Collision Detection System in VANETs

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Abstract -- With the day of Smart Cars and new-age technology, modules like Collision Avoidance systems which include ABS, Airbags, Speed Control, and other such features are found in every other car these days, however, the success rate for any machinery or system is never 100% and hence there are still chances of collision. This project is a Collision Detection System that aims to provide a safe fallback option that will be useful in the case where the Collision Avoidance system fails and the car meets with an accident. It uses multiple factors to determine whether the car has met with an accident or not, in which case the vehicle will send out an S.O.S signal to the next-of-kin and any nearby RSUs, OBUs in the VANET so that help can reach the victim in the golden hour, i.e the time before which the injuries might turn fatal.

Keywords — Collision Detection, VANET, Automatic Messaging System, Geolocation, Smart Cars, Car Flip, Accelerometer, Arduino, IoT, V2X Communication.

I. INTRODUCTION

The Internet of Things (IoT) is the interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure. Typically, IoT offers advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is implemented in nearly all fields of automation enabling advanced applications like a Smart Grid.

In this project, we are working on a “Collision Detection System”. An enormous population, with the increasing number of vehicles leads to heavy traffic and thousands of people die in road accidents across the world, creating a global hazard. Deaths and disabilities by road accidents are increasing with each passing year.

An increase in population and per capita incomes has led to an increase in ownership and the presence of vehicles on roads. Greater traffic volumes, over speeding, reckless and drunken driving, driver fatigue, poor road infrastructure and the presence of animals on roads are some reasons that are responsible for road fatalities. According to the World Health Organization (WHO), the percentage of road accident fatalities to the total number of deaths worldwide has increased by 2.2%. Approximately 1.35 million people die due to road accidents every year. In many cases, human lives are lost in road accidents due to delays in emergency medical assistance.

According to Golden Hour Principle, there is a high probability that timely medical and surgical aid can avoid death during the golden hour, which is the period after the traumatic injury. A decrease in the response time of emergency medical care can reduce the probability of death by one-third on an average. The percentage of people who die before reaching the hospital is high. In the recent past, information and communication technology such as IoT has been used to decrease the accident rescue time.

The victims of numerous accidents that frequently go unreported and result in fatalities need to be handled. The gadget needs to be capable of speaking with the neighborhood hospital and police station right away in the event of an accident. We require a method to aid in identifying these mishaps and pinpointing their locations so that the rescue crew and the rider's emergency contacts can be informed.

So, we recommend this technique, which is crucial for the thorough detection and individual control of regrettable accidents. Every day, millions of people are killed or injured in traffic accidents. The vast majority of incidents are not catastrophic, but neither is the tragically high death toll brought on by irrational delays in local emergency services. Since we don't know where a potential accident will naturally occur, we are ill-equipped to determine an accident site.

They normally offer adequate medical care to the injured person, but they urgently require assistance to determine the precise site of the accident. They can only do this by tracking their whereabouts and communicating with a family member or the local emergency services.

II. LITERATURE SURVERY

Ref No	Authors and Year (Reference)	Title (Study)	Algorithm Used	Merits	Demerits
1	Saranya S, Karthika G, Gayathri U, Ramya B, Avinashilingam N Year – 2021 https://www.academia.edu/49204628/IoT_Based_Accident_Detection_and_Life_Guard_System	IoT Based Accident Detection and Lifeguard System	No specific algorithm, this research paper describes the detection of the crash using a piezoelectric device by the observation of vibration caused by fatal crashes.	This device can capture the specific location of the vehicle it is paired withinIn the case of an accident, the device can immediately communicate with the local hospital and police station. As a result, the proposed system is essential for complete prevention and personal control of unfortunate accidents..	The device does not allow processing until the accident occurs, so there is a time delay. Also it is practically very complicated to include the data from medical insurance companies.
2	Aditya Maruti Naik, Algeena Carol Dsouza, Aditya Shetty Year: 2018 https://www.ijert.org/collision-and-rollover-detection-in-vehicles	Collision and Rollover Detection in Vehicles	This paper proposes vehicle collision detection and roller detection techniques with the help of satellite module. Satellites are used to track the device. RNS modules helps to send signals to satellite.	This system is going to help a lot of travelers whos unaccepted encounter with major injuries may make them unconscious on highway and remote areas or any low populated area.	
3.	Aris S. Canto , Pedro V.S. Matias , Rafael O. Moreira , Thyago A. Sampaio , Adriano E. Santos , Daniel F. Luiz , Celso B. Carvalho , Waldir S.S. Junior Year: 2022 https://ieeexplore.ieee.org/document/9869177	A Mobile IoT system for the detection and prevention of vehicular collisions	A system that uses a set of sensors, a microcontroller and a mobile application (Android) to notify emergency contacts and to inform the location of the accident.It uses 4 subsystems- Data collection system and web server, Gateway and mobile application, Prevention subsystem, Collision detection subsystem to deliver the collision warning..	The solution is scalable, and the algorithm can be applied in real-world scenarios with cars or robotic transport systems. Uses only statistics without using a more robust machine learning model, which allows for an acceptable response time at a lower processing cost. After a controlled test results in a error margin of 1.42-1.99%	Its tested only in a controlled environment with a remote-control car, in real life environment the error margin might significantly increase
4.	Shafin Talukder, SK. Tasnim Bari Ira, Aseya Khanom, Prantika Biswas Sneha and Wardah Saleh Year:2022 https://arxiv.org/abs/2205.07815	Vehicle Collision Detection & Prevention Using VANET Based IoT With V2V	This paper is made to present the results of a major analysis relating to emergency alert conditions at the time of collision (automobile).Additionally, the technique can be implemented in such a way that vehicles are alerted of possible closing barriers. A system that uses a set of sensors, a microcontroller and a mobile application (Android) to notify emergency contacts and to inform the location of the accident.	The battery performance of this activity tracking gadget is between 5 to 10 hours. Two-stage system to detect with a tracking module that can handle partial and complete objects Works in all different climates	Very costly Complex and high delay rate of detection Day and night detection rate varies

5.	Louis Montaut, Quentin Le Lidec, Vladimir Petrik, Josef Sivic, Justin Carpentier Year: 2021 https://www.researchgate.net/publication/360473905_Collision_Detection_Accelerated_An_Optimization_Perspective	Collision Detection Accelerated: An Optimization Perspective	Frank-Wolfe Algorithm, Nesterov acceleration	This research paper introduces a new collision detection algorithm by adapting recent works linking Nesterov acceleration and Frank-Wolfe methods. It benchmarks the proposed accelerated collision detection method on two datasets composed of strictly convex and non-strictly convex shapes	The research paper uses terms and mathematical applications that require previous existing knowledge and hence is rendered useful for only the targeted audience and not to the general public.
6.	C. Nandagopal, P. Anisha, K. Ganga Dharani, N. Kuraloviya Year: 2022 https://ieeexplore.ieee.org/document/9760714	Smart Accident Detection and Rescue System using VANET	Controlled Indexing, ADS,Message sending routing protocol,VANETs	Practically Implementable VANET High Accuracy Fast and efficient communication	Complex mechanism Only accident is detected its vulnerability is not known Can be vulnerable to noise and sensor faults
7.	Daniel Anadu, Charmant Mushagalusa, Nesreen Alsbou, Alaeddin S. A. Abuabed Year: 2020 https://ieeexplore.ieee.org/document/8409861	Internet of Things: Vehicle collision detection and avoidance in a VANET Environment	Iterative Filtering Algorithm	Simulates a vehicular ad hoc network by sharing messages between sensor nodes From the computer modeling, it is visible that the time involved in a small scale is about one-hundredth of a second. This is faster than the human processing brain	For this communication to be regarded as highly effective, messages transmitted between the cars should be of a small size and should be transmitted quickly and frequently. It is important to understand that the numerous data transmission could be inoperable except an adverse road condition or collision

III. INFERENCES FROM LITERATURE SURVERY

Technologies like VANET and IoT, which are quickly growing, are successfully used in systems related to vehicles. The collision detection ensures the driver's safety by using different types of LEDs for varying lengths of distance, which is the most crucial aspect of the proposed solution. Additionally, V2V communication has the added benefit of allowing for the warning of other adjacent vehicles when there is less than 10 meters between the two. However, it should be emphasized that V2V communication only functions if the other vehicle has the same technology installed. In the event of a collision, the system immediately begins to function with emergency rescue capabilities. Additionally, it uses GPS to continuously check the vehicle's current condition. This suggested method is extremely inexpensive in comparison to other solutions. Even though the suggested method is simple, adaptable, and easy to use, there are still a few identified issues that need to be fixed.

In these papers the importance of Internet of Things (IoT) as a constantly developing area of innovation has been discussed and also that it has successfully transported in a car. The several experiments have been performed that usually help in the coordination of healthcare meetings at the accident site and the recovery of family members. The device used can also capture the specific location of the vehicle it is paired within. In the case of an accident, the device can immediately communicate with the local hospital and police station. As a result, the proposed system is essential for complete prevention and personal control of unfortunate accidents.

Collision detection and roller detection techniques such as RNS (to send signals to satellite) and satellite module (to track the device) can be used. If the impact of collision is very high and driver is unable to confirm his /her condition, then the device sends the signal to the satellite immediately contacts nearby emergency care center by sending the exact location of accident with the help of prerecorded audio or in textual form.

GJK algorithm (a variant of the Frank-Wolfe method) is beneficial for both collision detection and distance computation settings for scenarios where shapes are intersecting or in close proximity.

A Vehicular smart system is a system that alerts and controls the speed of a vehicle, also notifies the individuals accordingly when an accident occurs. This system always monitors the distance between vehicles and obstacles that are in front, using distance sensor. It will alert the driver to control the speed and reduce the speed by itself when a critical distance comes. Whenever an accident takes place for uncertain condition, an email alert will be sent to the accountable individual with car details.

This proposed system solves this issue formed of regular ADS models. In VANET each active vehicle is observed as a node and each will communicate with one another and the transmission between vehicle and base station. In this system in order to prevent accident, this research work detects the possible parameters that cause an accident using Ultrasonic sensor to measure and alert the distance between vehicles

In robotics, manufacturing and computer-simulation; accurate and fast collision detection between general geometric models is a fundamental problem. The elucidation of this problem will gravely improve driver safety and traffic efficiency. A system for vehicle communication that addresses this problem is proposed in one of the papers. Vehicular Ad-Hoc Network (VANET) technology is utilized to create a distributed network allowing the exchange between automobiles on a large scale for the implementation of Vehicle-to-Vehicle (V2V), or Vehicle-to-Infrastructure (V2I) communication protocols. The goal of the research is to create a VANET environment and algorithm for collision detection. Collision avoidance emanates from the detection algorithm

IV. PROPOSED SYSTEM

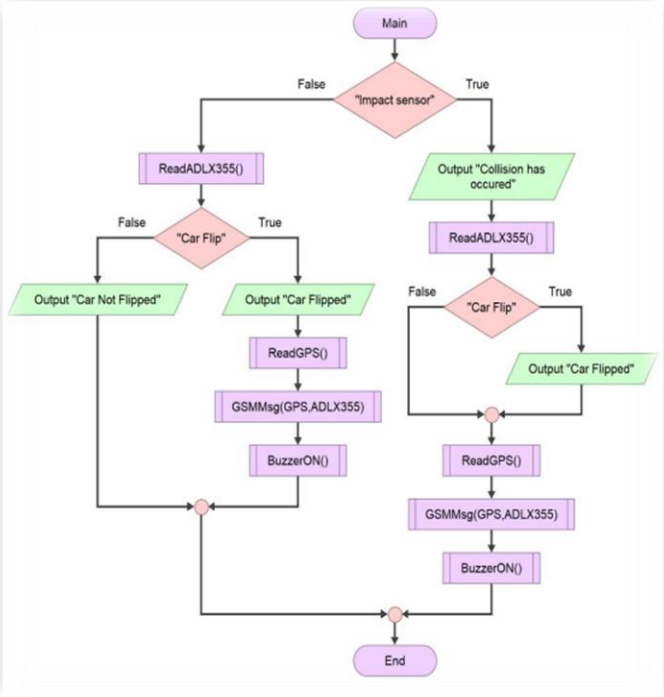
This entire project has been developed using an Arduino Uno Microcontroller board and 4 sensors, namely an accelerometer-ADXL335, an impact sensor (YL 99), a GSM Module (SIM 800A), and a GPS Sensor (GY 61). All the sensors are attached to the Arduino Board using jumper cables and a breadboard. We also use an LED light and an active buzzer that are used as an alarm to notify any nearby entities and the passengers themselves when a crash has happened.

How the entire project works is very simple, after the initial setup of all sensors and default values, the sensors constantly check for collisions and whether the car is flipped or not using the collision switch data and the roll and the pitch from the accelerometer. If the Impact Sensor gives a LOW value, it means that the key has been pressed and the system knows that a collision has happened. Once the Arduino gets to know that a collision has happened it sends out a consequent output and continues to read the data from the accelerometer, namely the roll and pitch of the vehicle. If these values pass the set threshold values a consequent output that the car has been flipped is also sent out.

Following that Arduino obtains the geolocation of the crash/vehicle from the GPS module, and passes all the relevant information like the Driver details, Vehicle Details, and the Geolocation to the GSM Module that broadcasts it to all nearby entities and the next-of-kin contact number fed into the system. Once the message is sent out the LED and Buzzer are activated to notify all nearby entities and the passengers and to make it easier for help to locate the vehicle in some situations.

In a case where the Impact Sensor gives a false value, the Arduino Board still checks on the values obtained from the accelerometer, and if those values show that the car has flipped but there was no collision trigger the same procedure of getting the Geolocation and sending out the relevant information along with the physical identifies turning on is followed.

The entire procedure has been summarized in a flow chart given alongside.



V. METHODOLOGY/PROCEDURE

In this project, we design a system that detects collisions in vehicles and can be used as a backup in the event that the existing collision avoidance systems fail, or it can be implemented independently as a precaution.

This is accomplished with the assistance of an impact sensor installed on the car's bumper. It compares the vibrations of the car to a threshold and detects an accident when the readings exceed the threshold and the switch is flipped. When a collision is detected, the orientation of the vehicle is determined using an accelerometer, which provides the complete 3-axis acceleration measurements.

The Arduino is an open-source microcontroller board, that possess the codes that determine the course of action and do so by processing the values given by the sensors. It thus gives instructions to the connected modules accordingly, hence acting as the brain of the system. Arduino UNO board is known to have higher efficiency and be more cost effective than Raspberry Pi Board that is used in existing models

With the help of the processed data obtained from the Arduino, on identifying an accident the location of the vehicle is be detected using the GPS module and sent along with the alert message to the personal contacts or the closest emergency locations or hospitals using the GSM module.This proposed system being an isolated module can be combined with other software and modules to develop an extensive product

VI. EXPERIMENTAL SETUP

- **Arduino Uno**

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and is the main brains behind the entire project. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits.

- **Impact sensor**

In order to detect collisions during the accident we use an impact sensor. The impact sensor is fitted on the bumper of the car. It is designed to detect the instances of the sudden impact in order to output a value or, in the case of impact switches, activates or deactivates a circuit or a device.

- **Accelerometer (ADXL335)**

To detect the orientation of the vehicle we use ADXL335. ADXL335 gives complete 3-axis acceleration measurements. It uses three linear potentiometers as a variable voltage source for each axis, as the acceleration in ADXL335 is directly proportional to the output voltage of each axis. The input data from the ADXL335 is processed by the Arduino and if and when the vehicle's roll and pitch values cross the threshold an alert is thrown claiming that the car has been flipped.

- **GPS (GY 61)**

A GPS module is usually a small board on which a GPS sensor is mounted with additional components. With the help of the processed data obtained from the Arduino, the location can be detected using the GPS module and the alert messages can be sent to the personal contact or closest emergency locations or hospitals using the GSM module.

- **GSM (SIM800A)**

The GSM shield allows an Arduino board to connect to the internet, send and receive SMS, and make voice calls using the GSM library. Once the collision or flip happens we also used a buzzer to alert the passengers that an emergency message is sent.

- **Buzzer**

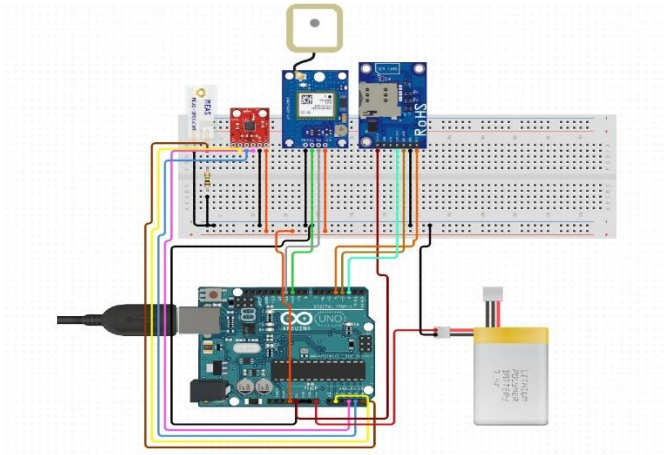
It is used to warn the passenger that a message is sent. It also helps to avoid false detection by warning the driver and the passengers that a message has been sent out incase there has been an error in detection

- **App**

App:- The app is used to send the SMS using the GSM module. It sends the co-ordinates of the location where the accident has taken place along with the message. The app shows the message sent and a google map having the information of the nearest hospital from the accident spot.

- **Power Supply**

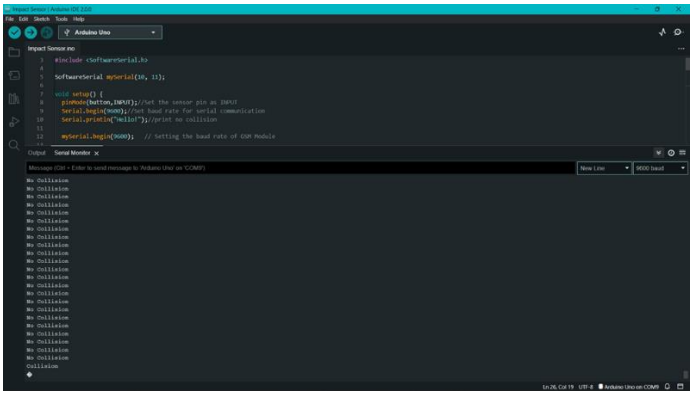
Here we use 5V power supply for the GSM, impact sensor module and 3.3V for GPS, ADXL335 to work on.



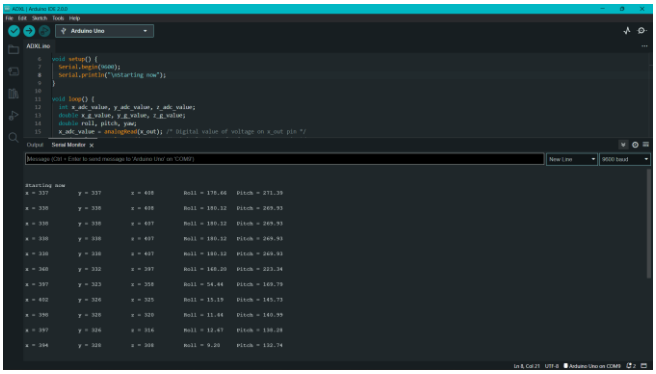
VII. RESULTS AND DISCUSSION

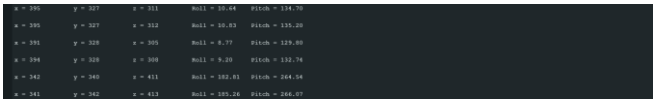
The testing and working of each individual module was ensured using sperate codes compiled in the Arduino language as shown below

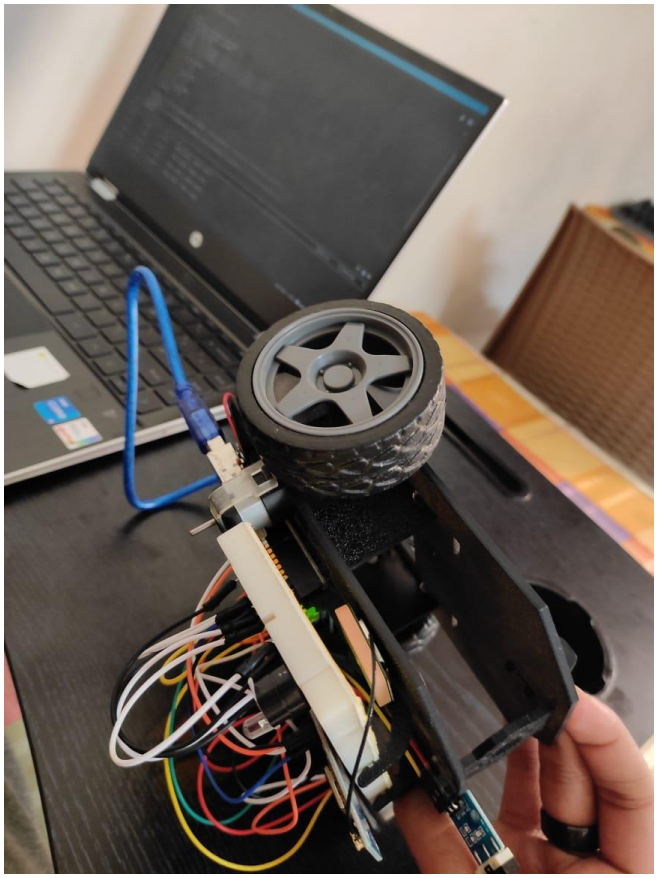
- Impact sensor



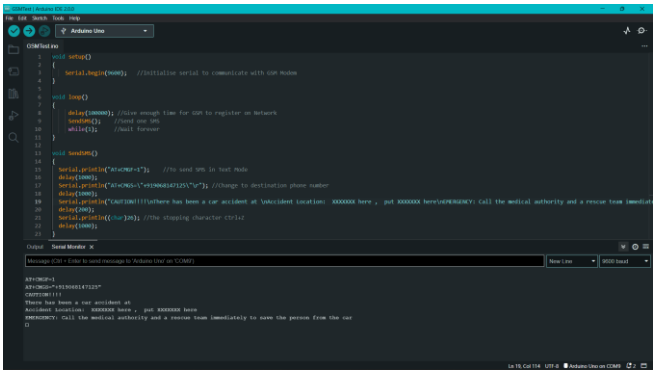
- Accelerometer

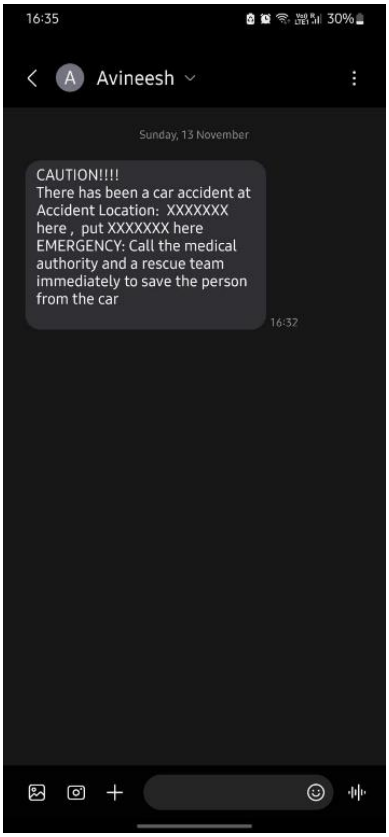






- GSM





- GPS

VIII. FINDINGS

- The Roll and Pitch values (recorded by using the acceleration in all the three axes) depends on the height and placement of the accelerometer module other than the acceleration in the respective axes.
- The values for Roll and Pitch were tried and tested to be constant around 180 and 270 for the stationary vehicle and the threshold values for flipped car were found out to be <150 and <200 respectively.
- The GSM module requires a minimum of 3 minutes, 180 seconds, to be recognized and get connected to a satellite in order to be fully functional and be able to send message and dial calls.
- The response time for the entire project to work after the onset of the impulse from the impact sensor or the accelerometer is less than 1 second.

IX. CONCLUSION AND FUTURE WORKS

Nowadays technology growth has also made a lot of changes in all the fields of science. Current transportation systems face several challenges such as traffic congestion, mobility, and safety from the tremendous increase in traffic accidents, especially in developing countries. Traffic accidents are one of the key causes of death and injury in the world. Accidents can occur due to engine failure, it might also happen due to careless driving or the fault of other drivers. A Vehicle collision detection system is developed to avoid accidents, based on GPS technology. Moreover, a real-time collision detection system has become a crucial safety feature in vehicles today, mainly after the evolution of autonomous and self-driving vehicles. It is proved to be very effective in minimizing the number of road accidents.

We have successfully implemented the system and have included many features in it. An impact sensor is fitted on the bumper of the car to sense the vibration. It detects the instances of the sudden impact to output a value or, in the case of impact switches, activates or deactivates a circuit or a device. The impact sensor has a predefined threshold value which depends on the size, acceleration, and other features of the car. If the vibration sensed by the car is greater than the threshold value then the sensor will classify it as a collision. To detect the orientation of the vehicle we use an accelerator. It gives complete 3-axis acceleration measurements. It uses three linear potentiometers as a variable voltage source for each axis, as the acceleration is directly proportional to the output voltage of each axis. The input data from the sensor is processed by Arduino.

The increase in vehicle population leads to road accidents, which is a grave issue to be dealt with utmost care by taking measures to save the lives of victims. Many times when an accident happens, people usually do not bother to help the victim because of the police inquiry and in case the victim is conscious, is unable to inform anyone because of either trauma or not knowing the location.

With the help of the processed data obtained from the Arduino, the location can be detected using the GPS module and the alert messages can be sent to the personal contact or closest emergency locations or hospitals using the GSM module. And the GSM shield allows an Arduino board to connect to the internet, send and receive SMS, and make voice calls using the GSM library. The app that sends the message also shows the location of the nearest hospital to the accident on the map along with a buzzer which is also sounded to inform the passengers and any nearby entities that an accident has happened. This buzzer is very useful to avoid unwanted panic in case of false detection as the passenger can inform his contacts that they are safe.

We are intending to work on the given project by enforcing more fine-tuned sensor settings to avoid false alarms and add security to the entire module against cyber attacks like, GPS Spoofing, Man-in-the-middle attack, Sybil Node attack etc. Adding an extra layer of encryption over the message that is transmitted as the SOS signal using algorithms like RSA or AES, will ensure the authenticity and integrity of the message coming from the vehicle and the acknowledgment sent out from any RSUs/OBUs in the VANET. We are also planning to amplify the physical identifiers to the project other than the buzzer and the LED so that it is easier for the authorities or any nearby entities to locate the vehicle

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