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ADAPTIVE CRUISE CONTROL SYSTEM

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Abstract:

Automobiles are perhaps the domain that represents the 21st century. The vehicles play a major role in our day to day life for transportation. The term Cruise Control refers to the concept of assisting drivers in the task of longitudinal vehicle control to avoid any accident or collision. With the increase in the world population the need for automobiles as well as its usage daily has increased drastically. This leads to heavy traffic, rush, collisions, and accidents. The automobile black box is used to analyze the cause of vehicular accidents and prevent a loss of life and property from vehicle accidents. This Paper is based on the Project topic of Adaptive Cruise Control. In our proposed system, we tried to implement ACC using the less expensive devices, also increasing the ease to use it and adding a few other features in it. The project aims to build a Semi-Autonomous system; that assists the driver for the longitudinal control on their vehicle while driving by using the ultrasonic sensor (HCSR_04). An alert (led or buzzer) indication is given when the inter-vehicle gap approaches the safety limit. A switch is provided to ensure the semi-autonomous use of the vehicle. Also, it aims to use IoT to keep track of the distance readings, speed readings, and stability of the vehicle using the NodeMCU and ThnigSpeak platform. This system also uses the GPS (Neo-6m) and GSM (SIM 800A) to send a text message to a pre-defined number in case of detection of an accident.

***Key words*- ACC, Ultrasonic sensor, Microcontroller, Internet of Thing (IoT), GPS module, GSM module, Opto-speed sensor, Black box, ThingSpeak.**

I. INTRODUCTION

FIGURE 1: REPRESENTATION OF ACC

In the 1970s first appeared the idea of driver assistance was started with the 'cruise control devices' in the USA. The most basic version of this type showed progressive results in accelerating and braking to maintain a constant speed but was inadequate to consider other vehicles on the road and hence was not practical to use this on a heavy traffic road. Having that in mind soon a better version known as 'Adaptive cruise control'(ACC) was invented.

Control is based on sensor information from an onboard sensors, such a system may use an ultrasonic sensor, radar, or a camera setup allowing the vehicle to brake when the vehicle detects the other car approaching and crossing the safe distance set by the developer of the system.

Adaptive cruise control does not provide full autonomy; the system provides some help to the driver that makes his experience a lot smoother and comfortable. Automobile and computer technologies are creating new levels of data services in vehicles one of which is the Automobile Black box. This automobile black box is used to analyze the cause of vehicular accidents and prevent a loss of life and property from vehicle accidents.

The proposed system makes use of sensors, controller (Arduino UNO) to implement cruise control. The speed of the vehicle is controlled according to the instructions set by the developer. It also involves the enhancement of security by tampering of the black box status.

The data received from the sensors are stored on the 'ThingSpeak' website continuously and this data can be retrieved after the accident. In addition the black box sends an alert message through the GSM module specifying the location of the vehicle retrieved from the GPS module to the predefined mobile number via SMS in case of an accident or any unusual behavior.

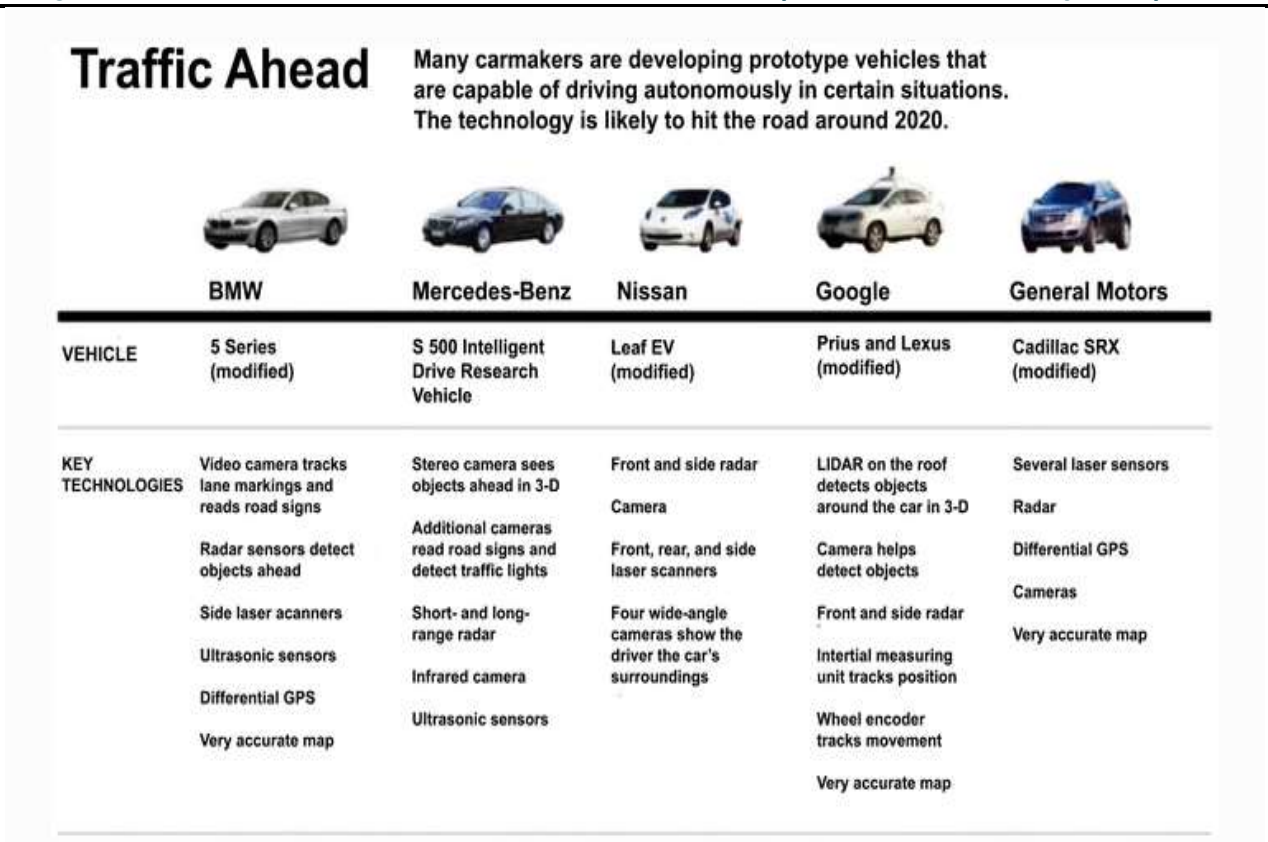
II. LITERATURE SURVEY:

FIGURE 2: CONTROL MARKET FOR ADAPTIVE AUTOMOBILE SHARE

Every once in a while we hear or watch it on Television about road accidents all over the world. This horrible news stuns the family members of the person in that tragic incident. Once a report said that the damaged property and other may equal 3% of the world's gross domestic product. To reduce this percentage, the idea of assisting the driver to help him throughout a long journey came into existence.

It said 90% of deaths on the world's roads occur in low and middle-income countries (21.5 and 19.5 per lakh of population, respectively) though they have just 48% of all registered vehicles. The statistics for India are chilling. At least 13 people die every hour to road accidents in the country, the latest report of the National Crime Records Bureau (NCRB) reveals. Calling road fatalities an "epidemic'' that will become the world's fifth-biggest killer by 2030.

An 'adaptive cruise control' system assisted the driver to keep a safe distance from vehicles on all four sides of its outer body. This system has only been available in all the luxury cars like Mercedes S-class, Jaguar and Volvo trucks, the U.S. Department of Transportation and Japan's ACAHSR have started developing 'Intelligent Vehicles' that can communicate with each other with the help of a system called 'Cooperative Adaptive Cruise Control'.



ACC has been implemented in various new Cars in Foreign countries; also the black box is included. But as we know these systems are not yet seen in automobiles in our country. Also the middle class and common citizens cannot afford the Automobiles with Adaptive cruise control and Black Box as they are very expensive as they have very high tech sensors and safety systems. So we are implementing a system that uses the regular cost sensors and regulator system in automobiles and tries to make the ACC and Black Box system that can be cost-efficient and also give proper and perfect results.

III. RELATED WORKS AND MOTIVATION:

Existing Method:

The earliest variants of the cruise control system were actually in use even before the automobile creation. The conventional Cruise control system automatically controls the speed of the car. The speed of the car will be set by the driver by adjusting the throttle position. In the cruise control system there is a speed limiter function that will work only for the predefined speed beyond that it will not work. However as the number of car increases on-road the conventional cruise control system is becoming obsolete.

Proposed Method:

The advanced method of the cruise control system is the Adaptive Cruise Control system (ACC). ACC is the system which not only maintains the speed of the car but also measures the distance between vehicle ahead of it and accordingly it will set the speed and keep the vehicle in one track. It also sends the location of the vehicle if any misfortune occurs, as an enhanced feature of the Black Box System. Fuel economy is improved by an adaptive cruise control system.

Our project aims to achieve a cost-effective, user-friendly system that fulfills the basic requirement of Adaptive Cruise Control (speed and distance observation and control) and Black Box (Security of the Driver by sending its location as a text message in case of emergencies).

IV. ARCHITECTURE

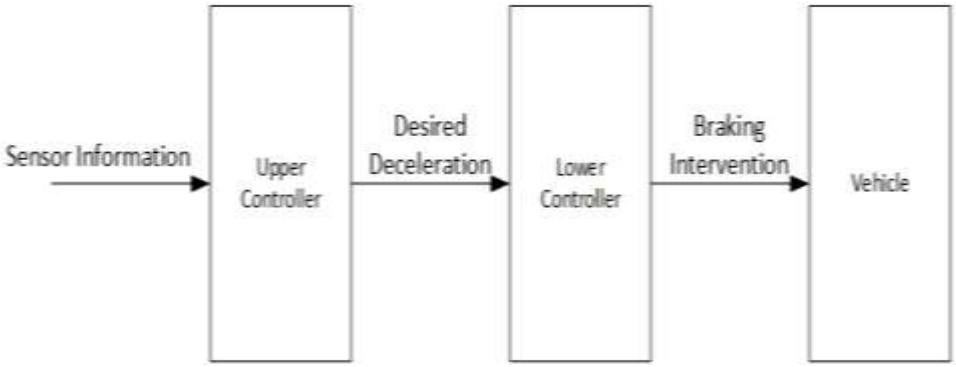


FIGURE 4: TYPICAL ARCHITECTURAL MODEL OF ACC

"60% of front-end crashes would not occur if the driver could react a split of second earlier" this fact was revealed based on the studies and research made so far. To overcome this reaction time, researchers have demonstrated that Adaptive Cruise Control significantly aids drivers in comfort by reducing driving stress and fatigue, which allows better focus while driving. This makes ACC systems an active safety system.

The model above (FIGURE 4) is the architectural model of the ACC system; it gives us a basic idea of the process of cruise control is implemented in an automobile. The sensors (distance sensor, speed sensor, etc.) collects the data from the surrounding. This data is given as input to the controller (Master); then the controller reads the data and accordingly decides accelerating or decelerating the vehicle and braking.

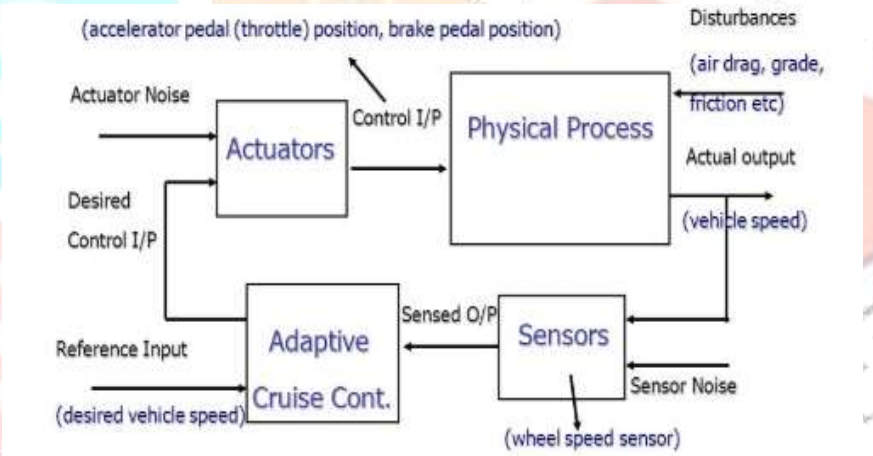


FIGURE 5: ACC SYSTEM DESIGN

• FIGURE 5 is the representation of the system design of the practical implementation of ACC or Adaptive Cruise Control in the Automobiles. A clear idea of the functioning of different devices in a loop and in sync with each other is obtained.

• The output data obtained from the Physical Process of a vehicle in the form of Speed, inter-gap distance, environmental factor's effect on our vehicle; is given as input to Sensors (here in FIGURE 5 speed is shown as a parameter as an example).

• The output from Sensors is given to ACC block; here the comparison of reference input and sensor output is done and according to the desired control input is given to the Actuators of vehicle.

• Finally the Actuators give the control signal to parts that leads to certain Physical Process. This further generates values that act as input to sensors and hence the loop goes on.

• The system proposed by us uses Speed (LM393 Opto-sensor) and distance (HCSR-04) sensors to read distance and speed parameters of the vehicle with the controlling element as Atmega 328p microcontroller and Node MCU, ThingSpeak platform to keep track of speed, stability of the vehicle and GPS Neo-m6, SIM 800A GSM to send the exact current location given by GPS as a text message to a predefined number through the GSM.

We tried to implement ACC as our project by aiming to obtain maximum efficiency by using the less expensive and user friendly devices and interfacings.

V. BLOCK DIAGRAM AND DESCRIPTION

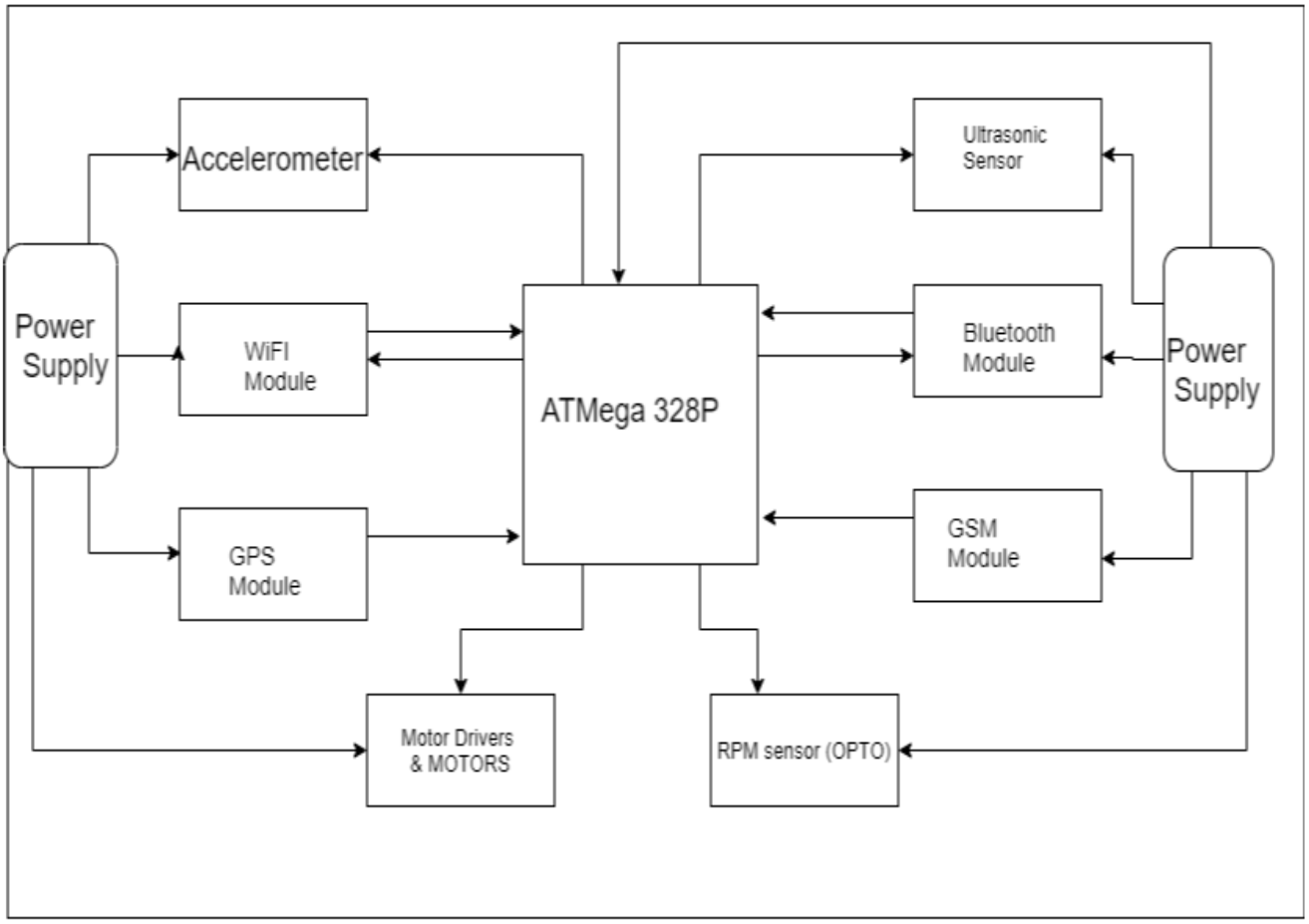


FIGURE 6: BLOCK DIAGRAM

A. SENSORS

a. ULTRASONIC SENSOR (HCSR-04):

The working principle of Ultrasonic sensor is "discharging sound waves at a frequency too high for humans to hear". Then the distance is calculated on the basis of the time required for the sound wave to be reflected back from the object. This is same as how radar measures the time it takes a radio wave to return after hitting an object.

If specific distance from sensor needs to be measured then, this can be calculated based on this formula:
Distance = ½ T x C (T = Time and C = the speed of sound)

The working principle of the Ultrasonic Sensor:
(1) Using the IO trigger for at least 10us high-level signal.
(2) The Module automatically sends waves of 40 kHz frequency and detects whether there is a pulse signal back (target object).
(3) IF the signal returns back, through high level, time of high output IO duration is the time from sending an ultrasonic wave to receiving back the wave after being reflected by the target object.

Test distance = (high level time X velocity of sound (340M/S)) / 2.

FIGURE 7: (HCSR-04) ULTRASONIC SENSOR

b. LM393 OPTO-SPEED SENSOR:

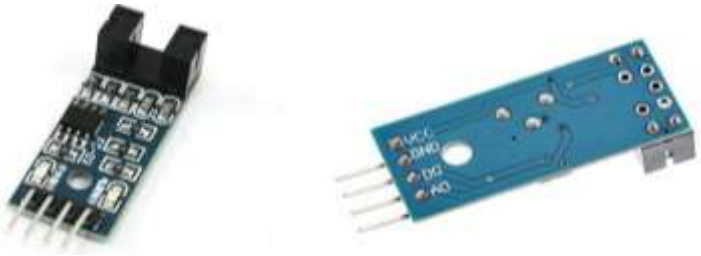


FIGURE 8: LM393 OPTO-SPEED SENSOR

Widely used in motor speed detection, pulse count, the position limit, etc. The DO output interface can be directly connected to a micro-controller IO port, if there is a block detection sensor, such as the speed of the motor encoder can detect.
Wiring specification:

- **VCC** Connect the positive 3.3 5 v power supply.
- **GND** Connect power negative.
- **DO** TTL switch signal output.
- **AO** This module does not work.
- The modules do not have Analog output.

B. ARDUINO UNO

Every system needs a microcontroller. Microcontroller is an on-chip Computer; in other words it's a computer on MOS integrated circuit chip. In our Project we are using Arduino UNO because a microcontroller as its coding can be done easily, also it is being a open-source platform we can easily understand concepts. Arduino has its very own programming IDE. ATmega328P is the core component of the Arduino Uno board. In the system proposed by us the speed sensor and ultrasonic sensor give data to UNO and after reading the data and comparing it with the set of values mentioned in the program (code); the UNO decides to accelerate or decelerate or stop the vehicle. Also it sends the text message using GPS and GSM modules, in case of detection of an accident. The data about the speed, distance, stability of the vehicle is continuously stored on the IoT platform, which allows the user to visit the web page any time and check the respective parameters.

C. WIFI MODULE (ESP8266)

The NodeMCU is a microcontroller with advanced features and an additional WIFI network. It consists of TCP/IP protocol stack and inbuilt SOC (System on chip). NodeMCU has an ESP8266 WIFI module that allows us to use it for cloud and wireless applications. Application hosting can be done easily by using the WIFI module in our system as it is IoT based. We can change the reference values or Safety Limits in our project according to the user requirement to set alert indications. The webpage contains all the data about the speed and distance variations, stability changes (if any).

D. HC-05 BLUETOOTH MODULE

Bluetooth modules are used for point-to-point wireless data transmission and reception for a short distance. Based on the version of the module we use the range of distance varies module to module. The HC05 module can be operated in Master or Slave configuration. The user sends appropriate commands to select the configuration. It uses UART serial communication protocol for data transmission through the UART pins of the module at 3.3 or 5 Volts TTL level. It is IEEE 802.15.1 standardized protocol and it uses frequency-hopping spread spectrum (FHSS) radio technology to send data over the air.
Depending upon transmitter and receiver, atmosphere, geographic and urban conditions its range up to <100m.
In the proposed system we connect HC-05 with the Bluetooth device of our android phone and use an app 'DABBLE App' to move the rover by commands through the gamepad of the DABBLE App.

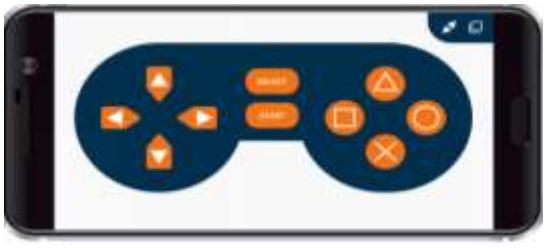


FIGURE 9: GAMEPAD OF DABBLE APP

E. INTERNET OF THINGS

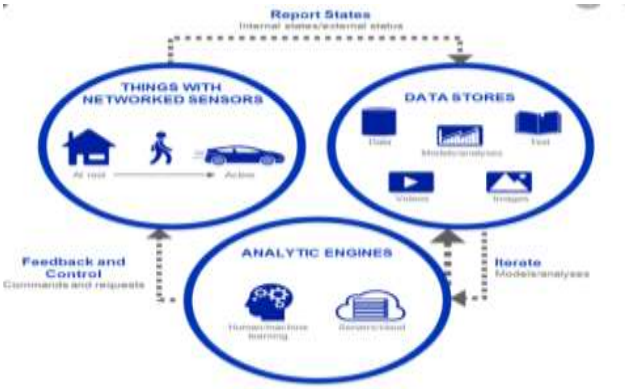


FIGURE 10: IoT REPRESENTATION

FIGURE 11: IoT WORKING

A network of devices connected via the internet that is capable of collecting and exchanging data is a IoT system. Kevin Ashton invented IoT. According to him; "a system where the Internet is connected to the physical world using different sensors" is called IoT. IoT creates a link between hardware and software systems and that makes it possible for today's world to have technologies like Smart devices, Smart power generating houses, home automation, and smart cities. Privacy and security are two important factors in IoT that should be considered while implementing IoT in any system. Real-time analytics, sensors, Control system, machine learning, embedded system, automation, actuator all contributes towards enabling IoT.

Here we will be using the ThingSpeak platform to display, respond and interact with the vehicle parameters. ThingSpeak platform keeps the data private and secure. Using this IoT platform total distance covered by the vehicle, count of the number of times the inter-vehicle gap has been in the alert limit, speeds of the vehicle on daily or monthly; is stored and can be very easily shared as mails or SMSs as well. Thinkspeak is linked through Arduino IDE software. ThingSpeak applet once made has all graphical data stored and viewed when needed.

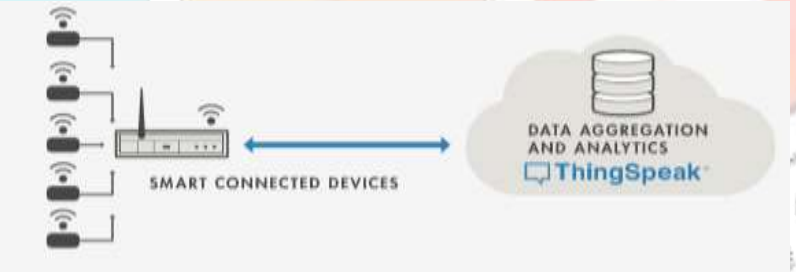


FIGURE 12: THINGSPEAK Platform

ThingSpeak is a platform that does the analysis of data and also acts accordingly on the data.

F. GPS (Neo-m6) MODULE

A satellite-based navigation system made up of at least 24 satellites is called GPS (Global Positioning System). Once your position has been determined, the GPS can calculate other information, like Speed, Bearing, Tracking, Trip distance, Distance to destination.

A GPS signal contains 3 different types of information:
1. Pseudorandom code: - Is an I.D. code that identifies which satellite is transmitting the information.
2. Ephemeris: - Data about the health of a satellite, current date, and time.
3. Almanac: -Data tells the GPS receiver where each GPS satellite should be at any time throughout the day.

NEO-6M global positioning system module, a very popular, cost-effective, high-performance GPS module with a ceramic patch antenna, an on-board memory chip, that can be conveniently integrated with a broad range of microcontrollers.

G. SIM 800A GSM MODULE

A GSM modem is just like a mobile phone; as it is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile phone. When a GSM modem is connected to a controller, this allows the controller to use the GSM modem to communicate over the mobile network. GSM modems are mostly used to provide mobile internet connectivity; many of them are also used for sending and receiving SMS and MMS messages.

In our project we are using the SIM 800A GSM module to send a text message to a predefined number in case of an accident. A 12 Volt 1.5-2Amp current supply is given to SIM 800A using 12-volt rechargeable battery and controlling current by adjusting resistors before applying power to the GSM module.

H. MOTOR DRIVER

Motor controller is a device that design to give a predefined performance of the electric motor. Motor controller might consist of the manual or automatic means of starting and stopping of the motor also forwarding and reversing of the motor. 15-20ma is the maximum current rating of microcontroller but motor requires more than 500ma current .so that motor driver is required.

In our project we are using an L298N motor driver .because it is a high current dual full-bridge driver which is designed to accept standard TTL logic. This motor driver can drive an inductive load like relays, solenoids; motors etc. It has low saturation voltage.

VI. FLOWCHART

- **FLOWCHART OF ADAPTIVE CRUISE CONTROL SYSTEM: -**

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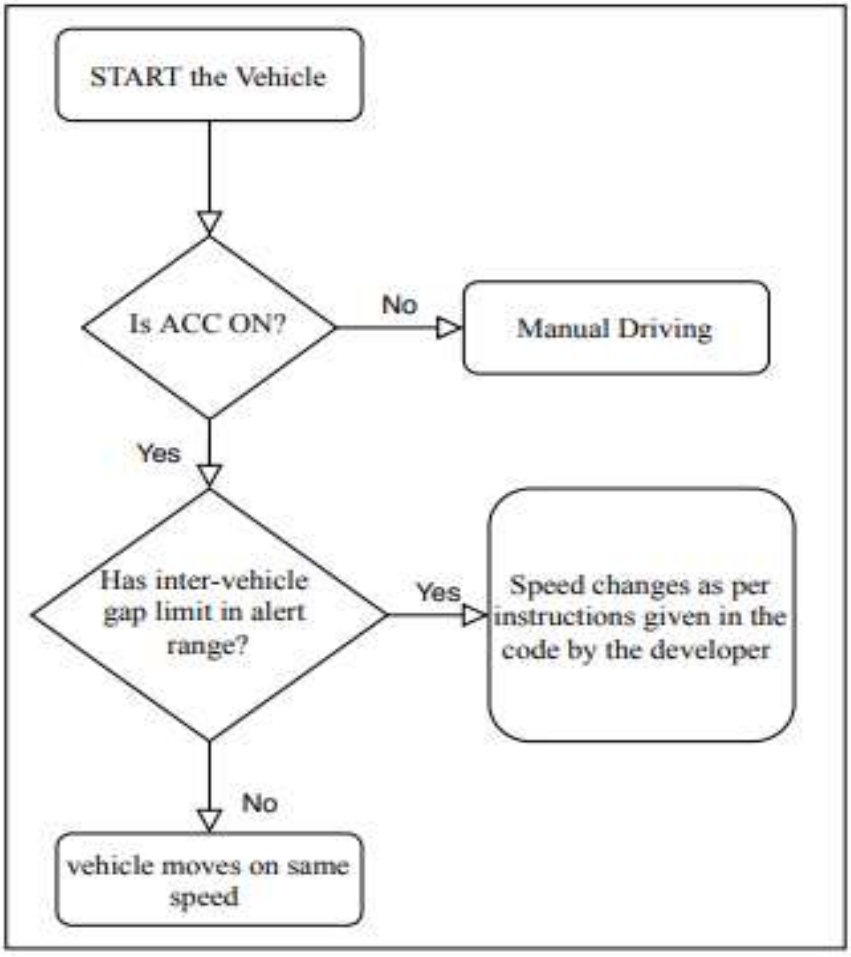

FIGURE 13: FLOWCHART OF ACC

❖ **FLOWCHART OF SMS SENDING FEATURE OF BLACK BOX SYSTEM: -**

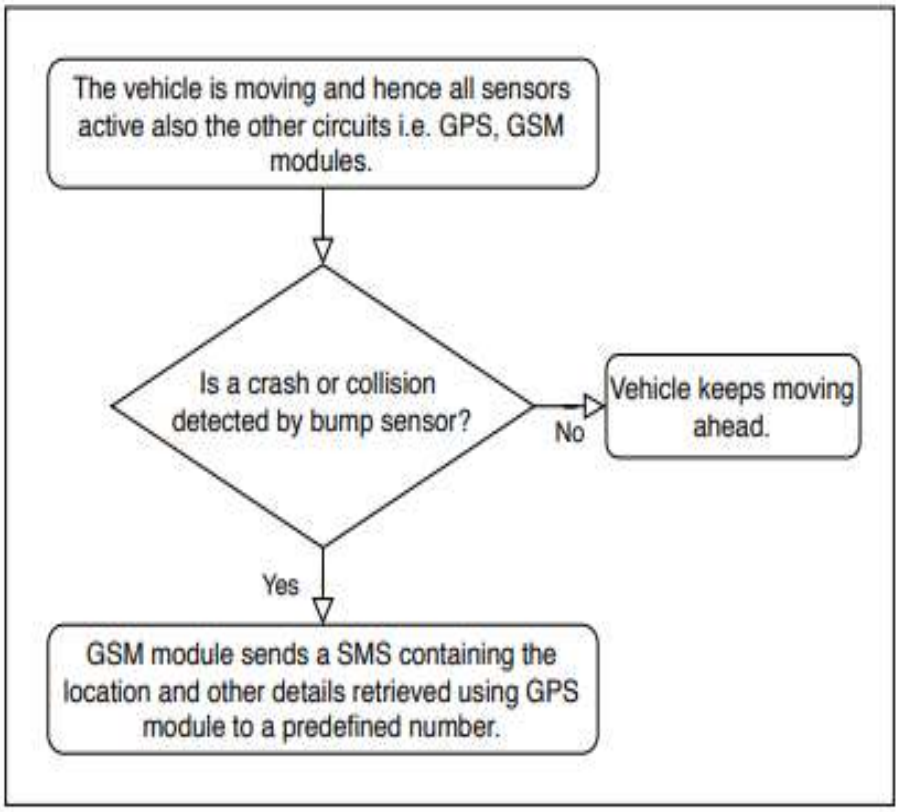

FIGURE 14: FLOWCHART OF BLACK BOX SYSTEM

VII. ABREVATION

1. ACC: Adaptive Cruise Control
2. GSM: Global System Mobile
3. GPS: Global Positioning System
4. SMS: Short Message Service
5. NCRB: National Crime Record Bureau
6. IO: Input-output
7. IDE: Integrated Development Environment
8. TCP/IP: Transmission Control Protocol Internet Protocol
9. SOC: System On Chip
10. FHSS: Frequency Hopping Spread Spectrum
11. UART: Universal Asynchronous Receiver /Transmitter
12. IoT: Internet of Things
13. WiFi: Wireless Fidelity
14. TTL: Transistor-Transistor Logic

VIII. CONCLUSION

The safety and comfort of the driver are achieved using Adaptive Cruise Control and Black Box systems. We used the ultrasonic sensor and LM393 sensor to get input data and retrieve the required results and control the speed of the vehicle and inter-vehicle gap. Also it reduces the number of brakes and switching operations done by the driver. The ThingSpeak applet assists us by storing the data given by the sensors in a graphical format and allows us to view or act based on stored data.

As a result, it ensures a reduction in stress level, so that the driver could drive comfortably, also the Safety is as the GPS and GSM modules successfully sends an SMS of current location in case of an accident. This project is very feasible as less expensive devices where being used to implement the system on a small scale basis.

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