LENS Proposal

Light Emitting Navigation System

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Objective

- Design and implement a prototype headgear that utilizes light detection and ranging, or LIDAR, sensor technology to detect objects and provide sensible feedback to the user in either audio or tactile format depending on user preference.

Motivation

•The most common technology used by the visually impaired today consists of a cane or a dog travel guide.

•Dr. Brian Gay visited an event that simulated the visually impaired experience, and it gave him the desire for this project.

•The aim in this team's design is to provide a cost effective approach that at a minimum reduces the need for a cane and provides adequate navigation indoors with the possibility of other environments.

Background

•Research into developing electronic travel aids (ETAs) to help the visually impaired navigate through their surroundings is ongoing.

•Benjamin et al created a cane which uses laser beams to detect overhead objects, waist level obstacles, and drop-offs [1].

•The Ecole Polytechnique Fédérale de Lausanne (EPFL), is a shoulder-mounted ultrasound system with vibration motors to provide feedback for the user [2].

•Still more research utilizes similar designs as the proposed, but most of these use ultrasonic sensors.

•The proposal is to instead make use of LIDAR.

Project Description

Primary Goal

- Design an autonomous navigational system for people with impaired vision that improves typical navigation and potentially removes the need of the cane.

Major Components:

- headgear, microcontroller, LIDAR and possibly ultrasonic sensors, vibration motors, and headphones.

  Head Gear
  - Designed and fabricated similar to virtual reality headsets and serve as a platform for the system to be installed on.

  Microcontroller and Accessories
  - Programmed to take readings from the LIDAR sensor
  - Select between which feedback they prefer: audio or haptic
  - Distance readings from the sensors will be used to output feedback via mcu

Project Goals

General

- The user will feel more comfortable navigating in their environment
- Low cost to enhance affordability

Range Finding Sensors:

- At least one LIDAR sensor for object detection
- Wide beam via single sensor or an array to enhance resolution
- Optimized power consumption via cycled pulses

Haptic Feedback

- Vibration intensity and/or frequency modulation based on distance
- Audio intensity and/or frequency modulation based on distances

Technical Specifications

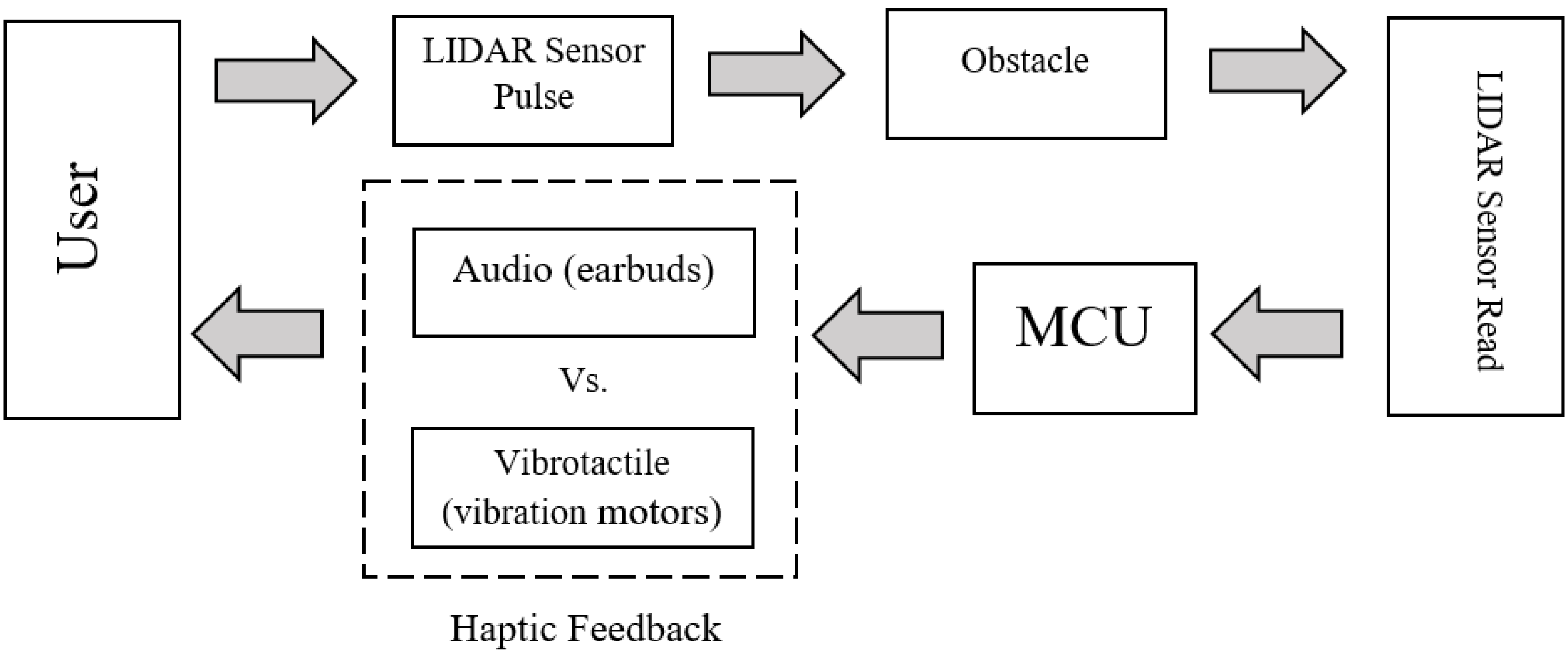
Table 1. Head Gear and System Housing Specifications	
Feature	**Specification**
Dimensions	17cm x 13cm x 9cm
Weight	450g -550g
Material	Plastic and Aluminum

Table 3. Headphones	
Feature	**Specification**
Style	Earbuds
Frequency Bandwidth	20Hz-20kHz
Impedance	$> 10\ \Omega$
Sensitivity	85 dBs
Connection Jack Size	3.5mm
Cable Length	1.5m

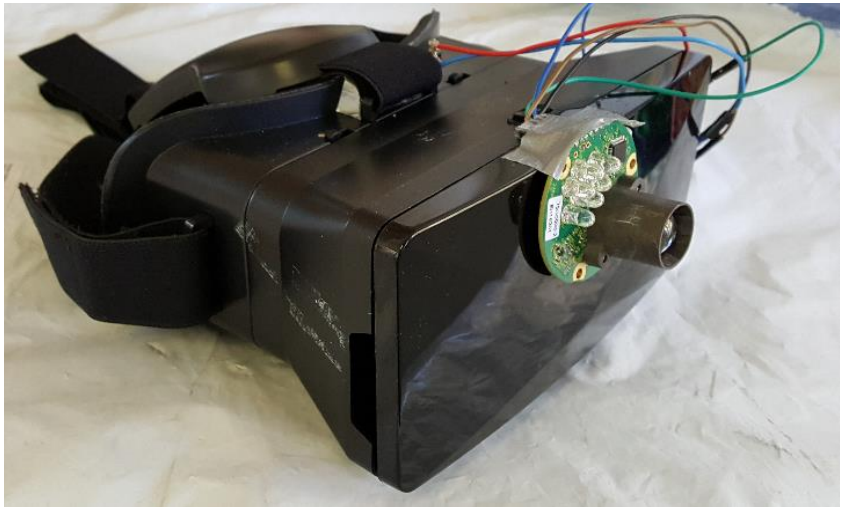
Technical Specifications Continued

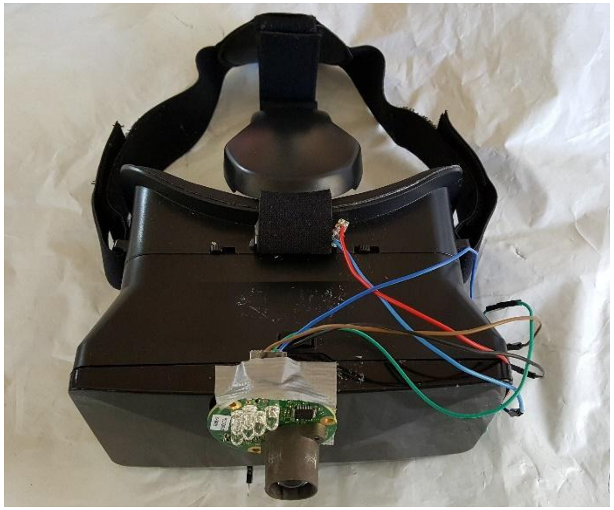
Table 2. Closed Feedback System Specifications	
Feature	**Specification**
MCU Processing Speed	> 96 MHz
MCU Operating Voltage	5V
Obstacle detection range	0.1m – 35m
Detection Accuracy	+/- 5cm
LIDAR Sensor Voltage	4V- 6V
Detection Refresh Time	< 100 ms
Vibration Motor Voltage	1.5V – 3.3V
Feedback Response Time	100ms -200ms
Battery Supply	7.4V – 8.2V | 2000 mAh – 3000 mAh (Li -ion)
Operating Life	8 – 12 Hrs (continuous use)

Approach


User
LIDAR Sensor Pulse
Obstacle
LIDAR Sensor Read
MCU
Audio (earbuds)
Vs.
Vibrotactile (vibration motors)
Haptic Feedback

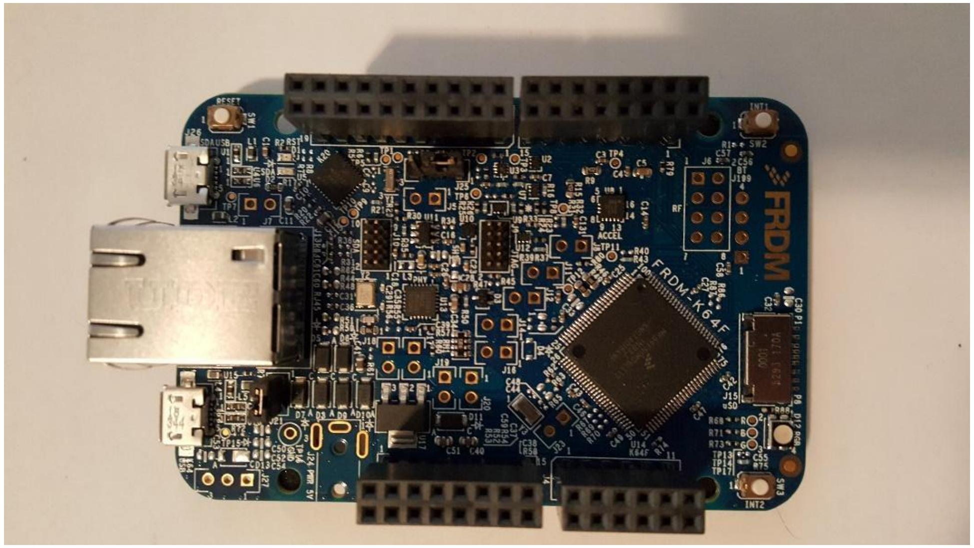
Early Prototype



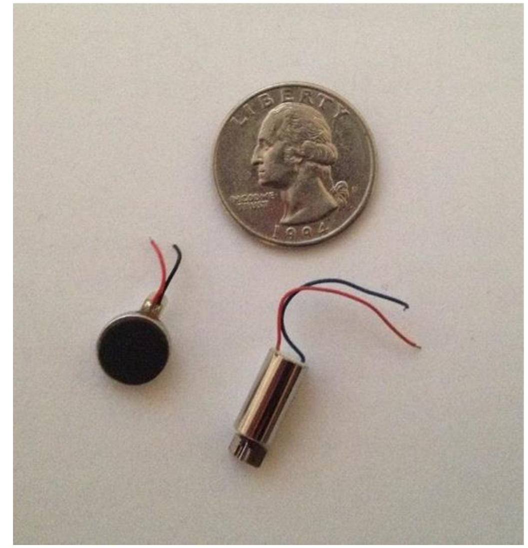


- Initial design inspiration from VR headsets

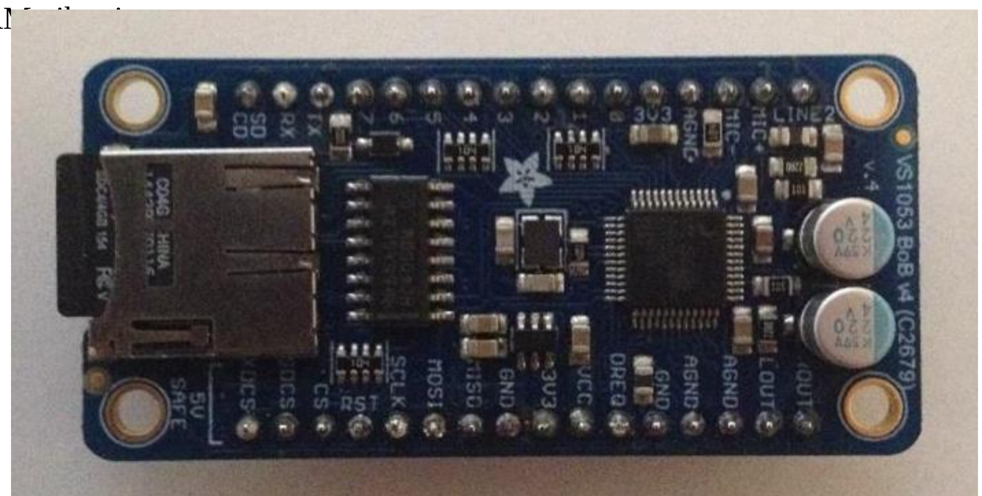
Electronics



FRDM-K64F MBED MCU



LRA and ERM



Adafruit VS1053 Codec

Adafruit

Device Fabrication

- Design Constraints
  - User Comfort
  - Weight
  - Simple Controls

- Materials
  - ABS Plastic
  - Aluminum

- Methods
  - 3D Printing
  - Machining

Constraints, Alternatives, and Tradeoffs

Constraints:

- **Expensive LIDAR**
  - Alternative: Ultrasonic Sensors
  - Tradeoff: Range and sensitivity to noise (crosstalk)

- **Weight of device**
  - Use only one sensor, i.e., LIDAR
  - Tradeoff: Accuracy

Codes and Standards

- **I^2C Communication Protocol**
  - Share data between LIDAR sensor, haptic feedback sensor and microcontroller
- **Inter-IC Sound (I^2S)**
  - Communication with VS1053
- **Universal Serial Bus**
  - Communication between microcontroller and PC

Tasks and Milestones

Major Milestones:

- **Object Detection**
  - Mapping the position of obstacles detected by the sensors
- **Sound Feedback**
  - Interfacing speaker modules with microcontroller
  - Determining sound patterns for feedback
- **Haptic Feedback**
  - Interfacing sensor with microcontroller
  - Determining vibration patterns for feedback
- **Assembly of Device**
- **Documentation and Presentation**

Market Analysis

Target Population:

- 285 million people estimated to be visually-impaired worldwide
- Out of this, 246 million have low vision

•About 90% of world's visually impaired live in low-income settings

Market Analysis

Existing Products:

- **Haptic Assisted Location of Obstacles (HALO)**
  - Haptic feedback to guide user
  - Arduino MEGA 2560 microcontroller is used
  - Current testing shows discomfort and confusion caused by the haptic feedback
- **iGlasses Ultrasonic Mobility Aid**
  - Secondary assistive device that would complement a traditional cane or guide dog
  - Costs $130
- **Object Detection and Guidance System**
  - Uses Kinect Sensor, tablet PC, and ATMEL XMEGA A1 microcontroller

Cost Analysis

- **Parts and materials costs = $360.28**
- **Labor hours per person = 91 hours**
- **Total development costs = $63,254**
- **Subtotal = $720**
- **Profit = $60**
- **Selling Price = $850**

Calculations made by assuming that 5,000 units are sold over a 5-year period and a labor cost of $40/hour.

Project Demonstration

- **Navigation through an unknown setting**
  - Maze-like environment
  - Navigation without collision with obstacle = Success!

- **Navigation by multiple people**

- **Longevity of headgear**
  - 8-12 hours lifetime
  - Comfortable wear

Current Status

- Project merged with a summer project that started with Dr. Gay
- A basic prototype was completed using Arduino Uno and LedderTech Lidar
- LedderTech seems to work fine but lacks adequate library support and is not as user friendly as Lidar Lite V3 available now
- Arduino did not provide enough horse power so an MBED platform was selected to move forward
- Plan to purchase Lidar Lite V3 if approved

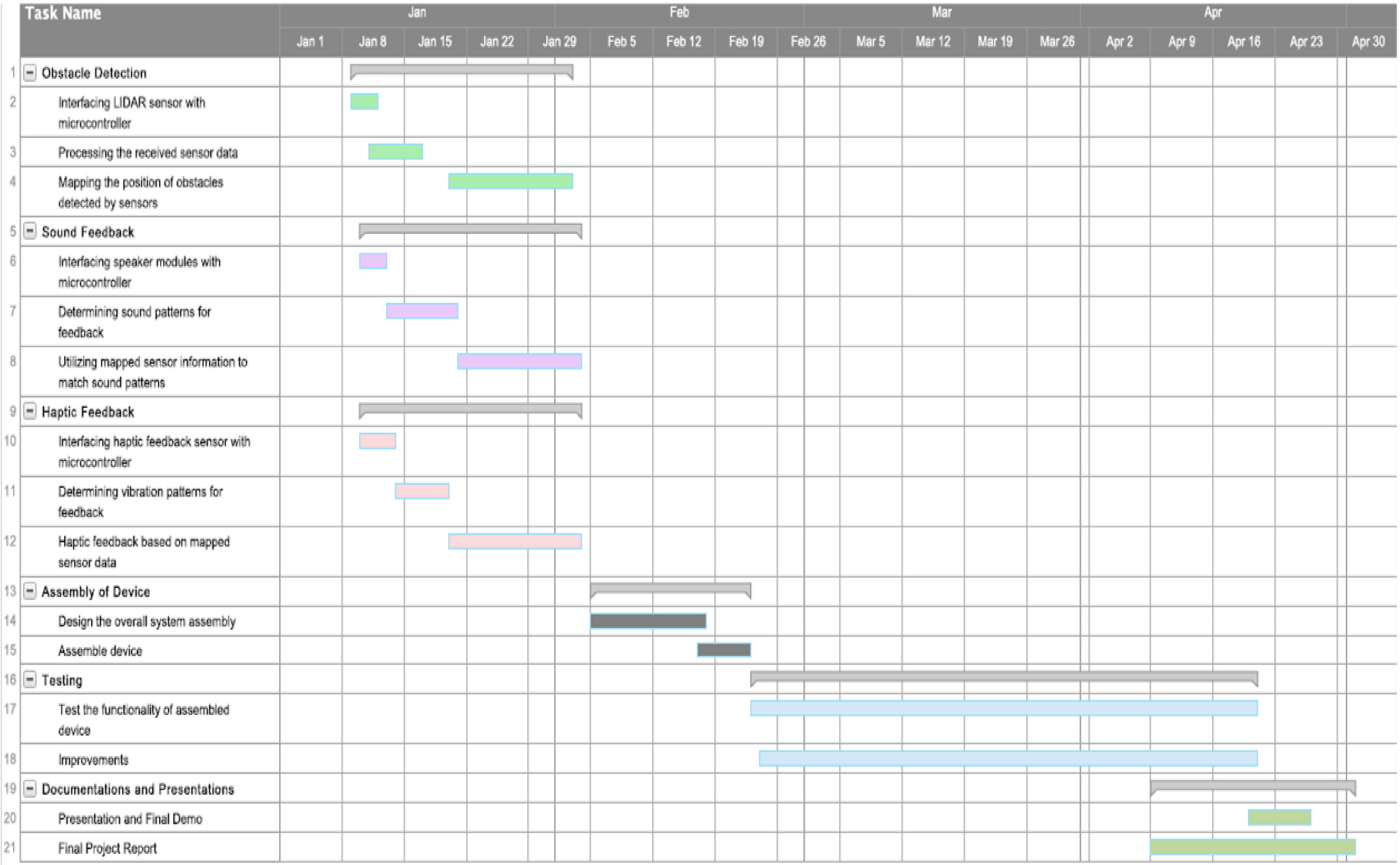
Questions & Answers

References

[1] G.-Y. Jeong and K.-H. Yu, "Multi-section sensing and Vibrotactile perception for walking guide of visually impaired person," vol. 16, no. 7, Jul. 2016. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4970117/. Accessed: Nov. 20, 2016.

[2] S. Cardin, D. Thalmann, and F. Vexo, "Wearable System for Mobility Improvement of Visually Impaired People,". [Online]. Available: https://pdfs.semanticscholar.org/e86d/49f813622d4a918abc201dbbf38cfd444e46.pdf. Accessed: Nov. 20, 2016.

Gantt Chart



Task Name
Jan
Feb
Mar
Apr
Jan 1
Jan 8
Jan 15
Jan 22
Jan 29
Feb 5
Feb 12
Feb 19
Feb 26
Mar 5
Mar 12
Mar 19
Mar 26
Apr 2
Apr 9
Apr 16
Apr 23
Apr 30
1 Obstacle Detection
2 Interfacing LIDAR sensor with microcontroller
3 Processing the received sensor data
4 Mapping the position of obstacles detected by sensors
5 Sound Feedback
6 Interfacing speaker modules with microcontroller
7 Determining sound patterns for feedback
8 Utilizing mapped sensor information to match sound patterns
9 Haptic Feedback
10 Interfacing haptic feedback sensor with microcontroller
11 Determining vibration patterns for feedback
12 Haptic feedback based on mapped sensor data
13 Assembly of Device
14 Design the overall system assembly
15 Assemble device
16 Testing
17 Test the functionality of assembled device
18 Improvements
19 Documentations and Presentations
20 Presentation and Final Demo
21 Final Project Report

Cost Analysis

Parts and Materials

Parts	Cost
Microcontroller	$59.95
LIDAR sensor	$149.99
Vibration Motor	$4.95
Adafruit MP3 Board	$24.95
Haptics Driver	$7.95
Battery	$22.50
Earbuds	$19.99
Circuit components (resistors, capacitors, wires, PCB, etc.)	$30
Fabrication and packaging materials (Aluminum, plastics, etc.)	$40
TOTAL	**$360.28**

Development hours

Tasks	Labor hours per person	Labor cost per person	Total cost for six members
Weekly meetings and reports	30	$1,200	$8,400
Presentations	1	$40	$240
Building circuit	25	$1,000	$6,000
Circuit testing	10	$400	$2,400
Software development	20	$800	$4,800
Code debugging	5	$200	$1,200
TOTAL	**91**	**$3,640**	**$21,840**

Cost Analysis

Total Development costs

Development Component	Cost
Parts	$360
Labor	$21,840
Fringe benefits, % of labor	$6,552
Subtotal	$28,752
Overhead, % of material, Labor, and Fringe benefits	$34,502
Total Development Cost	**$63,254**

Selling Price and Cost per Unit

Parts Cost	**$288**
Assembly labor	$20
Testing labor	$10
Total labor	$30
Fringe benefits, % of labor	$9
Subtotal	$327
Overhead, % of material, Labor, and Fringe benefits	$393
Subtotal, input costs	$720
Sales expense	$42.5
Amortized development cost	$28
Subtotal, all costs	$790
Profit	**$60**
Selling Price	**$850**