TERMS OF REFERENCE

Team Project & Professionalism KV6002

Supervisor – Edmond Ho

2nd Marker – Lynne Conniss

Hassan Mohammad, Zoe Irwin, Luke Rose, Ana-Sabina Irimia, Efsthatios Efstathiou

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➢ **Project Vision**

Our project vision is to produce a VR System for an immersive forensic virtual reality experience to emulate crime scenes for forensic investigation. For this project we are working with external consultants from the forensics department of Northumbria of which are interested in a proof-of-concept for educational purposes. Therefore, we intend to develop a 3D virtual reality crime scene environment where users can navigate and interact with the scene. The user will be uncovering a story developed by the group to examine the crime scene while using the Oculus VR headset to interact with various objects. A challenging aspect of this project is to create an accurate crime scene which feels natural for the user to navigate around while also being a notable educational tool. By using the Oculus VR headset coupled with Unity3D we can immerse the user using the latest advances in virtual reality technology. Using this latest technology, we can introduce new ways of user interaction to move around and interact with objects such as bodies, weapons and other evidence related to a crime scene. We will be working and consulting with the Forensics Department of Northumbria University in this project. In this team project we have 5 members collaborating on assigned tasks. As a group we are ensuring that we can:

Produce a system which can be used as an educational tool for the social sciences department using existing hardware provided by the university.

Produce an application which must be running in real-time with acceptable performance.

The group must ensure that all sub-systems must work together

Ensure the user can move around the 3D environment using the Oculus Rift device.

As a group we aim to produce a working prototype application and if successful it may be used in the wider university context for teaching and educational purposes for the forensics departments within Northumbria University.

Luke Rose

Group member, Luke Rose, will attempt to create a simulated crime scene environment, through the game engine Unity3D. This crime scene environment will be created in conjunction with the storytelling subsystem, as this will allow the environment to incorporate elements vital to the story, creating a more cohesive overall product. To create an immersive feel to the environment, the scene will be populated with existing 3d assets from the community due to time constraints of the project. For example, assets can be sourced for free from (https://assetstore.unity.com). In addition, lighting will be just as vital as populating the scene with 3D objects, so multiple light sources will be set up around the scene to create light and shadows. Finally, if enough time is left towards the end of the project and all the requirements above are completed to a satisfactory standard, then, a second scene could potentially set up for future development and future story lines.

Ana-Sabina Irimia

The group member, Ana-Sabina Irimia must work on the storyline subsystem to produce the story for the product. The aim of this project is to create an interactive experience where the user can search for clues around a recreated 3D room with the purpose of understanding what happened at the scene of the crime. This subsystem is an import part of the development process having the following requirements.

The requirements start by finding the initial concept for the project.

Followed by writing the story of the crime scene.

Design the storyboards that can clearly present the ideas to the visual developer that generates the environment.

After the three main requirements are complete the member might write alternative

Hassan Mohammad

Group member, Hassan Mohammad, will be responsible for the user interaction subsystems within the 3D Virtual Reality Environment of the application. Using the game engine Unity3D Hassan will be required to program and develop in conjunction with the Oculus Rift device to ensure that interaction with the controls will allow the user to perform tasks such as manipulating 3D objects and moving around the environment in real time. When Interacting with the 3D objects it is important that Hassan will take into consideration how fluid the movements and interaction feels from the user's perspective. In the work of (Kallmann & Thalmann, 1998) an emphasis is made on the importance of considering a 3D objects geometric properties and how the users are naturally thinking about the ways to interact with the object, a common example includes opening a door which involve multiple steps which can be taken for granted in the real physical world. The control mechanisms using the Oculus Rift device will also need to be taken into consideration. Examples of required interaction with 3D objects could include tasks such as opening drawers, cupboards and picking up objects such as pieces of evidence in the crime scene. If the main objectives and requirements of the subsystem are working as intended and time is remaining towards the end of the development stage, an attempt to create alternative ways to interact with over devices such as smartphones may be made.

Zoe Irwin

Group member, Zoe Irwin, will cover the User Interface of the VR application. In particular, the first requirement must be to design and develop the areas of navigation and menus, in which, both the expert and unskilled user can interact with the system. In addition, the non-functional requirement of this subsystem will be to produce an interface that will achieve a user-friendly feel for all. As user interfaces are largely dependent on visual information (Nguyen, 2012), it is important to produce an interface with additional graphics and sounds in order to immerse the users into the forensic scene environment. Another element this subsystem will cover is the basic instructions provided to the user on how to navigate throughout the system; without this, the VR application would be too complex and simply unattractive to users. Lastly if all previous requirements are completed to a good quality, then further sub menu interfaces could be developed for the future scope of the VR application.

Efsthathios Efsthatiou

Group member, Efstathios Efstathiou, will monitor and test the practical part for each member of the group to achieve a successful build of the application, by the end of the practical group work the product must be run-able and stable without any errors. To create a solid cooperation between the subsystems and the testing process every week it should be a meeting that the tester will update the testing documents and test the code in order to provide feedback to the members of the group individually. To accomplish a smooth and progressive group action it will be a documented testing results for every other subsystem, the document must be able to provide a detailed information of the overall image for every

subsystem, it will be dated in order to provide a progression details. Close to to the final product it will be an analysis of the subsystems objectives to see how close or far the final version is according to the plans we already agree, for example if a subsystem doing progress and works fine with other subsystems, it should be in the objectives, this is the monitoring part for the tester. Lastly if there is any extra time the product will be tested on different platforms (hardware and software) to understand the powers and limits of it.

➢ **Team System Specification – Requirement Capture & Analysis**

For the requirements capture on this team project, we met with Dr. Alan Langford, a senior lecturer in forensics at Northumbria University. In this meeting we discussed an application idea in which some key elements were mentioned. Such elements include the idea of producing a 3D environment to simulate a realistic room. One requirement established in the meeting was to produce a system that could potentially provide educational benefits to the forensics department so that it may be used in the future with other staff and students. Dr. Alan Langford mentioned in this meeting that he currently has a few Oculus Rift devices for the development of a 3D application, therefore we expect to use this device for the development of our project as we intend to create an immersive virtual reality experience which is running in real-time. By using this device for our development, we can create an application which also fulfils the team requirement of allowing the user to move around in a 3D environment to examine a hypothetical forensic crime scene.

The discussion of the requirements with Dr. Alan also underlined how he was open to new ideas and as a result we decided to analyse existing products to get a framework for the project. The work of (Conway, et al., 2015) has provided our project with different elements for the requirements capture. For example, the paper discusses how they aim to create a virtual crime scene while preserving a realistic simulated experience. From this we intend to build a similar virtual reality application that immerses users into a 3D interactive environment that can be used as an educational tool for university students. From previous knowledge on the module Software Engineering (KF5012) each team member collectively recognised that we need to ensure that each of our assigned sub-systems must work together in cohesion to ensure the product works as intended and the project is completed on time. To achieve this cohesion between the sub-systems the group has agreed to adopt an agile approach to developing the application, in Figure 1 a diagram depicting the agile approach is shown which details the stages of iteration, designing, coding, testing & fix and release.
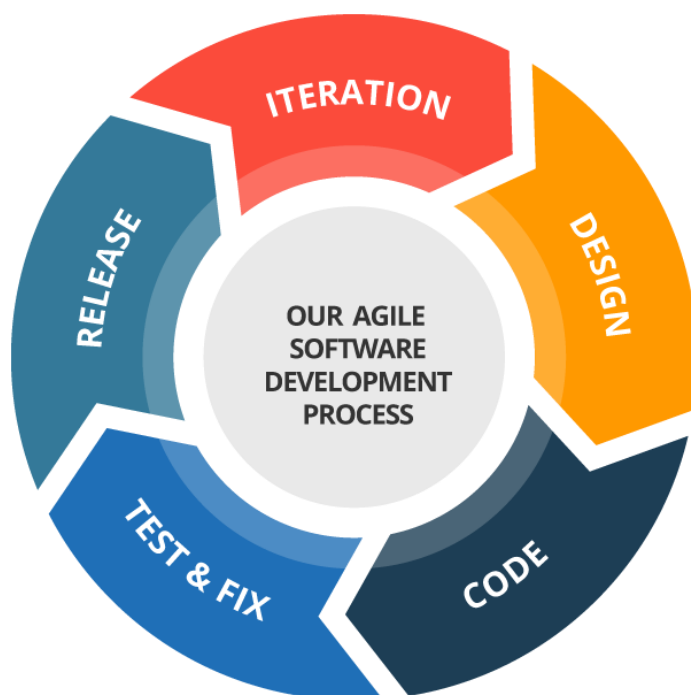

Figure 1. *A visualization of the agile method we aim to adopt for the project* (Webmix, 2018)

➢ **Specification of Main Functional Sub-Components**

Hassan Mohammad

The sub component of the User Interaction in this project is a key functional area of the project and the successful development of this application. This functional sub-component was derived from the requirements capture stage which took place in the form of meeting with the client face to face to discuss what they are looking for in the system being built by the group in order to set out a series of requirements which can be parsed into the main functional subcomponents. A big requirement gathered from this meeting was to implement user interaction features into a 3D virtual reality application which can be used for forensic analysis for the Northumbria University Social Sciences department. The user interaction is perhaps one of the most important aspects of the development of this project as it covers how the user and most importantly the client will be directly involved with the application as they use the Oculus Rift device to interact with 3D objects in the environment using a set of controllers. The client explicitly expressed the requirement to move around and view 3D objects in the virtual world with close detail and being able to perform actions such as picking up objects, opening and looking inside objects such as drawers, cabinets and cupboards which are found in forensic crime scenes that take place inside indoor buildings e.g. houses, hospitals etc.

The following list contains the identified functional requirements for this sub-system

- Integrate the Oculus Rift hardware controls with the VR application for the user's control
- Allow 3D objects to be manipulated within the VR application by allowing tasks such as rotation and close-up inspection
- Produce a control scheme/mechanism for the user to navigate and move through the 3D environment while wearing and using the hardware required.

The following list contains the identified Non-functional requirements for this sub-system

- Improve immersion by using real-life interactions as the basis model for how the user should be expected to interact with the 3D environment and the objects within it.
- The application should include feedback mechanisms to notify when the user has interacted with an object.

When forensic crime scenes are presented to judges and juries in the courtroom, technical descriptions of events and observations surrounding the crime scene are presented which can lead to misunderstandings and confusion as to what the forensic investigators have actually seen (Ma, et al., 2010). With the help of technology such as 3D Virtual Reality, forensic scientists can offer a visualisation of the data being presented in places such as courtrooms to better inform. The client for this project, Dr. Alan Langford, is currently using the software Return to Scene R2S which can recreate a crime scene in the form of 360 degree image from high resolution stitched images (Chan, 2005), this approach to representing the visual data in the form of a 360 degree image limits to what the user can look, manipulate and observe in the visual data. A Virtual Reality system which permits the user to have free reign over the control of their perspective and to manipulate objects in a 3D scene allows for the visual data of a crime scene to be further analysed in court cases.

<u>Luke Rose</u>

How are you going to define your individual requirements?

The requirements for the 3D scene subsystem will be create through a combination of requirements set by our client and various other similar products that also exist. This will allow for the client to feel that their requirements of the product have been fulfilled as well as using best practices that are commonly found in similar applications.

What are the sources of your requirements?

The first, and primary source, of the requirements of the 3D scene will come from our Client, Dr Alan Langford, who is a senior lecturer in forensics at Northumbria University. This will be achieved through a meeting with our client to discuss the specific requirements that he has in mind for our product. In addition, requirements for best practices will also be acquired through similar products such as CSI VR: Crime Scene Investigation (Academy, 2018). These two factors will be combined to fulfil the requirements for this sub system.

Functional requirements:

- Utilize 3D assets
- Create story driven objects within the scene
- Scale the room to the field of view of the Oculus Rift
- Use high resolution textures
- Create a fully enclosed room
- Create objects that the user can look under and around
- Include light sources in specific areas

Non-functional requirements:

- Re-create the living room for Manor House in Coach Lane Campus
- Create a realistic feel for the environment
- Elicit an immersive feel

<u>Ana-Sabina Irimia</u>

To develop the requested product the team must follow the main stages or phases of animation or game development. The first step in realising and delivering the required product for the client is by creating the story of the project. The story is a key factor that can make the user be interested or not in the product. As in the animation or game industry, the whole product revolves around the story. A great story can immerse the user and thus creating a wonderful experience leaving the person to crave for more.

The process of creating an animated film, game or other project starts first by thinking about or finding an initial concept. The initial concept can be an original idea thought by the creator or inspired from books, comic books or other sources (C., 2015). Once the initial concept is put into place the project can advance to the script or screenplay phase where the person in charge of the story must present the concept in a more detailed format.

The script or screenplay writer must gather all the information of the scenes, environment, characters, objects, and others and put them in a word format for a better underspending of

the underlying concept so that the storyboard artist can be able to recreate the envisioned world (C., 2015). After the script is finished the project advances to the storyboard phase, where the script is broken down into subparts as action, character, dialog, camera and other for a better understanding of what to illustrate in the panels (Rousseau & Phillips, 2013).

The storyboard phase is an important step in the development of the product as it will be the first graphic representation of the story. The storyboard is a series of multiple illustrations depicting the final version of the product's look (Simon, 2012) (Kerlow, 2009) (C., 2015). The storyboard is an aid in directing the developers to produce the project that was depicted or imagined by the director or in our case, client (Simon, 2012). Storyboards are not comics even though they are illustrations, they are used to plan the visual narrative of the story (Rousseau & Phillips, 2013). Visual development is the next phase in which the 3D modeller must recreate the story depicted in the storyboards. To recreate the story as imagined the 3D modeller must follow the storyboards throughout the process.

For this project the member in charge of the storyline subsystem will take the position of the "director" to write the story, complete the script and design the storyboards for the product. The theme of the initial concept, recreating a crime scene, was chosen from the beginning by the client which stated this being one of the requirements to develop this project. As requested by the client the story will revolve around a crime scene where the user will be in the role of the policeman/woman or detective that must discover clues with the aim of understanding and finding what and how it happened.

Once the story is decided the script can be written. The script will mostly present the environment, objects scattered around the room, interactive objects, and what will happen when the user interacts with one of those objects. The script will be written in such a way that it can have multiple outcomes or endings to challenge the perception of the user.

The storyboard for a usual animation or game project presents the design of the characters, their movements, and interaction between them, depending on the number of the characters, or the environment as well the lighting or camera movement. The project does not have a character, in its place stands the user that will have autonomy over his/her movement. The user will be able to move freely without any restriction and because of this, the exact actions of the character cannot be presented in the storyboards. The storyboards will show the placement of the objects in the room, present how the user can interact with the environment and where the clues of the crime can be located.

Zoe Irwin

Requirement definition is the most important component of every IT project design and implementation, irrespective if the project is a new system or are development of an existing one (Sahu, 2010). The process involves engaging with business and their accompanying stakeholders to establish requirements that are suited to the business needs. When regarding our project of a VR forensic crime scene environment, as a group, we have divided the system into a number of subsystems. The reminder of this section will cover the User Interface as this subcomponent is my area of design and development. In order to define individual requirements one method first adopted is to consult with the stakeholder and define their needs of the system. In doing so, the stakeholder had an open idea of how the User Interface looked and worked, therefore, I broke the system into two different requirements, using De Oliveira et al. (2013) Technique of identifying functional and non-functional requirements.

Functional:

allow basic navigation through a main menu screen

display and instruct the user on how to navigate around the scenes

make user interfaces more interactive with the use of sound & graphics

sub-menu interfaces for the user to interact with in the scene

university log in to allow access to forensic crime scene environment

Non-Functional:

make user interfaces as user-friendly

make user face consistent

make user face efficient, quick response times

make a high-quality interface

Initially, there were too many requirements for this subsystem so it was important to prioritise the requirements for example it is critical to deal with the most important and needed ones rather than defining the good to have ones. In doing so it was also important to remember the non-functional requirements are also critical for compliance and regulations, and can add value to the system reiterating it is not just about the functional elements.

With further research this helped define and priorities the important requirements; according to Bhaskar, et al. (2011) It is important to design a user interface that is attractive and enhances the user experience. From this I gathered that the user interface must take on the requirement of being as user friendly as possible and further visually pleasing therefore the functional requirement of making the user interface more interactive with graphics and sound was important. In order to interact there must a menu interaction style. This could be a "set of options displayed on the screen where the selection and execution of one or more of the options results in a change in the state of the interface" (Paap & Roske-Hofstrand, 1988). With general knowledge it can be said menus are more effective and popular to use amongst the average and unskilled users. In addition, the client also stated he wanted the application to be fully interactive therefore by using this idea of menus and further displaying instructions and navigation help will assist in creating a more functional system. Lastly the final aspect that could be considered is extra sub menus displayed throughout the environment, from previous observation of similar VR applications such as InCell VR (Luden.io, 2015) they have extra sub menus which provide useful information regarding progression. For example Nguyen, (2012) states it is useful to have access to documentation within the application including how to interpret visual representations and how to interact with elements in the scene.

Overall my established final 5 requirements for this subsystem of user interface can be seen in my project requirement plan as follows:

Project Requirement Plan		
Where Established	Requirement	Type
Client	allow basic navigation through a main menu screen	Functional
Research	display and instruct the user on how to navigate around the scenes	Functional
Client	User interfaces as user-friendly as possible.	Non Functional
Research	make user interfaces more interactive with the use of sound & graphics	Functional
Observation of VR Applications	create sub-menu interfaces for the user to interact with the scene	Functional

When regarding how I'm going to elicit these requirements, throughout we will work collaboratively together as a group (refer to code of conduct) and with the stakeholder in an agile approach to address new visions or alternative goals and agree upon what is best. Similar to Azadegan et al. (2013)method using a collaborative approach. When considering the first requirement regarding the basic navigation menus, it is important to consider story boards and diagrams as a basis for how the layout is going to be considered. Storyboards are particularly useful documents to show the navigation process in this case how the user's selection choice changes the scene of events (OCR, 2013).This is further reiterated by Soltanian et al. (2013) who suggests a good tool used for requirement elicitation Is using scenarios and prototypes. When regarding the display and instructions for users to navigate the scenes, this could be produced in an immersive way with a variety of different interactions to keep users entertained. Further relating to the area of user friendliness and visually pleasing elements of sound and graphics. These areas are down to observation of alternative games and research on the best approaches and qualities such as consistency and effectiveness to produce a successful end-product. Lastly when considering alternative sub menus again this is down to research of existing applications and how they have adapted these features to enhance the VR experience.

Efstathios Efstathiou

A balance between of the quality and quantity of the documented testing results is what I am looking for as a tester. Talking about the quantity the tests must be done quite often and according to the number of subcomponents and the subsystems the final documentation probably will not be short. Looking for a detailed and clear description about the weekly test results during the development, we will try to keep the documentation short but clear, that is how quality should be consider as there will be no insignificant parts in the final analysis paper (Guru99, 2019). Great results are expected if we manage to balance the quality and quantity of testing documentation as the time of the project is limited.

Each member of a team must be aware about the tester or other member opinions. For example if there is a hard phase on something very specific then the tester should be able to

point what is probably going wrong or if it is possible to keep working on something else as the tester can get deeper into the problem, it is always important to have another's person advise when you are working on something that requires focus and dedication (Test Institute, 2019), it always best to learn from our working environment and improve ourselves. The regularly testing and feedback part serve the purpose to create a final document that someone can clearly understand how the overall process of the testing and monitoring has come through, but one important thing is that each member can look after their misdirection, the slow working, the poor communication and all of us learn from our mistakes and be better till the next testing.

How are you going to elicit these requirements?

Respect the colleagues and the team.

Understand the requirements and brake them into simpler tasks.

Communicate as much as possible as it is the key for great teaming especially for the testing subsystem.

Keep records for each subsystem.

Create a testing form that can be detailed, on the point and not long.

Follow the testing form every week and try to improve it based on the needs of the team.

Adjust the testing process on team members (we are individuals/unique).

Try to keep the subsystem in schedule and the member of the team focus of what has to be actually done (avoid minor details or small problem).

Add some go to points that members feel comfortable to achieve by the next time,

Check if the team works together at the same time (helps the build-up).

Try to put together every subsystem at least 2 or 3 times during the practical part as everything might works perfect alone but cause a problem together.

Work on the previous test results to understand what the position of a subcomponent and estimate the time that will take to be done.

Disarrangement can always be helpful as the discussion and suggestions are the outcome of it.

➢ **Project Tasks and Deliverables**

Within this project there will be several tasks allocated within the group, we are looking at using an Agile development framework when working on the development of the application in accordance with the captured requirements that the group has agreed upon. In our approach to the development lifecycle of this project we must first capture the requirements needed for the project to commence. To capture these requirements, we have met with the client, Dr. Alan Langford, a senior lecturer in Northumbria University's Social Sciences department; the meeting proved to be quite useful as we captured the main components required for some of the basic functionality of the system, for example we captured the requirement of ensuring that the application can allow the user to manipulate and view 3D objects in the virtual reality environment. Other necessary requirements for the project will come from areas such as analysis of other existing products in a similar vein to what this group is trying to accomplish or perhaps from detailed internal discussion within the group and the group's supervisor.

The design of the group project will revolve around identifying the key functional and non-functional areas of the system to allow the application to meet its original objectives outlined by the captured requirements and initial aims. Designing the system around these high-level functional and non-functional requirements allows the group to focus on the most important and fundamental aspects in which the application can be of use to the client once the application is in its development and implementation stages.

In the build/development stage of the software development life cycle, the group will be working in the Unity3D game engine software package to develop the application using the high-level requirements outlined in the design stage as a guide. The group consists of 5 members where each member is to take a specific sub-system which has its own requirements to be completed to form the overall product. Technical details of how the application should function and feel will be discussed in meetings with the group to identify any areas which may require tweaks and further improvement.

Testing of the application will include a series of System Tests in the form of White/Glass Box tests where the group can assess if the product is meeting the functional requirements and can integrate with the hardware the group has chosen to use for this project; the Oculus Rift. By using these tests for the functional aspects of the product, the group can identify bugs and errors which may lead to performance issues that will arise when we are also conducting the performance tests on the application. When testing the performance, the key metric to monitor for this application is the Frames Per Second (FPS) of the application as this is a clear indicator of how efficient the source code is when running in real-time. A low FPS number indicates that the application will feel very sluggish and less responsive than a high number therefore leaving a bad impact on the client's experience with the groups system. As the development of this project has been set up into a series of sub-systems in order to split the workload among the group, the testing will need to include integration tests where the various parts of the code can be brought together to be evaluated on how well they integrate with each other.

The final stage of the development comes when the group is ready to implement all the sub-systems and tested features of the product into one application which can be integrated with the hardware required which in this projects case is a Desktop PC and the Oculus Rift Virtual Reality device. An executable application should be deployed and available to demonstrate to the client that showcases a culmination of all the work done on the project by the team.

One of the agreed deliverables for this project includes the Disclaimer required for the client to sign upon receiving confirmation on the project idea and the ethical considerations of this project. This disclaimer would come into existence during the final stages of the requirement capture phase in the development lifecycle for this project. Another deliverable is the source code files responsible for the development of the application and all the 3D assets which have been used to create the 3D virtual environment, the source code files will be have the necessary comments and formatting to make them presentable to the group, supervisor and 2nd marker. These source code files will be delivered at the end of the development life cycle as this marks the completion of the groups work development and implementation stage.

The following is a resource list required by the group to develop and complete this project:

High Performance Desktop PC's – These PC's will be capable of developing the 3D virtual reality application as they have the processing power required for a project of this type. These PC's will also include the software packages mentioned below.

Oculus Rift Virtual Reality Device – This device is the main hardware device we are developing the application for and will be running the live application in real-time for the demonstration

Unity3D Game Engine – This is a free powerful game engine software package which offers support for the development of applications with the Oculus Rift and runs on PC's. The software comes with plenty of official documentation, tutorials and guides on how to best work on developing applications. The group will be using the latest version of this software.

C# Programming Language – This is the programming language used by the Unity3D game engine and therefore is a resource needed to develop the application and write the source code.

Git Version Control – Git is a version control software designed to be used by groups of developers to manage their projects by pushing, committing and merging work together from a repository that holds the work in one place. This will improve our workflow as individuals can work remotely and view changes to the work with comments being made as to what was changed when and where.

GitHub Repository – GitHub is a free online repository designed to work with Git to store the work and creates an online space where any member of the group can access the files in their own time.

To identify the risks as a group the group proposes to create a risk assessment matrix with risks being assigned labels of how much impact they may have on the project if problems and unfortunate events were to arise. The risk assessment matrix will include an overview of the solutions needed to work around the risks should they interfere with the project and therefore will help with setting up contingencies to make this project run smooth.

Project Plan

Team Project Plan - KV6002 - Hassan Mohammad, Luke Rose, Ana-Sabina Irimia, Efstathios Efstathiou, Zoe Irwin													
Semester 2													
	Duration in weeks												
Tasks		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Discuss project vision in team meeting	2	█	█										
Produce project vision document	1		█										
Receive Ethical Approval on project	2			█									
Complete and Submit Ethics forms	1			█									
Meet with Client and gather requirements	2			█	█								
Produce and Submit a Terms of Reference Document	3			█	█	█							
Develop the application	6					█	█	█	█	█	█		
Test the application	2										█	█	
Prepare for demonstration	1											█	
Evaluate the work done by the group	2											█	█

➤ **Legal, Social, Ethical and Professional dimensions**

Legal Issues

A major legal issue that we will need to consider within this project is the incorporation of an End User License Agreement (EULA). This will provide a legal binding contract between the end user and us as the creators of the application. EULA's, help to protect both the creator of the product and the product itself by providing a license for a specific user to access and use the application you have created, without giving away ownership of the product. Also, providing a product with a EULA helps to prevent abusive behaviour from users by stating that the application cannot be used for specific practices. The main protection a EULA would personally provide for our group is the limitations to the liability that would be placed upon us without the use of the EULA. As this project is to be completed in a short period of time, for work that needs to be completed, the EULA, will allow our group to disclaim warranties to the users. Finally, a EULA will allow us the power to terminate licences without any further repercussion (Pegarella, 2018).

Throughout our project, we will be using the Unity game engine to create our product. As a result of using Unity, we will be utilising online assets from the online Unity official website (Unity Technologies, 2019). Any and all assets used within our project will be referenced and all credit will be given to the original creator. This will protect us from copyright law issues.

Social Issues

One important social issue we must consider with this project is the sensitive nature of our product. Although, our product will feature a hypothetical crime scene, most of the elements used to create the scene will be based on real life crime scene case studies. This may because a big social impact as these scenes may not be suitable for a younger audience. If we did not consider the issue of younger users accessing this product, we could face legal action with up to six months in prison and a fine of up to £5,000 (Service, 2012). However, we can control the restriction of this product to underage users by setting an age limit rating based on the Video Standards rating board in the UK (Council, 2018).

Ethical Issues

Ethical issues regarding virtual reality is an ongoing issue in today's society; the virtual scenes and environments individuals are presented with may contain graphic scenes of violence, combat and death. The Virtual Reality Society highlights their concerns between virtual reality and desensitisation. The idea that individuals become immune to acts of bad behaviour such as killing, and further failing to show emotion, in fact, some tend to appear more powerful and accomplished (Virtual Reality Society, 2017). In order to avoid this idea of desensitisation, our project idea is focused more on the educational side of forensic analysis, trying to minimise the visual graphics to less gore and more evidence related objects. It may be argued that this VR Forensic environment can cause distress and emotional damage due to the association of criminal activity. In order to prevent these issues, disclaimers will be implemented. By introducing a disclaimer related to age, being above 18+ this limits the access to younger children and by stating that the environment may provide scenes of distress, highlights to those that are sensitive to these areas can chose not to partake. Whilst discussing disclaimers it is important to note that our project will also cover the areas regarding motion sickness and pre-existing medical conditions to minimise the risks whilst

participating with this application. Overall confirming to rule number one of the health and safety and welfare of the IEEE Code of Ethics (IEEE Advancing Technology for Humanity, 2019).

Another ethical issue that has to be addressed before the design and implementation of this project is user protection when the VR headset is on. A previous study by Adams, et al. (2018) raised concerns about individuals being oblivious to real-world physical hazardous objects. The idea that you are bumping into objects, not hearing alarm bells or significant events. He further reiterated the environment in which the VR headset is used has to be safe and specific. To mitigate this issue as part of our project we intend to use controllers along with the oculus rift, by doing so, this means no walking around the room or colliding with dangerous objects reducing the risk of both harm to others and the user themselves. In addition to this, we will use the VR headset in a safe room with more than one other person to again reduce harm and for safety reasons. Further with this point if we do decide to implement music it will be of low volume enough to be involved with the VR environment yet still hear surrounding real-world commotions.

Professional Issues

As developers of this Forensic crime scene investigation virtual reality it is down to us to develop an application that meets the client's requirements; it is therefore important to follow strict deadlines, honour agreements, contracts, and fulfil our code of conduct responsibilities. In order to ensure a high degree of professionalism, resulting in a successful end product. In addition, as a group we should take responsibility of the technology authorized by the university, along with how we use it and the potential consequences that become of it. Fundamentally, it is important to consider the ethical areas of concern in this documentation to prevent violation of ethical principles. As previously discussed, adequate information regarding the effects of VR to its potential users should be discussed this is further addressed by (Wiederhold & Wiederhold, 2005) as they highlight the important of informed consent as well as the ethics of experimentation with humans.

Now, in terms of the application itself it should be well presented, easy to navigate, thoroughly tested and importantly the users should feel immersed in their surroundings. On the other hand, the documentation provided should be consistent in terms of style and layout and the referencing used must be from reputable resources avoiding plagiarism.

Other professional issues that must be addressed regarding the application is that as developers we must stay in line with the laws and legislations of the BCS (British Computing Society, 2015). For example, they state in their code of conduct you must uphold the reputation of professionalism and good standards as well as make your application inclusive. In order to do avoid discrimination when developing our application for those with difficulty hearing and learning we will provide annotations on the screen to advise and tell the story as users participate with the environment.

Lastly an act of professionalism we must obtain is version control and back-ups. No system will be successful without organized folders and files. In order to address this issue as a team have decided to use GitHub to manage version control. Although this is also a form of back up, it is still required we store an alternate form of back up on external storage for example a USB or Hard Drive and in doing so it should be regularly to avoid data loss (Hanselman, 2012).

➢ **Costing**

Disclaimer: The information calculated below is based on a work schedule of 5 days per week and the hours were estimated by dividing the 200 hours necessary for this course in the 3-month left until the end of the semester. By dividing the 200 study hours necessary for this course the conclusion was reached that an "employee" will work:

- 66.6 hours a month;
- 16.6 hours a week;
- 3.33 hours a day;

The salary for the employees was calculated based on this time schedule.

Cost of a fully serviced office space per week

The first step on calculating the cost of the overall project is by adding the rent of the office space. To decrease the cost, the space chosen to rent is situated further away from the city center. Amron House (alistair, 2019) is a small fully serviced office situated in North Shield with the rent of £52 for each employee per week.

Employee salary

As stated on the website of the National Living Wage (Foundation, n.d.) the true hourly rate for a person is £9.00.

To find the salary of one employee is possible by multiplying the hourly rate stated on the National Living Wage with the hours spent hour this project, thus giving the following results:

- 66.6 hours a month = £600;
- 16.6 hours a week = £150;
- 3.33 hours a day = £30;

Insurance cost

The cost of the insurance was found by searching for the government site. In the article National insurance rates (Service, n.d.) and categories have presented the cost of the insurance that must be paid by the employee and the employer.

An employee that receives a salary between £116 - £162 a week deduct 0% from their pay. The same rule applies to the employer contributions for National Insurance that must pay 0% towards employees' National Insurance tax.

Cost of hardware and software

Disclaimer: The price of the hardware and software is as of February of 2019. The price might change depending on the time past.

The goal of this project is to recreate a 3D room used for forensics training and to be able to create the environment, Unity will be used. Unity (Technologies, 2019) is a software application used for 2D or 3D games, animation and other types of project. To download Unity, the personal version is free of charge for companies or individuals which salaries do not surpass $100k (£76,670.00) per year.

The hardware used for this project is Oculus Rift and Touch Controllers (Oculus, n.d.) with a total cost of £369.16.

The cost of a fully equipped PC is between £700 - £1,000 estimated based on the price from February 2019. For this project, the decided price for a PC is £800.

Table 1: Costs per day

	Per 1 Employee		Per 5 Employees	
Fully serviced office space	£52.00pw	£10.40pd	£260.00pw	£52.00pd
National Living Wage	£9.00/h		£45.00/h	
Cost of insurance	0%		0%	
Employer contributions for National Insurance	0%		0%	
On-cost wages for an employee	£30.00pd		£150.00pd	
Business running costs	£10.40pd		£52.00pd	
Day Rate	£32.08pd		£160.40pd	

Table 2: Cost per 3 months

	Quantity	Price
Business running cost	-	£3,120.00
On-cost wages	x5	£1,800.00
Day Rate	x5	£3,208.00
Unity	1per PC	£0
Oculus Rift and Touch Controllers	1	£369.16
PC	5	£4,000.00
Contingency cost	1 pair of Oculus Rift + Touch Controllers	£369.16
	1 PC	£800.00
Total cost		£13,666.32

➢ **Subsystem Specification**

Hassan Mohammad

The subsystem of User Interaction is the responsibility of Hassan Mohammad and will be split into 5 high-level requirements that have different priority levels based on how vital they are to the development of the application and project requirements. The first 3 high-level requirements are 'Must' requirements of the subsystem and can be categorized as the minimum specifications to ensure that a working proof of concept can be demonstrated.

The user interaction subsystem is defined as a system which:

Must be able to navigate around the environment fluidly using the Oculus Rift VR Headset,

This area of the subsystem requires Hassan Mohammad to build a system which allows the user to navigate around the 3D environment using the Oculus Rift virtual reality device as the display and control interface for moving around. This requires considerations into how to map the controls of the Oculus Rift into the Unity3D game engine to ensure a fluid and smooth user experience. Moving around the 3D scene is vital if the user intends to explore and focus on manipulating and observing the objects visible in the crime scene environment which is a key requirement derived from the client.

Must be able to interact with various 3D objects in the scene,

This high-level requirement is a key component of the crime scene analysis we are intending to simulate in the 3D environment as Virtual Reality devices such as the Oculus Rift come with controls to manage this functionality of rotating objects, picking objects up from a surface for closer viewing and opening/closing objects such as doors and cabinets.

Must provide adequate feedback response and visual cues when interacting with the scene,

It is important when looking at user interaction systems to provide the user with feedback responses whether through visuals, audio or haptics to acknowledge their actions within the virtual space. The user must know when they have completed an action and where to move onto next. The visual cues in the 3D environment need to be adequate to indicate to the user on what type of action they should take to interact with the objects in the scene. To open a door, a door handle/knob should be present with a system to let them know that this object can be interacted with and it is not static.

Should mimic real life interactions with objects based on reality to improve immersion e.g. opening doors by interacting with a handle,

This high-level requirement is a 'should' requirement and therefore implies that the requirement is something that should be taken into consideration to improve the virtual reality application and how the user can interact with it. By mimicking real life interactions found in everyday life we can fulfil the goal and objective of making an application which feels natural and more immersive to the user, users can therefore gain a sense of familiarity and removes the need to learn completely new interaction mechanisms.

Could introduce alternative ways to interact with additional devices e.g. Smartphones,

The final high-level requirement specified for this sub-system is to introduce alternative ways to interact with additional devices such as Smartphones which also support Virtual Reality applications and development in the Unity3D game engine. If this requirement was met and accomplished it would widen the available reach of this application as Smartphones are

more affordable, simple and available in comparison with niche devices such as the Oculus Rift which requires a PC to function. This is listed as a 'Could' requirement as it is not the primary concern to get the project running with the minimum requirements and should only be considered if time is available at the end of the development process.

Luke Rose

Overview:

Building a 3D scene will be one of the subsystems within our whole system. This subsystem must simulate a crime scene that will work in accordance with the story written within another subsystem. To do this, the scene must include 3D assets that represent both objects in the room and story driven object (e.g. Evidence). In addition, the scene needs to be relatively realistic as per the requirements of the client. Therefore, this should be achieved but adding adequate lighting into the scene. Finally, if the subsystem can be finished to the relevant standard, while meeting the requirements stated above, additional assets could be created by Luke Rose and added to the scene.

Breakdown:

Must simulate a crime scene,

The first requirement in the 3D environment sub system will require a 3D scene to be built within Unity. This will involve attaching together 3D objects and assets to create the feel of an immersive room. This room will be the basis for our crime scene and as our system will be controlled by an Oculus Rift, the room will need to be scaled in reference to the size of the camera view of the Oculus Rift to create a realistic feel for environment. The layout of the room and the items contained within it will be based on pictures of a living room that the Forensics students at Coach Lane Campus, Northumbria, use. This is per request of the client, Dr. Alan Langford.

Must Represent the crime scene according to the story written,

One of the other sub systems within this project is to create the story for the crime scene. This will affect the second requirement within the 3D environment sub system as the extra items added to the scene will be story driven and invented by the person creating the story for the system.

Must use existing 3D assets to populate the environment to create the scene,

Due to time constraints within this project, 3D assets form the Unity Community must be used to populate the scene. If more time was available, then assets could possibly be created as part of this sub system. In addition, this sub system must use 3D assets as it will create a more realistic feel to the overall project and scene. This is important as the client wants to use this system for his students to use as a professional product.

Should Set up adequate lighting for the environment,

Like the previous requirement, this sub system should have a form of lighting within the scene because it will again allow to create a more realistic product in conjunction with the 3D assets in the scene.

Could develop own 3D assets using additional software to add to the scene,

If all the other requirements within this sub system are finished within enough time and to a high enough standard, the system could have its own 3D assets created by Luke Rose.

Ana-Sabina Irimia

The main goal of the storyline subsystem is to create the story of the product by following the phases depicted above. For the subsystem to be accomplished the person in charge must follow the main requirements:

Must be able to describe the events that took place in the 3D environment,

Once the initial idea of the project is chosen, in this case, to create a crime scene in which the user can interact and find clues, the production phase moves to the story section. The story for the project must be written down in script or screenplay format. By writing the script the details around the room can be depicted as well as how the user can interact with the objects in the 3D environment. The description of the events focuses on what and how the crime happened as well as how the user interacts with the objects in the room.

Must provide clues related to the storyline that assist the investigation in uncovering the whole story,

The clues will be presented in the script as well as in the storyboard for better visualisation of the objects and their position around the crime scene. They will not be up front to the user making it like a real-life experience of finding the object that helps define the crime. Like in a real investigation, the user will not have any help finding the clues.

Must produce a storyboard to describe events in the story,

Breaking down the script, the person in charge of the storyline subsystem will have to illustrate the storyboards, a key element in the visual development of the product. The storyboard will present the position of the objects in the room, how the user can interact with them and how the clues can be found.

Should write alternative pathways to the story to challenge the user's perception of the scene,

The story will be written with the possibility of an alternative pathway. The end can change depending on the clues selected by the user.

Could write stories for additional crime scenes,

The member in charge of the storyline subsystem must write the script that describes the possibility of different crimes that could have happened at the scene of the crime. Thus, aiding in the making of the alternative pathway requirement.

Zoe Irwin

As established the user interface is the main part of a system that facilitates the user to interact with the application in an efficient manner. To most end users, "the user interface is the system itself" (Saha & Mandal, 2015). Hence, why the usability of the system is one key attribute in creating a high-quality application. Therefore, the first requirement of the subsystem (User interface) is to create a system that **"Must allow basic navigation through a main menu screen".** The idea that both the naïve and specialised users can navigate with ease throughout the VR application. Jones (2011) highlights the importance of

asking questions when developing a new system for users such as "Are they able to navigate around and achieve their objectives with relative ease? Is the interface intuitive to both experienced and less experienced users?"

The next element of this subsystems requirements is that the system "**Must display and instruct the user on how to navigate around the scenes".** Without this, the application becomes challenging for users and perhaps too complex that they don't want to use it. Therefore, it is important to display sufficient information on how to both navigate through the menu options and the forensic environment scene itself. With this, the users can then adjust and immersive themselves in a virtual environment in which they can interact and make complex decisions.

Despite, having information readily available, it is vital that the text is clear and as concise as possible as people simply "don't have time to read" (Watzman, 2002). Therefore, when considering the last must the system "**Must make user interfaces as user-friendly as possible**". For example, be consistent with the design type, structure, navigation, language and decrease the amount of time spent reading and understanding. By ensuring this consistency the user experience will almost seem effortlessly and enjoyable throughout.

It can also be stated that graphics are a very powerful element of a user interface as they both efficiently and effectively save space on the page without detailed explanations (Watzman, 2002). When developing and designing the UI the visual quality should be one key aspect. For example, if the interactive application interface is visually pleasing with a lot of well-designed features and is actually fun to use, this can enhance the overall players experience and in addition can boost the sales of the application (Fox, 2005). Therefore, one area of this subsystems requirements is that the system "**should make user interfaces more interactive with the use of sound & graphics".**

Lastly, it should be accessible within the application for users to access help and alternative menus within the scene known as a sub-menu's. Therefore, one element of the requirements is that the system **"could have sub-menu interfaces for the user to interact with in the scene."** The idea whilst immersing into this interactive experience it should be problem free with help and advice on hand, as if the interface has a loss of structure and limited help, the users are less likely to enjoy or participate no matter how good the content is. All in all a poor designed interface with a lack of sub-menus and assistance is a major issue (Jones, 2011).

Subsystem 4 (Zoe Irwin)	User Interface A User Interface which: Must allow basic navigation through a main menu screen, Must display and instruct the user on how to navigate around the scenes, Must make user interfaces as user-friendly as possible, Should make user interfaces more interactive with the use of sound & graphics, Could create sub-menu interfaces for the user to interact with the scene,

Efstathios

Must have great communication with the team to interact with the development of the project efficiently. Firstly the role of the tester is to create a professional level connection with every member of the team. Communication among the team is a major priority and with out doubt the final product will be more accurate to what we wanted as a team, and also during the whole development process.

Must test the various sub-systems of the application and document the results. A detailed document on the whole process of the application will probably be one of the main testing part. The writing style should be short but describe the details of the testing and monitoring process. Various tests on each subsystems requirements and an overview about the progression of the team must happen frequently, the test results and the overall image for every subsystem will be documented as described above.

Must regularly test each build of the application and provide feedback to the other members of the group. Team member should work as a team but also must spent a lot of time building their own subsystems in order to build the different parts and work together to finalise the product. Each part of the subsystems build will be tested and monitored to stay reliable on group deadlines, feedback will be provided to the other members of the group both for the testing part of their build, and also a reminder for the schedule/ time management that we agreed as a team.

Should analyse set objectives and goals against the finished product. By the end of the project there should be a discussion for every subsystem if it has complete at least the "must" points of the requirements and tried to complete some of the "optional" parts of their work. Considering the documented results from the previous tests, tester should be able to create an analysis document/report for every subsystem and the main subject would be if the members completed the requirements successfully or not and for what reasons.

Could test the application on other hardware devices software systems. Ideally we could test the product in different hardware like smartphones or consoles and also in different operating systems like Apple and Linux software. A compatibility list could be made by the end of the overall project and it will be mentioned in the main document of the testing.

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