Pothole Detection and Road Condition Assessment

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ABSTRACT

Traffic Congestion, Road Accidents, Pothole detection are the major problems in urban as well as rural areas. In short, maintenance of roads is a major problem in developing countries. A well-maintained road contributes a major portion of the country's economy. Identification of pavement distress such as pothole not only helps drivers to avoid accident or vehicle damage but also helps authorities to maintain roads. A cost-effective solution is needed that collects information about the security of pothole and also helps drivers to drive safely. To overcome such problems proposed this system "Pothole detection and Road Condition Assessment". In this system, we use the Ultrasonic sensor, GPS and Webcam. So in order to provide a solution for pothole problem, we developed an android application which detects pothole automatically, as well as sends a notification to nearby users. User can see the location of detecting pothole on the map.

1. INTRODUCTION

Driving the vehicle on the road having a bad condition is very dangerous to the driver. Due to rains, oil spills quality of the road decreases such hurdles may cause road accidents. To overcome such problem, proposed this system 'Pothole Detection and Road Condition Assessment'. In this system, a sensor is used to sense the pothole, road quality. GPS system finds the position of pothole and rough road, and stores the Latitude and longitude in the database. Based on Latitude and Longitude User can see the location of the detected pothole and rough road area on a map, and also suggest an alternate path for this. All the data is saved in the database. This collected information on bad condition roads is helpful for recovery of the road. Android phones are widely used due to its features like GPS, computational ability and internet connectivity. There are many android applications which help the user in order to provide solutions to many problems related to their day to day life. Traffic congestion, Road accidents, Pothole detection are the major problems in urban areas as well as a rural area. So in order to provide a solution for pothole problem, we developed an Android application which detects pot hole automatically as well as sends a notification to the user. User can see the location of a detected pothole on map.

2. LITERATURE SURVEY

Rajeshwari Madli, Santosh Hebbar, Praveenraj Pattar, Varaprasad Golla et al[1], has proposed a paper which discusses previous pothole detection methods that have been developed and proposes a cost-effective solution to identify potholes and humps on roads and provide timely alerts to drivers to avoid accidents or vehicle damages. Ultrasonic sensors are used to identify potholes and humps and also to measure their depth and height respectively. The proposed system captures the geographical location coordinates of potholes and humps using GPS receiver. The sensed-data includes pothole depth, the height of hump and geographic location, which is stored in the database (cloud). This serves as a valuable source of information to the Government authorities and to vehicle drivers. An android application is used to alert drivers so that precautionary measures can be taken to evade accidents. Alerts are given in the form of flash messages with an audio beep.

Nilam Kumbhar, Dipali Mhetre, Amarina Mujawar, S.T.Khot et al[2], has proposed a system which describes driving the vehicle on the road having the bad condition is very dangerous to the driver. Due to rains, oil spills quality of the road decreases. Such hurdles may cause road accidents. To overcome such problem we proposed this system Intelligent Pothole Detection and Notification System. In this system, the ultrasonic sensor is used to sense the pothole. Image of such location is captured using the webcam. The GPS system finds the position of the pothole. All the data is saved in the database. This collected information of bad condition roads is helpful for recovery of the road.

Arun Kumar G, Santhosh Kumar A, Ajith Kumar A, Maharajothi T et al[3], describes one of the major problems in developing countries is the maintenance of roads. Well maintained roads contribute a major portion to the country economy. Identification of road distress such as potholes and bumps helps drivers to avoid accidents, vehicle damages and it also helps authorities to maintain roads. In this paper, we discuss the previous pothole detection method that has been developed and proposes a cost-effective solution to identify the potholes and bumps on roads. In our system, mobile phone sensors are used to identify the potholes and bumps. The proposed system captures the geographical location of the potholes and bumps using a GPS sensor in the Mobile phone. The sensed data are sent to the cloud storage for further processing. This serves as a valuable source of information for the government authorities and vehicle drivers. An android and web application can be used to display the road condition in the map.

Sudarshan S Rode, Shonil Vijay, Prakhar Goyal, Purushottam Kulkarni, Kavi Arya et al[11], has proposed a system in which Wi-Fi equipped vehicles collect information about the road surface and pass it to the Wi-Fi access point. The access point then broadcasts this information to other vehicles in the vicinity in the form of warnings. However, the system turns out to be an expensive one as all vehicles should be installed with Wi-Fi stations and more number of access points have to be set up.

Prachi More, Sudhish Surendran, Sayali Mahajan & Saurabh Kumar Dubey et al[12], has proposed a system where sensors are mounted on public vehicles. These sensors record vertical and horizontal accelerations experienced by vehicles on their route. The installed GPS device logs its corresponding coordinates to locate potholes and the collected data is processed to locate potholes along the path traversed earlier by the vehicle.

Artis Mednis, Girts Strazdins, Reinholds Zviedris, Georgijs Kanonirs, Leo Selavo et al[13], has proposed a real time pothole detection model using Android smartphones with accelerometers. Modern smart phones with android OS, have inbuilt accelerometers, which sense the movement and vibrations. The accelerometer data is used to detect potholes.

Sandeep Venkatesh, Shreyas Balakuntala et al[14], has proposed an intelligent system that has made use of laser line striper and a camera to detect and avoid potholes. This system maintains a centralized database of the location of potholes. It also sends warning messages to the nearby vehicles about the occurrence of potholes using Dedicated Short Range Communication protocol. The proposed system uses hardware like sensors and Arduino device which is used to detect pothole and is connected to a cloud server which sends real-time data to the mobile application. Thus proposed system is easy to implement and affordable to the users.

Kwang Eun An1, Sung Won Lee1et al[18], has proposed a paper which investigates the performance in detecting potholes with an image classification method based on the deep convolution neural network models. A pothole is one of the greatest threat to vehicle drives. It causes an accident by sudden steering of the vehicle wheel, forcing enormous stress on a vehicle tire or making a hard turning in a vehicle by late detection. It is crucial to find where a pothole is on the pavement. As the number of pavement increases, detecting a pothole becomes a great challenge in modern society. Several methods suggest detecting potholes using sensors. However, these methods require an installation on the vehicle in order to collect data of the pavement. Meanwhile, other methods are using smartphone sensors to reduce the cost of deployment and get an advantage of sensitive sensors without a complex installation on the vehicle. For this reason, a method using a smart phone camera with the artificial neural network becomes away in detecting a pothole on a pavement.

Vinay Rishiwal, Hamshan Khan et al[19], has proposed a system which presents a vibration-based approach for automatic detection of potholes and speed breakers along with their co-ordinates. In this approach, a database is maintained for each road, which is made available to the public with the help of global database or through a portal. Potholes and speed breakers are detected along with their severity using android's built-in accelerometer. The results of the proposed approach are tested over a 4 km flat road and compared to manual inspection of pothole and speed breakers on the same considered road. The accuracy of the proposed approach came out to be 93.75% for detection of potholes and speed breakers. This approach is cost-efficient and very effective for road surface monitoring.

Ionut Schiopu, Jukka P. Saarinen et al[20], has proposed a system with low complexity method for detection and tracking of potholes in video sequences taken by a camera placed inside a moving car. The region of interest for the detection of the potholes is selected as the image area where the road is observed with the highest resolution. A threshold-based algorithm generates a set of candidate regions. For each region, the following features are extracted: its size, the regularity of the intensity surface, contrast with respect to a background model, and the region's contour length and shape. The candidate regions are labeled as putative potholes by a decision tree according to these features, eliminating the false positives due to shadows of wayside objects. The putative potholes that are successfully tracked in consecutive frames are finally declared potholes. Experimental results with real video sequences show a good detection precision. with real video, sequences show a good detection precision.

Rashmi Chouhan, Anuradha Purohit et al[21], has proposed a paper which presents various clustering algorithms are proposed by the researchers in which the K-means is widely used partitioning clustering algorithm which is easy for implementation, has fast convergence property in the local area, and takes less time for execution. But the major drawback of this method is its random choice of initial cluster centroids. To overcome this problem, an approach for document clustering using Particle Swarm Optimization (PSO) method is proposed in this paper. PSO method is applied before K-means for finding the optimal points in the search space and these points are used as initial cluster centroids for K-means algorithm to find final clusters of documents. Results of clustering algorithms are tested on four different document datasets. The outcome shows that the most efficient clustering results are generated than traditional K-means algorithm.

3. ARCHITECTURE / FRAMEWORK

There are 3 layers in Architecture Design. The layers are Application Layer, Network Layer, and Data Processing Layer. Application Layer is the topmost layer of the architecture. It defines the user interface responsible for displaying received information to the user. Network Layer provides data routing paths for network communication. Data is transferred in the form of the packet via in an ordered format controlled by the network layer. The three main functions of the Data Processing layer are to deal with transmission errors, regulate the flow update data and provide a well-defined interface to the network layer.

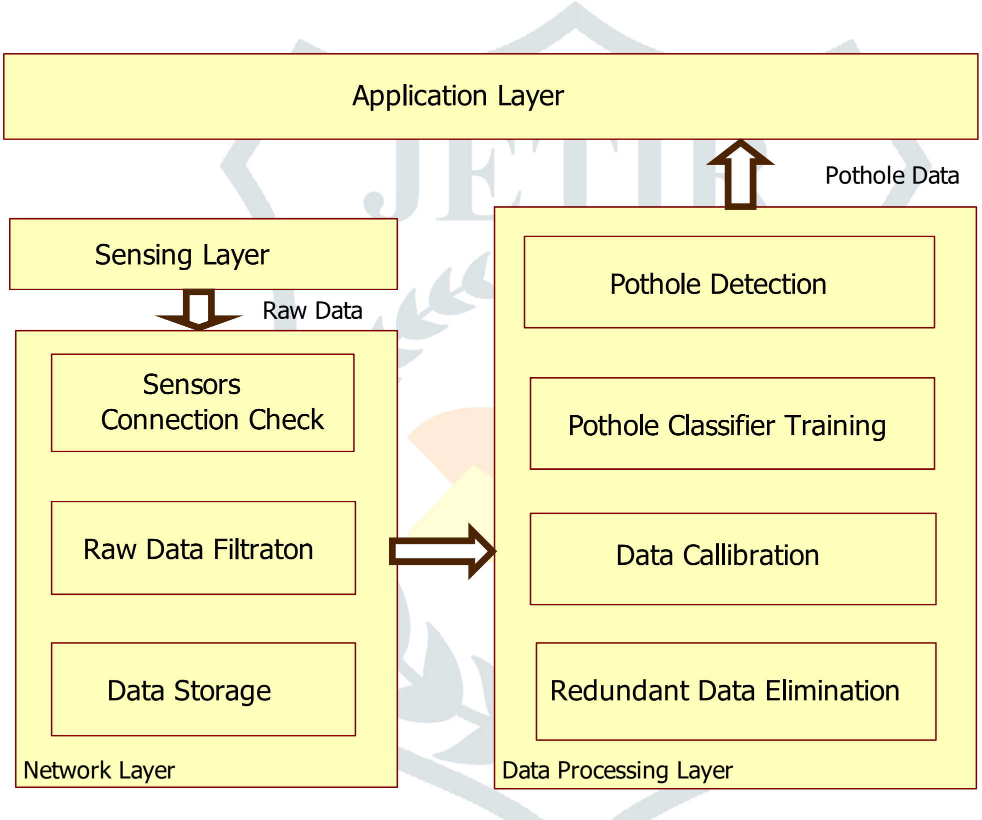

Figure 1. System Architecture

WORKING:

The proposed system captures the geographical location coordinates of potholes, the surface of the road using GPS receiver. The sensed-data includes pothole location and surface of the road, and geographic location, which is stored in the database (cloud). An android application is used to alert drivers so that precautionary measures can be taken to evade accidents. Alerts are given in the form of a red flag on the map.

4. METHODOLOGY

A. K-Mean Clustering Algorithm

This part briefly describes the standard k-means algorithm. k- Mean is a typical clustering algorithm in data mining and which is widely used for clustering large set of data. In 1967, Mac Queen firstly proposed the kmeans algorithm. It was one of the most simple, nonsupervised learning algorithms, which was applied to solve the problem of the well-known cluster. It is a partitioning clustering algorithm, this method is to classify the given date objects into k different clusters through the iterative, converging to a local minimum. So the results of generated clusters are compact and independent. The algorithm consists of two separate phases. The first phase selects k centers randomly, where the value k is fixed in advance. The next phase is to take each data object to the nearest center. Euclidean distance is generally considered to determine the distance between each data object and the cluster centers. When all the data objects are included in some clusters, the first step is completed and an early grouping is done. Recalculating the average of the early formed clusters. This iterative process continues repeatedly until the criterion function becomes the minimum.

Supposing that the target object is x, x_i indicates the average of cluster C_i, criterion function is defined as follows:

$$\sum_{i=1}^{k} \sum_{x \in C_i} |x - x_i|^2 \qquad \text{..............................(1)}$$

E is the sum of the squared error of all objects in database.

The distance of criterion function is Euclidean distance, which is used for determining the nearest distance between each data object and cluster center. The Euclidean distance between one vector $x=(x_1, x_2, \ldots x_n)$ and another vector $y=(y_1, y_2, .. y_n)$, The Euclidean distance d(xi, yi) can be obtained as follow:

$$D(x_i, y_i) = \left[\sum_{i=1}^{n} (x_i - y_i)^2\right]^{1/2} \qquad \text{..............................(2)}$$

The process of k-means algorithm as follow:

Input : Number of desired clusters, k, and a database $D=\{d_1, d_2, \ldots d_n\}$ containing n data objects.

Output : A set of k clusters

Steps :

1. Randomly select k data objects from dataset D as initial cluster centres.
2. Repeat.
3. Calculate the distance between each data object d_i $(1 <= i<=n)$ and all k cluster centres $c_j(1<=j<=k)$ and assign data object d_i to the nearest cluster.
4. For each cluster j (1<=j<=k), re-calculate the cluster centre.
5. Until no changing in the centre of clusters.

The k-means clustering algorithm always converges to local minimum. Before the k-means algorithm converges, calculations of distance and cluster centers are done while loops are executed a number of times, where the positive integer t is known as the number of k-means iterations. The precise value of t varies depending on the initial starting cluster centers. The distribution of data points has a relationship with the new clustering center, so the computational time complexity of the k- means algorithm is O(nkt). n is the number of all data objects, k is the number of clusters, t is the iterations of algorithm. Usually requiring k <<n and t <<n.

B. Haversine Algorithm

It contains “great circle distance” which represents the shortest path for distance modeling and optimal facility location on the spherical surface. Great circle distances take into consideration the geometrical reality of the spherical Earth and offer an alternative to the widely held notion that travel over water can be exactly modeled by Euclidean distances. The need for geometrical presentation of the spherical earth becomes very relevant when we take into consideration ever increasing junctions inside a city. The use of “Great circle distances” opens up another avenue for convergence of Navigation and Spherical Trigonometry into the advancement of logistics and facility location. In this paper, an evaluation of distance location using great circle distances is used to demonstrate the application of the concept.

It proposes and implements a method for performing shortest path calculations taking crowd sourced information, in the form of constraints and obstacles, into account. The method is built on top of Google Maps (GM) and uses its routing service to calculate the shortest distance between two locations. Users provide the constraints and obstacles in the form of polygons which identify impassable areas in the real world.

The haversine formula is an important equation for navigation, giving great-circle distances between two points on a sphere from their longitudes and latitudes. It is a special case of a more general formula in spherical trigonometry.

Haversine formula is used to determine the distance between one point to another point. This method is used for applications in geographic information systems. On the use of maps that already have two dimensions will have points depicted in integers. In the calculation steps, haversine are first will change the value of the latitude and longitude integer number into radians, and then these numbers are calculated in the algorithm haversine. Here is the formula of haversine:

$$d = 2r\sin^{-1}\left(\sqrt{\sin^2\left(\frac{\emptyset_2-\emptyset_1}{2}\right) + \cos(\emptyset_1)\cos(\emptyset_1)\ \sin^2\left(\frac{\varphi_2-\varphi_1}{2}\right)}\right) \qquad \text{..............................(3)}$$

Where,
lat: Latitude or Longitude
lon : Longitude or latitude
r: radius of the earth (r = 6.731 km)
d: Distance (Distance)

C. Naïve Bayes Algorithm

It is a classification technique based on Bayes Theorem with an assumption of independence among predictors. In simple terms, a Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature. For example, a fruit may be considered to be an apple if it is red, round, and about 3 inches in diameter. Even if these features depend on each other or upon the existence of the other features, all of these properties independently contribute to the probability that this fruit is an apple and that is why it is known as 'Naive'. Naive Bayes model is easy to build and particularly useful for very large data sets. Along with simplicity, Naive Bayes is known to outperform even highly sophisticated classification methods.

Bayes theorem provides a way of calculating posterior probability P(c|x) from P(c), P(x) and P(x|c). Look at the equation below:

$$P(c|x) = \frac{P(C|X)P(c)}{P(x)} \qquad \text{..............................(4)}$$

P(c|x) is the posterior probability of class (c, target) given predictor(x,attributes).
P(c) is the prior probability of class.
P(x|c) is the likelihood which is the probability of predictor given class.
P(x) is the prior probability of predictor.
we have used Naive Bayes to classify the shortest root.

5. RESULT AND DISCUSSION

The working model of the proposed system is shown in figure 2. It was tested in a simulated environment with artificial potholes and humps. The model was also tested in real time by fixing it on a motor bike (Honda Activa). Tests were carried out in two phases. In the first phase, information about potholes and humps was recorded and stored in the server database. In the second phase, flags are generated on a map based on pothole and hump information stored in the database. While testing in the simulated environment, the proposed system module was fixed on a toy-car and the threshold value was configured to 6 cm. During the tests, it was found that the proposed system module worked as expected to identify potholes and humps. Table 1 shows a set of potholes and humps identified by the system in the simulated environment. Information about potholes and humps was successfully sent to the android device and server. The snapshot of flags(red colored flag which indicated potholes) and suggestion of best and bad route can be seen in figure 3.

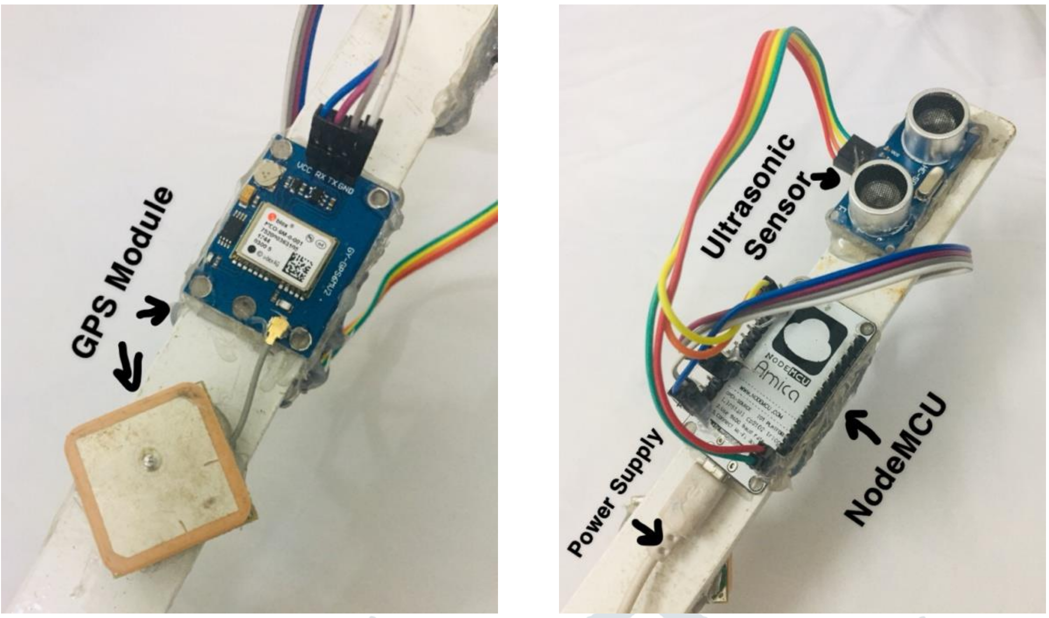

Figure 2. Working Model of Proposed System

Table 1. Information about potholes and humps collected in simulated test environment.

potholeId	height	latitude	longitude	potholeTime	type	userId
29	19.35	18.46685231	73.85762934	2019-06-01 18:29:41	P	1
30	3.1	18.46685272	73.85762985	2019-06-01 18:29:51	H	1
31	3.8	18.46685214	73.85763074	2019-06-01 18:30:06	H	1
32	13.2	18.46685206	73.85763078	2019-06-01 18:30:09	P	1
33	8.7	18.46685097	73.85763431	2019-06-01 18:30:12	P	1
34	6.3	18.46685114	73.85763472	2019-06-01 18:30:21	P	1
35	2.3	18.46685085	73.85763525	2019-06-01 18:30:28	H	1

In the above table, type 'P' indicates a pothole(which is indicated by red flags on map) and 'H' indicates a hump.

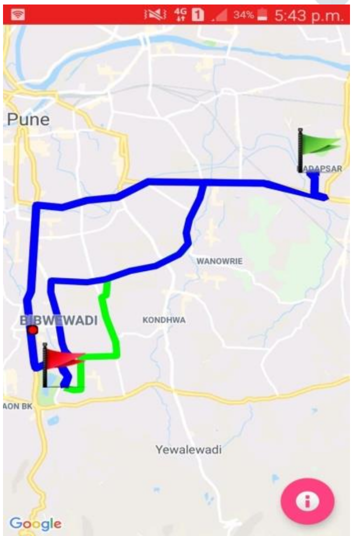

Figure 3. Detection of potholes and suggestion of best and bad routes

In the second phase of testing, the flags are generated on the map by moving the vehicle on routes containing potholes and humps and alerts were generated for potholes and humps recorded in the first phase. Figure 7 shows an alert generated by this application. Figure 4 shows the real-time testing of the proposed model. The proposed system module was fixed on Honda Activa and the threshold distance value was configured to 15 cm, which is the ground clearance for Honda Activa. The vehicle was moved on Pune's roads for the purpose of recording information about potholes and humps, and the test results were as expected. Table II shows a set of potholes and humps detected during real-time tests.

Figure 4.1. Proposed Model fixed on two wheeler bike for testing\

Figure 4.2. Detection of Hump

Figure 4.3. Detection of Pothole

Table 2. Information about potholes and humps collected during real-time testing.

potholeId	height	latitude	longitude	potholeTime	type	userId
112	22.5	18.46679715	73.85772216	2019-06-01 17:45:29	P	1
113	9.2	18.46685231	73.85762934	2019-06-01 17:47:01	H	1
114	7.5	18.46685097	73.85763431	2019-06-01 17:48:22	H	1
115	24.3	18.46685114	73.85763472	2019-06-01 17:48:59	P	1
116	23.7	18.46685085	73.85763525	2019-06-01 17:49:08	P	1
117	18.5	18.46679715	73.85772216	2019-06-01 17:50:11	P	1
118	20.6	18.46680814	73.85789123	2019-06-01 17:51:45	P	1

CONCLUSION

The model proposed in this paper serves important purpose that the system is able to detect the potholes on the surface of the road. The potholes are detected using the sensor. The GPS is used to find the location of detected potholes and humps. All the information is saved in the database. This timely information can help to recover the road as fast as possible. Hence the system will help to avoid road accidents.

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