

# VIRA | Virtual Insight into Real Athletics

Design Document

Group 33

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# Executive Summary

## Development Standards and Practices Used

### Software Development Practices

- Agile development process
- High cohesion, low coupling
- Modular code for maintainability and extensibility
- Good code formatting and documentation

### Engineering Standards

- Unit testing
- Documentation of design decisions, including UI and architecture
- Documentation of technologies and rationale behind them

## Summary of Requirements

- The user can log in and navigate to a module
- The user can complete a module, either in guided or quiz mode
- The user can see their performance data

## Applicable Courses from Iowa State University Curriculum

We have all taken different courses, so every group members' experience is different. In general, however, the list of applicable courses includes (but is not limited to):

S E/CPR E 185 *Problem Solving in Software Engineering*  
COM S 227 *Object-Oriented Programming*  
COM S 228 *Introduction to Data Structures*  
S E/COM S 309 *Software Development Practices*  
S E 319 *Construction of User Interfaces*  
S E 329 *Software Project Management*  
S E 339 *Software Architecture and Design*  
S E/COM S 362 *Object-Oriented Analysis and Design*

## New Skills/Knowledge Acquired Not Taught in Courses

We are all new to VR development, so all of us are learning what we need to know as we work. Along with that comes learning the Unity environment and designing VR applications. Additionally, only one of us is a student athlete, so the rest of us are all learning more about human anatomy and injury diagnosis procedures. Finally, as this is the largest course project any of us has undertaken, we are all gaining first-hand experience with the software development lifecycle, which cannot be taught in a regular lecture.

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# 1 | Introduction

## 1.1 | Acknowledgement

We would like to acknowledge the significant help of Joe Hubbard, an ISU athletic trainer who is our primary source of information related to athletic injury examinations.

## 1.2 | Problem and Project Statement

There is nothing as good as hands-on, in-person, real-time experience in performing the tasks of an athletic trainer. When students in the athletic training program have made it to the stage where they are able to work in the training room with student athletes, their time in the training room becomes very valuable. However, while they are learning, a full-time athletic trainer must watch them and guide them through what they should do. This makes it very difficult for athletes to get the attention they need when the training room gets busy. On top of that, there are many traumatic injuries that a student will never have experience with until they are working full-time in the field.

A virtual reality training program would allow athletic training students to get the extra experience and feedback they need without having to interrupt or wait for a full-time athletic trainer to finish treating another athlete. We propose a virtual reality program that consists of a set of training modules that walk an athletic training student through injury evaluation and diagnosis scenarios.

Our goals are as follows:

1. Create a virtual reality (VR) training program that provides student athletic trainers with more experience outside of class and work;
2. Give student athletic trainers realistic simulations of assessing injured athletes without performing real (and critical) examinations; and
3. Allow for easy future extension of VIRA by using a modular design.

## 1.3 | Operational Environment

VIRA is primarily designed for stationary, indoor use. As a VR program, it is important that the user be aware of their surroundings at all times. The physical component of VIRA, an Oculus Quest, should therefore not be subjected to extreme conditions.

## 1.4 | Requirements

### Functional Requirements

#### Before the Module

- The user can select a user profile when starting the application
- The user can select a mode (guided or quiz)
- The user can select a specific module, covering a traumatic injury not often seen in training

#### During the Module

- The user can toggle view modes
- The user can see the muscles and tendons of the limb they are assessing
- The user can select a muscle or tendon and see its name
- The user can manipulate the limb
- The application can guide the user through an injury evaluation
- The application can assess the user on an injury evaluation quiz
  - The user loses points for the following:
    - Assuming the injury before evaluating
    - Palpating the wrong spot(s)
    - Doing unnecessary tasks
    - Completing poor differential diagnoses
    - Skipping steps of an evaluation
- The user can view the angle at which they are bending the joint
- The user can exit the module and return to the menu

#### After the Module

- The user can view their performance statistics or assessment
- The user can see their progress on a particular module
- The user can restart the module or return to the menu

### Economic Requirements

- We shall not exceed the funding provided to us by the Department of Electrical and Computer Engineering (hereinafter “the Department” or “ECpE”)

### Environmental Requirements

- The application shall work in real-time and interact directly with the user
- The application shall recognize the user’s hands in close proximity
- The application shall track the user’s hand motions in the environment

## 1.5 | Intended Users and Uses

VIRA is intended for use by student athletic trainers to practice injury evaluation and diagnosis. These are students who wish to further develop their clinical skills and gain experience working with traumatic injuries they wouldn't typically see as a student worker. Our intended customer is the Department of Sports Medicine, as they will be assisting us with module testing and will evaluate our accuracy. Our goal is to create an educational program consisting of modules that will augment students' studies and on-the-job experience.

## 1.6 | Assumptions and Limitations

### Assumptions

For this project, we make the following assumptions:

- The Oculus Quest will allow for enough motion to simulate injury diagnosis;
- The Oculus Quest has a sufficient level of hand-tracking capabilities for VIRA;
- The maximum number of users will be at one at any given time;
- Multiple users will share the same device;
- The end product will not be used by anyone but athletic training students;
- The users have little experience in the specific diagnosis module(s) we create;
- The users have a sufficient understanding of English; and
- The users are physically capable of operating an Oculus Quest.

### Limitations

As VIRA is a student-proposed project and due to complications acquiring hardware, our limitations are as follows:

- We are using an Oculus Quest, restricting us to VR technology;
- We are operating on a small budget from the Department;
- The number of VIRA modules created will be limited by development time and any schedule setbacks; and
- The quality of the graphics will be limited by the version of Unity we are able to use and the functionalities available to us in Unity.

## 1.7 | Expected End Product Deliverables

### VR Training Module

The final product will consist of at least one VR training module by the end of the school year. This will include both the standard training mode, in which the user is guided through a specific injury evaluation and provided with feedback (see below), as well as a quiz mode,

in which the user will be assessed on their performance. The specific skills targeted by these modules are palpation and injury evaluation and diagnosis.

#### Feedback Dashboard

The module(s) will implement a feedback component. This system will monitor the student athletic trainer's progress as they work through a module and will assess their technique, accuracy, etc. and provide them feedback after they complete the module. This information will be connected to a specific user's account so that user will be able to see what they did well and what they still need to improve upon.



## 2 | Specifications and Analysis

### 2.1 | Proposed Design

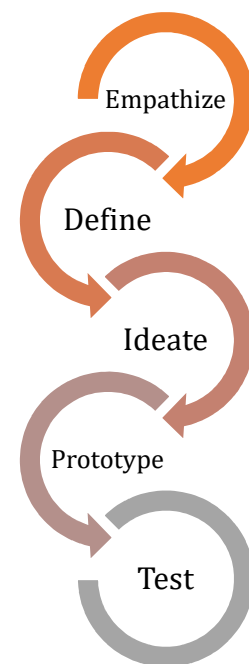
The program will be written for an Oculus Quest headset and controllers using Unity and will consist of modules that address scenarios that an athletic training student does not typically see while working in a clinic. The user will work through their chosen module alone, either standing still or sitting down. The module will consist of either a guided evaluation or a test evaluation of a virtual limb that is associated with the chosen scenario. The user will be able to manipulate the limb and gather more information by seeing different views of it, such as the muscle layer or tendon layer. The latter two enable further practice in palpation, which is key for injury evaluation.

For a guided evaluation, the program will use prompts via visual cues to guide the user into following and completing the evaluation process. For a test evaluation, there will be no guides for the reader, and they must manipulate the limb and make decisions about the options presented to them on their own. At the end of the training module, a virtual dashboard will appear to give the trainer feedback on how they performed during the training. It will also keep a history of how they have done on that particular module in the past so they can see the progress they are making towards doing it correctly. This project is intended to be scalable due to how unfamiliar the team is with augmented reality. We will begin with a single training module, then create others if time allows.

### 2.2 | Design Analysis

We collectively decided that our process would follow the design thinking process presented in class. *Figure 1* (right) shows a diagram of our process, which we will repeat in iterations. In some ways, it has worked well so far, in others, we have found some flaws. As we are still in the early stages of the design process, we have yet to prototype our modules.

One issue we have discovered is that a complication in one area of the project has the potential to complicate another area. For instance, we met with an athletic trainer with the idea of creating an AR application, but due to difficulties acquiring a Microsoft HoloLens, we will instead be creating a VR application. This will have an impact on the potential functionality of the modules and as a result, on the information we need to gather from the trainer. This will



*Figure 1 - Design Thinking Process*

likely manifest once we start development as we reconsider some of our planned functionalities. Currently, we do not plan to change our design process.

### 2.3 | Development Process

We will use an Agile process to develop VIRA. It is crucial that we receive lots of feedback from the end-users to ensure that we create exactly what they need. Working iteratively will allow us to check in with them regularly and will give us a good structure for our own time management. An Agile process will also ensure that we work collaboratively to have a shippable product at the end of each sprint, rather than working individually and hoping that one member's code will integrate with another's.

### 2.4 | Design Plan

Figure 2 shows our system block diagram, which we will use to guide our design. This diagram shows some of the use cases for our system as how different components of the system will communicate with each other.

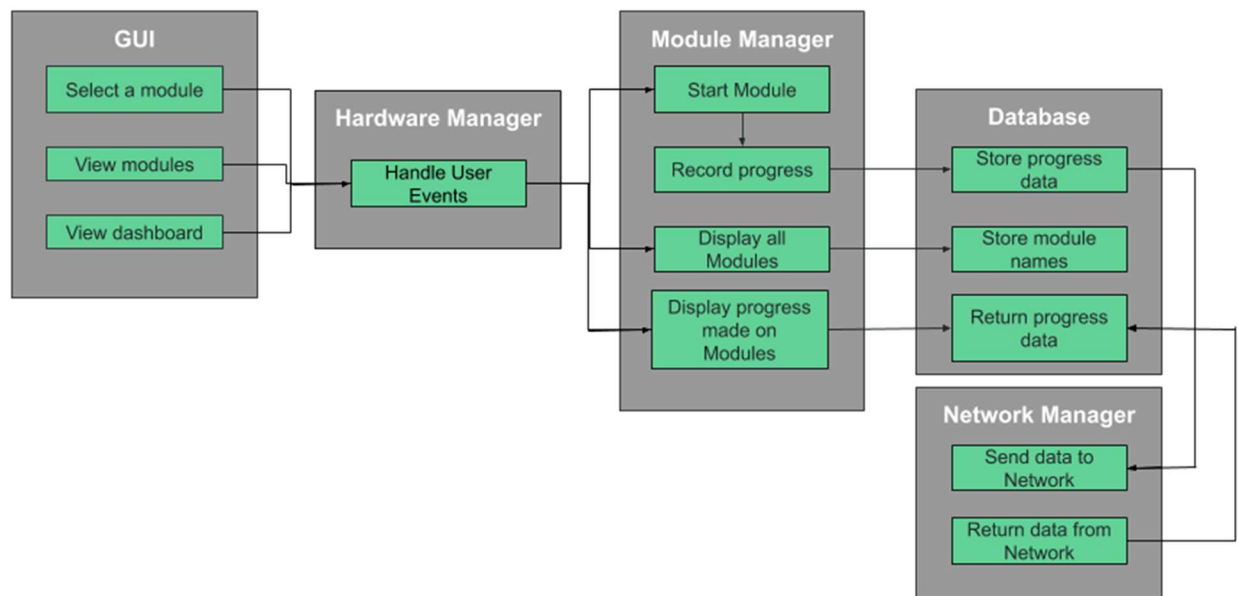


Figure 2 - VIRA Design Block Diagram

# 3 | Statement of Work

## 3.1 | Previous Work and Literature

There are several existing simulations for surgery (such as Touch Surgery) and athletic skills training, but we did not find any specifically designed for athletic trainers. These similar products are able to map the body and calculate its movements, which are aspects that we will apply to VIRA.

## 3.2 | Technology Considerations

During the proposal phase, we were considering two different routes for the projects: augmented reality (AR) or virtual reality (VR). We initially chose AR as the preferred technology as it would allow the user to practice injury evaluation with a real partner. They would be able to see another person and manipulate their joints. Unfortunately, after following several possible leads, we were unable to acquire a Microsoft HoloLens. As a result, we will instead be using an Oculus Quest, a VR headset. VR technology, while still useful, may not provide the best experience for the user, but we hope that we can still create modules that fulfill our main objectives.

## 3.3 | Task Decomposition

1. Create user profile selection
  - a. Create screen sketches
  - b. Develop basic graphics from screen sketches in Unity
  - c. Code transition from user selection screen to modules screen
    - i. Includes interaction with database
2. Create module selection
  - a. Create screen sketches
  - b. Develop basic graphics from screen sketches in Unity
  - c. Code transition from module selection screen to module
3. Create guided module
  - a. Establish narration/guided content with help from athletic trainer
  - b. Establish statistics to collect for feedback dashboard
  - c. Create screen sketches
  - d. Develop basic graphics from screen sketches in Unity
    - i. Develop models for the limb that fits the selected scenario
    - ii. Create different view modes
      1. Create skin view
      2. Create muscle view
      3. Create tendon/ligament view

- e. Code text and visuals for user guidance
    - i. Decision tree
    - ii. Limb movement indicators to guide user to move limb in a certain way
    - iii. Selections for next step or differential diagnosis (The user will be asked to choose what to do next or what diagnosis they want to make from a few options)
  - f. Code detection that the user has correctly followed the guidance
    - i. Detect if the user has moved the limb to the correct position as indicated
    - ii. Detect is the user has chosen the next step incorrectly
    - iii. Code redirect in case the use has done something wrong (may include more specific guidance or more explanations)
    - iv. Code statistics collection and store information in the database
  - g. Code muscle selection and corresponding identification
  - h. Code tendon/ligament selection and corresponding identification
  - i. Code transition from module completion to feedback dashboard
  - j. Choose which sound clips to use and where to use them
4. Create quiz module
- a. Establish narration with help from athletic trainer
  - b. Establish statistics to collect for performance dashboard
  - c. Create screen sketches
  - d. Develop basic graphics from screen sketches in Unity
    - i. Develop models for the limb that fits the selected scenario
    - ii. Create different view modes
      - 1. Create skin view
      - 2. Create muscle view
      - 3. Create tendon/ligament view
  - e. Code text and visuals for user guidance
    - i. Decision tree
    - ii. Limb movement indicators to guide user to move limb in a certain way
    - iii. Selections for next step or differential diagnosis (The user will be asked to choose what to do next or what diagnosis they want to make from a few options)
  - f. Code detection that the user has correctly followed the guidance
    - i. Detect if the user has moved the limb to the correct position as indicated
    - ii. Detect is the user has chosen the next step incorrectly

- iii. Code redirect in case the user has done something wrong (may include more specific guidance or more explanations)
    - iv. Code statistics collection and store information in the database
  - g. Code muscle selection and corresponding identification
  - h. Code tendon/ligament selection and corresponding identification
  - i. Code transition from module completion to feedback dashboard
  - j. Choose which sound clips to use and where to use them
- 5. Create user statistics dashboard
  - a. Establish which statistics will be used or not based on the given scenario
  - b. Create screen sketches
  - c. Develop basic graphics from screen sketches in Unity
  - d. Code selection of statistics to use based on scenario
  - e. Code user-specific data retrieval from database
  - f. Code necessary calculations to display the correct statistics
  - g. Code statistics display
- 6. Set up database
  - a. Design database schema
  - b. Create database
- 7. Establish connection between VIRA and database
  - a. Create Spring backend
- 8. Enhance graphics quality in Unity

### 3.4 | Possible Risks and Risk Management

There are a few different risks inherent to our project. First, due to the fact that we were forced to switch to VR from AR, there is the risk that VIRA will not function as we initially envisioned. This means that we may be compromising on some implementation decisions to make VIRA work properly. Similarly, VIRA is designed for athletic trainers and will thus require medical/anatomical accuracy that none of us are too familiar with. In order to mitigate the risk of our module not working as the client intends, we need to work closely with them.

Another risk is the fact that VIRA is a student-proposed project. We do not have corporate funding, that is, we have a limited budget. Finally, as mentioned previously, none of us has experience in VR development, which introduces a level of risk regarding what we want to achieve versus what we can achieve.

### 3.5 | Proposed Project Milestones and Evaluation Criteria

Our milestones are the top-level items in our outline in Section 3.3. Our evaluation criteria are as follows:

- Create user profile selection: The user can select a profile under which to record their activities
- Create module selection: The user can select a module to enter
- Create guided module: The user can navigate through a module and perform the tasks necessary to complete it
- Create quiz module: The user can take a quiz and be evaluated on the tasks they perform without step-by-step guidance
- Create user statistics dashboard: The user can view statistics on their performance in the modules and quizzes they have completed
- Set up database: Data can be stored and retrieved properly
- Establish connection between VIRA and database: VIRA can correctly access the database for user profile selection and displaying the feedback dashboard
- Enhance graphics quality in Unity: Graphics are smooth and realistic enough that the user can easily determine what is being displayed

### 3.6 | Project Tracking Procedures

We are using GitLab as our code repository. Additionally, we are using Trello to manage our task lists. Following Agile practices, as new tasks come up, we will add them to our backlog. They will then be assigned out to team members after each sprint and moved to our “In Progress” list. As team members complete the tasks, they will move them to our “Completed” list.

### 3.7 | Expected Results and Validation

Our desired outcome is that we have at least one fully functional module that helps incorporate technology into an athletic training environment. We will know that VIRA works by letting the clients test it several times throughout the development process. As they are the ultimate end-users, it is important that we ensure that what we create aligns with what they want.

# 4 | Project Timeline, Estimated Resources, and Challenges

## 4.1 | Project Timeline

All our tasks listed in Section 3.3 make up our Gantt chart (See [Appendix 1](#)). For August, September, and the first half of October, we focused on researching AR/VR software and hardware as well as similar projects that have been done elsewhere. We also met with an athletic trainer to gather the necessary steps for the training module and the expectations for the UI. From there, we created our requirements and design documentation. After that, we began learning Unity and ordered an Oculus Quest (after trying, unsuccessfully, to get a Microsoft HoloLens).

For the second half of October up until dead week of the Fall semester, we intend to design and set up our database, as well as the user profile selection and module selection screens. This is also the point where we will set up the connection to the database, likely through a Spring backend. After that, we will create and code one guided practice module and one test module (just the basic “gameplay” and user interactions). After we design the narrative and create the screen sketches, the two modules can be developed in parallel. We will not do anything except small tweaks and simple tasks over Winter Break.

When school starts again for the Spring semester, we will focus on the user feedback aspect of the modules. We will work on the code that determines whether the user’s actions will be perceived as correct or incorrect and then gives feedback or collects data for the statistics dashboard. After that, we will design and code the statistics dashboard that will be present at the end of the module. This takes us into the first half of March, with the rest of the Spring semester either left as buffer time or time to create more modules.

## 4.2 | Feasibility Assessment

We expect to have at least one working module completed by the end of the school year. This is a reasonable goal, as anything less would not be useful to the users. Our biggest challenge will be the team’s inexperience with VR development. None of us have worked with VR before, so everything will be a new learning experience, which will slow development.

## 4.3 | Personal Effort Requirements

Table 1 below lists the tasks we have done and expect to do for this project. The numbers provided are very rough estimates and will vary from person to person and from week to week. Following are descriptions of the tasks.

Table 1 - Individual Tasks

Task	Estimated Time (Hours Per Week)
Gathering requirements	2 (per sprint)
Researching	Variable
Acquiring hardware	4 (once)
Setting up development environment	< 0.5 (once)
Development	Variable
Testing	Variable
Writing design documents/presentations	3 - 5

### Gathering Requirements

The bulk of this task involves meeting with athletic trainers to discuss the next steps for the sprint. The time required for this will vary based on what we plan to accomplish that sprint and how familiar we are with the material required to do those things.

### Researching

We will need to research on a continual basis; from researching which hardware to choose to researching the best means of adding a model in Unity, we will constantly be researching to ensure that we do not reinvent the wheel.

### Acquiring Hardware

This will only need to be done once. We have been trying to secure our hardware since we formed our team, but we are now fairly confident that we will have what we need. Afterwards, we should not need to worry about acquiring any further devices.

### Setting up Development Environment

This is also a one-time task. Once we have our Oculus Quest, we can all make sure that our development environments are set up similarly. Once we all have Unity properly set up and are all connected to our GitLab repository, we should not have to do anything further for this task.

### Development

This is, of course, the bulk of our project's work. Most of our time should be spent working on the module and communicating what each of us has accomplished. Since we have spent most of our time as a team sorting out which technologies we will be using and working on presentations and design documents, we are uncertain of how much time we will need to put into developing a VR application.



### Testing

This encompassed unit, system, regression, and acceptance testing and is part of the development process. As we have yet to begin development, we are unsure of how much time will be spent testing.

### Writing Design Documents and Presentations

This includes working on all project management overhead, design documents, and presentations that are required for this course. Based on our time spent thus far, we estimate that this will take roughly three to five hours per week.

## 4.4 | Other Resource Requirements

The project will require an Oculus Quest VR headset. Additionally, we will require time to meet with athletic trainers to discuss requirements, allow them to test the program, and receive feedback from them.

## 4.5 | Financial Requirements

As this project is student-proposed, we do not have company funding like some other projects might. Thus, we are financially restricted to what the Department of Electrical and Computer Engineering can provide. We will absolutely require an Oculus Quest headset, which will cost around \$400.00. Additionally, we would like to have licenses to use the Pro version of the Unity 3D engine, which should be free for educational institutions.

# 5 | Testing and Implementation

## 5.1 | Interface Specifications

VIRA will be run solely on the Oculus Quest, so we will not need any software/hardware interface other than a USB cable.

## 5.2 | Hardware and Software

We will not need any additional hardware or software for testing VIRA. The Unity development environment provides us with unit testing and debugging capabilities. Acceptance testing will be completed by the end-users.

## 5.3 | Functional Testing

We plan to use Unity to perform unit and module testing. Our integration testing will most likely be performed by an automated GitLab CI script that will perform a set of tests every time a team member pushes changes. System and acceptance testing will be completed by the team and the end-users.

## 5.4 | Non-Functional Testing

To test usability, we will analyze how first-time users navigate through VIRA to assess its intuitiveness. For performance testing, we will monitor running speed, response time, and battery consumption of repeated uses to ensure that VIRA runs efficiently on the Oculus Quest. Since VIRA will be developed specifically for the Oculus Quest, we do not expect any compatibility issues. Our main security concern regards the user accounts. We will ensure security in our database and will minimize network requests to reduce the chances that information is stolen.

## 5.5 | Process

As we have not yet begun development, we have begun any sort of testing.

## 5.6 | Results

As we have not yet begun development, we have begun any sort of testing.

# 6 | Closing Material

## 6.1 | Conclusion

So far, we have worked toward designing our project, gathering and honing our requirements, and deciding upon our technologies. Our goals are to:

1. develop at least one complete VIRA module,
2. design a modular product to allow for easy extensibility, and
3. learn about VR development.

We have decided upon the Oculus Quest as our hardware because it is the best option for our budget. We have chosen Unity as our development environment because it is an industry standard for developing 3D applications such as ours.

## 6.2 | References

We are not currently using any outside data or information.

# Appendices

## Appendix 1 | Project Gantt Chart (Section 4.1)

