A Novel IoT Based Accident Detection and Rescue System

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***Abstract*—In South-East Asian cities such as Delhi, Dhaka road accidents are a very common occurrence which brings disaster to human lives as well as infrastructures. Sometimes people cannot reach hospitals prompt after an accident because of the traffic jam, deficit of ambulance, lack of a mechanism to timely propagate information to the appropriate authority. To ensure the safety of lives, this paper proposes an automated IoT based effective accident detection system. Immediately after an incident, the data information is sent to the webserver, instant SMS is forwarded to the victim's acquaintances and also to the relevant authorities such as traffic control room, nearby police station, ambulance service. To evaluate the performance of the system, a simulated road scenario has been designed. The result obtained after a thorough integration and system testing demonstrates that the proposed system not only achieves the stated goal of the research but also can deliver the expected outcome in a rather cost-effective way.**

Keywords*—IoT, load cell GPS, GSM, Wi-Fi module, rescue system.

I. INTRODUCTION

Owing to the intensive development in technology, various intelligent and autonomous systems have been invented in recent years [2-6]. Nowadays quite dependent on technologies which operate as an automated or semi-automated way to make things easier and comfortable for us [6-10].

In South Asian cities, the number of vehicles is on a constant rise, consequently, road accidents are increasing alarmingly. The accidents mainly occur for rush driving and overtaking. In 2017, the number of death by road accidents in Bangladesh reached 20,607 (2.62% of total death). In Bangladesh, even though it will soon be recognized as one of the developing countries, both economically and socially [17], the death rate is 15.56 per 100,000 of population. The total number of registered motor vehicles in Bangladesh is 3.4 million as of March 2018. The number of drivers is 3.8 million, 60% of which are illiterate [11]. Since numerous smart systems aiming to make provide us with a better life has been developed [1-10], there should be a technological solution in cases related to an accident.

No latest technology can avert accidents completely and do not even know where and when an accident may occur. In its current state, most of the time the life of the victim depends upon the responses of people nearby. Oftentimes due to legal complexities, people do not want to involve in any kind of rescue operation post-accident, resulting in tragic consequences for the victims. Sometimes bystanders do not even have enough time to help that victim. All these bottlenecks obstruct the quick transfer of the victim to the nearby hospital.

The acquaintances are often notified long after the incident. The overall situation is worsened by the fact that the tracing and reachability of the accident spot in a metropolitan area is a substantially difficult task. Thus in this paper, an automatic accident detection and rescue system is focused on using IoT by which the kin of the victim will be notified on time. Real-time notification to the nearest police station and traffic control server will also be transmitted. Nearest ambulance service will also be alerted through the internet with the location of the accident. The complete system will significantly improve the prompt co-ordination of the necessary actions after an accident. In the field of IoT, the objects communicate and exchange information to provide advanced intelligent services to the users.

The rest of this paper is organized as follows. Section II reviews some of the related works in this field. The proposed methodology is introduced in Section III. The system design and implementations are presented in Section IV. In Section V, the results and finding are discussed. Finally, Section VI presents the concluding remarks and future direction of this research.

II. RELATED STUDY

Khan *et al.* [2] described a system for accident detection using a three-axis accelerometer sensor to the cloud server. The framework automatically initiates the process of dispatching the nearest ambulance by processing the Global Positioning System (GPS) coordinates of the incident and providing a specific route to the accident spot in question. By using the related android application, ambulance driver can reach the spot in a rather efficient manner. Saga *et al.* [13] designed a framework where soon as the accident occurs, the airbag will open and auto-lock the breaks. Then a buzzer will

be switched on. The system incorporates a GPS module, through which a microcontroller determines the coordinates of the location.

Then the GSM (Global System for Mobile Communication) module sends this accident information to the victim's family for urgent attention. Khan *et al.* [14] proposed a smart rescue system based on an Android application. Under this system, the user will be automatically monitored at all times. However, the user can turn the system off if the need be. This system can detect any kinds of a jerk and generate an alert, a false alert can be cancelled by the driver. If the driver does not cancel this alert within 15 seconds, then it is assumed that a substantial accident has taken place and victim's location is sent via an API to the nearest emergency responder so that emergency rescue operations can be initiated. Ramya *et al.* [15] described an intelligent traffic light system (ITLS) where an ambulance can move easily without traffic light stopping it on the way. Through the GPRS (General Packet Radio Service, a packet-oriented mobile data standard on the 2G and 3G cellular communication networks) 3G modem, the traffic controller will get the location of the ambulance. If the ambulance is near to the traffic junction, then the corresponding signal will be green. Automated systems in traffic detection are also on the rise [27].

Fernandez *et al.* [16] put forward a system of accident detection that uses GPS, GPRMC and MCU through a speed monitoring algorithm. GPRMC is the most common sentence transmitted by almost all GPS devices, this sentence or line of data contains nearly everything a GPS application requires. If an accident occurs then the place of accident, speed before accident, time and date will be readily available through SMS using GPRS.

Ali and Eid [25] have considered the number of factors such as sudden alteration in acceleration, rotation and an impact force at the rear into their automatic accident detection system, the system uses fuzzy logic to finalize a decision and attained an accuracy of 98.67%. However, it only works if the accident occurs from behind.

Another recent proposition by Yee *et al.* [26] uses GPS and Accelerometer-based accident detection system. The system not only detects accidents but also provide the degree of severity of the crash. A limitation of the system is that it can only detect a service provider within 10 KM of the radius. Also, it is not clear how the system calculates many injured onboard passengers.

III. Proposed Methodology

In Fig. 1, the flowchart for the system is illustrated, which starts with the sensor check collision. Then it evaluates whether the accident has occurred. If it has not, then it does not execute any operation. But in case an accident does occur, then the sensor determines the location and sends it to the microcontroller. The microcontroller will direct an SMS to a previously stored number belonging to the kin of the victim. The SMS will have full details of the location.

Fig.2 visualizes the entire framework. In the proposed methodology, accident detection will be detected with a collision sensor. At first, when an accident occurs, the collision sensor detects the collision. After the detection, the GPS sensor sends the accident location to a microcontroller. Following which the microcontroller read numbers from database server via WiFi module. At last, the microcontroller sends SMS to the Smartphone to transmit the information on the accident.

As can be seen from Fig.1, the proposed accident detection system consists of some sensors, microcontroller and WiFi module in a single development board.

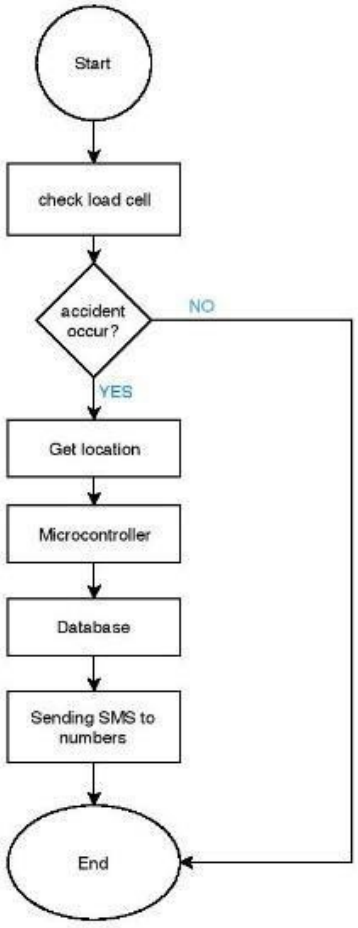

Fig. 1. System flowchart of the proposed scheme.

IV. System Design and Implementation

In this section, our practical approach is going to be discussed that has been taken to solve the problem. In the system, a sensor named load sensor has been used which detects the mass of the car and finds changes in weight. When an accident occurs, the detection will start by the Load Cell. Load Cell sensor is used to capture dynamic pressure and impact factor exerted on an accident. After any type of accident, the sensor sends the data. Consequently, the authority will know the state of the accident. The authorized entity will then be able to track the driver of the ambulance and send offline SMS. The SMS contains the location of an accident and the driver will receive necessary directions to go that spot. On the receiving end, the user whose number is stored in the database will get the SMS with the information on the accident. They can see the place of accident and use alternative way if necessary. Wi-Fi

module will provide the necessary internet connectivity facility.

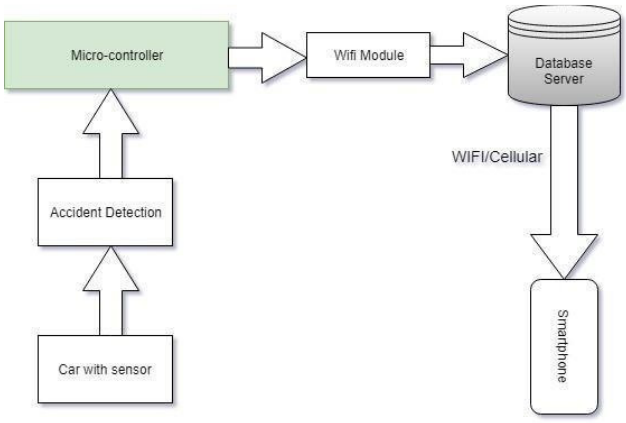

Fig. 2. Proposed system architecture.

A. *System Design*

This study was focused on creating a smart rescue system to instantly facilitate post-accident co-ordination. An experimental prototype is designed to better demonstrate the usefulness of the overall framework. Location coordinates of a vehicle are manually measured using GPS sensor and this location data is stored in the database through a microcontroller. These coordinates consist of latitude and longitude value; it will pinpoint the vehicle's position in the area. In Fig.3, the proposed IoT based prototype has been demonstrated where a road scenario can be seen and all modules connected to detect any incident. The materials are chosen for the prototype based on their availability, cost and performance. Hence, for the real-time application, these materials might be replaced with more rigid materials. A roadside scenario is made to test the prototype application where the following devices and materials have been used-

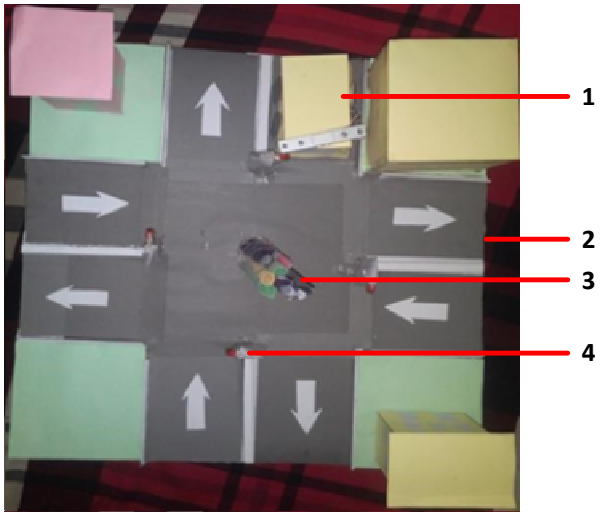

Fig. 3. Proposed rescue plan.

1) Smart car – A smart car is designed with Load cells and GPS to detect an accident.

2) Road scenery – A road scenery with roadside buildings is made for the prototype.

3) Traffic light – The traffic light is attached in the road scenery which is located in a common point where several roads are connected.

4) Collision sensor – Many collision sensors are attached in the road. The sensors check whether any accident has occurred or not.

Fig. 4. A smart car with a load cell and GPS module.

Fig. 5. Collision Detection using Load Cell.

In Fig.4, the car will be equipped with few Load Cells in front and rear. There will be a GPS sensor inside the car. This GPS sensor is linked with the Load Cells through which the accident will be detected and identification and pinpointing of the accident location will take place instantly. Every moment is important after a crash takes place.

B. *Implementation of the Proposed System*

In this section, Fig.5, Fig.6 and Fig.7 represent the overall implementation and demonstration for the proposed system. In Fig.5, Load Cells are used to detect the collision. When any vehicles push with reasonable force from the back or front of the car, then the Load Cells identify it as a collision. A Load Cell is a type of force measuring instrument that gauges the amount of pressure exerted on it. It has a transducer that generates an electrical signal whose

magnitude is directly proportional to the force being applied [20].

In Fig.6, the SMS sub-system of the framework has been shown. The SMS is sent via the GSM module to the number that is already stored in the database. The message will contain detailed information on the accident location. When the system collecting the stored contact numbers of users, the system will send SMS of accident location link to the users by GSM Module. GSM (Global System for Mobile Communication) is an architecture used for mobile communication in almost all of the countries now a day [21].

In Fig.7, a map is visualized to the user. When a user clicks on the link of the point of accident, the location will be displayed on google map. By knowing the location, any user or the rescue team can dynamically take the shortest route to reach the destination, an ambulance will also head towards the accident location to provide emergency medical assistance.

V. Result and Discussion

The result and testing part is divided into two sections which represent the uniqueness of the framework and accuracy of the results.

A. *Integration Test*

Integration testing is a type of testing where individual modules are combined and tested as a group. It occurs after the unit testing phase. Purpose of integrated testing is to expose faults within the interaction between integrated units [28]. Table I shows test cases, expected results and observed results for each module of the system. From the results acquire from Table-I all the modules can be seen working successfully in the system.

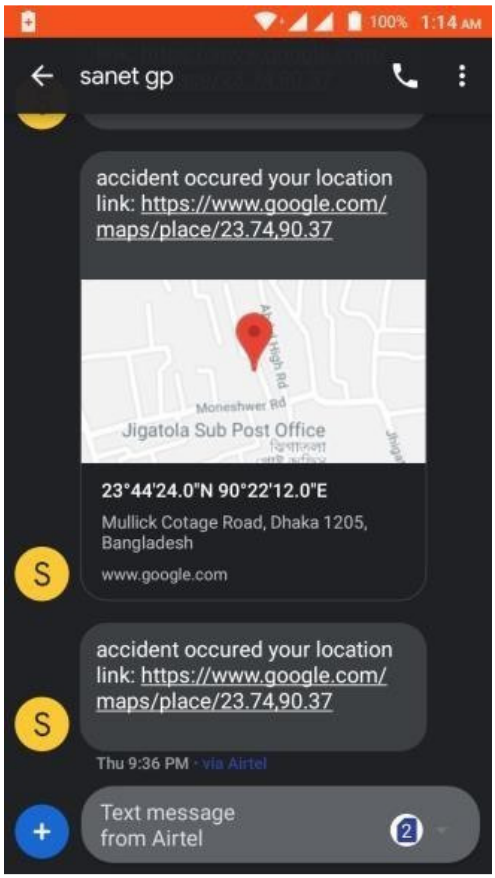

Fig. 6. Sending SMS after an accident.

TABLE I. Integration Test Result

Test Case	Expected Result	Observed Result	Test Result
When the accident occurred the Load Cell should be able to detect the accident	Can detect an accident.	Can detect accident	Pass
GPS module of this system should be able to detect vehicle location correctly	Location should be exact.	Location is exact.	Pass
GSM Module of the system should be able to send SMS	SMS will be sent.	SMS has been sent	Pass
The microcontroller should be able to send data to a server using the Wi-Fi module. The microcontroller should be able to retrieve data from the server	Can send and retrieve data to and from the server	Can send Can retrieve data	Pass

B. *System Test*

System testing of software or hardware is conducted in a complete and integrated environment to evaluate its compliance with the specified requirements. System testing takes all integrated modules that have passed integrated testing as its input. The testing then aims to detect any inconsistencies between the units integrated [29]. System testing can detect bugs with the interaction between different modules of a framework. Oftentimes, these interactions glitches may not have a huge impact on a modular level, but when the impact is measured on the overall performance of the system, such minor modular level impacts may become more serious than anticipated initially [22]. System testing helps us to identify any such inconsistencies at an early stage of the development. Table II. Shows test cases, expected results and observed results of system testing.

TABLE II. SYSTEM TEST RESULT

Test Case	**Expected Result**	**Observed Result**	**Test Result**
Users should be able to get SMS from this system successfully	SMS should arrive	SMS received	Pass
User should see accident location	Accident location should be seen	Accident location can be seen	Pass
Ambulance should be able to get the direction to reach the accident spots	Ambulance should get proper notification	Gets the required notification	Pass
Authority should be able to update server data	Can update server data	Data in the server can be updated	Pass

VI. COMPARISON BETWEEN EXISTING SYSTEMS AND PROPOSED FRAMEWORK

In this portion, in Table III, the difference between features available in some traditional systems and our proposed IoT based smart system is tabularized by which the advancement of our research work can be demonstrated.

TABLE III. PROPOSED FRAMEWORK IN COMPARISON TO EXISTING SYSTEMS

Test Case	Existing System	Proposed System
Detection Mechanism	Most other system do not use the functionality of Load Sensors	Load Sensors have been applied.
Providing instant direction to the accident spot	Current systems do not have this feature	Our system provides this feature
Cost effectiveness	Most of the prevalent frameworks use expensive mechanism such as Bluetooth	In-expensive GSM and WiFi modules have been implemented, giving a significant edge in terms of deployment expenses.

VII. CONCLUSION

The current study proposes and implements a smart accident detection and rescue system for busy metropolitan cities. This system ensures smart accident detection and rescue mechanism that can provide the exact location of the accident. It also aids any ambulance to get direction. Ambulance driver can take the shortest path to the accident spot and thereby rescue the victims in the least possible timeframe. Besides, our system puts a minimum of financial strain on the user to implement than many other systems, but with a more reliable output. In future machine learning techniques [24] can be implemented to get even better insights into the situation in an automated manner.

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