Low-vision Enhancement Optoelectronic Belt

Team: Ready || !
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November 13th, 2019

Executive Summary

The LEO (Low-Vision Optoelectronic) Vest is a wearable device that seeks to use sensory substitution to improve user function for those with peripheral vision impairment. The goal of this project is to provide an option for patients who suffer from reduced vision by enhancing their peripheral field of vision, as currently most medical treatment techniques focus on restoring or supplementing central vision. The device will be a portable, wearable system with a camera and computer that parses information from the camera and transmits the information as vibrations on the patient's skin to help them identify the location of objects outside their field of view. This project is inspired by an Intel project called IRSAW (Intel RealSense Spatial Awareness Wearable) which is no longer being pursued by Intel. This device will be more ergonomically patient friendly and implemented in such a way that more users will be able to benefit from this product.

1) Problem Statement

There are many people living with constricted central vision but a lack of peripheral vision, usually due to diseases like glaucoma and retinitis pigmentosa. Consequences of this limitation include decreased mobility, slower navigation, or impaired social interactions. A number of current designs, such as Electronic Travel Aids (ETAs), have not been widely accepted by the blind community because these devices are designed for general central visual impairment and not peripheral vision loss. Our design must address the needs of this patient population to avoid the failings of previous solution attempts.

2) Design Objectives

Our objective is to design a system that can take in visual information that the user cannot see and present it in a way they can interpret. To do this we need:

1. Portable wearable computing device
2. Visual data collection and analysis
3. Sensory substitution via vibration

3) Major System Requirements and Constraints

a) Major System Requirements

Figure 1: Motor Layout

- R1: The system shall take in visual information through a camera.
- R2: The system shall split up the visual information into 8 different visual fields.
- R3: The system shall communicate with the user through 8 vibration motors (6 on the chest and 2 on the feet)
- R4: The system shall detect the depth of the closest object in each of the 8 regions in its field of view.
- R5: The system shall trigger the vibration motor in the location corresponding to the object in the visual field such as an object in the top right of the visual field will cause the top right vibration motor trigger.
- R6: The system shall change vibration intensity based on the measured distance of the object in the visual field.

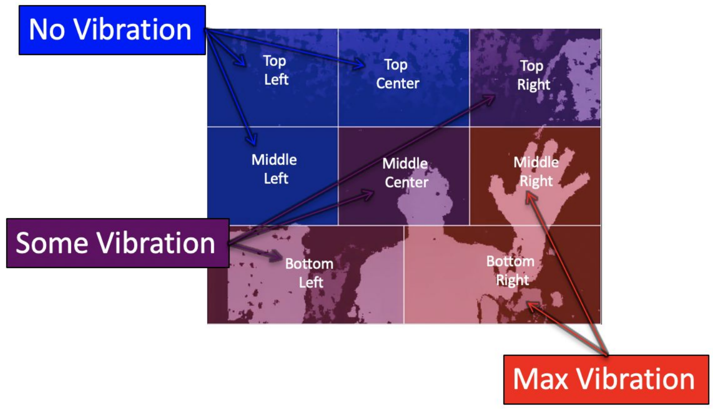

Figure 2: Camera Visual Field Layout

b) Major System Constraints

- SC1: The system should weigh no more than 10 pounds
- SC2: The system should have enough power supply to function for a 12 hour day.
- SC3: The system should respond with a vibration motor within a half a second of an object coming into the field.
- SC4: The system should be able to detect objects between 0.5 meters to 3 meters away from the user.
- SC5: The camera should detect input from a field of 40 degrees vertically, 70 degrees horizontally.

c) Standards

The communication for our system shall follow the Bluetooth Low Energy (BLE) standards. The hardware shall follow user safety standards for the battery, computer, camera, and vibration motors. We plan on following the C++ programming language standard.

d) Societal Factors

Public health, safety, and welfare: This system has the potential to have a positive impact on people who have peripheral vision impairment and allow them to navigate the world more safely. However, if our device malfunctioned and gave the user incorrect sensory replacement, it could be dangerous for the user and others.

Social and cultural factors: This product could have a negative social impact on the user by making their visual impairment more known to society by having a noticeable vision aid. There could be a stigma associated with the device, as wearing an aid may draw attention. However, this device would allow people to detect visual social cues better and function more independently and appropriately in social situations.

Environmental Factors: The lithium-ion batteries used for this device can be recharged, which would have a positive impact on the environment since the batteries could be used multiple times. However, the environment would be negatively impacted by eventually needing to dispose of the batteries.

Economic Factors: This product is more economically accessible to users than expensive conventional medical alternatives. However, this product would be more expensive and less accessible than simple vision aids such as a cane.

Global Factors: This product can be utilized globally provided that the user has frequent access to electricity.

4) Design Concept

a) Research and Investigation

The initial research our team performed consisted of a discussion with our sponsors to identify the shortcomings of previous designs. The discussion of “A novel, wearable, electronic visual aid to assist those with reduced peripheral vision” allowed our team to learn about the history of the problem and prototype. We found the core need to implement the product is a vibration on the body based on an object in the area of field. From that conversation we compiled a hardware and software parts list. The hardware consists of 8 microcontrollers each with a vibration motor and battery, a computing stick, a camera, and clothing items to hold the hardware on the user. In a previous iteration the compute stick was capable of handling the required processing needed; therefore, our team believes that if we use an equivalent computing stick with similar specifications then the signal processing will be feasible. The software components consist of C++ code in the Visual Studio IDE, Arduino code, and Bluetooth protocol for communication.

b) Selection of Design Concept

We will be implementing the system with four major design decisions. A compute stick, microcontroller, Bluetooth communication, and software libraries. Previous design devices include a Surface laptop; however we are planning to use the compute stick as it is portable and could be attached to the belt. The selection of the microcontroller is such that we can communicate with either Wifi, Wifi Direct, or Bluetooth Low Energy. Bluetooth communication will enhance the product because the user will not have to carry around a router. In addition, Bluetooth Low Energy could be more useful than Wifi Direct because it drains battery much slower. A multi-protocoled microcontroller will allow our team to utilize Wifi if needed. Our team will select software libraries that enable the product to process camera information and will be compatible with the rest of our design.

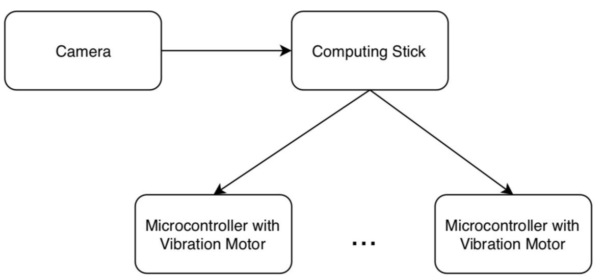

Figure 3: High Level System Design

Figure 4: Vest Layout

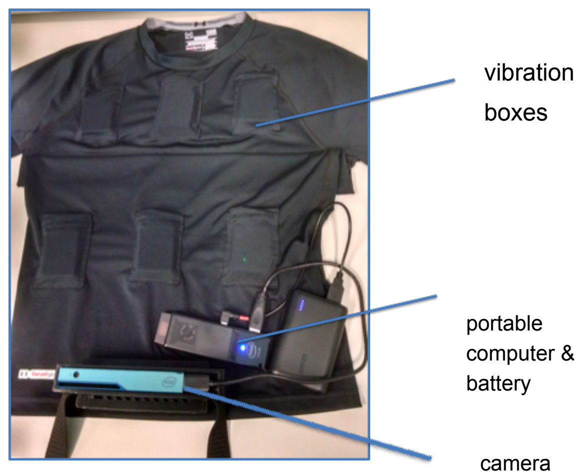

Figure 3 is a block diagram that demonstrates the architecture of the proposed system. Figure 4 is a basic concept of the placement of the vibration motors on the previous prototype.

5) Deliverables and Milestones

a) Project Deliverables

1. Compiled version of image capturing program
2. Wearable product
3. User/Operator manual
4. Design Documentation

We plan for these deliverables to be for a production ready system to produce a tool that can be used successfully in research.

b) Schedule and Timeline

Task	Start Date	End Date
Deliverable #0: Acquire Hardware	1/21/19	1/24/19
1. Order hardware: compute stick, microcontrollers, lithium batteries		
Deliverable #1: Runnable Main program	1/25/19	2/14/19
1. Replace incompatible libraries		
2. 32/64 bit program		
3. Rework deprecated network code		
Deliverable #2: System Operational in Stationary Setting	2/14/19	2/28/19
1. Build new motor units		
2. Wifi control over new microcontrollers		
3. Full system functional on standard computer		
Deliverable #3: Portable product	2/28/19	3/13/19
1. Full system functional on portable computing stick		
2. Bluetooth connection		
Deliverable #4: Documentation and	3/23/19	4/3/19

Presentation		
1. User manual		
2. Build tutorial		
3. Documentation		
4. Presentation Preparation		

Note: This schedule gives our team four weeks at the end of the semester so that if any of these sprints carry over into the next sprint then we can adjust our schedule as necessary.

6) Risk Management

a) Primary Risks to Project Success

Overview		
Risk ID	Description	Impact Level
1	Making the software libraries compatible with the system may involve rewriting a significant portion of code.	High
2	None of the team members have experience using Bluetooth as a communication protocol, so this may have a steeper learning curve to get working than originally planned	Medium
3	A team member may become unable to work for a portion of the semester, due to illness or unexpected circumstances	Low

b) Risk Management Plan

To help manage the risks of incompatible software libraries and difficulty with using Bluetooth, we have allotted an extra four weeks in our schedule to use as necessary. To minimize the risks of a team member being unable to work, we will share all of our code over Github and keep everyone informed of all aspects of the project while meeting weekly to discuss and review progress.

7) Budget

Some of the software and hardware we have listed above that will be needed to complete this project is already owned by our sponsors, so our budget will include only what we still need to purchase and not what the total cost of production from scratch would be. Note that this is also the cost it would take to produce three functional sets, as this would allow us to test multiple solutions in parallel, and ultimately multiple working sets in the end would be desirable.

Item	Quantity	Unit Price	Cost
Compute stick	3	$250.00	$750.00
3D Printing Cost	24 boxes (3 sets worth)	$5.00	$120.00
Portable Battery	3	$50.00	$150.00
Microcontrollers	26	$20.00	$520.00
Lithium Battery	24	$9.00	$216.00
Miscellaneous (wires, solder, resistors, etc)	-	-	$10.00
		Total:	$1,766.00

8) Team Considerations

a) Knowledge and Skills

All team members have used Agile development, either in industry during internships or in other classes, so we have the skills to apply Agile development to this project. We have also worked with embedded systems and protocols that will be used in this project in other classes. Additionally, Ian has worked on research in this lab and is familiar with some of the hardware and software that we will use, which will be helpful when implementing and debugging our design. We have also worked together on many previous projects, so we have experience collaborating on project implementation.

b) Team Organization and Function

Our team will determine a designated time at the beginning of next semester to meet every week. We plan to work together on all aspects of the project and troubleshoot problems together to get the best solutions as efficiently as possible.

c) Interaction with Sponsors

One of our members (Ian) has an established working relationship with the lab and sponsors. We have rapid access to and communication with sponsors. Additionally, we intend to meet with our sponsors at least weekly to get feedback from them as we meet each deliverable deadline.