Spacewarp VR Visualisation

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Development Team: Thomas Young , Marco Morroni , Paulius Bleksa, Beth Foxcroft

Client: Kenneth Mitchell (Disney Research)

Final Project Report

April 25th, 2018

Summary of Contents

This document contains all records pertaining to the management, planning and creation stages of the Spacewarp VR Visualisation project for Disney Research client Kenny Mitchell.

The document will begin with a background of the project, outlining the plan for the project and how we would go about completing these tasks. It will also go over any initial ideas that we had for the project and which ideas did (and didn't) make it into the final build of Spacewarp VR Visualisation.

The document contains a reference to the project's PID including the scope, project limitations, and risks of the project development process. This document will also include information about the specific project management techniques that were used throughout the planning and developing process including the software we used to track progress, the Agile Methodology and weekly sprint reports that were kept over the duration of the project, and some of the PRINCE2 methods used.

Ultimately, this document will discuss how the project met its' original aims and goals, how usable the system is, any technical limitations the system may have, as well as any possible improvements that could be made in future versions of the project.

Background

Aims

Our aim was to create a virtual reality data visualization environment in which the user can view, interact with, and find patterns in the data. The data was to be plotted on to a cylinder with the user placed in the centre to give the user clear 360-degree view of said data. Once in the environment, the user would be able to view attributes of a data point separate from the X/Y axis of the graph. Users would also be able to take advantage of a document lens that created a central viewpoint and distorted peripherals in order to allow the user to more easily focus on a smaller range of data points.

Scope

The Scope of the project remained fairly small leaving a lot of flexibility in the project thus the original scope was altered slightly as the project moved through its development. Some features were added that were not originally intended and some features removed that were no longer feasible given the time frame [Refer to the results section of the document for details concerning change]. The original scope of the project involved achieving the following;

- Data visualisation in a 3D space utilising VR
- Representing 2D data on a 3D object such as a line or bar graph and allowing the user to view the data visualisation in a 3D environment.
- Drawing the data visualisation onto the inside of the cylindrical object in which the user will be stationed in the centre. This will allow the user a full 360-degree view of the data.
- Allowing the user to zoom in on the dataset using the previously discussed Document Lens technique, or “Spacewarp" effect in order to view the data more closely and analyse it in much greater detail.
- Include a main-menu feature in which the user can choose to view certain types of Datasets.

Context

The context of the software will be written as seen from business/Data analytics perspective.

The software has the potential to be implemented into any office environment in which data visualisation is used to understand data. Some uses of data visualisation in the business case include: demonstrating trends in the market, value of current assets and income/expenditure graphs. Our team believes that this software package could aid in the understanding of data like this and big data due to the VR environment allowing for a more all-encompassing view of data that is beyond that of what can be displayed on a screen.

From the data analytics perspective, the software has the potential to aid in stock market analytics. Assuming live data could be displayed the analyst would be able to scrutinize data at a low level due to the additional attributes of a record being displayed upon selection. The comparison of things like stock price, the percentage of growth, or even investment risk factors would also be made much easier. The Document lens technique further enriches the functionality of the software by allowing the analyst to view small sections of the data up close. This would bring the advantage of allowing the analyst to see much more minute patterns and anomalies in data and possibly identify patterns more easily.

Limitations

Limitations that were placed on this project come in the form of practicality and time constraint. Concerning the former, full three-dimensional data visualisation is considered impractical due to the increased number of visual channels. Although these can be used to convey additional data attributes doing so often leads to the user becoming overwhelmed and unable to gather the desired information from the dataset. It is for this reason that we limited the actual visualisations to a 2D plane plotted around the cylinder as a pose to having the user placed directly within the data.

As for the latter, the time required to write the logic behind the generation of multiple different visualization techniques is considerable. It is for this reason that we have chosen to limit the number of data visualisation methods to two. A scatter plot and a bar chart Given the limited development time frame for the project is a feasible goal. Our data set followed a similar constraint. Gathering, Compiling, Cleaning and preparing the data along with implementation

and testing becomes very time-consuming. Especially considering each data set would contain five hundred to a thousand records. Also taken into consideration is attribute types as certain attributes cannot be visualised in the same way as others (i.e. Nominal and numerical data) meaning more varied attribute types would have required the team to implement different visualisation methods which as mentioned earlier the time frame did not allow for. It is for these reasons that we decided to visualise only a single data set using only two different techniques.

Results

Changes To original Scope

Due to our use of the SCRUM Agile Development Methodology, there were sometimes changes in the scope of the project with some planned features being added and some removed. This section will document all deviation from the original scope and the final end goals agreed upon. Omitted will be intermediary features that were not part of the initial scope but also not present in the final deliverable.

Our original scope [see scope above] stated that the main menu screen was to be available for the user to select different data sets to visualise. However, due to the time limitations placed on the project [see limitations above] the decision was made (in conjunction with the client) to remove the menu scene from the list of planned features and move the switching of visualisation techniques to a toggle button. Doing so saved the team a lot of time by avoiding the Design and Implementation of a menu interface whilst still allowing the user to switch between visualisation techniques.

An extension to the scope was added mid-development that allowed the user to select certain data points and have more attributes of that data point displayed to the user in some way. This was to extend the use of the software past simply viewing patterns in data points and possibly allow the user to identify relationships, correlations and rules present in the data.

Test Results

The testing method that our group chose to use was an iterative one. The project had three deliverables each with increased functionality when compared to the last. Once a deliverable had been met requirement testing was carried out on the new features implemented as well as already existing ones. This was to ensure that adding new features to did not affect the functionality of the features already implemented. APPENDIX C - Testing records

Goals achieved

This table lists the end goals agreed upon there priority and the actual outcome of that end goal.

Goal	Priority	Outcome
Generate Data visualisation from a data set.	HIGH	COMPLETED
Have multiple visualisation methods available	MEDIUM	COMPLETED
Data visualisation is displayed in a 3D environment onto a cylinder	HIGH	COMPLETED
The user is placed in the middle of the cylinder in a VR environment	HIGH	COMPLETED
Implement a document lens that allows the user to view data points more closely	HIGH	COMPLETED
The lens has variable zoom	HIGH	COMPLETED
The lens has variable peripheral distortion	MEDIUM	COMPLETED
Implement a laser pointer that allows the user to select specific data points	MEDIUM	COMPLETED
Display additional attributes of the selected data point to the user	MEDIUM	COMPLETED

[For an in depth breakdown of tasks and achievements see APPENDIX D - Technical Documentation and Sprint Tables

Project Management

Time Management

Before we began work on the project, we discussed the tools that we would use in order for us to communicate, track progress and manage our resources. We began planning back in December, before the project had even began. We used Slack to communicate over the course of the winter break, coming up with ideas on how we should run the project, suitable timeframes and potential meeting times where we could discuss our ideas in greater detail. It was at this stage where we decided to organise a Project Gantt chart. We created it on the 6th of January in order to pre-empt the workload (APPENDIX B - Gantt Charts). We had decided that we wished to use the Agile Methodology in order for us to split up the tasks and easily manage progress and client expectations. We would split up the project into milestones, each consisting of various weekly sprints.

We split up the project's development timeframe into 4 milestones. At the time that we created this Gantt Chart we were still to find out exactly what it was we were being asked to do, project scope and boundaries would remain unclear until we had our first client meeting. Despite this, we still wanted to pre-empt the amount of time it would take for us to reach the end of each milestone. To aid this, we wanted to make our milestones reasonably close together and also include a Stretch-Goal milestone and Beta Test milestone in order for us to complete the project in time and still have time to spare if we were to run over.

After we were given our project scope, it became clear that the tasks we had been asked to do were reasonably simple. The beginning of the project would prove to be the most time consuming due to us not having a very modern point of reference, we had to spend a bit of time trying to visualise exactly what it was that the client wanted us to do. We knew that after we had an idea of what was being asked of us, the rest of the project would be reasonably simple. So to remedy this, the first milestone would take the longest amount of time.

It was discovered that once we had completed the first milestone, the required tasks for the second milestone were much easier to implement than originally thought, so this allowed us to half the amount of time that it took us to complete it. This was especially useful as due to complications within the team, we were currently behind schedule according to our original Gantt Chart. This was not a problem though, as we had already planned for project delays, and

the 4 weeks we had set aside for Stretch Goals and Beta testing, could instead be used for completing the final milestone.

By the time we had completed the 2nd milestone, we still had around five weeks left of development time, and due to the 3rd milestone requiring chiefly UI and graphical changes, we could half the overall development time that it would take us to complete it.

In summary, the 3 milestones were designed to be completed in half the time as the last, so the first milestone took six weeks, the second milestone took 4 weeks, and the final milestone took 2 weeks. This time management technique meant that we were in no way rushed when it came to concluding the project, and as an added bonus, we were able to meet all of our intended goals. Unfortunately we were not able to accomplish any of our stretch-goals, however, the client has expressed their satisfaction with the current version of the project.

Resource Management

As stated before, we as a team had decided to use a variety of tools in order to help keep track of progress and decrease overall development time. We utilised Google Drive in order to keep our resources and documents organised and Github to store our project code.

Everyone shared responsibility when it came to organising the Google Drive. The team was split up into different smaller teams who had their own folders. Certain folders would contain either documents or project files such as assets or concept art. With these files being kept in an orderly fashion, it made it simpler for the team to navigate and find important files that would aid in the development of the project.

One very important feature of Google Drive is the addition of Google Docs, Google Sheets and Google Slides. We used these programs extensively when logging all progress made throughout the project. For example, when we first started our Project Initiation Document, we uploaded it to Google Drive and shared it with the entire team. This meant that we could update the document in real time and even work on two separate parts of the document at one time. What's more, we sent a version of the PID to our client who was able to suggest edits and leave comments at certain parts of the document. This was incredibly useful as it meant that we were able to pinpoint areas of the document that needed to be changed or improved.

Google sheets were also very useful in the creation of the Project Gantt Chart. Because it was stored on the Google Drive, it meant that everyone in the team had access to it and could map the project's progress. A copy of the Gantt Chart was also sent away to the client which they could look at that. Because this chart was constantly being updated, it meant the client could see what phase of the project we were currently working on.

In terms of software development, we opted to use git as our main VCS of choice through the use of Github. Initially, Marco and Paulius were tasked with the development of the document lens meanwhile Tuisku would tackle the data generation. This meant that it was very important that any changes made to these parts of the program were kept in separate branches until they were finally ready to merge at the end of each milestone. Tom, our SCRUM Master, was in charge of the weekly sprints as well as managing the Github repo initially, however, after Tuisku left the project, Tom was forced to help with the development of the data which meant that the task of keeping the Github Repo up to date fell to Marco and Tom.

Before we began development, Tom decided on a set of coding standards. A google document was uploaded to the Google Drive which the developers could view and make changes to if they wanted. This document would prove to be very useful as it would help the software developers understand each other's code. The document made sure that the developers used the same naming conventions and software structure as previously agreed both in the document and during team meetings.

Evaluation of Project Management

Looking back at the project, we feel that it was handled and managed very well. There are a few factors that lead us to believe this.

Firstly, we had planned on starting the project as quickly as possible, as early as December 2017. This meant that all the time spent in the first week of the project could instead be spent trying to figure out what tools we should use, questions to ask the client, even the coding standards and conventions we would use.

Because of this head start, it meant that we were able to begin development much sooner than some other teams. We already knew that we would be working with VR inside of Unity 3D,

however none of the developers knew how to use it, so they spent the winter holiday testing out VR in A 3D environment.

Secondly, we had planned ahead for possible shortcomings such as issues within the team and even problems with acquiring the VR hardware. In order to counteract any potential issues relating to team abilities, we created an initial Gantt chart that would allow for 4 weeks of additional development time if we needed to use it. This was especially useful when Tuisku left the project halfway through development, meaning that we would have to spend the time we had saved for bug fixing and completing stretch goals, completing the agreed project scope.

Another instance where time management was incredibly well planned was when the software development team first tried working on the document lens. Because this was an incredibly difficult and complicated part of the project, it took up a lot of time and resources, this did eat into the time of our second milestone, however, the time frame allowed for additional leeway.

Gantt Chart Comparison

Finally, a comparison between the Initial Gantt Chart and the final edition of the Gantt Chart should be noted. These can be seen in APPENDIX B - Gantt Charts.

The Initial Gantt Chart w/ Milestones showcases the start and end points of the three milestones.

Milestone 1: 29/01/2018 - 19/02/2018

Milestone 2: 19/02/2018 - 05/03/2018

Milestone 3: 05/03/2018 - 19/03/2018

Software Development was meant to start on the 22nd of January and finish on the 15th of April.

Compared to the Initial Gantt Chart, development began on the 28th of January, a week after the project was initially scheduled to start. This was because we had some issues trying to finalise the project's Scope and understand exactly what it was the client was looking for

The first milestone began on the 28th of January and was completed on the 15th of February. This meant that we were now ahead of schedule however it was originally hoped that we would complete the first milestone a week before as the project scope seemed relatively small.

The second milestone began on the 15 of February and was completed on the 15th of March. This was problematic as it meant that our 4-day project lead was now cancelled out and we were now technically running behind schedule. This was due in part to Tuisku leaving the project, meaning we had to restart the data generation side of the project from scratch.

The third milestone began on the 15th of March. Even though we were behind schedule this was not a problem as it meant that we could instead use the time we would have spent working on stretch goals could instead be focused on completing the final deliverable. Admittedly though, the third milestone took longer than initially expected. The main cause for this was due to the fact that it was during the Easter break and we had another very important deadline due for the week we went back to University. This meant that we finally completed the project on the 19th of April, exactly one month after we initially planned on completing the project. This left us a few days to bug fix and add additional features to the project before demonstrating it live.

In summary, even though the project did hit various roadblocks and delays, we were still able to complete all of our intended goals set out in the PID and include a few extra features that the client seems to be very happy with.

Conclusion

In the conclusion, we feel the project has been a tremendous success. Due to well-planned project management, a reasonably small scope, and a long development time frame, we have been able to meet all of our intended targets without having to cut or reduce the original scope.

The client has expressed their satisfaction with the finalised product and will be receiving the most up to date version of the project alongside this report. As an added bonus, we have been asked to co-author a technical paper which will be getting published through Disney Research, we do not have a title as of yet, however, we know it will be based around the idea of how Virtual Reality can aid the reading and understanding of data.

The final version of the project has gone through a number of tests. We have created test plans in order for us to make sure that newly implemented features are working correctly. We ran test plans after each milestone to make sure that no major bugs had occurred, that way we could continue onto the next milestone without fear of having to change or completely redo certain parts of the project. Additionally, to make sure that no new bugs were occurring after each milestone, we iteratively tested the entire project so that if new features had caused bugs in the older parts of the program then we could identify them easily. A good example of this occurring is when we began working on the third milestone. A strange bug occurred where whenever the user activated the laser pointer, it would warp through the lens, causing a strange peripheral distortion effect that actually negated the effect the document lens was designed to achieve. This was quickly addressed and fixed before the end of the final milestone.

Though the project does work very well, there is one bug that we were unable to fix. We believe that this bug is more to do with the Steam VR API instead of our code. The bug in question occurs whenever the user tried to activate and then deactivate the laser pointer. When the user turned it off, they would find that the trigger did not allow them to turn the laser pointer back on again unless the “Home” button on the HTC Vive controller was pressed. After the user did this, they could turn the laser pointer on and off without any issues. It was a very strange bug, however, it does not have any real consequence on the final product.

Though the project itself is not entirely system intensive, Virtual Reality devices cannot be used on all PC’s at this current moment in time. This is in part due to the graphical limitations of most office PC’s, and even though we can make our project as efficient as possible, it still does not

mean that a PC's hardware is good enough to launch any kind of Virtual Reality Environment. This is a negative point on our project, however, we have no intention for this program to be used by non-industry professionals on low-end spec PC's. The target market for this project were data analysts who would already own top Spec PC's that are more than capable of running Virtual Reality simulations.

In summary, we feel that this project was incredibly successful, despite the technical limitations and minor bug we are proud of the product we have created and are excited to see what the client thinks when they get to try out the finalised version of Spacewarp VR Visualisation themselves.

Appendices

Appendix A - PID

[START OF PID]

Table of Content

Project Goals

Our aim is to create a 3D space where the user can navigate, inspect and interact with data from a dataset. This program will use Virtual reality devices such as the HTC Vive to allow the user a full 360 degree view of the environment and Unity3D to generate the space. Data will be mapped onto a cylindrical object around the user where it will showcase data from a predefined dataset. Within the program the user will be able to explore the data in greater depth, and expand certain elements using a Document lens technique which will create a central focus point whilst compressing the peripherals.

Scope

The overall scope of the project is generally quite small which allows for a lot more flexibility in terms of what could potentially be added at a later stage of the development process. As of right now however, the general scope include;

1. Data visualisation in a 3D space utilising VR
2. Representing 2D data on a 3D object such as a line or bar graph and allowing the user to view the data visualisation in a 3D environment.
3. Drawing the data visualisation onto the inside of the cylindrical object in which the user will be stationed in the centre. This will allow the user a full 360 degree view of the data.
4. Allowing the use to zoom in on the dataset using the previously discussed Document Lens technique, or “Spacewarp effect” in order to view the data more closely and analyse it in much greater detail.
5. Include a main menu feature in which the user can choose to view certain types of Datasets.

Approach

The approach we will take towards this project involves using the Unity 3D game engine to bring together assets that we have created in 3DS MAX in order to produce the space in which the visualisation will be experienced. The logic of the software will be written in C# using Visual Studio and the hardware involved will be the HTC Vive VR headset and controllers to allow the player to see, move and interact in the three dimensional environment. A Document lens technique will be modified to accommodate the “Space Warping” effect (similar to the following but with a circular lens **(Appendix A)**

Pre-existing Fish-Eye lens techniques use a very similar algorithm to the desired Document lens we wish to use. By reversing the effect of a Fish-Eye lens we could, in theory, create a crude Document lens which creates a foundation for us to work with and improve further. Tests of this kind of lens technique will be trialled in order to make sure that the data it being warped correctly, and once this has been done, we will allow the user to control the lens effect from the HTC Vive Controller, pointing and clicking in order to zoom in on the data.

In terms of Data Visualisation, we will create an algorithm to directly read data from a predefined dataset (.csv), we are currently looking at using data based on the Stock Market, including stock price of the FTSE100, NASDAQ, and DOW. We can then “cherry-pick” specific parts of the data. The clean data will then be run this through a mapping algorithm in order to create a fully realised Line Graph (or similar) be it using a shader, creating a high resolution 8K texture of the graph or by distorting and warping 3D objects within the environment.

Once the data has been correctly sorted and is accurately represented in some kind of numerical form, we will then move on to map the resulting graph onto a cylindrical object which wraps around the player, allowing them to look around and view more and more of the data as they rotate. If however the user does not want to physically move around, we will add a feature that allows the user to “move” the dataset around for them, constantly updating the Cylindrical plane in front of them. A mockup of the data visualisation mapped onto the Cylindrical object from the perspective of the user can be found here **(Appendix B)**.

Once the Data has been imported from a data set and mapped onto a 3D plane and the “Space warp” effect has been achieved, we will look at further improving the program. Various tools such as Faceting and zoom modifiers could potentially be worked in. The Facet tool would be

used to allow the user to reduce the number of entries in the dataset and view data that is more relevant to their needs. This feature would process the entire dataset and apply a sorting algorithm that could potentially be attached to a slider in order to narrow down the total number of results.

Another feature that could be added is a variable zoom for the “Space warp” effect. This would involve a slider mapped to the current zoom amount of the lens which the user can either increase or decrease in order to view the data in greater or lesser detail. Radius of the lens could also be increase or decreased to view more data at once.

Project Organisation

Mark Barton: Project Manager, In charge of communication with client, tracking and documenting project progress, and delivering final product.

Thomas Young: SCRUM Master, In charge of verifying all Pull requests, documenting sprints and milestone effectiveness, and generating test cases

Marco Moroni: Software Development/Git Version Control, In charge of enforcing Git standards and Github organisation, and UI/UX Design

Paulius Bieksa: Software Development, Works alongside Tuisku in order to create the software for the final deliverable

Tuisku Luminen: Software Development, Works alongside Paulius in order to create the software for the final deliverable

Beth Foxcroft: Artist/3D Modelling, In charge of rendered concept art, generation of multiple 3D assets, and UI generation

(Appendix C)

Business Case

The program has the potential to be used within various office spaces around the world. Hundreds of meetings use data visualisation in order to demonstrate trends in the market, value of current assets, as well as profit and loss accounts. We feel that this software can be used to further enhance a business's understanding of Big Data as VR will allow the user to view more information than on a standard computer screen.

We plan to make the software adaptable so that it can work with various different types of data, not only could the program be useful in an office meeting, it could also be useful to Network Engineers analysing current network data in specific areas around the world. With the ability to warp and zoom in on specific parts of the dataset, you can view vast quantities of data at once without switching datasets, a tool that is especially useful when Network Engineers have to view such enormous amounts of data, from bandwidth speed in a specific area, to ping, to total number of network outages caused by a specific problem back in 2011. This program can allow the user to view the most minute of details.

Another excellent example of users who have to view vast quantities of data at once include Data analysts who work primarily with the Stock Market. Tracking real time data is an essential part of any data analytics job, however the Stock Market is notorious for being wildly sporadic fast paced. An Analyst has to be able to scrutinise the data at an incredibly low level. The ability to view the data as a whole and then zoom in on specific parts of the dataset in incredible detail would greatly improve the Analyst's understanding of things such as comparing things like stock price, percentage of growth, or even investment risk factors. The Document lens technique further enriches the user's experience, allowing someone such as a stock analyst to view the data more closely, identifying anomalies,outliers, as well as patterns and relationships within the dataset.

Constraints

Software constraints consist of limiting the actual visualisations to a two dimensional plane. The modeling and art work required to implement such a feature would be incredibly time consuming and over all not worth the effort when considering the questionable usefulness of three dimensional visualisations. We will also be limiting the capabilities of the product to a singular visualisation technique i.e the product will only be capable of displaying 2-D visualisations such as a Line-Graph or Bar Chart and not 1-Dimensional charts such as pie charts, however this 2D data will be mapped onto a 3D Cylindrical object. The amount of time required to program the logic behind generating multiple types of data visualisation would be fairly time-consuming when considering the development timeline for this particular project. If, however, we find that we have time to implement any extra features including multiple datasets or visualisation techniques, we can explore these options but as of right now we do not see it as a feasible option.

As of the time of writing this document, we have a total of 12 weeks to develop and fully test the program. This time constraint means that many items we may wish to add to the project's scope may need to instead be added to the list of various stretch goals in order to complete the core concept in time and also deliver a few extra features if necessary.

Stakeholders

Ourselves (The developers)

The Client (Kenneth Mitchell)

Disney Research

Edinburgh Napier University

Risks

There is a possibility that the implementation of a special “zoom” effect like the Document lens may not be easily achievable. As this effect has not been created within Unity before (or at least has not been made available to the public), we may struggle to recreate the effect using C#, compared to the version originally supplied using C++.

Because we have very limited knowledge of VR implementation in Unity, we may find that the logic behind some features, such as gesture tracking, may be incredibly difficult to program as they require precise motion tracking and a lot of different mathematical equations.

A final risk of the project is the management of 3D assets. Because we will be using Github as our main method of version control, we may struggle with storing up to date 3D assets. Github is notoriously difficult when it comes to asset management and as such we will need to find a way to store the most up to date 3D assets for use in the project.

Project Controls

Each milestone is broken up into weekly sprints, these sprints will be used in order to plan the next step of the development process and make sure that all goals within the milestone are being achieved at an acceptable rate. The tasks will be completed in order of priority, otherwise time will be allocated to each task depending on it’s priority level. The progress of each sprint will be documented and then stored in a file within our shared Google Drive so that in time we can look back and track exactly what has been done. Google Drive will also be used to store all important documents for the project including scope, the PID, the Project Plan, Gantt Chart, and each person’s individual diaries.

To supplement this, we will use Trello boards to keep track of the progress of each department during the development stage. Each board has specific tasks assigned to the person in charge of that department, the cards can be moved from various lists in order for the project manager to see what is to be done, what is currently being worked on, and what has been completed. Some boards, such as the Software Development Board, will include a list of things that need to

be fixed. Software Development have a list called “Issues”. This list will display any and all things that need to be fixed before the next sprint is completed such as bugs and glitches.

Each week, we will hold a meeting on Friday at 1pm where we will discuss the progress of the sprint, any problems that occurred, as well as plans for next week’s sprint. The minutes of this meeting will be noted and then attached to the “Group Meetings” folder on the Google Drive. This document will include what plans we have in place for next week, what we should focus on, as well as any possible ideas that we could include in the project in the future.

Reporting Frameworks

Weekly Sprint Reports will be written up in order to track the progress on both the current sprint including who is working on what feature and what has been achieved, who and what feature is to be completed next as well as comments on certain elements of the project. Mark (Project Manager) will be in charge of making sure that all Sprint related documents are kept up to date so that they can be further summarised inside a “Milestone Report”.
Milestone Reports, like the Sprint Report, will track the progress of each Milestone, outlining any items or features that need to be further developed in future Milestones over the course of the project’s development.

Test plans will also be produced for each “completed” feature that has been submitted during each sprint following an agile testing process. Every time a piece of the project is pushed to the “development” branch, the entire project will be iteratively tested in order to ensure that no bugs or glitches have occured. Test plans will be written up by Tom (SCRUM Master) in order to make sure that these projects have been properly and successfully carried out, outlining any problems that may have been found.

Additionally minutes will be taken at each meeting that will help the group follow on from last meetings discussion at a later date, Marco will be in charge of keeping record of all minutes

Schedule

The dates for our Milestones as well as various other hand-ins have been added to a Gantt Chart, this chart will be used to track the current task we are working on. This chart is constantly being updated in order to keep up to date with the latest changes and revisions **(Appendix D)**

Sign Off

Project Manager Signature:

Client's Signature:

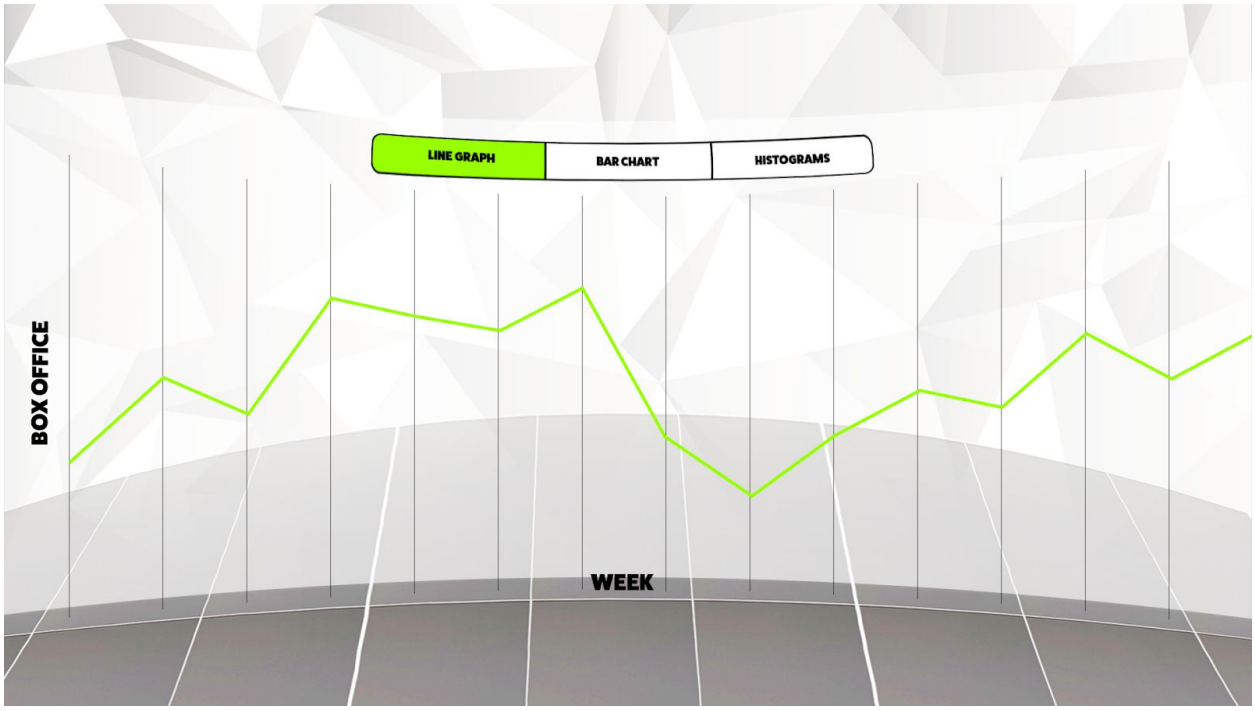
Kenny Mitchell

Appendices

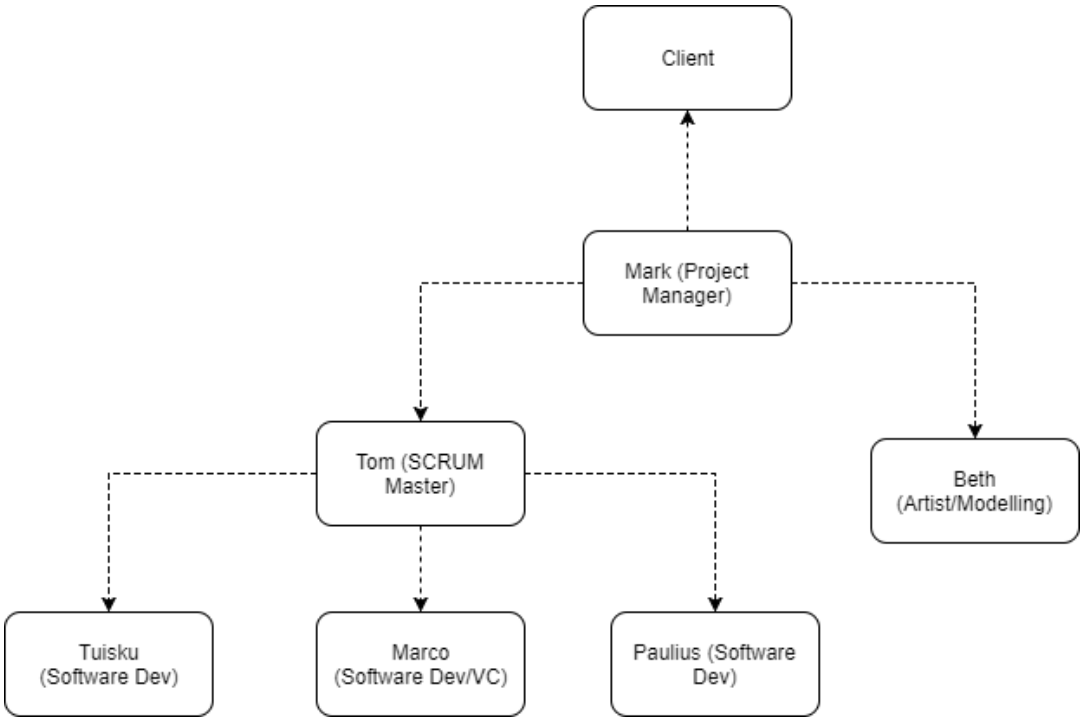
Appendix A (Document Lens)

http://aspoerri.comminfo.rutgers.edu/Teaching/InfoVisResources/images/visiontothink/infosphere/document_robertson/pages/fig3.htm

Appendix B (Draft Prototype of data visualisation)



Appendix C (Project Hierarchy)



Appendix D (Project Gantt Chart)

https://docs.google.com/spreadsheets/d/1dNsTRTjoE6WfB3HA0_z0N8SO258Cvso0_46TGuM1aCY/edit#gid=0

Appendix E (Learning Outcomes)

Paulius' Learning Outcomes:

While working on this project I intend to learn how to use the Unity 3D engine for developing three-dimensional applications, learn how to develop for virtual reality kits, in particular the HTC Vive, learn more about Unity 3D graphics pipeline and how to program shaders in said engine, research and implement ways of warping and manipulating camera perspectives in three-dimensional space and experimenting with recursive rendering techniques.

Tuisku's Learning Outcomes:
My main goal in this project is to learn to be a functional part of a development team. The project is heavily self directed and relies on research in to how to implement things unfamiliar to me which is a crucial step away from a small scoped university coursework to learning to create a real product for a client. As we are developing the product in Unity, it is also a chance to deepen my basic skills, which will support my degree in games development.

Marco's learning outcomes:
My goal is to improve my general Unity skills. I used Unity before, but only for very simple and basic projects. This project, in particular, will allow me to develop for VR for the first time.
I'll also work with Beth, therefore I'll need to learn how to import and handle assets properly in the engine.
My other goal is to refine my knowledge of Git version control, in particular with GitHub. I'll also try to guide people who are not confident with this tool and supervise how Git is being used throughout the project.

Mark's Learning outcomes
Throughout the project I would like to learn how to successfully manage a project. I have never been a project manager however I do have managing experience so I hope to harness my current abilities and integrate them into the development process.
I would also like to learn how to properly write a PID. Documentation is a strong point of mine but I would love to learn how to properly organise and create an official project document.
Lastly, I want to learn how to successfully organise a team, using tools such as Trello and Slack to manage time, resources and people in order to reach our goal. Throughout the project these tools could be especially useful.

Beth's Learning Outcomes
During the course of this project the main goal I intend to achieve is to gain valuable experience working and collaborating with a team comprised of various skill sets to produce one common goal. Having never worked with anyone outside of my own skill sets before I feel this is a valuable opportunity to try something new and explore a new upcoming industry that is Virtual Reality. Furthermore I hope to better understand the process of creating games and what my skill sets can offer to the team and process to make it successful. I also hope to further extend my 3D modelling skills in 3DS Max by creating various assets for the game and experimenting

with textures and lighting to give them the best results. Additionally, I hope to learn new softwares such as Unity to better grasp the process within designing and creating games as well as advancing my skills on lighting and texturing learnt in 3DS Max. Building on from Unity, I also hope to learn and understand the software development platform Github and how it is used efficiently within the gaming industry. And finally I hope to gain the overall experience of working within the games Industry to help me decide if it is something i wish to pursue career wise in the near future.

Thomas' learning outcomes

My learning aims for this project are to gain a greater understanding of the SCRUM agile development process and how it is implemented in a games development and how it differs when compared to industry deliverable software. As well as researching and applying an iterative testing process that best suits the aforementioned development method. Lastly I would like to further my understanding of version control and learn how to implement this more effectively in this and my future projects.

[END OF PID]

Appendix B - Gantt Charts

Initial Gantt Chart w/out milestones

	Start Date	End Date	Timeline	Status
SPACEWARP VR	08-01-2018	30-04-2018		Upcoming
Project Planning	08-01-2018	25-01-2018		Active
PID Hand-In	20-01-2018	29-01-2018		Upcoming
Sprint 1	27-01-2018	19-02-2018		Upcoming
Sprint 2	19-02-2018	05-03-2018		Upcoming
Work-In-Progress Report	01-03-2018	07-03-2018		Upcoming
Sprint 3	05-03-2018	19-03-2018		Upcoming
Beta Testing	19-03-2018	02-04-2018		Upcoming
Final Sprint	02-04-2018	15-04-2018		Upcoming
Final Report	15-04-2018	30-04-2018		Upcoming
		CURRENT PHASE		

Project Start Gantt Chart w/ milestones

	Start Date	End Date	Timeline	Status
SPACEWARP VR	08-01-2018	30-04-2018		Upcoming
Project Planning	08-01-2018	25-01-2018		Complete
Project Development	22-01-2018	15-04-2018		Active
Work on PID	20-01-2018	29-01-2018		Complete
Milestone 1	29-01-2018	19-02-2018		Complete
Milestone 2	19-02-2018	05-03-2018		Active
Work-In-Progress Report	01-03-2018	07-03-2018		Active
Milestone 3	05-03-2018	19-03-2018		Upcoming
Beta Testing	19-03-2018	02-04-2018		Upcoming
Stretch goals	19-03-2018	15-04-2018		Upcoming
Final Report	15-04-2018	30-04-2018		Upcoming
		CURRENT PHASE		

Milestone 1: Data mapped to the 3D plane, "Spacewarp" technique added to project, data being read directly from the dataset

Milestone 2: Second Dataset added, main menu added, UI with toolbar added, variable zoom and expansion of "Spacewarp" technique

Milestone 3: Full integration of HTC Vive controls, data faceting, multiple data entries

Comparison with the Final Gantt Chart

	Start Date	End Date	Timeline	Status
SPACEWARP VR	08-01-2018	30-04-2018		Upcoming
Project Planning	08-01-2018	28-01-2018		Complete
Project Development	28-01-2018	23-04-2018		Complete
Work on PID	22-01-2018	02-02-2018		Complete
Milestone 1	28-01-2018	15-02-2018		Complete
Milestone 2	15-02-2018	15-03-2018		Complete
Work-In-Progress Report	01-03-2018	07-03-2018		Complete
Milestone 3	15-03-2018	19-04-2018		Complete
Beta Testing	19-04-2018	22-04-2018		Complete
Stretch goals	19-04-2018	23-04-2018		Complete
Final Report	19-04-2018	02-05-2018		Active
		CURRENT PHASE		

Milestone 1: Data mapped to the 3D plane, "Spacewarp" technique added to project, data being read directly from the dataset

Milestone 2: Second Dataset added, main menu added, UI with toolbar added, variable zoom and expansion of "Spacewarp" technique

Milestone 3: Full integration of HTC Vive controls, data faceting, multiple data entries

Appendix C - Testing Records

Testing Deliverable one

This document will record the testing of the spacewarp VR visualisation software in the form of its **first** client deliverable features.

Document lens

Task	Pass/Fail	Details
Activate Lens	PASS	The lens is active on launch in the programs current state.
Deactivate lens	FAIL	There is currently no method of deactivating the lens
Lens moves with HTC Vive controller	PASS	The lens moves as a child of the controller. However visual tearing was noticed when this occurs.
The lens Distorts peripherals for the user	PASS	The lens creates a focal point in the center of the screen. Outside of this focal point it distorted

General

Task	Pass/Fail	Details
User Is Present in the Environment	PASS	The user is placed in the center of the environment
The user's Head movement is tracked correctly	PASS	The user's head movements are tracked smoothly.
The Fps of the program are at a reasonable rate (30fps)	PASS	The program never dips below 60fps
The users hand(controller) movement is tracked correctly	PASS	The users movements are tracked somewhat smoothly. However sensor positioning was not ideal for this test.

Testing Deliverable Two

This document will record the testing of the spacewarp VR visualisation software in the form of its **Second** client deliverable features.

Document lens

Task	Pass/Fail	Details
Activate Lens	PASS	The lens can be activated at runtime
Deactivate lens	PASS	The lens can be activated at runtime
Lens moves with HTC Vive controller	PASS	The lens moves as a child of the controller.
The lens can zoom in	PASS	This can be done by pressing up on the controller trackpad
The lens can zoom out	PASS	This can be done by pressing down on the controller trackpad
The lens Distorts peripherals for the user	PASS	The lens creates a focal point in the center of the lens. Outside of this focal point it distorted
Peripheral distortion of the lens can be increased	PASS	This can be done by pressing right on the controller trackpad
Peripheral distortion of the lens can be increased	PASS	his can be done by pressing right on the controller trackpad

Data Generation

Task	Pass/Fail	Details
Data Points are displayed on to a cylinder in the environment	PASS	Data points are plotted around the cylinder in the visualisation environment.
Data Points are Displayed in ascending order based on gross income	PASS	
The data points are being displayed 360 degrees around the user	PASS	Data circles the user with the user in the centre
The Data Points displayed are representative of the data set.	PASS	Examination of the data points and logic behind their generation found the data points where representative of there records

General

Task	Pass/Fail	Details
User Is Present in the Environment	PASS	The user is placed in the center of the environment
The user's Head movement is tracked correctly	PASS	The user's head movements are tracked smoothly.
The Fps of the program are at a reasonable rate (30fps)	PASS	The program never dips below 30fps
The users hand(controller) movement is tracked correctly	PASS	The users movements are tracked somewhat smoothly. However sensor positioning was not ideal for this test.
The user is Placed in the centre of the visualisation surface.	PASS	
The user can view all of the data in 360 degrees	FAIL	The user can turn 360 degrees however the large number of data points means the start and the end of the data overlap obstructing the user's view of the data.

Testing Deliverable Three

This document will record the testing of the spacewarp VR visualisation software in the form of its **Third** client deliverable features.

Document lens

Task	Pass/Fail	Details
Activate Lens	PASS	The lens can be activated at runtime
Deactivate lens	PASS	The lens can be activated at runtime
Activate lens with laser pointer active.	FAIL	The lens activates however causes the laser pointer to curve with the peripheral distortion cannot be marked as pass.
Deactivate lens with laser pointer active.	PASS	The lens deactivates and the laser pointer returns to normal
Lens moves with HTC Vive controller	PASS	
The lens can zoom in	PASS	
The lens can zoom out	PASS	
The lens Distorts peripherals for the user	PASS	The lens creates a focal point in the center of the lens. Outside of this focal point it distorted
Peripheral distortion of the lens can be increased	PASS	This can be done by pressing right on the controller trackpad
Peripheral distortion of the lens can be increased	PASS	his can be done by pressing right on the controller trackpad

Laser Pointer/Data Selection

Task	Pass/Fail	Details
Activate Laser pointer	PASS	The laser pointer activates using right trigger. However, on load it is required to enter the menu and return to get this feature to function.
Deactivate later pointer	PASS	Pointer deactivates using right trigger
Data point the laser pointer is aimed at is selected/highlighted	PASS	

Laser pointer "attached" to Vive controller	PASS	Laser pointer acts as child of the vive controller
Laser pointer is accurate enough for use.	PASS	All team members agree the pointers accuracy is definitely within an acceptable degree.

UI

Task	Pass/Fail	Details
Gross Income attribute of the selected record is displayed above the left controller	PASS	Displayed. However, currently the number is formatted incorrectly and requires thousand separating commas and a dollar sign.
Name attribute of the selected record is displayed above the left controller	PASS	
Studio attribute of the selected record is displayed above the left controller	PASS	
Year of release attribute of the selected record is displayed above the left controller	PASS	
UI text is legible	PASS	Orange text on white background
X/Y axis and label displayed above left controller	PASS	

Data Generation

Task	Pass/Fail	Details
Data Points are displayed on to a cylinder in the environment	PASS	Data points are plotted around the cylinder in the visualisation environment.
Data Points are Displayed in ascending order based on gross income	PASS	

The data points are being displayed 360 degrees around the user	PASS	Data circles the user with the user in the centre
The Data Points displayed are representative of the data set.	PASS	Examination of the data points and logic behind their generation found the data points where representative of there records

General

Task	Pass/Fail	Details
User Is Present in the Environment	PASS	The user is placed in the center of the environment
The user's Head movement is tracked correctly	PASS	The user's head movements are tracked smoothly.
The Fps of the program are at a reasonable rate (30fps)	PASS	The program never dips below 30fps
The users hand(controller) movement is tracked correctly	PASS	The users movements are tracked somewhat smoothly. However sensor positioning was not ideal for this test.
The user is Placed in the centre of the visualisation surface.	PASS	
The user can view all of the data in 360 degrees	PASS	Data set reduced to 500 allows for full view of all data.

Appendix D - Technical Documentation and Sprint tables

Sprint one (Research week)

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Tuisku
Research Possible UI design				
Research Hyperbolic lenses possible implementation methods				
Research Version control options and select most appropriate				
Research HTC Vive usage in Unity				

Sprint Outcomes
This week's sprint is an initial research week that will provide a basis for the start of the project and ensure that the scope of the project is feasible. At the end of this sprit we will have gained a more in depth understanding of the tasks / work that needs to go into the next stages of development as well as making sure that none of the features requested by the client are unachievable based on our skill set and the time frame available. We will also have selected a version control program that best suits the project.

Sprint Evaluation (filled in after sprint completion)
This week's sprint was carried out successfully meeting all the desired outcomes. The initial proposed scope of the project is certainly feasible in the given time frame and within the groups given skill set. The version control package that we have decided to use is git hub as research found that is more user friendly than its competitors. Unity dose offer an in-house version control system that initially seemed quite useful however upon closer examination we found that they package only allowed for the collaboration of two team members unless you paid for a premium version. We decided that this was not an option due to the budget of the project being Zero.

Sprint Two

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Tuisku
Implement Version Control / Gitignore				
UI Design Mock-ups				
Hyperbolic lens in depth research (possible fish eye lenses effect)				
Develop Unity HTC Vive Test environment				

Sprint Outcomes
This week we will start the development process. We should have the Test Environment Completed that will allow us to use the HTC vive within the unity game engine which will set us up well to begin developing the visualisation environment in the next sprint. We will have set up a repository on git hub with a working git ignore file that prevents unity assets from being stored on the repository. The hyperbolic lens effect will not yet be implemented as this is a complex part of the project and requires more research and practice implementation outside of main development. Unity has a built-in fish eye effect that is somewhat similar to the hyperbolic lens required and this will also be investigated. UI Mock-ups will also be created to Better communicate out vison for the project to the client.

Sprint Evaluation (filled in after sprint completion)
This Sprint was somewhat successful. The test environment was created but could not be tested due to the availability of the VIVE headset which was out of our control this may set back the next sprint when it comes to implementing the visualisation environment. The Repo was set up on git hub but there was an issue with the git ignore file that meant that unity assets where still being pushed this will also have to be added to next weeks sprint. The fish eye effect was also investigated and is a viable possibility for a prototype lens. UI mock-ups where completed very successfully and to the client's approval.

Sprint Three

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Tuisku
Fix git Ignore File so unity assets are not added to the repository				
Design back ground and graph texture for the visualisation display				
Apply fish eye effect to the unity view port				
Attempt hyperbolic effect implementation				
Add display surface to the Visualisation environment				

In this sprint we intend to fix some of the issues that occurred in the last sprint. The git ignore file will be fixed so unity assets are not added to the repository. An initial static graph texture will be created and applied to a cylinder in the unity environment for the project prototype. If there is time the fish eye lens will be applied to the unity viewport for prototype purposes. They Hyperbolic lens will have an attempted implementation outside the project.

Sprint Evaluation (filled in after sprint completion)
This Sprint was completed mostly successfully with the visualisation texture and the background being designed and created. The display surface was also added into the unity environment however the texture was not yet applied. the git ignore file was edited and no longer adds unity assets to the repository upon pushing. The fish eye (or prototype lens) was successfully added to a unity viewport however has not been implemented in to the project as of yet. The hyperbolic lens implementation has progressed however is fairly complex, so this will be carried into next week's sprints

Sprint four

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Tuisku	Thomas
Final development push for hyperbolic lens.					
Refine UI and view port design					
Develop data set for Visualisation display					
Solve unity Update and version control issue					

Sprint Outcomes
This sprint should leave us with a full User interface design to be implemented later. We should also be at the very least in the final stages of implementing the hyperbolic lens effect. We will have generated movie-based data to be visualised in the unity environment. Finally, the Version control issue involving the unity update may be fixed however this is not urgent as the team will continue to use the previous version of unity unless a feature in the new release is required.

Sprint Evaluation (filled in after sprint completion)
This sprint was completed with little error. The user interface design needs refinement and possible colour alterations. The unity update issue is no longer an issue as recent updates to the engine are highly unlikely to carry any feature that will aid in or development. A preliminary Data set has also been created however this is not finished

Sprint five

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Tuisku
Generate visualisation based of move data CSV				
Create 3d model for lens				
Refine lens technique to not obstruct the view of the data				

Sprint Outcomes
The outcomes of this sprint will be mostly refinement of the first deliverable completed last week. the lens will be altered remove the obstructions in the view of the data. the data gathered in the csv will be used to generate a data visualisation in the unity environment. This sprint contains less in the way of number of tasks however these tasks are considerably more complex and will take more time to complete.

Sprint Evaluation (filled in after sprint completion)
The lens has been corrected with the tearing effect removed and a zoom feature added. This completes the must have goals for lens effect and will now move into development for the previously agreed stretch goal. Tuisku has had to leave the group this week meaning the csv generation will be handed to another member of the group and pushed to next week.

Sprint six

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Thomas
Display Data Attributes Onto UI				
Add Laser Pointer to HTC Vivie Controller				
Gather, create, prepare/clean and format expanded movie data set.				

Sprint Outcomes
This week will be an extended Sprint period spanning two weeks due to other commitments members of the team must fulfil. Attributes of the current movie data set will be displayed in the environment in some form. A laser pointer will be added to the Vivie controller that will allow for the easy selection of data points. A new data set will be generated and cleaned that contains more attributes that the previous data set. The intention behind this is to allow the user to gain a better understanding of the data by allowing them to view said data in more detail.

Sprint Evaluation (filled in after sprint completion)
All goals for this extended sprint period have been met to a high standard. The laser pointer however has a small bug that causes the laser to bend when used in conjunction with the lens. This will be a task for the next sprint period. The expanded Data set has also been completed

Sprint seven

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Thomas
Move Data To display to child of Vive controller				
Fix Laser Pointer Bending Bug				
Create texture for HTC vive controller				

Sprint Outcomes
This is the last full week sprint period for the project and should leave the project in a deliverable state with the possibility of meeting stretch goals or fixing small bugs. The attributes of the selected data point should be moved to be a child of the Vive controller to clear view port space. The laser pointer should be fixed to point straight whilst the lens is turned on or should be disabled. A texture for the vive controller should be designed and created to give the software a more completed look.

Sprint Evaluation (filled in after sprint completion)
This sprint was carried out effectively. Sadly, the laser pointer must be disabled whilst the lens effect is active but as a work around the selected data point is highlighted in red, so functionality Is not affected. The Texture for the Vive controller has also been added, and the data display moved to a child of the left controller

Sprint Final

SCRUM MASTER – Thomas

Key – Priority high = Priority Medium = Priority Low =

Task	Marco	Paulius	Beth	Thomas
Move Visualisation Technique to button toggle.				
Alter Laser pointer colour				
Format Data attribute values				

Sprint Outcomes
This is a short final sprint to perfect small pieces of the software package and involved no major changed to the functionality of the program. The Laser pointers colour should be altered to better standout against the background. Switching of visualisation techniques should be set to a button toggle for simplicity and demonstration purposes. Attributes of the data displayed above the Vive controller should be formatted correctly.

Sprint Evaluation (filled in after sprint completion)
This sprint period was completed very quickly due to its simple nature. This is the final sprint in the development project and we will now move in to demonstrating the final deliverable.