Nav*EYE*gation Technologies

September 28, 2015

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

RE: ENSC 440 Capstone Project Proposal for the Gaze-controlled mouse

Dear Dr. Rawicz,

The enclosed is a proposal for our Gaze-controlled Mouse, which outlines our project for ENSC 305/440. Our objective for this project is to design and build a system which will allow the user operate a mouse using only their eyes without the need for costly eye-tracking hardware currently available on the market.

This proposal will provide a high level design and an overview of possible solutions as well as the potential risks and benefits for each. It will also include a projected timeline and budget for the project as well as company profile.

NavEYEgation Technologies is comprised of five dedicated 4th and 5th year engineering students: Ramin Nazarali, Nathan Samchek, Sunny Chowdhury, Mani Ahuja and myself. If you have any questions or comments please feel free to contact at me msantiag@sfu.ca.

Sincerely,

Monica Santiago
CEO, NavEYEgation Technologies

Enclosure: *Proposal for the Gaze-controlled Mouse*

NavEYEgation Technologies

Proposal for the *Gaze-controlled Mouse*

Project Team: Ramin Nazarali
Monica Santiago
Nathan Samchek
Mani Ahuja
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Submitted To: Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
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Issued date: September 28, 2015

Executive Summary

Our eyes are organs that can differentiate between 10 million colors (Wikipedia: Focus (optics).). We use our eyes as cameras that relay light back to the brain to process information at an extremely rapid rate. We use our eyes to do almost everything from our day-to-day activities to interact with various technological gadgets.

Technology is growing at a rapid rate. Virtually every home owns some sort of personal computer or a smartphone. These devices provide a powerful way to gain knowledge, communicate with other people, and interact with the world. Unfortunately, due to physical disabilities, many people are unable to use the current primary means for interacting with these devices: keyboards, mice, and touchscreens. Furthermore, even for people that can use these input devices, continuous, repetitive use can lead to medical issues such as carpal tunnel syndrome.

We propose a solution that is targeted to patients and professionals who are suffering from motor issues such as Parkinson's disease, Arthritis and carpal tunnel syndrome where the use of hands is difficult or downright impossible. This device will be controlled using the patient's eyes which will eliminate the need of hands.

Existing systems that propose a similar solution are extremely expensive and thus are not feasible for widespread personal use. Additionally, these systems usually have limitations that prevent them from being used with a wide variety of devices.

We propose the development of a gaze-controlled mouse, which addresses some of the issues aforementioned. The gaze-controlled mouse will use the pupils to correctly map the mouse cursor on a computer thereby using the patient's eyes to move the cursor effectively. Additionally, it will use a combination of blinks, dwell time, or other methods to interact with the computer. This will be accomplished by using cameras that will be mounted on the computer with its own image processing processor that capture the eyes and pupils and correctly map the position to the mouse on the computer.

The proposed time frame for the development of this project is ~10 weeks. This period is divided into Research, Design, Prototype, Integration, and Evaluation each lasting approximately 2 weeks. The tentative cost for this project is $700. NavEYEgation Technologies consists of 5 dedicated engineering science students hailing from computer and systems engineering concentrations that are confident in their ability to build something useful and cost effective that people with motor disabilities will benefit from.

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1. Introduction

Eye tracking technology is essential in the medical device market. Over the years engineers have researched and invented multiple eye tracking devices to help people with extreme disabilities. Existing devices are expensive and not affordable to individuals in developing countries as well as first world countries. Current products on the market demand high cost hardware integration to run existing software.

A typical gaze control device is an absolute necessity for people with diseases such as Motor Neuron Disease (MND), Cerebral Palsy (CP), Spinal Cord Injury, and also Locked-In Syndrome. People with Motor Neuron Diseases often have a weakened grip when picking up or holding objects. The disease also weakens the shoulder which makes lifting the arm difficult (Moto neurone disease). Ideal situations such as these require an eye tracking technology to make it comfortable to interact with a computer. Cerebral Palsy is a very common disease among kids, which affects muscle tone and movement. Our product, NavEYEgation can help such individuals use a mouse to interact while being immobile. NavEYEgation is also useful for people with deteriorating health (Cerebral palsy). People with head injuries and paralyzed body parts can have NavEYEgation mounted for assistance to control a computer mouse on a screen.

Although there are a few companies making eye tracking products but they have several limitations that reduce the functionality and minimize human interaction despite being costly. Our primary objective is to use a camera and integrate that with software, using OpenCV, to make it a cheaper and more marketable product. This product falls under the umbrella of Augmentative and Alternative Communicative (AAC) devices (Assistive Technologies: Concepts, Methodologies, Tools and Applications, IGI Global, 2013,). It can be used to click and move the cursor on the screen to help browse and even game without much stress on human eye.

The proposal provides an overview of our product as well as overall design considerations of our product along with market analysis, research, budget, and product schedule. Our proposal also includes alternative solution to our product along with company information.

2. Proposed Solution

There are several methods and combinations of techniques that can be used to achieve control over a computer cursor through a user's gaze. The two main approaches outlined involve the use of standard cameras, infrared cameras or a combination of both, together with image processing techniques running on the host device, or a third party device.

The main advantage to using an infrared camera over a regular camera is that it will give a better image of the fine details of the eye such as the iris and pupil locations. However infrared cameras are typically not as commonly available as regular cameras, and would reduce the accessibility of our final product. These and other factors will be taken into consideration as we progress.

2.1 Device mounted camera system

The first proposed method uses a single camera (potentially infrared) mounted next to the output screen intended to be controlled through gaze-tracking. The user's full face will be visible within the mounted camera's field of view, and the input from this camera will be fed through a software image processing algorithm outlined in Figure 1. The algorithm can run on either the device controlling the output screen, or for enhanced performance can run on a dedicated third party processing board.

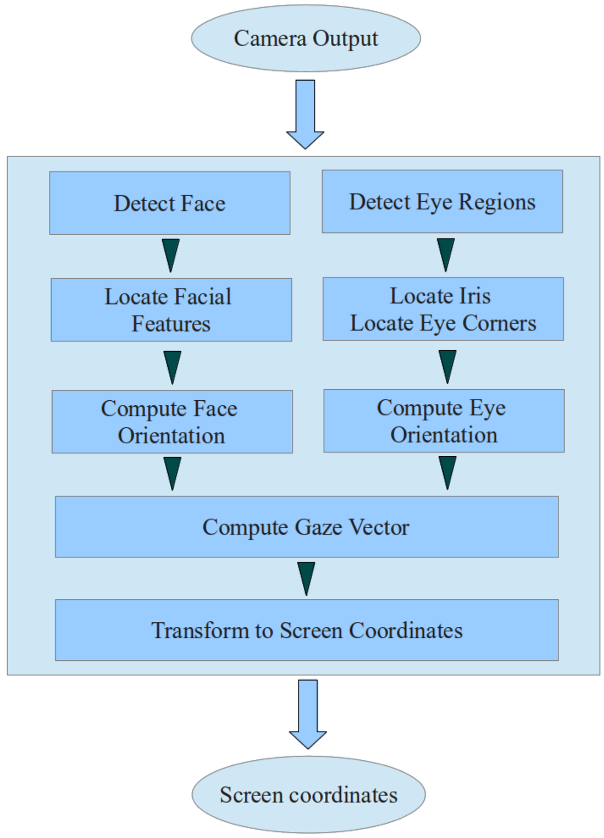


Figure 1: Algorithm for Device Mounted Approach

Prior to using this gaze tracking solution, a one-time calibration step must be performed. This procedure would consist of looking at several sequentially displayed points on the output screen the user is intending to use. The gaze of the user during this step would be recorded and used to establish the output screen's position relative to the camera.

The screen coordinates provided as output by the algorithm in Figure 1 would control the location of the computer's cursor, thereby achieving a gaze controlled cursor. In order to allow the user to perform “click” or “drag” actions with the cursor, different eye states will be mapped to these different actions. For example blinking both eyes twice can translate to a single click of the cursor, and closing one eye completely can correspond to a drag action.

Overall the intended final product of this first approach would result in a single self-contained device that would plug into a computer and enable the user to control the position and actions of the computer cursor with their gaze, or possibly just a software program that could be downloaded and run on the computer for the same functionality, providing the computer has a camera attached.

2.2 Head mounted camera system

The second implementation involves the use of up to 2 cameras (potentially infrared) and sensors such as a 3 axis gyro/accelerometer. The one required camera will be head mounted and focused on the user's eye, while the second optional camera will be mounted next to the output screen. The algorithm for this solution is shown below in Figure 2.

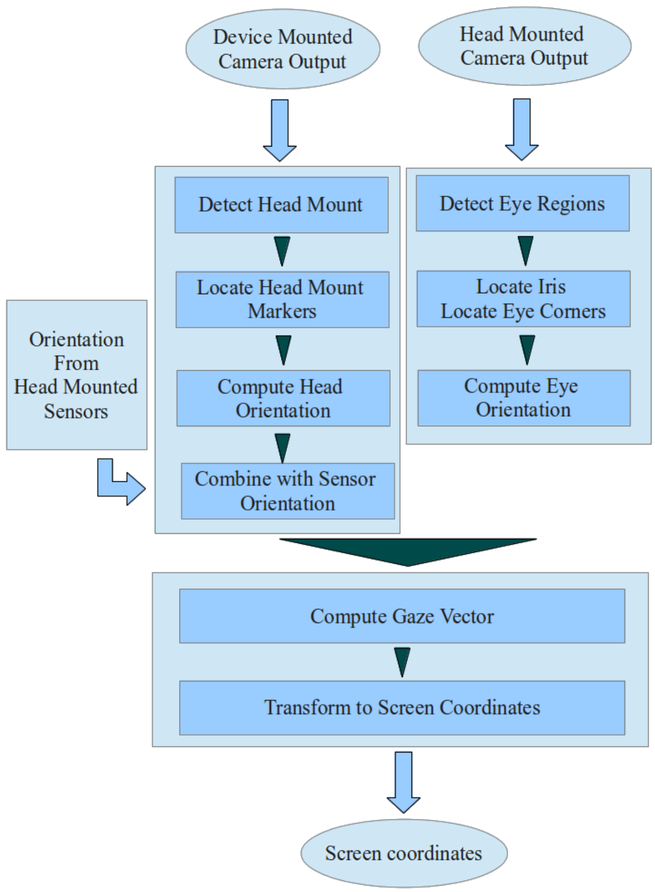


Figure 2: Algorithm for Head Mounted Approach

Functionally this head mounted solution works similarly to the device mounted solution, and has the same one-time calibration step involved. However the addition of a head mounted camera increases the precision of the computed eye orientation because the camera is now very close to the users eyes. This proximity allows the camera to image the eye at a greater resolution, and potentially allows for a more accurate determination of where the user is looking at on the output screen. Additionally the orientation of the head may be tracked to a greater degree due to the combination of different sensors involved, which would only further the systems total accuracy.

With this second approach, controlling cursor actions such as "clicking" or "dragging" will be accomplished in the same manner as the first proposed solution (i.e. blinking both eyes twice can translate to a single click of the cursor, and closing one eye completely can correspond to a drag action).

Overall the intended final product of this second approach would result in a helmet-like device and a standalone board which would be connected to each other. The board would then plug into a computer and enable the user to control the position and actions of their computer cursor with their gaze.

3. Market Analysis

There are not many companies that are developing gaze-controlled mice so the competition is not very strong. There are some products that are expensive or have limitations that reduce the functionality and decrease the human interaction component of it. Some of the companies and their limitations are stated below:

3.1 Competition

tobii: While tobii prides itself into being the leading eye tracker solution in the world, the price for this device is well above $1,500 USD, which instantly drops it from being used in rural medical areas where funding is scarce for elder care facilities and hospitals.

THE EYE TRIBE: The eye tribe tracker is wonderfully created and is priced incredibly well at $99 USD however it has some limitations for it to be implemented on a large scale basis. Particularly, the lack of USB 2.0 support and minimum CPU power required (i5/i7) automatically excludes older computers which is of concern since not many medical institutions use high performance parts.

Optikey: This is a free software which is programmed quite well however the lack of hardware makes it difficult to integrate with the host computer. All the image processing aspect of device is done on the computer which can use up memory quite fast.

iMowse: This is a student project created by one of the students at BCIT. While it is a great attempt, the gaze can only controlled in vertical and horizontal lines which severely limits other functions and is extremely basic.

All these products have their advantages and disadvantages. Our focus is to create something for motor disabled patients that have perhaps lost the use of their arms or makes it extremely difficult for them to use such as arthritis or carpal tunnel syndrome.

3.2 Research Rationale

There are several different eye tracking software available in the market as aforementioned. After thorough research and brainstorming, the two most common disadvantages our team encountered was price and hardware compatibility. Our team at NavEYEgation Technologies aim to resolve these problems by designing a gaze-controlled that is affordable and widely used and compatible with older, less powerful computers.

4. Budget

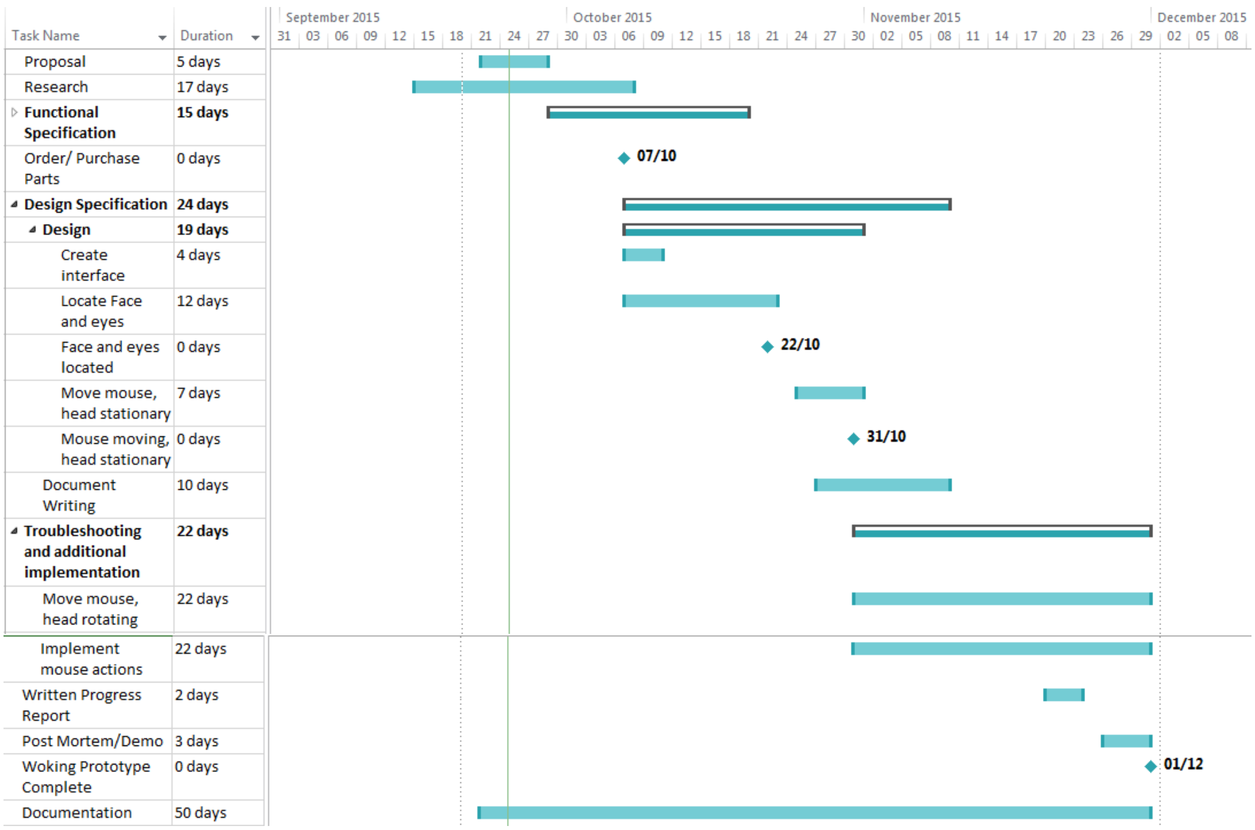
The table below gives a rough estimate for the budget needed to develop the early prototype of our project. It factors in shipping costs for online orders as well as equipment already in our possession. Our list of equipment is subject to change as the implementation of the project is refined, and added costs may apply. To cover the potential added costs, a miscellaneous costs section has been included. The bulk of our budget is allocated to purchasing the cameras and any additional sensors used to detect the movement of the user's pupil. Unfortunately, we have not received any updates from the ESSEF on how much funding our group will be given at the time of this written proposal.

Table 1: Equipment List and Breakdown of Expenditures

Item	Estimated Cost
Cameras	$240
Sensors	$130
Processing Unit	$130
Miscellaneous Materials	$130
Structural Components	$70
TOTAL	$700

5. Schedule

The following Gantt chart shown in Figure 3 & 4 shows the projected start, duration and completion dates for the major phases of this project. They have been scheduled largely around the due dates of the functional and design specifications. A breakdown of the major deadlines and milestones is shown in figure 5.



Figures 3& 4: Gantt Chart showing Milestones and Dates and Durations of Key Tasks

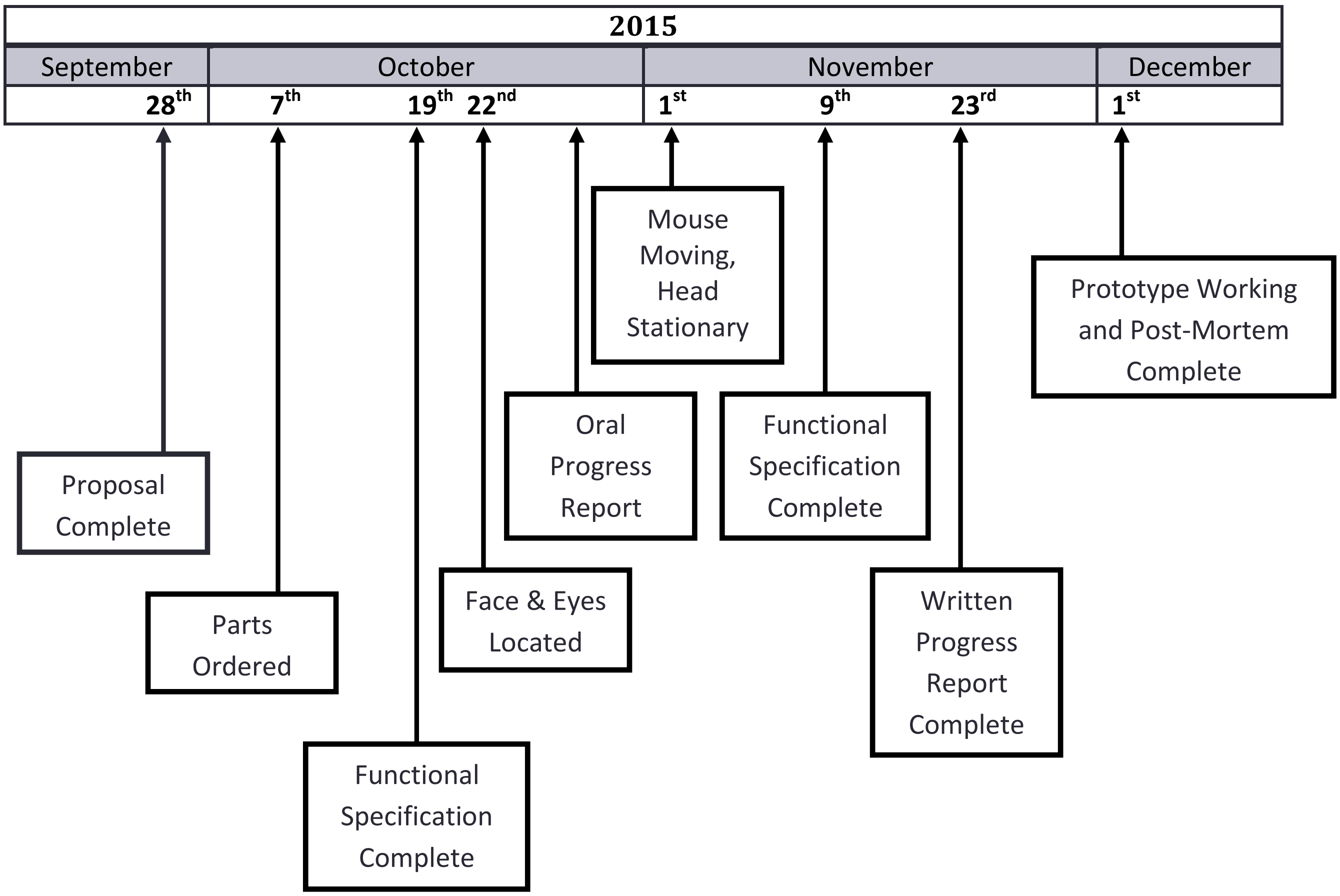


Figure 5 Major Milestones and Deadlines

6. The Team

Monica Santiago, Chief Executive Officer (CEO)

Monica is a fifth-year computer engineering student. She will be serving as the project manager. She has completed two co-ops with BlackBerry as an Audio Engineering Associate where she performed audio tests on handheld devices and wrote documentation for testing processes. She served as project manager of a team of four for an iPhone application development project for a software development course. She has also had over five years of experience using electronics lab equipment.

Nathan Samchek, Chief Financial Officer (CFO)

Nathan is a fifth-year systems engineering student with a minor in computer science. He will be acting as the Chief Financial Officer. He has a wide range of experience in software having been a part of projects ranging from image compression and processing to machine learning and data analysis. He also has experience with hardware from circuit design and robot development projects.

Ramin Nazarali, Chief Operational Officer (COO)

Ramin is a fifth year systems engineering student with a minor in computer science. He will be acting as the Chief Operational Officer and will manage internal business. He has completed two coops at Tantalus Systems where he gathered performance data on different customer systems and developed tools to increase employee productivity. He has a wide reaching skillset over both software and hardware through experience developing robotics platforms, and also enjoys teaching students about the technical details of software development.

Mani Ahuja, Chief Technology Officer (CTO)

Mani is a fourth-year computer engineering student. He will be in charge of day to day activities and will be reporting directly to Monica, the CEO. He has completed three co-ops at ZE PowerGroup Inc. as a Data Quality Monitor and as an Application Support Analyst where he was entrusted with ensuring that client data was up to strict standards on a day to day basis. He has also trained various new employees and places a great amount of attention to detail in what he does.

Sunny Chowdhury, Chief Information Officer (CIO)

Sunny is a fifth year engineering science student with dual concentration in Electronics and Computer engineering. He will be the Chief Information Officer for this project. His primary goal is to track project status in order suggest and implement necessary changes during prototyping of the product. He will also be in charge of testing and debugging the product as its being built.

He has a broad knowledge in both electronics and computer aspects of engineering. Several courses in electronics and programming have given him a good understanding of engineering components and how to use them in a project. His expertise lies in testing and debugging hardware components as well as writing and implementing software. He took part in Software Engineering project and acted as a Quality Assurance Engineering for an application made by his group during the course. The application, SFUOnCampus, was awarded 3rd place in the competition setup by SFU ancillary services.

He has also completed three co-ops at ZE PowerGroup Inc. as a Service Quality Analyst (1st & 2nd term) and Application Support Analyst (3rd term). These co-ops have given him a broad understanding on how data mining companies work using database and software. He was assigned tasks that involved error reporting, troubleshooting the errors, and performing historical data analysis.

7. Conclusions

Our team at NavEYEgation Technologies aims to design a cheap, accurate, reliable, and applicable gaze-controlled input device for motor disabled people. Current solutions are either expensive, inaccurate, or unusable by a wide variety of devices. Our design will incorporate both solutions found in existing products and our own skill and experience to solve these issues.

The initial design will involve integrating a camera with image processing techniques to track the gaze of a user, mapping this vector to a location on a computer screen, and implementing methods for interacting with the interface. To accomplish this, our team will work together to develop the necessary software and hardware with a goal of completing the project in three months.

Our ability to incorporate existing solutions, learn from existing failures, and desire to see our product in every home, separates our product from its competition. Our product will provide the ability to interact with a wide range of computers and similar devices in a way that saves users time and money.

8. References

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