May 31, 2018
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
British Columbia, V5A 1S6

RE: ENSC 405W/440 Project Proposal for OptiCue

Dear Dr. Rawicz,

This document which contains Aperture Solutions' proposal for OptiCue, contains a summary of our planned capstone project. The purpose of this proposal is to discuss the applications of real-time facial expression recognition under the constraints of being portable and discrete. Our goal is to provide technology that would give those who cannot recognize social cues the tools to navigate their personal and professional lives with better communication skills.

This proposal will provide an overview of our prototype, including the scope of the project as well as the associated risks and benefits. It will then discuss the market and competition for this product, an overview on the project's timeline including relevant milestones, a summary of the finances for this project including budget, costs, and potential funding, and an overview of the company with summaries on the relevant skills of each member of the group.

Our group, consisting of 4 engineers spanning several concentrations including electronics, systems, and computing, includes Ricardo Dupouy, Steven Lippmann, Maggie Parkhurst-Bartel, and Greyson Wang. Descriptions of each engineer is provided in the section Company Overview.

Our team appreciates your time in reviewing our proposal for OptiCue. If you have any questions or concerns regarding our project, please contact me at mparkhur@sfu.ca.

Sincerely,

Maggie Parkhurst-Bartel

Maggie Parkhurst-Bartel
CEO
Aperture Solutions

APERTURE
SOLUTIONS INC.

PROJECT PROPOSAL:
OptiCue

Partners:
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Submitted To:
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Dr. Andrew Rawicz, ENSC 440
School of Engineering Science
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Issue Date:
May 31nd, 2018

Executive Summary

According to the centre for disease control, recent studies in Asia, Europe, and North America have revealed that between 1 and 2% of the global population have been diagnosed with autism [1], this translates to a global autism population of 76 million individuals. One of the main difficulties facing these individuals is social impairment and communication [2]. This means that many autistic individuals can find social interaction quite challenging, since many of the subtle aspects of interaction such as facial expression, body language, or tone of voice can be difficult to detect or understand. Our company's goal is to provide a tool to make social interaction easier. The OptiCue will perform facial expression detection, provide feedback on the subject's mood, and help the user to avoid miscommunication.

The OptiCue will consist of three core components. First, a wearable camera attached to the frame that will gather the images that will be processed. Secondly, it will include a controller, most likely a Raspberry Pi, that will handle the processing of the images and include the logic that will dictate what feedback to send to the user. The third component is the audio feedback consisting of sending pre recorded messages i.e. "happy", "sad", "angry", etc. to a headphone jack so that the user may get updates from a pair of headphones. Finally, the device will also include a battery and charger to enable portability.

Aperture Solutions is made up of 4 passionate and determined engineers from Simon Fraser University. With backgrounds spanning electronics, computing, and systems, our team members have experience working with microcontrollers, real-time embedded programming, circuit design, image processing, digital system design, and software design. With this background, our team's goal is to take the concept of facial expression recognition software and use it in a portable and discrete method, while keeping the cost low to make this device available to any individual who might need it.

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1 Introduction

Facial recognition software has made great strides in recent years, with Apple's Face ID as one example. While this new security feature is handy and eliminates the need to enter passwords, we have a more conscientious application in mind. Our vision is to use facial detection software to aid in the identification of facial expressions for those who struggle to do so on their own. Our device will alert the user of the meaning behind the current facial expression of anyone whom the user might be interacting with. In this way, we hope to help those with disorders, such as autism, to learn about social cues and how people use them to communicate.

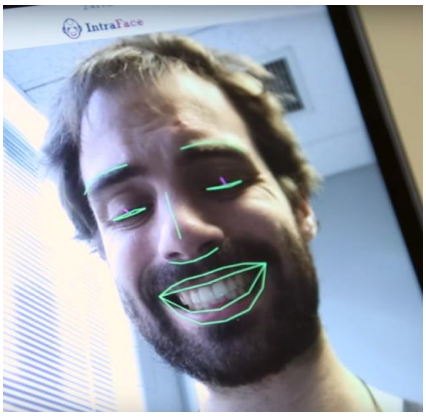


Figure 1 Example Facial Recognition Detection

Facial expressions provide a bulk of social cues in an interaction that gives us feedback on how people feel. However, people with conditions such as autism, ADHD, Social-emotional agnosia, and Asperger's syndrome are unable to read or make sense of these reactions and respond appropriately [1][2].

Our device will provide brief audio feedback to the user on the emotions of the person they are interacting with based on their facial expression. This will help ease the lives of people living with these disorders and act as a tool for them in simple social interactions.

This proposal will discuss current facial expression recognition software and its applications, and how we plan to use this technology to act as a tool for individuals unable to recognize social cues. Our team will provide a high-level overview of our product including risks and benefits, as detailed in section 2. The market and competition will be explored in section 3. Section 4 will conclude with a list of milestones and our project outline. Finally, section 5 will list the costs of each component needed to build the prototype and provide a rough estimation of the amount of funding we need.

2 Project Overview

2.1 Background

While research on the various disorders that cause people to be unable to read social cues and emotions from facial expressions has continued for decades, with the most well-known disorder, Autism, receiving formal scientific research dating back to 1938 [1], treatment to help people cope with these conditions has been lacking. For example, research on the improvements from using psychosocial intervention for autism is determined to be too lacking in controlled, primary studies to draw any conclusions from, and is at best only able to suggest that some form of treatment is likely preferable to having no treatment at all [3].

Our team came up with a complementary approach. Rather than directly treating the individual, we would like to build technology that people living with these disorders can use to help ease their lives. This has the benefit of not exposing our users to medications or long-term therapies, many of which have been applied with little or no primary research, and some even at the cost of the long-term health of the individual [4][5].

2.2 Scope

The scope of this capstone project includes the design and creation of a prototype for OptiCue. This prototype must be small enough to easily carry around and be able to process images of faces sent by the mounted camera. The software must then track changes in facial expressions to determine the person's mood in real time.

Our prototype will achieve the following functionality using:

- A Raspberry Pi computer to run the software
- Software written in a mix of Python and C
- A camera to take images of the faces
- A power-supply
- Headphones to give the user output messages

The prototype's size is constrained by the size of the Raspberry Pi model that we will be using. However, the final product will be much smaller, as many of the components in the Raspberry Pi used for the demo are not needed.

2.3 Risks

Company

Our project will rely heavily on timing. As designers, most of our hardware and software design approaches will be centered around meeting certain time constraints. The key aspect of our product is the ability to provide feedback to the user based on the facial expressions of the listener. If this feedback

takes more than a few seconds to arrive then this can result in miscommunication and invalid information. As our project involves a lot of information being transmitted and analyzed between hardware peripherals, it is imperative that these operations are done as fast and efficiently as possible to meet the timing requirements.

Another key aspect of our design is portability. We need components that will allow for a discrete and small final product, while at the same time giving us enough computing power to perform all the processing and analysis involved. Our product is mainly targeted toward children, and thus we need a discrete design that will not distract or bother the user. There needs to be a balance between size and computing power, and it is crucial to be able to keep the design compact.

Safety

We do not expect significant safety hazards for either the designers or the users. The primary risks associated with using the product are the electronic components, which can become an electrical hazard if the user allows the circuitry or the battery pack to be exposed to water or high temperatures. The headphones used to deliver feedback to the user may also cause prolonged hearing damage if the user turns the volume too high.

To minimize risk of shock and/or burns due to electronic malfunctioning or user error, we will be implementing various safety features. The main safety feature we plan to add is a fully sealed system enclosure that will not be user serviceable. Additionally, the system will contain a single, embedded lithium battery pack that will last the life of the device and therefore will not need to be replaced. Since the battery poses the greatest threat to user safety we will be monitoring it closely, watching for overheating, high/low voltages and short circuits. Naturally, we will also be including PTC fuses to protect both the user and the electrical components from any short circuits that might occur.

2.4 Benefits

Ease of Life

Not being able to recognize or understand social cues can cause stress and anxiety for an individual, especially in important situations such as in a professional environment. By providing a tool that tells the user of a person's current emotion, the user no longer needs to worry about a possible miscommunication.

Research Tool

This technology can be used to further research in possible treatment options and provide information on how understanding social cues is learned later in life.

Safety

Existing treatment includes putting people on long term medications to reduce the symptoms. However, these medications come with side effects, and have very little research to determine their safety [5]. Our device provides an alternative to ingesting medications and has inherently much fewer risks.

3 Market and Competition

3.1 Competition

The use of wearable technology to help, rather than attempt to treat people with these types of disorders presents a brand-new market that has largely remained untapped. There is currently only one other project with a similar concept to ours, which is an AR glass called Empower Me by Brain Power LLC [6]. Shown in Figure 1, Empower Me is OptiCue's main and sole competitor. It uses google glasses to create an augmented reality game where children can play a game to learn how to recognize facial expressions.

While Google Glass does offer a very impressive array of features, requiring access to a pair of glasses valued at $1500 makes this difficult for widespread market acceptance. In addition, google glass also became a commercial failure that was quickly discontinued by google [7].

Our product will not require any specialized devices that may be discontinued outside the control of our company. In addition, the components that make up our product will be much more affordable to the average consumer than Google Glass. Finally, while lacking a fun gaming interface, this also makes it possible to use our product in a practical situation outside a therapy session.

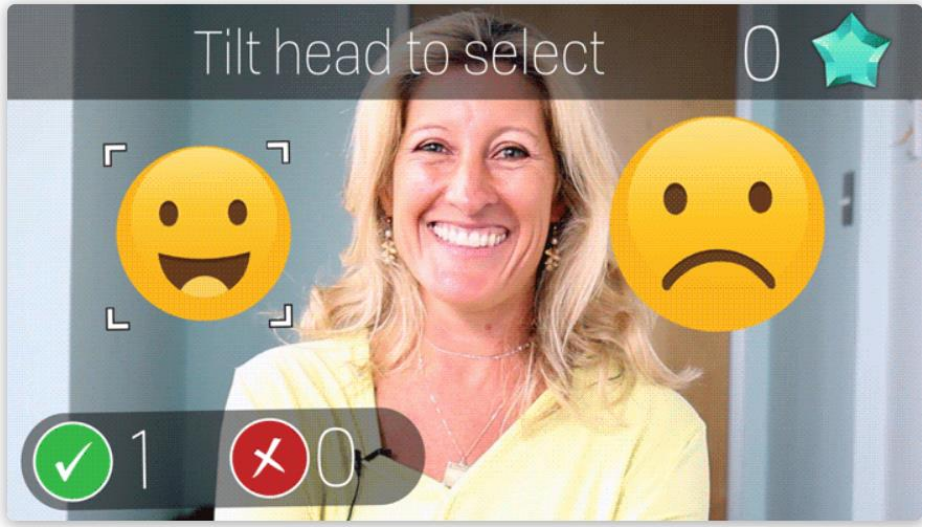


Figure 2 Google Glass Emotion Recognition

3.2 Market

Autism spectrum disorder (ASD) is reported to occur in 1 of every 59 children, of all ethnic and socioeconomic groups [1]. On average people diagnosed with ASD spend 4-6 times more on medical expenditures [1]. The OptiCue is meant to be an affordable product for everyone, not an expensive treatment.

Studies show that individuals diagnosed with ASD can learn to manage social interactions, by enacting these situations in a controlled environment [8]. Our product can be marketed to families for use with young people and children in their development years, as well as in schools and daycares. There are certain Milestones that children should reach before a certain age [9], such as showing affection for a close family member, or showing concern for a crying friend. The OptiCue can be introduced as a form of training or therapy during these development years, to help meet these milestones.

4 Project Timeline

Figures 3 and 4 below show our projects Gantt, and milestone chart respectively. The project schedules span May to August and list all major milestones as well as important subtasks.

PROJECT TIMELINE

Aperture Solutions
OptiCue

Project Start: Mon, 5-7-2018
Display Week: 1

MAY | JUNE | JULY | AUGUST

TASK	NAME	DURATION	START	END
Task 1	Research and Planning			
Task 1.1	Brainstorm Project Ideas	1 week	5-7-18	5-17-18
Task 1.2	Discuss Ideas with Andrew/Steve	1 day	5-17-18	5-17-18
Task 1.3	Assign Group Roles	1 week	5-17-18	5-24-18
Task 1.4	Assign Project Work	1 week	5-21-18	5-24-18
Task 1.5	Project Proposal	1.5 wee	5-18-18	5-31-18
Task 2	Design Prototype			
Task 2.1	Teamwork Inventory 1	1 week	5-31-18	6-7-18
Task 2.2	Design Progress Meeting 1	1.5 wee	6-7-18	6-19-18
Task 2.3	Requirements/Specifications	3 weeks	6-1-18	6-21-18
Task 2.4	Design Progress Meeting 2	1.5 wee	7-12-18	7-24-18
Task 2.5	Teamwork Inventory 2	3 weeks	7-2-18	7-26-18
Task 2.6	UI Design Appendix	2 weeks	7-9-18	7-26-18
Task 2.7	440 Planning Appendix	1.5 wee	7-16-18	7-26-18
Task 2.8	Prototype Design Specifications	4 weeks	6-19-18	7-26-18
Task 3	Presentation/Demo			
Task 3.1	Poster Presentation	1 week	7-26-18	8-2-18
Task 3.2	Engineering Journals	12 wee	5-7-18	8-2-18

Figure 3 Gantt Project Chart

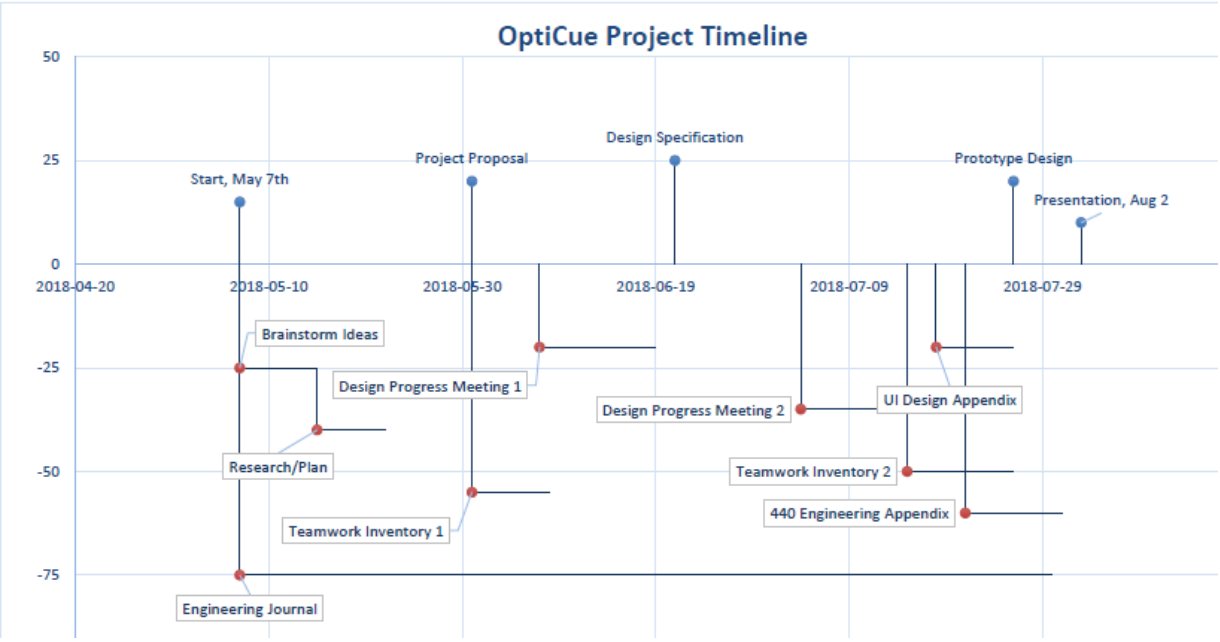


Figure 4 Milestone Chart

5 Finances

5.1 Project Costs

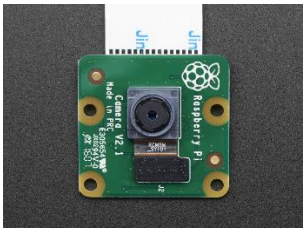
The projected costs of building our product were found based on component orders from common electronics distributors (see appendix for list of vendors). The prices calculated below will cover the cost of the prototype and an approximate cost for larger scale production. These prices do not include lease/building costs, production equipment costs, labour costs or consumables costs.

The prototype will be constructed using off the shelf parts to reduce the cost and ensure compatibility between our components. This will also help in the design process since these products are well documented and have a large online community. This also gives us an opportunity to easily swap out components if we find that something is over or under our design specifications.

Prototype Parts List		
Component	Description	Price (CAD)
Raspberry Pi Zero W	System processor	$10
Raspberry Pi Camera Module V2	High definition camera, 8MP	$30
PowerBoost 500 Charger	Battery management module	$15
2200 mAh Lithium Battery	Energy Storage	$10
Audio Jack	Sound output connector	$2
Resistors, Capacitors etc.	Various components needed for audio and other module connections	$30
Other	Taxes, Shipping and Handling etc.	$40
Total		$137

Table 1 - Prototype Parts and Cost

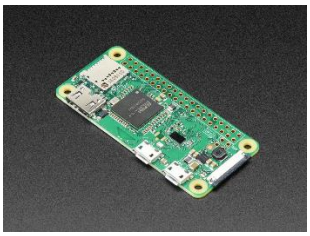
* Prices stated in the table above are prices as of May 2018 and are subject to change.



Raspberry Pi Camera Module V2:

The main sensing component of the system. This high definition camera will be responsible for picking up subtle details in the subject`s face. We hope to reduce the resolution of the camera to reduce cost in production.

Figure 5 Raspberry Pi Camera



Raspberry Pi Zero W:

The brain of the device. This will be the main processor in the system and the hub for all the peripherals. This will be held by the user and therefore needs to be small enough not to be a burden, while also being powerful enough to process and analyse the incoming images.

Figure 6 Raspberry Pi Zero W

Production Parts List		
Component	Description	Price (CAD)
Raspberry Pi Zero W	System processor	$10
Zero Spy Camera for Raspberry Pi Zero	Small 5MP camera	$15
Battery Charger IC	Battery management chip	$6
DC/DC Converter	Convert 3.7V to 5V	$1.50
2200 mAh Lithium Battery	Energy Storage	$9
Audio Jack	Sound output connector	$1.50
Resistors, Capacitors etc.	Various components needed for audio and other IC connections	$15
PCB	Printed circuit board	$10
Other	Taxes, Shipping and Handling etc.	$40
Total		$108

Table 2 - Production Parts and Cost

* Prices stated in the table above are prices as of May 2018 and are subject to change

5.2 Potential Funding

Our competitor, Brain Power [6], achieved 500% of its goal in a crowdfunding campaign on just the very first day [10]. This demonstrates that there is significant interest in wearable technology that help these disorders. Since we do not intend to put our project into production on a large scale, crowdfunding is not our preferred approach.

We also have access to several sources of funding specifically for Engineering students to complete capstone projects. The following funds will likely help us fund the Capstone project:

- Wighton Engineering Development Fund, administered by Andrew Rawicz, is awarded to projects benefiting society. Our project will provide significant benefits to society, as mentioned above, compared to similar treatment options for autism.
- The Engineering Science Student Endowment Fund is awarded by SFU's Engineering Science Student Society (ESSS). Our prototype is entrepreneurial and therefore meets the funding criteria.

6 Company Overview

6.1 CEO

Maggie Parkhurst-Bartel is a fourth-year systems engineer from Simon Fraser University. Passionate about creating automated solutions, she has a strong background in software with a hardware perspective in languages such as C, C++, and Python. She has experience in communications developing muxponder applications for optical transport network (OTN) processors and designing testing environments for OTN processors using Python from her work term at Microsemi. In her spare time, she has worked on automation and game engine design projects such as designing a video game from the ground up using VHDL and C on an FPGA and creating a control system for an electromagnetic lock using a Raspberry Pi.

6.2 CTO

Steven Lippmann is a systems engineer studying at Simon Fraser University. Steven has lots of experience working with low level software and hardware design. He also has experience establishing Bluetooth connections between devices and decreasing the latency between the request and the connection. Working with embedded systems has given him valuable skills such as manipulating the states of embedded processors to reduce power consumption and increasing the overall system efficiency. Being a systems engineer, Steven is also familiar with 3D CAD design and has experience with SolidWorks and similar modelling tools which he has used for 3D printing components of various projects.

6.3 CCO

Ricardo Dupouy is a fourth year Electronics Engineering student. He spent 8 months working with Digital Systems and ASIC development at Microsemi as a Co-op Engineer. Ricardo has great interest in both Digital and Analog Electronics. Through his personal projects and work at Microsemi, he has developed skills writing low level software to run on microcontrollers as well as higher level applications and test scripts using Python. Ricardo also shows practical knowledge of analog circuitry crucial to stable and reliable power supply structures. He is always looking for the next challenge and opportunity to learn.

6.4 COO

Greyson Wang is a fourth year Computer Engineering student with an interest in Artificial Intelligence and Computer Graphics. He has completed 8 months of co-op at Simba Technologies as a Software Engineer, where he helped add support for various new data sources in the Memphis Driver, preformed code maintenance, and developed the core DML functionality in the SQLite driver. He has a good understanding of agile software development, and is proficient in writing clean, maintainable code.

7 Conclusion

The OptiCue will be the bridge in communication between the socially impaired and their community. Our sophisticated design will allow the user to understand how their actions impact those around them, and it will provide a tool to ease into social interactions and better communication. The focus of the design is portability. It is meant to be a part of the daily routine of the user. Discrete, easy to carry, and rechargeable.

Our team of driven engineers shares the same vision. Providing affordable solutions to customers, solutions that require minimum changes in their daily routines but offer major improvements to their livelihood. We believe that our product, the OptiCue, will be a powerful tool to ease those with social impairments into interactive situations and better communication.

The team at Aperture Solutions strives to solve problems that affect the everyday lives of individuals. In a time where communication plays such a major role in society, social interaction is a key aspect of a daily routine, whether it is at work, school, or simply at home. Our team has come up with an affordable and interactive design to be used as a tool that will aid those with social impairment in their everyday interactions.

8 References

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[2] N/A, “Autism Spectrum Disorder Fact Sheet”, 2017, https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Autism-Spectrum-Disorder-Fact-Sheet

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9 Appendix

9.1 List of Vendors for Product Design

Adafruit Industries https://www.adafruit.com

DigiKey Electronics, Inc. https://www.digikey.ca

Mouser Electronics, Inc. https://www.mouser.ca

9.2 Links to Prototype Components

Raspberry Pi Zero W https://www.adafruit.com/product/3400

Raspberry Pi Camera Module V2 https://www.adafruit.com/product/3099

PowerBoost 500 Charger https://www.adafruit.com/product/1944

2200 mAh Lithium Battery https://www.adafruit.com/product/1781

Audio Jack https://www.digikey.ca/product-detail/en/cui-inc/SJ1-3523N/

Resistors, Capacitors, etc. https://www.digikey.ca

Battery Management IC, DC/DC Converter, etc. https://www.mouser.ca