The RIM : Road Interference Mapper

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Team 35

Introduction

- Current method for surveying potholes and road debris is just manual location.
- The RIM expedites the detection process of road interferences such as potholes and debris.
- A motor vehicle attachment that automatically detects, counts, and maps road interferences as the vehicle moves over them.

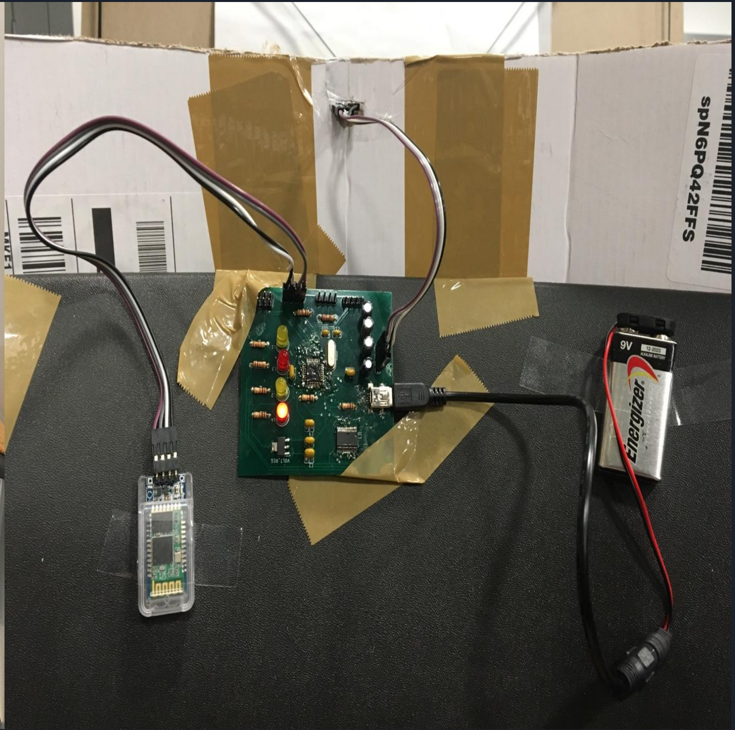
Objective

- Prevention of evitable vehicle damage
- Low cost smartphone app for drivers
- Easy mount underneath vehicle

High Level Requirements

- Sensors must be able to detect potholes and debris of at least .25 m in length, .25 m in width, and at least .04 deep
- The RIM counts potholes and debris within +/-2 potholes and debris
- The RIM can detect potholes and debris at speeds up to 9.5mph

The RIM System

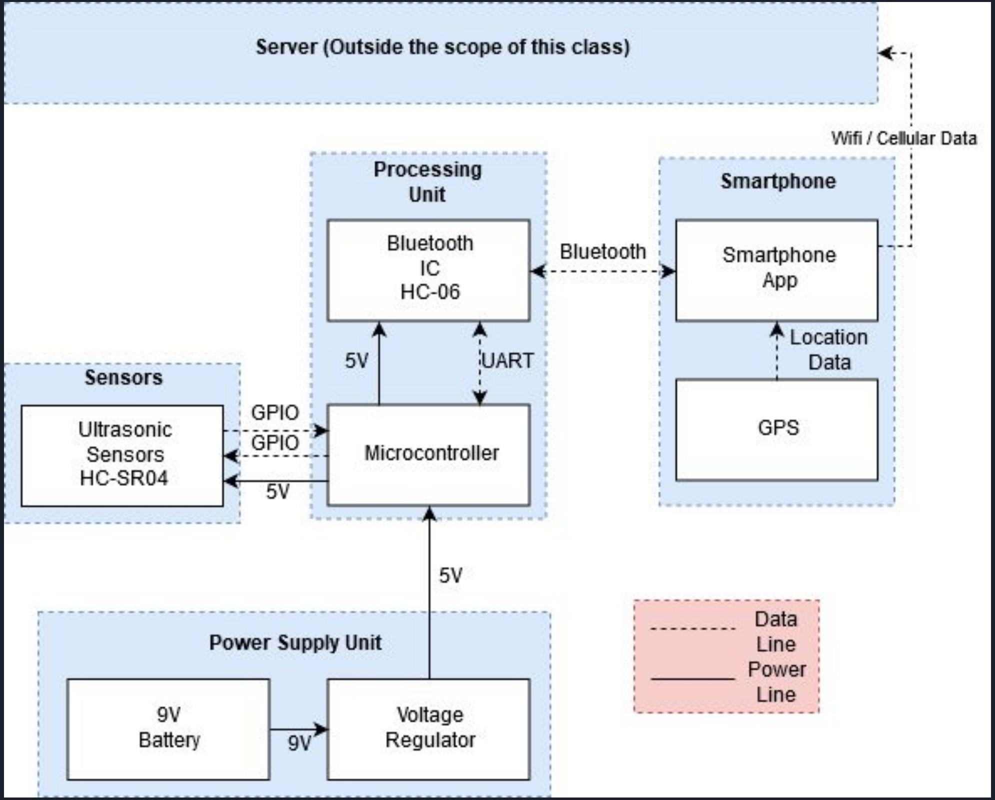


Demo Terrain

System Overview

- Hardware:
    - Power supply - 9V battery
    - Printed Circuit Board (PCB)
    - The Bluetooth Module
    - Ultrasonic Sensor
- Software:
    - Arduino IDE
    - Android Studio

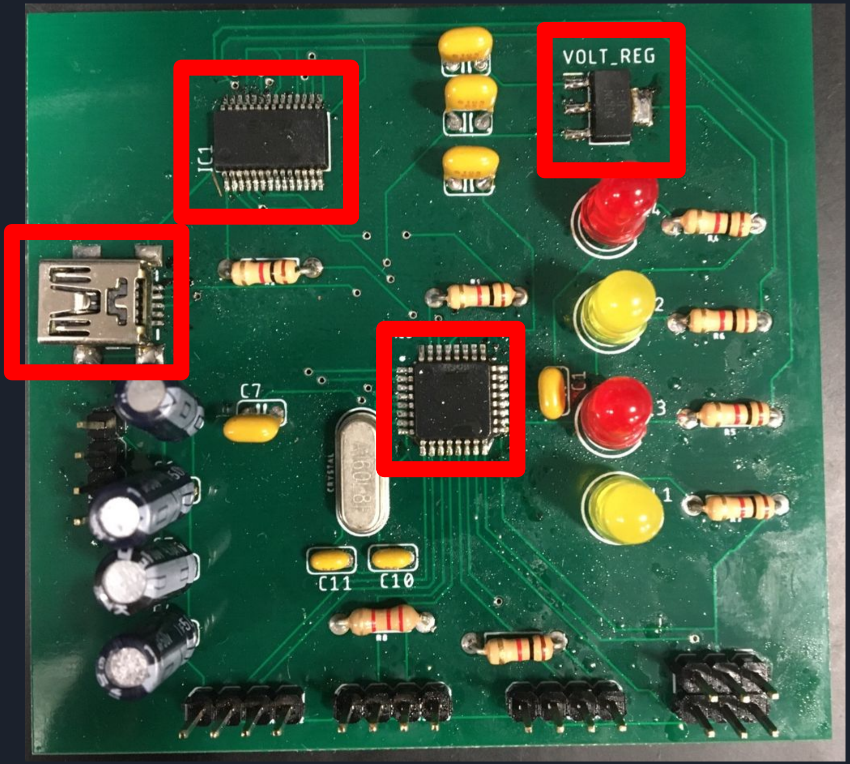
System Block Diagram



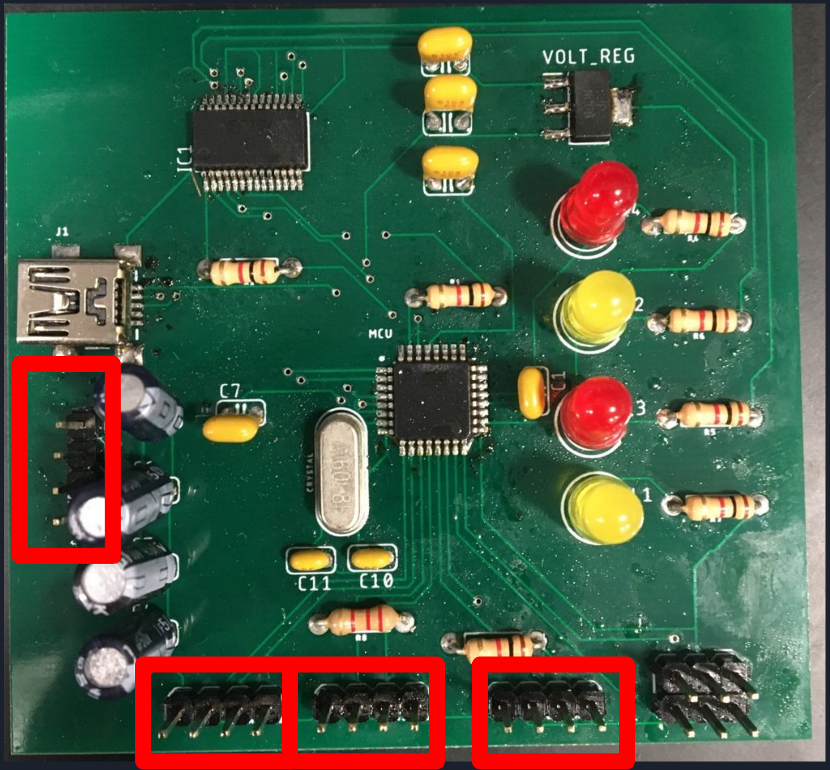
Components

- ATMEGA328P-AU (MCU)
- FT232RL (USB UART IC)
- LM1117IMPX-5.0 (Voltage Regulator)
- Mini-B USB Port

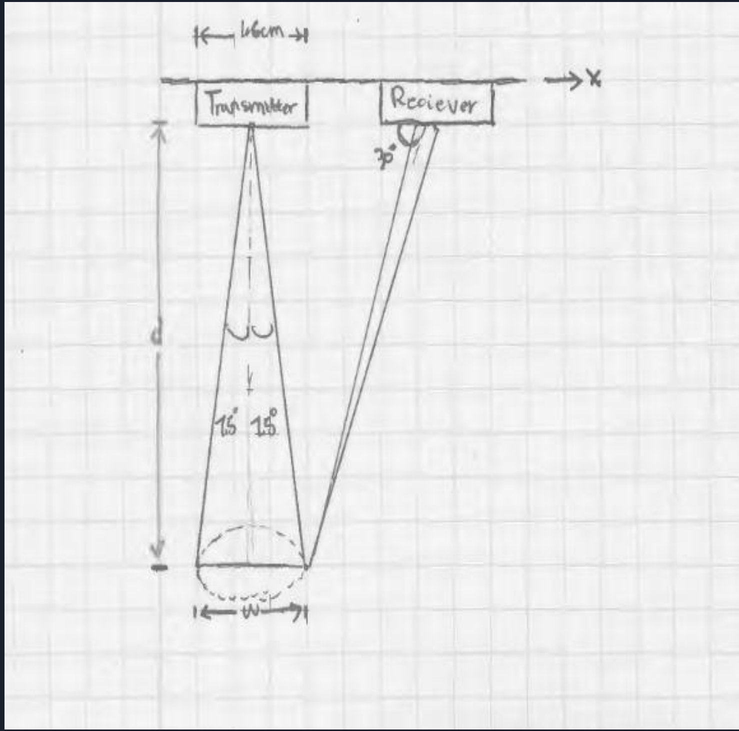
Printed Circuit Board (PCB) - 1

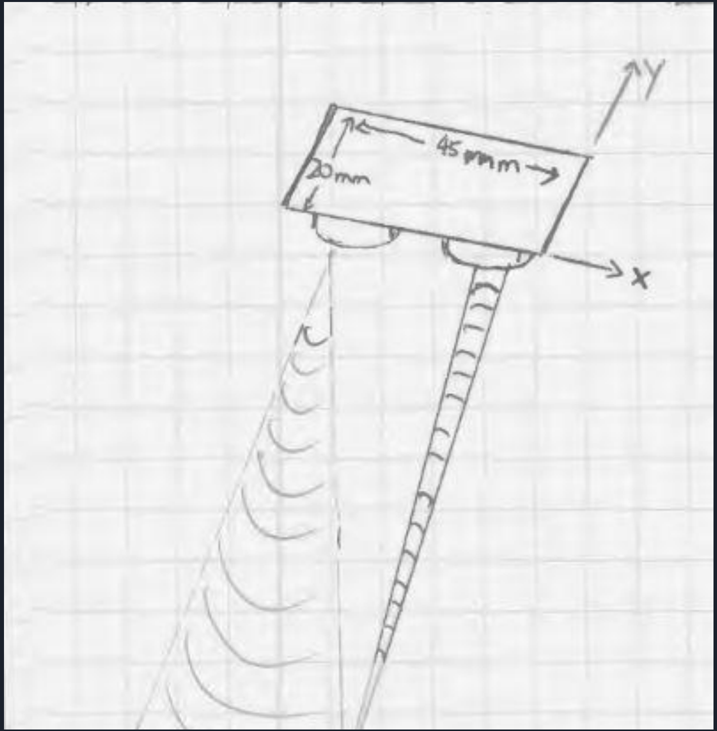


Printed Circuit Board (PCB) - 2

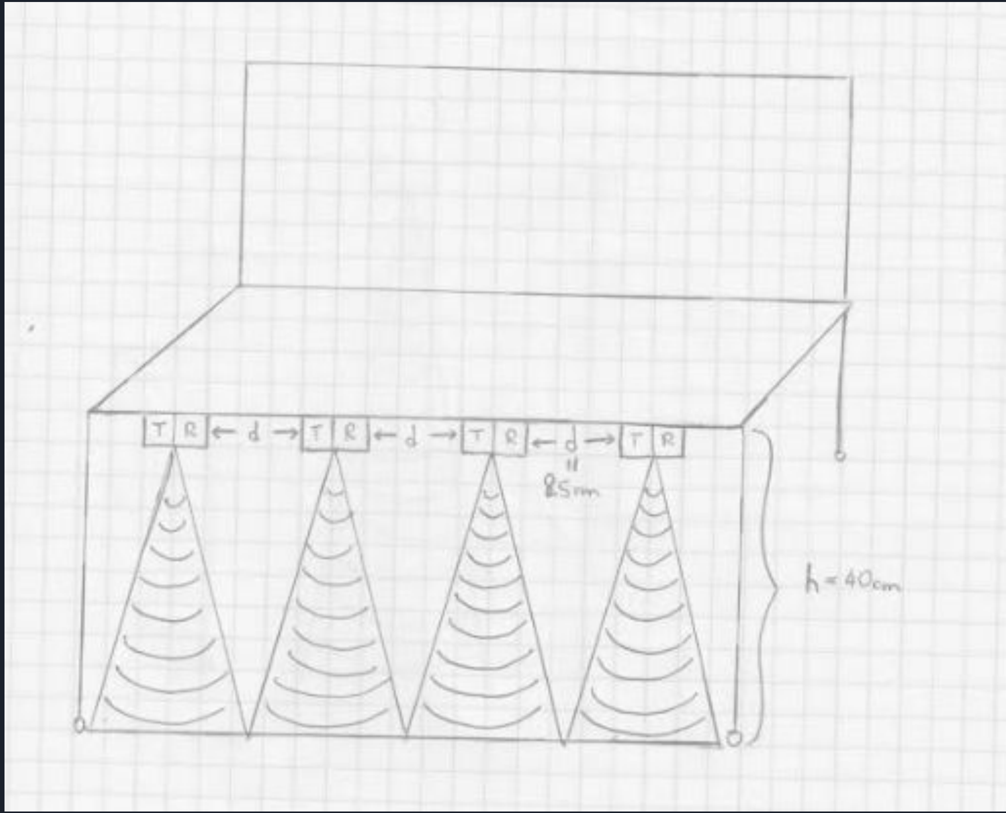


Ultrasonic Sensors





Ultrasonic Sensors



Ultrasonic Sensors: Range Behavior

cm	µs	cm	µs	cm	µs	cm	µs	cm	µs
0-30	Noise	50	3030	68	3910	86	4820	104	5710
34	2040	52	3140	70	4020	88	4920	106	5830
36	2160	54	3220	72	4120	90	5010	108	5910
38	2280	56	3330	74	4220	92	5120	110	6020
40	2415	58	3410	76	4310	94	5210	112	6110
42	2580	60	3520	78	4420	96	5320	114	6130
44	2620	62	3630	80	4510	98	5400	116	6230
46	2680	64	3710	82	4630	100	5510	118	6330
48	2840	66	3820	84	4730	102	5620	120	6410

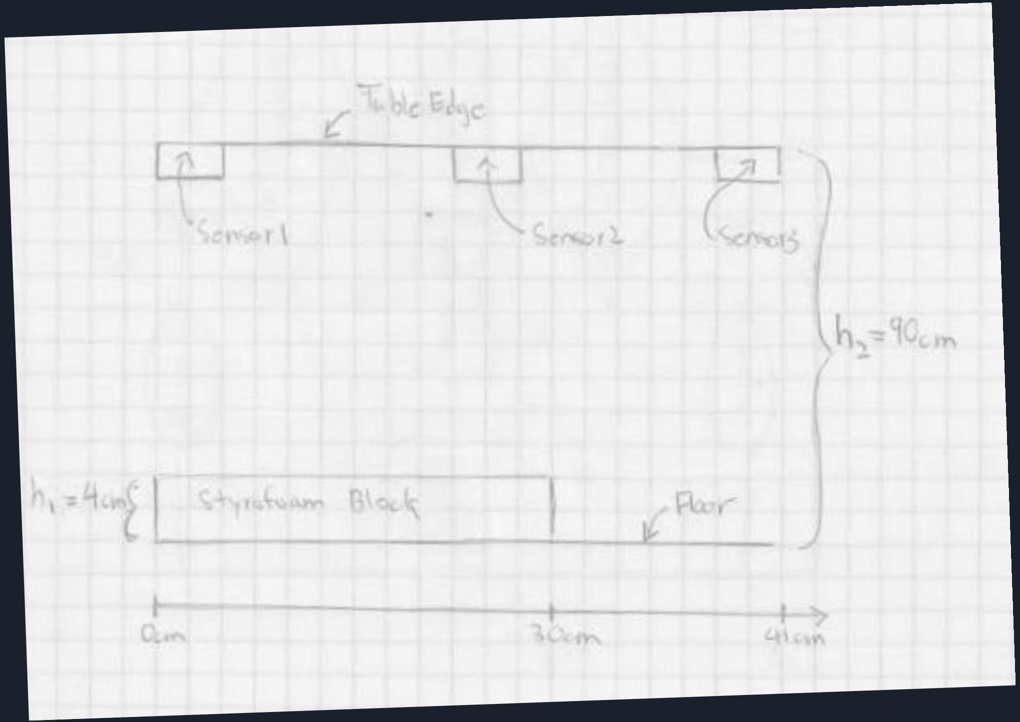
Ultrasonic Sensors: Range Behavior

- Test Result:
  1. Sensors are extremely noisy when measuring distances closer than 34 cm.
  2. Sensor data have error margins of about +/- 200 μs at all distances

- Design influence:
  1. Place sensors at a height of about 86 cm above level ground.

- Observation
  1. Will only be able to discern distance differences of at least +/- 4cm.

Ultrasonic Sensors: Spread Behavior



Edge of Book (cm)	Sensor 1 (μs)	Sensor 2 (μs)	Sensor 3 (μs)
30	4770	4800	4990
31	4800	4820	5010
32	4780	4810	5010
33	4790	4790	5000
34	4810	4800	4810
35	4820	4770	4810
36	4790	4800	4820
37	4810	4810	4790
38	5000	4800	4810
39	4950	4820	4810
40	5020	4790	4800
41	5010	4810	4800

Ultrasonic Sensors: Spread Behavior

- Test Results:
  1. No matter what position the interference is at, two sensors will be able to detect it at all times.
  2. Center sensor detects interference at all times.

- Design influence:
  1. Remove edge sensors. Keep center sensor.

Ultrasonic Sensors: Sampling Rate

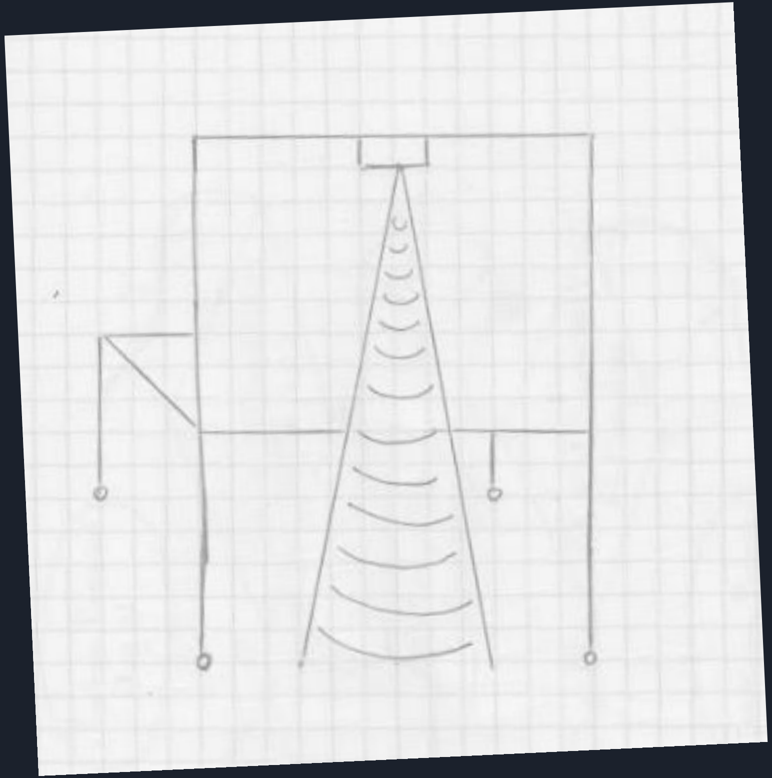
Time interval number (10 second Intervals):	Samples Collected
1	180
2	183
3	162
4	179
5	170
6	186
7	165
8	167
9	179
10	183
Average number of samples/ 10 seconds	17.54

Ultrasonic Sensors: Sampling Rate

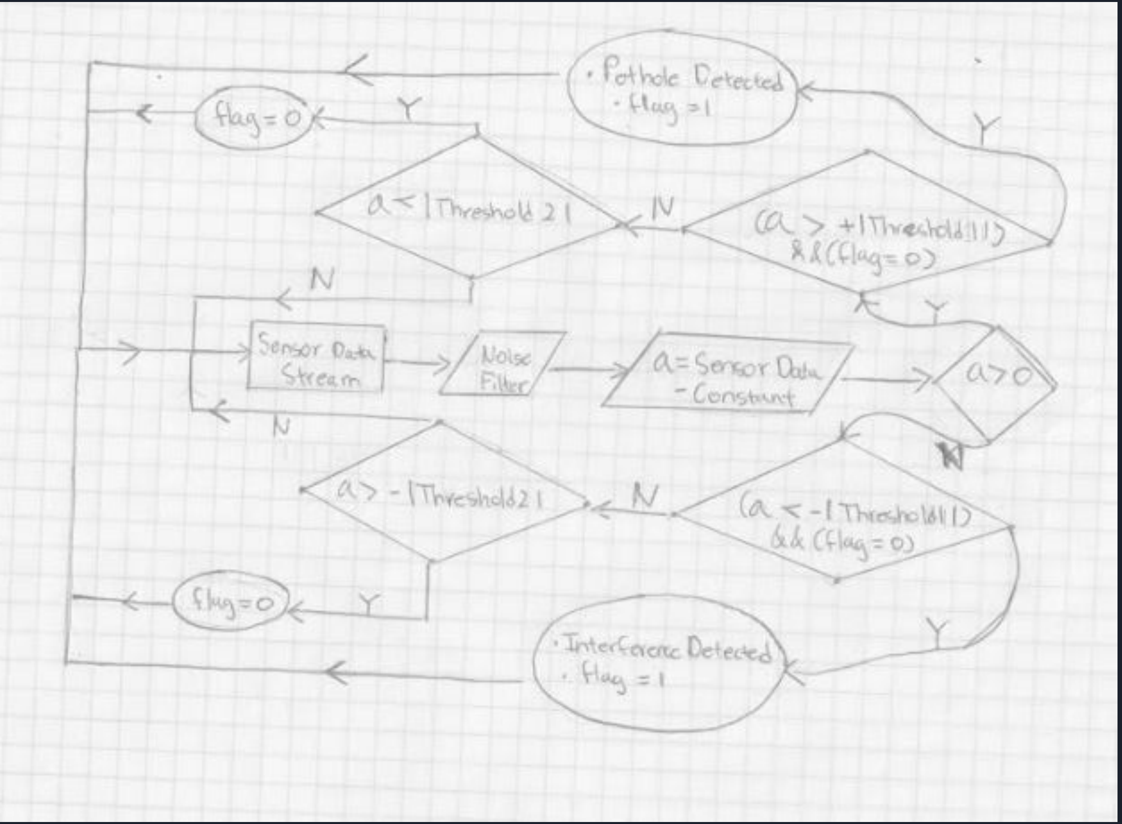
- Test Result:
  1. Using the HC-SR04’s suggested measurement cycle of 60ms, we expected a sampling frequency of 17Hz which was confirmed.
  2. Even though we got about 17 samples/second, not all samples were reliable data points.
  3. Effective sampling rate of sensors will be slower than planned. The RIM will not be able to travel at the designed speed.

- Design Influence:
  1. New sensors?
  2. Place sensors in series, one in front of the other w/ a phase offset to increase sampling rate?

Ultrasonic Sensor: Final Design



Detection Algorithm: Design



Detection Algorithm: Problems

1. Missed Counts
   - (Sensor output over interferences) - constant < Threshold 1
   - Flag is raised when it should be lowered

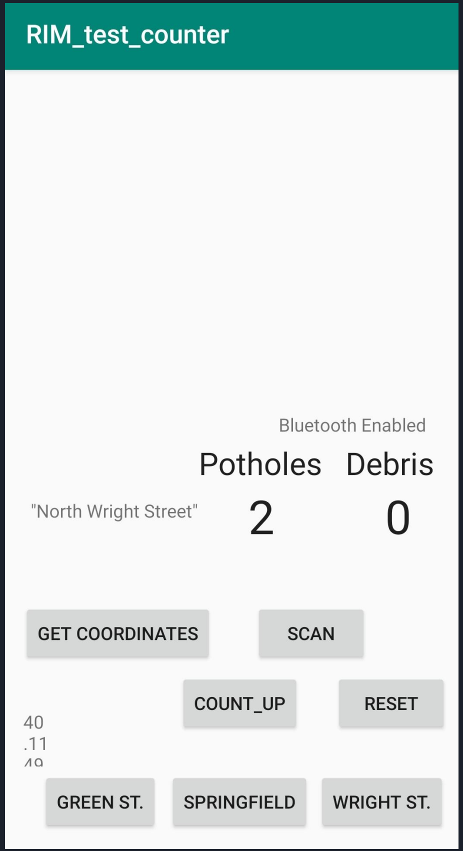
2. Double Counts
   - |(Sensor output over level ground) - constant| >Threshold 1
   - Flag is lowered when it should be raised

Detection Algorithm: Solutions

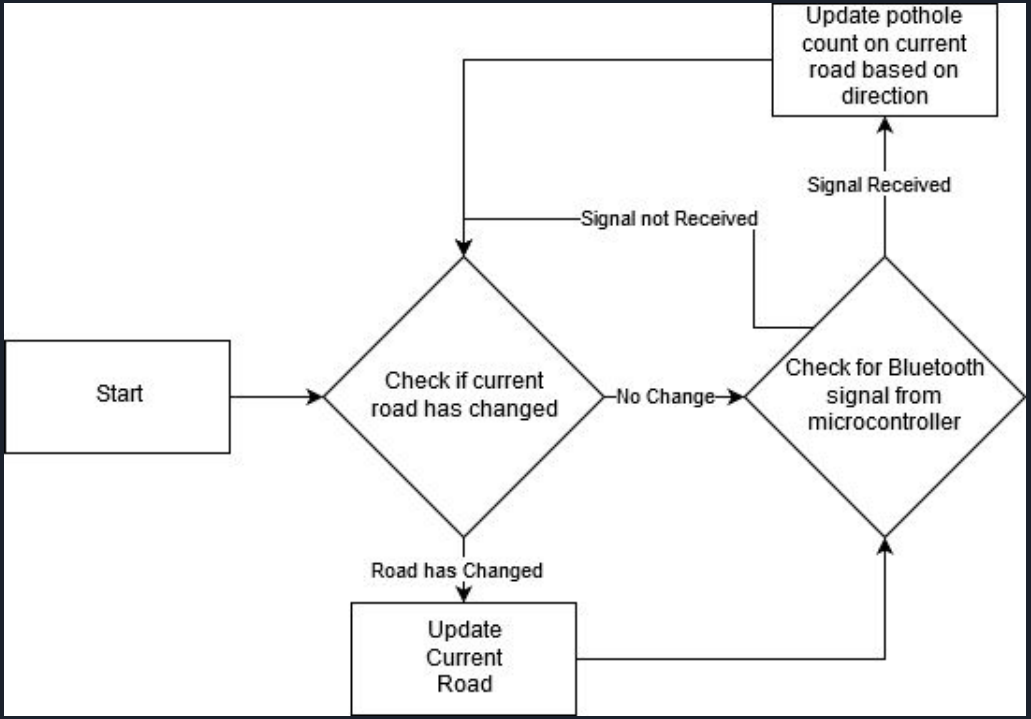
Test	1	2	3	4
Double Counts	0	5	2	0
Missed Counts	5	0	0	0
Threshold 1 (μs):	400	200	200	200
Threshold 2 (μs):	400	400	200	75

Smartphone Software

- Location Tracking Software
  - Get current longitude and latitude coordinates
  - Use Nominatim to get closest street based on those coordinates
- Bluetooth Communication Software
  - Connect to Bluetooth Module
  - Communicate with processing unit through bluetooth



Smartphone Flowchart



Location Tracking Software

- Google Location Manager for longitude and latitude
  - Use either internet or GPS depending on accuracy
- Nominatim Reverse Geocoding
  - Send request to API through the internet
  - Response is closest street
- Update Pothole and Debris counters based on closest street


```
place_id:      247064427
licence:       "Data © OpenStreetMap contributors, ODbL 1.0. https://osm.org/copyright"
osm_type:      "way"
osm_id:        5339010
lat:           "40.1128072390702"
lon:           "-88.2186964524825"
place_rank:    26
category:      "highway"
type:          "tertiary"
importance:    0.1
addresstype:   "road"
```


Closest Street Response

Bluetooth Communication Software

- Receive bluetooth signal from Processing Unit to signify pothole or debris
    - <POT> - Signal for pothole
    - <DEB> - Signal for debris
- Update corresponding count upon receival of signal

Smartphone Software Testing

Testing

- Different Bluetooth signals were sent to the smartphone and the time to reception was observed.
- Closest road feature was tested at different roads.

Results

- All Bluetooth signals were sent and received near instantaneously, (< 1 sec).
- Each road result was the correct road.

Results

- Requirement 1 - Able to detect potholes and debis at least .04m deep
  - Testing environment was built to this requirement and the system was able to detect those potholes.
- Requirement 2 - Counts potholes and debris within +/-2 potholes and debris
  - The RIM was able to count interferences within this bound.
- Requirement 3 - Can detect interferences at speeds up to 9.5mph
  - Due to the limitations of the ultrasonic sensors, this was not achievable.

Further Work

- Improved Sensors
  - Higher sampling rate
  - Improved accuracy
  - More reliable at higher speeds
- Improved location Mapping
  - More accurate GPS to actually map location of interferences instead of just counts
- Improved Voltage Regulator with Higher Efficiency
- Scale Up