Problem Statement:

Intelligent pothole detection system using micro-controllers to provide real-time services.

Introduction

Poor road conditions are becoming a severe hazard for the common people of India. In India, road-related conditions are a factor in 22,000 of the 42,000 traffic fatalities each year, majorly during night or during monsoon season. To address this issue, we tried to detect these potholes using micro-controller sensors which are, otherwise difficult to identify. This project done on a smaller scale, has the capability of vast scaling, provided ample time and resources.

This prototype is under the Safety & Security, Transportation and Governance classes of Smart City.

Idea Description

We planned to address this issue in three parts. First was the Data Collection, second was the data analysis for pothole detection, and third was the real-time broadcasting of the predicted data, and notifying authorities about

- ***Data Collection:*** Data is collected using mobile phone which are attached to the public mode of transport, i.e., local buses and cabs. These mobile phones have sensors in them that can detect vibrations by gyroscope, accelerometer and ultrasonic sensors. The vibrations are collected and converted in .csv by a service Android app, running in the background when a vehicle traverses a route around the city. Due to limited time, this data is generated manually by us, by using the phone's sensors. The location (latitude and longitude) is also fetched by the GPS from phone. The data is generated by making simulated troughs and crests at various time-stamps.

- ***Data analysis and pothole detection:*** This .csv data is further fetched by Raspberry-Pi board where it is analysed to predict the occurence of a pothole. This occurrence is measured in terms of Threshold which specifies the depth of the pothole. Raspberry-Pi board after necessary analysis, send the data to the AWS server which ultimately shows the user a map, specifying all the points of potholes.

  The purpose of using AWS server was to make the process more automated by using a Machine Learning algorithm. We were expecting to make a system where the data collected by sensors in .csv are sent to AWS server where the ML classifier trains on the training data and then predicts the real-time situation to send the required information (pothole presence) to the user.

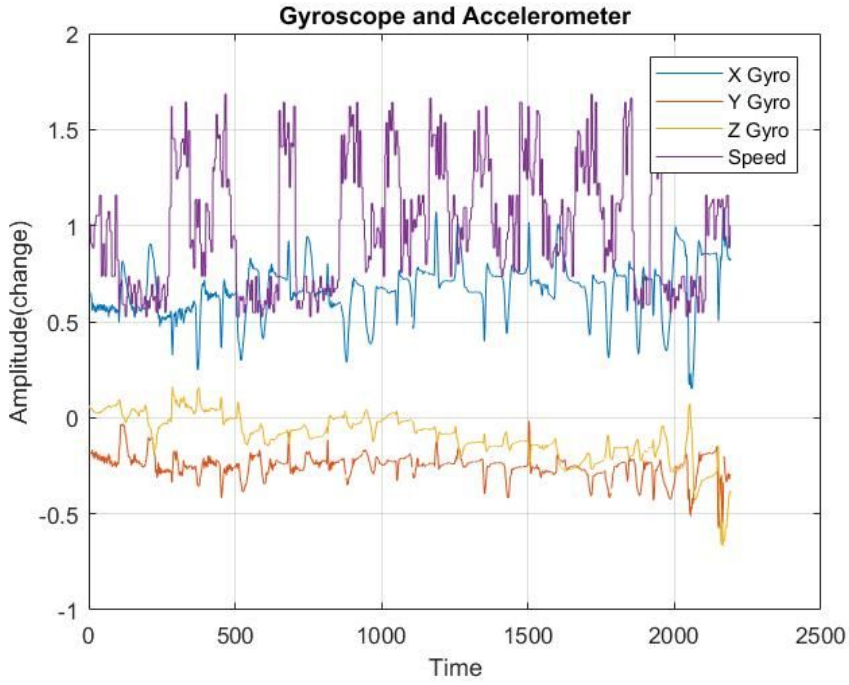
- ***Real-time broadcasting:*** This Raspberry-Pi board on processing the training data, has the capability to retrieve the real-time data to determine the current situation of a road. It then broadcasts the information to all the users once connected with the Google Maps. This can be done by using appropriate ML algorithm which is trained and can predict the presence of pothole by using the real-time data taken on AWS server.
- As the data is collected with time-stamp, a record can be maintained to determine the time period for which the potholes are not filled. This situation further can be notified to the governing bodies to get immediate attention.

Technical Description

- ***Data Collection:*** The data is collected from the sensors to collect a 8 features - time-stamp, gyroscope x, gyroscope y, gyroscope z, speed, ultrasonic depth, longitude and latitude. We used a simulated data of 6500 tuples having a considerable number of potholes to be mentioned. This is a data of 2 minutes and 30 seconds. For the ease of computation, we pre-processed and reduced the data to 2100 tuples without losing any potholes. This training data is collected in the form of .csv file.

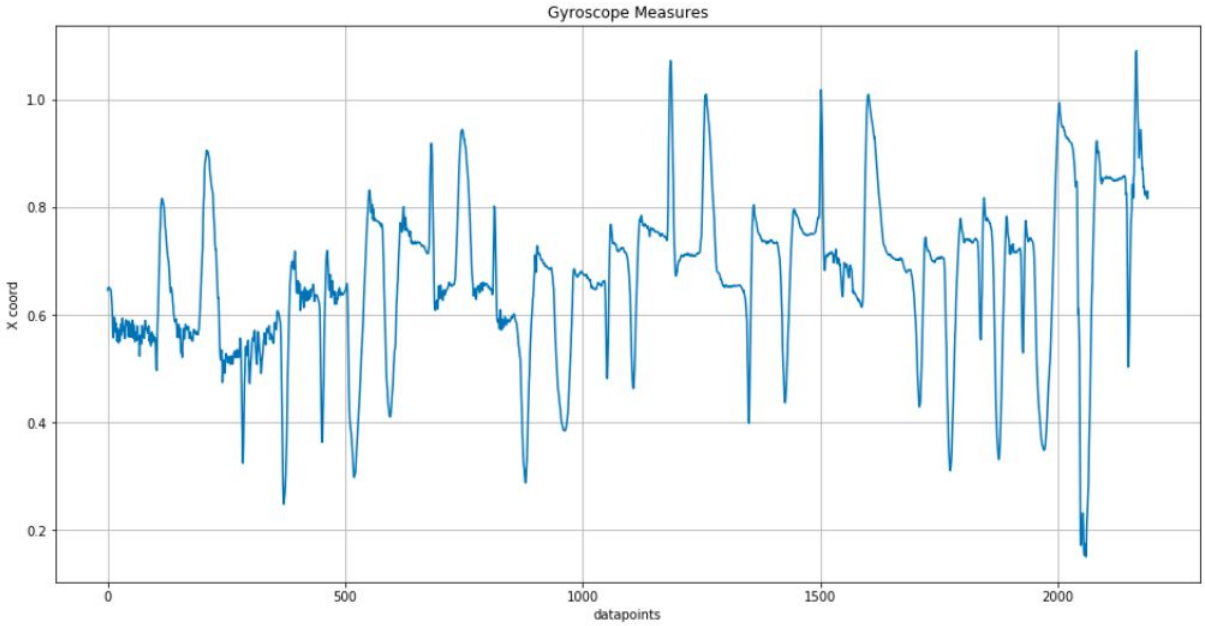
Gyroscope

(Fig1) This is a visual representation for Gyroscope axes.

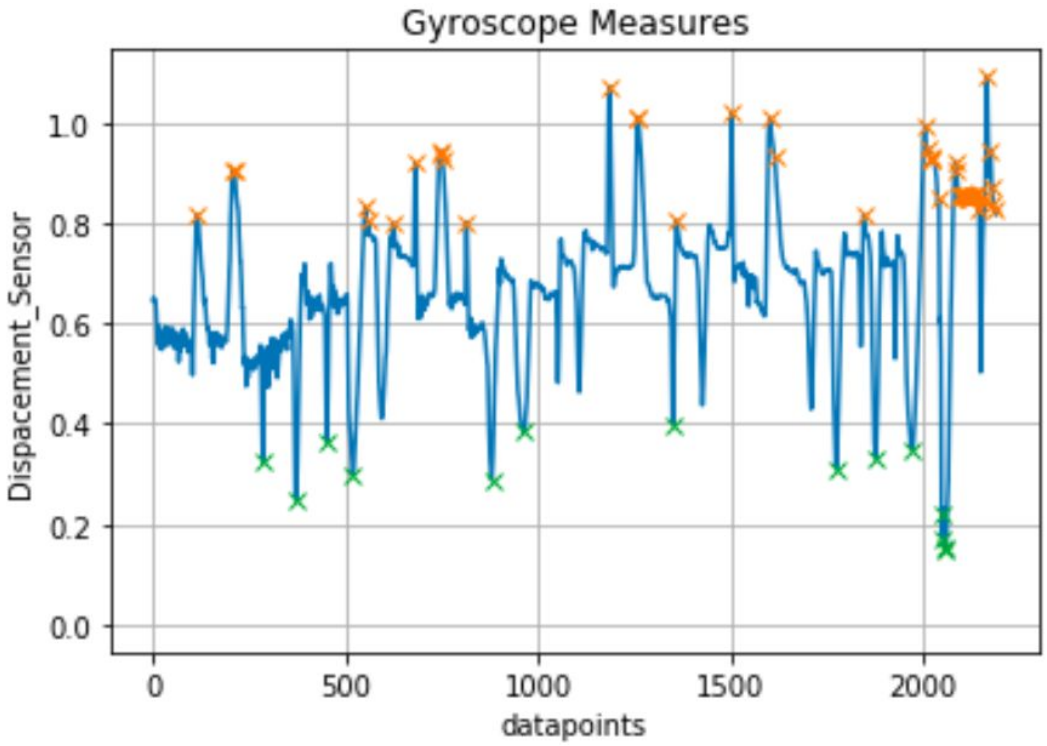


- ***Data analysis and pothole detection:*** This particular parts deals with the Exploratory data analysis. By plotting the curve for the features we inferred out that the data consisted of “small amplitude ripple patterns” which are specifically observed because of the mechanical vibration offered by the vehicle while moving. Then, we had relatively higher peaks that are mainly present in the 2 quartile and 3 quartile of the range. We concluded it as the mean value, and we considered the data points belonging to the 4 quartile as the “PotHole_Hit” points which needs to be taken care of. A threshold is determined by the mean value in the direction of -y to show the presence of pothole.

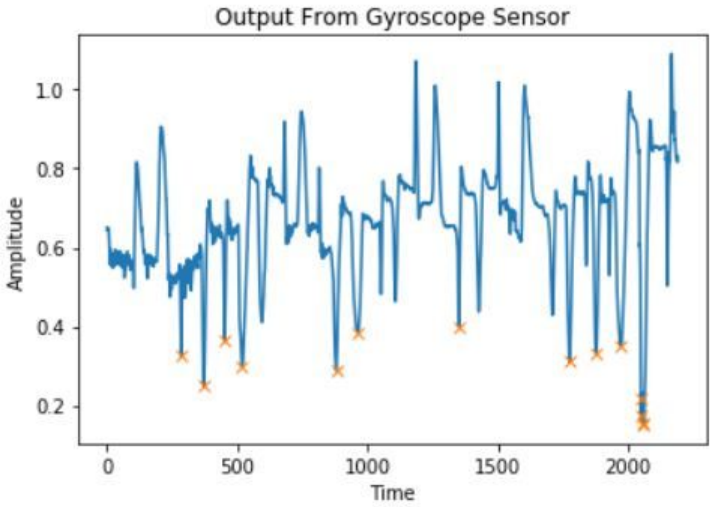
  This when trained by ML algorithms give more appropriate results.



(Fig2) The above figure shows the original data pattern of Data that was collected through X- Axis of the Gyroscope sensor. As we can observe at each pothole there is a considerable dip in the graph and the time interval depends upon the velocity of the device.



The above figure shows the identified peaks which are greater than a threshold value. These threshold value are defined by taking the mean of all data points and maximum value in case of bumps and minimum value in case for potholes. The lower peak (negative Y-axis) represent the pothole. Higher the magnitude of the dip, higher is the risk factor. This can be easily seen from the following figure.



- ***Real-time broadcasting***

  The processed data is now dumped into a csv file and converted to json file for further processing. The json file is hosted on the web server (eg. AWS web server).

  A jsp file is created which takes the above generated JSON file as the input, and marks the latitude and longitude of the detected potholes on the google map through the Google Map API. It can be further extended to include the magnitude of the potholes and customize the map using circle size and heatmaps. Furthermore, the map also plots the current location of the vehicle(through mobile) using the api of geolocation.

  This JSP file is again hosted on the AWS web server and ensures collection of real time data at regular intervals of 10 sec. Thus people can get real time updates of the approaching potholes, which can alert them, and hence lead to reduction of road accidents.

The red marks show the location of potholes in the vicinity of the vehicle's location.

For *detecting potholes under the car* which cannot be detected using the vibrations measured using the sensors. Thus we use **ultrasonic sensor** to detect the actual depth of car from the road.

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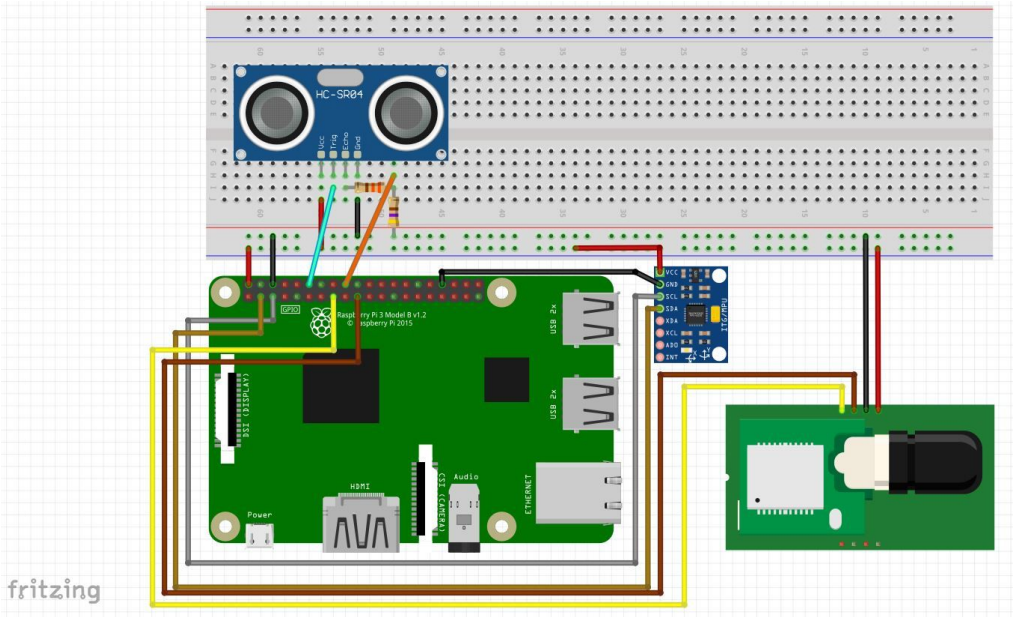
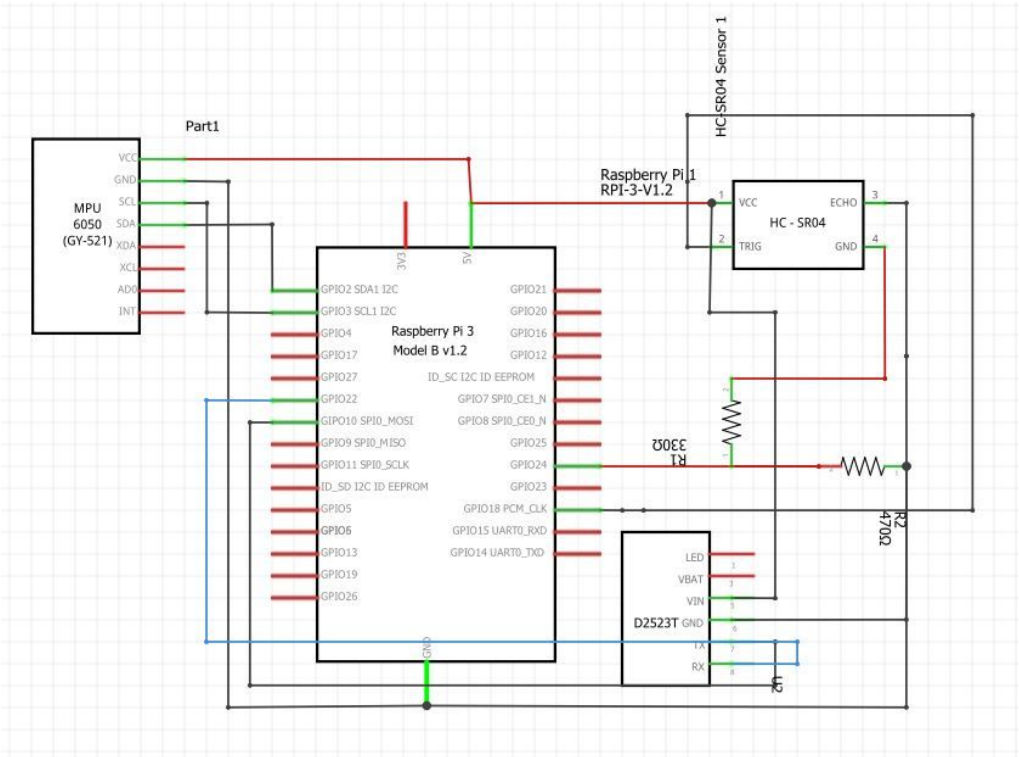
Schematics and Circuit Design





Modules:

- GSM Module
- Gyroscope and Accelerometer Sensor
- Ultrasonic Sensor
- Raspberry Pi 3

Future Scope

This integration of sensors and real time data processing offers great potential benefits in the future. If the required time is put in towards building this pothole detection system, then it can save a lot of lives by preventing road accidents. It can be further extended in every dimension, which have been discussed in the report throughout, like:-

1) Addition of more features for the detection of potholes, like taking into consideration the width of the road, timestamp, etc, which would reduce biases and lead to more precise prediction of potholes.
2) Using machine learning algorithms like SVM to test the further gathered data based on the hypothesis, trained through training set. This can provide us with real time prediction of potholes, along with timestamp.
3) The timestamp can also be used to inform the authorities of the severe potholes, which require immediate repair, and notify them based on the timestamp if the action hasn't been taken within a stipulated time.

   Many more extensions can be made to this project in the future, in order to increase the scalability and the governance.

Result

Accidents due to pothole are growing and authorities are also not able to keep track of all the pothole. So this app can work as a saviour in this situation, by providing twin functionality of alerting the public of the approaching threat, as well as informing and reminding the authorities at regular intervals of these potholes which require quick repair. These can hence lead to a better, and safer road to drive upon.