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Survey on Road Surface Monitoring System Using Internet of Things

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***Abstract:** In recent past Internet of Things (IoT) has been focused on recent research in various concerns. It is a very large network where it connects all smart objects together into the single network. It extends its usage into real-time applications like smart cities, smart house, and smart transportation. It is integrated to fog computing, to enable the services to every edge node in the network. Fog computing is enhanced prototype of the cloud computing, which provides the data storage to the devices at the edge nodes. Fog/Edge computing is distributed infrastructure, where the application of data is logically distributed between the data source and cloud. In recent years, greater attention has been given by many countries to monitor the Road Surface Condition; many solutions have been proposed to reduce the accident and traffic flow, which make use of mobile sensing and even vehicle sensing system. In this paper, we discuss the methods used for road surface monitoring using the IoT and related security issues during the data transmission between the nodes. In the end, this paper conducts the comprehensive analysis, to find the accuracy and efficiency of data transmission between the nodes and the usage of IoT in a smart transportation system.*
***Keywords:** Internet of Things (IoT), Fog Computing, smart transportation, cloud computing, Road surface condition.*

I. INTRODUCTION

In recent years, the usage of the internet has increased rapidly. It provides the anywhere, anytime connectivity with anyone, which makes the human's life easier. Every real-time objects/ things are connected to the internet to make the work easier. IoT is playing the major role in the various domains as well as the individual user by scheduling the day - to- day works. In many organizations, IoT is used to take the decision quickly at the critical situation, and also it reduces the human works. In addition to that IoT has deployed into houses, where home appliances/devices are controlled remotely and monitored. There are many types home automation systems which provide the various services, such as remote controlling appliances, voice alert, and theft alert as it is very useful for physically disabled persons. Population increases the ownership of vehicles increases exponentially. Due to enormous growth in vehicles usage, traffic management and road safety are the major challenges in many countries. Monitoring the road surface quality is a major indicator to avoid the accidents, such as slipperiness, potholes and bumps are parameters of road surfaces qualities. In worldwide, many governments spend millions of dollars to maintain the surface of the road, they have separate patrol crews to examine the surface of the road with the motive of identifying the potholes, bumps and rectify them periodically to avoid the accidents, and this process is not efficient and requires many manual resources. By using the advanced technologies, the road anomalies can be easily maintained. In many countries, smart transportation infrastructure has been constructed, which is used for traffic management and also to ensure the road safety. IoT uses the nodes and sensors to communicate between the vehicles, the main issues in IoT are security aspects, where data transmission between the node/device are not in a secure manner. In this paper we discuss and analysis the road surface monitoring system in detail. We organize this paper as follow, In Section II, related work and methodologies used in road surface monitoring. Problems and challenges in security, in Section III. And in Section IV, Detailed analyses of methods used, and find the efficiency and accuracy among them. We conclude this paper Section V.

II. RELATED WORK AND METHODLOGIES

They are many proposed model in recent years based on the road surface monitoring system, to avoid the accidents and ensure the travelers' safety, this paper is focused on major methods used to detect the irregularities of road surface as follows, [2] the author proposes the model to monitor the road surface using the image processing technology. The proposed model uses the simple bicycle, to capture the image and process the data. It consists of two core modules: laser light module, where it emits grid laser light and camera module, it captures and alerts the cyclist if the road surface is bad.

The surface of the road is detected by using the template matching method, (i.e) The template image of a good road surface is created and it is compared with an obtained image (captured by the camera) periodically.

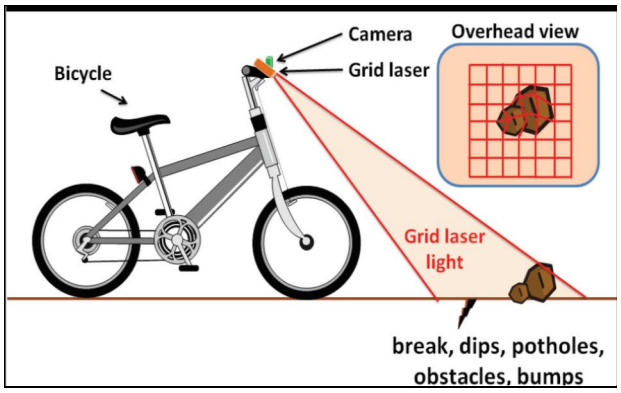

Fig. 1 Overview of system model

The correlation coefficient may differ when the obtained image has potholes or bumps. If the correlation coefficient of both images differs, then the surface if the road would be bad and it alerts the cyclist.

Yazan A. Alqudah & Belal H. Sababha [4], used a gyro rotation information, which is obtained from the sensors to detect the variation on the road. This model conducts the drive test, which has round-trip path with approximate 3.7 km's. They have repeated the test several times to ensure consistency. The dashboard of the vehicle is mounted with mobile phones, are used to collect the gyro rotation data and also have GPS, a speed of vehicles as log files. The phone with gyro rotation information is readings of a road surface, which can't be visualized and get the information easily. To get the information author uses the gyro rotation data as variability, which indicates the potholes, bumps on the road surfaces.

Variability is measured by variance,

$$v = \frac{1}{N-1}\sum_{i=1}^{N}|X_i - \mu|^2,$$

For analyzing the data, author uses moving variance,

$$v(n) = \frac{1}{m}\sum_{i=n-m+1}^{n}|X_i - \mu(n)|^2,$$

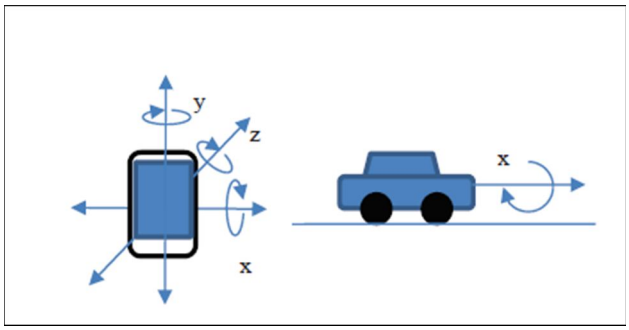

Fig. 2 sample system model

The author also proposed the Dynamic Time wrapping (DTW) method, to get the accurate measures of each path. Generally, DTW is used in speech recognition system to measure the similarity between two temporal sequences. Similarly, the author uses the two-time sequences which vary in speed to find the minimized path in a total cumulative distance with accurate measures.

The authors proposed the model to identify the irregularities of the road by using the smartphones [3], and they have highlighted the major 4 advantages over other existing systems. a) novel energy efficient, accelerometer analytics in phone b) communication of

data between phones and backend has been reduced, c) multi-user fusion method to authentic the road maps, d) privacy of user data during the data sharing. The model consists of three modules: *Extractor, Classifier, Fusion modules.* User's smartphone capture the accelerometer sensed data continuously and these data were extracted by extractor module. In classifier module, scores were generated for each identifier in road surface and stored in backend server along with location using RESTful interface. At the backend, fusion module runs to aggregate readings depends on locations and store the aggregated scored along with a location. The mobile application now decides based on feature indicated by the score. If it exists (score) the answer will be yes and it is plotted on the map as obstacle and alerts the drivers in the way.

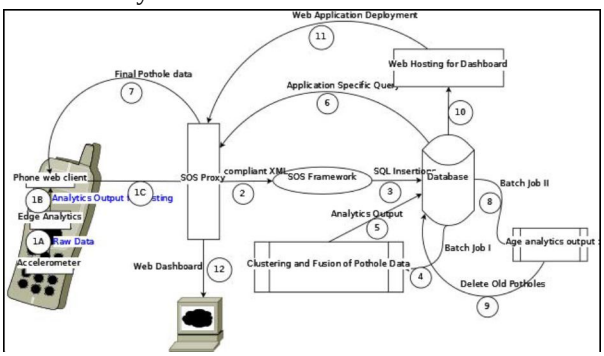

Fig. 3 pothole application data flow

The security is a major concern in IoT. The author focused on security by preserving the privacy of user's data during the transmission between the devices and cloud server [5]. The model has a separate control center, sensors, RSU as fog node and cloud server. The CC is used to generate the partial private key for registered users in order to avoid the escrow problem. Mobile sensors are embedded into vehicles to detect the surface of the road, the RSU (fog node) is an extension of cloud services, were able to react and make decisions. The sensed data from the vehicles are sent to RSU for immediate processing. At last the processed data is sent to cloud server, which has historical information about the data that is sent by RSU. The RSU is used to reduce the processing in a cloud server. This model uses Certificate Aggregate SignCryption (CLASC) scheme, where they have separate control center to ensure the data transmission in a secure manner.

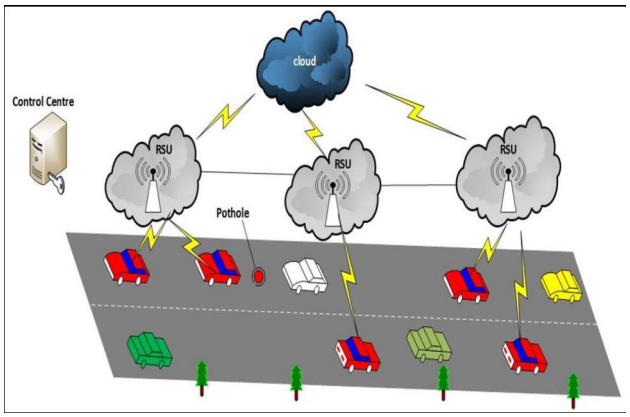

Fig. 4 System model

This KGC will generate the partial private key and send to the corresponding user in a secure manner. The user key is generated by taking user identity as input and return the secret value and corresponding public key, by this user will generate their own public key and shares in a cloud. Signcryption is done to each user's data. "n" set of user data signcryption has been aggregated by a separate algorithm and return the ciphertext. At the receiver, an aggregated chipper text has been verified. In the end, the ciphertext has been converted to original message by using aggregated unsigncrypt.

III. PROBLEMS AND CHALLENGES IN SECURITY

A security issue has become the major concern in this field, due to enomours usage of IoT devices in day-to-day life. In previous section, we have seen that quality of road surface are detected using the sensors in the vehicles. These data's are transmitted between the nodes to identify the quality of road and to deliver the same to users. During the transmission, these data's can be

fabricated by hackers/intruders. They can intrude the network and modify the data that passes through a channel; they even control the whole transmission channel and monitor the transaction of data between the nodes. They can also remove some packets from data, or even replace the original data. Moreover, the nodes in the network will become a malicious node and the whole network will be the same. Then, the receiver will get the forged report from server and whole system would be crashed.

One of the major challenges is to ensure that, data generated by the sensors are transmitted between the node/device are in secure manner. This can done by, Data integrity: all message origination should be protected. *Authentication:* the sensor node and edge node should authenticate each other to ensure the originality of data. *Anonymity:* During authentication process, the sensor node information should be hidden from the receiver.

IV. RESULT ANALYSIS

In this section, we represent the comprehensive analysis of methods used in road surface monitoring system that we discussed in earlier section. Analysis is given in the Table I below.

Author name	Title	Methods used in paper	Defects identified
Yoshiaki Taniguchi, Hiroyuki HIsamatsu	A study on Road surface condition monitoring system using Bicycle-Mounted Grid Laser Light	Uses a laser light mounted on bicycle to alert the cyclist, by using the image processing technique.	It can't be implemented in Low moving vehicle and High moving vehicle
Yazan A. Alqudah, Belal H. Sababha	On the analysis of road surface conditions using embedded smartphones sensors	Uses the gyro rotation information from the sensors, which is gathered at round trip of vehicle, and also use the Dynamic time wrapping technique to get the accurate representation of road.	The computation cost is low.
Avik Ghose, Provat Biswas, Bhaumik, Monika Sharma, Arpan Pal, Abhinav Jha	Road condition monitoring and alert application using in vehicle smartphone as Internet –connected sensor	They have three major methods to extract the sensed data from the sensor, process the data in classifier module, and store those data in server. At last these data were used by the end user (application).	Lack of security in data transmission between the sensor and vehicle, as well as less security in application.
Sultan Basudan, Xiaodang Lin, Karthik snakaranarayanam	A Privacy preserving vehicular crowdsensing based Road surface condition Monitoring System using Fog Computing	They use the separate control Centre for secure data transmission between nodes. CLASC scheme is used for node and data security.	The computation cost is high, partial private key exchange between fog node and vehicle requires the high duration for authentication.

TABLE I comprehensive analysis of methods used for monitoring the road surface condition.

From the analysis, we suggested the method that can implemented in real time application with less computation cost and in secure manner. The vehicle with mounted sensor can sense the data from the path and forward the data to nearby fog node (where the data processing is done). All these processed data are aggregated and sent to server for the access for end user.To ensure the security for data transmission, each vehicle in the network are identified by single unique ID for authentication between node and vehicle as well as server to vehicle.

V. CONCLUSION

IoT is emerging technology, where many countries have started to deploy the IoT devices in their cities to maintain the traffic, monitor the public transportation, monitor the public safety, and check the quality of road etc., In this paper, we discussed the major methods that are used for monitoring the road surface condition, and also represents the comprehensive analysis among those methods to find the efficiency and to ensure the privacy of users data. At the end of the analysis, we suggested the method that can be deployed as a real-time system in the efficiency and secure manner.

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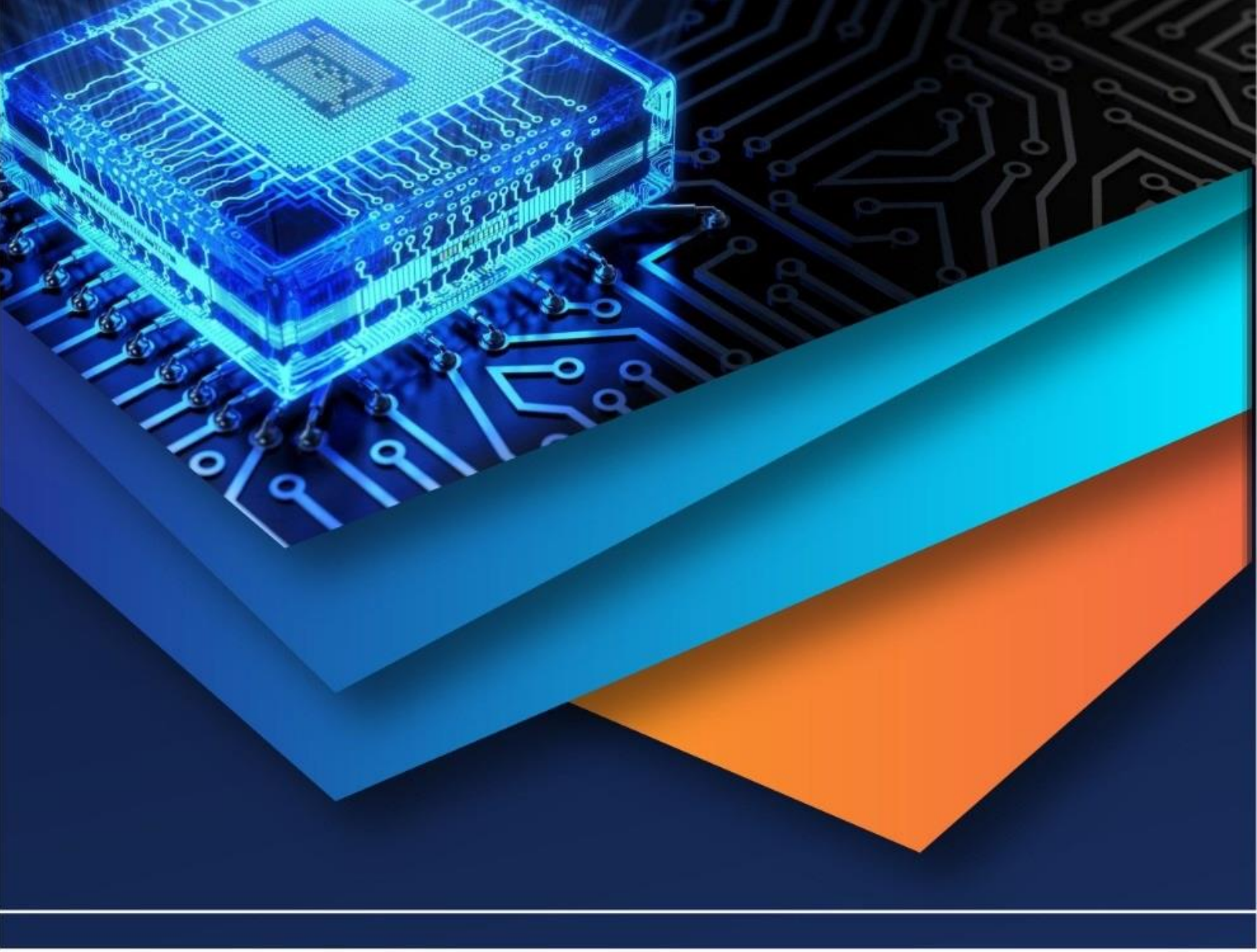

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