# A Comparative Evaluation of Walking Methods for Reducing Simulator Sickness for a High-Fidelity Archery Virtual Reality Simulation

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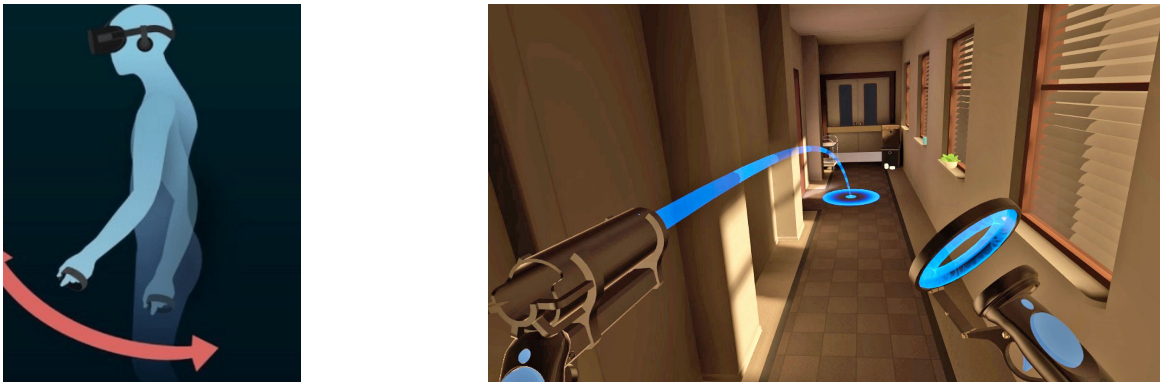

**(a)** Arm swinging

**(b)** Teleportation

**Figure 1.** Existing virtual reality walking methods

*CCS Concepts:* • **Human-centered computing** → **Human computer interaction (HCI)**; *Interaction paradigms*; Virtual reality.

***Keywords:*** Simulator Sickness, Virtual Environment, Walking Methods, Locomotion

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## 1 Abstract

The rate of development of Virtual Reality (VR) hardware and software is rapidly increasing and VR technology is being applied to many more interesting and useful areas. Considering the growth in VR accessibility, VR is being more widely adopted and it is important that the health risks be considered. VR is being hindered by a sensory effect, known as simulator sickness, that triggers: dizziness, nausea and disorientation in the VR program users, as they navigate virtual environments. In this research we will examine three different walking methods: two that are common practice in VR locomotion and one of our own design, a haptic cradle solution. We will evaluate each method, considering the extent to which they induce simulator sickness and the levels of presence that the users experience while using each method. This insight will provide a clearer understanding of the extent to which each technique induces simulator sickness and whether our designed solution, the cradle, mitigates these effects.

## 2 Project Description

The term locomotion in Virtual Reality(VR) defines movement from one place to another within a VR environment. Locomotion methods can thus vary in different VR environments. These different methods include: walking, flying and

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driving, though locomotion is not limited to just these methods. Implementations of these locomotion methods can use a variety of controls that can be implemented either with software or hardware. We often find though that these locomotion methods commonly induce simulator sickness where simulator sickness is a simulator sickness is a sensory effect experienced by VR users that causes nausea, dizziness, and disorientation. Thus, due to one experiencing similar symptoms to that of motion sickness, Hyun et al define simulator sickness to be a subset of motion sickness[13]. Due to the negative experience simulator sickness can provide in VR it therefore discourages user involvement in VR, tarnishing user experiences by decreasing their immersion and enjoyment.

When carrying out any of these locomotion techniques in VR one can often experience a difference in what their visual system experiences and what their sensory system experiences. This contradiction experienced by the visual and sensory systems during locomotion in VR is the cause for the above explained simulator sickness according to Sensory Conflict Theory, a theory laid out in 1990[14]. Other theories explaining the causes for simulator sickness exist, such as the Postural Instability Theory [17] and the Poison Theory [24], but this research is based on Sensory Conflict Theory, as we drew on this theories influences, to make decisions regarding the design of the VR environment that will be used in the experiment. //

Considering how much more easily accessible VR hardware is today combined with the increased power and decreased price of consumer grade graphics cards, such as the NVIDIA 3000 series, VR technology is available to more users and thus simulator sickness poses a threat to the wider adoption of VR. The development of low-fidelity VR applications is yet another factor that contributes to the wider adoption of VR as high powered VR sets are no longer required and therefore cheaper VR equipment has been made available to consumers. Thus we now find stand-alone VR devices, such as Facebook's Oculus Quest 2, that do not require expensive computers to operate. Devices like the Oculus Quesr 2 are cheaper than tethered VR equipment and with this added competition, other devices like the HTC Vive have decreased in price. With all this in mind, we see further than simulator sickness is one of the main factors standing in the way of VR's wider adoption,https://www.overleaf.com/project/610698aa4b19362f6c3a6d1a rather than price and accessibility of VR equipment.

VR has been shown to have many practical and positive use cases in society, thus motivating the use of VR among more than just gamers and enthusiasts. VR hardware has been used for the following societal uses: assisting people with autism [4][12], conducting phobia therapy [9][16] and helping reduce pain in burn victims during the process of bandage wrapping and re-wrapping [22]. Furthermore, VR has acted as a training tool for learning to drive and has been used as an effective helicopter simulation platform for the military [3]. These important use cases show that VR has the potential to benefit society and the motivation to reduce simulator sickness becomes more clear than ever.

As it is our aim to reduce simulator sickness whilst walking in VR, we will be comparing three walking methods: arm swinging, teleportation and the cradle method - a novel method we will design for this study. Arm Swinging and teleportation are widely used in VR today, with teleportation being supported in most games and the industry standard for walking in VR. Arm swinging requires one to swing their arms in real life to move in a VR environment, whereas teleportation requires a user to point at a desired destination, to be transported to that location - allowing for rapidly traversing VR environments.

In this research we propose a new walking method, the Cradle Method. Using the Cradle Method a user will be surrounded by a band that provides haptic feedback upon interaction, which we believe will aid in preventing simulator sickness. This is based on the idea that haptic feedback will provide a physical response to a user's a environment locomotion, decreasing their simulator sickness. Furthermore, this is based on the idea of cross modality. While experiencing the VR environment, utilising more than one sense (in this case both sight from the VR headset and touch from the Cradle) it will reduce the levels of simulator sickness that the user will experience. This further supports the Sensory Conflict Theory as we will align what different senses experience, to reduce simulator sickness. We predict it will reduce the degree of simulator sickness experienced by a user since it provides extra stimulation to the senses, yielding a cross modality effect.

We will test the walking methods in an high-fidelity archery environment, which we will name the Robin Hood Environment(RHE). The RHE will require users to traverse the environment, testing each walking method, while simultaneously firing a bow at targets placed in the environment.

## 3 Related Work

Large amounts of research has been done with regards to simulator sickness induced by travel techniques in VR. The conducted research has shown contradicting results about the causes of simulator sickness [10][15][18]. Though, there have been other studies that clearly show certain contributing factors as to the cause of simulator sickness, such as age[15], gender[8] and VR hardware properties[21]. Furthermore, research has been conducted regarding travel methods' relationship to the sense of presence in a virtual environment and furthermore its effect on simulator sickness. Thus, previous research has established a base of factors and influences affecting the degree of simulator sickness one would experience while using VR.

Having established what contributes towards the degree to which someone experiences simulator sickness, it is important we can somehow measure the degree to which the experience simulator sickness. Evaluating simulator sickness is most commonly done using a self-assessed, subjective measure, the Simulator Sickness Questionnaire (SSQ). It is a non-invasive method in which a participant can assess their degree of affliction[5]. The SSQ requires one to fill out a questionnaire that rates the severity of the symptoms they have experienced. More than this, we are also able to measure simulator sickness using physiological aspects of the participants, as was done by Brookhuis and de Waard[7], on monitoring mental workloads of drivers in simulators . These metrics together, will enable us to create an in-depth evaluative technique, where we can assess the degree to which participants experience simulator sickness.

In terms of the locomotion methods in our simulation, it is appropriate to test a few implementations of walking to get a range of techniques and simulator sickness levels. We will implement two existing methods and a novel method, the Cradle Method. The first of the existing methods is the arm swinging method which requires one to swing their arms in real life to move in a VR environment. The second method is the teleportation method which requires a user to point at a desired destination and be instantaneously transported there. The teleportation method is an industry standard of locomotion and can be found in most VR experiences that require locomotion controlled by a user.

Finally, we will be measuring immersion in our VR environment. Immersion or presence in VR is heightened as real-world sensations are introduced into the virtual space. Haptics provide physical feedback, via an attached or unattached device - that simulates an effect from real life. Haptic devices such as the HapticSnakes, developed by a team collaborating from three universities [1], provide users with varying types of feedback. These include: gripping, tapping and brushing and the experiment showed that the users, could be affected by these simulated actions in a very similar way to how they would be affected in the real world. Other haptic elements have been investigated, such as a force-feedback user controller that simulates grasping objects and the sensations associated with this [23]. While there is a lack of haptics research available, what is available shows a strong relationship between presence and simulator sickness [11][2], and thus by introducing haptics to achieve a greater user "presence", we may see a decrease in simulator sickness experienced.

# 4 Problem Statement

## 4.1 Research objectives and questions

The most well-known health risk regarding VR, specifically with regarding to locmotion methods, is simulator sickness, a subset of motion sickness[13]. Not only is simulator sickness a health risk, but as described above it hinders the wider adoption of VR. Thus, the goal of this study is to provide a fair comparison of different walking methods and the degree to which they affect simulator sickness, presence and performance for a high-fidelity archery VR environment called the Robin Hood Environment(RHE). The RHE will be a forest environment to deliberately induce a mild form simulator sickness in the participants, through its uneven grounds and the trees dominating the field of view. Inducing a mild level of simulator sickness will provide a base level of simulator sickness to help compare the degree to which a particular walking method has an affect on simulator sickness.

With this objective in mind we can now declare our research aims: (1) Compare 3 different walking methods in an archery-based VR environment to determine which results in the lowest level of simulator sickness (2) Compare 3 different walking methods in an archery-based VR environment to determine the effects of the walking method on presence (3) Compare 3 different walking methods in an archery-based VR environment to determine which walking method results highest accuracy of target shooting in the archery-based VR environment, known as performance. To achieve these aims we can pose the following research questions:

1. Will a novel method of walking in VR, namely the Cradle Method, result in lower simulator sickness scores after executing tasks in the RHE in comparison to arm swinging and teleportation methods?
2. Will a novel method of walking in VR, namely the Cradle Method, result in higher presence scores after executing tasks in the RHE in comparison to arm swinging and teleportation methods?
3. Will a novel method of walking in VR, namely the Cradle Method, result in greater performance scores after executing tasks in the RHE in comparison to arm swinging and teleportation methods?

# 5 Procedures and Methods

## 5.1 Method

**5.1.1 Robin Hood Environment Development.** The RHE will be designed and built as a high-fidelity virtual environment suited to a VR archery-based game. This environment will be used to compare walking methods and assess the simulator sickness, presence and performance of a participant. Therefore, the environment should be designed in such a way that a user can navigate it using all three walking techniques namely the arm swinging, teleportation, and the novel Cradle methods. While traversing the RHE A user will also be able to use a bow and arrow to shoot targets that will be placed in trees. These targets will randomly become visible at a distance far enough from the user to encourage movement between shooting targets. Encouraging a user to move and therefore use the locomotion methods will allow us to measure simulator sickness effectively.

We will need to implement certain design aspects of RHE to help induce a base level of simulator sickness. The reason we will induce a mild form of simulator sickness is so we can analyze the degree to which the walking method effects how much one experiences simulator sickness.

The following are the landscape features that will be implemented to induce a base level of simulator sickness: The ground of RHE will be designed uneven in nature as one would experience it in real life. A user will visually experience an up-and-down motion as one would walking in real life, without the accompanying sensory experience they are used to from real life. This aligns with the Sensory Conflict Theory, meaning there will be a mismatch between the visual and sensory systems, thus inducing simulator sickness.

Archery has been chosen as a medium as it requires traversal of the environment and the simultaneous shooting of targets. This combination requires the users to focus on using their controls to aim and shoot while having to traverse the environment at the same time. Combined with uneven ground, this will provide a mild level of simulator sickness. Finally, we have chosen to use a forest environment as a wider field of view has been shown to cause simulator sickness, further attempting to create a base level of simulator sickness from which we can measure others. A wood will allow objects to appear in the users' peripheral vision, inducing a slight amount of simulator sickness. This will allow us, as mentioned above, to set a base level of simulator sickness and discover the degree to which the walking methods affect the levels, experienced by the users. This further allows us to draw more valid conclusions.

To build the RHE we will use Unity3D, a platform for creating interactive, real-time content. Unity3D is also capable of managing high fidelity models and prefabs and is therefore suited to the RHE's needs. We will be using the C# programming language as it commonly is used in Unity3D and well documented and supported. Unity3D also has existing VR compatible libraries, including but not limited to the Unity VR library. This will enable automatic rendering to a head-mounted display and enable automatic head-tracked input. Finally, Unity3D also supports the HTC Vive, the hardware we will be using, and can export games that are compatible with Windows 10, the operating system we will be using.

**5.1.2 Cradle Method Development.** A user should be able to navigate the RHE with the following walking methods: Arm swinging, teleportation, and a method we will be develop named the Cradle Method. Thus, one of the main goals of this project is to develop the new Cradle method of walking.

This method will involve creating and utilising a physical hardware device that will provide haptic feedback to the user. This device will surround but not touch the user, although design specifications are subject to change. The haptic feedback will be provided in the form of elastic resistance - as a user walks into the band and then gets pushed backwards. The cradle solution will work coherently with the virtual environment, as when the user is pushed back by the elastic resistance, the displacement of their head position (which is being tracked in the software), will result in a shift in the environment, to simulate movement. This cradle-band will be designed to work with the software to provide accurate user feedback, which will translate into less simulator sickness being experienced by the user.

**5.1.3 Participants.** We know from previous research that older people experience greater levels of simulator sickness [15][10]. Thus, to avoid skewing the results of the simulator sickness levels we will limit participants to ages 18 - 30 years old, as these ages tend to be affected by simulator sickness in a similar manner. We also know from previous research that evidence overwhelmingly supports that gender can affect the degree of simulation sickness that one may experience [2][8][6], thus in the participant sign up process we will ensure a balance of male to female participants to avoid skewing simulator sickness scores. The study will not reject or accept participants based on their: gender, race, ethnicity, or socio-economic background. These factors are being excluded as there has been no research that shows these factors have any effect on simulator sickness. Participants are required to be neurotypical, meaning we will accept those who do not display or are characterized by autistic or other neurologically atypical patterns of thought or behaviour. A single study has shown that autism does not affect the degree of simulator sickness that one experiences [19], but this is not sufficient evidence to prove the theory, and thus we will screen out those who are considered not neurotypical. The finall requirement is that a participant have no co-moribidities. Due to the COVID pandemic, we must screen these people out as they are at higher risk from the Corona Virus than those without co-morbidities. Finally, to ensure safety and flow of information from researcher to participant we must ensure communication is clear, as such participants will be required to speak fluent English as the primary researchers' first languages are English.

We will recruit our participants from Cape Town-based universities, as well as personal relations as they are most likely to fit the age limit and language requirements. We will use the following methods of recruitment: Phone calls, social media, email, and online forms.

We can summarise the inclusion criteria as laid out by this section are as follows:

1. 18 < Age < 30
2. Neurotypical
3. Fluent in English
4. No Comorbidities
5. University student
6. Cape Town

## 5.2 Procedure

To answer our research questions we plan to run a human trials in which participants will have the opportunity to experience the RHE through the use of the three walking methods. The trials will consist of the following phases:

1. Hardware Preparation
2. Information, safety consent
3. ECG attachment
4. Task execution
5. Evaluation

In this experiment we will be trying to answer our research question as laid out in 4.1. In this experiment we will therefore be measuring simulator sickness, presence and performance of a participant. We will do this by allowing participants to navigate the RHE using different treatments(the walking methods) and collect data during and after the users RHE experience through a subjective questionnaire and objective measures such as physiological measures.

**5.2.1 Simulator Sickness.** The most common way of measuring simulator sickness, as seen in previous research, is by using the simulator sickness Questionnaire(SSQ). The SSQ is a questionnaire, developed in 1993 and has been widely used since. It asks a VR user to rate a list of 15 symptoms from 0 to 3, 0 being the least severe experience of a symptom and 3 being the most severe. Each symptoms fits into one of the following categories: Nausea, oculomotor and disorientation. Using the answers from the questionnaire, the values are entered into a formula. By assigning weightings to each category in the questionnaire and using values from the answers the SSQ will calculator ones final score and indicate a users experience of simulator sickness.

The SSQ has been used in many research papers and is widely accepted. Though there is a version of this questionnaire that has been adapted specifically towards VR, the VRSQ. The VRSQ hasn't been widely used in research and we will therefore use the SSQ to measure simulator sickness. We will require each participant, after having executed tasks in the VR environment, to fill out the SSQ. After trials have been completed, the collated data, the SSQ data from all participants, will be statistically analysed for differences to see if there a relationship between the tested walking methods and the degree to which the users experienced simulator sickness. This will help us to answer our first research question.

Finally, some research has shown that simulator sickness can be detected and therefore measured by physiological signals. To detect and measure these physiological signals wee will be using ECG equipment attached to a participants body. This is a more objective measure and will be used in our data analysis, further contributing towards answering our research questions. To record the data from the ECG equipment we will be using complimentary computer software to receive the physiological signals from the ECG equipment with the help of the UCT Psychology Department.

**5.2.2 Presence.** The next aim of this research, as laid out by our second research question, is to measure presence in the RHE. We understand the sense of presence as the subjective sense of being immersed in a virtual environment. As presence is a subjective measure, like simulator sickness, we will measure presence with a subjective questionnaire that a participant will fill out af[20] which have been refined over years of testing.

We have chosen to use the Witmer and Singer questionnaire, known as the Presence Questionnaire(PQ)[**?** ] to measure presence in our participants. The PQ has been commonly used in VR research. The questionnaire has been refined over many years with the most recent version being PQ Version 3. Version 3 of the PQ uses a seven-point Likert-type scale and contains 29 questions. These questions are divided into four sub-scales: Involvement, sensory fidelity, adaption/immersion and interface quality. After a participant has experienced the RHE and after having filled out the SSQ, the participant will be required to fill out one final questionnaire, the PQ. Like the SSQ, we will take the PQ results after trials have been completed and conduct a statistical analysis to compare presence scores among the different walking methods that we will be testing.

**5.2.3 Performance.** The final aim of the research, as laid out by the third research question, is to measure performance in the RHE. Performance refers to the accuracy of hitting a target after shooting the bow and arrow. To measure performance we will implement and accuracy thread that will constantly run in the background of the RHE. This thread will constantly listen for a arrow hit event, meaning it will take note when a arrow succesfully hits a target. Thus, this thread will be measuring what we will call the Target Hit Ratio(THR). The Target Hit Ration is defined as follows:

$$TargetHitRatio(THR) = \frac{\sum(SuccessfulTargetHit)}{\sum(ArrowShots)} \quad (1)$$

Thus, when a user successfully hits a target the THR will increase, and when a participant misses a target, the THR will decrease. When a participant is finished in the RHE, the THR will be saved and then later used in statistical analysis to answer our research questions, namely the third research question.

## 6 Ethical, Professional and Legal Issues

To answer our research questions, we will have to run human experiments. Thus, to ensure that the research is conducted in a responsible and ethical manner, and to ensure the safety and minimize risk to our participants, we will require ethical clearance from the UCT ethics board. Ethical clearance will be required for the following reasons:

The virtual environment will be designed in such a way as to induce a slight degree of motion sickness. This is to create a baseline level of simulator sickness to test. Additionally, a user may experience a greater level of simulator sickness due to the different walking methods they will experience during the experiment. Considering the motion-sickness-like symptoms, the participants will need to provide a signed informed consent form, as provided by the researchers, to participate in the experiment. The consent form will contain the necessary information such that a user is fully informed on what the research is for and why it is being conducted. The form will also be verbally explained to a participant to ensure absolute clarity. This will be in the information, safety consent phase of the experiment, after which they will be required to sign it. Inline with the POPI act, we will also inform a participant of the data that we will be collecting and using and require their consent to use it in our statistical analysis after trials have been completed. Finally, the consent form will stipulate that a participant may choose to withdraw from the given research at anytime. With all this, we will require ethical clearance from the UCT Ethics Committee.

To measure the effects of simulator sickness in the participants, electrodes and other measuring devices will need to be connected to them. A professional will need to be employed for this procedure and ethical clearance will need to be granted for this as well. The hired professional and the participants will be compensated for their assistance and time given to the study and the payment amount must be ethically calculated, taking into account the time required from the participants.

Finally, ethical clearance is required to ensure the safety of our participants during the COVID-19 pandemic. COVID-19 can affect people in many different ways with people presenting all kinds of symptoms, such as a dry cough, headaches or other more extreme symptoms. Thus, we will be required to adhere to the strictest of COVID-19 guidelines as set out by the University of Cape Town and the South African Government. To ensure strict adherence to these guidelines, the researchers must meet with the UCT Computer Science Department's COVID-19 Compliance Officer in which they will be briefed on the guidelines and other safety information.

In terms of intellectual property, the authors retain the copyright as a matter of law, however, this copyright has been assigned to the University of Cape Town, on a contractual basis. As per the source code, it will be open source and no proprietary software will be needed.

## 7 Anticipated outcomes

**7.0.1 Expected Challenges.** In designing the RHE we expect to encounter certain challenges. We will design the RHE such that it induces a subtle form of simulator sickness, though we for-see a challenge of making sure it is only a mild form of simulator sickness rather than unintentionally causing a user to experience great amounts of simulator sickness. A greater form of simulator sickness would not only compromise our user experiments, but would render our experiments unethical as we would be negatively impacting our participants.

Another challenge we expect to encounter is implementing our locomotion techniques while simultaneously allowing for control of the archery controls. This combination may result in participants not being able to effectively participate in the user experiments and so we aim to balance locomotion and the archery controls such that a participant can easily take part in the VR environment.

We also expect design and implementation of a cradle method to be difficult as we need to ensure the interaction with the cradle accurately reflects in the virtual environment. More so, it requires a new hardware device to be built and designed from scratch which may pose a difficulty to both researchers. Thus, to reduce this challenge we will consult UCT's Computer Science technical staff, Sam Chetty.

Finally, a challenge we expect to encounter is recruiting participants for said research. Due to the COVID-19 pandemic we may find people are not wanting to get involved in face-to-face research, and thus we must ensure we start recruiting participants as early as we can.

**7.0.2 Expected results.** Given our research questions, we can define key factors that will determine the success or failure of this research.

As shown in previous studies, different locomotion techniques result in varying levels of simulator sickness experienced by a user. Thus, given the nature of this research being simimlar to those of previous studies we can expect similar results in that different walking methods would result in varying levels of simulator sickness experienced by a user.

We can further define our expected outcomes based on our proposed research questions.

Due to the haptic feedback and based on the idea of cross-modality, we expect the Cradle Method to result is a lower degree of simulator sickness experienced by a user than the traditional arm swinging and teleportation methods. Furthermore, as simulator sickness and presence are shown to be negatively correlated [11][2] we expect the Cradle Method to result in increased levels of presence in comparison to the other walking methods we will test. Finally, we expect performance when using the Cradle Method to be higher than that of arm-swinging or teleportation. This is based on the idea that a user is required to use their hands only for shooting the bow and arrow whereas if they were using arm-swinging or teleportation, their hands need to be used for locomotion and shooting the bow and arrow. Thus,k we expect that when using the Cradle Method, performance will be increased as a user will exclusively use their hands for aiming and shooting the bow and arrow.

# 8 Project Plan

## 8.1 Risks

Risks and risk mitigation strategies are defined in the risk matrix seen in Appendix A

## 8.2 Timeline

The project will run over 4 months, beginning July and ending with the submission of the web page on the 18th of October. A more detailed timeline can be found in the Gantt chart found in Appendix B.

## 8.3 Resources

In order to achieve our project aims and conduct our research for this project, several resources are required. These resources can be categorized into hardware and software resources.

### 8.3.1 Hardware resources.

- High performance GPU
- HTC Vive headmounted display
- HTC Vive controllers
- Hardware components to design the Cradle
- Monitoring equipment for physiological tests

### 8.3.2 Software resources.

- Windows 10 operating system
- Unity3D
- Blender/Maya
- Software to read physiological data

## 8.4 Deliverables

- Literature Review
- Project Proposal
- Project Proposal Presentation
- Project report draft
- Final project report
- Final code submission
- Project website
- Project poster

## 8.5 Milestones

The project milestones are shown below and have been illustrated in the Gantt chart as seen in appendix B.

- Project Proposal Presentation Submission
- Ethics Application Submission
- Finalising our Research Proposal
- Completing First Phase of Development
- Completing Second Phase of Development
- Completing Software Feasibility Demonstration
- Successfully Running Our Experiment
- Completing Our Analysis of the Experiment Data
- Finalising Final Paper Draft
- Completing the Project Demo
- Final code submission
- Finishing the Poster
- Completing the Web Page

## 8.6 Work Allocation

The work will be allocated in two sections: mainly software development, with a smaller hardware development section.

In terms of the required software, we require both an implementation of our locomotion techniques and an environment in which to carry them out. The environment will be more extensive, as it will have to handle allowing the participants to move around in it and fire a bow and targets in a wooded landscape. Ryan will work on this solely, being aided by Hayden. This is because Hayden will be responsible for implementing the locomotion methods and this will take less time.

Both Ryan and Hayden will assist in the building of the haptic cradle hardware and ensure that the change in motion that the users experience effectively maps to the software.

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## A RISK MATRIX

| Risk | Probability | Impact | Mitigation |
|---|---|---|---|
| Team member contracts COVID-19 | High | High | Keep up to date documentation on software and hardware development such that another team member can complete the work should a team member fall ill |
| Participant contracts COVID-19 | High | High | Adhere to strict COVID guidelines |
| Supervisor becomes disengaged | Very low | Medium | Regularly meet and engage with supervisor to retain engagement and interest |
| Inability to access UCT virtual reality equipment | Low | High | Inquire with UCT that hardware is available when necessary. |
| Scope creep | Medium | Low | Be weary of adding extra functionality and experiments. Adhere to the Gantt chart as closely as possible. |
| Not obtaining ethics clearance | High | High | Be clear and precise about all aspects of ethics in the project proposal and ethics proposal. Ensure every aspect of risk is covered in ethics and projects proposal |
| Inability to recruit participants | Medium | High | Start recruiting and advertising early as to avoid a last-minute rush for participants. |
| | | | |
| Team member drops out | Low | High | Constant support of one another and constant check ins to ensure mental health of the project team |
| Lack of experience in Unity and VR | Medium | Medium | Utilise Unity3D's documentation for VR and |
| Failure to meet project requirements | Medium | High | Research team to constantly compare project outputs with requirements and meet with supervisor regularly. |

**Figure 2.** Risk Table

# B GANTT CHART

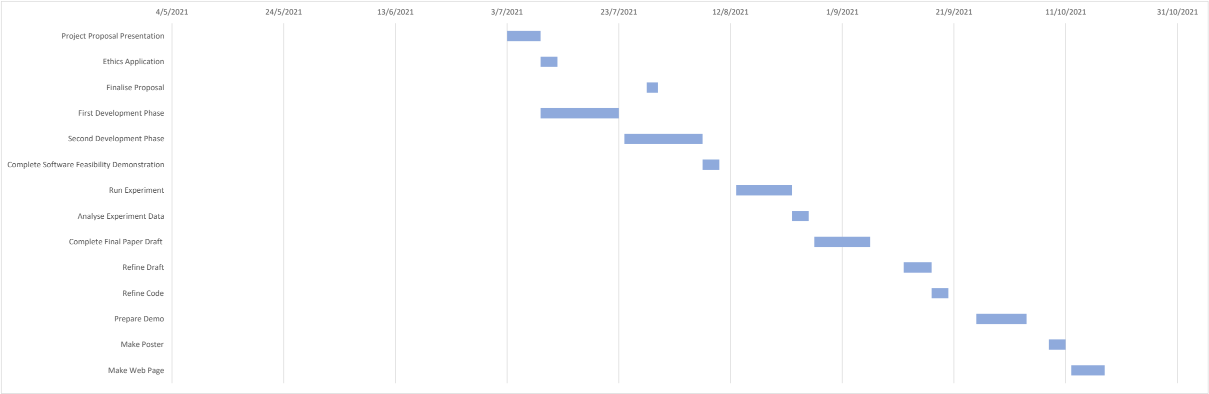

**Figure 3.** Gantt Chart