Journal of Engineering and Applied Sciences 14 (15): 5176-5182, 2019
ISSN: 1816-949X

Hybrid Route Choice Navigation Based on Road Anomaly Data

Myron C.J. Fernandes and Beaulah Soundarabai
Department of Computer Science, CHRIST (Deemed to be University), Bangalore, India

Abstract: This study aims to include the option for the users to choose from the routes based on road quality when using Google Maps for navigation. The proposed system aims to collect data about road anomalies and accordingly, give the users more choice of routes from source to destination e.g., faster but bad roads, slower but smooth roads, lengthy but smooth roads etc. These choices will be in addition to the existing ones provided by Google Maps. Our system uses Global Positioning System (GPS) along with sensors like accelerometer, gyroscope to measure the size and level of the anomaly. The goal is to improve the travel quality and experience for the users especially for elderly people, pregnant women, sick people infants, etc., along with help for transportation of fragile and delicate goods. We have used Google Maps API, Android, Firebase and Python to implement our model and we can generate a Google Map with the scatter plot of anomaly data.

Key words: Google Maps, routes, road anomalies, mobile sensors, Firebase, Python, clustering, dynamic routes, GPS

INTRODUCTION

Google Maps navigation started out as a mobile application for Android and iOS. It was later turned into the Google Maps (Anonymous, 2016) application along with a lot of added and improved features. It makes use of an internet connection either as mobile data or WiFi, along with a GPS (Anonymous, 2017) satellite connection to track the exact present location of the device being used. It allows the user to enter the destination and it plots the route from the current location to the destination on the map along with voice assistance from almost every turn. During navigation, the application also shows other possible routes to choose from and it also shows the traffic levels by using different colours on the route on the map. When we navigate using Google Maps, we are usually provided information about the best and shortest route possible form the source to the destination. But there is no information about the quality of roads in the routes chosen. This study presents the opportunity to add an extra but very important parameter named 'Road Quality' to the existing Google Maps navigation service by which the users can also get an option to choose the route based on the quality of roads available.

Our mobile phones are equipped with many sensors that are being used for various purposes. The most obvious are all about movement. These include the accelerometer for measuring movement and orientation and the gyroscope for measuring angular rotation across three axes and giving more accuracy to the accelerometer reading (Anonymous, 2019). Similarly, such sensors are embedded into recent car models especially, hi-tech cars like the ones produced by Tesla, Inc, BMW, Mercedes-Benz, etc.

Crowdsourcing data is a trending topic of discussion with a lot of data coming from social apps and some other apps like Google Maps. Crowdsourcing is a way of gathering data from internet users. It is a sourcing model which can take contributions from individuals and even organizations. Crowdsourced data can be gathered for various purposes which include analysis, predictions, finding out trends, etc. The concept of crowdsourced data can be implemented to be manual or can be fully automated.

In Google Maps, location information is crowdsourced from the users driving or riding their vehicles and thus, we can know the traffic levels in that region of the map. It is achieved by gathering data on the density of smartphone users on the roads in real time. This crowdsourced data is then used for changing the colour of various routes in that region to indicate traffic levels and also redirect other traffic in a way to avoid regions with heavy traffic thus ensuring faster navigation time. It also has the feature of alerting people through push notifications on their smartphones about the traffic levels on the daily route they take to work, on the way to drop their kids to school or on their way back home from work, so that, they can be aware of a traffic situation in advance.

Limitations of the current system are, the current system of navigation by Google Maps lacks the ability to provide information about the quality of the roads. The

Corresponding Author: Myron C.J. Fernandes Department of Computer Science, CHRIST (Deemed to be University), Bangalore, India

system will give information about the traffic levels at various places on the route but there is no information about the the reason for high level of traffic. It does not tell whether there is a road accident, some road works going if protests or some procession is going on etc.

Motivation: When we travel and use Google Maps for navigation, we usually get the shortest route chosen but many times these roads can be pretty bad and the experience of travel is unsatisfactory. It wouldn't be a problem if the ride took a few minutes longer and the roads were better. Currently, the present system does not provide such a choice while choosing a route for navigating from source to destination. There are optional routes to choose from but they do not mention whether the roads will be better on the optional route.

This opens up an opportunity for improvement in this system by adding more features and enhancing the experience for the users while navigating. Rather than just sticking to and improving the existing systems, we can also add more functionality and thus, add more factors in finding the best route to travel by. Many times when sick persons, children and elderly people travel, it is necessary to have good roads as this can affect the ride quality and also make such people fall sick due to excessive movement. If we can have an option for choosing additional options where road quality is specified this problem can be avoided.

Also, transportation of fragile goods, flammable goods, water tankers etc. require good roads while travelling from source to destination. Good roads will ensure that fragile goods and items arrive safely at the destination and chances of damage are significantly low. Tankers transporting flammable liquid and other chemicals also need good roads, so that, these potentially disastrous commodities are transported safely. Even while transporting water, a lot of water from the tanker is wasted if the roads are bad and bumpy. The water keeps falling out of the tankers at almost every road anomaly. Such wastage can be reduced if the road quality is improved because water is a precious resource and we cannot afford to waste it in such ways.

We can also use this data gathered to locate the anomalies on the road and see to it that they are taken care of by road repairs and other public works required. This will be a major advantage of gathering all of this data and putting it to good use.

Literature review: Rahman *et al*. (2015) have proposed a new system for choosing a faster path between a source and a destination on Google Maps based on various types of delays that occur on the paths. By calculating the delays like signal delays, straight path delays, cross section delays, etc., the system can choose the most time efficient path between any given pair of choices. The focus of this system is to reduce travel times when navigating through the city using Google Maps. The system collects data such as traffic flow, road volume to capacity ratio, vehicle queue length and green cycle length by using wireless sensor nodes and CCTVs on the cross sections. The system uses a modified version of Webster's statistical regression based model for delay estimation.

The system was tested on a dummy map in a few cases in the early stages of the project. This map consisted of paths, cross-sections (junctions) and signals. A source and destination were chosen and all the possible paths between them were generated and the system had to choose the most effective path. The shortest path is not always the fastest due to the road traffic loads and hence, time is a priority as compared to the length of the route.

As they moved on to more real time testing, they chose the source and destination with a metropolitan city. They put the system to work and as the data began to flow the results were effectively generated. The system was programmed to generate the fastest path along with the 2nd and 3rd fastest paths to travel, thus, giving the user a choice of three. Hence, it can be used as an adaptive system for time effective journeys within cities. Binu and Viswaraj (2016) have proposed a carpooling system with an added feature of car and person tracking via. GPS using Google Maps. It also has a feature where the users can report traffic anomalies like road works, vehicle accidents, strikes, processions, etc., along with a recursive expectation maximization algorithm to check the how true the anomalies are.

The advantages of this system are many as many of the current carpooling applications lack live location tracking along with pickup point and drop off point shareable with other persons. It is very useful for tracking the the journey of children, elderly persons, etc. Along with a lot of time saving included as the traffic anomalies are know in advance and hence, such roads can be easily avoided. Thus, it improves the overall experience of carpooling and will be as encouragement to potential users of such carpooling facilities.

Yi *et al*. (2015) proposes a system where in a smartphone was used in the cars and hence, the cars were called as SPCs. These SPCs were used to check and gather data about the quality of roads as it is moving. This car can be driven around cities and other places where the road quality is measured and accordingly, the location of the road anomalies is recorded by using the sensor data in the smartphones.

This data can then be plotted on Google Maps and then it can be used for purposes such as road repairs and and monitoring the quality of road repairs done. It can be used to verify that the repairs done by the road work contractors is as good as they have assured and if not further action and inquiries can be done into this matter.

MATERIALS AND METHODS

Proposed work: The proposed system makes use of sensors or the smartphone in the car for the purpose of gathering the anomaly data. Based on the smartphone sensor data we set a threshold value, so that, unnecessary data is eliminated. The data that is being recorded is the size of the anomaly at the time it is encountered and the GPS coordinates at the location where it occurred. We also get the impact of the anomaly based on the accelerometer readings that exceed the threshold value.

The data will be gathered using the smartphone in the car of the person driving and as soon as a road anomaly is encountered the application will report the incident. The crowdsourcing model of data collection is used for this purpose. This will avoid the need of the user to manually input the location of the anomalies. The only major user interaction will be the user switching on and off the application before and after the drive, so that, the application can begin its process of data collection. This is essential, so that, the data will be gathered only when the user the driving and not at other times, also as this will add a lot of false alerts and insignificant data will be gathered in the database algorithm.

Algorithm 1; Anomaly detection:

PRE: Fetch the threshold value to be used
X1, X2->X axis of the accelerometer
Y1, Y2->Y axis of the accelerometer
Z1, Z2->Z axis of the accelerometer
anomaly check (threshold)

1. Start
2. Initialize X1,Y1, Z1 with values from Accelerometer
3. Loop(Infinitely)
   a. Get X2, Y2, Z2 values from Accelerometer
   b. DIFF = Difference between X1, Y1, Z1 and X2, Y2, Z2 every 250 msec
   c. If the DIFF>threshold
      i. Read the Longitude, Latitude coordinates of the location from GPS sensor data and push the values along with DIFF value to the server
4. Set X1 = X2, Y1 = Y2 and Z1 = Z2
5. Repeat

POST: Dataset with the location data about where the road anomalies have been encountered and the intensity of the anomaly

RESULTS AND DISCUSSION

A runnable class is created to repeated check the inputs of the movement sensors. Here, the reading are gathered and checked with the previous value checked by the same sensor. If the difference is significant, i.e., exceeds the threshold set, if will be pushed onto the server along with the location of the occurrence of the event. This will signify the location of the anomaly and the impact of the anomaly, thus, we can get to know both the location of the anomaly as well as how intense the anomaly is.

The threshold value is used for the purpose of avoiding unnecessary detections and preventing noise in the data to a certain extent. If the DIFF value is greater than the threshold, only then will it be considered. Otherwise, the value may generally be insignificant and maybe be erroneously (Fig. 1).

The difference will be checked every 250 msec, so that, we have a regular refresh of the DIFF value. Further, processing will be done on the data on the cloud for obtaining the cleaned and precise results out of the data with the use of data mining techniques.

The anomaly data is stored in the device and uploaded onto Firebase Cloud Firestore with the use of mobile data on the device. In case of inconsistent data connection, firebase also has a feature to cache the data and upload it when the connection is stable. Firebase Cloud Firestore is a flexible, scalable NoSQL cloud database to store and sync data for client and server-side development. The data will be sent to the server as a JSON object and the data can be extracted out of the JSON string. The available data can be used for reporting in real time with the help of requests to the server and the rest of the data can be stored in the database as it will have many uses in the future and this data can be mined for finding patterns and also for purposes of making predictions based on the data available.

The preprocessing of data will be done with a Python scripts to sort out the essential information out of the incoming data and process it to gain valuable information and infer a conclusion out of it. The data that may require preprocessing in situations like getting corrupt values, getting wrong location data like zeros for longitude and latitude, etc. This process will be happening at real time and the data will keep flowing into the server. The data will be stored using a NoSQL database and it can be used for future mining of data. The preferred database is Firebase Cloud Firestore.

The data gathered in the database will be used for further processing. One of the things that will be done is clustering the data, so that, we get the clusters which will be the more or less the approximate location of the

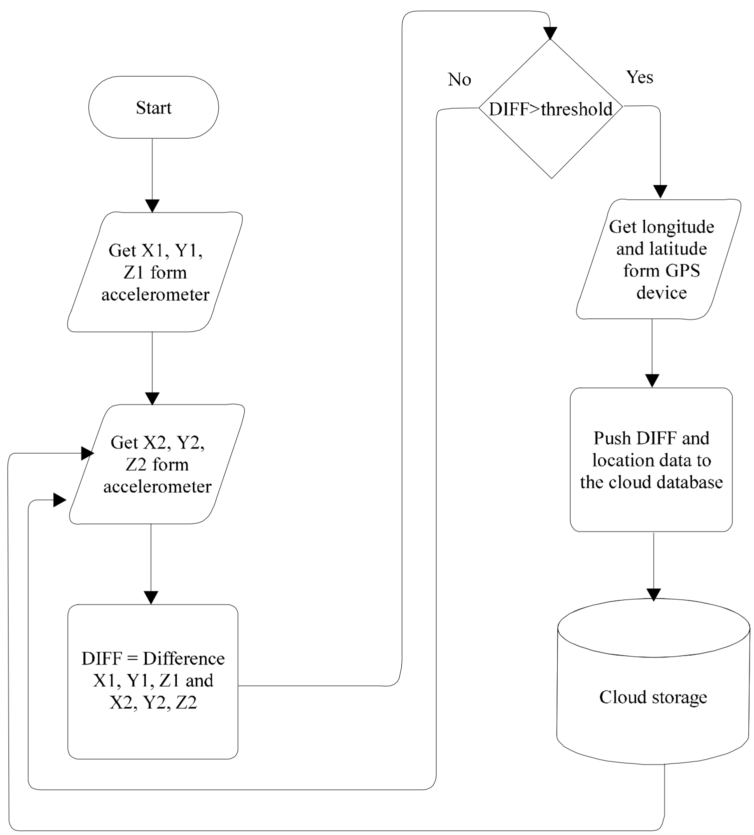

Fig. 1: Anomaly cheek process

anomaly on the road. The clustering is necessary, since, we are crowdsourcing the data and helps avoid noise and outliers.

The method of density based clustering (Ester *et al*., 1996) will be used because of the ability to take any arbitrary shape while forming the cluster. A collection of the exact location of the anomaly will be stored separately and will be used for plotting the location of the various anomalies on Google Maps. The DBSCAN clustering algorithm (Ester *et al*., 1996) will be used for this purpose. There are two parameters to the DBSCAN algorithm. One is Epsilon which is used to specify the radius and the second is the minimum number of points required in the specified radius. Accordingly, if the number of neighbouring data points satisfy the parameter of minimum points then that point and the points within the radius will be included into a cluster March 19, 2019 (Ester *et al*., 1996).

The algorithm also does the job of assigning labels to the data points to specify which cluster it belongs to like '0', '1', '2', ..., etc. In addition to this, it also labels the outliers/noise with the label '-1'. Hence, this algorithm was ideal for the data that was being gathered by this system. The output of the algorithm can be seen in the following Fig. 2.

This clustering can also be easily visualized. For the visualization we have used the matplotlib library in Python. The clusters are assigned unique colours and the outliers are marked as black dots. This helps to get a better idea of the quality of the clusters and helps to decide whether the parameters need to be tweaked to get better results or not. The minimum points parameter can be used to get the clusters of anomalies that have been reported very often and have been encountered many times. If the minimum points parameter gets a low value then the number of clusters will increase and vice versa (Fig. 3).

Based on this data, we can plot the occurrences of these anomalies on a map in our case Google Maps. After plotting we can observe the map of the recorded occurrences as this will give us a better idea about where and how bad the road anomalies are. Once, we have gathered the data and done the processing we can use it for various purposes and in our case we will use it for

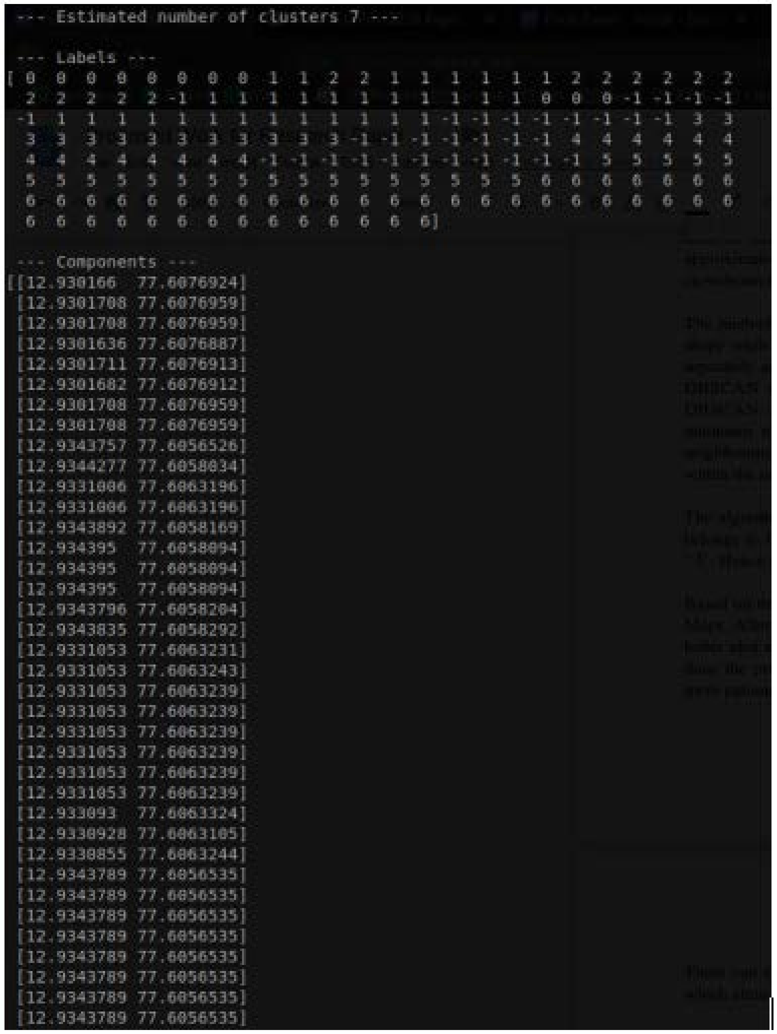

Fig. 2: DBSCAN clustering results

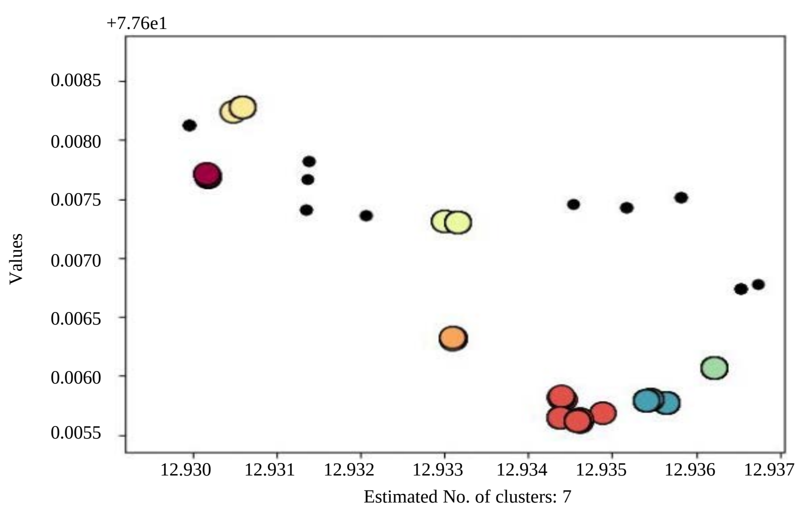

Fig. 3: DBSCAN cluster plots

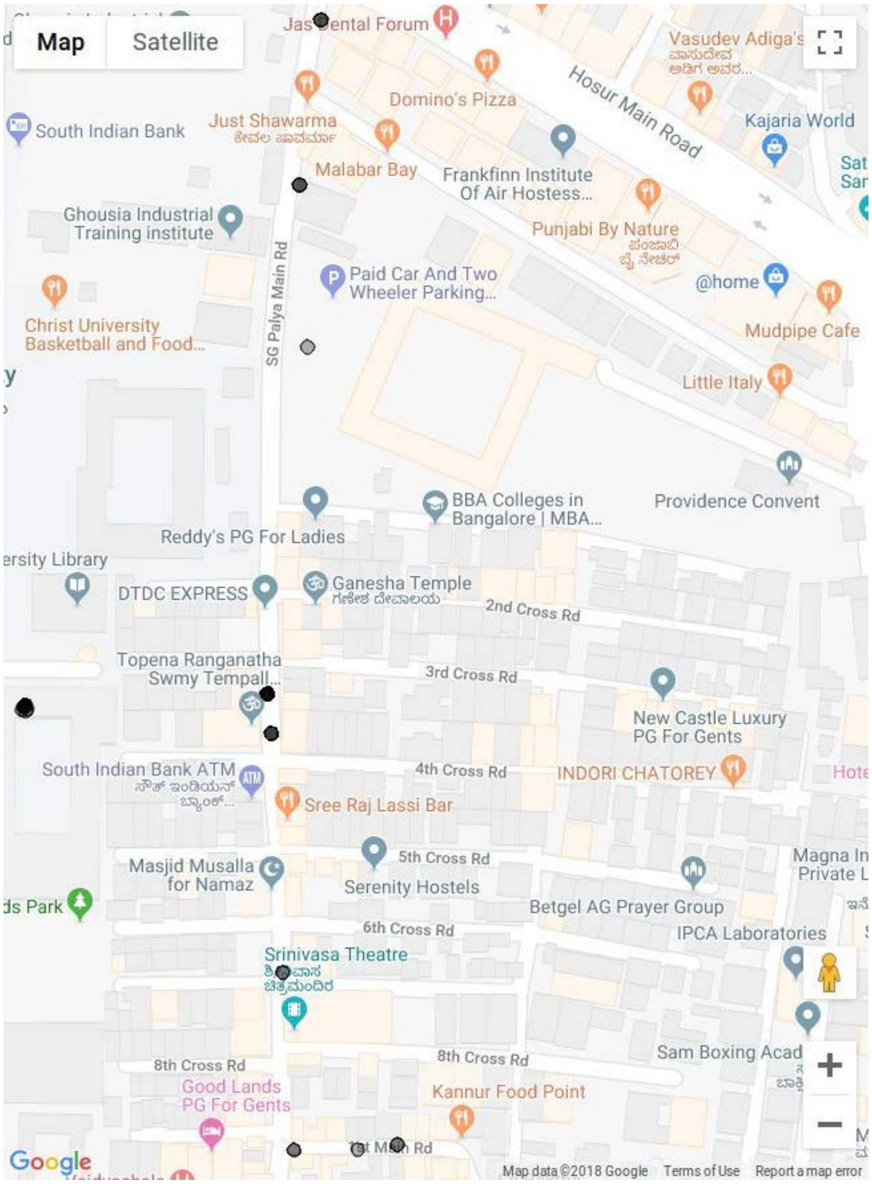

Fig. 4: Anomaly data on Goole Maps

adding more parameters in the route choosing while navigating using Google Maps. The data points plotted on the map will be the points that have been assigned to a cluster by the DBSCAN algorithm (Ester *et al.*, 1996) (Fig. 4).

The anomalies are shown on Google Maps as black scatter points. We get a very good representation about the anomaly data collected and the map is the best way to visualize the quality of the roads based on anomalies. Figure 1 and 4 show the anomalies detected during the test runs of the anomaly detection Android application.

CONCLUSION

Based on the ideas from adaptive route selection system, road pavement monitoring and GPS assisted carpooling, a hybrid system where all the components come together to get the best possible route, GPS assisted navigation along with traffic anomaly information is created. Added to this, we also have a system of measuring road quality with mobile sensing technology. Thus, we can have a hybrid system wherein multiple choice can be provided to the users when he chooses his destination on the maps. Choices like fastest route, fast but bumpy roads, slower but smooth roads, etc. Also, more options like transporting fragile goods, travelling with sick people infants, etc. will be available to get the route best suited for such situations. The system can either be embedded into car and this can be a separate project itself or a mobile application can be developed to gather all the required reading and send them to the main server where the data processing will happen with real time data.

REFERENCES

Anonymous, 2016. Here's how your phone is tracking you right now. Future US Media company, San Francisco, California, USA. https://www.techradar.com/news/phone-and-communications/mobile-phones/sensory-overload-how-your-smartphone-is-becoming-part-of-you-1210244

Anonymous, 2017. GPS: The global positioning system. Global Positioning System, USA.

Anonymous, 2019. Cloud firestore. Firebase, San Francisco, California, USA. https://firebase.google.com/docs/firestore/

Binu, P.K. and V.S. Viswaraj, 2016. Android based application for efficient carpooling with user tracking facility. Proceedings of the IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), December 15-17, 2016, IEEE, Chennai, India, ISBN:978-1-5090-0613-7, pp: 1-4.

Ester, M., H.P. Kriegel, J. Sander and X. Xu, 1996. A density-based algorithm for discovering clusters in large spatial databases with noise. Proceedings of the 2nd International Conference on Knowledge Discovery and Data Mining, August 2-4, 1996, Portland, pp: 226-231.

Rahman, S., N. Yeasmin, M.U. Ahmmed and M.S. Kaiser, 2015. Adaptive route selection support system based on road traffic information. Proceedings of the 2015 International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), May 21-23, 2015, IEEE, Dhaka, Bangladesh, ISBN:978-1-4673-6675-5, pp: 1-6.

Yi, C.W., Y.T. Chuang and C.S. Nian, 2015. Toward crowdsourcing-based road pavement monitoring by mobile sensing technologies. IEEE. Trans. Intell. Transp. Syst., 16: 1905-1917.