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Automated Crash Event Data Recording System in Vehicles for Auto-Insurance Industry using IoT

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Abstract*—The Automobile sector is the leading edge of global economic growth which intensifies the market share rapidly. The Automobile Insurance Industry ensures financial protection against property damage or corporal injury resulting from traffic collisions and against liability that could also arise there from. One of the strenuous processes explored in this industry is claiming the fund. In current scenarios, the most of auto insurance industry works on various tested traditional methods leading to time-consuming claim settlement and also fraudulent claims. The low level of accuracy and the manual processes are the raising encumbrances for an insurer which leads to dissatisfied customers. This paper proposes, an Event Data Recorder (EDR) which is fixed in the vehicles that continuously monitors and acquires the behavioural information of the automobile and the motorist during the crash. Once the crash event occurs, the EDR sends the data before and after the incidents automatically to the cloud with the help of IoT. Analyses of these recorded variables helps identify the genuine reason behind the cause of accident with better accuracy. Thus, this automated Event Data Recording System helps the Auto Insurance Industry to make facile claims and in the reduction of fraudulent claims.

***Keywords*— Internet of Things (IoT), Crash Data Retrieval (CDR), Event Data Recorder (EDR), Insurance, Sensors.**

I. INTRODUCTION

As per the statistics (2006 to 2015), put forward by OICA in the year 2017, study shows that around 947 million passenger cars and 335 million commercial vehicles were in operation worldwide [1]. World Health Organization's (WHO) fact files claim that about 1.3 million people die each year on the world's roads and between 20 and 50 million sustain non-fatal injuries. Over the course of a typical long, driving lifetime, an average automobile user experiences a total of 3-4 accidents.

An automobile insurance is an arrangement between the insurer and the insured wherein the insurer provides coverage against any financial loss happening because of damage to the vehicle caused either through an accident or because of any natural calamity or any liability arising out of an accident or theft. Common automobile insurance coverage options include liability coverage, uninsured and underinsured motorist coverage, comprehensive coverage, collision coverage. The Comprehensive policy do not cover accidents due to drunken drive, deliberate accident, any contractual liability, etc. [2]

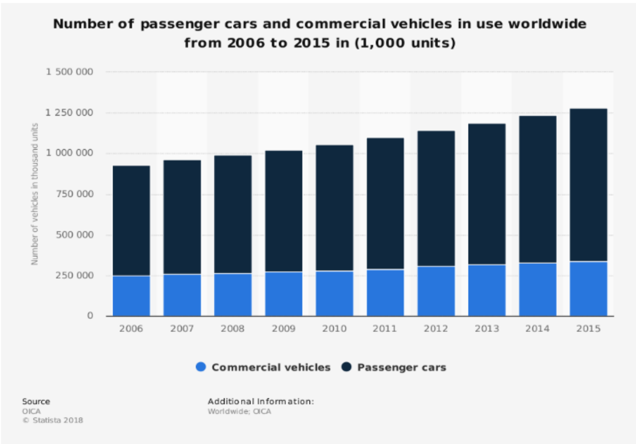

Fig. 1 OICA Statistics

Over the years, insurance policies were designed focusing on the vehicle rather than the customer, as the risk profile of a driver could not be determined accurately. One in ten insurance claims turn out to be fraudulent. Motor insurance fraud is generally of two types – one is the 'opportunity fraud' – otherwise known as 'soft fraud' (i.e. seeking more than the loss) and the other is deliberate act to cheat known as 'hard fraud' (faking incident, hiding previous driving records, backdating claims, etc). The reasons for fraud going undetected happens because criminals themselves are knowledgeable and smart in using tools such as the internet. An international range of 10-15% fraud goes undetected each year. As a result, insurance claiming procedures become time consuming and leads to dissatisfied insured customers.

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With advancements in the insurance industry and a positive shift in customers' demands, the technology of the Internet of things (IoT) is expected to rule this industry. IoT are essentially embedded systems and smart objects connected to internet with unique IP continuously monitoring and acquiring the behavioural information of the automobile and the address which can be discovered and communicated over internet. The IoT devices may have external peripherals like Actuators and Sensors.

This paper proposes, an Event Data Recorder (EDR) which is fixed in vehicles that monitor the motorist through the various sensors in and around the vehicle and stores this accurate and reliable information on the timing, chronology and the actions taken in the pre-crash phase and the reactions happen during the crash in a primary memory buffer continuously until the crash stops them. Once the crash event occurs, the EDR sends immediate pre-crash data and post crash data (closest) to a secondary buffer which is transmitted to a cloud storage via IoT. The auto insurance companies can in turn access the variables to understand what caused the crash. Thus, ensuring auto insurance companies to make facile decisions and in the reduction of fraudulent claims.

II. LITERATURE SURVEY AND BACKGROUND STUDY

There are several approaches used for deploying EDR systems. Bing-Fei Wu et al, proposed an EDR system which records and analyses the driving behavior of the motorist and various parameters in order to identify the cause of accident. This EDR system does not concentrate on collision made by other vehicles and components failure in vehicles [3]. The paper "An embedded based approach for accident analysis using event data recorder" proposes an EDR system to find number of traffic violations by a vehicle in order to reduce the accidents[4]. Collision can be avoided through auto emergency braking with the help of Ultrasonic and Proximity sensors. This work reveals that how data is being analysed to avoid collision rather than focusing on storage of data for later investigation [5]. The paper "Event data recorder in automobile" proposed by Aqib Jamal et al, the EDR designed is very helpful for the study of crash parameters but it is inefficient in the accessing of data ie; only Crash Data Retrieval (CDR) system team can manually retrieve the data which is a costly process [7].

In order to understand if the collision occurred due to drunken driving, Kong Sheau Tong et al implements the MQ3 sensor as breathalyzer to detect if the motorist is under the influence of alcohol or not, since loss due to drunk and driving is an exclusion of the third-party liability cover policy [8]. National Transportation Safety Board (NTSB) and National Highway Traffic Safety Administration (NHTSA), USA were made a research work on the implementation of EDR in vehicles to reduce the accidents, especially to reduce the death of children by crashes. Hopefully, the latest technologies based EDR systems helped to reduce the number of accidents per day [9]. The work done by T. Venkat Narayana Rao et al reveals the monitoring and controlling system for rash driving in vehicle which helps to take motorist's behaviour as also a parameter to analyse the cause of accident [10].

With the support of the paper proposed by Zeinab Kamal Aldein Mohammed et al, the impact of IoT on Automobiles paved the way towards the development of automated EDR for the proposed system [11].

A. Event Data Recorder

EDRs are devices which record information related to an "event." In the context of this paper, the event is defined as the occurrence of vehicle crash. Automobile vehicles have multiple sensors that monitor and control certain aspects of the vehicle to assist in driving and to maintain optimal vehicle performance. An Event Data Recorder (EDR) is an onboard device that receives information from these sensors and records that information received several seconds before and/or a fraction of a second after a crash or near-crash situation [8]. The data is intended to help understand how a vehicle's various systems functioned and the driver's behaviour before, during and after a crash. Furthermore, EDR is responsible for triggering the airbag restraint system. Typically, EDR is a microcontroller which accepts data inputs from various sensors, processes it and generates the event data for the events as well as the controlling or triggering signals for restraint systems. The various sensors deployed in the proposed EDR system are discussed below.

1) Seat Belt Sensor: Seat Belt sensor mat detects if the occupants in the passenger and rear seats have buckled up once the vehicle has begun moving. The Reed Switch sensor has been designed to be the best and most reliable way to detect when a seat belt has been engaged. With no doubt this sensor can be easily be fitted into the vehicle and can support the EDR by sensing if the in-vehicle passengers were making use of the seatbelts at a particular instance of time.

2) Brake Monitoring Sensor: The pedal position can be detected with the help of brake monitoring sensors. The characteristics of the voltage signal depend on how the brake pedal has been pressed. The data recorded by this sensor prove to be valuable in analyzing if sudden brakes were been applied or to detect soemthing as extreme as the occurrence of failed brakes.

3) Eye Blink Sensor: This Eye Blink sensor senses the eye-blink behaviour using infrared. The variation measured using the infrared waves is detected as per the eye blinking movements. If the eye is closed the output is high otherwise output is low. This sensor finds its application in EDRs' to analyze if the driver was in drowsy state or not.

4) Temperature Sensor: The temperature sensor uses the converter to convert the input temperature value to an electrical value. The sensor works by measuring the temperature that has being given off by the thermostat and/or the coolant itself. Any abnormal temperatures which may have led to cause an accident or vehicle damage can be noted when analyzing the data from this sensor.

5) Proximity Sensor: Proximity sensors are designed to detect the presence of nearby objects without any physical contact by emitting a beam of electromagnetic radiation (infrared) and looks for changes in the field or return signal.

The object being sensed is referred to as the proximity sensor's 'target'. In the case of the proposed Event Data Recorder, proximity sensors can be used to detect any object or obstacle in closeproximity to the vehicle at a nominal range which can be standardized before deploying it in the vehicle.

6) Accelerometer Sensor: One of the most common inertial sensors is the accelerometer and it is capable of sensing a vast range of inertial measurements of velocity and position. These sensors contain microscopic crystal structures that get stressed by accelerative forces, which causes a voltage to be generated. Accelerometer sensors are very essential to EDRs to continually record the velocity of the moving vehicle.

7) Alcohol Detection Sensor: This alcohol sensor is suitable for detecting alcohol concentration in the air. The sensing range can be set in such a way that it imitates breathalyzers. These sensors can be deployed to support the proposed Event Data Recorder to detect the presence of alcohol which can help understand if the driver was under the influence of alcohol. Thus, it becomes a key sensor to understand if any accident that occurs was due to drunken driving.

8) Vibrator Sensor: Vibrator sensors are critical to vibration sensing and monitoring. On the influence of a striking force, the mass causes a shear stress to be applied to the sensing crystals which in turn results in a proportional electrical output by the piezoelectric material. By implementing a vibrator sensor in the proposed EDR, the sensor can detect vibrations experienced by the vehicle in the case of a mild to a very strong collision. The vibrations detected over a threshold value is taken as the triggering signal for storing the "event" in cloud.

B. IoT for Insurers

IoT has the potential to decrease the number of fraudulent cases faced by the auto insurance industry causing a loss of millions of dollars every year. The age-old methods followed in the auto-insurance industry are revamped and aligned to support the modern-day introduction of IoT devices which can help insurers be aware of the state of an automobile and its parts from a remote position without even coming in contact with the automobile. The insurers can easily differentiate old and current, fake and legitimate damages, thus making it possible to process a claim for current damages. Insurers across the globe will soon be freed from traditional time-consuming claiming procedures by adapting and integrating IoT in their business models.

C. IoT for Consumers

Over the face of time, vehicle owners have experienced various problems while claiming for auto insurance. Higher customer satisfaction comes from quick insurance proceedings rather than arguing over facts and involving multiple third parties and dragging the procedures. Integrating IoT makes it a win-win situation for both the consumers and the insurers as they benefit from a fair, faster process and real-time data.

III. PROPOSED MODEL

As mentioned in section I, this paper aims to bring about a technological advancement in vehicles' Event Data Recorder system for the mutual benefit of the auto insurance company (insurer) and the motorist (insured). Thus, it helps to make the insurance claim procedure simple and fast as well as to reduce the fraud claims with the help of smart technologies. The figure-2 shows the architecture of proposed automated Event Data Recorder (EDR) system.

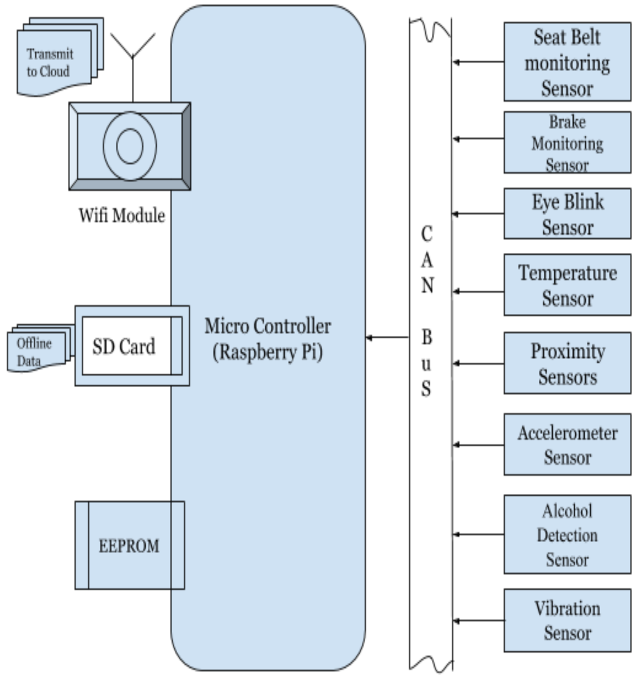

Fig. 2 Block Diagram of EDR

The figure-3 represents the overall working architecture involving the environment in which the EDR is placed.

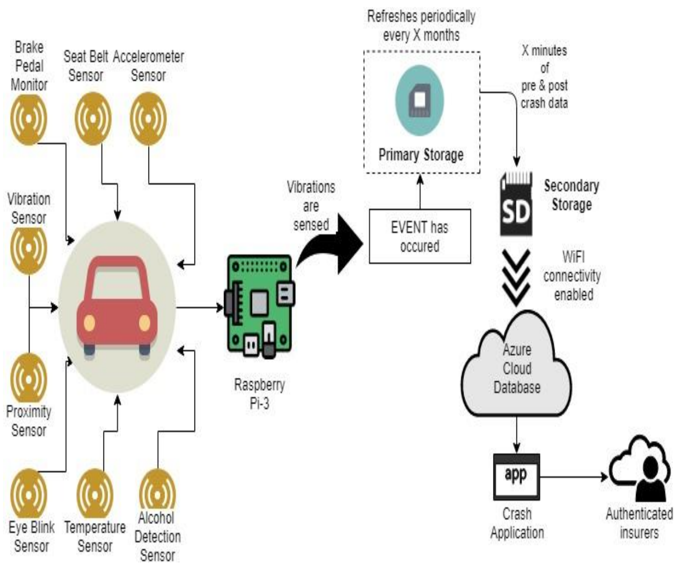

Fig. 3 Working Architecture of EDR System

The automated Event Data Recorder (EDR) is placed inside the vehicle, the sensors in the EDR continuously monitor the activities of vehicle and the motorist and feeds the data gathered from various sensors into the microcontroller.

The received data is stored linearly in the primary storage (EEPROM) which is set to get refreshed periodically every X months (say 3 months, based on the storage capacity of EEPROM). The sensors include vibration sensor, proximity sensors (rear & front), accelerometer sensor, alcohol detection sensor, seat belt sensor, brake monitoring sensor, temperature sensor, eye blink sensor.

The vibration sensor being the focal point of the EDR system is responsible for transmitting the triggering signal to detect an event (crash) by comparing the input with a threshold value which is pre-set. If incase it exceeds the threshold value, then it indicates that an event has occurred and hence the event data recorder system transmits a signal to enable X minutes (say 15 minutes) of pre, on-crash and post-crash data to be moved from the primary storage to the secondary storage.

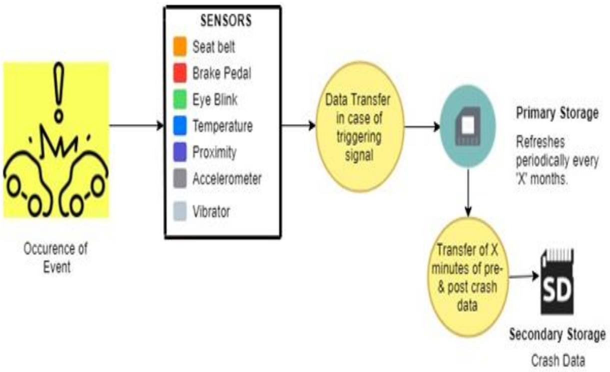

Fig. 4 Flow of crash data on the occurrence of an event

The SW-520D sensor is used for measuring the vibrations. As soon as the Wi-Fi connection is available, the crash data already stored in the secondary storage is transmitted safely to the Cloud without any loss of precious data. In the extreme cases when there is no Wi-Fi connectivity, the data is safely encrypted inside the EDR (SD card) and can be manually retrieved, legally by the authorized insurance companies.

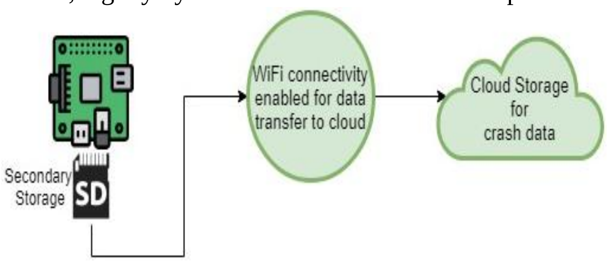

Fig. 5 Transfer of crash data from SD card to cloud

The introduction of cloud technologies ensure that large amount of data can be stored and retrieved easily and only the concerned insurance companies can get authentication to view the data through UI (Car Crash Application) for the respective vehicle, identified by a unique vehicle ID and access the variables to analyze how the accident occurred, the driving characteristics, the intensity of the crash, the timeline of events and most importantly to decide if the accident was legitimate or not.

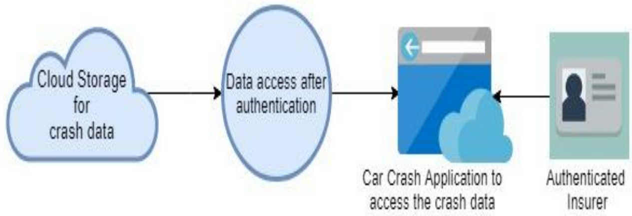

Fig. 6 Access of crash data from cloud

IV. IMPLEMENTATION AND EXPERIMENTAL RESULTS

A. Event Data Recorder

In order to experience the real time implementation of automated EDR system as mentioned in section 4, we created a miniature using the following equipment.

Sl.No	Sensor Name	Utilization
1.	Seat Belt Monitoring Sensor (MK 03)	Some of the major accident safety measures in vehicle such as Air bag is coupled with seat belt; Thus, the monitoring of seat belt usage by motorist is essential to detect the case of accident. MK 03 sensor returns boolean values to mention buckle is locked (Low) or not (High).
2.	Brake Pedal Monitoring Sensor (MK 16)	The sensors located at each brake actuator inside the vehicle, monitors if over-stroking, unresponsiveness or braking failure has occurred. These sensors can detect major brake problems in real-time.
3.	Eye Blink Sensor (Digital - IR based)	This sensor detects the drowsiness of the driver ie., if the eye is closed it returns high otherwise low. 5V (High) →“1” when Eye is close. 0V (Low) →“0” when Eye is open.
4.	Temperature Sensor (LM35)	To detect the temperature level before the crash and after the crash; A 10-bit Analog sensor; Every 10 mV is converted to 1-degreecelsius.
5.	Proximity Sensors (HC SR04)	A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. The sensor's transmitter pin sends a high frequency sound signal. If it detects any object within 3 ft (ranging distance), the signal gets reflected and is further picked up by the transmitter pin.
6.	Accelerometer Sensor (ADXL 345)	This sensor shows how the speed of the vehicle changes over time. The change in capacitance in all three axes (X, Y, Z) is converted to an output voltage proportional to the acceleration on one of the affected axes.
7.	Alcohol Detection Sensor (MQ 3)	This sensor becomes the breathalyzer component of this project to check if the driver was under the influence of alcohol or not. It can detect the presence of alcohol gases at concentrations from 0.05 mg/L to 10 mg/L.

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8.	Vibration Sensor (SW 520D)	This sensor is a high sensitivity non - directional vibration sensor. It produces an electrical signal that is proportional to the acceleration of the vibrating component to which the sensor is attached. Multiple vibration sensors can be fitted at different positions of the vehicle exterior.

The following figures depicts the final prototype of the proposed EDR ready for installation in vehicles.

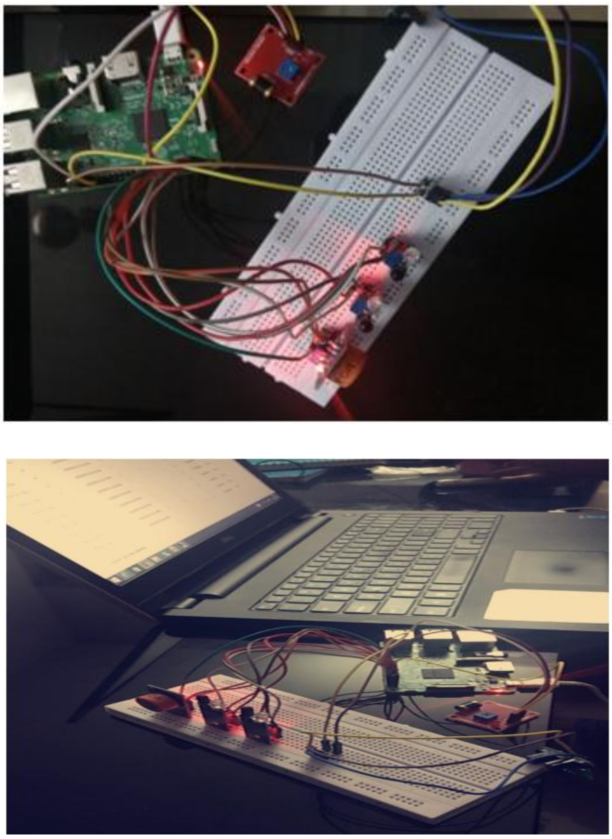


Fig. 7 Event Data Recorder Module

A web portal is developed to manage the crash report. The figure- 8 shows the portal to a Car Crash Application that was developed exclusively for this project. Further, figure- 8 depicts, a list of events that were detected by the various sensors along with their respective time stamps and associated GPRS locations. For insurance companies who have access to the database for all registered vehicles can view and access the data using Microsoft Azure.

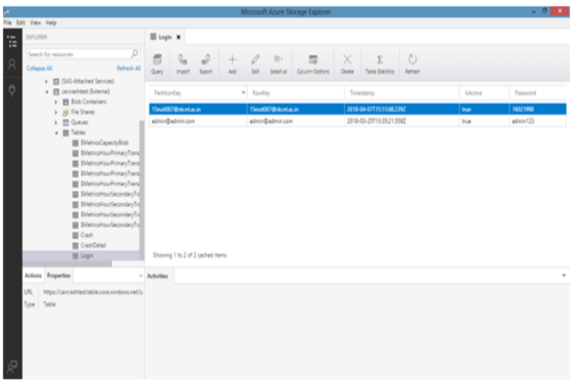
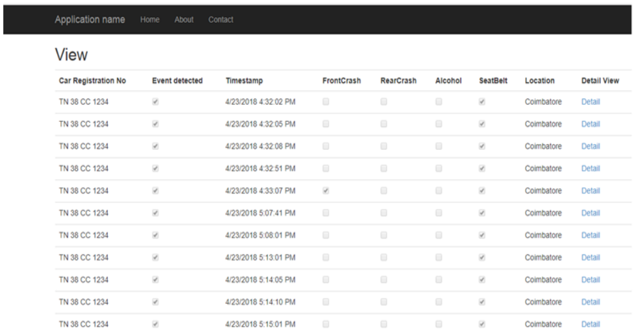


Fig. 8 Microsoft Azure Cloud Storage



Car Registration No	Event detected	Timestamp	FrontCrash	RearCrash	Alcohol	SeatBelt	Location	Detail View
TN 38 CC 1234	✓	4/23/2018 4:32:02 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 4:32:05 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 4:32:08 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 4:32:51 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 4:33:07 PM	✓			✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 5:07:41 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 5:08:01 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 5:13:01 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 5:14:05 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 5:14:10 PM				✓	Coimbatore	Detail
TN 38 CC 1234	✓	4/23/2018 5:15:01 PM				✓	Coimbatore	Detail

Fig. 9 Pre and Post crash data

B. Behaviour analysis of Motorist and Vehicle

With appropriate privileges, the Insurance company's authorities can access the data collected to assess for the cause of the accident. Further they can evaluate if it was legitimate or not.

For example, in the scenario below, we try to assess the brake pedals of the vehicle under investigation. When the EDR system was implanted into a car weighing 2000 kg the following observations were made,

i. The driver was cruising at extremely unsafe and high speeds of upto 100 km/hr when vibrations were picked up by the vibration sensor.

ii. The driver had to apply sudden brakes at forces of upto 15 kN (kiloNewton) to bring the vehicle to a halt to avoid a fatal road crash, at 4:33:15 PM.

iii. The EDR also notably picked up on data from other sensors including the proximity range during the pre-crash phase, the seatbelt status and if the driver was under the influence of alcohol or not and if he went into a drowsy state.

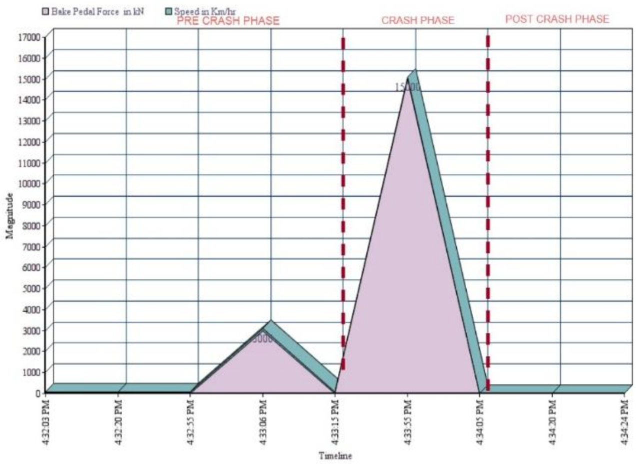


Fig. 10 Analysis of Brake Pedal Force

V. CONCLUSION

Last but the least, EDRs could increase the quality, accuracy and reliability of evidence for crash investigations by exploiting the data stored over the cloud which have minimum error leading to reduced arguments over facts and lead to more fair conviction, thus protecting the crash victims, vehicle owners and drivers.

It would be helpful to speed up court judgments and insurance proceedings and make it available in less time. In an appropriate regulatory frameworks EDR data could be accessed by police, crash investigators, car manufacturers, road safety researchers and insurers.

In future, the recorded variables can be analysed using Machine Learning algorithms which offers better accuracy and a full automated system to identify the more accurate reasons behind the cause of accident and to reduce the fraudulent claims. This can also help insurance companies to include some new policies and to revise their old ones. Inclusion of a GSM module to send alert messages to registered contact numbers when the vehicles undergoes a crash.

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