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LocalSonic

Local Guidance System (LGS)

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- Team Members
- Overview of Local Guidance System
- Motivations
- Goals
- Technical
  - Hardware
  - Firmware
- Schedule
- Expenses
- Existing Issues
- Marketing
- Future Work

Presentation Outline

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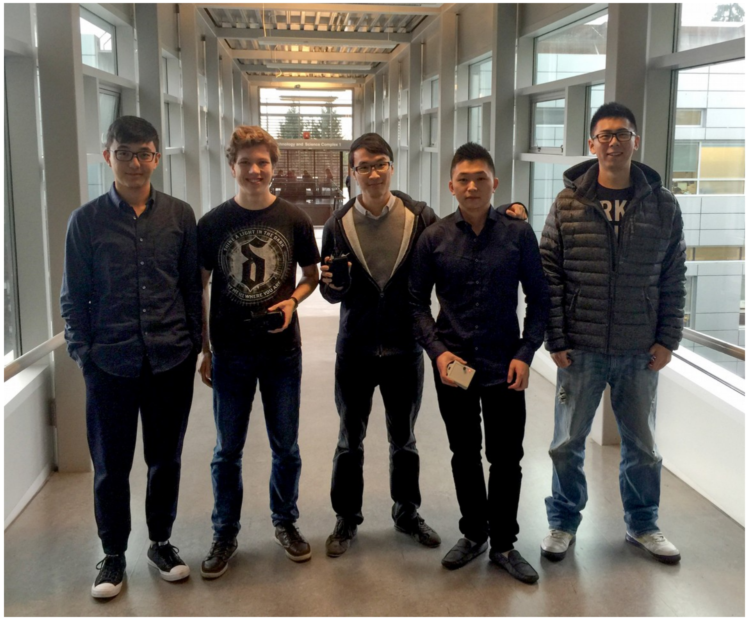
- CEO: Andrew Chan (Firmware and Testing)
- CTO: Justin Crosby (Firmware Lead)
- COO: Yihao Zhang (Hardware Lead)
- CIO: Shuo Yang (Hardware)
- CFO: Han Shen (Hardware)



Team Members

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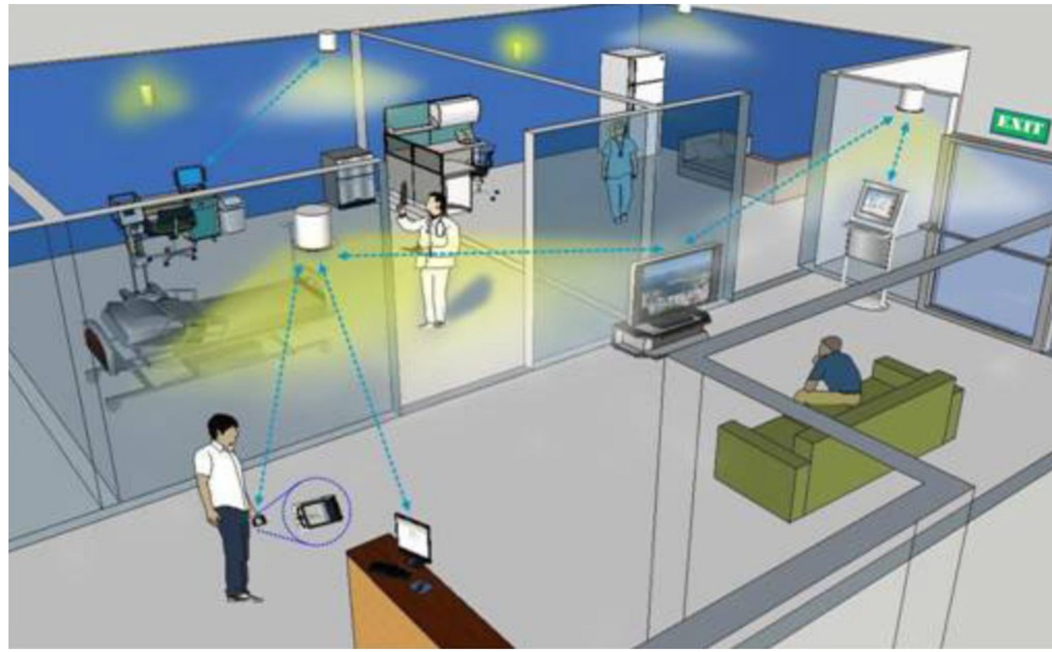
- What is the LGS?
- Existing solutions in the market
- How the LGS is different

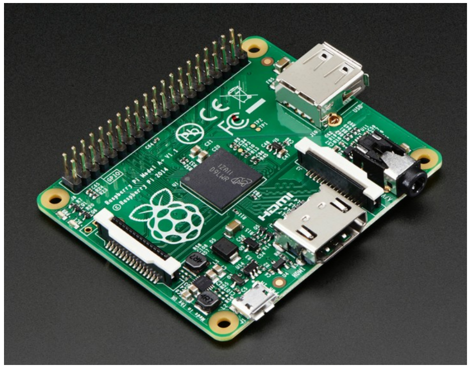
Overview

- Indoor local positioning system
- Our current goal is to help visually impaired people
- Long-term goal is targeted at comprehensive indoor building navigation



What is the LGS?

- Main technologies
  - Radio transceivers
  - Ultrasonic emitters and receivers
  - Raspberry Pi’s



What is the LGS?

Existing Solutions

- Ultra-Wideband Radio
- Wi-Fi
- Bluetooth
- Infrared

Why did we choose ultrasonic for our project?

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- Target Audience
- Accuracy
- Costs
- Future improvements

How the LGS is different

"Approximately half a million Canadians are estimated to be living with significant vision loss that impacts their quality of life, and every year more than 50,000 Canadians will lose their sight" [1]

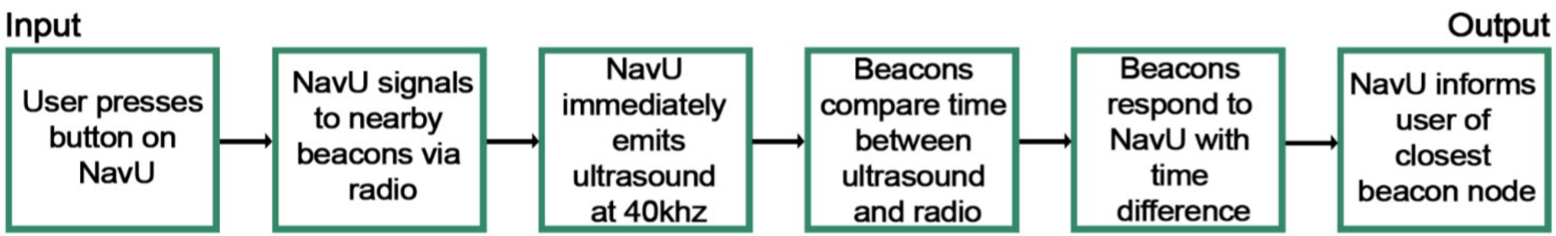
- Visually impaired people often have difficulty maneuvering in large indoor buildings

- GPS is not appropriate for indoor use

Motivations

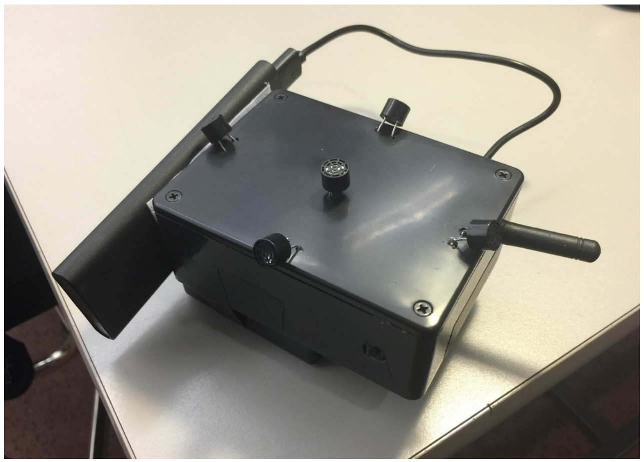
- Implement a scalable, low cost system that can triangulate users
- Provide audio feedback to users about their location
- Create a system that can be interfaced by other front-end applications

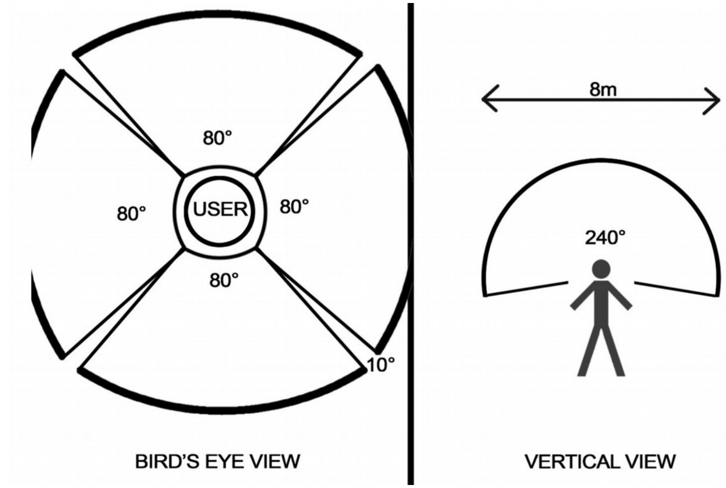
Goals



- Triggered by user
- Response within 3s
- Sound output to user through headphone
- In the demo, we will be using speaker with AUX input

Technical (System overview)





- NavU
  - Five ultrasonic emitters
  - One radio transceiver

NavU Overview

- One beacon contains one Raspberry Pi
  - Connected to at least 2 ultrasonic receiver nodes
  - Uses one radio transceiver

Beacon Overview

- Scalability
  - For any number of beacons, emitters, and receivers
- Speed
  - Needs to deliver user feedback quickly
- Accuracy
  - Needs to deliver accurate feedback

Firmware Objectives

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- Iterate through each beacon and its receivers sending a radio signal with 5 samples each
  - Inefficient, but necessary in this version
- Beacon acknowledges the signal and starts its clock
  - Neither can continue until the ack is sent
- NavU emits ultrasound after ack
- Beacon stops its clock when the ultrasound arrives and saves the value of the difference

The Algorithm

- Take an average time of flight ruling out outlier values
  - Very large and very small values are immediately thrown out
  - Other outliers are removed via calculation
- Find the closest receiver to the NavU along with the corresponding location, distance, and emitter
- Multiply this time of flight by the speed of sound
- Take these three pieces of data and format it into a 16-bit packet
- Radio this packet back to the NavU

The Algorithm - Calculation

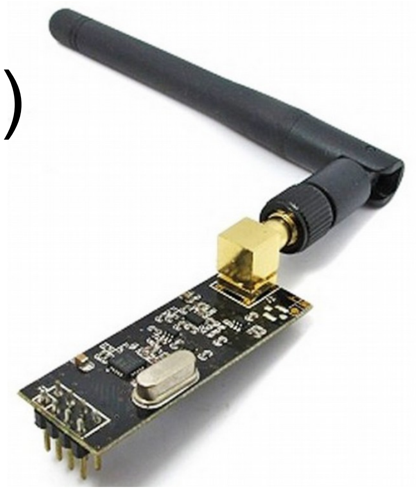
- NavU receives packet and converts to location, distance, and emitter
- The process is repeated for each node in the system
- The NavU calculates the closest of the beacons from the data collected
- Each location, distance, and emitter corresponds to a sound file stored in an array
- These sound files are played in sequence
  - For example: “Room 1 is 1.5 meters to your right”

The Algorithm – User Feedback

- Hardware requirements
  - Ensure the range of 4m
  - 3.3V maximum voltage output from receiver node into Raspberry Pi
  - 0.5mA current input limit of Raspberry

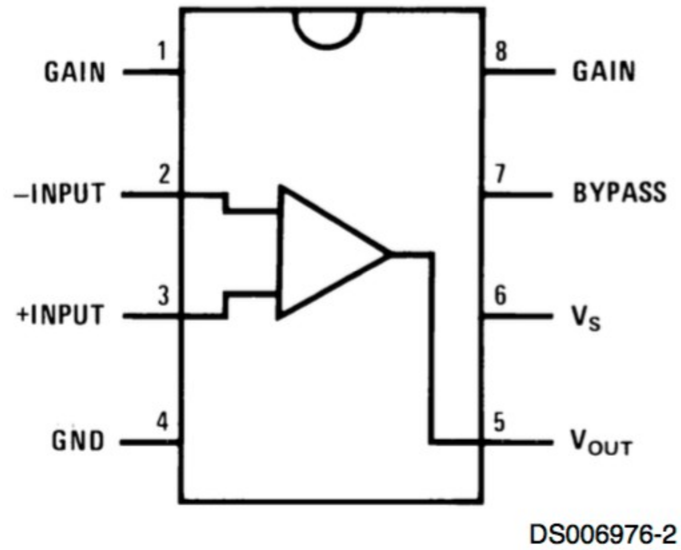
Hardware

- Radio transceiver(nRF24L01+)
  - 2.4GHz
  - Used for time stamp and transmitting data
- Ultrasonic emitter and receiver(MA40S4)
  - 40kHz signal
  - Detectable range: 0.2m – 4m
  - Used for range calculation



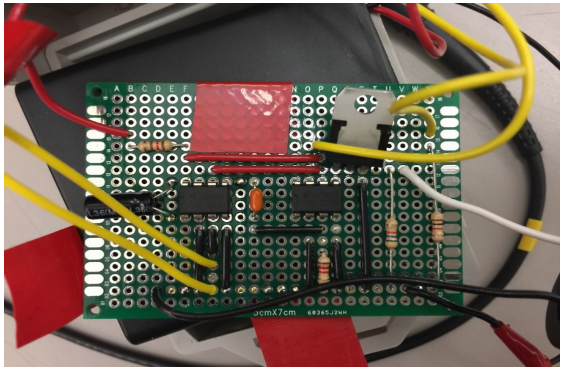
Hardware

- LM386 Op-amps
  - Pre-built gain range from 20 to 200
  - +/- 5V supply voltage
  - Low DC noise
  - 300kHz bandwidth
  - Used at ultrasonic receiver side

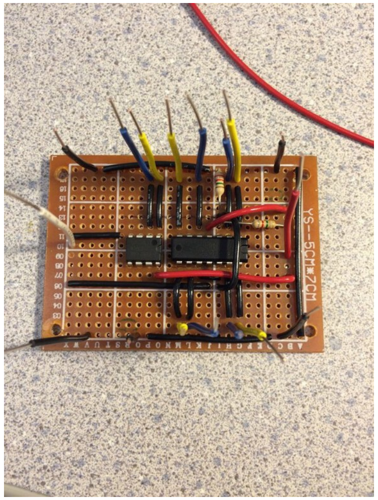


Hardware

- Ultrasonic receiver prototype board



- Ultrasonic emitter prototype board



Hardware Results

- Power consumption
  - Receiver
    - Draws 10mA from the batteries
    - 4*AA batteries = 2500*4 = 10000mAh
    - Last 10000mAh/10mA = 1000 Hours = 41.78 Days
  - Emitter
    - Draws 0.83mA from the batteries
    - 2* Nine-volt batteries = 2*1200 = 2400mAh
    - Last 2400mAh/0.83mA = 2890 Hours = 120 Days

Hardware Results

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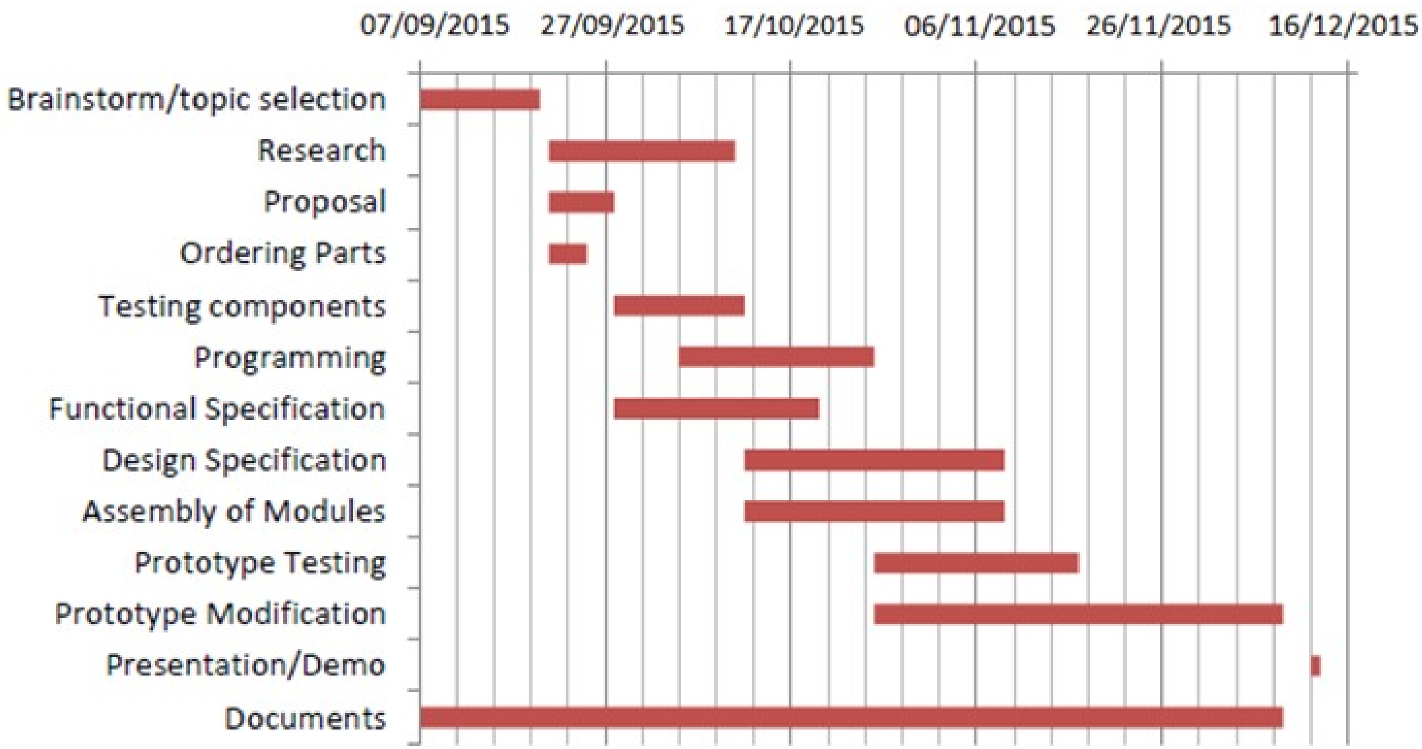
- Power consumption continued
  - Raspberry Pi A+
    - Approximately 500mA
    - Portable changer = 5000mA
    - Last 5000mA/500mA = 10 Hours

Hardware Results

- Estimated schedule



Project Schedule

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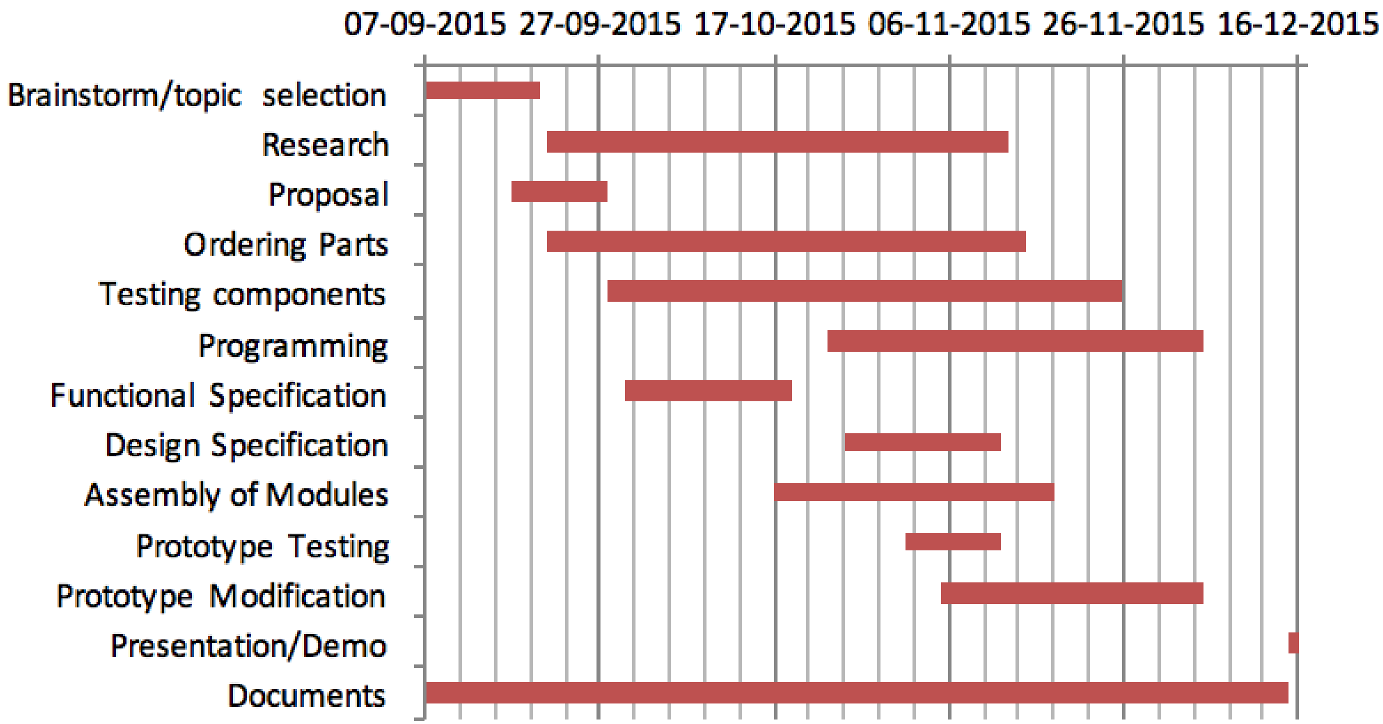
- Actual Schedule



Project Schedule

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- Frequency range
- Emitter radius
- Connection
- Device size

Existing Issues

Project Costs

- Project actual cost: $763.61

- Parts & Components purchasing: Digi-Key, Lee's Electronics, RP Electronics, MemoryExpress (Richmond), Amazon.ca

Expenses

Estimated Cost V.S. Actual Cost

Items List	Estimated Cost	Actual Cost
Batteries	20	26
Op-Amps	10	37
Capacitors	5	5
Prototyping Boards	10	20
Enclosures	20	57
Raspberry Pis and accessories	80	193.2
Radio Transceiver	50	105.61
Ultrasonic Components	250	153
Wiring and Other Hardware	30	166.8
Total	475	763.61

Expenses

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Component Cost Breakdown

Component Cost Breakdown						
Receiver Node		**Beacon**		**NavU**		
Ultrasound Receiver	$7.65	Radio Transceiver	$13	Ultrasonic Emitter	5	$38.25
Cap, Resistors, and Wires	$2.68	Enclosure	$6.25	Enclosure	1	$7.36
Enclosure	$6.25	Raspberry Pi A+	$38	Raspberry Pi B	1	$55
Prototyping Board	$2	Portable Rechargable Pack	$13	9V Battery	2	$13
Batteries	$2.4	Jumper Wires	$13.92	9V Battery Holder	2	$3
Other Hardware	$1.6	total	$84.17	Rechargable Pack	1	$13
OP-Amp	$1.6			Radio Transceiver	1	$13
total	$24.18			OP-amp	2	$1
				Switches	3	$0.3
				PCB Board	1	$2
				Jumper wires	10	$13.92
				total		$159.83

Expenses

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Estimated Production Cost in future

Production Cost

Receiver Node	Quantity	Cost	Beacon	Quantity	Cost	NavU	Quantity	Cost
Ultrasound Receiver	1	$5	Radio Transciever	1	$8	Ultrasonic Emitter	4	$20
LED	1	$0.05	Enclosure	1	$2	Enclosure	1	$2
Enclosure	1	$2	Microcontroller	1	$12	Microcontroller	1	$20
PCB and components	1	$5	Rechargable Pack	1	$13	Rechargeable Power Source	1	$15
Power Source	4	$2.4	PCB	1	$5	Radio Transceiver	1	$8
OP-AMP	2	$1.6	toal		$40	Gain Circuit	1	$5
total		$16.05				toal		$70
Reduce the cost%		66%			47.50%		43.7%	

Expenses

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- Current target:
  - To help visually impaired people
    - Elementary/secondary schools
    - Supermarkets and convenience stores
    - Indoor buildings(with the limitation of 8m hallways)

Marketing

For elementary and secondary schools

- According to Statistics Canada data [2]:

Alberta (2,306)	**Northwest Territories** (60)	**Prince Edward Island** (99)
British Columbia (2,665)	**Nova Scotia** (582)	**Quebec** (3,404)
Manitoba (931)	**Nunavut** (53)	**Saskatchewan** (1,059)
New Brunswick (403)	**Ontario** (7,003)	**Yukon Territory** (28)
Newfoundland (354)		

18,947 elementary and secondary schools in Canada

Marketing

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For supermarkets and convenience stores:

- According to the data provided by *Canadian Grocer* in 2012 [3]
  - Number of supermarkets: 2384
  - Number of convenience stores: 6919
  - Number of shopping centers: 133

Marketing

- Estimated price for the coverage of an average-sized elementary school
  - $2000
- Estimated price for the coverage of an average-sized supermarket (e.g. Superstore Metrotown)
  - $6000
- Estimated price for the coverage of a small-sized shopping mall (e.g. Lougheed Mall)
  - $20000

Pricing

- From using radio technology only into radio transceivers and ultrasonic emitters/receivers
- From Arduino to Raspberry Pi
- Skipped the app design and put into future goal

Changes In Scope And Design

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- Successfully developed hardware circuit to be compatible with Raspberry Pi's I/O specification
- Successfully accomplished triangulation with ultrasonic signals to accurately calculate user distance with audio feedback
- System has been tested in a realistic environment with successful results

Project Summary

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- Design an app with speech input and shortest path algorithm
- Combine receiver and beacon radio
- Develop API for software interfacing
- Prefabricated enclosure
- PCB and specialized power supplies

Future Work

- Dr. Rawicz, Professor Whitmore
- TAs: Jamal, Lukas, Shaun and Zehra
- Friends: Daniel Cao, Davin Mok, Gabby Mijatovic, and Nancy Slinn

Special Thanks

- Questions?

References

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