DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

SYSTEM REQUIREMENTS SPECIFICATION
CSE 4316: SENIOR DESIGN I
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THE EYET GUYS
THE EYE TRACKER

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Revision History

Revision	Date	Author(s)	Description
0.1	03.13.2019	DG	document creation
0.2	03.17.2019	DG, GH, JE, PW, JD	complete draft

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1 Product Concept

This section describes the purpose, use and intended user audience of the Eye Tracking Remote product. The Eye Tracking Remote is a product that tracks the user's pupil movements in real time. By combining with software functionalities, it will give the user a free-hand operating experience. The user of the Eye Tracking Remote will be able to control the operating system of a computer by using pupil commands.

1.1 Purpose and Use

The purpose of making the Eye Tracking Remote is to enhance and increase the functionalities of the current eye-tracking hardware, to give the user a better operating experience. It is aiming to get data of the user's pupil movements and send the organized data to Eye Type software. By using the Eye Tracking system, the user can type and communicate with the others only by eye movements.

1.2 Intended Audience

The Eye Tracking product is to be made publicly and will be available for UTA engineering Senior Design students. The audience is designed for a particular customer, Mrs. Marci. The Eye Tracking Remote is a specific component of the Eye Tracking system.

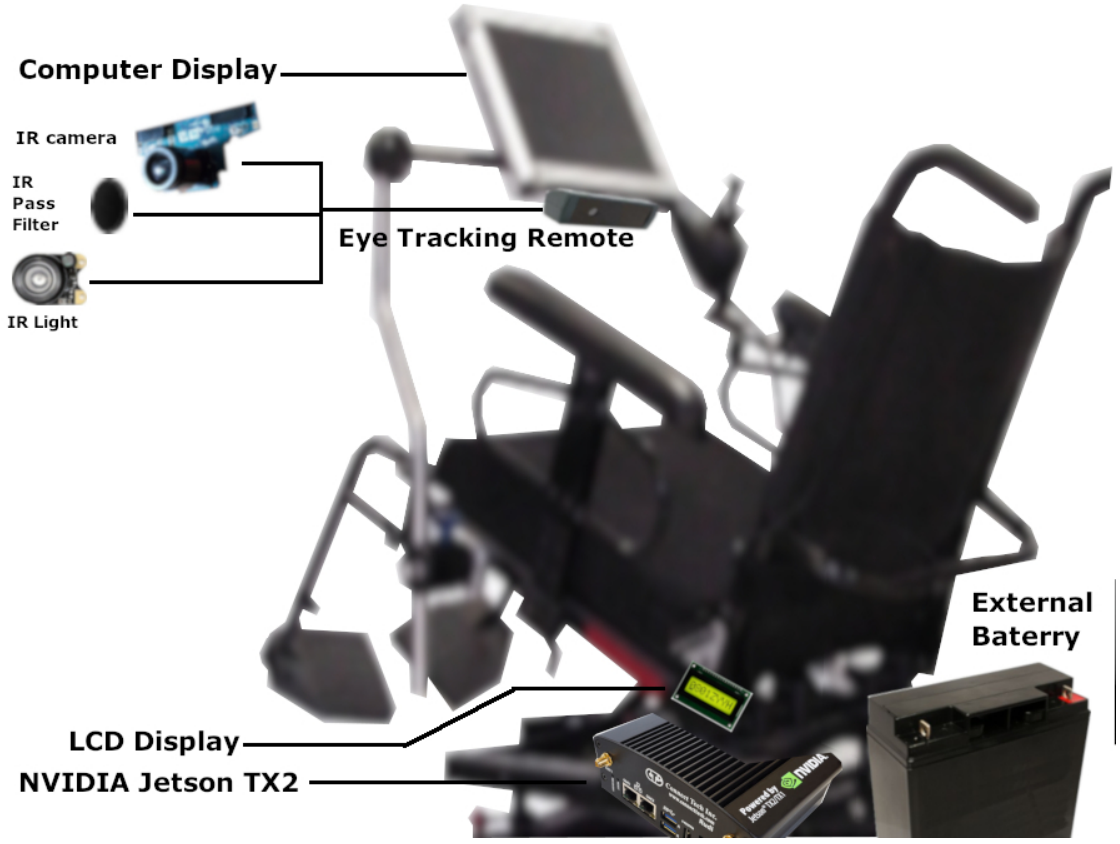


Figure 1: X conceptual drawing

2 Product Description

This section provides the reader with an overview of Eye Tracking Remote. The primary operational aspects of the product, from the perspective of end users, maintainers and administrators, are defined here. The key features and functions found in the product, as well as critical user interactions and user interfaces are described in detail.

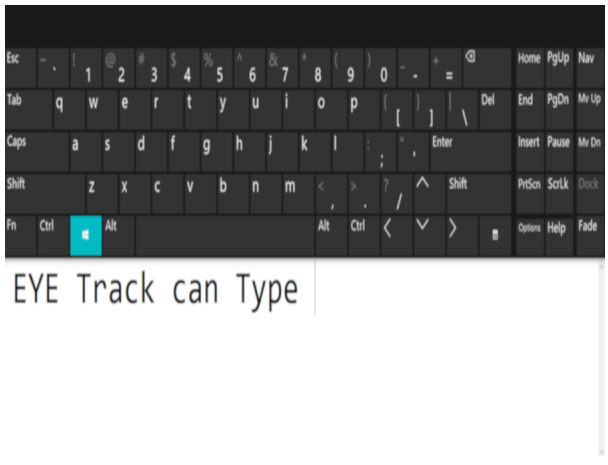
2.1 Features & Functions

The main feature of the Eye Tracking Remote is to find the coordinates where the user's pupils are focusing at on the screen. Then the Eye Type software will cooperate to allow user to type statements and communicate with other people. The additional functions include but not limited to, eye-commands and awake-from-sleep mode. One PSEye camera with IR lens is used to capture user's eye positions and movements. The image information goes to NUC embedded computer for digital processing. And the calculated screen coordinates and eye gesture commands will be sent to Eye Type software for later on process analysis. An external battery is needed for NUC and LCD screen. The computer display will be used to visualize the pictures captured by the cameras and also data analysis on the NUC. An extra LCD will be used to simply display coordinates of pupil focus point.

2.2 External Inputs & Outputs

Product Components	PSEye Cameras with IR lenses	NUC Embedded Computer	Computer Display	LCD Display
External Inputs	End user's pupil movements and focus point positions	Pictures with pupil data	Pictures taken by cameras; screen coordinates and Eye Gestures	Coordinates data
Outputs	Pictures including pupil data	Calculated screen coordinates and Eye Gesture commands	Eye Type program	Messages

2.3 Product Interfaces



(a) Computer Display

(b) LCD Display

Figure 2: Interfaces display examples

3 Customer Requirements

The following section details the specific customer requirements from Marci's family regarding the Eye Tracker. All the following are requested, however not all will be of critical importance. Each of the following requirements will be classified as critical, high, moderate, low, or future. All critical requirements must be met otherwise the Eye Tracker prototype will be a failure. Following the implementation of all critical features, we will then move along and implement high-importance requirements. Following the implementation of high-importance requirements, we will then move on to moderate-importance requirements and so on.

3.1 Eye Tracking Requirement

3.1.1 Description

This requirement specifies that our system must be able to track Marci's eye(s). This requirement also includes the ability to be able to reliably re-calibrate the eye-tracking capabilities of our system. The eye-tracking reliability of our system should last as long as needed until Marci is either moved, the camera is moved, or the system is turned off and then back on again.

3.1.2 Source

The source of this requirement is both the sponsor (Dr. McMurrough and UTA) as well as the customer (Marci and her family).

3.1.3 Constraints

One constraint that relates to this requirement is that the video produced by the PlayStation Eye Camera will not record Marci and store that data in any location that could vulnerable to unauthorized access at a later time. Another important constraint which relates to this requirement includes the need to re-calibrate if either Marci is moved or the camera is moved. If either of these things occur, Marci will be forced to re-calibrate the eye-tracking capabilities of the system.

3.1.4 Standards

IEC/EN 62471 - This standard covers safety requirements related products using LED IR lights and provides the acceptable safe ranges of such light to the human eye. [3]

3.1.5 Priority

1 - Critical
Without the ability to track Marci's eye(s), our system will be entirely useless.

3.2 Portability Requirement

3.2.1 Description

The Eye Tracker prototype system should be portable. The system must be able to move around with Marci as she travels from one place to another. This entails the system being mountable on her wheelchair as well as having a mobile battery source to power the system.

3.2.2 Source

The source of this requirement is both the sponsor (Dr. McMurrough and UTA) as well as the customer (Marci and her family).

3.2.3 Constraints

The primary constraint associated with this requirement is battery-life related as the system won't be up 100% of the time. This will require the need to recharge the battery, however we plan on providing

multiple batteries for quick on-the-spot replacement. As well as having multiple batteries, the system will be able to run through a constant supply of power from an outlet.

3.2.4 Standards

IEEE 1625 - This standard establishes criteria for design analysis for qualification, quality, and reliability of rechargeable battery systems for multi-cell mobile computing devices. [1] FDMI MIS-D - Defines standard for mounting interfaces on monitors with 12 inch to 23.9 inch screens. [2] ANSI C18.2M - Portable Rechargeable Cell and Batteries Safety and Specification standards. [1] [4]

3.2.5 Priority

2 - High
This requirement is of high importance because it is not necessarily required for the basic funtions but is very important to the

3.3 Single Camera Requirement

3.3.1 Description

The Eye Tracker prototype system should utilize only one camera which will track a single eye of Marci's. This will allow for more accurate tracking of the eye as well as translation of gaze vector to coordinates on the LED screen. This will also eliminate the need to coordinate 2 gaze vectors into 1 pixel coordinate on the screen.

3.3.2 Source

The source of this requirement is the customer (Marci and her family).

3.3.3 Constraints

One constraint that relates to this requirement is that the video produced by the PlayStation Eye Camera will not record Marcie and store that data in any location that could vulnerable to unauthorized access at a later time. Another important constraint which relates to this requirement includes the need to re-calibrate if either Marci is moved or the camera is moved. If either of these things occur, Marci will be forced to re-calibrate the eye-tracking capabilities of the system.

3.3.4 Standards

IEC/EN 62471 - This standard covers safety requirements related products using LED IR lights and provides the acceptable safe ranges of such light to the human eye. [3]

3.3.5 Priority

2 - High
This requirement is of high importance because it was requested by the customer but is not necessary for the system to perform its basic functions and to be complete.

3.4 Daytime Usability Requirement

3.4.1 Description

The Eye Tracker prototype system should be usable outside if there is bright sunlight. Marci's current system is hard to use in outdoor lighting. As such, we should have a screen with a minimum back-light brightness and perhaps an anti-glare film over the screen.

3.4.2 Source

The source of this requirement is the customer (Marci and her family).

3.4.3 Constraints

The primary constraint associated with this requirement will be battery-related. As the brightness required for reading and sight increases, the lifespan of the battery will be reduced.

3.4.4 Standards

FDMI MIS-D - Defines standard for mounting interfaces on monitors with 12 inch to 23.9 inch screens. [2] ISO 13406-2 - Ergonomic requirements for work with visual displays based on flat panels – Part 2: Ergonomic requirements for flat panel displays. [5]

3.4.5 Priority

2 - High
This is high priority because it would greatly improve the quality of the product for the customer but is not required for the product to be considered complete.

3.5 Auto-articulating Camera

3.5.1 Description

After primary requirements are met, the customer seemed interested in the possibility of the camera being able to find Marci's eye, articulate it's orientation to be centered on it, and zooming in for as part of a separate calibration process before the eye tracking algorithm calibration, this would remove a manual step from the process.

3.5.2 Source

The source of this requirement is the customer (Marci and her family).

3.5.3 Constraints

The primary constraint associated with this requirement will be calibration performance related, it must not interfere with the calibration period performance requirement, it therefore should not by it's addition cause the need for any more calibration sessions than would be necessary without this feature.

3.5.4 Standards

3.5.5 Priority

4 - Low
This is not necessary for the product to be considered complete but it would be a nice addition if it meets the constraints.

4 Packaging Requirements

The product will be delivered when fully finished with all the necessary software and hardware. The finished product will run on the Linux OS, which is what was referred by Dr. Mcmurrough. Because in the future it won't need any update to its OS like windows and Mac OS does. The end product won't necessarily will be packaged but it will a remote eye tracking system that fits in front of our clients wheelchair. As for the instruction on how to use the product, we will be showing that our self to the customer when we delivered the item. The hardware will be pre-assembled. The hardware consist of camera, the screen, and battery. Also the packaging of the product must be rugged.

4.1 Camera Mount

4.1.1 Description

Camera is one of the essential components of the hardware system, which will be used for eye tracking and a mount must be designed to contain the exposed PCB, hold any lenses or filters needed in front of the sensor, hold the IR lights to illuminate the viewing target, and with any manual articulation device so that the camera may be pointed at the customer's eye, or the possible low priority automatic articulator.

4.1.2 Source

The source of this requirement is the customer (Marci and her family).

4.1.3 Constraints

We can't buy a really expensive one because we have to stay in budget. The camera mount must also be designed to be compatible with the screen and TX2 constructions so that they can all fit together.

4.1.4 Standards

4.1.5 Priority

1 - Critical
This is a critical priority because with the camera only we can track the clients eyes.

4.2 Screen

4.2.1 Description

Screen is also one of the important factor in the product, because that is where the person will be able to type from.

4.2.2 Source

The source of this requirement is the customer (Marci and her family).

4.2.3 Constraints

We can't buy a really expensive one because we have to stay in budget.

4.2.4 Standards

List of applicable standards
1: The screen should be clear for the client to see and should last for longer period of time.

4.2.5 Priority

3 - Moderate
This is a moderate priority because only it may not be within the scope of our project, it may be part of the other team's project.

4.3 Battery

4.3.1 Description

A battery is necessary to meet the mobility requirements of the customer and to power the eye tracking system. The previous system had its own on-board battery and will not be able to be reused for our product.

4.3.2 Source

The source of this requirement is the customer (Marci and her family).

4.3.3 Constraints

Can't have a huge battery because it will be difficult to install on with the system. Should be something that would not be hard to replace, and the battery construction must allow for easy switching and access.

4.3.4 Standards

4.3.5 Priority

1 - Critical
This is a critical level priority because it is required for the completion of the product.

4.4 TX2 Enclosure and PCB Board

4.4.1 Description

The embedded controller must have a custom PCB fabricated that contains all the necessary peripheral ports and pin outs for the design, and must be designed with screw holes to be mounted inside its enclosure which also must be designed with ports for power and any outputs or inputs, and with a power light, and place for the character LCD display. The TX2 enclosure will likely be mounted to the screen package so that it is in close proximity to the camera mounting place.

4.4.2 Source

Team

4.4.3 Constraints

The major constraints are size and weight and compatibility with the other packaging constructions. Other constraints include proper ventilation and heat management and room for any required components.

4.4.4 Standards

4.4.5 Priority

1 - Critical

5 Performance Requirements

This section will include system performance related requirements for the product. The product will meet these critical performance requirements mentioned by the customer with regards to battery life, eye tracking algorithm throughput and latency, calibration time, calibrated period, and day time performance.

5.1 Battery Life

5.1.1 Description

The whole power consumption from the holistic eye tracking system as well as the capacity of the chosen batteries must be such that the functional battery life extends to meet the daily need of the customer. The customer also requested a simplified method of battery switching so that constant battery power can be used, rotating multiple batteries between charging and powering. The functional battery life of one must be between 8 and 12 hours. The battery housing on the wheelchair must be able to house two batteries simultaneously to facilitate seamless switching. The charging setup must be able to charge two batteries simultaneously to facilitate seamless constant battery power for the system.

5.1.2 Source

Marcie's family.

5.1.3 Constraints

Major constraints include the size and weight of high capacity batteries, since they must fit on the wheelchair and be easy to switch out for the family. Other constraints include optimizing the power consumption of the system to allow for the required battery life.

5.1.4 Standards

List of applicable standards
IEEE 1625 - This standard establishes criteria for design analysis for qualification, quality, and reliability of rechargeable battery systems for multi-cell mobile computing devices.
ANSI C18.2M - Portable Rechargeable Cell and Batteries Safety and Specification standards.

5.1.5 Priority

2 - High
This is of high priority because it is important for customer satisfaction but not for product completion.

5.2 Eye-tracking Algorithm Throughput and Latency

5.2.1 Description

The eye-tracking algorithm and code must be optimized for the platform such that it's data throughput meets a minimum rate, as well as a minimum processing latency for data in to data out, so that the eye tracking algorithm will be a non factor in the performance of the eye typing program. The throughput will be 60 Hz or above, up to the limit of the camera sampling rate. The processing latency of the eye tracking algorithm will meet industry standards, between 25 and 35 ms.

5.2.2 Source

Marcie's family and industry standards.

5.2.3 Constraints

The major constraints on this are the specs of the camera and the image data in which determine the maximum sampling rate, as well as the processing power of the embedded processor, and CUDA GPU

utilization in the code which determine the processing latency.

5.2.4 Standards

List of applicable standards

5.2.5 Priority

2 - High
This is of high priority because it is important for customer satisfaction to have comparable performance to other products on the market, but the product could be considered completed if it functions well enough for the customer to use.

5.3 Calibration Time

5.3.1 Description

The product must have a maximum time to complete the calibration sequence, not longer than the current system. The calibration sequence must also not be unnecessarily difficult. The product must fully calibrate the eye tracking algorithm to map to screen coordinates in a maximum time of about 30 to 60 seconds, less if possible while maintaining accuracy.

5.3.2 Source

Marcie and family.

5.3.3 Constraints

One constraint the time is the difficulty of the calibration, a more difficult one might yield a shorter calibration time if it gathers more information, or it might yield a longer time if the customer is unable to properly complete it the first couple tries. Another constraint might be latency between the display on the screen and the eye tracking system itself.

5.3.4 Standards

N/A

5.3.5 Priority

2 - High
This is of high priority because the customer wishes the product to be equal or better compared to her current system but the product could be considered completed without it.

5.4 Calibrated Period

5.4.1 Description

The product should maintain it's calibration practically indefinitely as long as the user has not been moved, as the customers current system does. The product must maintain it's eye tracking algorithm calibration without the offset between the true gaze coordinates and the predicted gaze coordinates growing significantly throughout the normal course of the day, <1% of the total linear distance of the diagonal of the screen over 12 hours of use.

5.4.2 Source

Marcie and family.

5.4.3 Constraints

One constraint is the accuracy of the mapping algorithm that converts gaze vectors to screen coordinates. Another would be the stability of the camera mounting and the stability of the customer.

5.4.4 Standards

N/A

5.4.5 Priority

2 - High
This is of high priority because the customer wishes the product to be equal or better compared to her current system but the product could be considered completed without it.

5.5 Daytime Performance

5.5.1 Description

The product should have a screen module such that the customer is able to perform at least 95% as well in full sunlight with regards to typing speed. This means a screen of sufficient brightness, perhaps 2000+ Nits, perhaps also with an anti glare film over the screen.

5.5.2 Source

Marcie and family.

5.5.3 Constraints

Constraints include the effectiveness of anti glare films, and the brightness of Texas, and whether it is possible to maintain a lower brightness indoors with a high brightness screen to avoid eye fatigue or possible damage.

5.5.4 Standards

IEC/EN 62471 Standard for light emitting devices

5.5.5 Priority

3 - Moderate
This is of moderate priority because the customer wishes the product to be better than the existing system with regards to daytime use but the product could be considered completed without it and it may be out of budget.

6 Safety Requirements

In this section requirements related to the safety of the customer, as well as the safety of our team will be listed and explained.

6.1 Laboratory equipment lockout/tagout (LOTO) procedures

6.1.1 Description

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 Source

CSE Senior Design laboratory policy

6.1.3 Constraints

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 Standards

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 Priority

1 - Critical

6.2 National Electric Code (NEC) wiring compliance

6.2.1 Description

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 Source

CSE Senior Design laboratory policy

6.2.3 Constraints

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 Standards

NFPA 70

6.2.5 Priority

1 - Critical

6.3 RIA robotic manipulator safety standards

6.3.1 Description

Robotic manipulators, if used, will either housed in a compliant lockout cell with all required safety interlocks, or certified as a "collaborative" unit from the manufacturer.

6.3.2 Source

CSE Senior Design laboratory policy

6.3.3 Constraints

Collaborative robotic manipulators will be preferred over non-collaborative units in order to minimize potential hazards. Sourcing and use of any required safety interlock mechanisms will be the responsibility of the engineering team.

6.3.4 Standards

ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems, RIA TR15.606-2016 Collaborative Robots

6.3.5 Priority

1 - Critical

6.4 Ventilator

6.4.1 Description

A ventilator is a machine used by those who need assistance in breathing by providing oxygen. Since our customer has ALS and can not breathe on her own, she will require that a ventilator is integrated into the total system.

6.4.2 Source

Marci's family members

6.4.3 Constraints

The main constraint is that the ventilator can not consume too much power. Also, require that the hoses used for the ventilator are secure so that they don't come off. If they become lose the our patient will lose a crucial supply of oxygen.

6.4.4 Standards

Power usage can not be too high. Hoses must always be secured

6.4.5 Priority

1 - Critical
It won't matter if everything else in the system works correctly (eye-tracking algorithm, camera, etc.). If there is a significant problem with the ventilator then our patient could very likely die.

7 Maintenance & Support Requirements

Maintaining the required components will require the people from the group who worked on the parts. because the work load will be divided into separate team, hardware and software. So in the future at least one of the person from software group and hardware group needs to maintain the product after built. Our software components include: The open-CV eye tracking system. Maintaining the camera and the screen. Also the battery (if it were to go out in the future).

7.1 Open-CV eye tracking algorithm

7.1.1 Description

The eye tracking system will be on version control after we built the product and if the future it were to need update we will do it in the version control and update it on the product after ward.

7.1.2 Source

Our eye tracking algorithm will be on version control.

7.1.3 Constraints

Our constraints include: We might decide to have our eye tracking algorithm in a Private version control where nobody is able to mess with it and change thing; We Can't have someone eye tracking algorithm that we are not allowed to use.

7.1.4 Standards

Open Source licence

7.1.5 Priority

2 - High

7.2 Camera and LED Screen

7.2.1 Description

The camera and the screen won't really need much maintenance unless they really break down, then our only choice is to replace them.

7.2.2 Source

We will probably end up buying the camera and the screen from an outside source if it comes to replacing either one.

7.2.3 Constraints

Our constraints include:
1: In the future we won't be able to pay for any of these item out of our pocket if they need maintenance or to be replaced.

7.2.4 Standards

N/A

7.2.5 Priority

2 - High

8 Other Requirements

In this section, the requirements determined by our team in the design process are listed. The main things included here are product features identified by the team in discussions about the design.

8.1 Server over USB

8.1.1 Description

The system will use a server-client model over the USB connection to the Eyetype system in order to exchange the necessary data to facilitate eye typing and calibration and eyegestures.

8.1.2 Source

Team discussion.

8.1.3 Constraints

The largest constraints are the speed of the USB connection and the efficiency of the server to be able to respond and operate with minimal latency and maximal throughput.

8.1.4 Standards

N/A

8.1.5 Priority

1 - Critical
This requirement is critical because it is required to perform the basic functions of our system.

8.2 State Machine

8.2.1 Description

The product code will be directed by a state machine that is meticulously designed to account for any possible condition and appropriately perform the required function. For example, the state machine will guide the system through calibration, and any emergency or failure case, as well as allowing for the user to utilize eye gestures to force a calibration. The state machine determines which operations to perform and what input or output to accept or give.

8.2.2 Source

Team discussion.

8.2.3 Constraints

The state machine must not inadvertently get stuck or cause inconvenience to the user, it must be thoroughly tested to ensure proper function and interaction with other elements of the system.

8.2.4 Standards

N/A

8.2.5 Priority

1 - Critical
This is of critical importance because is is required for the product to be considered complete.

8.3 LCD Status Display Feature

8.3.1 Description

The product will include a small LCD character display to show status messages and provide any other valuable information about the system.

8.3.2 Source

Team

8.3.3 Constraints

The main constraints are budgetary since it is extraneous.

8.3.4 Standards

N/A

8.3.5 Priority

3 - Moderate
This is listed as moderate as it seems like an easy reasonable addition to increase the ability for the machine to be trouble shot easier and allow for easier use for the customer, but it is not at all necessary.

8.4 Power Supply and Light

8.4.1 Description

The product will require an appropriate power supply and power regulation, that manages whether power is coming from the wall or battery unit, and delivers the appropriate power to all components. Also a light that indicates that the power supply is delivering power to the system for troubleshooting purposes.

8.4.2 Source

Team

8.4.3 Constraints

The main constraints are all the parts being used, their power consumption and needs of the system,

8.4.4 Standards

IEC 60601-1 Standard for medical electrical equipment

8.4.5 Priority

1 - Critical
This subsystem is critical for the product to even function.

8.5 IR Remote Device

8.5.1 Description

The customer currently has an external device that is attached to their system which allows for any device controlled by an IR remote, like TVs to be controlled. Perhaps this feature could be integrated into the design to remove an external component.

8.5.2 Source

Team

8.5.3 Constraints

The main constraints would be that it does not interfere with the system's function or interfere with the data transfer over the server-client link,

8.5.4 Standards

IEC/EN 62471 Standard for light emitting devices

8.5.5 Priority

4 - Low
This subsystem is of low priority because it would be a nice sensible addition but is in no way necessary to contribute to the main function of the system.

8.6 Camera Peripheral Device

8.6.1 Description

The product requires a camera peripheral that has an IR pass filter and IR lights to illuminate the target, and an interface that is compatible with the TX2.

8.6.2 Source

Team

8.6.3 Constraints

The camera devices must be of sufficient specs to meet the performance requirements of the eye tracking algorithm and also must fit in the budget.

8.6.4 Standards

IEC/EN 62471 Safety standard for light emitting devices

8.6.5 Priority

1 - Critical
This subsystem is critical for the product to even function.

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