An Intelligent Smartphone Based Approach Using IoT for Ensuring Safe Driving

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

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Declaration

We, hereby, declare that the work presented in this thesis is the outcome of the research performed by us under the supervision of Amit Kumar Das , Lecturer, Department of Computer Science and Engineering, East West University. We also declare that no part of this thesis has been or is being submitted elsewhere for the award of any degree or diploma.

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Letter of Acceptance

This Thesis Report entitled *"An Intelligent Smartphone Based Approach Using IoT for Ensuring Safe Driving"* submitted by Mohd. Abdullah Al Mamun (ID: 2013-1-60-021) and Jinat Afroj Puspo (ID: 2013-1-60-037) to the Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh is accepted by the department in partial fulfillment of requirements for the Award of the Degree of Bachelor of Science and Engineering on August, 2017.

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Abstract

Road accident is a widespread problem all over the world. The number of the vehicle is increasing rapidly. As a result, the probability of accidents is also increasing simultaneously. So, it is important to ensure safe driving on the road. In this paper, we propose an IoT-based system for providing safe driving. This system will collect data using Smartphone and show the car driver about the overall condition of the road. In this modern era, Smartphone has become available to mass people and cheap. These days about 87.5% Smartphone is running on the Android operating system. Hence, we have developed an Android based application which will collect data from a vehicle and send it to its nearest IoT-Fog server for processing the data quickly. We also developed algorithms using k-means clustering approach which finds the location of Speed-breaker, bump, potholes, real-time accident/blockage and accident prone area of a road. After calculating the result, it will be sent to the driver's smart phone and shown in Google map of driver's Smartphone. The driver will also get alerted by voice while driving. The result and the data will be stored in Cloud for further use. We have tested our proposed system through numerical as well as experimental evaluations. Simulation result shows that our approach can provide better performance compared to state-of-the-art methods.

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As it is true for everyone, we have also arrived at this point of achieving a goal in our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one's mother language. Therefore, we would not like to make efforts to find best words to express our thankfulness other than simply listing those people who have contributed to this thesis itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

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There are numerous other people too who have shown us their constant support and friendship in various ways, directly or indirectly related to our academic life. We will remember them in our heart and hope to find a more appropriate place to acknowledge them in the future.

Mohd. Abdullah Al Mamun
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Table of Contents

List of Figures

List of Tables

List of Algorithms

Chapter 1

Introduction

1.1 Internet of Things(IoT)

In this era, Internet of Things is a popular term. IoT is a gigantic network connected by different devices which collect and shares data. IoT is used in different places like smart micro ovens, which cook food automatically for us in perfect time; self-driving cars, which detects objects in their path and avoid it; wearable fitness devices, which measure our heart rate and the number of steps we have taken, etc.

1.1.1 Working procedure of Internet of Things(IoT)

Here, different devices are connected to an IoT platform, it collects data from different devices and analyzes the data to share the most valuable information for computation and other use.

These strong IoT platforms can separate data between which is exactly need and which has to be ignored. This data is used detect possible anomalies before they happen, to make recommendations and to detect patterns. As an example, if we have a super shop business, we might want to know which products are popular and which are not. By using Internet of Things, we can:

- Use different sensors to detect which areas in the shop are crowded, which products are sold and which types of product are attracting to the customer;
- Analyze the available sales data to identify which products are selling fastest;

- Compare the sales data with the supply data, so that the most selling products don't go out of stock.

The information gathered using IoT devices help us to take right decisions about which product to stock, based on real-time information, This helps us both to save time and money.

1.2 Cloud computing

Cloud computing is a system which provides different services remotely. The users of cloud computing can access applications, stored data and software from everywhere and anytime, to access it they just need a device and Internet connection. These services are hosted by an outside party -"in the cloud." It means that the client does not have to think about their system's configuration, storage and power. They can only enjoy it. Cloud is a system that stores data from different devices and retrieves data to various devices from o?-site locations [1].It also performs calculations. It can process an enormous amount of data in a short time. It can handle a large amount of data smoothly. Also, cloud computing allows to increase and decrease the resource of the server according to its need in every second. So, it lowers the cost because we don't need to buy higher configuration than we need.

1.2.1 Working procedure of cloud computing

Cloud computing is a system to share information, resources, and software with the support of the network. The data can be stored on physical servers which are maintained and controlled by the cloud computing provider. Some popular cloud computing providers are Amazon, Google, Microsoft, IBM, etc. Clients can access their data stored in the cloud anytime and from anywhere through the Internet. Users who claim these services can access them from online with the support of web browsers or specialized computerized programs.

1.2.2 Advantages of cloud computing

- *Cost Savings:* Cost Savings: By using cloud computing, we can save substantial capital cost. We don't have to pay extra money for the resources we don't use. We just pay for the resources we used. We can also disengage the services whenever we like. There is a misunderstanding that only large businesses can afford to use the cloud, but in reality, cloud services are extremely cheap and flexible that anyone can afford it. .

- *Reliability:* It is more reliable than the home-server. Because if a server fails or if the server's data is erased then the cloud provider retrieve the lost data from another server which was back up earlier.

- *Manageability:* It is very easy to manage a cloud computing platform. Because the service provider provides a simple web-based user interface for accessing applications, software, data, and services. We don't need to install anything manually.

1.2.3 Disadvantage of cloud computing

- *Downtime:* Since cloud service providers have to give services to many clients each day, they may become overwhelmed and may face a technical blackout. As many devices are connected to the cloud, and each device is transferring data to the cloud and retrieving data from the cloud so the bandwidth may become slow. It means the connection might be slow.

- *Security:* Though cloud service providers secure their server with the best technology, there is a chance to get hacked. If the cloud server is hacked then all data will be useless. And also the service providers have the access to other people's data. It might harm the business.

- *Limited Control:* Since the cloud service provider provides the client their custom made an interface, there is a limitation to control a server.

1.3 Fog computing

Fog computing is known as edge computing, which is decentralized computing. It solves the problem by keeping and calculating data closer to the nearest local computers. Fog computing is used to enhance efficiency and reduce the amount of data transferred to the cloud for data analyzing, processing and storing. Some example of fog computing is a smart city, smart grid, smart buildings, self-driving vehicle and software-defined networks.

1.3.1 Working procedure of fog computing

Device and sensors collect the data, but they don't have the resources to perform advanced analytics, to compute large data, to perform machine learning tasks and store the data. Though cloud servers have the ability to do these, they are often too far away. So it takes much time to transfer a huge amount of data, so the communication with the device becomes slow. In fog computing system, the computation of the data takes place in a smart router or gateway, or in a data hub. So the fog reduces the amount of data to send it to the cloud. It is a reminder that fog computing does not replace cloud computing; it is used for short term computation at the edge, and the cloud is used for longer term computation.

1.3.2 Advantages of fog computing

- *Frees up network capacity :* Fog computing uses less bandwidth than the cloud computing, it means that it doesn't cause bottlenecks. So, it frees up the network capacity.

- *It is truly real-time :* The computation is done in real time. It refers that it is so fast to communicate with the device.
- *Boosts data security :* As the collected data stays in its origin country, it is secure. Because sending data to a foreign country may violate some laws.

1.3.3 Disadvantages of fog computing

- *Physical locality :* Fog computing is done in locally, so it cannot be accessed from anywhere like cloud computing does.
- *Not scalable :* Fog computing is not scalable like cloud computing. So the resources of fog computing are fixed. As a result, the expense can grow up.
- *Memory limitation :* Fog does not have massive data storage like a cloud. So it is one of the greatest drawbacks for fog computing.

1.4 Necessity of Safe Driving

In this 21st century, safe driving becomes one of the most frequent urges in urban life. Safe driving not only assures less time for driving but also it secures an accident-free drive. Now, the probabilities of accidents and traffic congestion are increasing due to increasing the number of vehicles and dangerous condition of the roads. So safe driving becomes everyone's top concern. Though driving could never risk-free, one should aim to drive 'low-risk.' For low-risk driving, one should be aware of the road circumstances. There are various conditions on the road because of which vehicle may fall unexpectedly like- potholes, bumps, speed-breaker, etc[2]. These measures can cause variable speed that may not only lead to serious injuries but also result in an accident. This can result in wasted and lost time for the others who are stuck behind the wheels for the accident or road-blockage. So, to have more secure, accident-free and comfortable driving, the driver should be aware of these road anomalies. The driver can avoid a road accident by making sure not to drive over the potholes. They can also prevent road accidents by reducing the speeds of the vehicle at the time of crossing a bump, speed-breaker or accident prone spots. By avoiding real-time accident or road-blockage, they can ensure a quick, secure driving

1.5 Our Approaches for safe driving

In our study, we mainly focus on safe driving that is established on an IoT-based system. The IoT (Internet of things) based system refers to a system of inter-networking connected devices embedded with actuators, sensors and network connectivity that enable these devices to collect and exchange data. It is the ever-growing network of physical objects that feature an IP address for network connectivity, and the communication which occurs between these objects and other Internet-enabled devices and systems. With the right implementation of this IoT technology, many new possibilities could be unlocked. For our study, we developed an IoT-based system to detect road anomalies such as potholes, bumps, speed-breaker, real-time accident and accident-prone location. This is used for warning the drivers if there are any pothole, bumps, speed-breaker, real-time accident and the accident-prone area in their route. This IoT-based system also includes a fog based decision-making system. Low latency and QoS is important in our proposed IoT based system, and fog could fill the latency and range gap in the IoT[3]. The fog refers to an architecture that provides services for computing, storing, and networking between the edge of the devices rather than routing everything through a central data center in the cloud. In another way, it can be defined as a decentralized computing infrastructure in which data, compute, storage and applications are distributed in the most logical, efficient place between the data source and the cloud. It essentially extends cloud computing and services to the edge of the network, bringing the advantages and power of the cloud closer to where data is created and acted upon. In our study, the fog system has been developed to analyze the data gathered in servers that are collected by the android application. These data are analyzed by fog to provide concerned drivers real-time information about traffic and road conditions such as- the potholes, speed breakers, bumps, real-time accident and accident-prone area on the road[4]. By this real time information, the driver can be aware of road condition and can avoid accident or tragic congestion. This analyzing process includes clustering. Clustering is an algorithm that is used to separate similar data points into intuitive groups. A cluster is, therefore, a collection of objects which are “similar” to them and are “dissimilar” to the objects belonging to another cluster. In our proposed work, we need to arrange regular data and irregular data that’s why clustering is necessary for our work. In our study, speed and acceleration data of vehicles are needed for clustering to detect potholes, bumps, speed-breaker and real time accident. These data including longitude, latitude are collected from the Android application of driver’s smartphone. For finding accident prone area, we use previous data of accident for clustering. Fog has limited memory to store data. That’s why we are using the cloud to store data for further use. Cloud refers to Internet-based computing which provides shared computer processing resources and data, to the computer and other devices on demand. Here, the cloud is necessary to sync fog information with the cloud [5].

1.6 Contribution

IoT has become buzz word now days. And it introduces cloud computing and fog computing. We have tried IoT, cloud, fog and machine learning algorithms for ensuring safe driving. Safe driving has become most common urges to the people. For ensuring safe driving in paper [6], the author mainly focused on early detection of vehicle accident. For this they use neighbor model, regression tree, feedforward neural network and IoT devices[7]. But it gives 90% false alarm. In Paper [8], the author's target is to find out the bumps of a road and plotting them on Google Maps. For this they use K-means clustering algorithm for training data and Random forest classifiers for validation of testing data. But this works are not enough for ensuring safe driving on the road. That's why we have introduce and IoT concept for ensuring safe driving. The key contributions of the proposed work can be summarized as follows:

- A new IoT Based model has been developed that includes both fog and cluster architecture for safe driving.
- This IoT system informs the user the accident prone area analyzing previous data. It also informs about the overall road condition.
- Longitude, latitude, speed and acceleration data of vehicles have been collected from smart-phone of the users. However, speed and acceleration are used for clustering.
- This clustering is used in fog to detect potholes, speed breakers, bumps, and real-time accident on the road using speed and accelerometer value of the vehicle.
- Moreover, cloud is used to sync fog's information[9].

1.7 Organization of the Report

We have structured our rest of the thesis works as following: In chapter 2, we have discussed about related works for safe driving. In chapter 3, System description & model is being elaborated. Chapter 4, introduces our proposed work for detecting road condition and the accident-prone area. Chapter 5 presents the implementation and result in details. In chapter 6 conclusion and further scope of our proposed work has been highlighted. Lastly, proper references of our thesis works, a list of acronyms and notations as well as our list of publications has been illustrated respectively.

Chapter 2

Related Works

2.1 Introduction

In this chapter, we will discuss some previous work related to ours. Previously many works have been done similar to ours. Some works are related for detecting road anomalies using different machine leaning algorithm. They have used different ways for collecting data. Some of the works are related to traffic flow estimation. They tried to know the overall condition of the traffic. Some are related to prevent road accident. And some are for route optimization. We have gone through their researches to know details about their work and find out where we can improve. Our motivation is to make more reliable approach for safe driving.

2.2 Related Works

Some related works has been described below. We have divided those related works in 7 section. Each section has been described properly.

2.2.1 Detecting Traffic condition

In Paper [10], the author studied on analyzing traffic data quality which is collected from various road sensors. The author provided a method to detect some errors in this information. The author of paper [11] suggested that Road Traffic Microwave sensors (RTMS) are more reliable data for traffic analyzing[12]. The author of paper [13] and

[14] uses videos and images of CCTV cameras to determine traffic condition. Here the advantage is to identify different state for various types of vehicles.

2.2.2 Road accident

The author of paper [15] uses road occupancy, road density, and vehicle velocity data to find anomalies of the path towards analyzing new traffic event. In paper [6], the authors use same data with different machine learning algorithm and big data processing to detect highway road accident. But it gives 90% false alarm. The author of paper [16] also uses same data to calculate average trip time using Bayes model. In paper [17] the author concentrated on calculating road capacity and they suggested methods for more efficiency. The author of paper [18] provide a model for estimating the surpassed time interval between the occurrences of an accident and clearing. It depends on different road conditions and infrastructure differences.

2.2.3 Determining road surface

In paper [19], the authors use external sensors like GPS and accelerometer-equipped in a car to collect data of a road then analyze those data to determine the surface condition of a road. The author of paper [20] proposes a machine learning algorithm to predict the types of road and extracts compelling features from different vehicles. For prediction first, they train it from a data set based on road types.

2.2.4 Detecting road anomalies using smartphone

The authors of paper [21] uses a smart phone for safe driving. They have developed an Android based application which is installed on the vehicles to find out the car's condition, like gear shifts. It can also detect the surface status of the road like bumps, potholes, rough roads, uneven roads, and smooth roads. Along with this findings and behavior of the driver which is determined by phone's accelerometer, it can be aware the driver to drive safely. In paper [22] the authors use the motorcycle-based mobile device to collect data, and they use both supervised and unsupervised machine learning algorithms to find out the condition of the road. They also use SVM learning for better performance for detecting road anomalies.

2.2.5 Machine learning algorithms for detecting road anomalies

The authors of paper [23] introduces a system called Nericell that collects data of a road using mobile smartphones equipped with Sensors (GPS, accelerometer, microphone) and communication radios to detect bumps and potholes, braking and honking. It is researched and developed by Microsoft. In paper [2], the authors also use accelerometer sensor of a smartphone and machine learning algorithm to determine potholes and plotting them on Google map. They use Neural Network technique to justify threshold values which give them 90%-95% accuracy. In paper [8] the authors also uses accelerometer sensor of a smartphone to find out the bumps of a road and plotting them on Google Maps. They use K-means clustering algorithm for training data and Random forest classifiers for validation of testing data. In paper [24] the author also use smartphone sensors to detect road condition. They also use GSM for sending messages to the relatives of the driver if there is any accident. The authors of paper [4] determines different types of potholes using smartphone accelerometer sensors.

2.2.6 Finding accident prone area

In paper [25], the author collected accident related data of Dhaka city and used K-means clustering algorithm and Expectation-Maximization (EM) algorithm to find out the accident prone area of Dhaka city. The author of paper [26] uses a Fuzzy clustering algorithm to determine accident prone area highly. Here they used Fuzzy C-Means (FCM) clustering algorithm which is an extension of the k-means algorithm.

2.2.7 Real time road monitoring

In paper [27], the authors propose a traffic monitoring system which uses GPS data to find individual vehicle location and process the data and send the route information to the user. This project was called Mobile Millennium project. The auhtors of paper [28] have developed an algorithm to detect real time accident on the road. They didn't implement their work. They just give hypothesis on their work

2.3 Conclusion

In previous work they didn't use IoT. So in this book we proposed some intelligent approach using IoT, cloud, fog and machine learning algorithm which is more reliable and give much better result for finding potholes, bumps, speed-breakers, real time accident and accident prone area. By knowing this circumstance driver can aware of the road and drive safely.

Chapter 3

System Description & Model

3.1 Introduction

For better understanding our work, in this section, we will discuss our System and the design will be over viewed. The component we are using in our system are android-based smartphone for collecting raw data, fog for instant calculation and cloud for storing the result for further use[29].

3.2 System Description & Model

We tried our best for presenting our model. For better understanding we have included some figure of the model and explained it.

3.2.1 Description of the Device

In this day's smartphone becomes available to all and cheap. So, in our work, we are using smartphone which runs on the Android operating system. Minimum requirements for the smartphone are Global Positioning System(GPS) sensor, Accelerometer sensor, and internet connection. The smartphone is placed in the car for collecting data of a vehicle. For calculating the speed of a vehicle, we use real-time GPS location and moving the time of a vehicle. The GPS of the smartphone also collects real-time location of the device to locate road anomalies on the road. The accelerometer sensor measures the proper acceleration of the device. It has three axes, and they are x-axis, y-axis, and z-

axis. Figure 3.1 shows the direction of three axis of the accelerometer sensor of a phone. The value of x-axis changes when the phone is moved left or right. The value of y-axis changes when the phone is moved back and forth. The value of z-axis changes when the phone is moved up and down. We are using only accelerometer z-axis. Because in our work we need to know when the vehicle is shaking. This z-axis data will help to detect potholes, bumps, speed-breakers and real time accident occurred on the road. If the speed of a vehicle slowdowns suddenly and again speedups again to its normal speed then we will predict that there is problem in the road on that location. To differ pothole, speed-breaker and bump we use accelerometer z-axis. There are two threshold values. One is lower threshold value and another is upper threshold value. If the value of z-axis is less than the lower threshold value, then it's pothole. And if the value of z-axis is higher than upper threshold value, then it's speedbreaker or bump. The phone sends speed, location, and accelerometer z-axis data of a vehicle to the fog every λ times and get results and shows them on the phone. Here, λ is different time interval according to different kinds of vehicle. Some vehicle runs fast and some vehicle runs slow. The vehicle which runs fast they change their locations very quickly. And the vehicle which runs slowly they need more time to change theirs location with the respect of fast moving vehicles. That's why we are using different time interval to send data. As a result clustering will be more efficient.

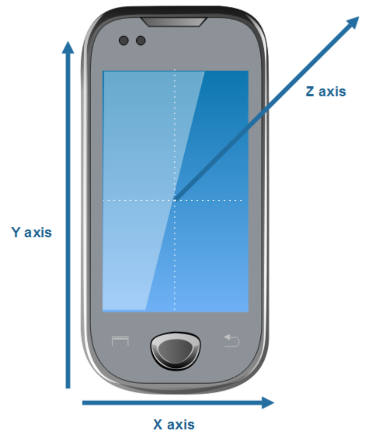

Figure 3.1: Three Axis Accelerometer Diagram of a Smartphone

3.2.2 Description of the model

In Figure 3.2 we can see there are smartphone devices in each car. The phone is set in the car horizontally for getting maximum accurate data for z-axis. Every device is connected to its nearest fog. And every fog is also connected to each other. They are also connected to the cloud. They are always communicating with each other. The smartphone devices in the vehicle are sending latitude, longitude, speed, and accelerometer data to the fog continuously. The fog processes the data and sends the result to each smartphone and each fog. It also sends the result to the cloud to store information for further use. The left side picture of Figure 2 is the screen shot of the app. In this picture, it is shown that the smartphone is obtaining latitude, longitude, speed and accelerometer value. This data is being sent to its nearest fog.

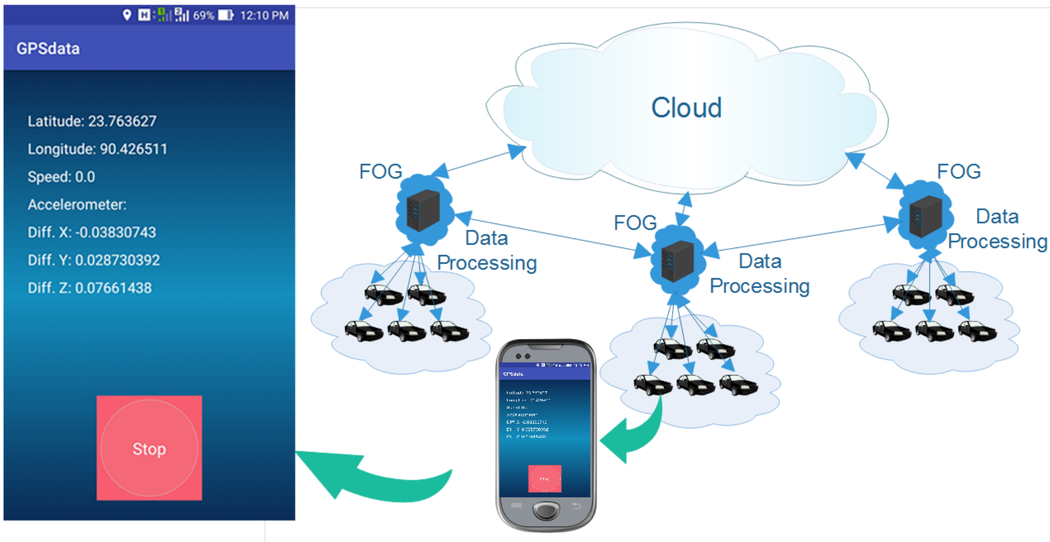

Figure 3.2: Over All Design of the Model

3.2.3 Detecting Potholes & Speed Breaker

If there is a pothole or bump on the road, then every vehicle will slow down its speed on that location, and after passing it, the car will accelerate again. So, for a particular spot if all the vehicles slowdowns and speedups again then fog will decide that there is a problem on that spot. For separating potholes, speed-breaker and bumps it will evaluate its z-axis data. If the z-axis value is less then lower z-axis threshold value then it is a pothole, if the z-axis value is higher than upper z-axis threshold value, then it is bump or speed breaker.

3.2.4 Detecting an Accident

In Figure 3.3, we can see a green car suddenly crashed. As it was sending data to the fog continuously, the fog will process the data and find out that suddenly the speed of the vehicle becomes zero after a massive change of z-axis. So it will decide that an accident occurs. If a single vehicle stops on the road suddenly and all other vehicle is passing, then it will not settle for the accident. It will determine with the information of the maximum vehicle. So the fog will send this report to other cars. It will also send the reports to other fogs and in the cloud too. The cloud will keep this result for further use like finding accident prone area. Fog is always syncing its information with the cloud.

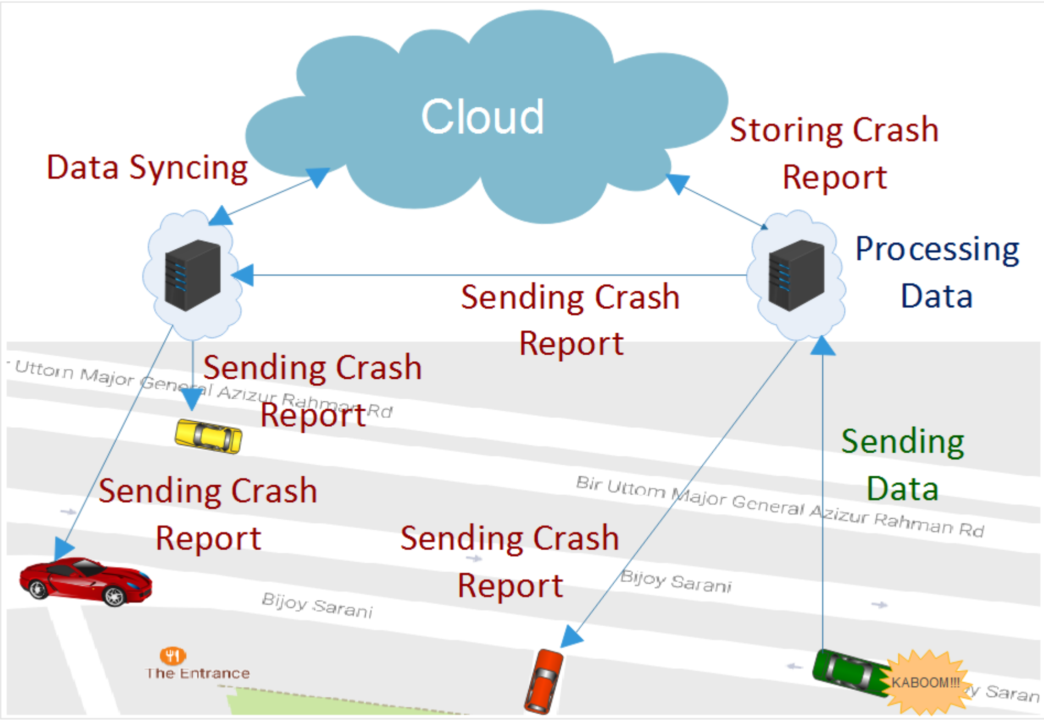

Figure 3.3: Detecting Accident

3.3 Conclusion

In this era safe driving is a big issue. And for safe driving we have come with this model. In this model we have tried to explain how IoT, cloud and fog can give more accurate result for finding potholes, bumps, speed-breakers and real time accident which will help the driver for safe driving.

Chapter 4

Proposed Work

4.1 Introduction

In the previous chapter, we have tried to represent about the structure of our model. In this chapter we will try to explain details about how our model works and gives us the best result. We have also introduced some machine learning algorithms here. We have also developed some algorithms for finding potholes, bumps, speed-breaker, real time accident and accident prone area.

4.2 Machine learning Algorithm

Machine learning is one kind of artificial intelligence (AI) [20]. It allows a program to predict the outcomes more accurately. The primary purpose of machine learning is to build algorithms that take input data and use statistical analysis so that it can predict an output value which is in an acceptable range. Machine learning algorithms can be categorized into two type, one is supervised and another is unsupervised. In supervised algorithms, it is required to provide both input and desired output data for training. In unsupervised algorithms, it doesn't need to be trained with outcome data. In our model, we need unsupervised algorithms because we don't need to train with outcome values. Clustering is one of the best-unsupervised algorithms.

4.2.1 Clustering Algorithms

The primary target of our proposed work is to detect potholes, bumps/speed-breakers, real-time accident and accident prone area on the road. For this, we propose two algorithms- one is named LSA for detecting potholes, bumps/speed-breakers, real-time accident and other is called FAA which is for detecting accident-prone spot. For our algorithms, clustering is needed to find the threshold value. In this section, we will discuss overall clustering idea and proposed an algorithm for our model. Clustering is considered as a method of unsupervised learning to implement the partitioning operation. In our work, we use clustering because it deals with finding a structure in a collection of unlabeled data. Here, clustering analysis is essential for determining the threshold by organizing data into groups whose members are similar in some way.

Clustering analysis is classified as- Exclusive Clustering, Overlapping Clustering, Hierarchical Clustering, Probabilistic Clustering. A different algorithm is used for clustering that belongs to one of the clusterings above types such as- K-means, Fuzzy C-means, Hierarchical clustering, Mixture of Gaussians, etc. In our proposed work, we have used 'Weka GUI Chooser' for clustering the data using K-means clustering algorithm. K-means clustering algorithm belongs to exclusive clustering. It works well with a large set of data.

4.2.2 K-means clustering algorithm

The aim of K-means clustering algorithm is to partition all objects into k clusters. Here, every data set creates clusters with their nearest mean value. Suppose a set of numeric objects are $\{o_1, o_2, ..., o_m\}$. Here each element of this set(i.e. each object) is a v-dimensional real vector. *K-means* clustering searches for a partition of the m observations into $k(\leq m)$ sets n=$\{n_1, n_2, ..., n_k\}$ for minimizing the within-cluster sum of squares(i.e. variance). Formally, the objective is to find:

$$arg_n min \sum_{i=1}^{k} \sum_{o \epsilon n_i} ||o - \mu_i||^2 arg_n min \sum_{i=1}^{k} |n_i| Var\, n_i, \tag{4.1}$$

Here, μ_i is the mean of points in n$_i$. This is equivalent to minimizing the pairwise squared deviations of points in the same cluster

$$\sum_{Cluster\, c_i} \sum_{Dimension\, v} \sum_{o,y \epsilon c_i} (o_v - y_v)^2, \tag{4.2}$$

This is also equivalent to maximizing the squared deviations between points in different clusters as the total variance is constant (between-cluster sum of squares).

4.2.3 Reasons for using K-means clustering algorithm

In our proposed model, we use K- means clustering algorithm because it gives the best result for exclusively clustering large data sets so that individual datum belongs to a distinct cluster. On the contrary, another algorithm such as Fuzzy C-means uses fuzzy sets to cluster data for which each point may belong to two or more clusters with different degrees of membership. So the use of K-means clustering algorithm in our architectural model is to classify the data into two distinct clusters. We are using speed and accelerometer z-axis as a parameter for clustering. These two clusters are typical values and random values of speed and accelerometer. Here clustering is necessary to find the threshold value of speed and z-axis. Later, these threshold values have been used in our proposed algorithm to detect potholes, speed-breaker, bump and real time accident on the road. The value of irregular cluster is the critical point for deciding the threshold value.

4.3 Detecting Road Anomalies

In Figure 4.1, two clusters have been shown. Cluster-1 represents standard vehicle speed, and z-axis and cluster-2 represent variable speed and z-axis, which represents potholes, speed-breaker/bumps and real-time accident on the road. From cluster-2 we get threshold values for speed and accelerometer z-axis. We assume that the threshold for speed is S_{th} , the upper threshold for z-axis is Z_τ and lower limit for z-axis is Z_ψ.

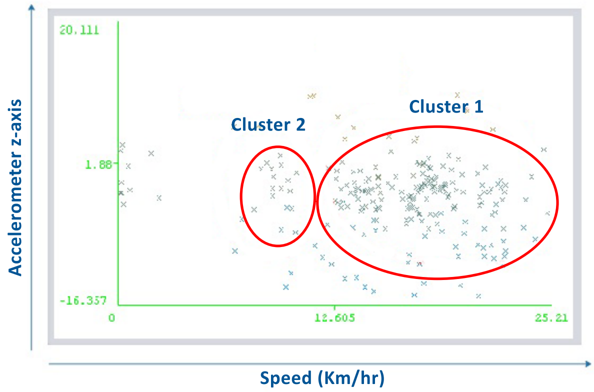

Figure 4.1: Clustering of accelerometer z-axis over speed

For finding the location of potholes, bumps, speed-breaker, and real time accident on the road we use following *LSA algorithm*.

Algorithm 1 *LSA (Location Separation Algorithm)*

INPUT:

S_η : *Speed of the current row*

S_ρ : *Speed of the previous row*

S_Π : *Speed of the next row*

S_ω : *Speed of the row after the next row*

S_{th} : *Threshold for speed*

Z_η : *Accelerometer z-axis value of current row*

Z_τ : *Maximun Threshold for accelerometer z-axis*

Z_ψ : *Minimum Threshold for accelerometer z-axis*

OUTPUT: *Latitude and longitude of potholes, bumps, speed-breaker & accident*

1. *Read all row from fog database*
2. **while** *End of row* **do**
3. **if** ($S_\eta < S_{th}$ AND $S_\eta > 0$) AND ($Z_\eta \leq Z_\psi$) AND ($S_\rho > S_\eta$) AND ($S_\Pi > S_\eta$) **then**
4. *Saving location of current row as pohthole*
5. **end if**
6. **if** ($S_\eta < S_{th}$ AND $S_\eta > 0$) AND ($Z_\eta \geq Z_\tau$) AND ($S_\rho > S_\eta$) AND ($S_\Pi > S_\eta$) **then**
7. *Saving location of current row as bump or speed-breaker*
8. **end if**
9. **if** ($S_\eta < S_{th}$ AND $S_\eta > 0$) AND ($Z_\eta \leq Z_\psi$ OR $Z_\eta \geq Z_\tau$) AND ($S_\rho > S_\eta$) AND ($S_\Pi < S_\eta$) AND ($S_\omega == 0$) **then**
10. *Saving location of current row as accident*
11. **end if**
12. **end while**

4.4 Detecting Accident Prone Area

For finding accident prone area, we have used previous data of accident. We collected this data from Accident Research Institute (ARI) at Bangladesh University of Engineering and Technology (BUET). This data holds some total accident in each area. For clustering these data, we again use k-means clustering algorithm on 'Weka GUI Chooser'. Figure 4.2 is showing three clusters.Cluster 1 represents low rate accident area. Cluster 2 represents the moderate accident prone area. Cluster 3 represents accident prone area highly. The mean of cluster 2 is the threshold value for average accident area, and we assume that it is TH_α. And the mean of cluster 3 is the threshold value for high accident area, and we assume that it is TH_Π .

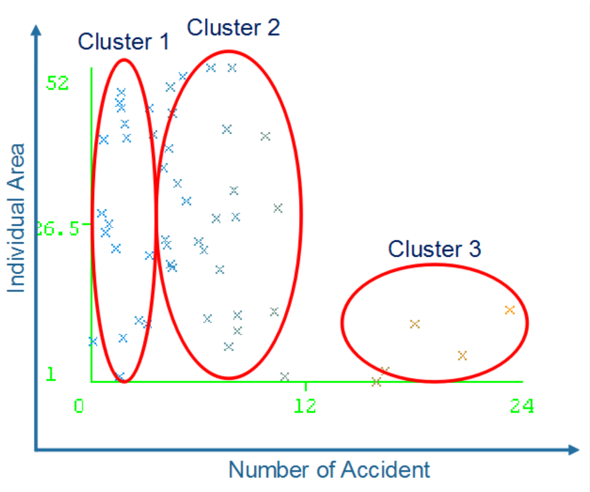

Figure 4.2: Clustering for finding threshold value of accident prone area

For finding the accident-prone location, we use the following *FAA algorithm.*

Algorithm 2 *FAA (Finding Accident Area)*

INPUT:

TH_{α} : *Threshold for moderate accident area*

TH_{Π} : *Threshold for highly accident area*

A_{ω} : *Number of total accident in individual area*

OUTPUT: *Latitude and longitude of accident prone area*

1. *Read all row from cloud database*
2. **while** *End of row* **do**
3. **if** $(A_{\omega} \geq TH_{\alpha})$ AND $(A_{\omega} < TH_{\Pi})$ **then**
4. *Saving location of current row as moderate accident area*
5. **end if**
6. **if** $A_{\omega} \geq TH_{\Pi}$ **then**
7. *Saving location of current row as highly accident area*
8. **end if**
9. **end while**

Here, when a new accident occurs, this data will send to the fog and the fog will send it to the cloud for updating accident prone area. As cloud holds all the previous data of accident. And the new accident information will be added to the previous data. And clustering will be performed again to find out the threshold values. And the calculation will be carried out in the cloud. And the cloud will send the updated result of accident prone area to the fog and fog will send it to the smartphone.

4.5 Voice Alert

After evaluating the result, the road anomalies will be shown on google maps of the driver's smart phone. But it is dangerous to keep an eye on the smart phone continuously. There will be high chance to occur an accident while checking the phone. So we come with an idea to solve this problem. Voice alert can address this issue. While driving, the phone will alert the driver in a loud speaker that is there any pothole, speed breaker or bump 200 meters ahead. It will also warn about accident prone area saying "You are entering accident prone area, please drive carefully." It will also alert the driver if any accident occurred or if the road is blocked one kilometer near him. It will alert the driver saying "Please be careful, the road is blocked ahead."

Figure 4.3: Voice Alert

In Figure 4.3 we can see, there is a pothole 200 meters ahead of the car. And inside the car, the phone is sending and retrieving data from the nearest fog. The phone is updating its GPS location continuously. So, the fog machine will get its location, and it will calculate that is there any road anomalies 200 meters ahead of the car's exact location. If there is then, it will send that car a voice alert. Since the fog machine finds a pothole 200 meter ahead of the car; it sends a voice alert to the phone. And the phone alerts the driver with its loudspeaker.

Algorithm 3 *ADV(Alerting the Driver with Voice)*

INPUT:

L_c : *Current GPS location*

D_1 : *200 meter distance from current location*

D_2 : *1 kilometer distance from current location*

OUTPUT: *Voice Alert Respect to Road Condition*

1. *Read all row from fog database*
2. **if** (pothole detected between L_c AND D_1) **then**
3. *VoiceAlert "Pothole Ahead, Be careful"*
4. **end if**
5. **if** (speedbreaker detected between L_c AND D_1) **then**
6. *VoiceAlert "Speedbreaker Ahead, Be careful"*
7. **end if**
8. **if** (AccidentProneArea detected between L_c AND D_1) **then**
9. *VoiceAlert "Entering accident prone area, Be careful"*
10. **end if**
11. **if** (AccidentOuccred between L_c AND D_2) **then**
12. *VoiceAlert "Road blocked or Accident Occurred Ahead, Be careful"*
13. **end if**

4.6 Conclusion

In this chapter we have tried to explain details of our working function. We have provided some figures to understand the approaches better. We have also included some algorithm we developed.

Chapter 5

Implementation & Result

5.1 Introduction

In this section we will discuss about how we set up the model in real life and collected data. We will explain the graph of collected data for better understanding our approaches. And in the end we will provide some evidence that our approaches works with the best result in real time.

5.2 Experimental setup

Here, we will discuss about the configuration of the devices we used for our experimental setup.

5.2.1 Smartphone

For the implementation purpose, We use Asus Zenfone 5 smartphone to collect raw data. It has Accelerometer, Compass, GPS and Proximity Sensor. The details feature of the phone which we will need for our experiment are -

Accelerometer Sensor:

- Type: KXTJ9 3-axis Accelerometer.
- Power Consumption: 0.570mA.
- Refresh Rate: 50 Hz.

- Minimum Delay: 20000 s.

GPS:

- A-GPS: Yes.
- GLONASS: Yes.

Network:

- WLAN: Wi-Fi 802.11 b/g/n, Wi-Fi Direct.
- Cellular Network: HSDPA+ (4G) 42.2 Mbit/s, HSUPA 5.76 Mbit/s, UMTS.

We have developed and android based application which collects speed, GPS location and accelerometer data and sends to the fog. Figure 5.1 is the screen shot of the app we developed.

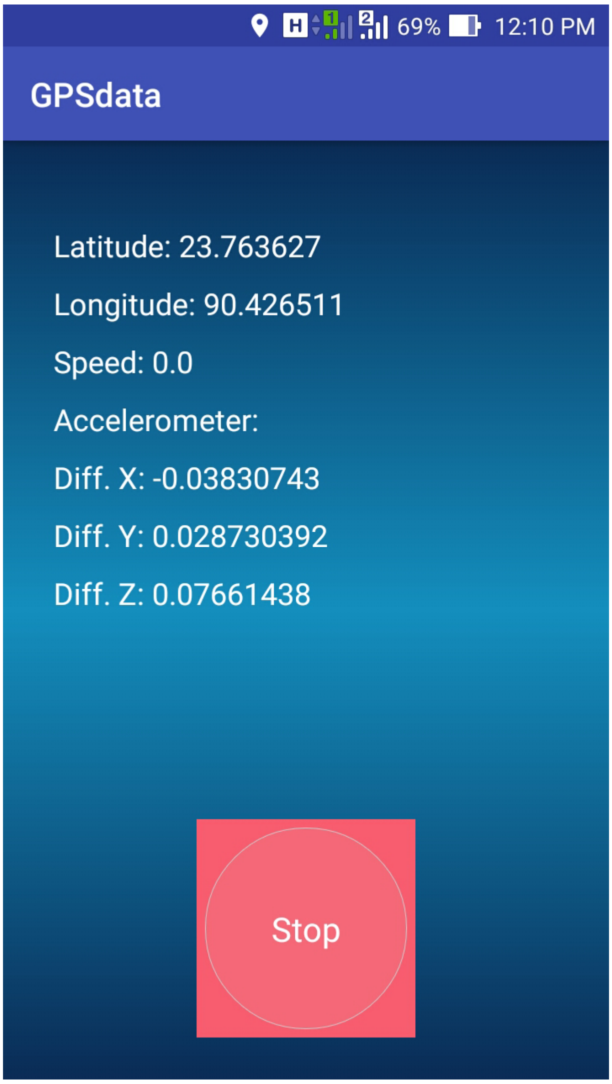

Figure 5.1: Screenshot of the app

We have used a bicycle at the area of Aftab Nagar in Dhaka city for collecting data. We used the same road four times for collecting dynamic data. We use cellular network to connect with the internet for communicating with FOG.

5.2.2 Cloud

We are using DigitalOcean cloud services[30]. It is one of the best cloud service provider. It is also cheap in price. The configuration of our system is -

System Configuration:

- Operating system : Ubuntu 16.04
- RAM : 2 GB
- CPU_s : 2 CPU_s
- Space : 40 GB SSD disk
- Bandwidth Limit : 3 TB

5.3 Explanation of Graph

After collecting the data from a smartphone, we have generated graphs with those data for better understanding our approaches. In this section, we will also show the result of detecting potholes, speed breakers/bumps, real-time accident and accident prone area.

5.3.1 Impacts of vehicle speed over time

The graph in Figure 5.2 describes the speed of the vehicle. The x-axis of the chart refers to the time in second, and y-axis of the chart relates to the speed of the vehicle in km/h. The red dashed line indicates threshold speed. Red circles are showing that the speed of a vehicle suddenly slowdowns and then speedups again. This situation refers that there are potholes or speed-breakers/bumps on those locations.

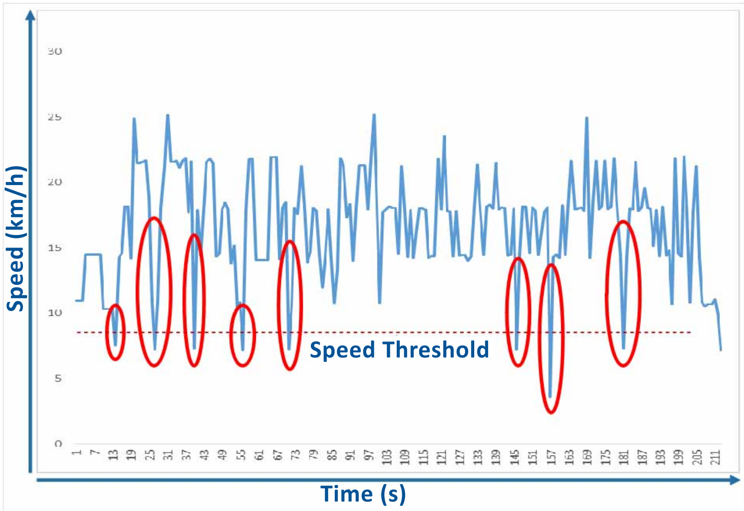

Figure 5.2: Impacts of vehicle speed over time

5.3.2 Impact of Accelerometer z-axis over time

The graph in Figure 5.3 describes accelerometer z-axis data. The x-axis of the chart refers to the time in second, and y-axis of the diagram refers z-axis of the accelerometer in m/s^2. The top red dashed line indicates the upper threshold for accelerometer z-axis and the lower red dashed line shows, the bottom limit for accelerometer z-axis. If the value of accelerometer z-axis suddenly changes greater than the upper threshold value, then it has a chance that there is a speed breaker or bumps on that location. If the value of accelerometer z-axis suddenly decreases more than the lower threshold value, then it has a chance that there is a pothole on that spot. Orange circles are indicating the possibility of speed breaker or bump, and the red circles are showing the possibility of potholes.

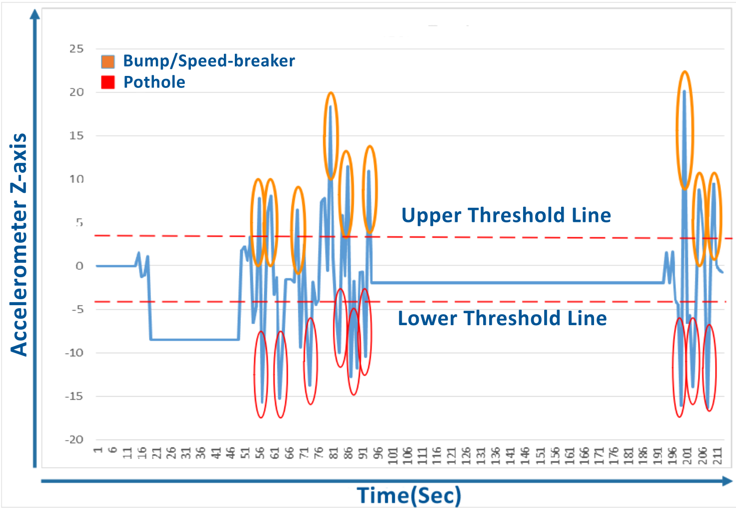

Figure 5.3: Impact of accelerometer z-axis over time

5.3.3 Impact of vehicle speed & accelerometer z-axis over time for detecing road anomalies

If we merged Figure 5.2 and 5.3, then we will get Figure 5.4. The graph in Figure 5.4 describes how speed-breaker/bump and potholes are detected. If the speed of a vehicle suddenly decreases lower than the threshold speed and at the same time if the z-axis value decreases less than the z-axis lower threshold or increases the axis value higher than the upper limit, then we have detected speed-breaker/bumps or potholes. The red boxes are showing the points of potholes and speed breakers/bumps. In our approach, we are considering both speed and z-axis value for detecting potholes and speed-breaker/bumps. So it gives us the more accurate result.

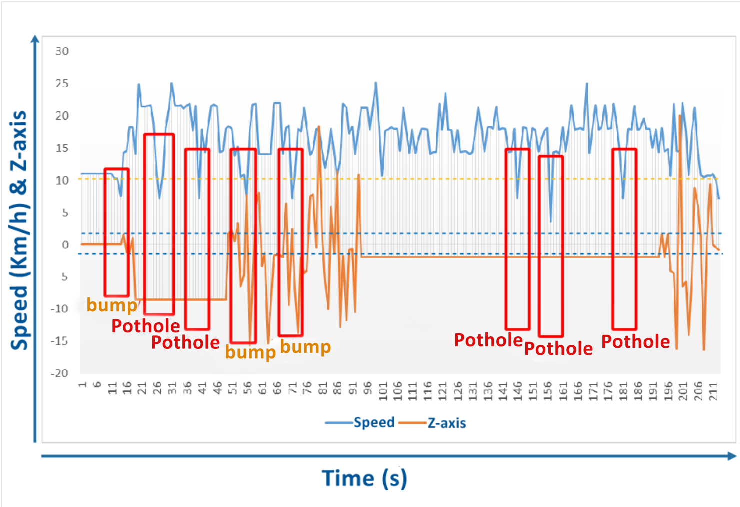

Figure 5.4: Impact of vehicle speed & accelerometer z-axis over time for detecting road anomalies

5.3.4 Impact of vehicle speed & accelerometer z-axis over time for detecting accident

The graph in Figure 5.5 describes the detection of an accident on the road. The blue curve is indicating speed, and the orange curve is showing accelerometer z-axis. Inside the red circle, we can see that the speed suddenly slowdowns and become zero and at the same time the z-axis value is going up and down. This situation refers that the car suddenly stops and there was a massive shake. So it has a high probability that an accident occurs in that place.

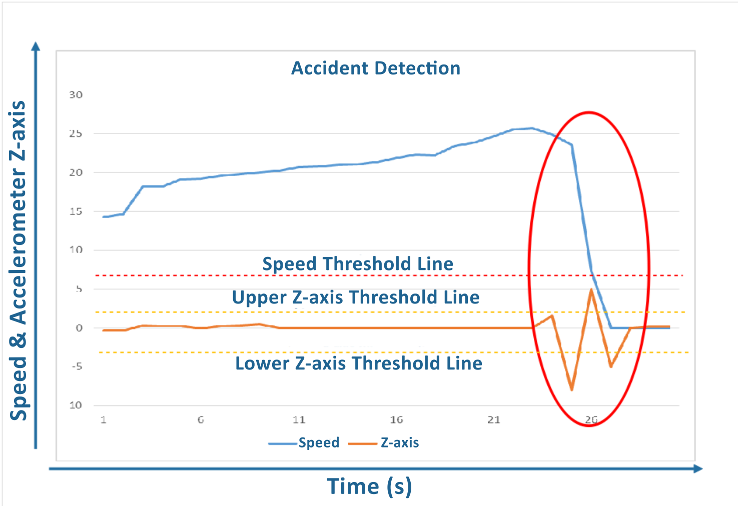

Figure 5.5: Impacts of vehicle speed & accelerometer z-axis for detecting accident

5.3.5 Impacts of number of accident over individual location

The graph in Figure 5.6 is indicating the moderate accident prone area and high accident area. The x-axis is representing the particular area. Here each number is showing the specific area of Dhaka city. y-axis is representing a total number of accident in each different area. After running k-means clustering algorithm to this data set, we find two threshold line. The red threshold field is indicating accident prone area highly, and the orange threshold line is showing moderate accident prone area.

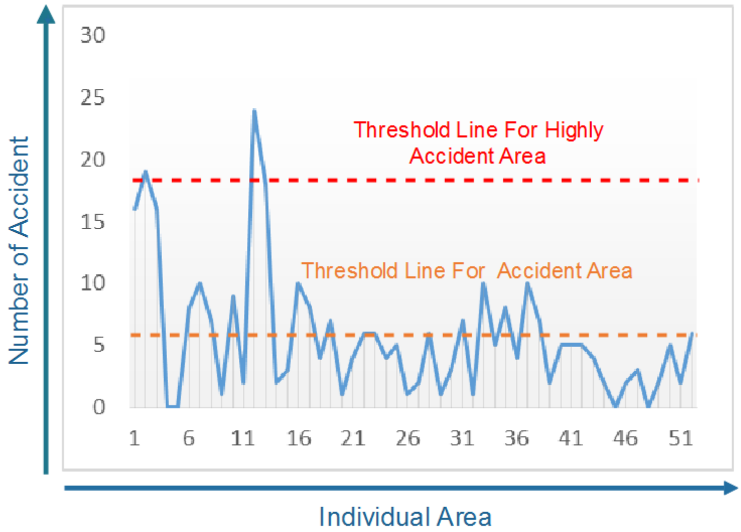

Figure 5.6: Impacts of number of accident over individual location

Figure 5.7, 5.8, 5.9, 5.10 and 5.11is the chart of some accident occurred in Dhaka city. This data has been collected from Accident Research Institute (ARI), BUET. In the graph the x-axis represents some accidents, and the y-axis represents the name of the area. From Figure 5.7 and 5.8 we can see that in Jasim Uddin Road and Kakoli (Mymensingh Road) most of the accident occurred. And some area like Staff Road Crossing, Shonir Akhra crossing and in another area, no accident has occurred.

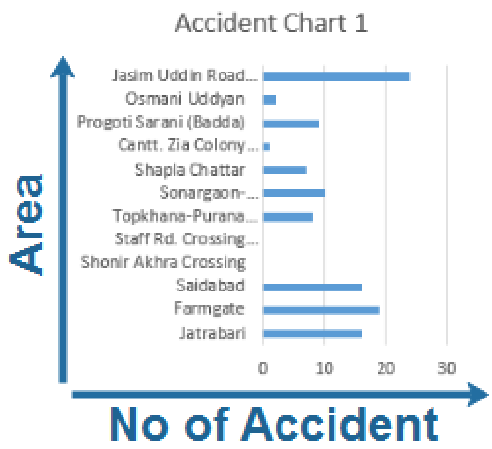

Figure 5.7: Number of Accident in Dhaka city

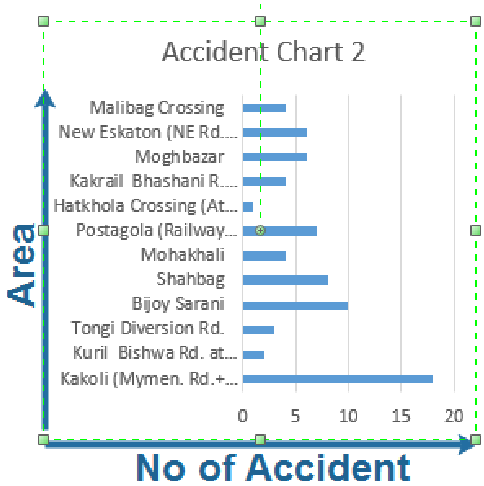

Figure 5.8: Number of Accident in Dhaka city

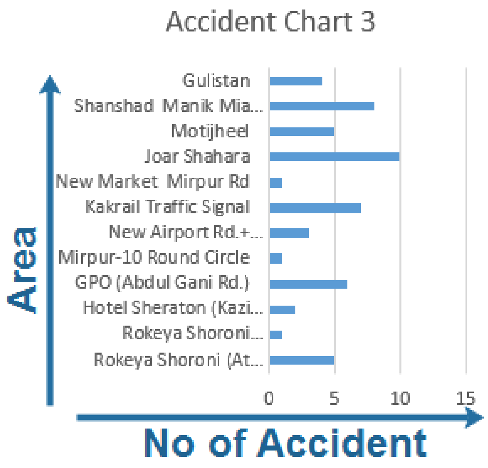

Figure 5.9: Number of Accident in Dhaka city

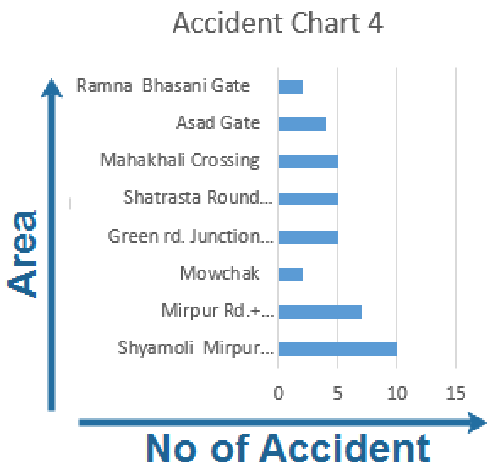

Figure 5.10: Number of Accident in Dhaka city

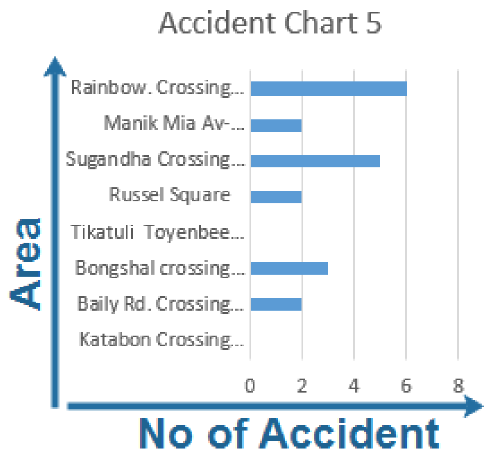

Figure 5.11: Number of Accident in Dhaka city

5.4 Comparing with Other Papers

Table 5.1 shows the comparison between our paper and other papers to ensure safe driving. In our paper for finding potholes, street-breakers, and road-blockage we are using both accelerometer and speed of a vehicle. But in other paper, they just used accelerometer data.

Table 5.1: Comparison between Our Work vs Previous Works

References	Detec -ting Pot- holes	Detec -ting Speed- breaker /bumps	Detecting Road- blockage or accident	Finding Acci -dent Prone Area	Imple- menta -tion of IoT
In our paper	Yes	Yes	Yes	Yes	Yes
SDM [12]	Yes	Yes	No	No	No
PDSMA [14]	Yes	No	No	No	No
ADMAR [15]	Yes	Yes	Yes	No	No
RPDAA [16]	Yes	No	No	No	No
AAPC [18]	No	No	No	Yes	No

5.5 Result on Google Map

We used Google Map API to show the effect. Drivers can beware of the road condition while they are driving by seeing this map. Figure 5.12 is the screenshot of Google map from the phone. In this Figure, it is showing the potholes and speed breakers on Google Map. In Figure 5.13, it is showing the street view of Google map and a speed-breaker. A purple marker is indicating the speed breaker on google street view.

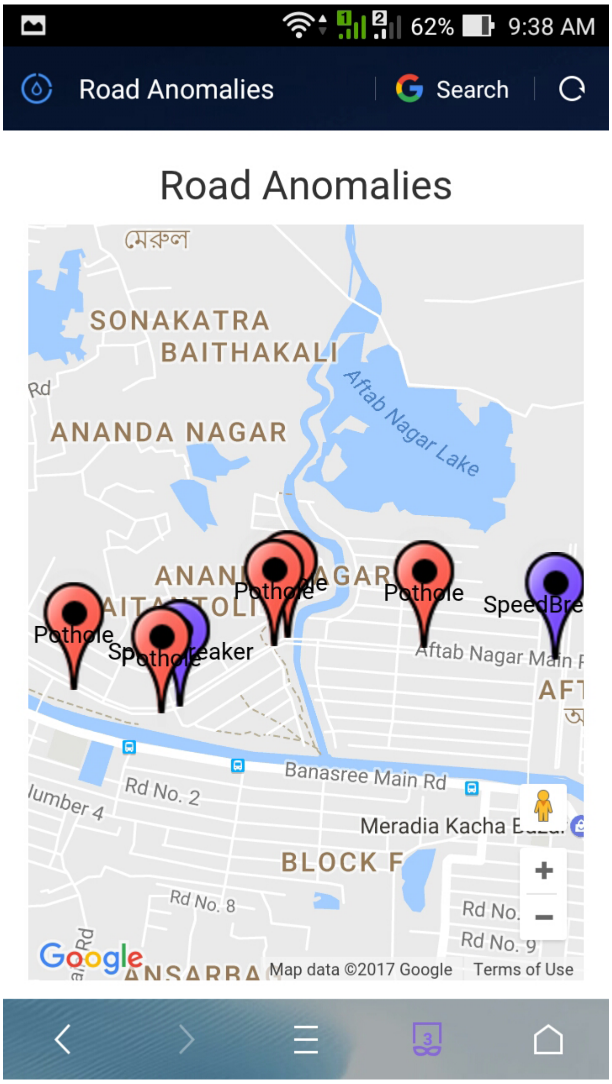

Figure 5.12: Showing Result on Google Map

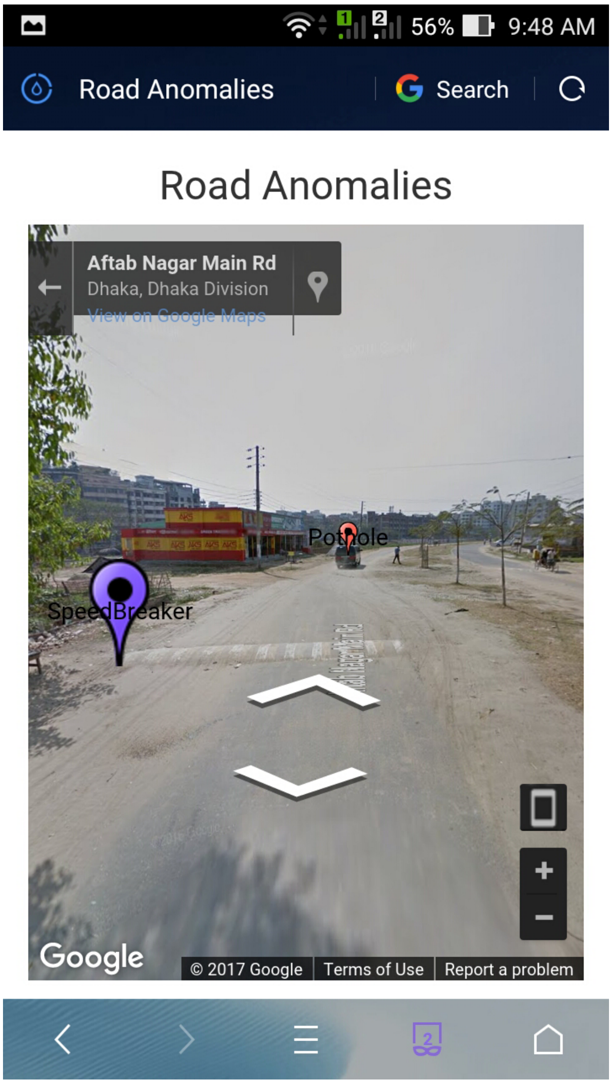

Figure 5.13: Showing Results on Google Street-view

Figure 5.14 & 5.15 are the screenshots of the accident prone area on google map. The red circles are indicating the moderate accident prone area of Dhaka city. And the yellow circles are showing most accident of Dhaka city highly.

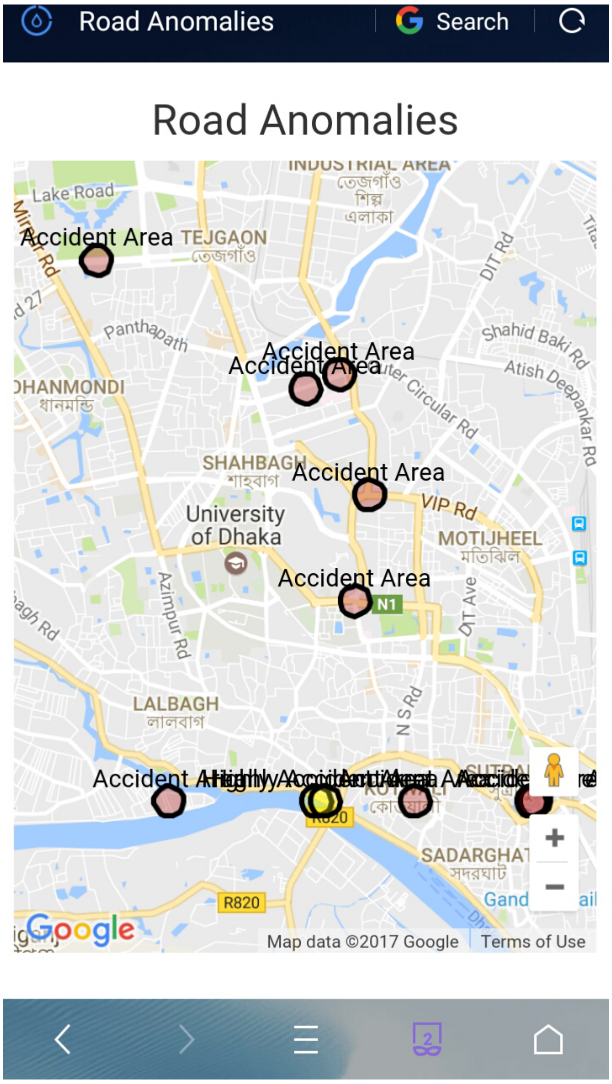

Figure 5.14: Showing Accident Prone Area on Google Map

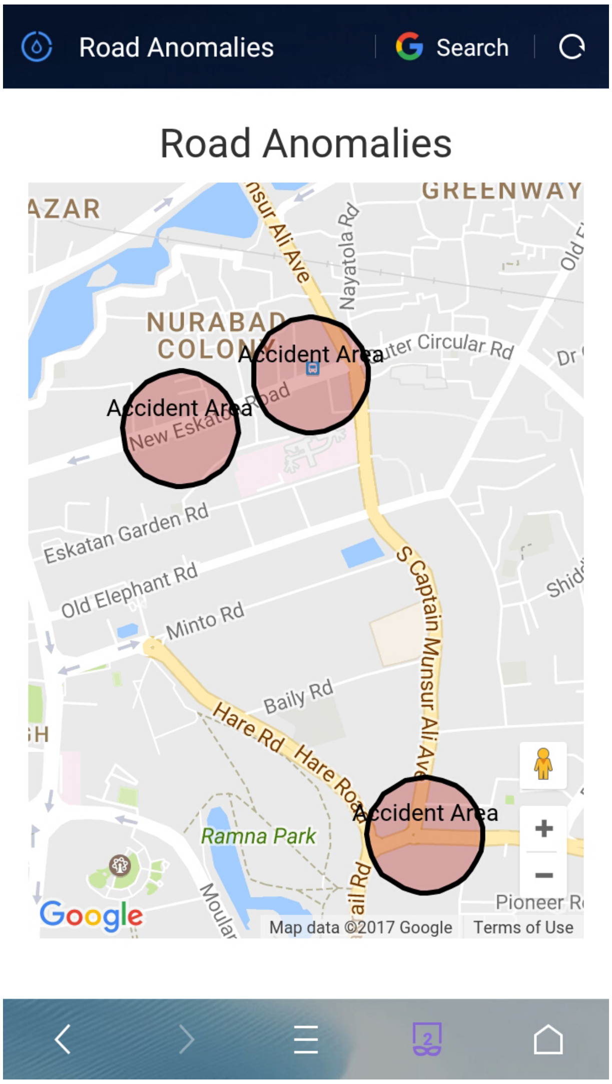

Figure 5.15: Zoom view of Figure 5.14

This pictures are proving that our approach is working correctly with the best results.

5.6 Conclusion

We have explained our collected data for understanding how is our approach working. We have showed the result on google maps. We have also included a street view of google map which proves that our approach is working correctly. We have also compared our work with others.

Chapter 6

Conclusion and Future Works

6.1 Conclusion

Road accident cannot be erased entirely, but it can be controlled by demonstrating the condition of the road to the vehicle driver. In our study, we propose a system which will ensure safe driving on the road by the implementation of IoT that connected every device to another device. Here, the system inputs (longitude, latitude, acceleration and speed data of vehicles) are obtained using Android application to have real-time implementation capability. Moreover, the model includes two computational intelligence techniques that are cloud and fog based system. We have used K-means clustering algorithm on training data. In this work, the smartphone is used aiming to remove the need for deploying individual sensors in a vehicle or at any road junctions.

6.2 Future Works

Though, the primary motivation for this approach is to be able to provide a real-time traffic monitoring system that can ensure safe, accident-free and quick driving; there are also many scopes to improve. The further scopes of this work that we are aiming to work in future are -

- Predicting Early Accident.
- Suggesting safe path comparatively to other

- Suggesting path that consumes less time to ride

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Appendix A

List of Acronyms

IoT	Internet of Things
SVM	Support Vector Machine
IT	Information Technology
SLA	Service Level Agreement
QoS	Quality of Service
RTM	Road Traffic Microwave sensors
CCTV	closed-circuit television
GPS	Global Positioning System
GSM	Global System for Mobile communication
EM	Expectation-Maximization
FCM	Fuzzy clustering algorithm
AI	Artificial Intelligence
LSA	Location Separation Algorithm
FAA	Finding Accident Area
BUET	Bangladesh University of Engineering and Technology
ARI	Accident Research Institute
ADV	Alerting the Driver with Voice
WLAN	Wireless local area network
A-GPS	Assisted GPS
GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema

RAM	Random Access Memory
CPU	Central processing unit
TB	Tera Byte
GB	Giga Byte
SSD	Solid State Storage Device

Appendix B

List of Notations

$==$	This is equal sign
$<$	This is less sign
$>$	This is greater sign
$\leq$	This is less than equal to sign
$\geq$	This is greater than equal to sign
$\sum$	This is sign of summation
ϵ	This is epsilon

Appendix C

List of Publications

International Conference Paper

1. Mohd. Abdullah Al Mamun, Jinat Afroj Puspo and Amit Kumar Das, *"An Intelligent Smartphone Based Approach Using IoT for Ensuring Safe Driving"*, International Conference on Electrical Engineering and Computer Science(*ICECOS-2017*), Palembang, Indonesia, *IEEE Sponsored*, 2017(Accepted).

International Journal Paper

1. Jinat Afroj Puspo, Mohd. Abdullah Al Mamun and Amit Kumar Das, *"aI-SD: An Intelligent Smartphone Based Approach Using IoT for Ensuring Safe Driving"*, Future Generation Computer Systems (FGCS), Elsevier, 2017 (Under Review).