# Pothole Detection Using Smartphones

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## System Specifications

- Create an iOS app to detect potholes and map the geolocation data.
- Applicable for widely available mounting devices.
- Not allowed to use any 3rd party hardware.

## Application Concept

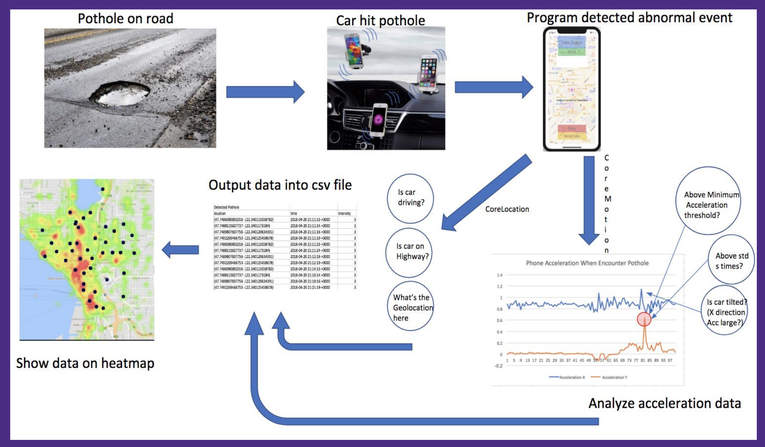



Fig 1 - Concept on how application works

## User Interface

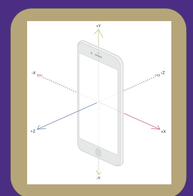

Here are the following buttons that are in the application:

- Start
- Clear Output
- Stop
- Send Data
- Pothole Sensitivity Stepper
- GDrive Sign In/Out

Fig 2 - User interface of the application

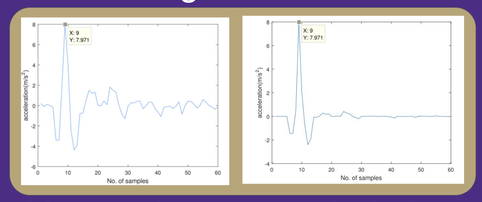
## Technical Approach

- Collect accelerometer data from the phone.
- Cluster the data into 100 segments/second.



- Apply the Max-Abs filter to filter out noisy data but leave out the abnormal signal.

$$\frac{y * |y|}{(Max(y) + 1)}$$




- Implement an algorithm to detect a pothole by comparing the standard deviation of the data with each sample point and the pothole detection parameter (from experiment).

$$\left| \frac{y - \mu}{\sigma} \right| > T\left(\frac{V}{V_{th}}\right)$$

y : Y-axis accelerometer data
M : average of data sample
$\sigma$ : STDEV of data sample
$V_{th}$ : 10 km/hr
V : current speed
T : pothole intensity parameter

- Define event classification to differentiate a pothole and bump using an X-Y Filter. We check the window of X-axis motion data that parallels with the abnormal Y-axis sample and compares it with pothole/bump parameter.
- Set up the parameter of the car speed to 6-45 mph.
- Implemented using Xcode (Swift 4.1).

## Accuracy

| | |
|---|---|
| Precision | 65% |
| Recall | 81.25% |

Application tested on iPhone 7 and iPhone X - iOS 11.3

## Results

| latitude | longitude | date | sensitivity |
|---|---|---|---|
| 47.61642181 | -122.318026 | 2018-05-18 02:3 | 3 |
| 47.61642259 | -122.3179701 | 2018-05-18 02:3 | 3 |
| 47.61642344 | -122.3179091 | 2018-05-18 02:3 | 3 |
| 47.61642458 | -122.3178268 | 2018-05-18 02:3 | 3 |
| 47.61642561 | -122.3177533 | 2018-05-18 02:3 | 3 |
| 47.6164268 | -122.3176674 | 2018-05-18 02:3 | 3 |
| 47.61642792 | -122.3175868 | 2018-05-18 02:3 | 3 |
| 47.61642909 | -122.3175031 | 2018-05-18 02:3 | 3 |
| 47.61643036 | -122.3174121 | 2018-05-18 02:3 | 3 |
| 47.61643151 | -122.3173293 | 2018-05-18 02:3 | 3 |
| 47.61645514 | -122.3147839 | 2018-05-18 02:3 | 3 |
| 47.61645705 | -122.3146805 | 2018-05-18 02:3 | 3 |
| 47.6159495 | -122.3142486 | 2018-05-18 02:3 | 3 |
| 47.6158051 | -122.3142467 | 2018-05-18 02:3 | 3 |

Fig 3 - The detection result in the form of .csv file. Data is uploaded to the user's google drive account

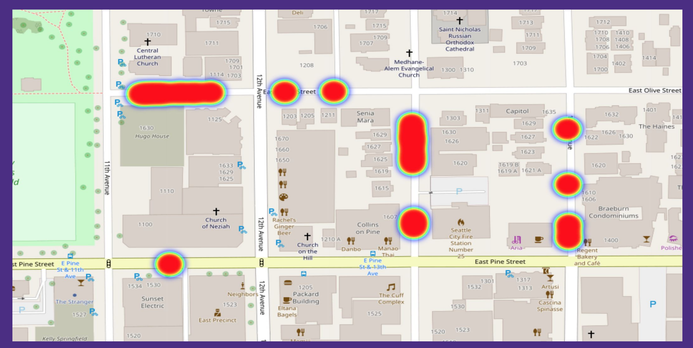



Fig 4 - A heatmap example of a block around Capitol Hill, Seattle, WA

## Future Work / Discussions

- X-Y Filter doesn't do well on differentiating the pothole and bump because both sample data is similar but it helps decrease false positive.
- The accuracy rate depends on the type of the car that we used.
- Add a feature to identify a pothole if there are multiple records in one particular event, which acts as a second barrier to false positives rather than just relying on the one single car.
- An integration of the current application alongside with third party camera will produce better results with less false positive.
- Expanding the application to Android would also be feasible.

### References

[1] P.M, H. and Gopi, V. (2017). Vehicle Vibration Signal Processing for Road Surface Monitoring - IEEE Journals & Magazine. [online] Ieeexplore.ieee.org. Available at: https://ieeexplore.ieee.org/document/7959046/ [Accessed 29 May 2018].