be achieved
* Provide logging of user interaction so that the suite can be a suitable location for psych studies and demos

**Background**

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| Source | Summary | Explanation |
| Phil Heslop [1] | * Senior technician * Oversees use of Newcastle University’s CAVE virtual reality suite | As it is Phil who is in contact with the CAVE suite most of the time, I intend on consulting with him at regular intervals throughout my project in order to ensure that my solution is meeting the requirements for the system. I also anticipate discussing the success of my solution with Phil with regards to him giving his opinion on the share-ability and usability of the system, as they are relatively subjective characteristics and so the impression from someone with a detailed knowledge of the current system will be highly valuable. |
| CQ3A (Cave Quake III Arena) [2] | * Quake3 renderer * Developed specifically for the CAVE | Commonly known as the “Hello World” of virtual reality, this is the engine currently in use within the University’s CAVE. It is sufficient for producing 3D models, however it is also commercial software that is now relatively dated and restricted. |
| CAVELib™ [3] | * Virtual reality software API * Provides a platform for creating interactive three-dimensional environments for use within a CAVE | This is proprietary software that is currently used within the CAVE. It governs the task of ensuring that all of the images rendered are stereoscopic and also that these graphics are displayed correctly across each of the CAVE’s screens. My project will essentially involve me re-writing this API for a modern system. |
| WebGL [4] | * JavaScript API * Can be used to render both two and three-dimensional graphics within a web browser | This is the web equivalent of OpenGL that makes it possible to render graphics on the web without the requirement for any plug-ins. Also, like OpenGL, it is open source meaning that it is highly accessible and documented. It is relevant to my project as it’s likely that I will be using WebGL in order to implement my solution, due to the fact that it contains the features that will allow me to create a toolset meeting the requirements for this project. |
| three.js [5] | * JavaScript library * Can be used to create and display three-dimensional graphics within a web browser. | This library is important as I intend on using it in conjunction with WebGL as it is lightweight and also open source. Again, this means it is extensively documented and supported, ensuring that it is both future proof and can be understood by those without any advanced programming or graphical knowledge. |
| [6] | * A research paper that describes how the use of virtual reality can be beneficial in locomotive design | This paper is relevant to my project as it describes one possible application of a CAVE system that is similar to one of the intended uses of my toolset, providing 3D architectural designs. It outlines using the 3D visualisation technology and stereoscopic immersion that can be achieved using a CAVE in order to design and model trains. This highlights the importance that my toolset meets the two objectives relating to these two features, as this will ensure that it can be used for a variety of purposes, such as the one outlined in this paper. |
| [7] | * Outlines a research use-case for a CAVE system * Explains the possible benefits of using virtual reality for research | The paper describes the bespoke use of a CAVE system in order to provide physical rehabilitation exercises for patients with rheumatoid arthritis. This is relevant because one of the main aims of this toolset is to enable the CAVE to be easily used for research, meaning it should be feasible for someone to develop, using this paper as an example, a series of interactive exercises that can be displayed within the CAVE for participants to complete. |

**Diagrammatic work plan**





**Explanation of work plan**

In order to get a more concrete understanding of the features and requirements of the toolset that I will be creating, I have already conducted a semi-structured interview with Phil Heslop to determine how the current system functions and also any improvements that could be made. As Phil has a lot of experience with the suite and the technology used he has a detailed knowledge of what the end solution should comprise.

As well as this, I’ve spent time researching into WebGL and three.js so that I have a greater knowledge of their use and capabilities. In particular, I have spent a relatively significant amount of time investigating whether or not it will be possible to create a system capable of producing stereoscopic images, with WebGL and three.js in conjunction with the projectors within the university’s CAVE. This is because there are currently certain limitations with regards to WebGL, namely the fact that it is based on OpenGL ES2.0 and as such it doesn’t support quad-buffering.

This missing technology is paramount in displaying stereo images and consequently the only way to display stereoscopic images in WebGL currently is via a workaround. This involves adding two cameras to the scene and defining the width as half of the original, which results in the scene being displayed twice, side-by-side. At this point you must define a coefficient to slightly alter the view of each scene, representing the distance between your eyes. Finally, when displayed on a 3D capable TV or monitor, each successive frame will be taken from the other scene, resulting in a stereoscopic image.

Despite this being a tangible and technically sound solution to the problem, it is hindered by the fact that the projectors within the university’s CAVE do not support side-by-side loading. As a result, my supervisor and I have continued to investigate this area in order to discover if there are any other potential resolutions to the lack of quad-buffer support within WebGL. Currently there has been the suggestion of a hybrid solution that would consist of a WebGL and three.js implementation that would be running in conjunction with a relatively small C or C++ program which would take the images being output from three.js and then essentially ‘piece’ them back together in order to achieve a stereo image.

Throughout my project I intend on using an agile software process model. This is because I will be implementing various features into the toolset one at a time and certain tasks have the potential to take less or more time than initially planned, due to any issues that I may run into during development. A process model such as SCRUM allows change with ease and will ensure that my project can be organised and sufficiently planned.

Another benefit of using an iteration and sprint focussed cycle is that I can constantly have a working prototype available and frequently demonstrate this to Phil in order to receive feedback, like a sprint review meeting. In that sense, I am seeing Phil as the product owner with this toolset. We will also be able to discuss any impediments that may have arisen during the iterations work.

As you can see from my Gantt chart, I have divided each intended feature into three distinct stages: understanding, development and testing. This has allowed me to visualise the various dependencies that some of my tasks have, for example I must successfully complete the relevant understanding task for a feature before I can begin to develop and implement this feature into my system. Similarly, development work must have started on a feature before I can possibly perform any testing of the feature. I must then complete the testing of a feature before I progress to the next understanding task.

In general I have anticipated that it will take 2 days in order to understand a particular feature. Following this, I have allocated 2 calendar weeks in which to develop the feature. I then plan to begin concurrently testing the feature once it reaches ~50% completion, which I estimate will take 1 calendar week. This allows for development and testing to be completed close to each other, ensuring that I won’t be left with large testing tasks after completing a feature before I can proceed with the next.

With regards to potential risks during my project, I intend to follow the basic premise that if a feature is taking too long to develop, i.e. it has overrun the planned implementation time, then I will simply place that feature on hold so that I can then continue with another feature unobstructed. I will then be able to revisit any particularly complicated features at a later date. I believe that this is a thoughtful plan as it will ensure that upon completing my project I have a working end solution, rather than potentially having a system which doesn’t function at all if I were to spend too long on a troublesome feature.

**References**

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