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BETTER AND SMARTER EMERGENCY MEDICAL ASSISTANCE DURING ROAD ACCIDENT AND VEHICLE IMPACT

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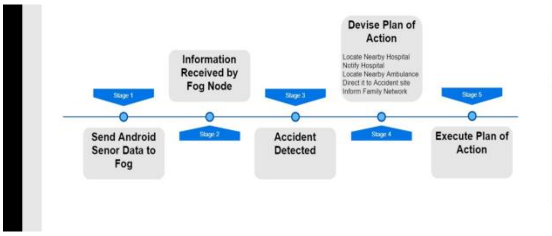
ABSTRACT: Emergencies, by definition, are unpredictable and rapid response is key requirement in emergency management. Globally, a significant number of deaths occur each year, caused by excessive delays in rescue activities. Vehicles embedded with sophisticated technologies, along with roads equipped with advanced infrastructure, can play a vital role in the timely identification and notification of roadside incidents. However, such infrastructure and technologically-rich vehicles are rarely available in less developed countries. Hence, in such countries, low-cost solutions are required to address the issue. Systems based on the Internet of Things (IoT) have begun to be used to detect and report roadside incidents.

The majority of the systems designed forth is purpose involve the use of the cloud to compute, manage, and store information. However, the centralization and remoteness of cloud resources can result in an increased delay that raises serious concerns about its feasibility in emergency situations; in life-threatening situations, all delays should be minimized where feasible. To address the problem of latency, fog computing has emerged as a middleware paradigm that brings the cloud-like resources closer to end devices. In light of this, the research proposed here leverages the advantages of sophisticated features of smartphones and fog computing to propose and develop low-cost and delay-aware accident detection and response systems, which we term Emergency Response and Disaster Management System (ERDMS).

An Android application is developed that utilizes smartphone sensors for the detection of incidents. When an accident is detected, a plan of action is devised. Initially a nearby hospital is located using the Global Positioning System (GPS). The emergency department of the hospital is notified about the accident that directs an ambulance to the accident site. In addition, the family contacts of the victim are also informed about the accident. All the required computation is performed on the nearby available fog nodes. Moreover, the proposed scheme is simulated using iFog sim to evaluate and compare the performance using fog nodes and cloud data centres.

I. INTRODUCTION

Preventing death and serious injury from road traffic accidents is becoming an increasingly important goal for governments around the world. The United Nation General Assembly, on 18 April 2018, stated that “Road traffic deaths and injuries remained a major public health and development problem with broad social and economic consequences”, adopting a draft resolution entitled “Improving global road safety”. The supporting document recommends Member states “address road safety holistically; implement a good road safety management system” among other initiatives. The provision of timely aid to victims involved in accidents is a key requirement to help minimizing the impact of vehicular accidents. To this end, devising appropriate notification and response is crucial to saving human life.
According to the World Health Organization (WHO) Road Traffic Facts, 1.24 million road accidents occur around the world. In Pakistan, for example, 15 people lose their life each day to such accidents, on average.



Recent information released by the Pakistan Bureau of Statistics shows that of 9,582 accidents over a year (2016-2017), 4,036 (or 55% of the total) have resulted in death. With such fatality rates, it is paramount that road safety is improved, and appropriate strategies and systems are developed, particularly in developing countries. The Internet of Things (IoT) offers promise to address these issues through the development of emerging low-cost intelligent traffic management systems. In a significant number of vehicular accident scenarios, the victims are unable to call for

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assistance. In such situations, a plan of action is required which includes informing relevant authorities and rapid provision of medical assistance to the victims. Traditionally, such decisions are made by humans which causes unnecessary delays. The delay in communicating emergency information to the emergency services can increase the possibility of fatalities following a road traffic accident. This requirement has led to many modern vehicles being equipped with built-in emergency response systems to detect accidents and create appropriate notifications. Such technology has not only become a real option around the world, but from April 2018, the automatic emergency call system, eCall, is legally required to be installed in all new cars receiving type approval in the European Union (EU) - regardless of manufacturer, model or price category.

Whilst such regulatory advances will help address fatalities from accidents involving new vehicles, these will form a small proportion of vehicles involved in accidents globally, especially, accidents in developing countries. A challenge remains how to address the rapid response to accidents involving older vehicles, and in those countries where the installation of such systems is not mandated. Moreover, it is also very complicated to install advanced systems in older vehicles.

II. LITERATURE SURVEY:

This section gives a comparative study of the formerly developed algorithms for accident detection. The survey throws light on the key aspects of the papers studied and also highlights their positive and
negative points. Reference proposed a Mobile Application for automatic accident detection and multimodal alert which uses an Accident Detection Algorithm. It uses an eCall system to automatically detect Vehicle accidents along with Collisions and Roll-overs. The Acceleration Severity Index (ASI) evaluates the potential risks for occupants. A Communication Flow Algorithm has been proposed in which Backend Systems interact with IoT using Database Management Systems and Web sites. Gateways interconnect the end devices to the main communication infrastructure of the system. IoT peripheral nodes produce the data that is to be delivered to the control centre. Proposed an Incident Detection Algorithm to identify incidents, verify the nature of incidents and provide emergency services based on the nature. A Wreck Watch Approach has been introduced in which the device accelerometer detects wreck utilizing device sensors to detect traffic accidents and notify first responders. Users utilize maps to view wreck information and other motorists can view accident locations immediately and avoid accident locations. Also, users can upload or view images of the wreck to the server to provide first responders with additional information related to the accident.

The ABEONA Algorithm is proposed in, in which an accident is detected using crash sensors of the airbag sensors. A GPS is used to locate an accident spot and Vehicular Ad-Hoc Networks (VANET) are used to broadcast messages. It enables rescue services to forecast traffic congestion events and re-route their path accordingly to reach the location as soon as possible. Traffic signal module in this system receives the information about the accident and the VANET signal receiver is switched ON to search for ambulances closest to the traffic signal. Introduced an application for accident detection in vehicular networks through OBD-II (On-Board Diagnostics) devices and android based Smartphones. The application checks whether Bluetooth is enabled returning an error otherwise. It attempts to contact the OBD-II device defined. In case it is found the different protocols supported are checked to determine which one is valid for the current vehicle. If bidirectional communication is established successfully, the application will start the system monitoring process. If either the airbag is triggered, or the deceleration detected is greater than 5 KGs, we consider that an accident has occurred. If the data channel is available then it retrieves GPS and accident details followed by sending critical data and making an emergency call immediately.

III. ANALYSIS:

The accident detection and multimodal alert system not only generates a voice call and SMS to emergency numbers but also broadcasts a Decentralized Environmental Notification Message (DENM) message to all the cars in the vicinity. It has a provision to control false positives by generating warning notification only if the driver fails to interrupt an automatic countdown sequence. Internet of things for smart cities provides solutions for implementation of urban IoT and developing it into a smart city concept. Incident Detection Algorithm identifies and verifies the nature of the accident in a short duration which in turns fast-tracks the medical response.

This paper states that implementation of FMS incident detection programs holds the promise of substantially reducing the accident notification time and, hence, the fatalities resulting from highway accidents. The reference depicts the usefulness of smartphones as a promising media for accident detection systems by suggesting a smartphone application: Wreck Watch, which accurately detects traffic accidents by taking the contextual data of the user in vehicle and high G-force filters, used to reduce the chances of false positives.

It uses crash sensors to detect the crash and open the airbags. This not only detects but also informs the emergency services. It uses VANET. ABEONA algorithm estimates the best path to the spot taking into consideration traffic, distance etc. It combines existing vehicles with smartphones via wireless OBD-II interfaces which facilitates monitoring the

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vehicles and as soon as an accident is detected it triggers an automatic warning.
The experimental results show that the whole process of reading critical data and delivering the information through email, SMS and emergency call is completed within three seconds one of the most important features of HDy Copilot is its automatic accident detection mechanism, from the eCall system. The algorithm detects accidents in situations like collisions, rollovers and airbag deployment. The algorithm is constantly analyzing the incoming USB data, particularly, the OBD-II data frames. If the connection to USB is lost, the application stops receiving the data, but does not stop its execution and continues to function. The time elapsed between the occurrence of a rollover and the start of the Countdown Activity is 690 milliseconds, which shows that the application responds quickly.

If the countdown is not stopped then an SMS is sent to the contacts after 10 seconds and a voice call is placed after approximately 5 seconds after the delivery of the SMS.

This waiting time is necessary to ensure unobstructed GSM connectivity failing which the call would fail. Thus, this algorithm provides the best solution to accident detection and provides better accuracy and satisfies most of the requirements of the proposed system.

IV. DETECTION PHASE SPECIFICATION

The most important factor that is used, by car accident detection systems, to detect car accidents is the G-Force value, of above 4G [4], experienced by smartphone accelerometer sensors. Also, [9] mentioned that, several studies have been performed on rear-ended impacts with volunteers; the data used in these studies mean a unique opportunity to analyze how acceleration influences the risk of injury. The results are shown that most occupants suffer from neurological signs, and have a mean acceleration above 4G. Actually G-Force value is not enough evidence to detect car accidents, which would lead to false positive signs

The proposed detection phase, running inside the smartphone, continuously sampling and reading the smartphone accelerometer sensor to detect the collision. In the case of an accident, the smartphone experiences the same acceleration force experienced by the occupants of the vehicle, because smartphones are frequently carried in a pocket attached to the occupants [4]. In fact, there are several issues that have to be considered during the accident detection phase. These issues are listed and analysed as follows:

To filter out acceleration values caused by **dropping the phone inside the vehicle** or **sudden stop**, whose acceleration values could be interpreted as car accident, the empirical results mentioned in [4] showed when the smartphone is dropped inside the vehicle, it experiences approximately 2G's on the y-axis and z-axis with nearly 3G's on the x-axis before it is reset.

Also(braking) that does not result in a crash, the acceleration experienced by the smartphone is less than that experienced during the fall, it experiences approximately less than 1G's in each direction. Therefore, 4G is chosen as the acceleration threshold value to suppress any false positives occurs inside the vehicle the most important system done in this field is activated when the vehicle is at a high **speed** of above 24 km/h [4] and the smartphone acceleration experiences greater than 4G. This system didn't take into account accident detection when the vehicle is travelling at a **low speed**, below 24 km/h, which is also subject to an accident.

Thus, one of the main contributions of this paper is the detection of car accidents at a **low speed**, below 24 km/h, and the smartphone acceleration experiences greater than 4G.

Also it is worthwhile to take into account some cases that cause false positives like **accidental dropping the smartphone while the user is outside the car and other false positives whose acceleration values are unknown**. So to address these issues and to minimize the false positives presented from these cases, other parameters are investigated and adopted to determine whether the phone is inside the vehicle or outside the vehicle.

V. HIGH SPEED ACCIDENT

The **first parameter** used to make sure that the user is inside the vehicle is the **high speed** of the vehicle (as well as the smartphone). For example if the speed of the vehicle (as well as the smartphone) is greater than the speed threshold value (24 km/h) it would indicate that the user (as well as the smartphone) is inside the car. At the same time, any acceleration event experienced by the smartphone is greater than an acceleration threshold value (4G); it is interpreted as a sign of an accident.

VI. LOW SPEED ACCIDENT

Since, among all road-traffic accidents, 90% occur at speed less than 14mph (22.53km/h), which cause severe injuries to the occupant [6]. Hence, the following two states illustrate the use of the proposed low speed parameters in the **CADANS**.

The **second parameter** used to make sure that the user is inside the car is when the car is continuously travelling at a **low speed**, less than the speed threshold 24km/h, which is also subject to an accident. This parameter is called **speed variation period** which is used to measure the speed variation values in certain periods of time while the whole speed is below the speed threshold (24 km/h). The idea behind that is when the traffic is oscillating, while it is below 24 km/h, the car won't last for such a long time at steady speed. Actually from practical tests, the **speed variation period** is chosen to be **30 seconds** to indicate the user is still inside the car.

On the other hand, if the user is walking or slowly running while carrying a smartphone, then its speed variation is mostly different than when he is inside the car which is moving at a variation of a low speed mentioned above.

To differentiate between the two states, the **standard deviation** is calculated of different speed values measured for each period of 30 seconds interleaved of 15 seconds from the previous and successive **speed variation period**. From the practical experiments it is found that the standard deviation of different speed values, for the person who is walking, for the speed **variation period,** is ranging between **1.056** and **1.88,** and the standard deviation, for the person who is slowly running is **2.06** as Other experiments are conducted for the car travelling at various speeds under the threshold 24 km/h; it is found that the standard deviation for these experiments is rang. Hence, if the acceleration event experienced by the smartphone is greater than 4G and the standard deviation of the **speed variation period** parameter is greater than the threshold **(2.06),** then it indicates a sign of accident. Vehicle is traveling at a high speed and suddenly or gradually reduces its speed below the speed threshold 24 km/h. Hence, in this case, the **second parameter** mentioned in step (**a)** above is used to handle this phenomenon. Actually the **second parameter** cannot be activated unless a certain period of time has been passed to allow for the standard deviation to be calculated. Therefore, the **third parameter** used to make sure that the user is inside the car (while the car is at a high speed and reduced to low speed) is the **maximum period** of time that the vehicle is travelling from the last location where the speed was reduced below the speed threshold 24 km/h

From the practical result, it is found that a **maximum period** of elapsed **30 seconds** is quite sufficient to make sure that the user is unable to exit the car during the **maximum period**.

This parameter, in particular, is used in case the speed of the car was exceeding the threshold and then was reduced to stop at intersections, traffic lights or due other unexpected events. Hence, if the acceleration event experienced by the smartphone while the car speed is reduced below 24 km/h is greater than 4G and the elapsed time is less than the above mentioned **maximum period**, then it is interpreted as a sign of an accident. Clearly, if the above mentioned **maximum period** is passed with no sign of accident, then this situation is handled by the **second parameter.**

VII. NOTIFICATION PHASE

Car accident detection phase without notification phase is like doing nothing. Logically the most important task of the detection phase is the accuracy of the detection process, while the most important task of the notification phase is the speed and the type of information that are supplied to the emergency responders to respond to an accident. Shows the architecture of the proposed notification phase.

DRIVER AND/OR

PASSENGER NOTIFICATION

when detection phase confirms that an accident has taken place then a smartphone GPS receiver is required to find the geographical location of the accident and then utilizes the built-in 3G data connection to send accident information such as: G-force (acceleration force) experienced by the occupants during an accident, speed of the vehicle, the GPS location, airbag deployment state, time of the accident, and a recording video (showing what happened immediately after the accident is detected) are sent to emergency responders for fast recovery .

BYSTANDER'S NOTIFICATION

CADANS allows for uninjured people and bystanders to send multiple streams of videos and images from an accident location. Also a smartphone GPS receiver is required to find the precise accident location and then transmits this notification to emergency responders required to find

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the precise accident location and then transmits this notification to emergency responders.

SMS NOTIFICATION

To strengthen the notification phase, it is found a good idea to notify the contacts of the driver/passenger, such as family members, about the accident through sending SMS message that comprises the location where the accident is held.

E-CALL

ECall is an automatic in-vehicle emergency call service developed in the European Union. The benefits of the eCall system are primarily based on the faster relaying of essential initial accident information, such as the type of accident and the precise accident location. The aim of this study was to estimate the impacts of an automatic emergency call system on accident consequences in Finland. The main results indicated that eCall could very probably have prevented 4.6% of the fatalities in accidents involving motor-vehicle occupants. The percentage was higher for accidents involving no vehicles in which the current eCall could be installed.

This is probably because the emergency call delays were also longer in these accidents.

The results of the case study, case study + phone log and questionnaire show that, in most accidents involving motor-vehicle occupants, the emergency call had been made less than five minutes after the accident. In 4% of the cases the emergency call had been made more than thirty minutes after the accident.

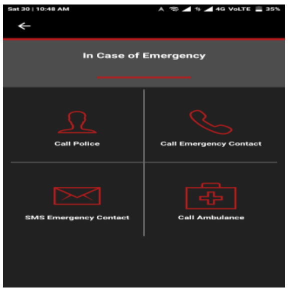
CURRENT NOTIFICATION

By pressing this button the application shows the current location of the user on the map.
Adding Accident:

By pressing this button the user is redirected to a new page where the user has to provide the marker (coordinate) for accidents location. After providing the accident location, a user is asked for the date, time, severity, number of vehicles involved in the accident.

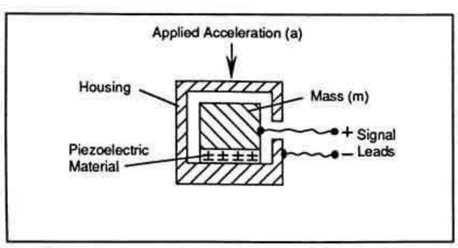
VIII. DRAWER NAVIGATOR

- Drawer navigator provides basic features.
- Drawer navigator has a home button which redirects to the home screen from any screen.
- Drawer navigator has a profile button which displays the user details. A user can also update some information like password, name, and emergency contact number.
- Drawer navigator has a share button which is useful for sharing this application easily on WhatsApp, text message etc.
- Drawer navigator has an emergency button which will be useful in case of an emergency or accident. By pressing this button, it will redirect to another screen which has the options to call on emergency contact number, SMS the current location to emergency contact number and also to call the police and ambulance.
- Drawer navigator has the log out button which will log out the user from application.



IX. ACCELEROMETER SENSOR

An accelerometer is a device that measures the vibration, or acceleration of motion of a structure. The force caused by vibration or a change in motion (acceleration) causes the mass to "squeeze" the piezoelectric material which produces an electrical charge that is proportional to the force exerted upon it.



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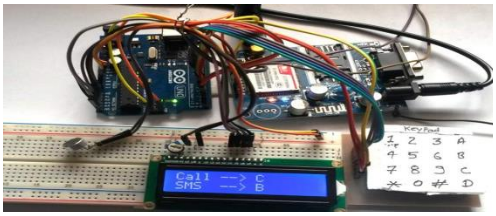

X. ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

1. Automatic alert on crossing speed limit
2. Immediate help can be provided
3. Nearest hospitals can be located
4. Accident rate can be reduce
5. Parents monitor their child driving

DISADVANTAGES:

1. Application does not support offline Function
2. GPS does not works on offline

XI. PERFORMANCE RESULTS

Due to safety matter and the significant damage concerned, crash testing of the **CADANS** in real environments (real car accident) is not realistic and practical. Also the lack of the availability of laboratories that can be used to simulate the crash environment is making the crash testing difficult to achieve. However, constructing some cases that simulate the scenarios of the proposed detection phase mechanism and testing the **CADANS** against these cases would yield a high confidence that supports the reliability and certainty of **CADANS**.

These tests are performed on the **CADANS** in a real environment; by having the driver drive the vehicle at different speeds, so the speed of the vehicle is not steady all the time. Also the other factors, like G-Force and sound decibel are imitated inside the car while the car is moving at different speeds. The idea is to create an environment that mimics the real environment as these mimic environments are required to test the **CADANS** under different speed conditions (low speed and high speed). Before going to demonstrate the tests on **CADANS**, the following important issues that must be taken into account are listed below:

As mentioned and analyzed in detection phase specification, the smartphone must experience a forcible acceleration event,Which is greater than 4G, to be interpreted as indication of an accident.So to achieve this issue, during these tests, the smartphone is dropped forcefully inside the vehicle to obtain acceleration events greater than 4G. Actually this case has repeated many times but the acceleration value experienced by the smartphone has approximately reached 3.5. Also another experiment is conducted inside the vehicle, which is shaking the smartphone very vigorously, to try obtaining acceleration events greater than 4G. In fact the maximum acceleration force experienced by the smartphone, in this case, is 3.9971G.

Since it is difficult to obtain forcible acceleration value greater than 4G from the simulated test, a threshold value of 3G is used to test the **CADANS** for the value of the G-force experienced by the smartphone accelerometer sensor to indicate a sign of an accident.

XII. FUTURE ENHANCEMENT

1. We can apply the neural networks clustering algorithm like K-means etc. for finding the efficient Accident prone area.

2. We can also increase the efficiency for finding the accident-prone area by dividing the google maps into blocks and find the accident-prone areas of only one block in which user is present.

3. We also take an input of time, date, severity, number of vehicles involved, So we can run the important queries like in which particular time the most of the accident occurs, average severity of accidents in one month etc.

4. We can also take the reasons of accident from users to deduce the reason for that area to be accident prone and we can also inform the respective authorities so that necessary steps should be taken.

5. We can provide the feature in which a user enters the starting point and destination point and application shows

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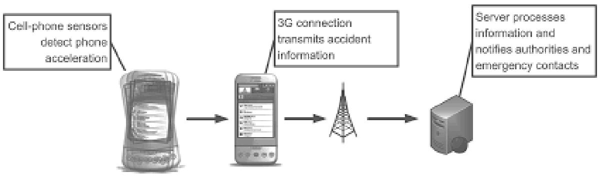
the different paths with the number of accidents occurred in each path.



Since it is difficult to test the **CADANS** in real accident to achieve a high decibel level of sound event (greater than 140db) without existence of airbag deployment, the radio inside the vehicle is played with high volume and all windows of the vehicle are closed.

XIII. CONCLUSION

It has been realized that the smartphone based car accident detection system is not an easy task to handle. It is really surrounded with many obstacles that prevent the researchers from achieving a 100% accurate detection system.

One of the main obstacles is determining that the occupant is inside or outside the vehicle while the vehicle is travelling at a low speed. The proposed system minimizes the impact of this obstacle which is proved in the practical results conducted in this work.

Every smartphone based accident detection and notification system is exposed to false positives. In the proposed system, helpful supporting features were added to the system to increase the accuracy of detection process and reduce the probability of false positives, which are briefly listed below:

A. **CADANS** presents a confirmation screen which gives the user the opportunity to confirm the accident, thus in case of false positive occurs the user can cancel the alarm and notification is aborted.

B. CADANS allows for uninjured peoples or bystanders to take images/videos and send them to emergency responders, for reporting the accident.

C. **CADANS** utilizes smartphone camera to record a video, showing what is happening at the instance of an accident immediately after the detection process indicates that there is an accident. This video is sent to the emergency responders for further inspection and analysis.

D. To notify the family or friends quickly about the accident, the proposed system sends SMS message which contains accident location coordinates to predefined emergency contacts.

As a future work, a further analysis can be tried to improve the accuracy of detection phase and reduces the probability of false positive signs that are generated from being the user is inside or outside the car when the vehicle is travelling at a low speed. Therefore, it is suggested that the researchers investigate in the field of “Activity Recognition” based on smartphone sensors, which is used to detect the current activity of the user whether he is driving, walking, running.

Also, a voice recognition module can be constructed and added to the proposed system to differentiate between airbag deployment and benign noise. Achieving this enhancement would increase the proposed system reliability and decrease false positive signs.

In this article, e-NOTIFY system is presented, which allows fast detection of traffic accidents, improving the assistance to injured passengers by reducing the response time of emergency services through the efficient communication of relevant information about the accident using a combination of V2V and V2I communications. The proposed system requires installing OBUs in the vehicles, in charge of detecting accidents and notifying them to an external CU, which will estimate the severity of the accident and inform the appropriate emergency services about the incident. This architecture replaces the current mechanisms for notification of accidents based on witnesses, who may provide incomplete or incorrect information after a long time. The development of a low-cost prototype shows that it is feasible to massively incorporate this system in existing vehicles.

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