A
PROJECT REPORT
ON

Pothole Detection Using Mobile Sensors

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CERTIFICATE

This is to certify that the project report entitled

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This is to certify that this is a bonafide work carried out under the supervision of Prof. **A. N. Kalal** and it is approved for the partial fulfilment of the requirements of Savitribai Phule Pune University for the award of the Degree of Bachelor of Engineering (Information Technology).

This project report has not been earlier submitted to any other institute or University for the award of any degree or diploma.

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ABSTRACT

India is a developing economy which has the second Largest roadways network and it covers more than 5,603,293 kilometres (approx.). Among the different transport systems about 75% population in India is dependent on Roadways. Properly Maintained roads contribute to nation's economy. Timely inspection and maintenance is necessary for improving durability and quality of roads and helps in reducing road accidents.

Every year countless accidents and deaths occur due to potholes which could have been preventable if there had been a prior warning or if the civic authorities were able to repair these potholes in time. With this system can help in reduction of road accidents and save human lives on Indian roads. Our system will identify pits on the road by utilizing accelerometer and GPS of the Smartphone placed on the vehicle. The system will process this data using the designed algorithm and transfer the collected data (in some time intervals) to the database via internet. The data then will be utilized to classify pits into different degree (low, medium, high) which can be used by authorities to identify and to provide necessary maintenance to the roads.

We have compared the performance of various machine learning models (Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), Naive Bayes, Decision Tree, Random Forest and Ensemble Voting)for designing such system based on different parameters (Accuracy, F-score, Precision and Recall) and identified that Random Forest is the best model for pothole detection.

Keywords : Support Vector Machine(SVM), Accelerometer, GPS, Pothole detection.

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Chapter 1

INTRODUCTION TO "POTHOLE DETECTION USING MOBILE SENSORS"

1.1 Introduction to Project

INDIA, the second most populous Country in the World and a fast growing economy, is known to have a gigantic network of roads. Roads are the dominant means of transportation in India today. They carry almost 90 percent of country's passenger traffic and 65 percent of its freight. However, most of the roads in India are narrow and congested with poor surface quality and road maintenance needs are not satisfactorily met. No matter where you are in India, driving isa breath-holding, multi mirror involving, potentially life threatening affair. Pathetic condition of roads is a boosting factor for traffic congestion and accidents. Roads in India normally have speed breakers so that the vehicle's speed can be controlled to avoid accidents. However, these speed breakers are unevenly distributed with uneven and unscientific heights.

One approach to road damage detection is to use human reports to central authorities. While it has the highest accuracy, assuming that people are fair, it also has the most human interaction and is not comprehensive. Statistical analysis can be used to estimate damage probabilities of road segments based on their usage intensity. Integration of vibration and vehicle counting sensors in the pavement are used for statistical data collection.

In the past few years, researchers have proposed various solutions to some of the aforementioned challenges. These solutions leveraged several technological tools such as roadside sensors, vehicular sensors, and smartphone sensors.

The system utilizes acoustic and radar sensors to measure tire vibrations and accordingly detect road surface anomalies such as potholes and bumps by their features. In addition, optical sensors are used to differentiate between the types of

defects and confirm the validity of detected anomalies. Even though this system accurately detects road anomalies, it requires costly modifications to the vehicles, which may be prohibitive to some drivers.

To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and humps and also helps drivers to drive safely. With the proposed system an attempt has been made to endorse drivers to ward off the accidents caused due to potholes and raised bumps.

1.2 Problem Definition and Scope

1.2.1 Problem Definition:

To provide automatic pothole detection using machine learning (SVM).

1.2.2 Scope:

The scope of the project is to automatically detect the pothole through the sensors reading, sensors used are inbuilt in android smartphone such that gps, accelerometer, gyroscope.

1.3 Aim Objective

1.3.1 Aim:

Designing an automated system to detect pothole on road using android mobile sensors, using machine learning (SVM) algorithm.

1.3.2 Project Objective:

- To provide a system which will provide information about the pothole so that user will take proper prevention step.
- To inform a owner of vehicle about whether his driver driving vehicle in which condition.
- Pothole detection system using android phone proposes to utilize the GPS system of phone and different sensors like accelerometer, magnetometer, etc.

Chapter 2

Literature Survey

2.1 Literature Survey

ARUN KUMAR G, AJTH KUMAR A,SANTHOSH KUMAR A, MAHRAJOTH -IT. [1]

In this paper authors have proposed a system called Inexpensive Multimodal Sensor Fusion System for Autonomous Data Acquisition of Road Surface Conditions which is a field application of a novel, relatively inexpensive. It is shown that the proposed multi-sensor system, by capitalizing on powerful data-fusion approaches of the type developed in this paper, can provide a robust cost-effective road surface monitoring system with sufficient accuracy to satisfy typical maintenance needs, in regard to the detection, localization, and quantification of potholes and similar qualitative deterioration features where the measurements are acquired via a vehicle moving at normal speeds on typical city streets. This paper discusses previous pothole detection methods that have been developed and proposes a cost-effective solution to identify the potholes and humps on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. In this paper Pothole Patrol system uses 3-axis accelerometer and GPS mounted on the dashboard to monitor road surface. It not only identifies potholes but also differentiate potholes from other road anomalies. It collects the signals using accelerometer. It uses machine learning algorithm to identify potholes. These signals are then passed through a series of signal processing filters,

SHAHD MOHAMED ABDEL GAWAD, AMR EL MOUGY. [2]

In this paper authors have proposed system is implemented in a distributed way over two main entities: The smartphones of the users, and acloud-based backend server. At the smartphones, the functions of the system are implemented in a phone application

(an Android application is proposed as a proof of concept). This application utilizes readings from the phone's accelerometer and GPS sensors to perform road anomaly detection. To support the detection mechanism, a perception algorithm is also implemented in the application, and consists of a machine learning technique that calculates the detection threshold. At the cloud-based backend server, the detected anomalies are saved and forwarded to all other users of the system, where they are displayed on a map. The phone application also supports notifications to warn drivers of the presence of anomalies in their path. To calculate the confidence level of the detected anomalies, a reinforcement learning algorithm is implemented at the cloud server. This algorithm utilizes a proposed reward function, which is also able to "forget" anomalies which have not been reported for a period of time. This is implemented in order to detect maintenance work that fix road anomalies.

ARTIS MEDNIS , GIRTS STRAZDINS , REINHOLS ZVIEDRIS , GEORGIJS KANONIRS , LEO SELAVO .[3]

In this paper authors have proposed, In Preliminary data from the accelerometer sensors were collected using a modified LynxNet collar device on an urban road with various potholes. The device is based on Tmote Mini sensor node with Texas Instruments micro-controller MSP430F1611 and Analog Devices 3-axis accelerometer

ADXL335. In this method author used Pothole detection algorithm Z-THRESH, Z-DIFF, STDEV(Z), G-ZERO.

ETUKALA JASWANTH REDDY, PADHURI NAVANEETH REDDY, GOVINDULA MAITHREYI, M. BHARATH CHANDRA BALAJI, SANTANU KUMAR DASH, K. ARUNA KUMARI. [4]

In this paper authors have proposed system Arduino software from Arduino developer is used to develop program for many Arduino based devices. Node MCU is one such board that need to be imported and the program can be written in extensive languages like C, C++, Java, etc.

KASHISH BANSAL, KASHISH MITTAL, GAUTAM AHUJA, ASHIMA SINGH, SUKHPAL SINGH GILL .[5]

In this paper authors reported that very limited research work has been done using accelerometer or gyroscope sensors for classification of pothole data using various machine learning algorithms. proposed Mobile Sensing System (MSS) for road irregularity detection using Android OS based smart-phones and explored that an accelerometer can be used to classify potholes. They devised various algorithms for deployment on devices with low computational ability and their evaluation on the data acquired using different Android based smartphones. Using a scheme of identifying when the sensor readings reached a certain threshold value, they achieved true positive rates as high as 90% in the context of classifying different road irregularities.

In this paper authorsalso tbuild a real time map which is constantly updating with latest road conditions (presence of potholes). Further, We have compared various machine learning models (Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), Naive Bayes, Decision Tree, Random Forest and Ensemble

Voting) based on various performance parameters (Accuracy, F-score, Precision and Recall) and identified that Random Forest is the best model for pothole detection.

2.2 Comparison of literature survey

In following table we shown which technology used for existing system for implementation of system. In this existing systems mainly GPS, accelerometer, gyroscope, etc. Technology used for implementation purpose.

Sr. No	Title	Technology used	Description
1	Road Quality Management System using Mobile Sensors.	• IOT • GPS • Android Sensors	• Coordinated accelerometers can be used to measure differences in proper acceleration, particularly gravity, over their separation in space; i.e., gradient of the gravitational field. This gravity is useful because absolute gravity is a weak effect and depends on local density of the Earth which is quite variable.
2	Dynamic Mapping of Road Conditions using Smartphone Sensors and Machine Learning Techniques.	• Machine Learning – Perception Algorithm	• Inside the vehicle, the mobile device moves relative to the motion of the vehicle. This allows us to monitor the vehicle's motion using the smartphone's accelerometer, which is a motion sensor that measures acceleration readings in the 3 X, Y and Z axes. Here, the Z- axis readings indicate the vertical

			acceleration of the vehicle, given that the smartphone is placed horizontally on the dashboard, aligning its z-axis with that of the vehicle. • In this refered paper machine learning -perception algorithm used for detection of potholes.
3	Real Time Pothole Detection using Android Smartphones with Accelerometers.	• Pothole detection algorithm Z-DIFF • Pothole detection algorithm Z-THRESH. • Pothole detection algorithm STDEV(Z) • Pothole detection algorithm G-ZERO.	• In this proposed paper author used visual data analysis tools and searching for specific data patterns authors found that there exist certain events characterized by specific measurement tuple. • Threshold values between 0.1g and 0.8g were used for tuning the Z-DIFF algorithm. • However, the window sizes and specific threshold levels had to be determined for the tuning of the algorithm and especially for pothole event detection.
4	Development and Analysis of	• Arduino IDE	In this paper potholes are detected using NodeMCU

	Pothole detection and Alert based on NodeMCU	• NodeMCU	• NodeMCU : Initially Node MCU should be connected to a Wi-Finetwork so that it can have access to internet and can be able to connect to the http client, in this system our http client is the webhooks server through which we need send the location information .
5	DeepBus: Machine learning based real time pothole detection system for smart transportation using IoT	• Machine Learning	• In this paper auther compared the performance of various machine learning models (Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbors(KNN), Naive Bayes, Decision Tree, Random Forest and Ensemble Voting) based on different parameters (Accuracy, F-score, Precision and Recall) and identified that Random Forest is the best model for pothole detection.

Chapter 3
Requirement And Specification

3.1 System Requirement

The Proposed System requires followings Hardware and Software

3.1.1 Software Requirements

- Operating system : Windows 7/10
- Coding Language : Java, PHP
- Local database : Xampp server
- Android Application IDE : Android Studio 4.1
- JDK 1.8 or above

3.1.2 Hardware Requirements

- Android Smart Devices : 2
- Android OS : 6 or above
- Android Devices Ram : 2GB and above
- Atleast 20 GB Hard-disk

3.2 Specification

1. Android

- Android is a mobile operating system based on a modified version of the Linux kernel and other open source software, designed primarily for touchscreen mobile devices such as smartphones and tablets.
- Android is developed by a consortium of developers known as the Open Handset Alliance, with the main contributor and commercial marketer being Google.

2. PHP

- PHP is nothing but Personal Home Page.It is a server side scripting language designed primarily for web development.
- PHP code is embedded into HTML code and it can be used in combination with various web template systems.

3. Java :

- Java is a general purpose programming language i.e. class based; object oriented and design to have as few implementation dependencies as possible.
- Java is used in both software and web development.

4. FCM messages :

- Firebase Cloud Messaging (FCM) offers a broad range of messaging options and capabilities. The information in this page is intended to help you understand the different types of FCM messages and what you can do with them.

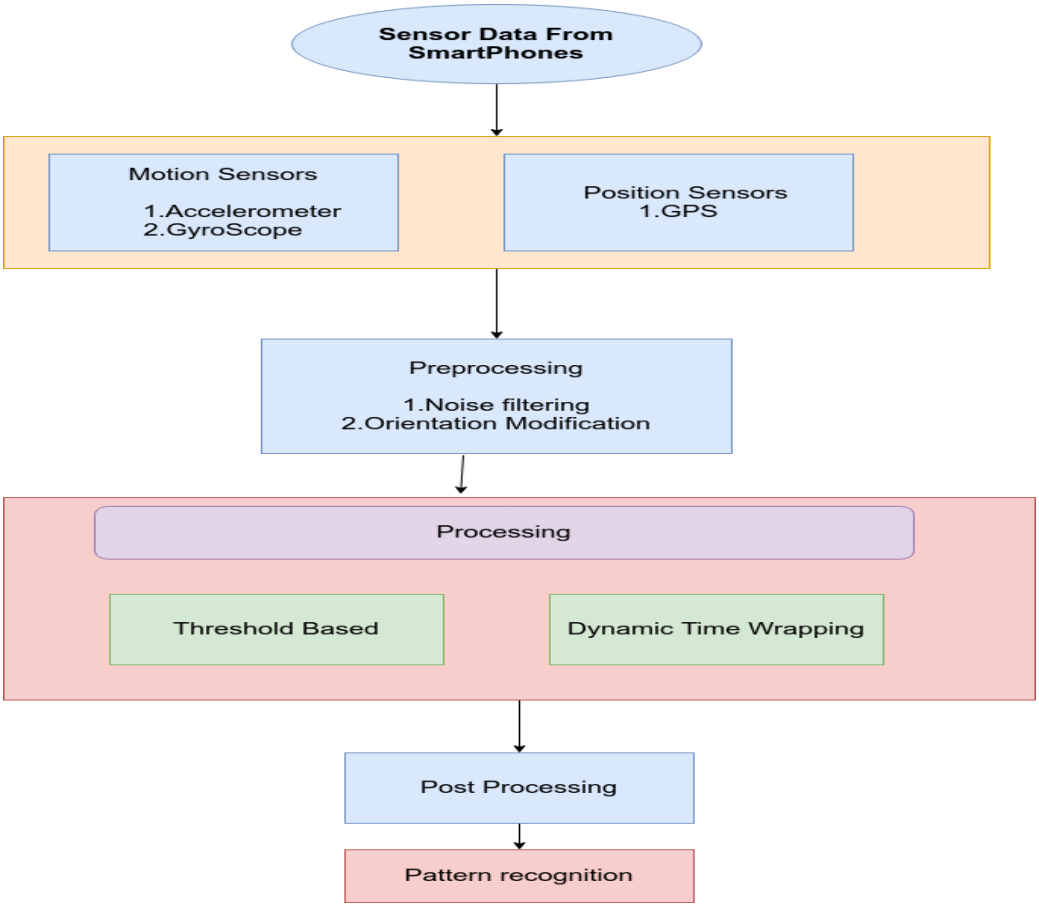
Chapter 4

System Design

4.1 System Architecture

The working of system is illustrated on this picture i.e step by step it is being described below:

In system architecture firstly sensors data collected with help of android smartphone sensors. To detect motion of vehicle accelerometer and gyroscope used. For position of vehicle GPS sensors are used.



4.2 Data Flow Diagram

A data-flow diagram (DFD) is a way of representing a flow of a data of a process or a system (usually an information system). The DFD also provides information about the outputs and inputs of each entity and the process itself. DFD describes the processes that are involved in a system to transfer data from the input to the file storage and reports generation.

Data flow diagrams can be divided into logical and physical. The logical data flow diagram describes flow of data through a system to perform certain functionality of a business. The physical data flow diagram describes the implementation of the logical data flow.

4.2.1 DFD Level 0 :

In DFD level 0 this is car alert module which can perform sending user details to owner.

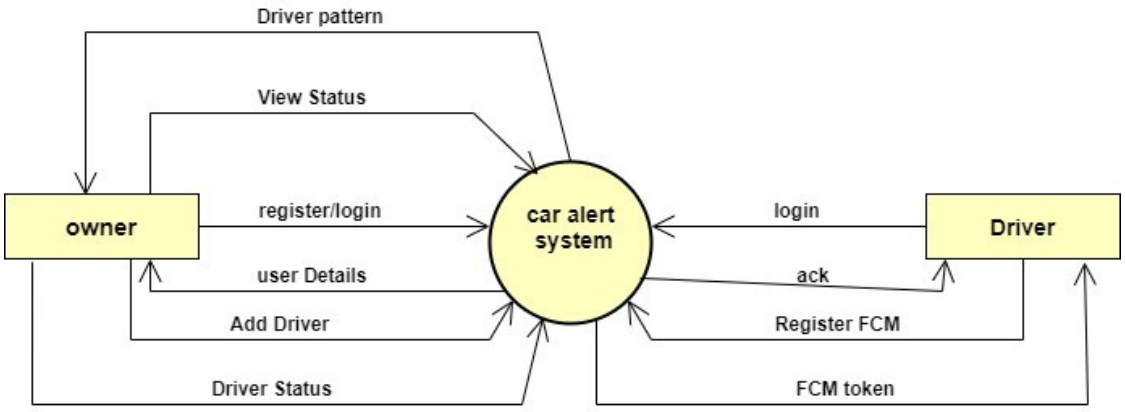


Figure 4.2: DFD (Level 0)

4.2.2 DFD Level 1 :

In DFD level 1 in this diagram owner module described which can send request to database server to access driver details. Also owner module able to access driver pattern, send acknowledgement as well as send driver status to owner.

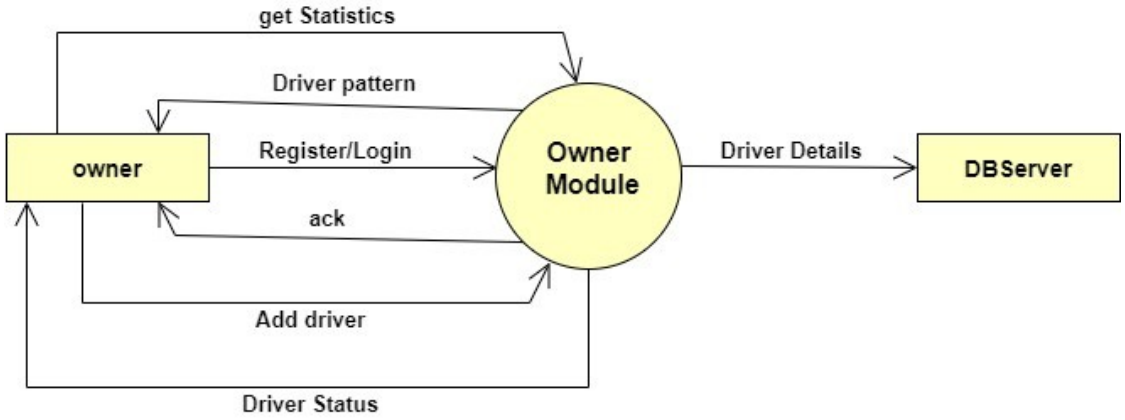


Figure 4.3: DFD (Level 1)

4.2.3 DFD Level 2 :

In DFD level 2 in this diagram driver module described which can send driver details to database also send alerts to database.

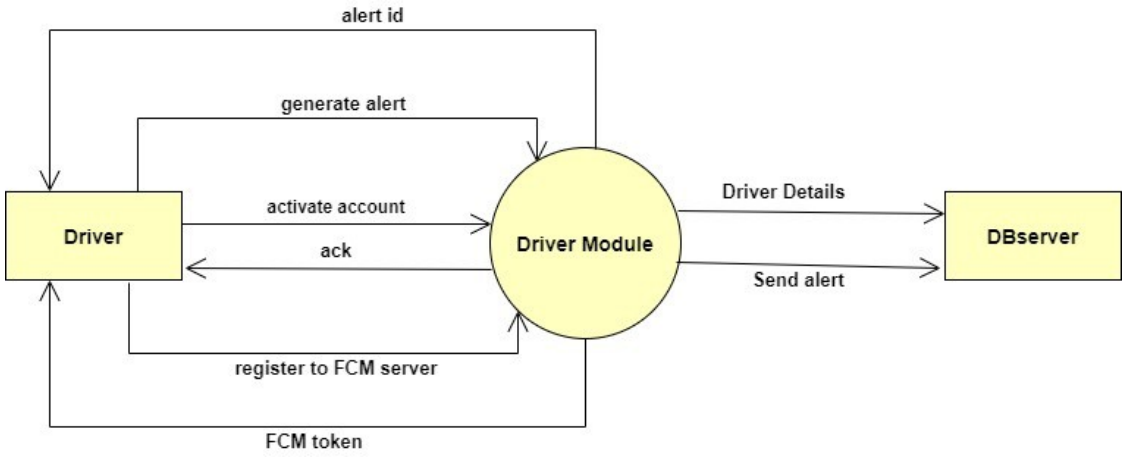


Figure 4.4: DFD (Level 2)

4.3 Use Case Diagram

Use case diagrams consists of actors, use cases and their relationships. The diagram is used to model the system/subsystem of an application. A single use case diagram captures a particular functionality of a system. Hence to model the entire system, a number of use case diagrams are used.

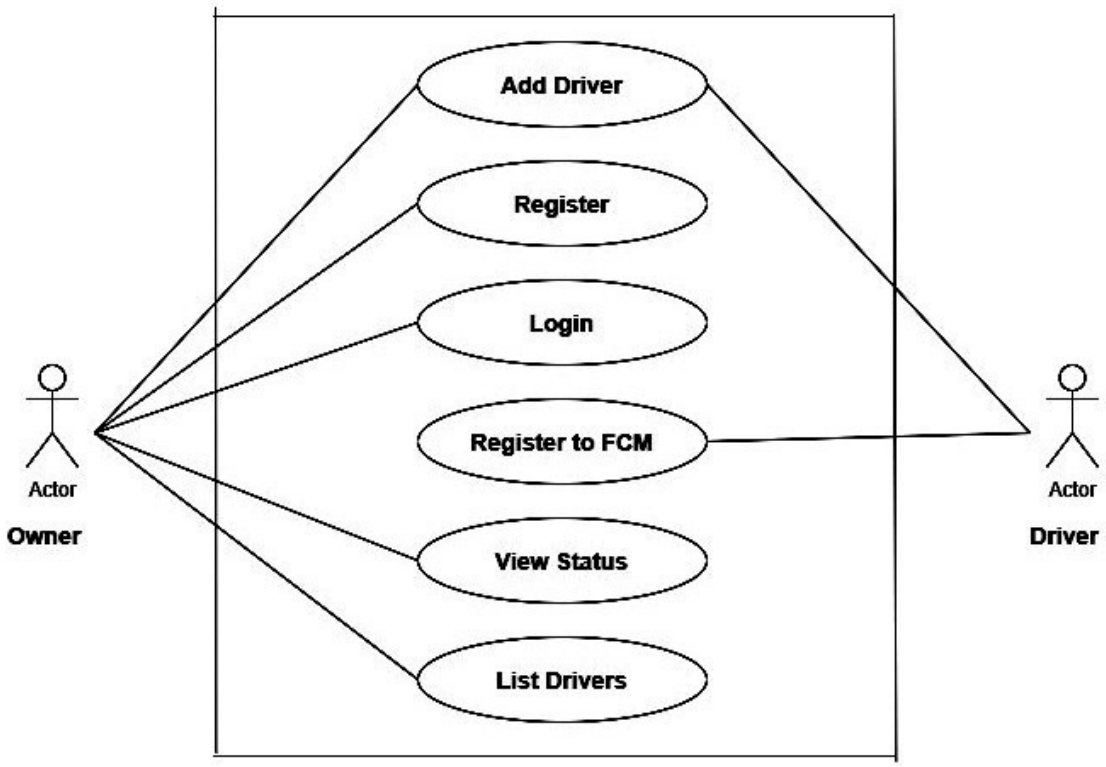


Figure 4.5: Usecase Diagram of system

4.4 Activity Diagram

Activity diagram is defined as a UML diagram that focuses on the execution and flow of the behaviour of a system instead of implementation. It is also called object-oriented flowchart. Activity diagrams consist of activities that are made up of actions which apply to behavioural modelling technology.

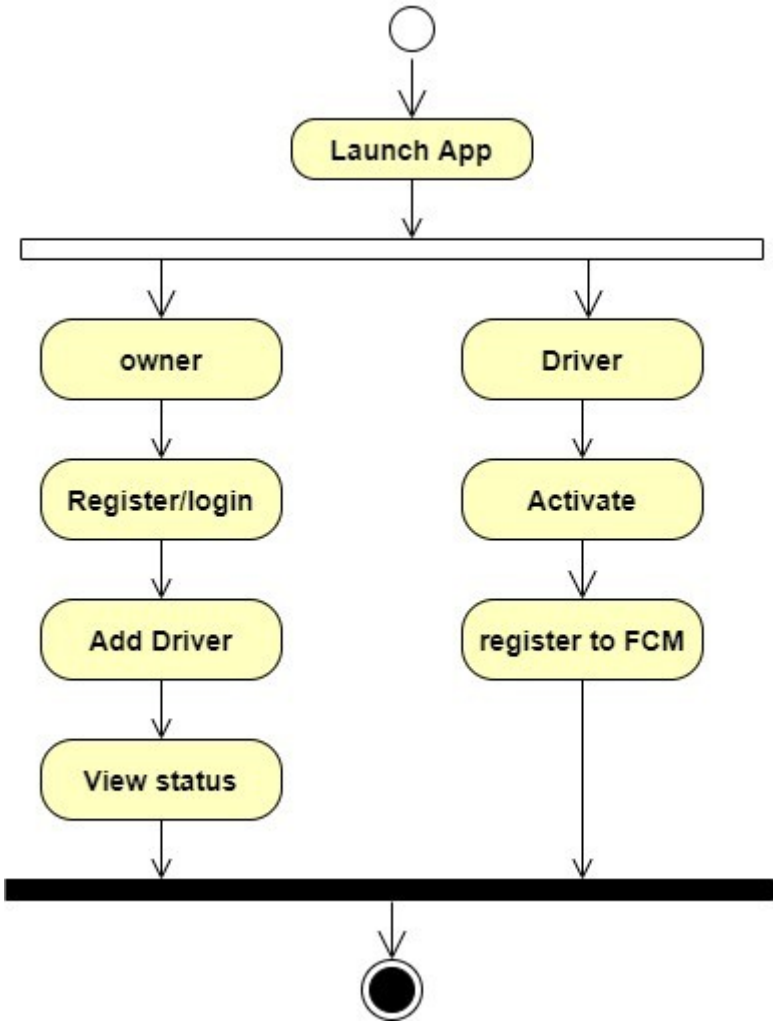


Figure 4.6: Activity Diagram

4.5 Sequence Diagram

A sequence diagram simply depicts interaction between objects in a sequential order i.e. the order in which these interactions take place. We can also use the terms event diagrams or event scenarios to refer to a sequence diagram. Sequence diagrams describe how and in what order the objects in a system function.

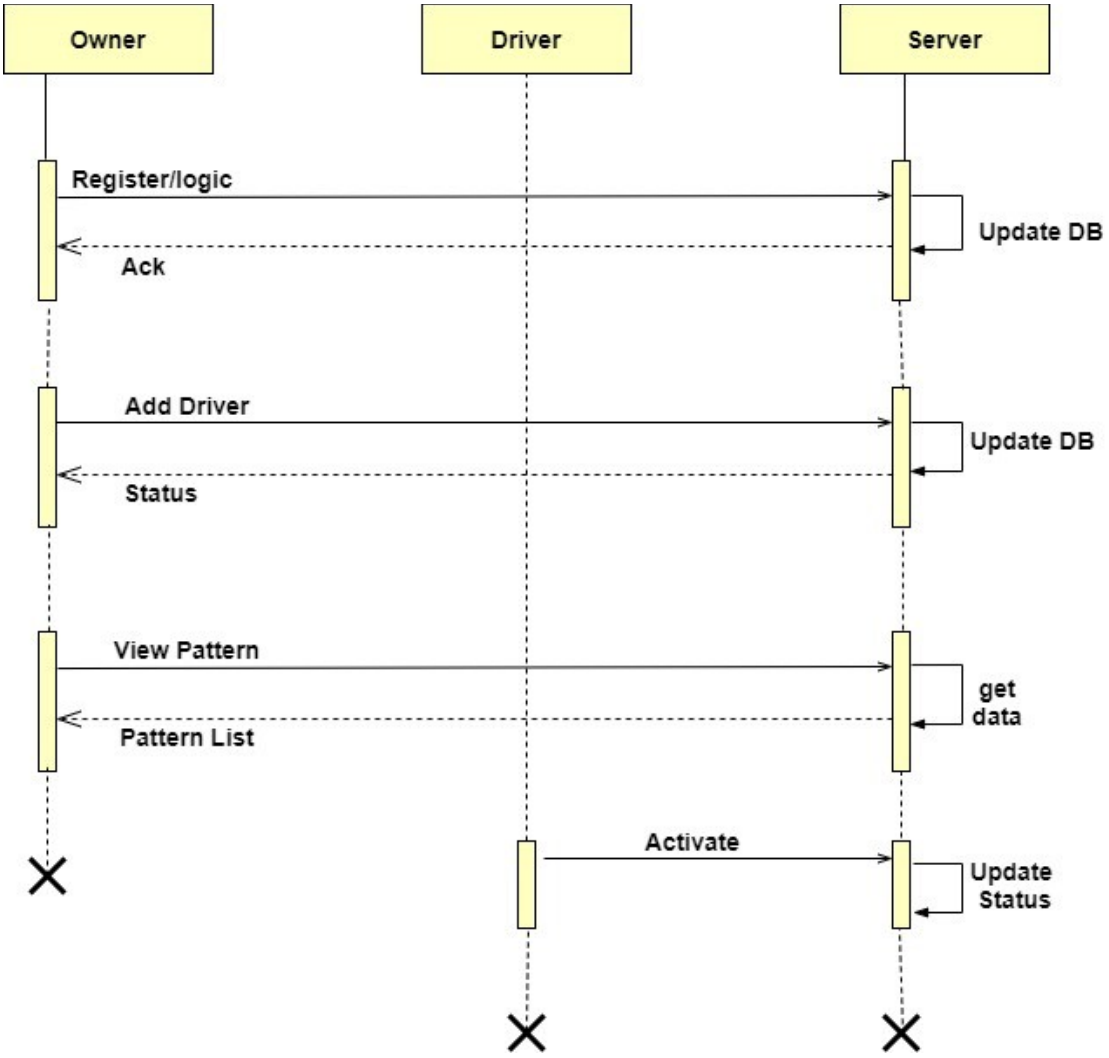


Figure 4.7: Sequence diagram of system

Chapter 5

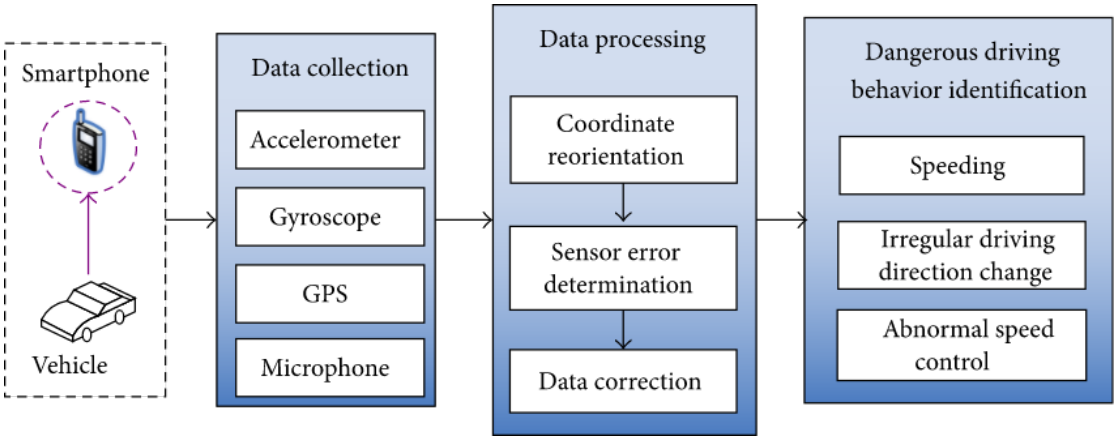
System Implementation

5.1 Algorithm

5.1.1 Support Vector Machine(SVM):

A) SVM

Support vector machines (SVMs) are a set of supervised machine learning methods used for classification, refression and outlier detection.



5.1 Data Collection and Data Processing

The advantages of support vector machines are:

- Effective in high dimensional spaces.
- Still effective in cases where number of dimensions is greater than the number of samples.
- Uses a subset of training points in the decision function (called support vectors), so it is also memory efficient.
- Versatile: different kernel functions can be specified for the decision function. Common kernels are provided, but it is also possible to specify custom kernels.

The disadvantages of support vector machines include:

- If the number of features is much greater than the number of samples, avoid over-fitting in choosing kernel functions and regularization term is crucial.
- SVMs do not directly provide probability estimates, these are calculated using an expensive five-fold cross-validation.

B) Threshold Algorithm (Steps):

Step-1 : Register to mobile's sensor listener.

Step-2 : Capture sensors values <x,y,z> using accelerometer.

Step-3 : Calculate force on axis as gX=x/gravity.

Step-4 : Calculate gForce as SqureRoot(gX*gX+gY*gY+ gZ*gZ)

step-5 : Compare gForce with threshold(3.25) if it is greater than threshold raise event.

Chapter 6

Results and Evaluation

6.1 Testing Modules for proposed system

1. Unit testing :

Unit testing is a level of software testing where individual units components of a software are tested. The purpose is to validate that each unit of the software performs as designed. A unit is the smallest testable part of any software. It usually has one or a few inputs and usually a single output. In computer programming, unit testing is a software testing method by which individual units of source code, sets of one or more computer program modules together with associated control data, usage procedures, and operating procedures, are tested to determine whether they are fit for use.

2. Component testing :

Component testing is defined as a software testing type, in which the testing is performed on each individual component separately without integrating with other components. It's also referred to as Module Testing when it is viewed from an architecture perspective.Component-based usability testing is a testing approach which aims at empirically testing the usability of an interaction component. The latter is defined as an elementary unit of an interactive system, on which behavior-based evaluation is possible.

3. Integration testing :

Integration testing is a level of software testing where individual units are combined and tested as a group. The purpose of this level of testing is to expose faults in the interaction between integrated units. Test drivers and test stubs are used to

assist in Integration Testing.Integration testing is the phase in software testing in which individual software modules are combined and tested as a group. Integration testing is conducted to evaluate the compliance of a system or component with specified functional requirements. It occurs after unit testing and before validation testing.

6.2 Analysis of System :

Sr No.	Parameter	Existing System	Proposed System
1	Time required to use system	Different application use there for it is time consuming	Different module are used in one system hence it is Save time
2	Use of system	No GUI present.	User can be handle easily. User friendly GUI.
3	Flexibility of system	Changes may not easily make.	Changes made by developer only.

6.3 Testing

Software testing methods are traditionally divided into white box testing and black box testing. These two approaches are used to describe the point of view that a test engineer takes when designing test cases. Testing a project or any software system forms the backbone of a good software system. Tests are conducted on the software to find out errors and bugs and remove them. Test plans are created with a view to remove errors that can plague or hamper the project in case the errors are encountered in runtime environment. A good test plan is created with a view to try to disintegrate a system to find out yet undetected errors and to correct them. Testing of software is

done at each module and also at the macro level, that is, on integration of the entire package as a whole. A good test plan is the one which can detect maximum number of errors or bugs in the software system. Testing helps in enhancing the overall quality of the product as it helps in removal of errors which in turn increase its quality.

6.4 Goals and Objectives of Testing

As said earlier, a good test plan is made with a view to find the maximum number of errors. The goals and objectives to be taken into consideration while testing any software system are as follows:

1. Extensive testing must be done with a view to uncover maximum number of errors.
2. Try to break down the system by giving it a variety of values with a view to find hidden bugs.
3. Testing every module in the project at the internal level as well as the boundary level.
4. Using various testing tools and strategies like black box and white box testing.
5. Removing errors and testing again for any unforeseen changes in the entire software product.

6.5 Scope of Testing

Testing involves a very broad scope and has many advantages. Proper testing can help previously uncovered errors which may have been harmful to the proper working of the system. Thus, a good testing strategy would be to have a number of test plans for each individual module and then to rigorously t4est the entire software product as a whole. A good testing strategy helps in eliminating errors and the overall quality of the software is increased.

6.6 Black Box Testing

Black box testing treats the software as a "black box"—without any knowledge of the internal implementation. Black box testing methods include: equivalence

partitioning, boundary value analysis, fuzz testing, all-pairs testing, model-based testing, specification-based testing, tracability matrix and exploratory testing.

Specification-based testing : Specification-based testing aims to test the functionality of software according to applicable requirements. Thus, the tester inputs data into, and only sees the output from, the test object. This level of testing requires thorough test cases to be provided to the tester, who then can simply verify that for a given input, the output value, either "is" or "is not" the same as the expected value specified in the test case. Specification-based testing is necessary, but it is not sufficient to guard against certain risks.

6.7 White Box Testing

White box testing is when the tester has access to the algorithms & internal data structures including the code that implement these. A level of white box test coverage is specified that is appropriate for the software being tested. The white box and other testing uses automated tools to instrument the software to measure test coverage.

Types of white box testing :

The following types of white box testing exist:

1. API testing (application programming interface) - Testing of the application using Public and Private APIs

2. Code coverage - creating tests to satisfy some criteria of code coverage (e.g., the test designer can create tests to cause all statements in the program to be executed at least once)

3. Fault injection methods - improving the coverage of a test by introducing faults to test code paths

4. Static testing - White box testing includes all static testing Code completeness evaluation White box testing methods can also be used to evaluate the completeness a test suite that was created with black box testing methods.

6.8 Test Case

1) Test Case Name : Login

Scenario Description : Login using entering email and password.

Test Case Id	Test Case Name	Test Case Description	Test Steps			Test Case Status	Test Case Status
			Steps	Expected Result	Actual Result		
1	Login	Enter email and password	Enter email	Update in database	Store in Database	Design	Pass
			Enter Password	Update in database	Store in Database		
			Click Login	Home Screen	Loggin Successfully		

Table 6.8.1: Test Case 1

2) Test Case Name : Pothole Detection

Scenario Description : This is dummy test case, due actual car non-availability. We tested with shaking the android device manually.

Test Case Id	Test Case Name	Test Case Description	Test Steps			Test Case Status	Test Case Status
			Steps	Expected Result	Actual Result		
2	Detect Pothol -es	Detection of potholes using shaking device	Shake android device	Generate alert for pothole detection	Pothole detection	Design	Pass

Table 6.8.1: Test Case 2

Results and Evaluation

A) Owner Side

In implementation part two algoritms are used support vector machine and Threshold based algorithm.

The application is designed for the purpose of getting notification to owner and driver and get information of potholes. Using this application owner can add new driver or remove driver.

6.1.1 Application Home Screen

Using home screen we provided three features for owner login, driver login, guest login without login using email and password.

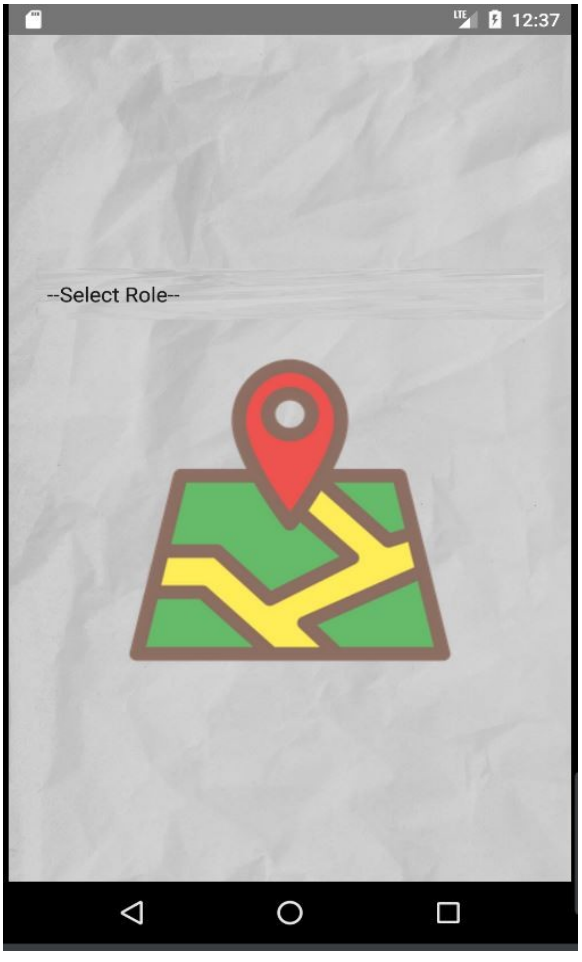


Figure 6.1.1: Application home UI

6.1.2 Guest Login Features

We can use this features in guest login which are start tracking of potholes and second features is using google map to show map of where potholes are detected.

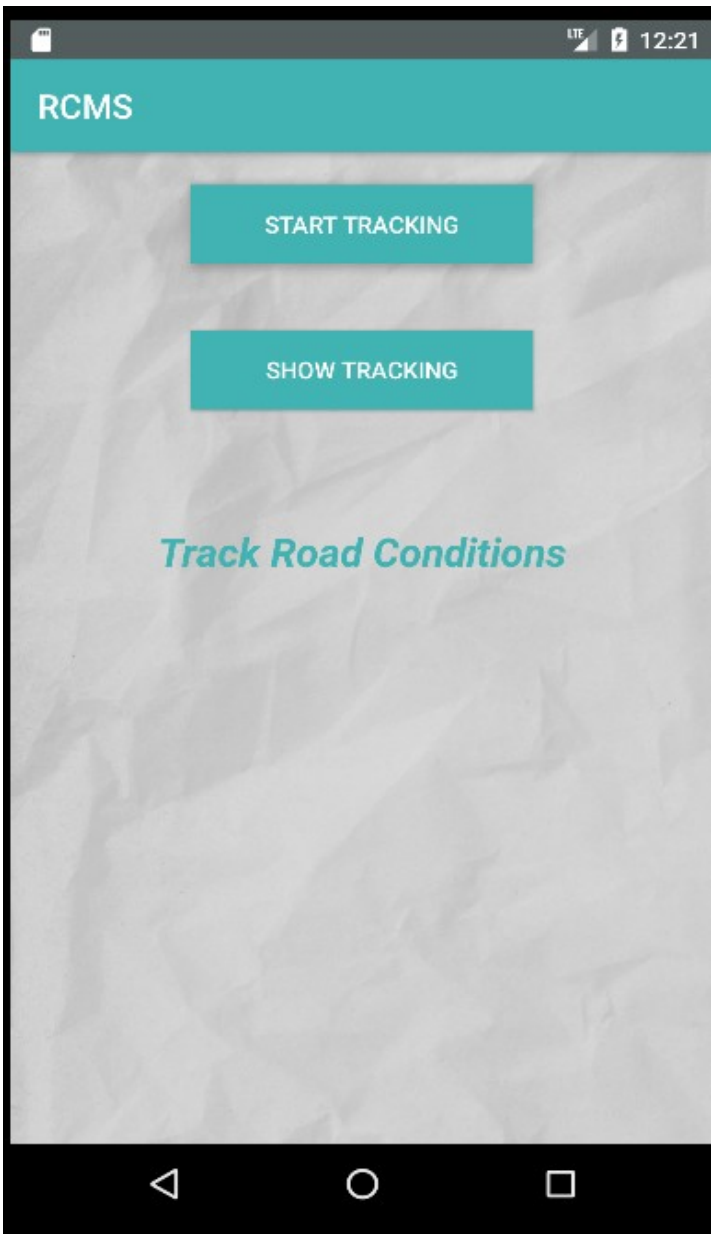


Figure 6.1.2: Guest Login Features

6.1.3 Owner Side After Login Features

We can use this features in owner side login which are used to see graph of alerts, potholes detected location, where sudden left taken ,etc. As well as we can add different emergency numbers.

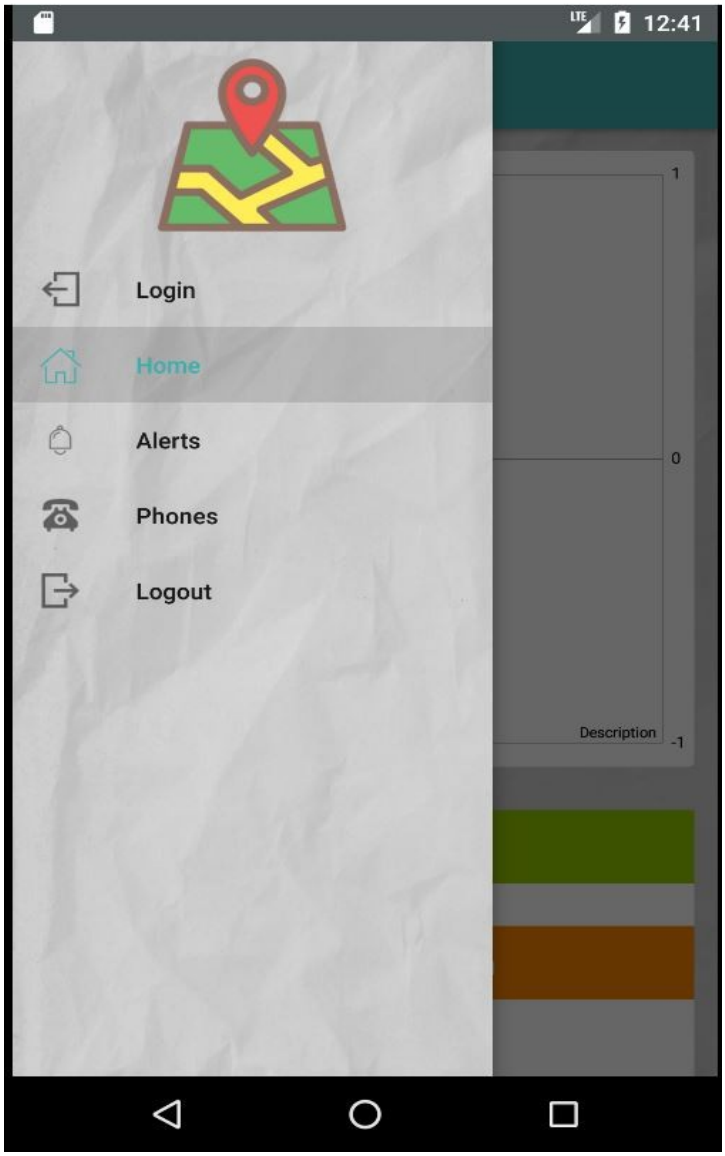


Figure 6.1.3: Login Side Features

6.1.4 Alert Graph View

After login in owner app we can see the graph of alerts which are updated in database which are always update by the driver side app in database.

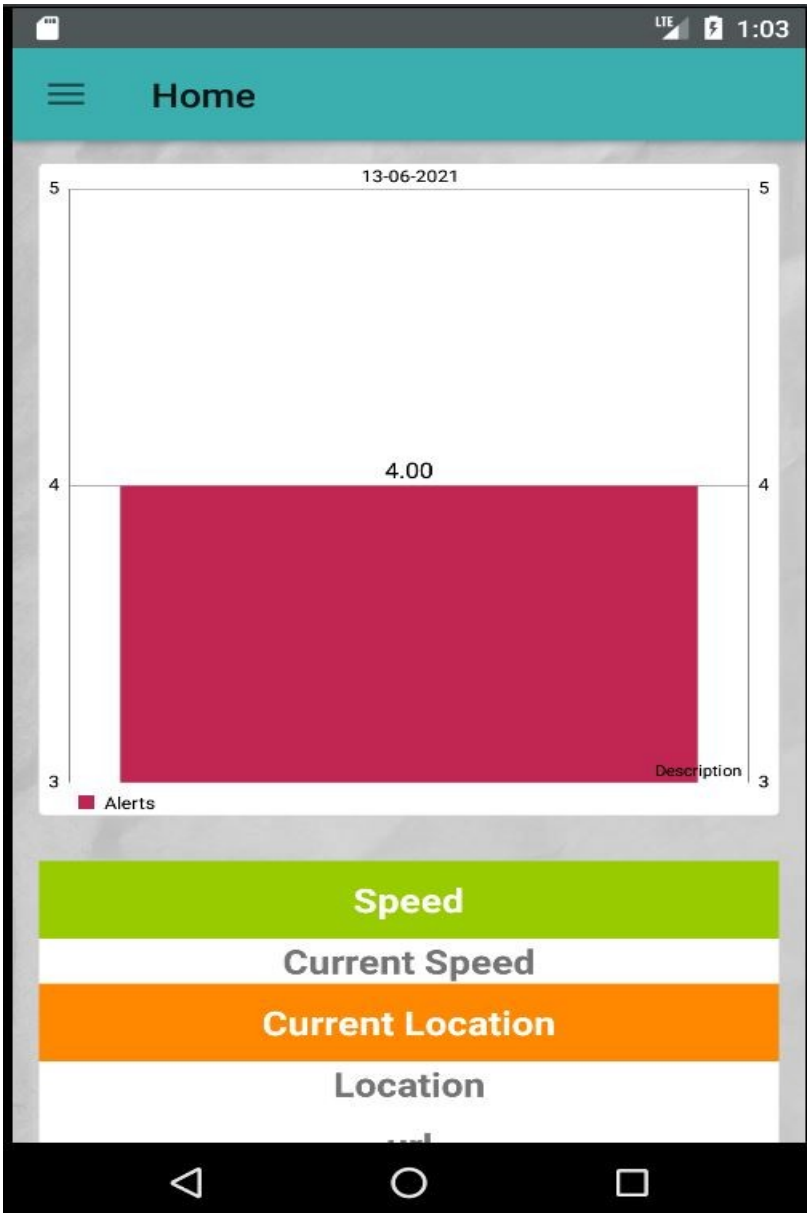


Figure 6.1.4: Alert Graph For Owner

6.1.5 Viewing Alert

We can see alerts which are updated from driver side.

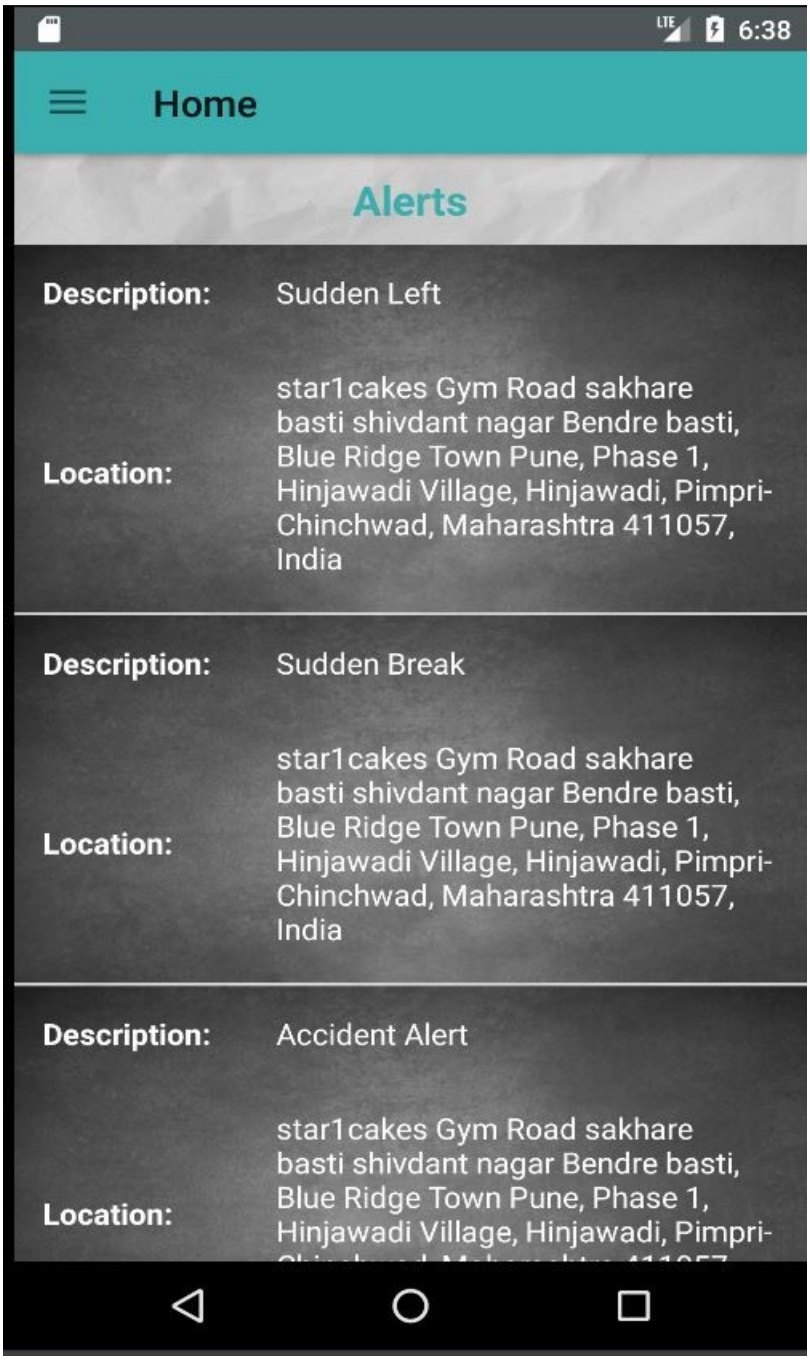


Figure 6.1.5: Alert Viewing

B) Driver Side

6.1.6 Driver Side Features

We can see here driver side features.

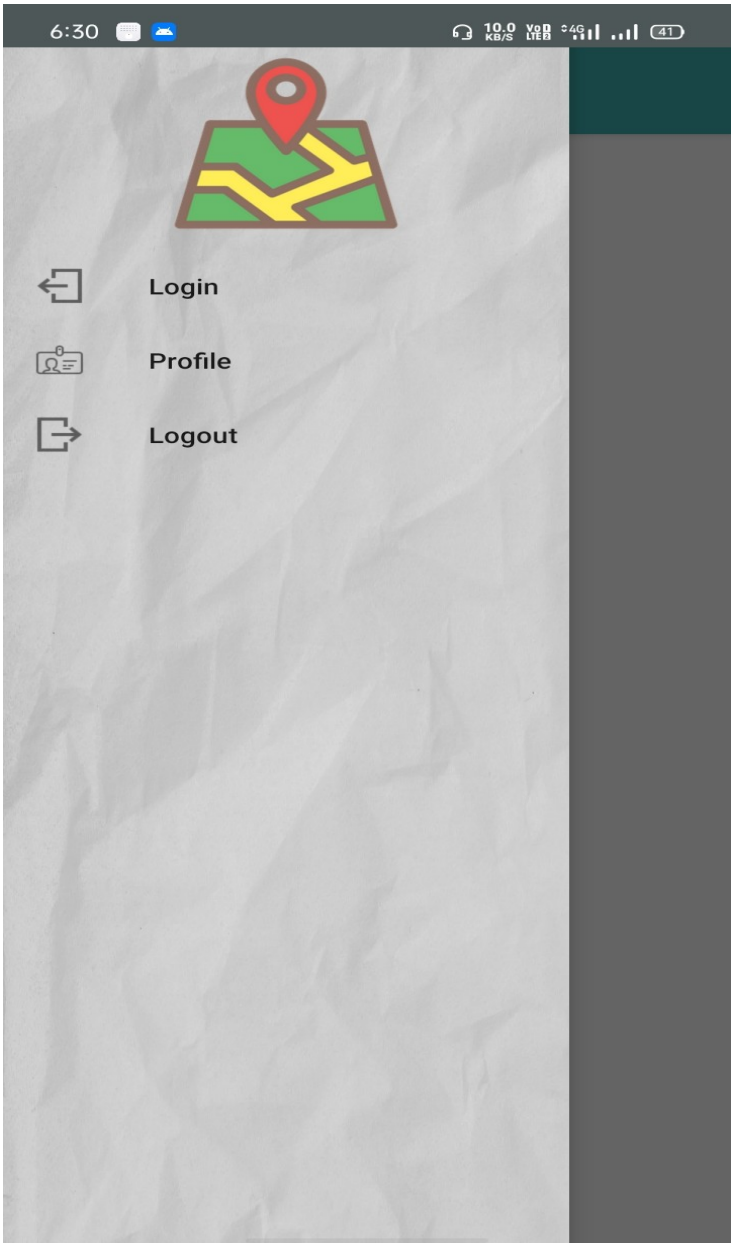


Figure 6.1.6: Login Side Features

6.1.7 Driver Side Registration

We can register the driver in system using first name, last name, emial, contact, password and owner email.

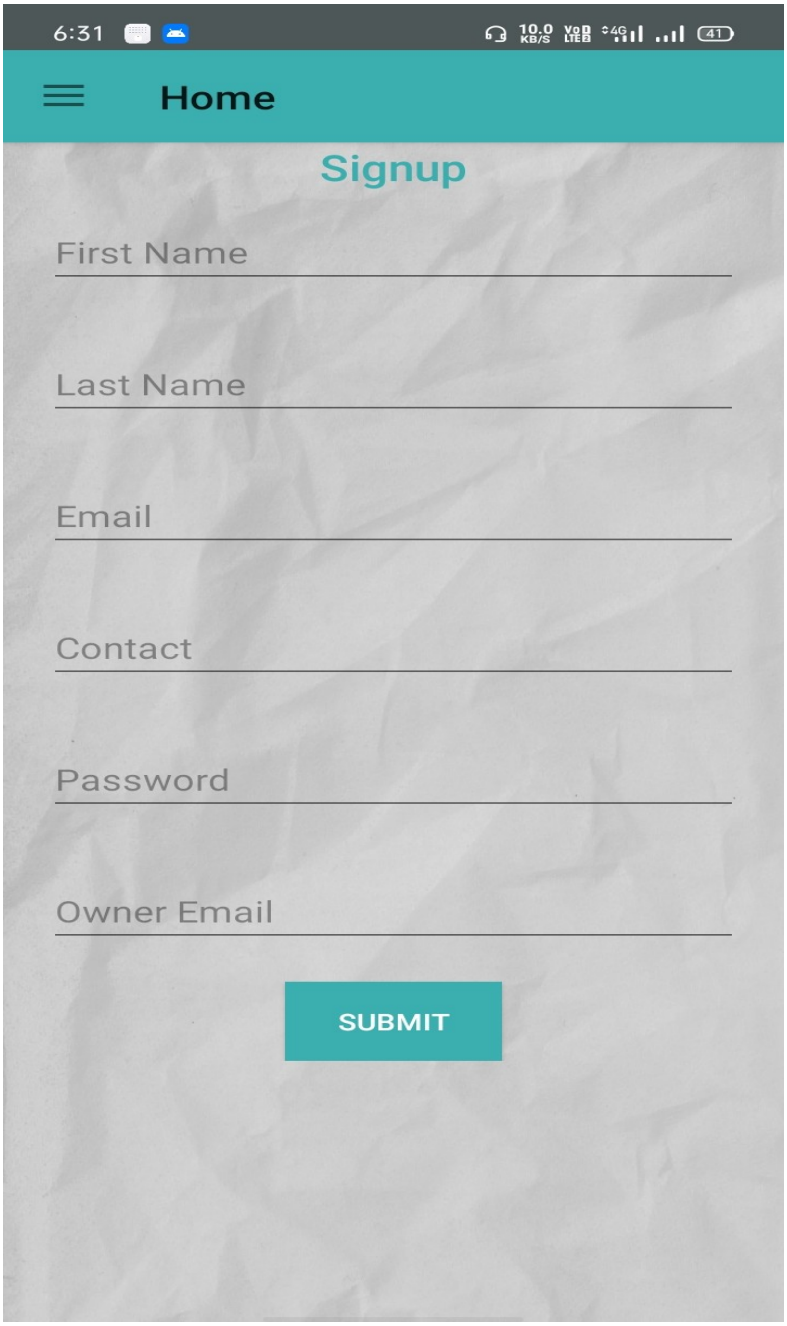


Figure 6.1.7: Registration Of Driver

6.1.7 Driver Side Login

We can login in the driver app using in system by entering emial and password.

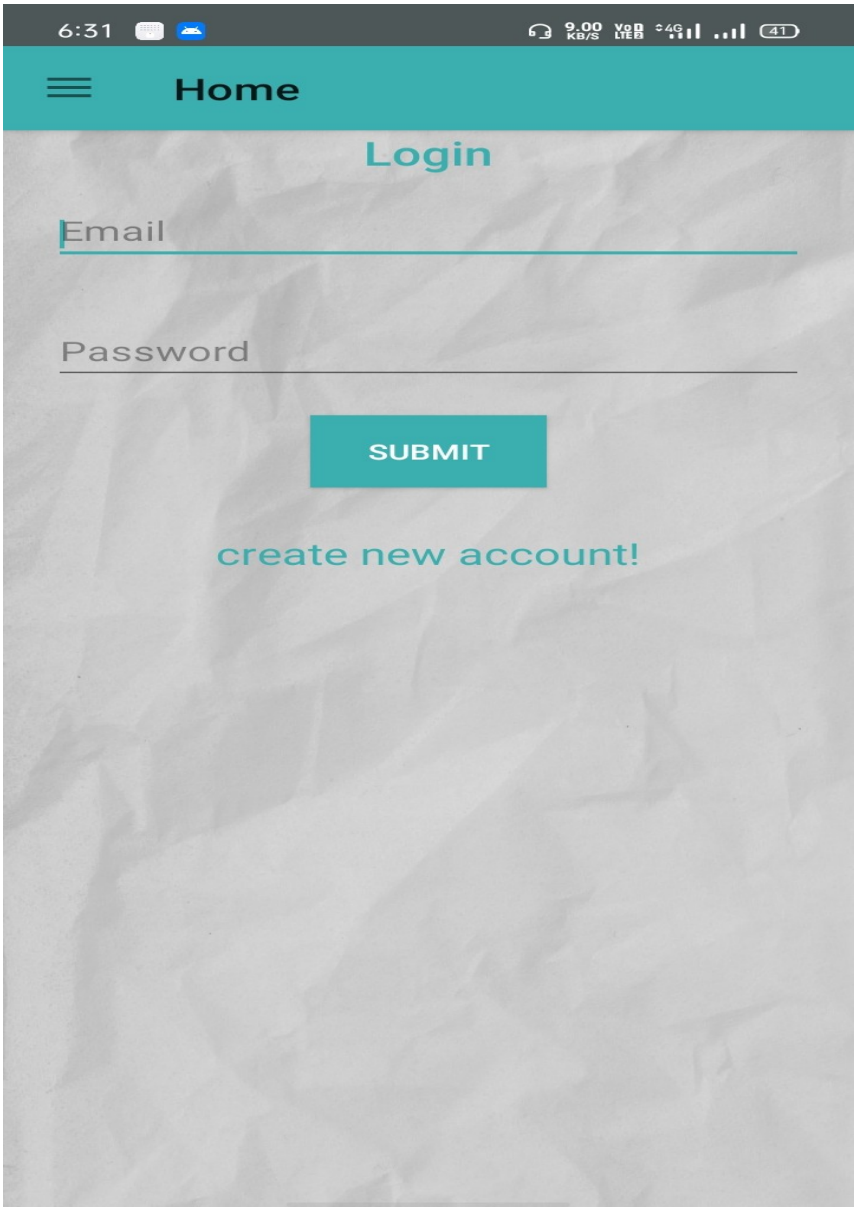


Figure 6.1.7: Login Of Driver

6.1.8 Driver Profile Viewing

We can view the driver profile details using feature called profile.

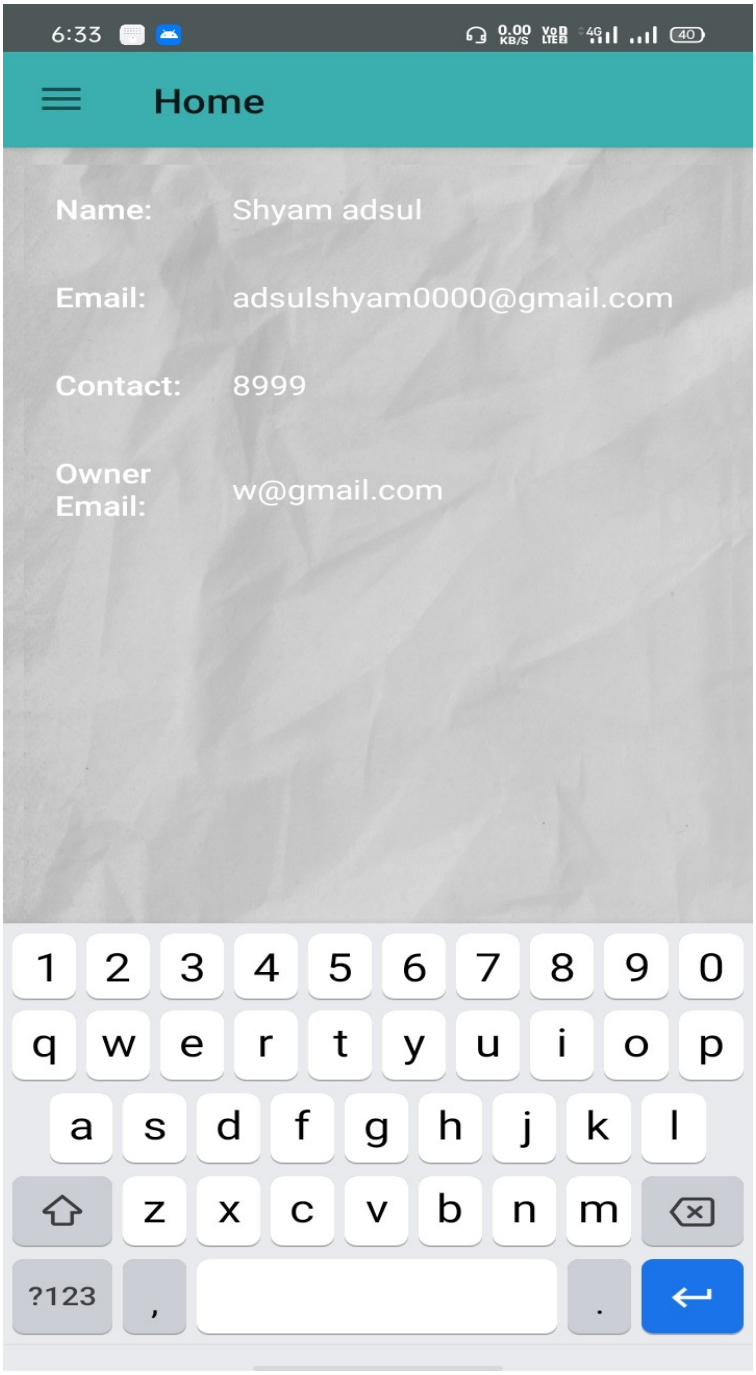


Figure 6.1.8: Driver Profile Viewing

Chapter 7

Conclusion

This system will be used to not only detect different potholes on the road but also provide the information related to potholes. system will Inform a user about whether they are driving rash or slow.

The aim of this system is to find out the location of potholes in the road using the mobile sensors. Android Smartphone sensors are having more importance in this project, as they are cost effective and increase scalability.

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List all the material used from various sources for making this project proposals

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