Smart Cane

Proposal

CSCE 483/Spring 2020

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Problem Statement

- Problem Background
- Needs Statement
- Goal and Objectives
- Requirements
- Design Constraints and Feasibility

Problem Background

Navigation is something we take for granted, but can be a major concern for the blind and visually impaired.

One of the most common, and widely recognized, tools used by the blind community to address this issue is a “white cane.”

Our project is to upgrade a white cane with additional functionality - namely, directions provided through haptic/audio feedback, integration with smartphones, in-building navigation and orientation, and quick access to emergency services

Needs Statement

There are obstacles that a traditional white cane would be unable to, or unlikely to, detect.

Orientation inside a room or building can be difficult for the visually impaired if there are not identifiable changes in the texture of the floor.

Goal and Objectives

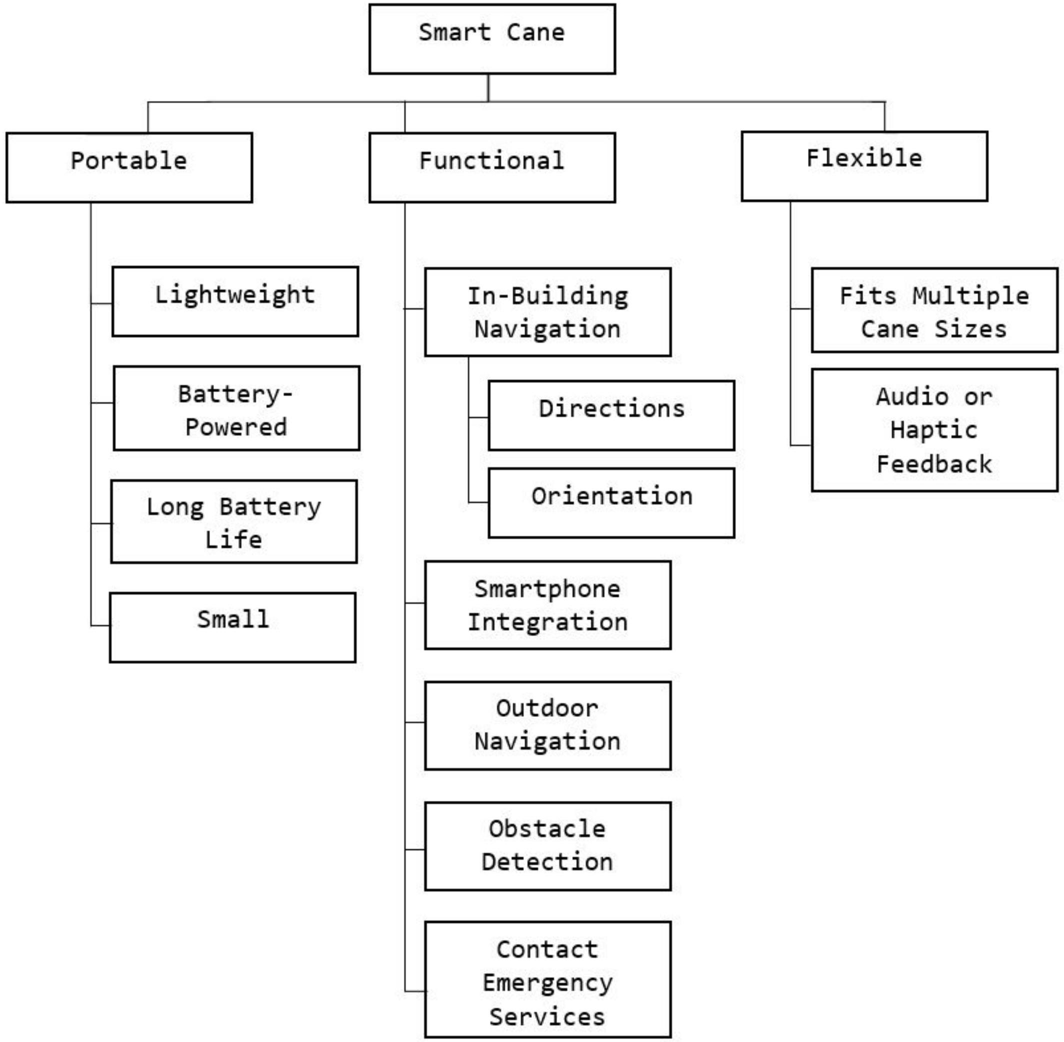
-Provide robust, consistent detection of obstacles in the path of a user

- Give clear directions to the user that leverage the accessible-friendly features of campus

-Provide orientation and directions to the user inside of buildings on request

-Allow the user to quickly contact emergency services

Requirements: Objective Tree



Requirements

Marketing	Engineering	Validation Rationale
Must run for at least 4 hours without charging	A portable lithium battery should provide sufficient battery life	This is a device that must be portable, and therefore must have a decent battery life.
Must be 2.5 pounds or lighter	Total sum of device weight should fall within those parameters.	The user will need to swing the cane back and forth, and too heavy a device could make that tiring.
Must not exceed the volume of a cylinder with a diameter of 4 inches, and a height of 8 inches	The RasPi 3 is the largest planned component and it falls within those parameters.	Must be able to be held in an average hand.
Must be able to attach to a cane	An adjustable clamp will allow a range of canes to be attached.	Users do not want to have to give up the canes they are familiar with.
Must connect to a smartphone	A Bluetooth sensor will allow communication with a smartphone with Bluetooth capabilities.	This allows us to better integrate with existing systems the users are familiar with.
Must be able to communicate through audio and haptic feedback	Small motors run by the Pi will provide haptic feedback, while a speaker will be attached to provide audio feedback.	Different users have different preferences that must be accounted for
Must find directions to a desired location	The GPS sensor should allow integration with existing maps.	This is a core area of need for the userbase.
Must detect obstacles in a 3-foot radius of the device at a minimum of 10 feet in front of the user	Input from a camera will be fed into image recognition software to detect obstacles in the desired range.	Obstacle detection is the main function of a cane, the goal of the project being to augment that device.
Must track orientation and location	A gyroscope and accelerometer will be attached to track those parameters	This is critical in particular for indoor navigation, a key area of need.

Design Constraints and Feasibility

Four primary constraint areas:

Power: A device isn't really portable if it has to constantly be on a charger

Weight: White canes are designed to be waved constantly by the user

Size: To much bulk can interfere with function, and result in a poor aesthetic appeal

Function: The core needs must be addressed - obstacle detection, navigation, and orientation.

Literature and Technical Survey

Literature Review

Existing Cane Products/Projects:

- **UltraCane**: An all in one device that uses 2 ultrasonic sensors to detect objects between 2-4m ahead ,waist down, and 1.5 m ahead, waist up.
    - -feedback is relayed to the user through 2 vibrating thumb buttons
    - -button vibration indicate direction, and frequency indicates proximity
    - -price is £590.00 ($762.20)

Literature Review

-Smart Stick: Uses three ultrasonic sensors to detect obstacles and potholes (400 cm range), arduino is used to calculate distances and detect objects. An android application is used to alert user, as well as make phone calls to emergency contacts and navigation.

- -Feedback to user is done using text to speech
- -Different gestures drawn call different emergency contacts
- -Speech to text can be activated to choose a destination
- -claimed cost to build is $35

Literature Review

-Sound and Touch Based Smart Cane (design and sensor test): This cane uses ultrasonic sensors to detect obstacles, if an obstacle is detected near(d<50cm) the user a “stop” command is output from a bluetooth headset, if it is far(50cm<d<100cm) away an “obstacle” warning is output. If a moving object (towards the user) is detected, a motor vibrates in the handle. Heat sensor is added to detect hot objects.

- -bluetooth headset connected through android app
- -intensity of vibration indicates speed of obstacle
- -buzzer noise indicates hot object

Literature Review

Existing Research/Technology:

-Robot-Assisted Indoor Navigation: Research project that developed robots that can guide those with visual impairments around an indoor space using radio frequency identification (RFID) tags.

- -Can be customized to an exact environment
- -Tags must be deployed ahead of time throughout the room/building
- -users can interact with robot using speech and wearable keyboards
- -Cannot detect route blockages, if obstacle detected the robot looks for free space to move into, but continues towards detected RFID tag

Literature Review

-**Haptic Assistive Bracelets for Blind Skiers:** Blind or visually impaired skiers wore armbands that communicated turning instructions from instructors. Normally blind skiers simply follow instructors closely and listen for voice commands

-a combination of audio instructions and haptic feedback was preferred by test subjects

- instructors used buttons on their ski poles to communicate with armbands via bluetooth

Our Development Direction

-We intend to use similar methods of object detection (ultrasonic sensors), our focus on feedback is with haptic vibration to guide the user, but optional audio feedback will be present

-Many of the mentioned projects had an app that handled things like navigation, user interaction. We hope to do the same (using IOS), to allow for apple watch usage as well.

-Our intent is to create a device that can attached to a regular cane, which is different from the products we have researched.

-The cane projects/products we researched didn't offer anything to help with indoor navigation except for object detections. We hope to add a functionality that will allow the user to set waypoints, which will act as markers that will allow the user to retrace their steps.

-Our development cost (~$230) will be lower than existing commercial options

Proposed Work

- Evaluation of Alternative Solutions
- Design Specifications
- Approach for Design Validation

Evaluation of Alternative Solutions

Using a Raspberry Pi instead of Arduino

- Can do more operations at once
- Has 1 GB of RAM compared to a few KB from Arduino
- It is a lot faster
  - 1.2 GHz vs 16 MHz
- Already comes with bluetooth and wifi.
- Only downfall is the cost
  - Arduino UNO R3: $18.00
  - Raspberry Pi 3 B: $48.00

Evaluation of Alternative Solutions

Relying on bluetooth rather than wifi

- It’s better for the scenarios that visually impaired people face.
  - Ex: going through campus

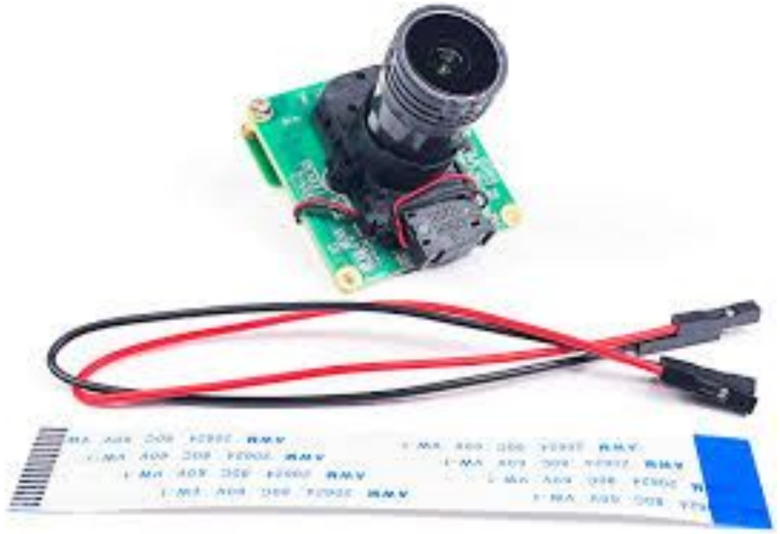
- This also ensures a more continuous connection if the user is moving around a building.

Evaluation of Alternative Solutions

Using a camera to aid in detection

- We don’t rely only on the Ultrasonic sensors.

- Doesn’t put a huge burden on our budget, but it does improve our product.



Evaluation of Alternative Solutions

“Breadcrumb” system to aid in tracing back route

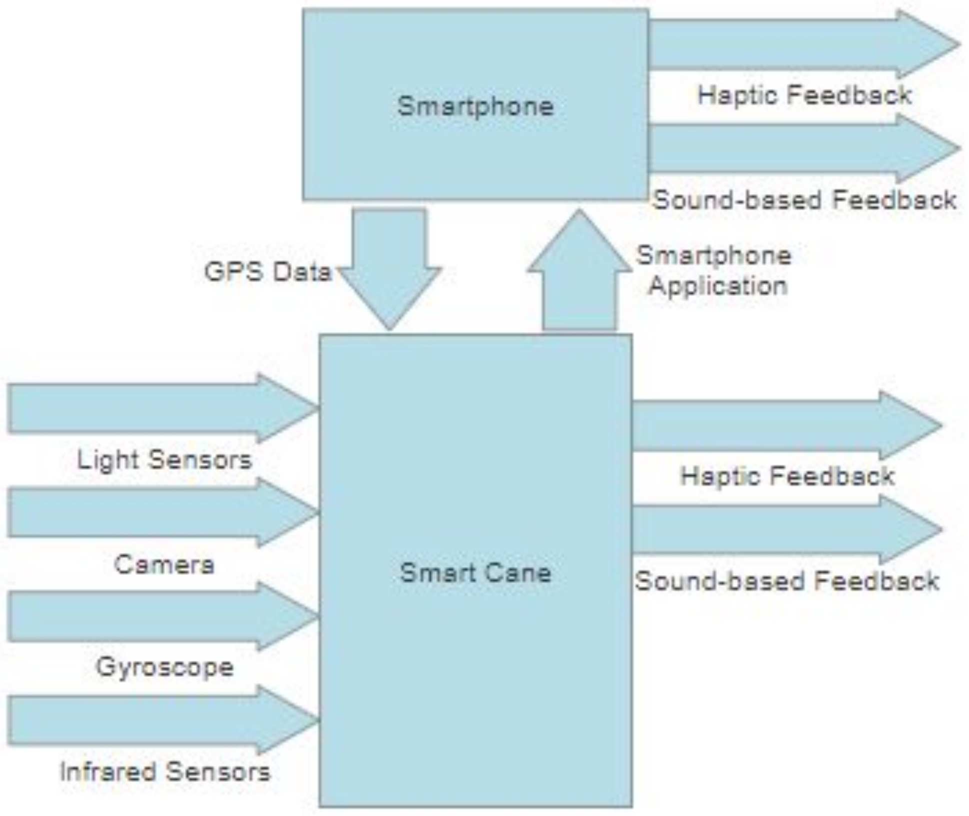
- An addition to just directing the user from point A to B.
- Helps them retrace their steps a lot easier.

Evaluation of Alternative Solutions

Robust system with toggle options

- Rather than having a fixed system with a lot of feedback, make the feedback toggle.
- Makes it better for users, since some might get very distracted with certain feedback.

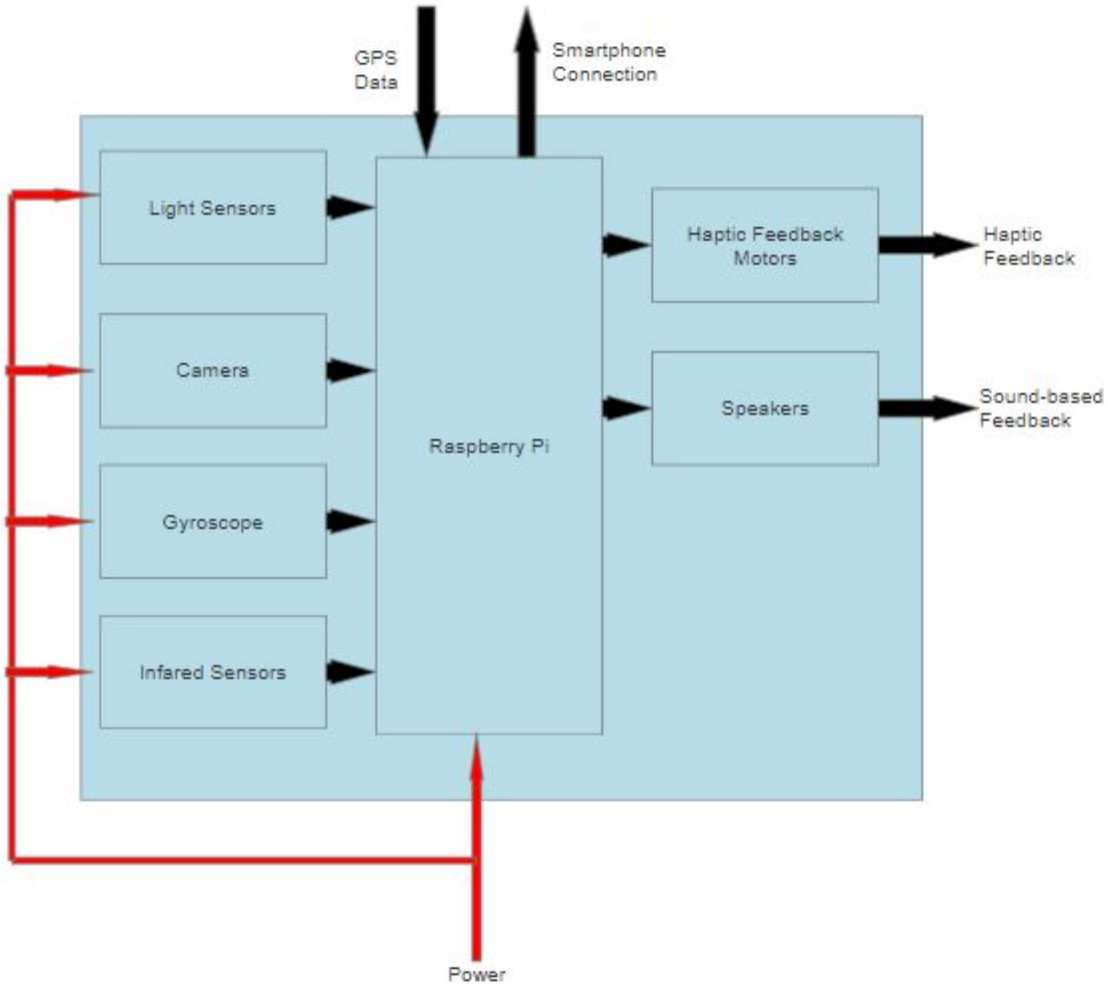
Design Specifications (Level 0)



Level 0 Diagram

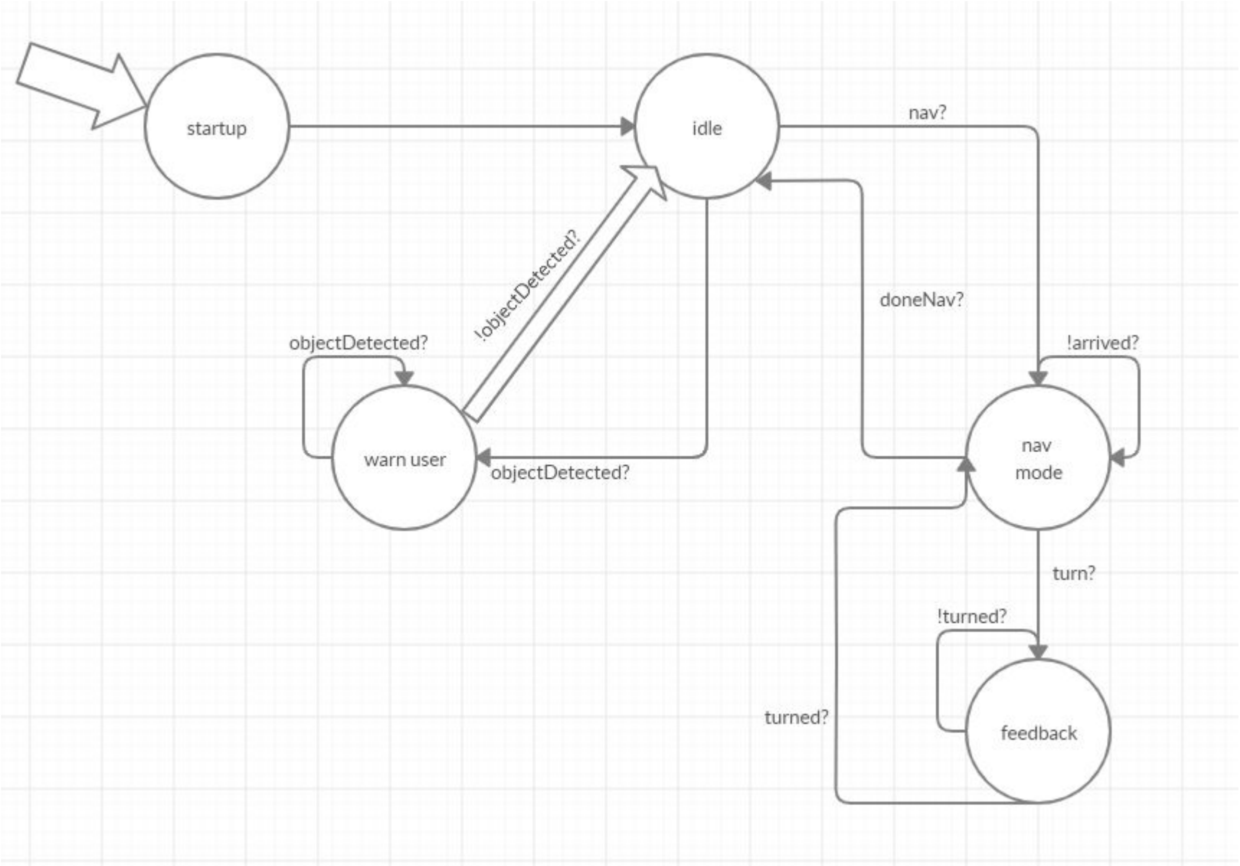
- 4 Standalone Inputs
  - Data from light sensors
  - Data from camera
  - Data from the internal gyroscope
  - Data from the infrared sensors
- 1 Optional Input from Smartphone
  - GPS data
- 2 outputs
  - Haptic Feedback
  - Sound-based Feedback
  - Smartphone can mirror these outputs, but is not necessary

Design Specifications (Level 1)



- Internal modules and their interactions within the cane itself
- Raspberry Pi acts as central brain, processing all incoming data from the sensors and sending the appropriate responses through the haptic feedback motors and speakers
- Smartphone connection brings in additional GPS data for map tracking and navigation

Design Specifications (FSM)



- Idle - always checking for incoming objects
- Nav Mode - Gives feedback based on directions

Approach for Design Validation

- In order to make sure the product is in good condition for the user, we will first start by testing the battery life and smaller components to make sure they get correct measurements.
- We will then test the iOS App to make sure it can communicate with the device and can take special gestures/commands by the user.
- Once we have a physical prototype, we will perform many tests to check if the cane can guide us through a building and also outside on campus. Since we also have the contact of a campus staff member who is blind, we will ask him to give us his insight on the efficacy of the cane by testing it out. We will take into consideration any improvements he thinks we can apply.
- Finally, we will test the robustness and stiffness of the cane to make sure it is durable and that its settings can be modified to satisfy each individual user's preferences of feedback.

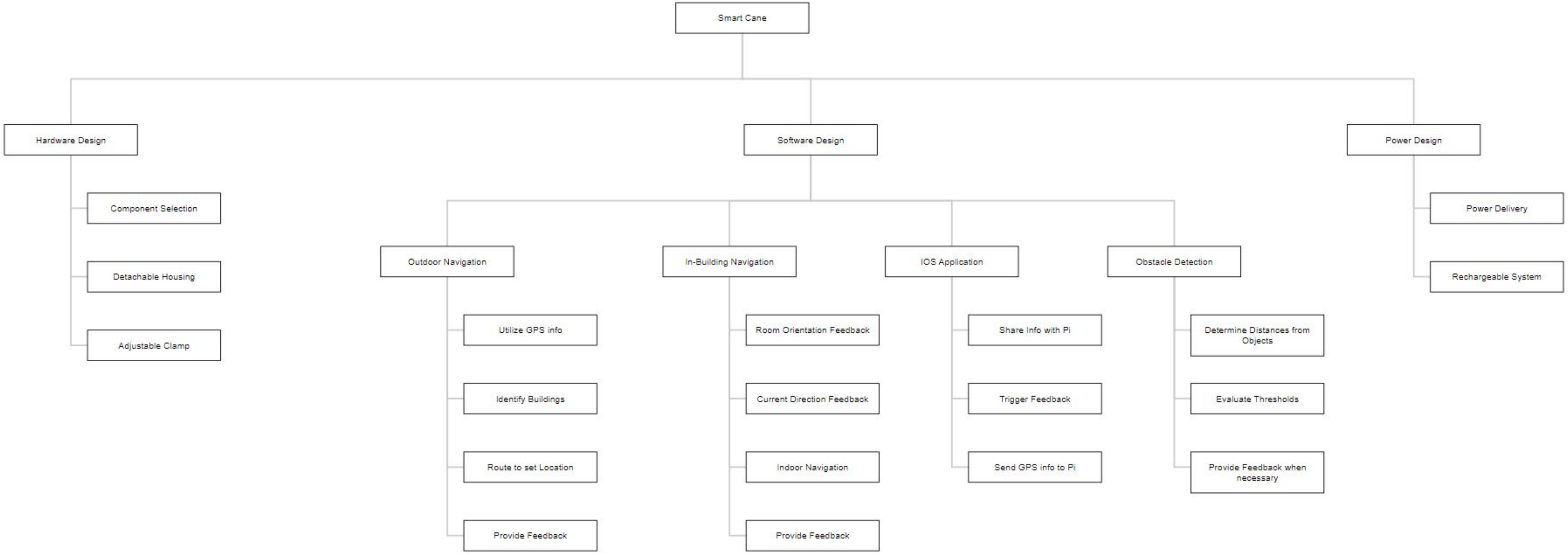
Engineering Standards

- Project Management
- Schedule of Tasks
- Economic Analysis
- Itemized Budget
- Societal, Safety and Environmental Analysis

Project Management

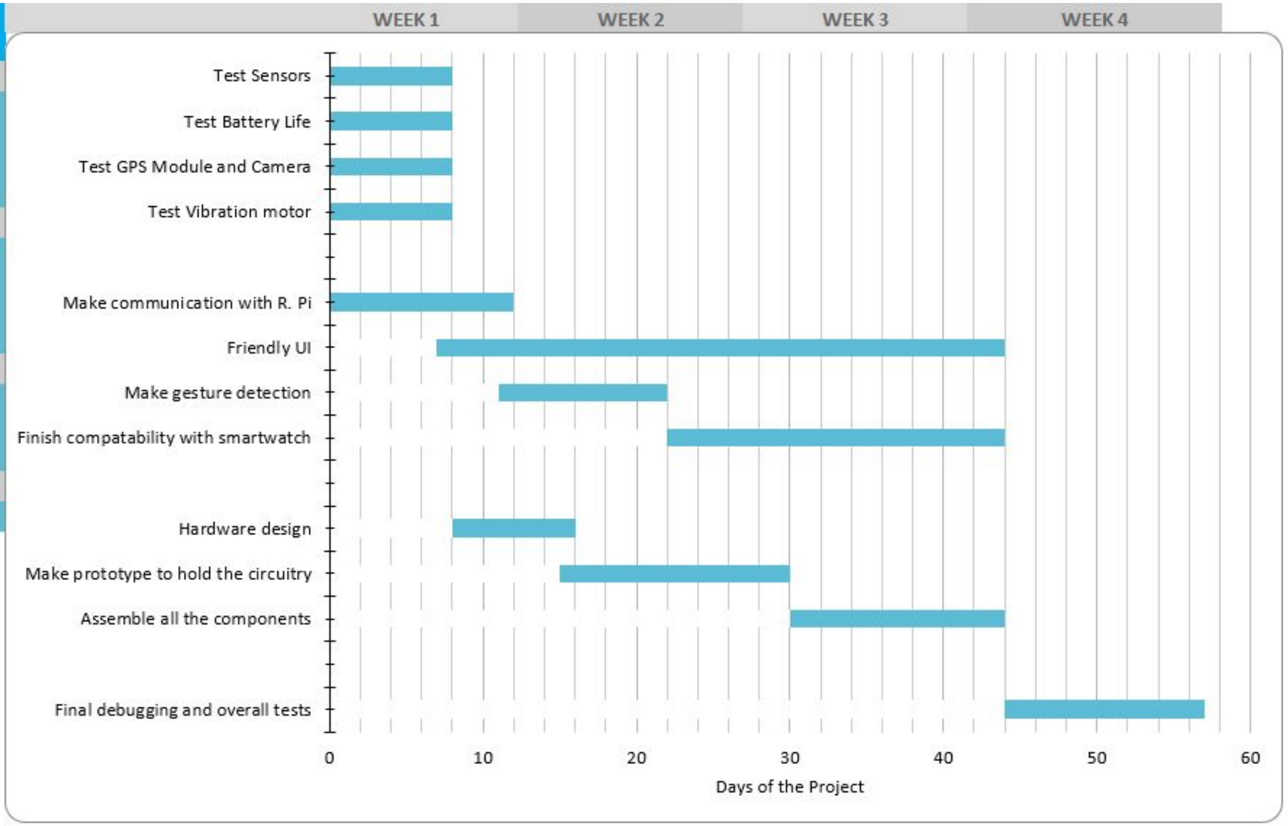
- Baltazar Guerra: Team leader, system and software design.
- Shawn Popal: Software design, app development, finance and purchases.
- Arthur Helmen: Hardware and circuitry design, component testing.
- Matthew Giuffrida: Hardware and software design, prototype testing.
- Jonathan Williams: Software design and prototype testing.

Project Management



Schedule of Tasks

TASK NAME	START DATE	END DATE	START ON DAY*	DURATION* (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Testing initial Components						
Test Sensors	2/24	3/2	0	8	Arthur	0%
Test Battery Life	2/24	3/2	0	8	Matthew	0%
Test GPS Module and Camera	2/24	3/2	0	8	Baltazar	0%
Test Vibration motor	2/24	3/2	0	8	Jonathan	0%
iOS App Development						
Make communication with R. Pi	2/24	3/6	0	12	Shawn	0%
Friendly UI	3/2	4/7	7	37	Baltazar	0%
Make gesture detection	3/6	3/16	11	11	Shawn	0%
Finish compatability with smartwatch	3/17	4/7	22	22	All	0%
Assembling Physical Product						
Hardware design	3/3	3/10	8	8	Arthur	0%
Make prototype to hold the circuitry	3/10	3/24	15	15	Jonathan	0%
Assemble all the components	3/25	4/7	30	14	Matthew	0%
Debugging and Testing						
Final debugging and overall tests	4/8	4/20	44	13	All	0%



Economic Analysis

- Current Market Solutions are very pricey and do not satisfy every requirement
  - In-Building Navigation
  - Outdoor Navigation
    - Unique Solution for the Texas A&M Campus
  - Modular Solution

- Improve functionality while reducing price significantly
  - Providing solutions to key issues specific to the Campus
  - Parts are readily available
  - No maintenance required

Itemized Budget

Item	Quantity	Estimated Cost
Raspberry Pi 3 B	1	$45
Ultrasonic Sensors	3	$6
Infrared Sensor	2	$4
Light Sensor	1	$1
Gyroscope	1	$15
Camera	2	$60
Vibration Motor	5	$5
Speaker	1	$5
Battery	1	$39
White Cane	1	$15
GPS Module	1	$37
Total	**19**	**$232**

Societal, Safety and Environmental Analysis

- Goal of this product is to aid the lives of those who are visually impaired, hopefully allowing them to navigate through the Texas A&M campus as seamlessly as possible

- Safety naturally is the number one concern
  - Crosswalks, Buses, Utility Vehicles, People
  - Many unpredictable variables on a day to day basis

- 100% electric power system
  - Rechargeable Battery

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