An IoT-Based Intimation and Path Tracing of a Vehicle Involved in Road Traffic Crashes

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***Abstract*—Road traffic crashes are the major risk factor in everyone's day-to-day life due to the fast increase in the number of vehicles. It is now a more challenging task to deal with existing traffic systems with massive traffic. In the current scenario, the Internet of things (IoT) based solutions will make the transport system more intelligent. This solution will help to reduce congestion and increase the safety of everyday people. Fast reporting of driving abnormalities[1] will help in preventing the life of the person involved in traffic crashes. Traffic crashes can be addressed using sensors, audio, and video-based analysis. The work presented here is a fast information sharing system with the date and time of the event, the detailed geographical location with Google map URL, speed, and the path traced using global positioning system (GPS) data. The fast reporting system uses various sensors to collect the vehicle data and notifies the driving abnormality, whenever any abnormal situation occurs. It will help the rescue team, insurance people, or relatives for easy navigation to the desired location. The limitations of communication bandwidth requirement and the powerful central processor may reduce detection performance; however, fast reporting could save many precious lives from danger.**

Keywords*—*Traffic crashes, Driving abnormality, Global positioning system (GPS), Fast reporting, Internet of things (IoT).

I. INTRODUCTION

Traffic crashes are unpredictable and unintentional events. It usually occurs in congested areas may be due to human fault, machinery fault, parking issues, or any other environmental issues. In India, the total count of registered motor vehicles is more than 21 million as per the report of 2015, and one death occurs every four minutes due to traffic crashes [1]. From the reports of world health organization (WHO) [2], 1.24 million people were killed on the road, and up to 50 million people were injured. The primary reason for half of the deaths in road accidents is due to a lack of treatment in proper time. In India, the fatalities based on road accidents have increased at the rate of 5% per year. But simultaneously, the population grows at the rate of 1.4% per year. As per the report [3], the fault of a driver accounts for 78% of the total accidents that happened in 2013.

Risky driving is the major fault in a car accident, which may be due to loss of attention (such as drunk driving, distracted driving, drowsy driving, using a mobile phone during driving, over speeding, driving without safety equipment) [4]–[8]. The prevention of accidents is more important as human beings control vehicles. The vehicle's safety system based on low-cost electronics equipment is most important to save the lives of the people [9]. The camera-based system can be utilized to monitor the dangerous driving behavior like lane changing [10], and the prevention of collision can be achieved by using sensors like ultrasonic sensors and radar-based systems [11], [12]. The safety solution, like airbag deployment, uses micro-electro-mechanical systems (MEMS) accelerometer technology, and its impact is based on the sensing capability, which is more when the impact point is closer to the accelerometer [13].

The accelerometer and gyroscope sensors can be used with global positioning systems (GPS) to determine the vehicle's position, orientation, and velocity. The data from the sensors built-in devices or vehicles are gathered, and different operations can be implemented for its analysis and necessary action. The use of electronic and digital tools is increasing rapidly, and it becomes an essential part of our daily life. Internet of things uses smart devices that are available with programmable and remote control devices. The IoT also establishes communication among devices by the exchange of data using wearable or wireless devices [14]–[16]. The work presented here is a low-cost device for vehicular data collection and analysis to identify the driving abnormality. A cloud-based alert mechanism is used for fast notification. The objective of the system is to eliminate time delay between the occurrence of accidents and dispatch of the first responder with low-cost implementation. The rest of the paper is organized as follows. Section II explains the problem definition, and Section III explains the methodology and Section IV provides the experimental results, Section V provides conclusion with future scope.

II. PROBLEM DEFINITION

The growth in technologies creates an opportunity for intelligent transport systems (ITS) to deal with road accidents. Different surveillance systems analyze the data acquired in the form of videos, audios, and sensors for detection of the road accident. In some cases, visual data are not sufficient to analyze, whereas audio data can be used for the identification of hazardous situations [17]. A sensor-based system can be included in the transportation infrastructure to make smart transport where users can avail of the information benefits like driving assistance, collision alert, traffic control, and road

[1]In this article, the abnormality is the behavior of the vehicle when it meets an accident while on the move.

conditions. A more cost-effective and efficient system can be developed based on sensors data, which will be valuable for end-users and other transport management systems [18].

III. Methodology

One of the objectives is to provide a fast solution for emergency cases, where help and assistance is the primary requirement. The overall approach of traffic crashes intimation system is represented as a block diagram shown in Fig.1.

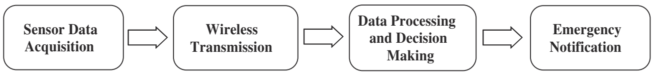

Fig. 1: Block diagram of overall system

The process of fast intimation comprises of four stages,

- In the first stage, sensor modules installed around the vehicle acquire the required data.
- In the second stage, the acquired data are processed and transferred to the central processing unit or fusion center (FC) over Wi-Fi. The process of data transfer from sensor modules to the central processor is achieved based on the message queuing telemetry transport (MQTT) protocol.
- In the third stage, all the computations are carried out in the fusion center and the decision on happening of any driving abnormality is made based on a certain threshold level.
- In the final stage, whenever abnormality in driving is detected based on threshold based centralized data fusion technique, a packet of data containing the details of accident location is sent to the cloud database. An emergency notification containing (date, time, location coordinates, Google map URL) is then sent to the nearest response unit. The transfer of data from the central processor to the cloud server is done through HTTP (hypertext transfer protocol).

The interfacing of the sensor module with a central processor is shown in Fig. 2. Here the data are collected from a host vehicle, with multiple in-vehicle sensors and a Wi-Fi enabled microcontroller. The central processor receives the data over Wi-Fi and takes decisions based on an accident detection algorithm. This system measures the important parameters like change in speed, rotation (yaw, pitch, roll), etc. for identification of driving abnormality. A GPS receiver is used to get the position, velocity, and timing information of the moving vehicle. Two methods of communication are implemented and tested. The first HTTP connection is established for point-to-point communication and then MQTT protocol is used for sending of data from sensor nodes to the server (Pub-Sub approach). The connection between publishers and subscribers is handled by the broker, which filters all incoming messages and distribute to subscribers.

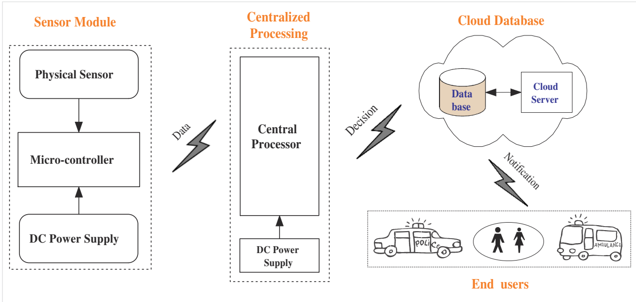

Fig. 2: Sensor module interfacing

A. GPS data collection

GPS receiver computes position and time, which is displayed in different message formats over a serial interface. The GPS receivers output generally follows the national marine electronics association (NMEA) standard format [19]. The NMEA sentence format type 'GPRMC' is used, which is the recommended minimum specific GPS/transit data [20].

For an example, the received GPRMC format of GPS data is "225446, A, 4916.45, N, 12311.12, W, 000.5,054.7,191194,020.3, E*68". The first term gives the time stamp in coordinated universal time (UTC) (like 22:54:46), the second term validates the working of GPS module with 'A' as ok and 'V' as invalid, the third term (4916.45, N) means the latitude 49 degrees 16.45 minute north, the fourth term (12311.12, W) means longitude 123 degrees 11.12 minute west, the fifth term (000.5) gives speed over ground in knots and so on. Both latitude and longitude are in decimal numbers, so to convert into degrees, minutes to decimal degrees by realizing that there are 60 minutes in a degree. So for above case 16.45 minutes = 16.45/60 degrees = .27416 degrees. Hence the 4916.45N must be converted to 49.27416 degrees. A knot is a unit of speed equal to one nautical mile per hour, which is 1.852 km/h (approximately 1.15078 mph or 0.514 m/s).

B. Alert mechanism

The acquired data are sent to the central processor to make a decision on accident status and send alert information whenever the accident detected. The alert mechanism requests the intermediate services to send a notification to the user. A push notification message pops up on a user's mobile like an SMS or alert but it reaches to those who have installed the application. The notification can be URLs, links and notes from a computer e.g., Raspberry Pi to the mobile device and vice versa. The cloud-based notification uses a free web-based service IFTTT (If This Then That) along with the webhook application. The processing occurs in the IoT platform IFTTT as shown in Fig. 3.

The HTTP request is made on the below mentioned uniform resource locator (URL) as, https://maker.ifttt.com /trigger /Event_Name /with /key /API_Key', params = "value1":Latitude,"value2":Longitude, "value3": Map _URL). The "Event_Name" is the event that is created on a webhook to react when a request is made from the central processor,

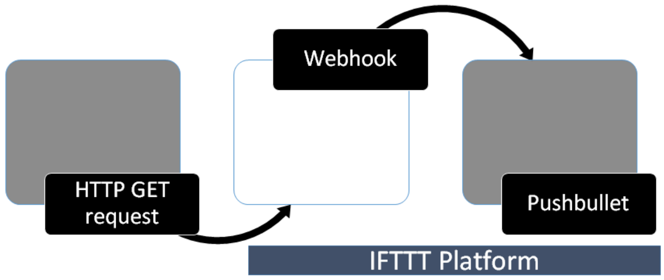

Fig. 3: Push notification architecture using IFTTT

for example, accident detected. When an event happens, the webhook delivers data to the Pushbullet service and the person gets notified about the accident location with google map URL. The application program interface (API) key is a specific key given to connect two programs (e.g., python script running on the central processor and the webhook on the IFTTT platform). An alternating approach is performed for simultaneous notification through SMS and Email, where the installation of an android application is not required. However, SMS subscription is required to send a notification to a large number of end-users. The IoT platform set-up for IFTTT is shown in Fig. 4. In this work, we just tested the feasibility of

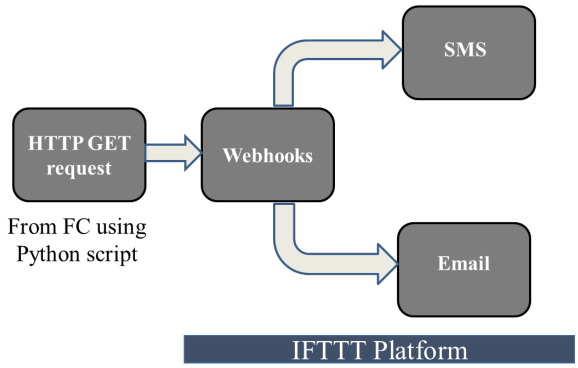

Fig. 4: SMS and E-mail architecture using IFTTT

a cloud-based alert mechanism in near real-time. However, a dedicated study on latency is not carried out.

C. Vehicle path tracing

The latitude and longitude data from the GPS receiver are stored in comma-separated values (CSV) files. The tracing of geographical coordinates is performed by reading the stored GPS coordinate data line by line from the CSV file, and then it is plotted which holds the latitude and longitude till user interrupts. The tracing of the path is performed using Node-RED, which is a flow-based development tool to connect together the hardware devices with APIs and online services in IoT. The overall flow mechanism to trace the path is shown in Fig. 5.

The nodes, in general, react to certain inputs and pass on

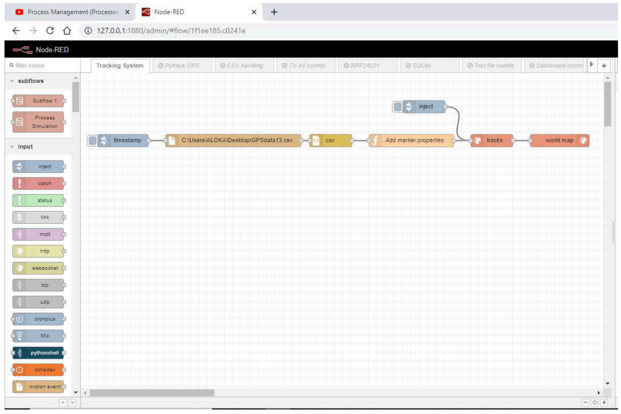

Fig. 5: Node-RED flow setup

some output. The different node operations are described as follows.

- The first node is called inject, which starts the job to start reading or initiating the process.
- The second node is the file node which is provided with the file directory of the data file.
- The third node is a CSV node specifically used to handle CSV file related requirement handling. In this case, the node blocks the first row which is the headers in the data file.
- The next node is function node, which is programmed with certain JavaScript code to create payload for the next nodes, which are the latitude, longitude, marker properties, icon and others that would be shown on the map. The JavaScript Object Notation (JSON) format is used here for creating JavaScript objects. The payload used for plotting the track is: msg.payload = "name": "Track", "lat": msg.payload.Latitude, "lon": msg.payload.Longitude, "layer": "drawing", "iconColor": "red", "fillOpacity": 0.8.
- The next node is a track node that is particularly used for the application for latching the values coming to the last node which is the world-map node. It is configured with several points and layers to hold.
- The last node is the world-map which caters us with the maps and other zoom-in/out, navigation through the map capabilities.

IV. Experimental Result Analysis

In this article, more emphasis is given to automated information transfer and evidence gathering for post-accident analysis. Field testing is performed to acquire the required parameters using wireless sensor modules. In the field testing, the sensor modules are used in a car (Maruti-800), and a test run is performed. The data variations are observed following the variation of speed in normal or bumpy surfaces. The sensor data and the notification details (only when any driving abnormality occurs) are stored in the cloud database. The information that is shared as a notification in the cloud database is shown in Fig. 6. The notification contains the date and time of the happening of an event, details of the system used to do this operation as device ID, geographical coordinates of the location where abnormality occurred.

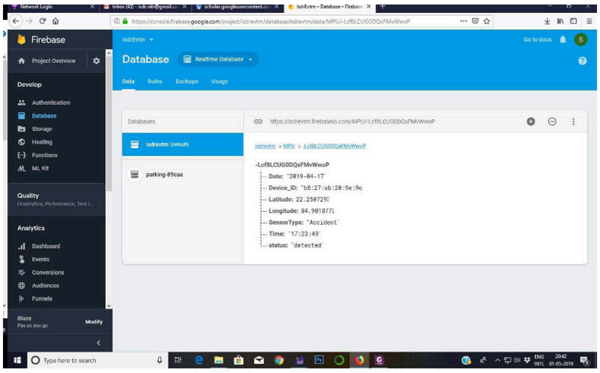

Fig. 6: Cloud based notification with location details

The notification from the cloud server can be delivered to the end-users using different ways for easy communication. Three different possible approaches have been made for easy setup and information sharing. An android application based method known as push notification received on users mobile is shown in Fig. 7. Here user needs to install an android application from the Google play store.

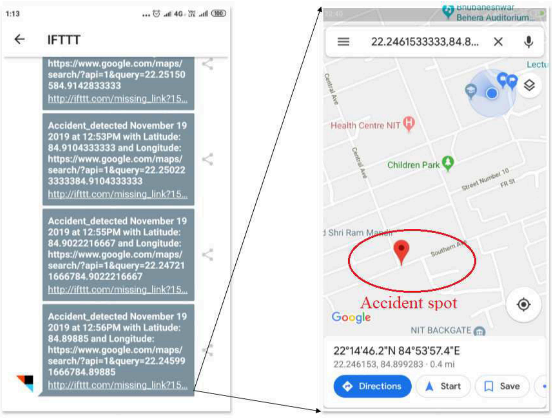

Fig. 7: Push notification on user's device

Another option is to use Internet service to provide alert to the end-users without the need for any android application installation. It uses the SMS and E-mail service to alert about any abnormal driving situation. However, the SMS subscription is required for bulk messaging. The notification also contains a Google map URL for easy navigation to the emergency spot. In some cases, the SMS may get delayed depending on the mobile network availability on the user end. Hence another backup alternative is also used for simultaneous alert, assuming a strong Internet service is available. All the ways of notification can be combined and applied so that there will not be any loss of notification. The notification received as SMS and E-mail alert are shown in Fig. 8 and Fig. 9 respectively.

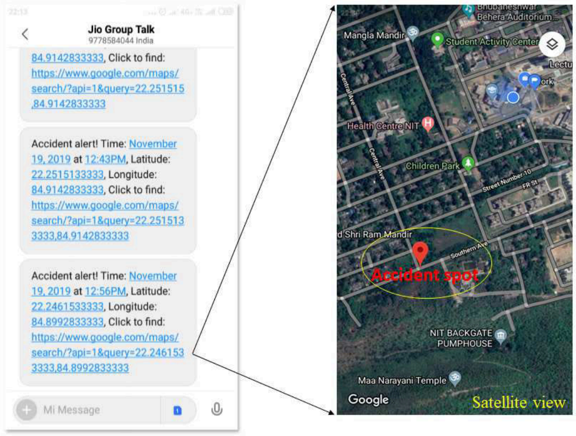

Fig. 8: SMS alert on user's device

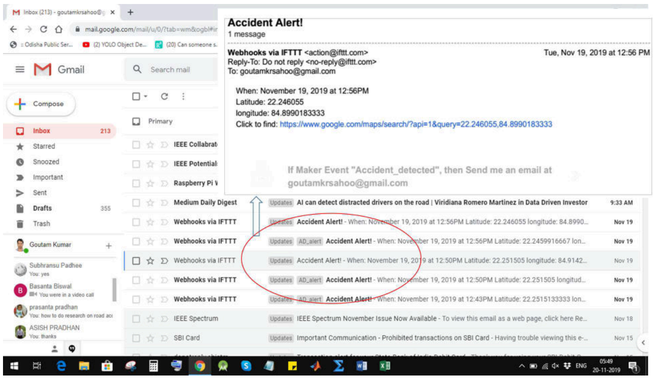

Fig. 9: Email alert on user's device

In all the notification cases, the GPS coordinates with URL help the end-users to get navigated to the location where any abnormality occurs. It provides a user-friendly application to reach the people who need immediate help and will be a useful approach considering the current smart city scenario for intelligent transportation applications. It may help to reduce the rate of fatalities as per the Indian road infrastructure scenario. Another application for analyzing the route followed by a vehicle before and also after any abnormality occurred. This method also can be utilized by the vehicle owner to verify the travel made and also the speed maintained during the travel. Whenever there is any abnormal situation, we can verify the travel route as well as the speed reached on or before anything happens. It also helps insurance people to avoid the claim made by the user while any vehicle crash occurs. Hence, the path tracing of the vehicle involved in road traffic crashes using GPS coordinates is shown in Fig. 10, which will add valuable information while incorporated with emergency rescue operations during any driving abnormality happens.

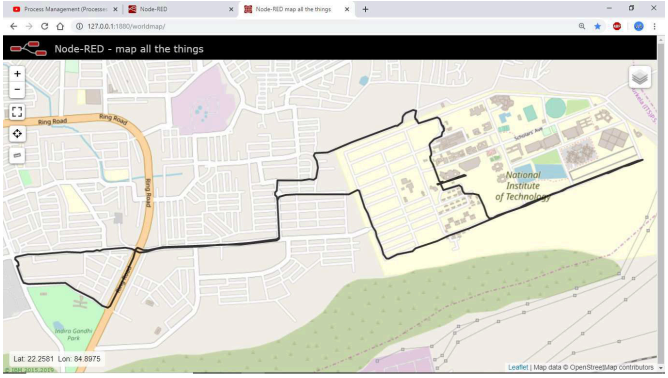

Fig. 10: Path tracing of vehicle involved in road traffic crash

V. Conclusions and Future Works

In this work, the data acquired from in-vehicle sensors are used to identify the driving abnormalities based on centralized data fusion technique. Once any abnormality detected while driving, the packet of data containing the location details is sent to the cloud database and the emergency alert is dispatched. The alert data contains the date, time, location coordinates and Google map URL. These data help the rescue team or relatives for easy navigation to the desired location. This work is in the primary stage and it is field-tested by creating abnormal car driving situations like striking a hard mud surface with high speed in a safe mode. The sharp turning and speed variations are also done to test the working of an emergency alert system. The system sends notification within 1 to 2 minutes after the incident assuming all devices working properly with good Internet signal strength. The large communication bandwidth requirement, a powerful central processor and also the failure of the whole central processing system may put limitations; however, fast reporting of an abnormal event could save much precious life from danger. The path followed by the vehicle is traced to provide additional information for a detailed analysis of the event that occurred. In the future, video-based accident detection and alert system can be implemented to improve accuracy with low false positives.

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