VISU AID

NOW I SEE

A Travel Aid for the Visually Impaired

Anita Kadkhodayan
Steven Lee
Darya Namvar

Road Map

- Team Introduction
- Project Objective
- Project Design
- Project Progress
- Finance
- Conclusion
- Future Work

Team Introduction

- Steven Lee (CEO)
  - Team Leader
  - Hardware development focus
- Darya Namvar (VPE)
  - UI Circuit design and software focus
  - Financial manager
- Anita Kadkhodayan (VPS)
  - Software development focus
  - Communication manager

Road Map

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  - ✓Motivation
  - ✓Background and related work
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Motivation

"*There is no better way to thank God for your sight than by giving a helping hand to someone in the dark*" –Helen Keller

- More than a million Canadian living with blindness or significant lose of vision

- Our goal is to help visually impaired toward a more independent lifestyle

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Background and related work

- White cane
- Robotic cane
- Sonar glove
- Tongue display Unit

Background and related work

- Jacket and vest combination
  - Gerard Medioni, professor of computer science at the USC Viterbi School of Engineering
  - glasses observe the environment and the vest gives directions
  - It uses vibrating motors
  - Camera in glasses gives 3D images
  - Computer and battery in backpack
  - SW is complicated

Background and related work

- Kinecthesia
  - Eric Berdinis and Jeff Kisk, at Weiss Tech House
  - Wearable belt
  - Processor, Camera and Vibration Motors that detect objects in 3 directions

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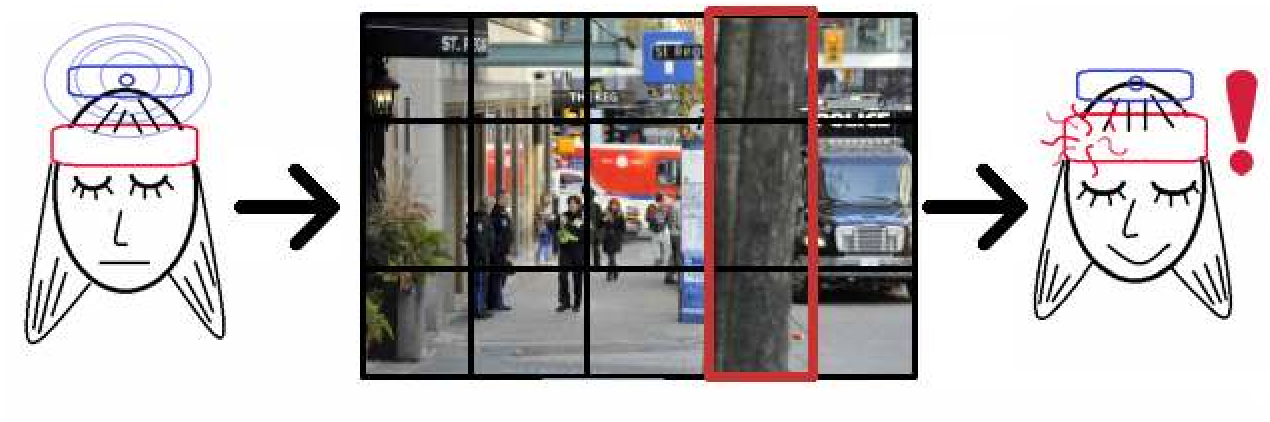
NOW I SEE



- Uses a depth camera to detect obstacles in front of the user
- Informs user of obstacle by vibratory stimulation interface placed on forehead

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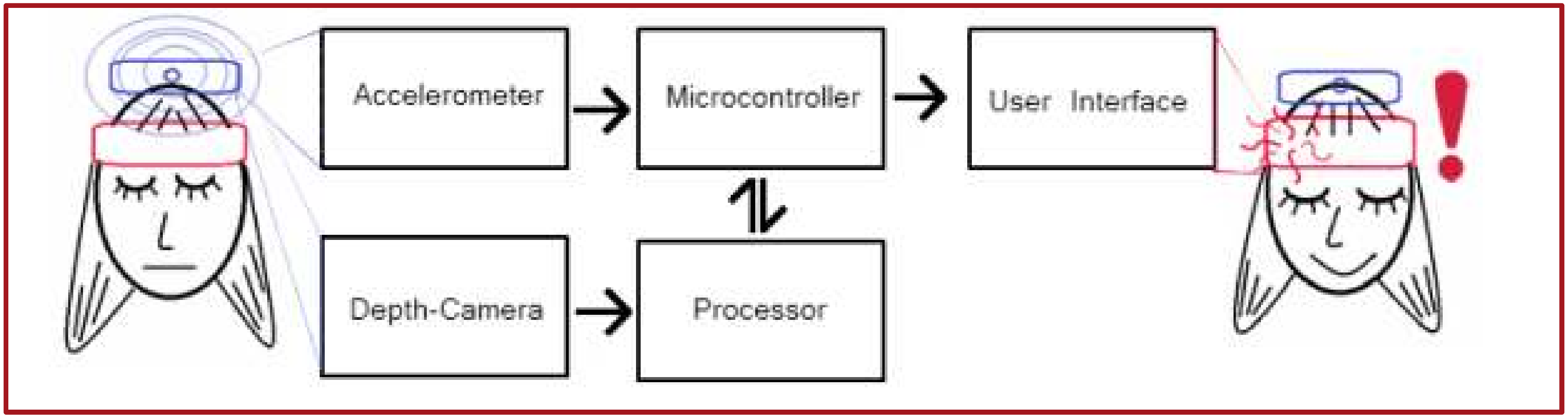
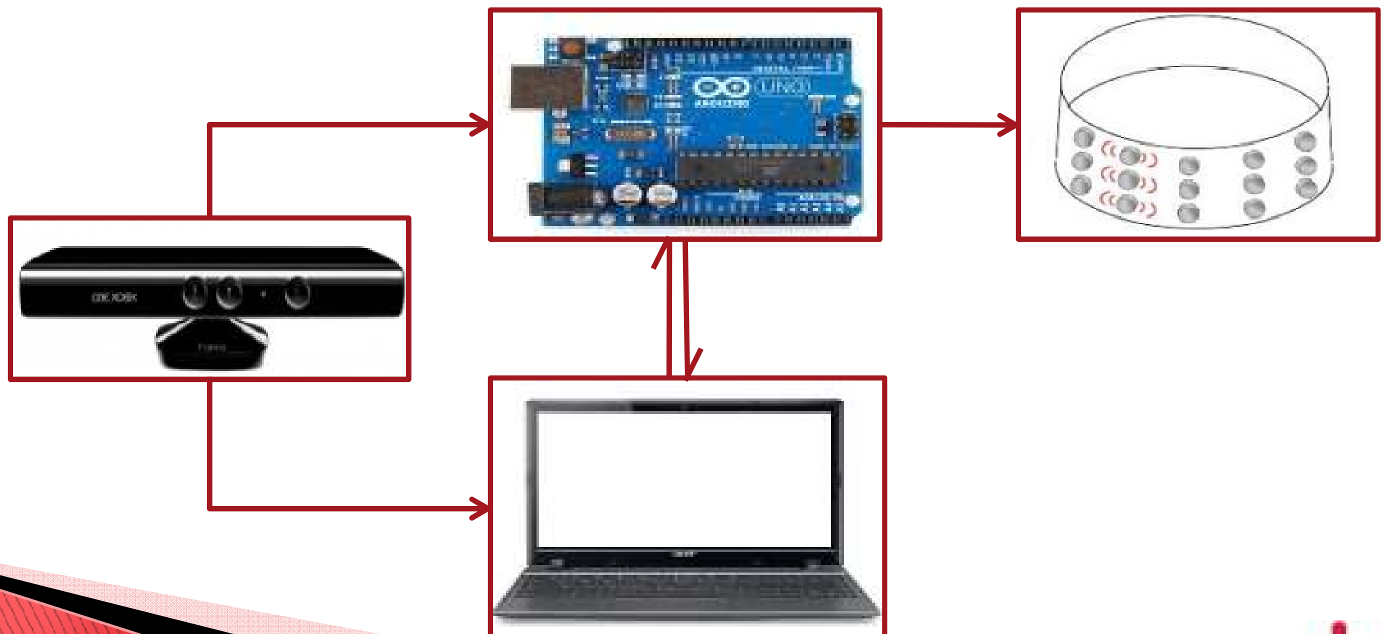
System Overview





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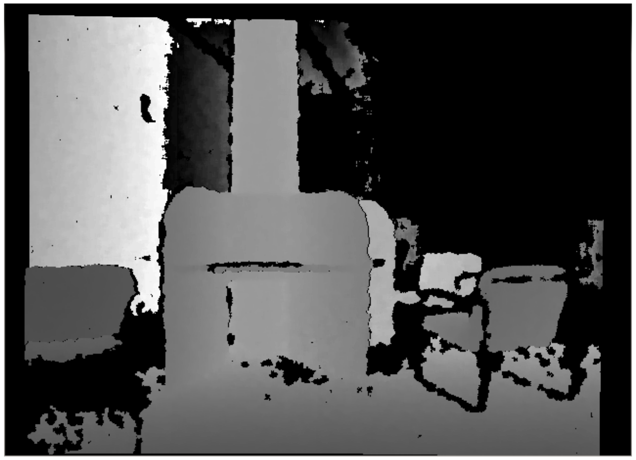
Hardware Design

- Depth Camera
- Accelerometer
- Central Processor
- Microcontroller
- User Interface Module
- Power Supply Module
- Device Mount

Depth Camera

- Microsoft Kinect
  - Affordable
  - Easy to find
  - Large resources available
  - Familiar



- Alternative:
  - Asus Xtion Pro

Depth Camera

- Depth Camera Specifications

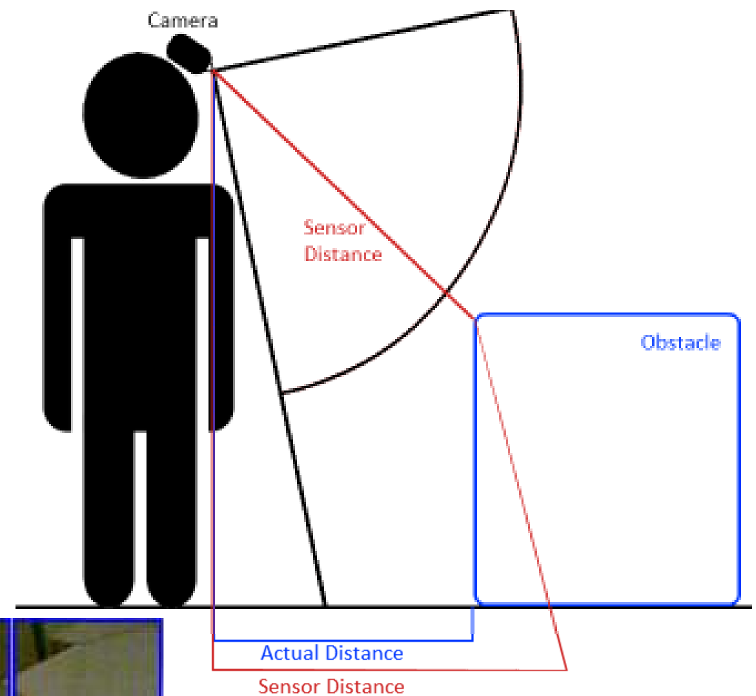
Specification	Capability
Frame Rate	30 frames per second (FPS)
Viewing Angle	43° vertical by 57° horizontal field of view
Output Range Dimensions	640 X 480 pixels
Depth Range	0.4 m ~ 4.0 m
Spatial Resolution	~1.8 mm (at 1.5 m from camera)
Depth Resolution	11 bits, >1 mm
Power Requirement	12V DC, 1.08A, 13W

Depth Camera – Mounting

- Mounting of the depth camera

Accelerometer

- Needed for:
  - Ground detection
  - Subsection Division
  - Scene Mapping

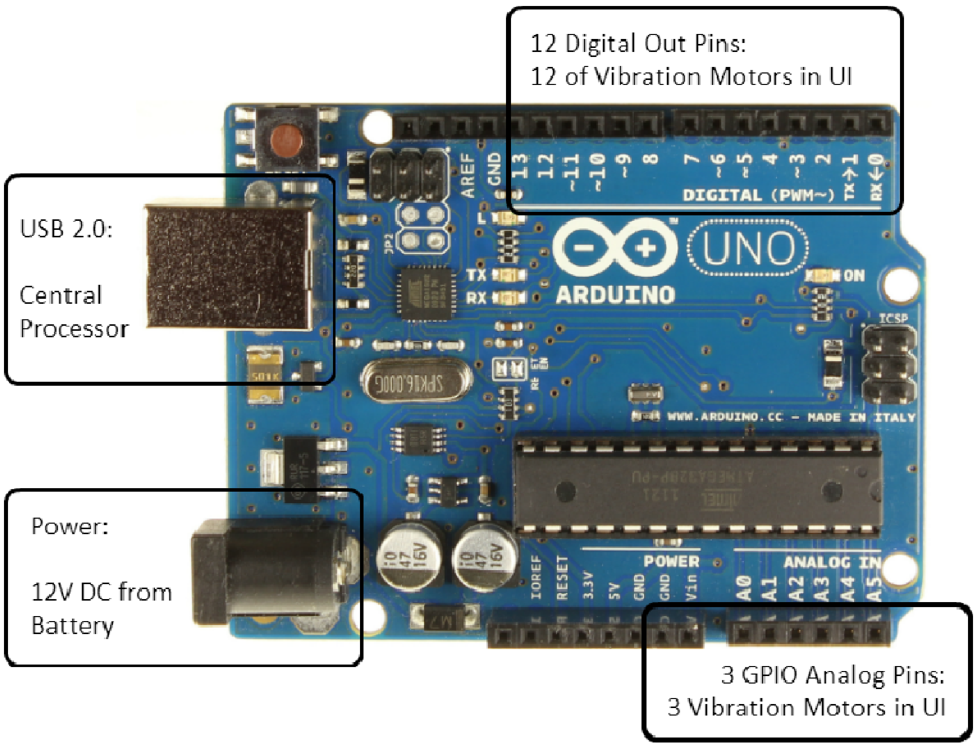


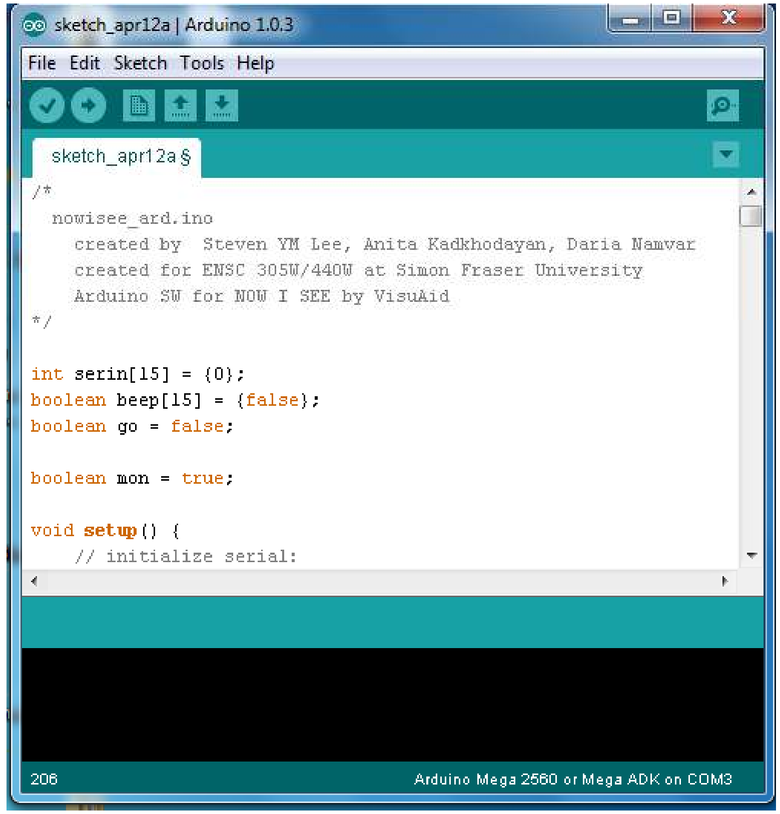
Central Processor

- Laptop
  - Asus C710 Chromebook
  - Full x86 Architecture (needed for Kinect)
  - Ubuntu Linux for ROS
  - Runs on a separate battery

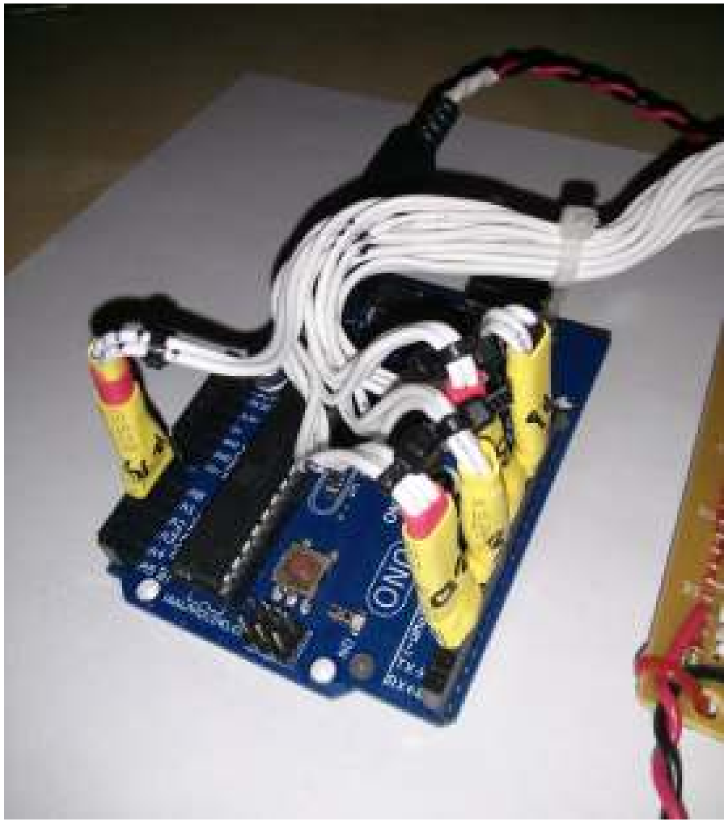
Microcontroller

- Arduino Uno

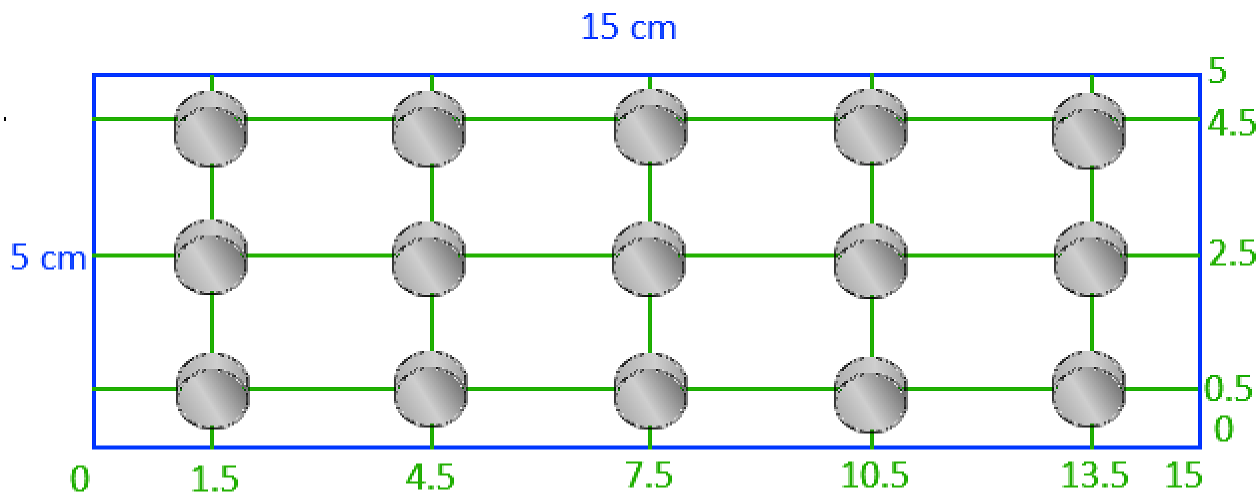


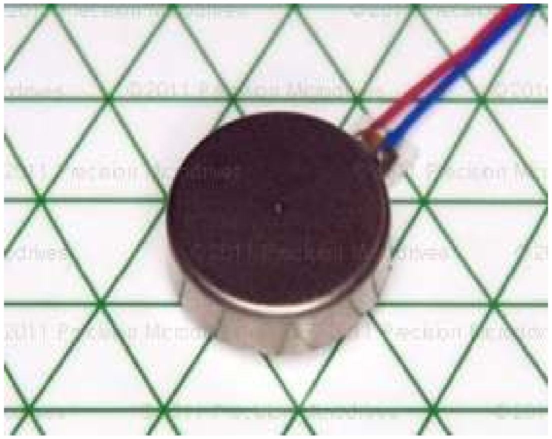


Microcontroller



User Interface Design





User Interface Design

User Interface Design

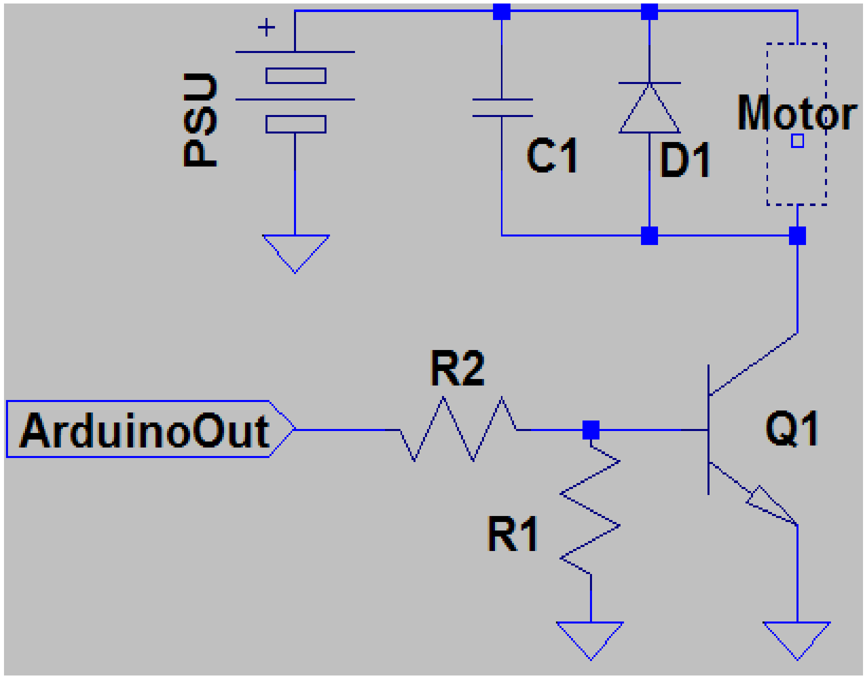
- Vibration Motors Specification

Specification	Value
Body Diameter	12 mm
Body Height	3.4 mm
Operating Voltage	3.0 V DC
Rated Operating Current	53 mA
Nominal Power Consumption	160 mW
Nominal Vibration Frequency	180 Hz
Typical Start Current	115 mA
Typical Rise Time	110 ms
Typical Stop Time	210 ms

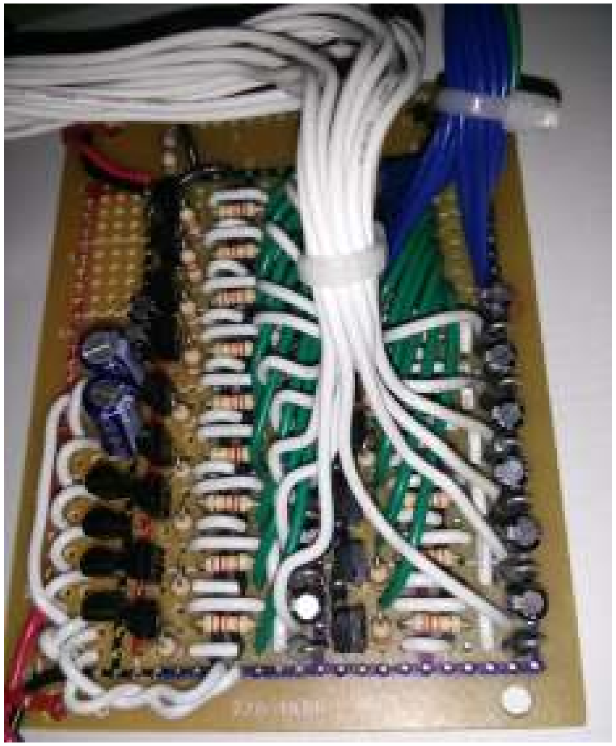
User Interface Controller Circuit

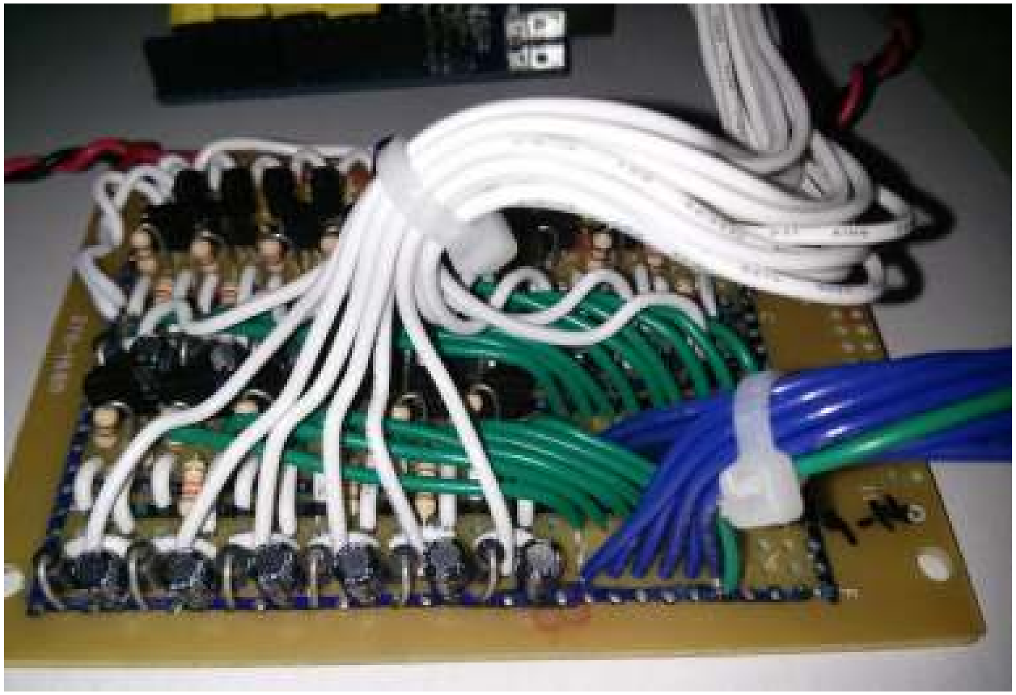
- Circuit Design

Component	Value
C1	0.1 uF
D1	1N4148
Q1	2N2222
Motor	312-101
R1	3.9k
R2	12k



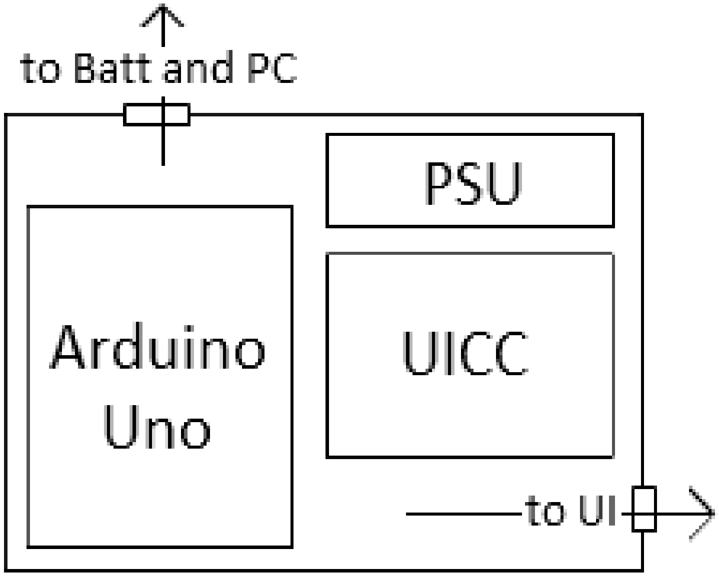
User Interface Controller Circuit





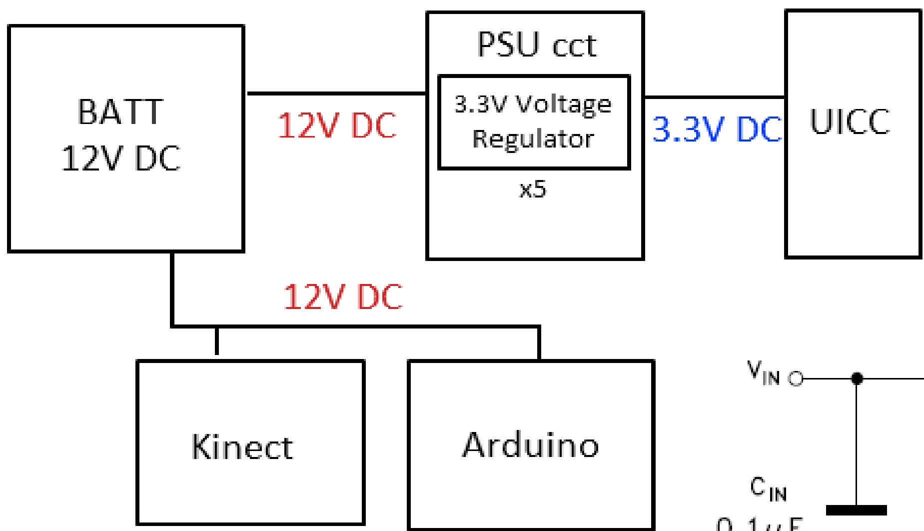
Enclosure

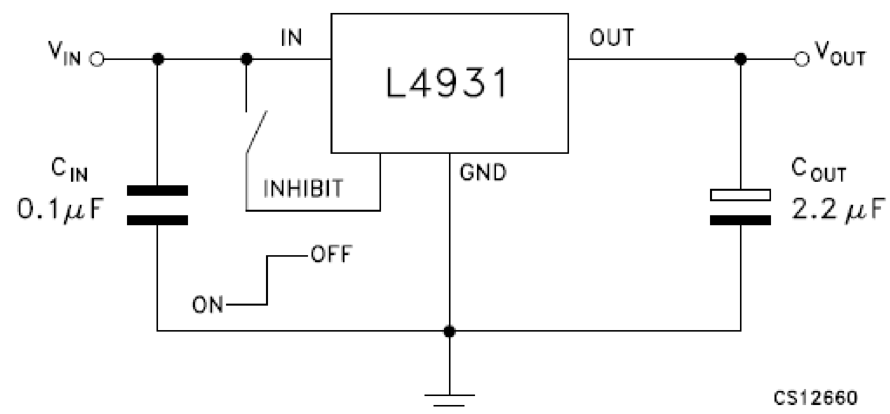
- Enclosure – Arduino + User Interface Controller Circuit + Power supply Unit



Power Supply Unit

- Overall Design





Power Supply Unit

Power Supply Unit

- Battery specification

Characteristic	Specification
Output Voltage	12 V DC (nominal)
Current Capacity	1.3 Ah
Energy Capacity	15.6 Wh
Type	Lead Acid(rechargeable)

- Lead Acid:
  - Easy to find, affordable
  - Heavy and hazardous – not for production

Power Supply Unit

- Power consumption summary

Component	Consumes
Kinect	13W (1.08A @ 12V DC)
Arduino	2W (400mA @ 5V DC)
Vibration Motor	2.6W (53mA @ 3.3V DC X 15)
Overhead	+ 15%
Total	**20W**

- 15.6 Wh / 20W ~= 45 Minutes

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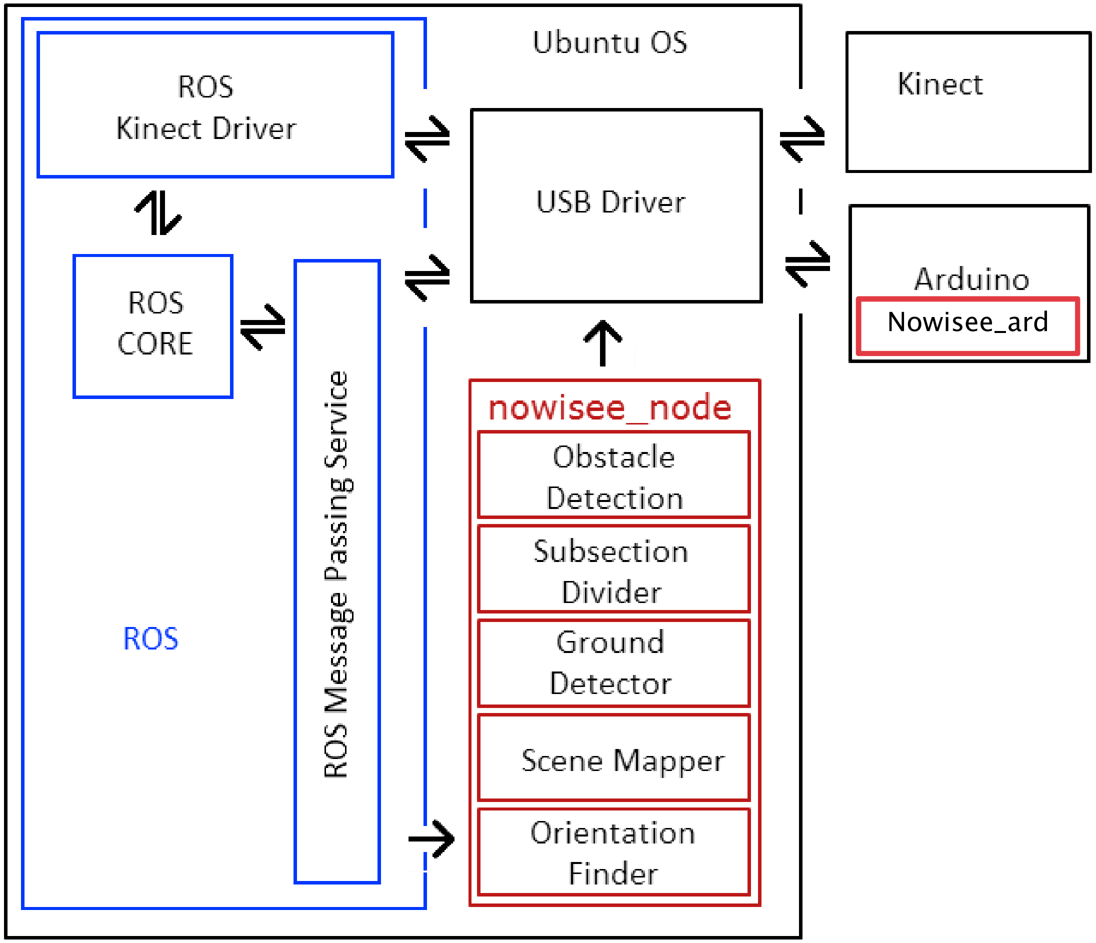
Software Design

- Software Overview
  - nowisee_node (C++, ROS)
  - nowisee_ard (Arduino)



Operating System (OS)

- Linux based OS needed for ROS and easy programming
  - Ubuntu Linux
    - ✓ officially supported for ROS
    - ✓ Previous experience

- Alternative:
  - Windows OS
    - ✓ too "heavy"

Robot Operating System (ROS)

- Provides drivers for Kinect sensors
- Integrated with OpenCV for easy image processing handling
- Inter-node communication service
- Kinect drivers: Freenect stack, Kinect_aux package

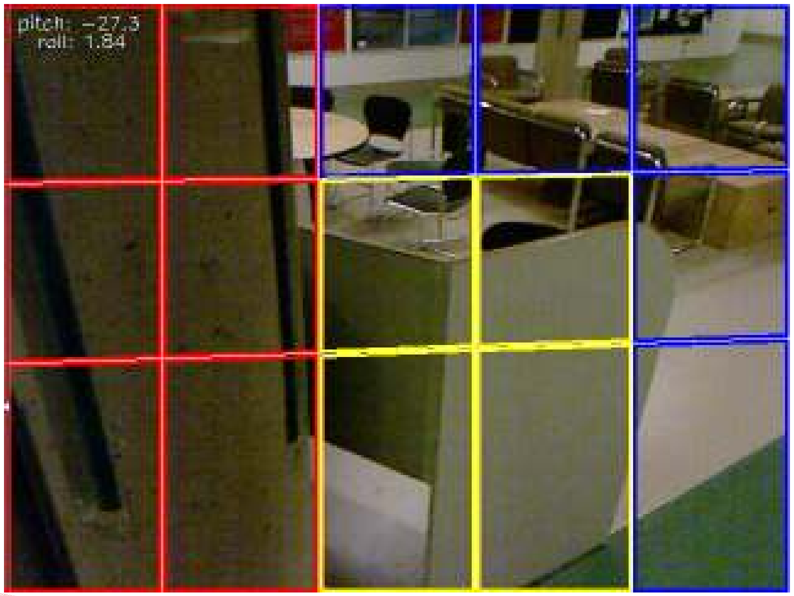
Robot Operating System (ROS)

- Freenect Stack
  - Includes open source library, driver, API for Kinect
  - Fetches depth values from Kinect
  - Publishes them in an array of values

- Kinect_aux Package
  - Accesses accelerometer of Kinect
  - Acceleration given in vector form

nowisee_node

- Original C++ Program Written for NOW I SEE
- Input: raw data coming from Kinect camera
- Output:
  - ✓ Corresponding command sent to Arduino
  - ✓ Visualisation



nowisee_node

- Image/ data processing:
  - ✓Orientation Finder
  - ✓Scene Mapping
  - ✓Ground Detection
  - ✓Subsection Division
  - ✓Obstacle Detection

Camera Orientation Calculation

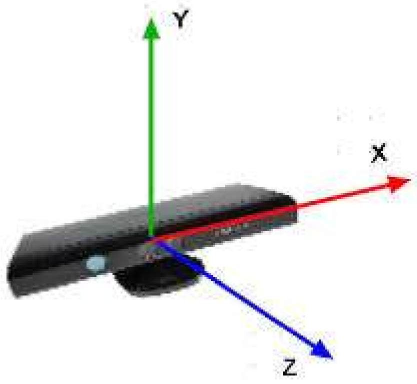
- Information provided by the accelerometer is in the form of vector:

$$(g_x, g_y, g_z)$$

- Roll(θ_z) and Pitch(θ_x) of camera is resolved

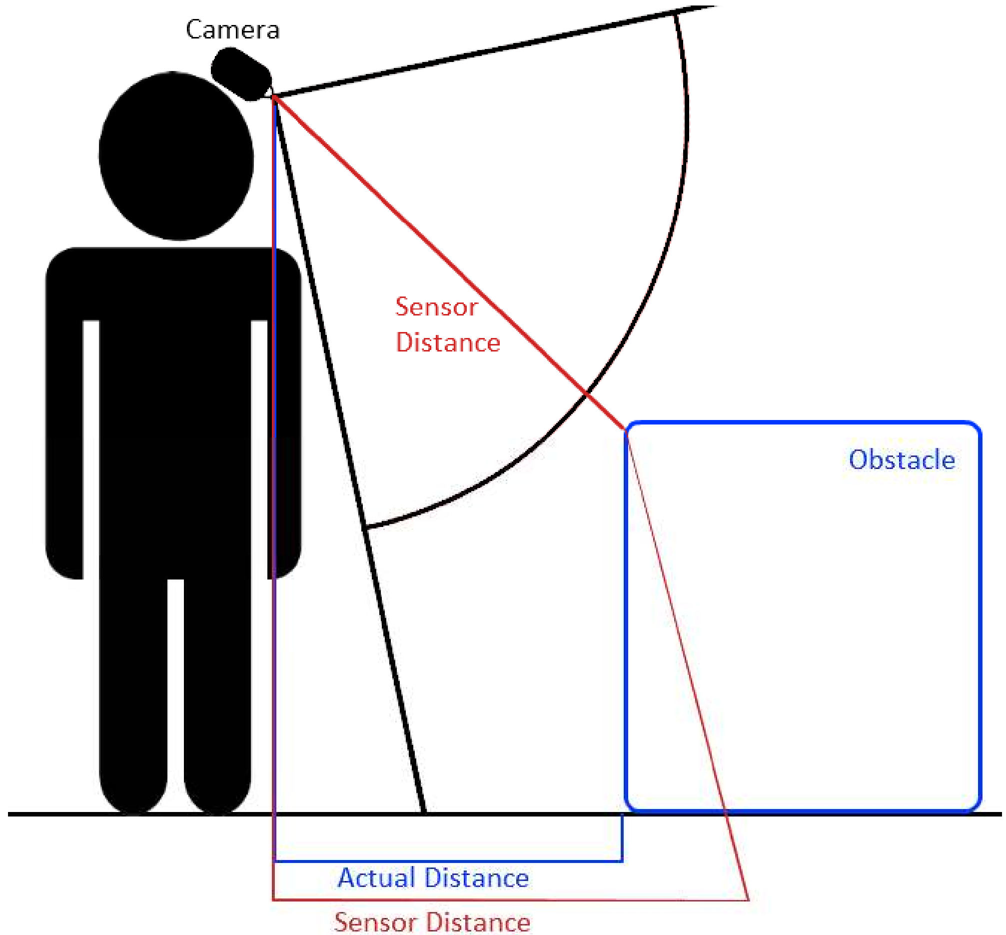
$$\theta_x = \tan^{-1}\left(\frac{g_z}{\sqrt{{g_y}^2 + {g_x}^2}}\right)$$

$$\theta_z = \tan\frac{g_x}{g_y}$$



Scene Mapping

- Our camera is installed at an angle
- As a result, distance measured by camera is not always equal to actual distance from user

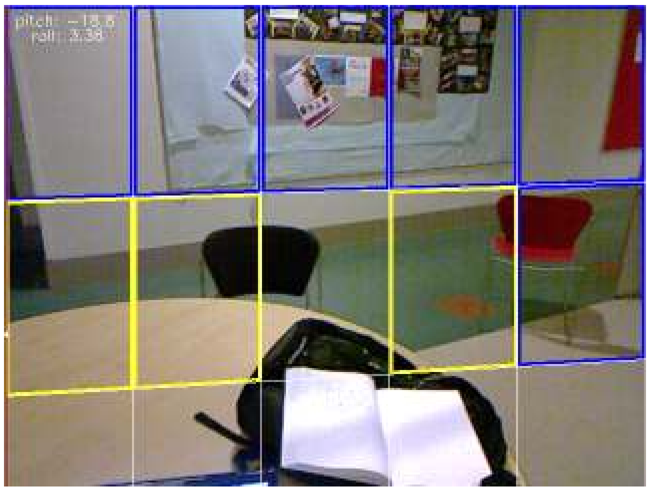


Ground Detection

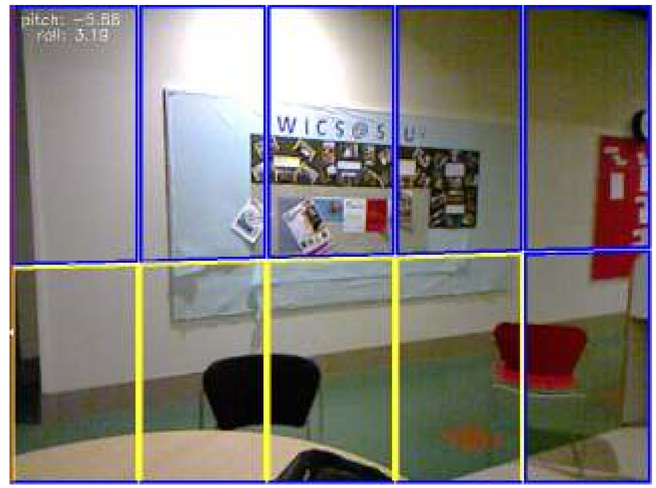
- Estimate ground by camera's orientation information and known height of user
- Ground detected at 3m from user
- Lowest row represents ground

Subsection Division

- 15 subsections of vibration motors
- The division of the horizontal is uniform
- In vertical direction, bottom row is dedicated as ground, and rest is evenly divided



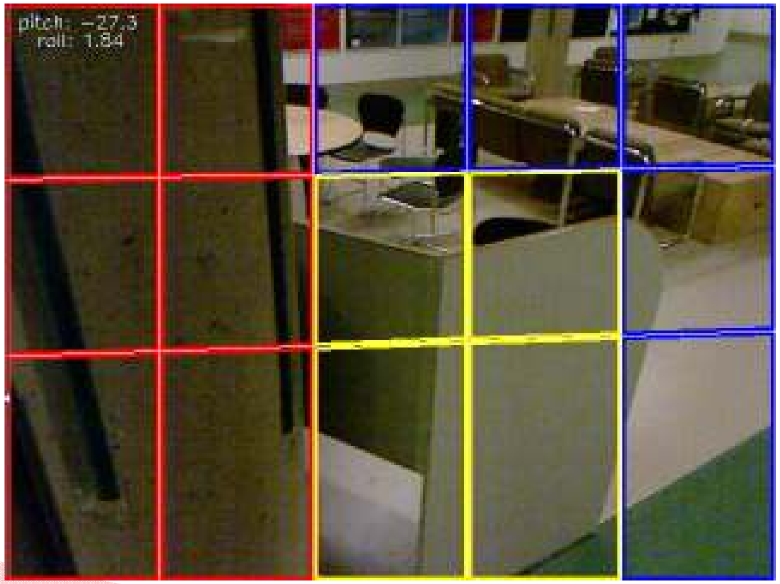
Ground is within FOV



Ground is outside FOV

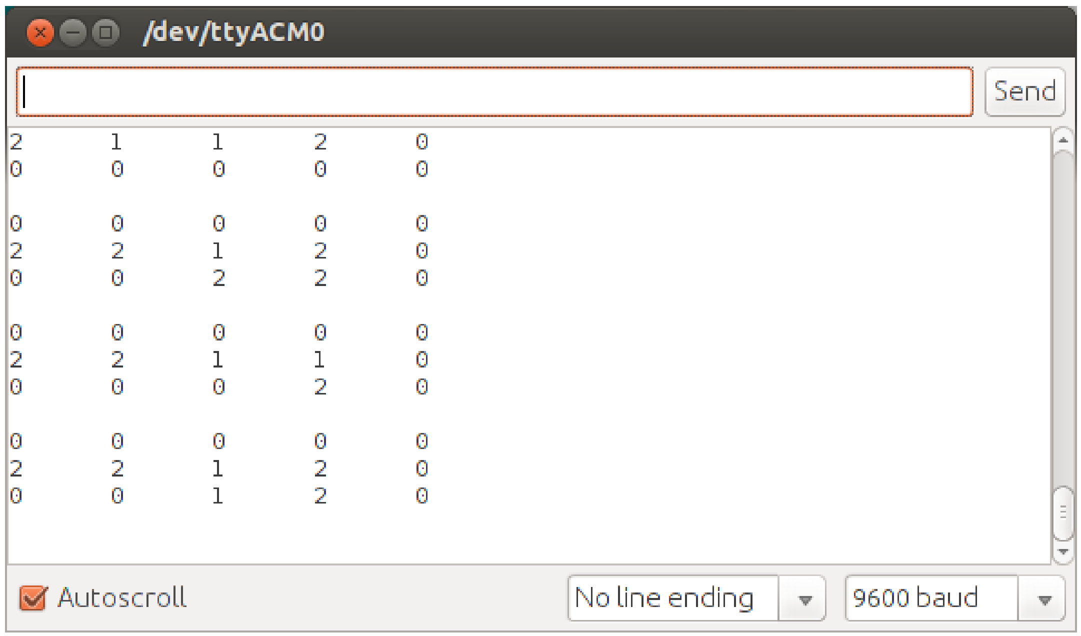
Obstacle Detection

- Two tier thresholds: at 1m and 2m
  - Farther than 2m – clear
  - Farther than 1m – warn ("flashing")
  - Closer than 1m – alert
- Depending on threshold reached, different commands are sent to UI



Nowisee_ard

- Controls Motors
  - Gets commands from nowisee_node
  - Processes commands and executes them
  - Visualisation



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Workload Distribution

Task	Anita	Daria	Steven
Hardware Design	X	X	XX
Hardware Modification			XX
PSU Design		X	XX
PSU Implementation		X	XX
Software Design	XX	X	X
HW-SW Communication	XX		X
Image Processing	XX	X	X
Software Implementation	XX	X	X
Linux/ROS	X		XX
UI/UICC Design	X	XX	
UI Implementation	X	XX	X
UICC Implementation	X	X	XX
Arduino Programming	X	XX	
Parts Acquisition	X	X	X
Administrative	X	XX	
Documentation	X	X	X

Responsibility: XX – Primary X – Secondary

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Challenges/ Changes

- Central Processor
  - Initially chose Raspberry PI
    - Kinect requires full architecture (Rasp PI has ARM)
  - In need of idle laptop
    - Need to install Ubuntu
    - End of semester
  - Modified a Chromebook
    - Broke down, lost everything, did it again

Challenges/ Changes

- Pit Detection
  - Sensor measurements were too unstable
    - Kinect is not designed for use during movement
  - Problem found too late in development
  - Alternatives were too complicated
    - E.g. requiring mapping, modeling and tracking environment, etc.
  - Had to give up this feature

Challenges/ Changes

- User Interface: 3x5 Array
  - For POC device, only 3x3 array was planned
  - Was not too hard to extend this to 3x5 – more interesting as well

Challenges/ Changes

- Circuitry Work/ Wiring
  - UICC was introduced after proposal
  - A lot more work but not reflected in schedule
  - Had to put all on hold and power through, delayed software implementation

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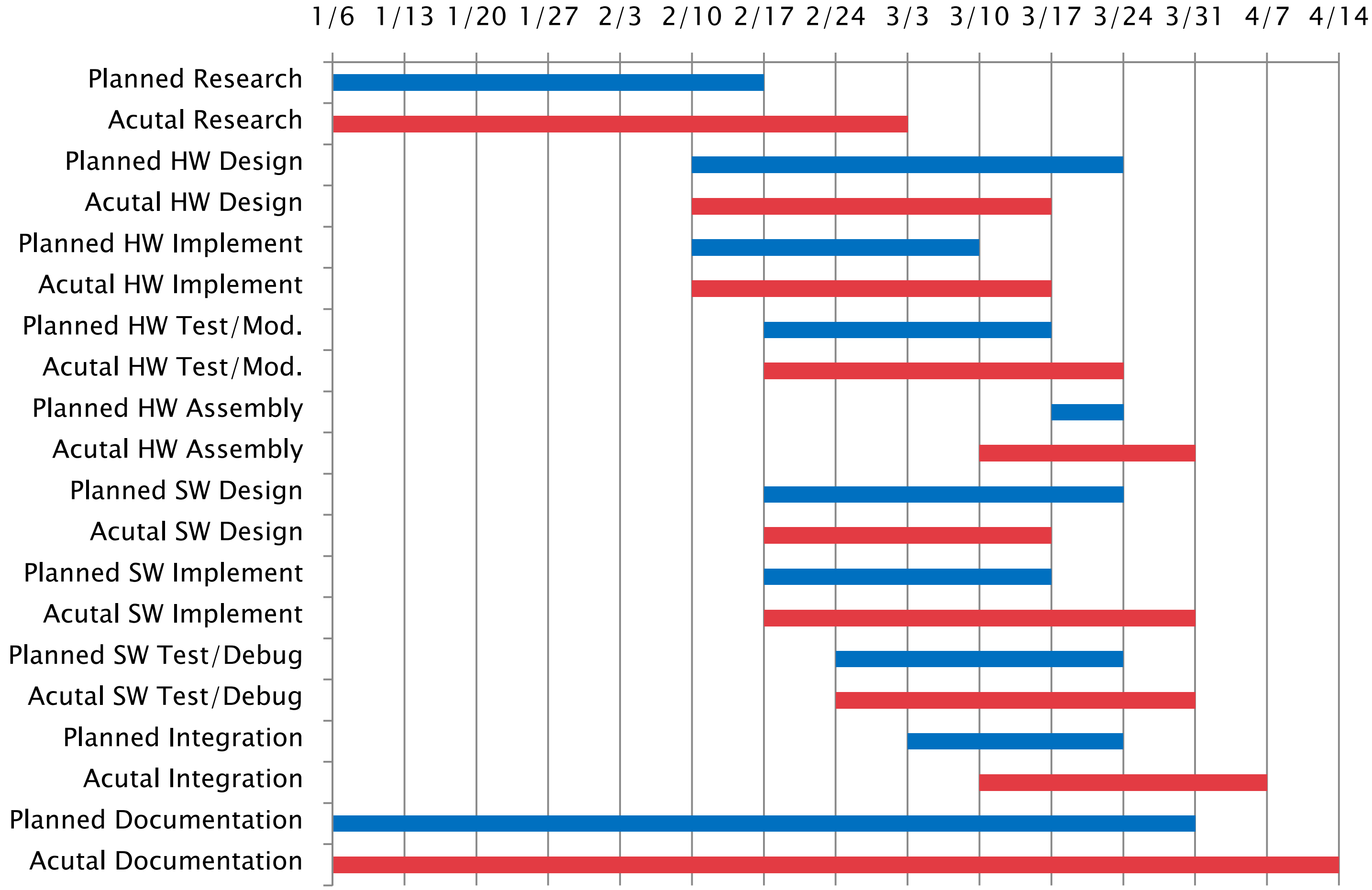
Schedule


1/6
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3/31
4/7
4/14
Planned Research
Acutal Research
Planned HW Design
Acutal HW Design
Planned HW Implement
Acutal HW Implement
Planned HW Test/Mod.
Acutal HW Test/Mod.
Planned HW Assembly
Acutal HW Assembly
Planned SW Design
Acutal SW Design
Planned SW Implement
Acutal SW Implement
Planned SW Test/Debug
Acutal SW Test/Debug
Planned Integration
Acutal Integration
Planned Documentation
Acutal Documentation

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Budget

- Funded $350 via ESSEF

Component	Part	Est. Cost	Actual Cost
Depth Camera	XBOX 360 Kinect Sensor	$130	$56
Microcontroller	Arduino Uno, REV 3	$35	–
Processor	Raspberry Pi– Model A	$40	–
Vibration Motors	Vibration Motor, Flat Coin	$85	$63
Accelerometer	IC Accelerometer, XY AXIS	$10	–
Mount Apparatus	Bike Helmet	$35	–
UI Mount	Head Band	$10	–
Breadboard		$10	–
Prototype Board		$10	$3
Electronic Comp.	Various	$35	$226
Battery		$50	$13
Additional Parts, Overhead, Shipping, etc.		$50	$25
	Total	**$500**	**$386**

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VisuAid

Market/ Competition

Camera	Motors	Proc. + Contr.	Elec. Comp.	Other Parts	Overhead	Total
$30	$15	$25	$25	$25	20%	**$144**

- We expect for a production model under $150
  - With mass production, component costs can come down
  - Design with only necessary components to save
  - Start as novelty product and go mass production

- Government subsidies also possible
  - Lower retail price, easier to sell

Market/ Competition

- “More than a million visually impaired in Canada” – CNIB
  - If secure10% market place, 100,000 units
    - Could enter with 25% – already a large market
  - Could license to larger companies:
    - Medical device companies (e.g. GE, Siemens)
    - Google – to work with Google glass

- Currently no competition
  - All related technologies we were able to find were in the research phase

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Conclusion

- NOW I SEE is a travel aid device that helps visually impaired patients to navigate easier
- Our product is easy to use and portable
- Current design is for proof of concept, alternatives could have been implemented as discussed
- NOW I SEE is reasonably priced in comparison with available product with the same level of technology

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Future Work

- Detection of the pits on the ground
- Incorporate depth camera in eye glasses
- Use safer, light weighted batteries with longer energy capacity
- Improvement of the UI design
- Contacted CNIB asking for any interest in our project

Special Thanks

- Dr. Kamal Gupta
  - For providing initial ideas for NOW I SEE
- Dr. Whitmore & Dr. Rawicz
  - For a great course ☺
- Jamal Bahari
  - For having long meetings with us
- All other TAs
  - For their comments on our documents

Questions?

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Camera's Angle

- Kinect vertical view angle = 43°

$$\emptyset' = 43^\circ - \emptyset$$

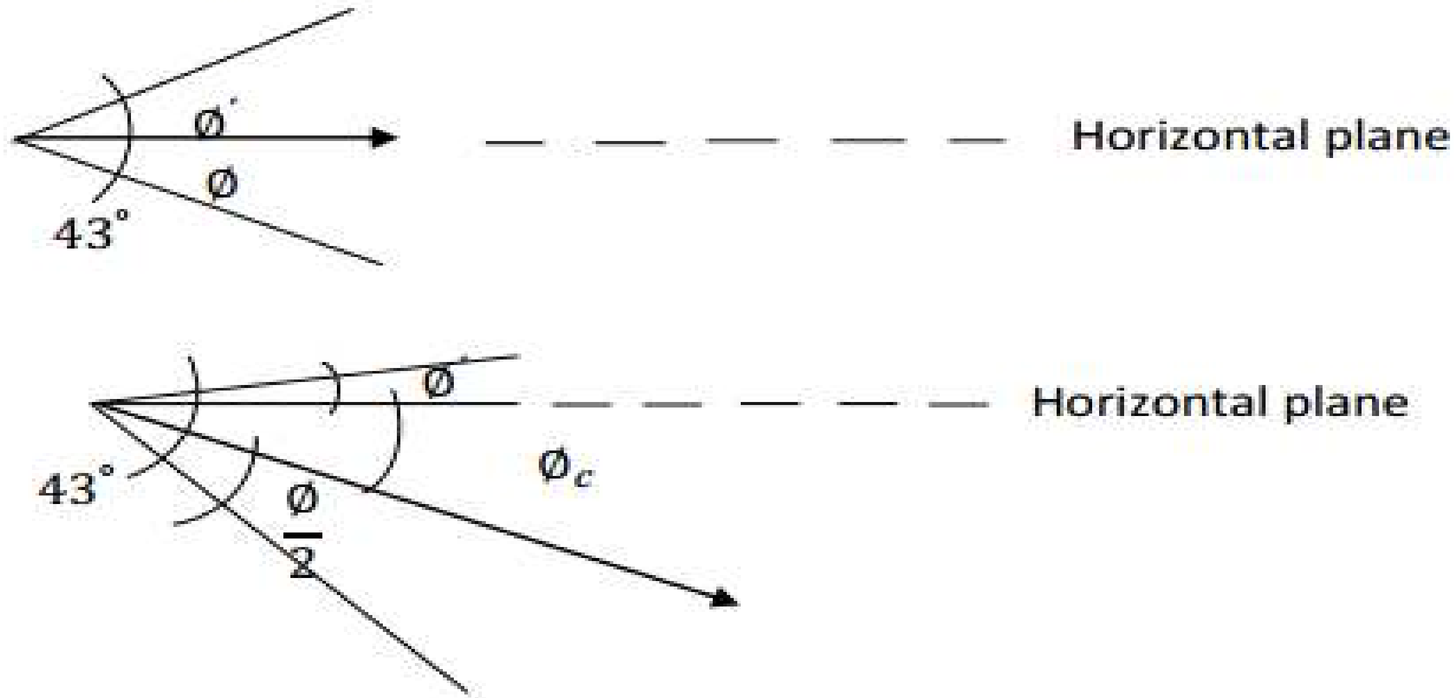
- Average height of a normal person is taken to be 1.75 m
- Distance of the object from the person is calculated by:

$$x\,(m) = \frac{\tan(\emptyset)}{1.75^*\,(m)}$$

Camera's Angle(cont'd)

- Angle of the camera:

$$\phi_c = \frac{43^\circ}{2} - \phi'$$



Subsection Division

- 15 subsections of vibration motors
- The division in the horizontal plane is more or less uniform
- In the vertical direction, the bottom row will be dedicated as ground, and the rest will be evenly divided

High	High	High
Low	Low	Low
Grnd	Grnd	Grnd

High	High	High
Low	Low	Low
Off	Off	Off