User Information Augmentation. Vision Based Information Delivery System

Project Plan

Group: sddec19-14

Client: Radek Kornicki

Advisor: Aleksandar Dogandžić

Team members:
Omar Abbas
Jonah Bartz
Aaron Michael
Dennis Xu

Team email: sddec19-14@iastate.edu

Team Website: http://sddec19-14.sd.ece.iastate.edu

Revision 1

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HUD: Heads up display

Generic Interface

Peripherals

HMI: Human Machine Interface/Interaction

1. Introductory materials

1.1 Acknowledgement

Likes of this project have already been accomplished by different groups such as the researchers at the University of Pennsylvania. They have developed a drone that is capable of estimating the relative position of the human calling it with respect to quadrotor, and moving to a position the human gazes as at. This has been highlighted in the IEEE spectrum website, however the difference is that the user was wearing a set of glasses, whereas our project uses eye detection. However, they do use the same module we do and therefore studying their project may prove beneficial.

In addition, There is a Virtual Reality Center here on campus that seems to utilize the same projector we do, but with a different computer. However since we have some resources on both sides we will have a reference when we need it.

The client for this project is a representative of Danfoss and an alumnus of Iowa State. Mr. Radek Kornicki is a huge contributor to manufacturing research and technology development at the Electrical and Computer Engineering department at Iowa State. Not only has he provided us with the opportunity to work on such an innovative project, but takes initiative and starts certain processes on his own before requesting our attention for it.

1.2 Problem Statement

The User Information Augmentation project's ultimate goal is to build an eye trackable heads up display system, also known as an HUD that will deliver to the user whatever data they program it to within a glance. It seeks to utilize eye movement such that it makes the optical control more intuitive and provides it over the of the application window while maintaining full tangible control of the system. In layman's terms, it allows you to make your eyes request information as well as observe it without having to pause control of the system.

Problems our solution seeks to solve encompass anything that may involve human machine interaction (HMI). It seeks to mitigate human error when dealing with machinery in a critical environment and will be accomplished so by guaranteeing that certain information has been registered by the user.

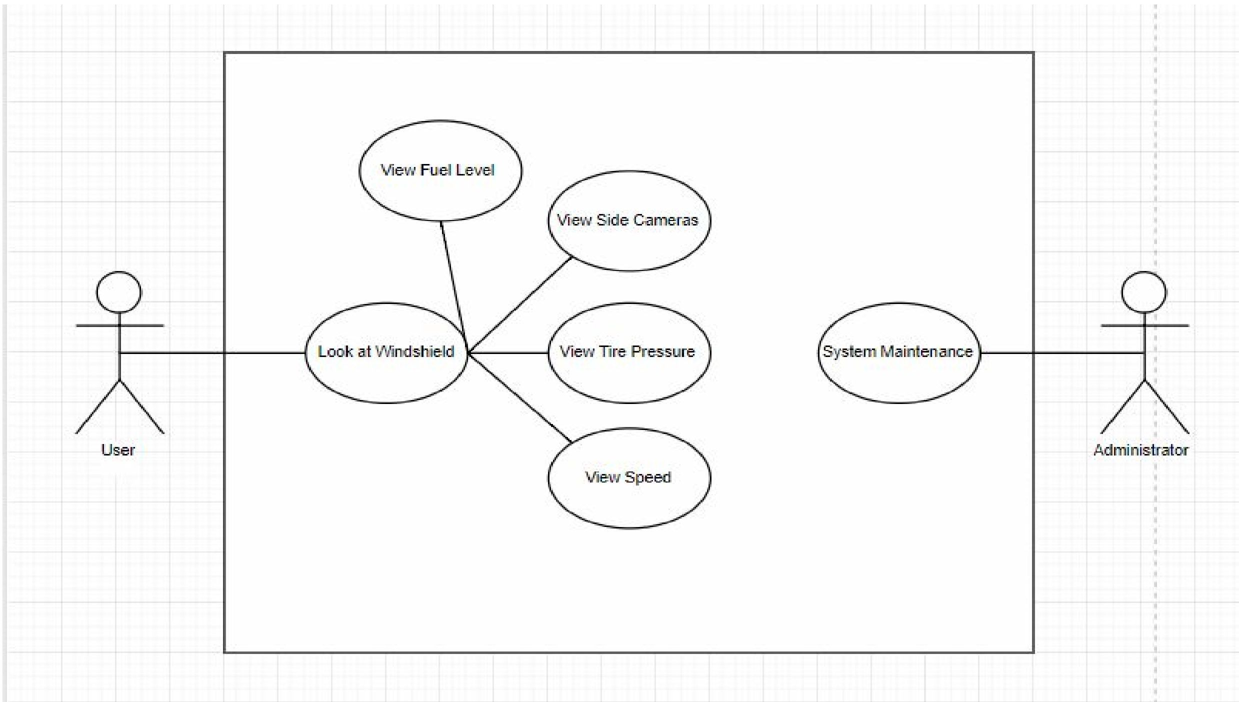

Figure 1: Use Case Diagram

1.3 Operating Environment

Our client is the The Danfoss Group, known for manufacturing products and providing services used in powering mobile machinery, solar enginery refinement, food preservation and much more. The R&D division of Danfoss is determined to improve the technology in off-highway vehicles including agriculture and construction. Our embedded system may be somewhat applicable in any of their branches, from agricultural environments where there are other heavy machinery that will be surrounded by soil usually, to motor control rooms where a quick glance at machine status may be come in handy. This project may also be useful in areas where looking continuously at a point may in fact prove more stable than hovering a mouse pointer of it. This leads us to the conclusion that our product must be minimal in size and be contained in a portable package that is applicable anywhere.

1.4 Intended user(s) and Intended use(s)

Since Danfoss features a broad range of technology services, our solution has to be applicable and generic. There are many use cases the client has provided us with and our goal is to explore this technology and see what kind of features we can produce. However, one specific use would be connecting this peripheral to the system a user controls to observe certain structures related. What they look at exactly on their screen may display some information about what they see in the form of an HUD (Heads-Up Display), which is a common term that stands for clear, concise messages relevant to the users environment. Another use case provided by the client would be a lane detection system. When a user drives large agricultural equipment on normal roads there are issues with staying in the lanes due to the size of the vehicles. The system we create could notify the driver when the wheels are outside of the lanes on either side and provide a display of where the lanes should be in relation to the driver through a heads up display, because when driving these large vehicles the lanes are not easy to see.

In addition, this project can be used in areas where attention to detail is critical. A bus driver, for example, has to be sure that the road ahead is clear to drive. If someone were walking in front of the bus and the driver did not happen to see it, our product would signal him to look there and will signal back once it confirms that the user has registered that information.

1.5 Assumptions and Limitations

Our assumption is that this peripheral will be used when the system is able to track the users eyesight. We may not be able to guarantee marine solution and we may not be able to deliver during an environment of turbulence, however that maybe a later goal. Our work is bounded to the following materials:

- Nvidia Jetson TX2 Module
- Tobii Eye tracker
- Generic projector

We are to deliver a viable solution and use case for this problem that may develop an area of interest for the user. This will be an interface that will attempt to be applicable to any system with room for it.

In addition, we also believe that the maximum amount of users at a given moment may only be one. Having two sets of eyes may horribly confuse the tracker and having two eye trackers tracking two different people may recurse into interference between the two devices and the information they exchange. We take this to be the biggest limitation as having multiple users with highly intelligent vision based information delivery systems on the target may conclude in more observation during their work.

Moreover, we are limited to solutions that involve the windows operating system, and that eliminates a lot of open source technical software we could have with this project on other UNIX based systems

1.6 Expected End Product and Other Deliverables

Our Expected End Product is to design and build an eye triggered interface that will assist in using technological machinery and electronic applications. This interface will exchange information with the user regarding the environment they are in to give them better intuition with their technology and to tighten the grip between the user - machine interface. We are to deliver a prototype consisting of the aforementioned components that accomplishes the aforementioned description as efficiently as possible.

Our final deliverable will be a module smaller than the board we have now, about 6 inches in length and width, capable to connect to any wifi/ethernet system and request data from a tobii eye tracker, which is about 13 inches is length and less the one in width, and allow the user to interface using just their vision.

2. Proposed Approach and Statement of Work

2.1 Objective of the Task

In modern industrial and agricultural areas there is definitely need for critical attention to detail. the objective of the task is to minimize the amount of error during that session by any means. An example can be confirming that someone looked at a certain spot in the screen to make sure that they know it is there. Certain things like this could make all the difference in production and minimizing accidents.

2.2 Functional Requirements

Below is a list of functional requirements for the system:

1. The system shall display information to the user through the use of a projector or monitor.
2. The system shall display information to the user according to where they look.
3. The system shall alert the user through changing color if a danger should arise.
4. The system shall be functional and portable

Moreover, the system has to encompass a friendly user interface that is programmable. It will be reliable and secure such that it is impenetrable for certain methods such as hacking.

It will be maintainable such that the hardware is present in a convenient location for the system administrator to look at when necessary.

2.3 Constraints Considerations

The constraints for this project are the hardware requirements. The project must run on a Jetson TX2 and use an eye tracker to identify where the user is looking. These constraints have lead the team to look into development environments that use Linux and many open source options to advance the usage of the eye tracker in this project which may also be a commercial issue as the client specifically requested a Windows Operating system solution. In addition, there is an official set of documents that must be completed for this project, including a non disclosure agreement, which means that while this project is in process we are not to expose the progress to anyone, and that may limit the resources we can utilize.

The current design will have testing done on a monitor for convenience and will eventually lead to using a projector on a windshield in some scenarios. These considerations have lead the team to decide a central location of the senior design lab as the place where testing and storage of the technology will be located. Finally, another technological constraint is that we are not allowed to integrate wearable devices into this project. To elaborate, we are unable to use an eye tracker in the form of glasses, and so this will complicate the project due to the fact that their maybe obstacles in the way of the user and their eye tracker.

2.4 Previous Work And Literature

For this project the book *Eye Tracking Methodology* by Duchowski will be of value when implementing the proposed design. Eye tracking is a new concept to the team so this book will prove invaluable when it comes to designing and implementing the design laid out in this project plan.

2.5 Proposed Design

The current design that we are looking into uses cameras, both normal and infrared, as well as a head tracker. The system will feed into a microprocessor and then alert the user about potential issues that might be in their surroundings. The microprocessor will use this data to draw lane lines onto the screen and issue points that the user should be looking at. The information will initially be projected onto with a projector and a specialized screen for testing. We have a lot of equipment that is being provided to us so our design is limited by that front. Other things we could do is adding a lidar to do range finding.

An alternative design may be not involve the Tobii eye tracker but an eye tracker in the form of glasses. This design may eliminate boundaries between the user and the machine and maximize accuracy when tracking their gaze.

2.6 Technology Considerations

The Jetson TX2 is the fastest, most power-efficient embedded AI computing device. Built around NVidia Pascal, it is loaded with 8Gb of memory and features a variety of standard hardware interfaces making it exceptionally suitable for our project, it be declared that it is not an inexpensive piece of equipment.

The Tobii Eye tracker is a multipurpose eye tracker usually utilized in means of gaming. It features embedded processing and seamless integration through means of a usb port and can interface with most Operating systems.

Both of these pieces of equipment proved to be rather expensive, but they may change depending on the abstraction of this project.

Our team has taken numerous counts of technological devices into consideration, however one that may prove extremely useful can be a depth camera. Although it fits no where in our project as of yet, it may still be used for face recognition that is connected to the eye tracker or to retrieve a certain profile of an object on the other side. In addition, using glasses would ease the process of detecting the users gaze however the client specifically requested that we not use any eyewear.

2.6.1 Technical approach considerations

Our technical approach is mainly to use the given module's Operating system to interface with the Tobii eye tracker. We will use the open source code to provide us with many options and ways to interact with the physical hardware and display the required information to the user. There will be various scenarios that require different forms of attention and so we will utilize whatever peripherals we are provided with to achieve the purpose. As the prototype progresses and grows, we will utilize different testing environments to further manifest any changes needed and deliver the prototype.

There may be necessary technical support and so our team will be in close contact with the different areas of expertise (Such as NVidia, on campus VRAC, Electronics Technology Group), and if permitted we will hopefully use some of their hardware/software debugging methods to overcome any obstacles in our way.

2.6.2 Testing Requirements Considerations

The testing requirements considerations for the project are as follows: the project will have to run on the hardware that is provided. A predetermined data set will be obtained to give testing a consistent stream of data to work with and test expected versus actual resulting display from the program.

There have been several environments where this project maybe considered, however for the sake of this class and time appropriated by the client these scenarios may be left ultimately unexplored.

2.7 Security Considerations

The security considerations for this project are minimal. The project should run independently of an internet connection so the project should be immune from most common attacks through that connection. All physical hardware will be stored in the senior design lab in a locker secured by a lock. This will prevent any theft of materials during the course of the project.

It will convey the maximum threshold of accuracy so that safety is ensured in usage as well. Failure of this device's reliability may result in undefined behaviours that may cause harm.

2.8 Safety Considerations

The safety considerations for this project are focused on the testing environment. Rather than testing in a combine, the project will be tested on a piece of polycarbonate with prerecorded camera footage to prevent any accidents occuring while testing the system during production. All testing will be done indoors to limit the risks of injury to participants and team members.

2.9 Task Approach

Figure 2 and 3 show the basic block design of the hardware and the software components. The hardware side of things is simplistic. All of the sensors need to connect to our microprocessor and then the microprocessor will output the results onto a screen.

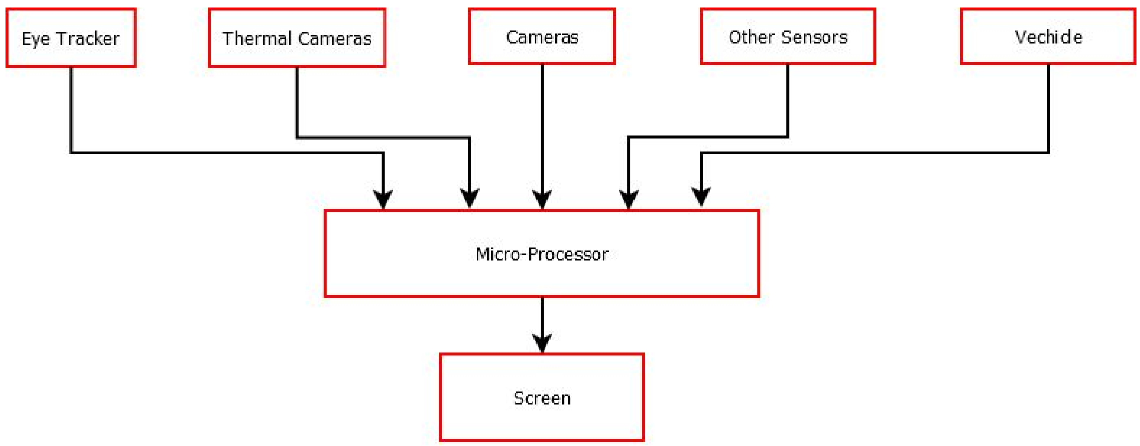

Figure 2: Hardware Block Diagram

The complex part is on the software side of things. We need to implement a computer version component that will interpret what the cameras sees. We then have to link that information together with the other sensors and make decisions upon all of the information.

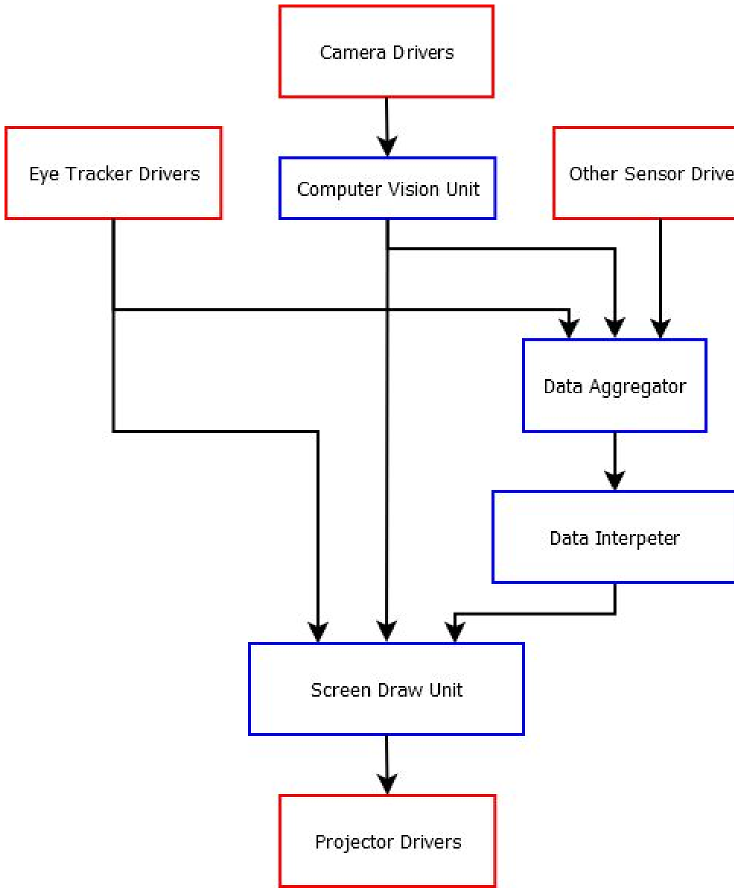

Figure 3: Software Block Diagram

2.10 Possible Risks and Risk Management

The main risk of this project is the newness of the concept. This is new territory for what is being done with much of the system in many ways is new. This team is also new to all the hardware being implemented which adds to the risk. The major risk is that the project will fail due to over ambitious use cases. This will be minimized by ensuring the client is up to date with all limitations of the software and the hardware with the intent of updating deliverables and/or functional requirements to meet any development in the limitations found.

2.11 Project Proposed Milestones and Evaluation Criteria

Milestone 1: Tobii Eye tracker connected to Jetson TX2. This milestone's evaluation criteria is that the eye tracker is connected to the Jetson TX2 and working.

Milestone 2: Camera integration. The criteria shall be that the camera sends the appropriate information to the Jetson TX2 for further analysis and display.

Milestone 3: Issue detection completion. The criteria for this milestone shall be that an issue is detected by the system and relayed to the user.

Milestone 4: HUD display completion. The criteria for this milestone shall be as follows: the eye tracker correctly tracks the user's eye and the information laid out in the functional requirements is displayed to the user appropriately.

2.12 Project Tracking Procedures

This project will use Trello to track the status throughout the lifetime of this application. The Trello board will have different categories to track work as the project progresses. These categories are project backlog, in development, testing, finished, and a list of known bugs within the project. This organization will allow for easy tracking of who is working on what as team members can be assigned to various tasks on the Trello board.

Direct communication regarding the project will happen using Slack. There will be different channels that correlate to the different fields we have defined in Trello, this will give the members of this team a more direct form of collaboration and will ease their interface as they work towards completing the purpose of that field.

2.13 Expected Results and Validation

The expected result is complete efficiency in tracking the eye and delivering information based on its position. The way we will validate this execution is by passing it to a volunteer who would try and utilize it in an appropriate workspace. Our confirmation would be their performance before and after utilizing this eye tracker and the margin of that difference will determine its effectiveness.

2.14 Test Plan

Given that our project has fairly isolated parts at the beginning we can validate our parts separately. In order to validate our cameras we can output their view and selection areas onto a monitor. Our eye tracker can be validated by drawing a dot on a monitor that will indicate where the tracker thinks the user is looking at. The other sensors can just be validated by placing them in situations where they should trigger. The HUD can be validated by creating a basic image with certain image placement data and determine if it is drawn correctly. As we start linking the different parts we can contiunely validate the updated connections until we have a complete system.

3. Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

In the first semester our primary task will be researching and testing the equipment we have. We will spend the time looking into the software required to control our eye tracker and cameras. Afterwards we will start testing the equipment and validating them for our purposes. In April we will start working on getting the eye tracker to the location of the users eyes. Since we plan on using an already developed system, this shouldn't take very long. Afterwards we will start working on getting the object detection system working. This system will be designed by using a normal camera and an infrared camera.

In the second semester we will start by finishing up the object detection system. The next task we need to accomplish is the issue detection system. The issue detection system needs to gather all of the sensor data and then determine if something dangerous is happening. It then indicates to the user of any issues. The final large scale system is the one for drawing the HUD. The two subtasks are creating a basic design and then a calculation system that will determine where to draw the image onto the screen.

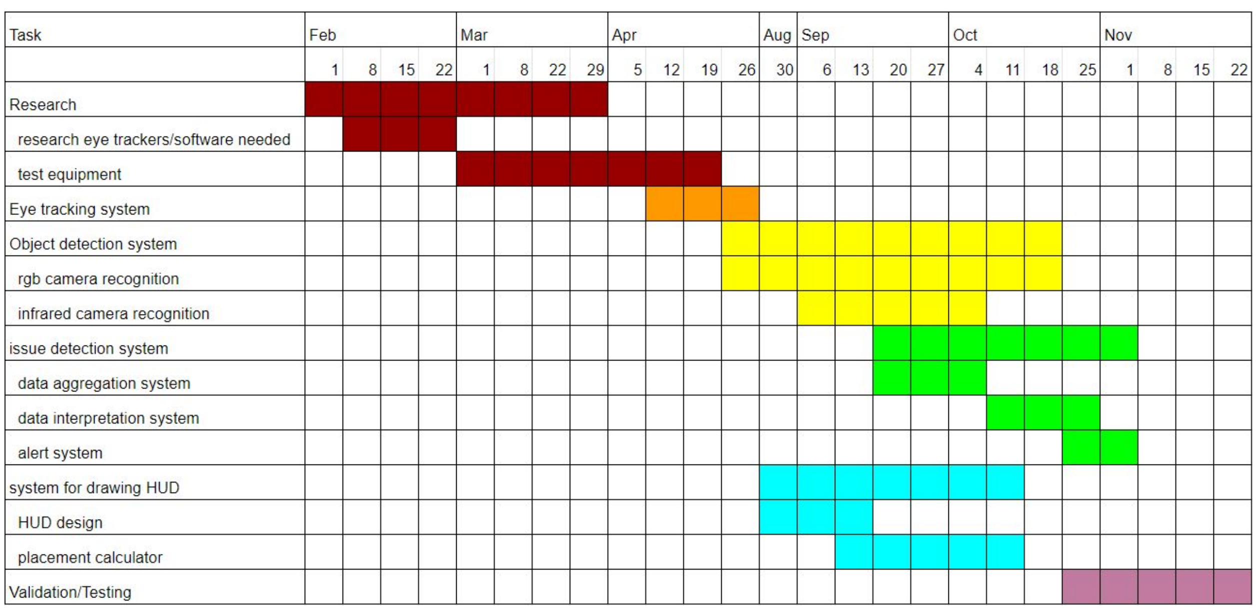

Figure 3: Gantt Chart

3.4 Feasibility Assessment

There are a lot of separate tasks that need to be accomplished for the project to be completed. This is both a positive and a negative. The positive is that we can test and validate systems individually without too much hassle. The negative is that at the end everything needs to be working properly for the entire system to work. If we get backed up on any system it could unexpected delays to appear at the end.

The two main tasks that might cause delay is the projector calculations and the lane detection system. The projector calculations will be very tricky since we have to merge the camera information and the eye tracker to figure out where we want to place an image. The object detection system will be the the system that will take the longest to get completed. The reason for this is because of how many different things there are in the world. Luckily we don't need to discern everything so the task should be similar.

Looking at theses issues we have determined that a basic test case should be accomplishable in the next 2 semesters.

3.3 Personal effort requirements

Task	Effort (hours)	Explanation
Research	20	Researching and testing the equipment we have.
research eye trackers/software needed	6	Researching will probably be continued throughout the project but most of the decisions should be made at the beginning so we can start designing.
test equipment	14	Testing equipment carries an unknown aspect to it. While we could finish the task fairly fast this has the most possible issues that could pop up. We might need to go back into researching other components.
Eye tracking system	6	The eye tracking system we have is a an already developed system so most of the work should be getting if setup.
Object detection system	28	Object detection is a very complex issue and will probably take the longs amount of time. Thankfully we can vastly simplify the issue by have a set test case.

rgb camera recognition	18	The normal camera will be doing the brunt of the object detection so this would take the longest to integrate.
infrared camera recognition	10	The infrared camera is mostly used to supplement the normal camera so it should take less time.
issue detection system	20	The issue detection system is made up primarily of the interpretation system. Given we have a set scenario we only have so much to look out for.
data aggregation system	6	It could be difficult to set up given all of the data that needs to go into the system. It is subject to delays in the other systems.
data interpretation system	10	Interpreting the data could be difficult give the amount of data.
alert system	4	The alert system is mostly setting up connections to the HUD drawing system and the data interpretation system.
system for drawing HUD	18	The HUD could talk a lot of time given our lack of expertise in how to do these types of calculations.
HUD design	6	The general design of the HUD shouldn't take too much time. It's requirements will probably need to be continually added onto throughout the project.
placement calculator	12	The placement calculator could be very difficult to get working properly since we might not be able to test on the system it's design for.
Validation/Testing	10	Testing will be done throughout the project but we need to leave a good amount of time at the end so we can both find and fix potential issues.

3.4 Other resource requirements

The resources needed for the project are provided by the client. These resources are a Nvidia Jetson TX2, Tobii eye tracker, front projection glass, projector, and camera. Any additional resource requirement that are discovered will be provided to the team by the client as appropriate to the advancement of the project.

Peripheral resources may also come in request as for different environments, this application may tailor differently in different environments.

3.3 Financial requirements

At this time no financial requirements have been identified beyond what has been provided to the team by the client. However, the end product should be as least costly as possible as this solution may be duplicated into multiple departments or users. Proper design and architecture will be required to mitigate costs and effort.

Cost of Device (approximately):

TX2: $540

Tobii Eye tracker: $150

Generic Projector: $80

Total Cost: $770

4. Closure Materials

4.1 Conclusion

Today's world is becoming more and more integrated with information. One area where this information could be most useful is while operating large machinery that allows the user to see all the relevant information at a glance without taking their eyes off what is right in front of them. The goal presented throughout this document is to create a heads up display that utilizes eye movement to intuitively control information presented to users.

The approach laid out about shows the main aspects needed to implement the solution are an eye tracker with the Jetson TX2. Additional features will be added through camera support. The key features of the project are well defined and will ensure that the final project is feasible and possible within the timeline presented in this document.

4.2 References

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