Accident Tracking & Emergency Response Management using IoT

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Abstract - *Road safety has become an issue of concern, particularly in large populations, over recent years. Indian roads are extremely disaster-prone. According to a survey made by the Ministry of Road Transport & Highways, road accidents are responsible for one death approximately every four minutes. Further breaking down the statistics, the data revealed that at least 17 deaths were a result of the 55 accidents reported on average every hour. Hence, the prompt deployment of Emergency Medical Services is extremely crucial to minimise the loss of lives.*

The objective of this paper is to set in place a fully automated system design that will minimise the time gap between the occurrence of an accident and deployment of medical response. This can be done by combining accident detection and Emergency Medical Services systems. The proposed design makes use of an accelerometer and a piezoelectric sensor to trigger the Arduino microcontroller, which retrieves the user's location through the GPS. Communication between the IoT device and the database is done using a GSM/GPRS module. An Android app is designed to collect the relevant health information of the user, emergency contact information, and hospital details during initial registration.

Key Words: **Accident Detection, Accident Prevention, Emergency Management, Internet of Things**

1.INTRODUCTION

Several factors are responsible for the frequent occurrence of road accidents in India. The rapid growth of population has led to an increase in the number of vehicles, subsequently resulting in traffic congestion.

The poor condition of Indian roads, especially during monsoon season, is an additional contributing factor. These roads are a combination of modern highways, and narrow, unpaved roads which are consistently rebuilt. A mix of high-speed motor vehicles, low speeds NMTs (Non-Motorised Transport) and pedestrians all gather on the same perilous road infrastructure. In this scenario, the sheer carelessness of a single driver ultimately places countless lives at risk. Moreover, it is hard to implement services that would otherwise work in consistent road conditions.

This issue is one of the most contributing factor to the rising rate of accidents and deaths. Therefore, the need of the hour is to provide emergency services systems that would alert for medical aid at the earliest.

The scene of any road accident is chaotic. The crowd consists of 3 major groups, namely, the passersby, the drivers, and most importantly, the victims. The injured party requires immediate medical attention. Some passersby may try to contact the ambulance and the victims' relatives. A crowd inevitably gathers, which leads to traffic build up around the casualty. In this situation, the ambulance may find it impossible to reach the accident site on time. Slower, inefficient emergency response ultimately increases the risk of losing lives.

The adoption of technology facilitates automated and efficient solutions. Through the use of the Internet, instant transfer of data can be achieved. IoT-based solutions depend on both the collection as well as the processing of real-time data from connected devices, thereby making intelligent decisions such as triggering notifications and computing analytics. IoT stands for 'Internet of Things' which refers to the interconnected network of devices and sensors capable of communicating with each other. In this paper, we propose a system design that detects an accident and connects the driver to his emergency contacts and emergency services (such as hospitals and ambulances).

The remainder of the paper is organized as follows: Section 2 reviews some relevant works on accident detection, prevention and emergency management. Section 3 describes our proposal by delineating the individual components. The advantages and applications of the proposed system is discussed in Section 4. Section 5, closes the paper with concluding remarks and the future scope of the research

2. RELATED WORK

VANET (Vehicular Ad-Hoc Network) technology has gained prominence in the field of research due to a growing demand for applications ranging from road safety to traffic control and management. It helps in creating a network, or a collection of independent entities, with the ability to communicate among themselves. In short, it facilitates communication between vehicles, as well as between vehicles & their infrastructure.

A Smart City framework using VANETs was the basis of study [2]. VANETs helped in improving the mobility, thereby increasing road safety. This helped in minimizing transportation problems such as road congestion, which was caused due to increasing population. Another study [14] proposed a WSN roadside architecture for intelligent transport systems, which supported both accident prevention and post-accident investigation. In a study regarding emergency braking [15], the basis of the research was on the different principles of VANET. This work presented a simulative study of emergency braking applications challenged by embedding mobility, dynamics of a car, and driver's behavior model into a detailed networking simulator (ns-3). However, due to security problems in VANETs and the challenge involved in developing a secure protocol, it was left as future work.

A reliable, cheaper traffic management system [5] using RFID (Radio Frequency Identification) tags & RFID Reader was used to monitor, manage traffic and detect collisions. It also introduced a Smart city network. This work was far more reliable than a CCTV camera-based system [4]. The Geo-fencing approach [13] helped emergency cars pass traffic lights in the shortest time possible, thereby reaching the hospital faster. This approach is used to depict an enclosed area around a specific place to warn users when an equipped vehicle crosses its borders. Using RFID technology, the perimeters can be defined dynamically which generates a radius around the desired location. Identifying areas prone to accidents has also been studied in [20]. The system makes use of available traffic congestion information from smartphones, and using ML Algorithms was able to detect accident prone zones with a success rate of 80%.

The use of smart devices to aid drivers has also been studied in detail. An IoT based Smart Helmet called 'Konnect' [9] was made using a tri-axial accelerometer, which would detect an accident based on the tilt of the driver with respect to the ground. Necessary alerts would be sent out to the emergency contacts, and the accident detection could be terminated by the driver. It was found to be both cheap and effective for two-wheelers. Another study used Smartwatches to derive the hand movement of the driver [17] and was successfully able to obtain a precision rate of 97% in determining 'unsafe' hand positions. A different study [10] attempted to warn drivers about potholes on the road with the use of ultrasonic sensors and GPS found on smartphones.

To alert the driver at the time of emergency, it was found that by muting music [1] a 5% drop in speed can be achieved in danger zones. An alternative approach to preventing accidents is by alerting drivers from colliding during the change of lanes. Smartphone cameras in [6] were used to detect unintentional lane departure or if the driver was too close to the vehicle up front. Overall, it was both economical and practically usable. Another system [16] employed automatic brakes to prevent collisions in intersections by integrating Intersection Movement Assist system alongside Intersection Collision Avoidance. Finally, [18] also employed a similar collision warning system. It was able to detect feasible lane change, minimum safe distance between vehicles and even had the feature of adapting to different driving styles.

The leading cause of road accidents is often due to the unfit state of the driver. Many reported accidents are a result of drunk or drowsy driving. Attempts have been made to identify such drunk or drowsy drivers and alert them, therefore preventing accidents before they occur. One such study [19] analyzed the eye movement of the driver to analyse whether the driver was drowsy or not. It made use of a live video feed and image processing in OpenCV. A buzzer was triggered to wake the driver up. Another system [7] identified factors (such as rate of blinking, alcohol consumption, and movement of the car and nature of the roads) and proposed using an SVM to classify the driver's behaviour as 'drunk' or 'not drunk'.

Till date, not many systems have been implemented to aid victims of road accidents by contacting the EMTs. However, [8] proposes a complete system for individual health monitoring of patients, as well as a Bluetooth-activated emergency response. Several sensors (such as heartbeat monitors, vehicle crash sensors) are used and the system is connected to the hospital. The overall efficiency of the EMS is increased.

3. PROPOSED DESIGN

The aim of this system is to be able to detect the occurrence of an accident and subsequently send a message with the GPS location to the victim's emergency contacts, and notify the Ambulance and hospital services simultaneously. In this section, the architecture and components will be elaborated.

3.1 System Architecture

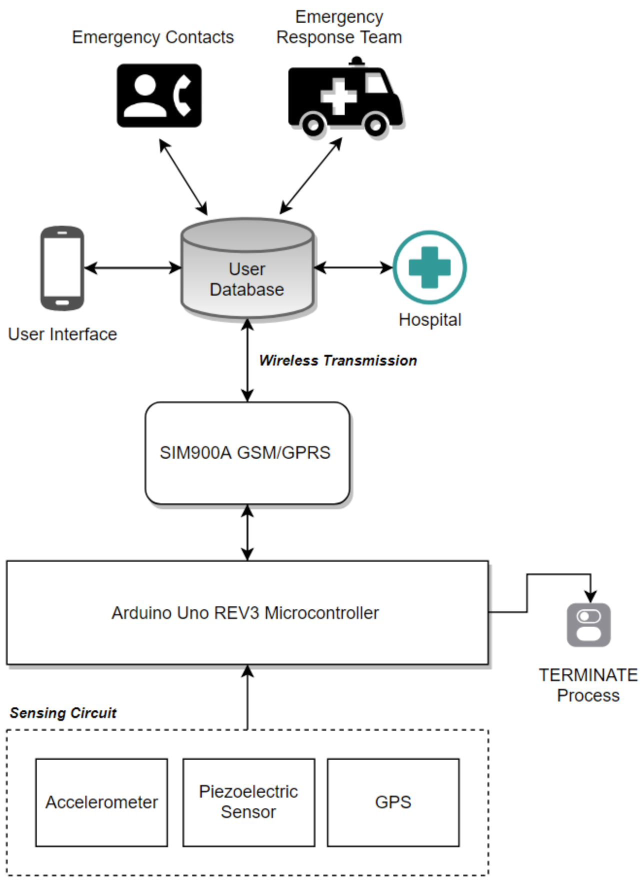

Fig -1: System Architecture diagram

1) Sensing Circuit: This is the component of the system that detects the occurrence of an accident and retrieves the GPS location.

a) Accelerometer: ADXL335 is a three-axis analog IC that reads the X, Y, Z axis acceleration as voltages. By measuring the angle at which the vehicle is tilted with respect to the earth and by sensing the amount of dynamic acceleration, the accelerometer can find out how fast and in what direction the device is moving and whether an accident has taken place.

b) Piezoelectric sensor: Piezoelectric effect is the property of certain materials to generate an electric charge in response to applied mechanical stress (such as pressure, force, strain, even temperature). In this case, when the vehicle crashes, the piezoelectric detects the force applied and warns the microcontroller by sending an electric charge.

c) GPS: The Global Positioning System (GPS) is a satellite-based navigation system that accurately calculates the user's location based on the signal transmitted by the satellites to the receiver. The NEO-6M GPS module receives information like latitude, longitude, altitude etc. in the form of a string, parses it and hence communicates with the microcontroller.

2) Arduino UNO R3 Microcontroller: Arduino UNO R3 is based on the ATmega328 AVR microcontroller board. It has 20 digital input/output pins, a 16MHz resonator, USB connection, power jack, in-circuit system programming and a reset button. Apart from connecting the various sensors to the microcontroller, the TX and RX pins of the R3 are connected to the SIM900A module, ensuring serial transmission of data.

3) SIM900A GSM/GPRS: SIM900A is a dual-band GSM/GPRS modem with frequencies of 900/1800 MHz that can transmit data. Its operating voltage range is 3.2 to 4.8V and draws only 1.0mA in sleep mode. In order to function, a SIM card has to be inserted. Additionally, SIM900A also offers GPRS functionality, which has a data rate of 56-114 kbps and provides a connection to the internet. GSM and GPRS are programmed using AT commands.

4) Database: The database stores the information that the user provides during account registration, collects the real-time accident data and retrieves accordingly. For example, an emergency contact would be notified of the accident location and which EMT has been dispatched, whereas the hospital would be able to access the vital health information of the victim, such as his blood group and medical background.

3.2 Working of the System

The microcontroller, along with the entire system, is powered from an external supply (such as a battery). When the system is in its initial state, all the values are below the threshold and no corresponding action is taken. The system continuously monitors the values recorded by the accelerometer and the piezoelectric sensor.

When the microcontroller detects a change in the measured values, it detects the occurrence of an accident. Typically in this scenario, the vehicle either experiences a collision or gets tilted. This produces a response from the accelerometer and piezoelectric sensor, and the latter sends an electric charge to the microcontroller, thereby alerting it.

The system does have a physical TERMINATE button, which can be pressed by the driver in case of a false positive. In this case, the entire alert process is terminated at once. That is, if the driver is physically unharmed, then he may choose to simply press the TERMINATE button and no alerts will be sent.

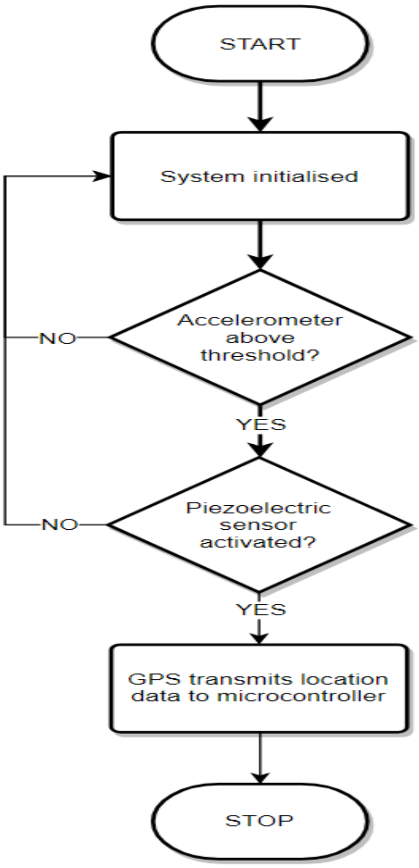

Fig -2: Process Flow Diagram for detecting accident

In the case that the process isn't terminated, the microcontroller retrieves the accurate latitude and longitude data from the GPS module after it is parsed. The microcontroller activates the GSM/GPRS module. Using GPRS, the GSM module establishes connection with the database and retrieves the emergency contact information which it sends a text message to. Simultaneously, the GPRS also transmits the location data to the database. The database reflects this information in the Application UI.

Information regarding both the accident location as well as the victim gets sent to the hospital-side interface. This can be used to dispatch an ambulance to the site as soon as possible, and keep a track of the victim's medical record.

If the victim has previous history of visiting a particular hospital, then that hospital is given priority for treating the patient. In the meantime, the emergency contacts are constantly updated about the status of treatment for the patient, such as which EMT has been dispatched and which hospital he is being taken to.

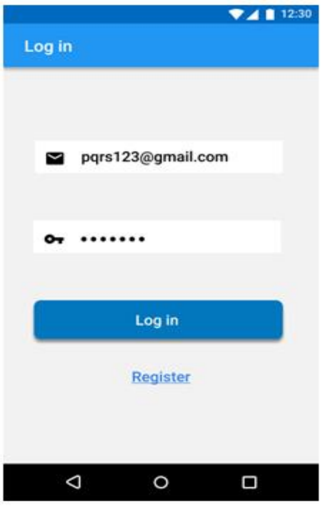

Fig -3: Login Interface

Fig -4: Emergency Contact Information

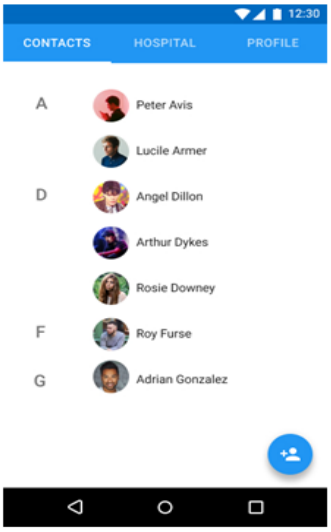

Fig -5: Emergent Contacts

Fig -6: User's Hospital Details

Fig-7: User's medical details

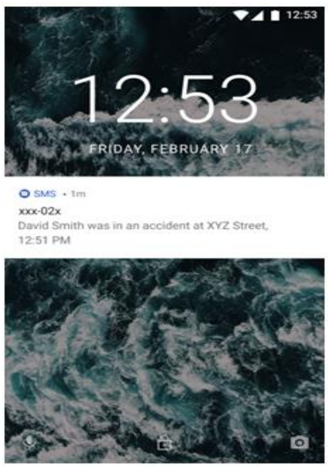

Fig -8: Lock Screen Notification

4. CONCLUSIONS

This paper elaborated on the design and construction of a completely automated IoT based accident detection and emergency response system. In this proposed work, the system is physically present on the vehicle. Hence, the working of the system does not rely on any external devices. The complete information regarding the accident and the necessary health data of the victim is shared with the individual parties (such as the emergency contacts and the hospital). This guarantees that the action taken is more efficient and ensures that the required medical assistance is made available. Alerting the emergency contacts helps create further awareness of the situation. The cost of actual implementation is also considerably less compared to other designs, due to the availability of low-priced sensors.

Future work will look into the actual implementation of the system and recording of results. The system can be further improvised by adopting an accident prevention approach over accident detection.

REFERENCES

[1] Dunlop, Mark D., Marc Roper, Mark Elliot, Rebecca McCartan, and Bruce McGregor. "Using smartphones in cities to crowdsource dangerous road sections and give effective in-car warnings." In Proceedings of the SEACHI 2016 on Smart Cities for Better Living with HCI and UX, pp. 14-18. ACM, 2016.

[2] Barba, Carolina Tripp, Miguel Angel Mateos, Pablo Reganas Soto, Ahmad Mohamad Mezher, and Mónica Aguilar Igartua. "Smart city for VANETs using warning messages, traffic statistics and intelligent traffic lights." In Intelligent Vehicles Symposium (IV), 2012 IEEE, pp. 902-907. IEEE, 2012.

[3] Yuan, Zhuoning, Xun Zhou, and Tianbao Yang. "Hetero-ConvLSTM: A Deep Learning Approach to Traffic Accident Prediction on Heterogeneous Spatio-Temporal Data." In Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining, pp. 984-992. ACM, 2018.

[4] Hooda, Waris, Pradeep Kumar Yadav, Amogh Bhole, and Deptii D. Chaudhari. "An Image Processing Approach to Intelligent Traffic Management System." In Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies, p. 33. ACM, 2016.

[5] Chouksey, Siddhant, and Sumedha Sirsikar. "An Efficient And Economical Solution For Future Traffic Management System Using RFID." In Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies, p. 86. ACM, 2016.

[6] Tang, Samuel Jia Wei, Kok Yew Ng, Boon How Khoo, and Jussi Parkkinen. "Real-time lane detection and rear-end collision warning system on a mobile computing platform." In Computer Software and Applications Conference (COMPSAC), 2015 IEEE 39th Annual, vol. 2, pp. 563-568. IEEE, 2015.

[7] Sahabiswas, Suparna, Sourav Saha, Prachatos Mitra, Retabrata Chatterjee, Ronit Ray, Paramartha Saha, Rajarshi Basu, Saurav Patra, Pritam Paul, and Bidrohi Ananya Biswas. "Drunken driving detection and prevention models using Internet of Things." In Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2016 IEEE 7th Annual, pp. 1-4. IEEE, 2016.

[8] Lakkis, Sari I., and Maher Elshakankiri. "IoT based emergency and operational services in medical care systems." In Internet of Things Business Models, Users, and Networks, 2017, pp. 1-5. IEEE, 2017.

[9] Chandran, Sreenithy, Sneha Chandrasekar, and N. Edna Elizabeth. "Konnect: An Internet of Things (IoT) based smart helmet for accident detection and notification." In India Conference (INDICON), 2016 IEEE Annual, pp. 1-4. IEEE, 2016.

[10] Madli, Rajeshwari, Santosh Hebbar, Praveenraj Pattar, and Varaprasad Golla. "Automatic detection and notification of potholes and humps on roads to aid drivers." IEEE Sensors Journal 15, no. 8 (2015): 4313-4318.

[11] Ryder, Benjamin, and Felix Wortmann. "Autonomously detecting and classifying traffic accident hotspots." In Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers, pp. 365-370. ACM, 2017.

[12] Du, Peng, Jianguo Chen, Zhanhui Sun, and Yue Li. "Design of an IoT-GIS emergency management system for public road transport networks." In Proceedings of the 1st ACM SIGSPATIAL International Workshop on the Use of GIS in Emergency Management, p. 12. ACM, 2015.

[13] Noei, Shirin, Hugo Santana, Arman Sargolzaei, and Mohammadreza Noei. "Reducing traffic congestion using geo-fence technology: Application for emergency car." In Proceedings of the 1st International Workshop on Emerging Multimedia Applications and Services for Smart Cities, pp. 15-20. ACM, 2014.

[14] Bohli, Jens-Matthias, Alban Hessler, Osman Ugus, and Dirk Westhoff. "A secure and resilient WSN roadside architecture for intelligent transport systems." In Proceedings of the first ACM conference on Wireless network security, pp. 161-171. ACM, 2008.

[15] Segata, Michele, and Renato Lo Cigno. "Emergency braking: a study of network and application performance." In Proceedings of the Eighth ACM international workshop on Vehicular inter-networking, pp. 1-10. ACM, 2011.

[16] Maile, Michael, Qi Chen, G. Brown, and Luca Delgrossi. "Intersection collision avoidance: From driver alerts to vehicle control." In Vehicular Technology Conference (VTC Spring), 2015 IEEE 81st, pp. 1-5. IEEE, 2015.

[17] Bi, Chongguang, Jun Huang, Guoliang Xing, Landu Jiang, Xue Liu, and Minghua Chen. "SafeWatch: A Wearable Hand Motion Tracking System for Improving Driving Safety." In Proceedings of the Second International Conference on Internet-of-Things Design and Implementation, pp. 223-232. ACM, 2017.

[18] Dang, Ruina, Jieyun Ding, Bo Su, Qichang Yao, Yuanmu Tian, and Keqiang Li. "A lane change warning system based on V2V communication." In Intelligent Transportation Systems (ITSC), 2014 IEEE 17th International Conference on, pp. 1923-1928. IEEE, 2014.

[19] Anjali, K. U., Athiramol K. Thampi, Athira Vijayaraman, M. Franiya Francis, N. Jeffy James, and Bindhu K. Rajan. "Real-time nonintrusive monitoring and detection of eye blinking in view of accident prevention due to drowsiness." In Circuit, Power and Computing Technologies (ICCPCT), 2016 International Conference on, pp. 1-6. IEEE, 2016.

[20] Thomas, Robert W., and José M. Vidal. "Toward detecting accidents with already available passive traffic information." In Computing and Communication Workshop and Conference (CCWC), 2017