International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 06 | June 2019 www.irjet.net p-ISSN: 2395-0072

Smart Vehicle with Crash Detection and Emergency Vehicle Dispatch with Efficient Traffic Control

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Abstract - *According to the World Health Organization, more than a million people in the world die each year because of transportation-related accidents. This smart vehicle and emergency rescue dispatch system provides a solution to this problem. The time required by a rescue team to accurately detect and reach the crash site is minimized by the implementation of this project. This system comprises mainly of two parts. The first part collects, processes and sends the relevant information like GPS Location and Pulse Reading of passengers from the vehicle using a GSM Module. This part consists of sensors that detect collision (Vibration Sensor), number of occupants and status of pulse (Pulse Sensors), and the location data from a GPS module. All these are sent to a Central agency who dispatches the nearest Emergency vehicle to the acquired location. The second part relates to efficient management of the traffic in the path of the emergency vehicle using RFID based traffic signal controlling, where the Emergency vehicle driver can control the traffic signals to favour his lane.*

Key Words: Vibration sensor, Pulse sensor, RFID based traffic management, ATmega32.

1. INTRODUCTION

According to the World Health Organization, more than a million people in the world die each year because of transportation-related accidents. The risk of accident or crash on road has become an unavoidable issue globally and of everyone's concern. They have predicted the figure would reach 1.9 million casualties by the year 2020 if no action is taken. Survivors of such accidents also have a chance of incurring a lifelong disability. 91% of the fatalities on the roads occur in middle and low income countries. Even with so many initiatives in place accidents are still a major factor. This is because poor traffic management and a lack of awareness for road safety. The paper discusses the implementation of a Crash detecting vehicle and with the emergency vehicle dispatch along with efficient traffic control using basic sensors, a GPS module and RFID System. The Crash is detected and the crash location is sent to rescue team who assigns a nearby rescue vehicle to reach the location. To minimize the delay in reaching the location caused by traffic junctions, the Signal control of various lanes is given to prioritized rescue vehicles so that they can move without discontinuation of their motion. The System uses various sensors and modules like vibration sensor, Pulse Sensor, GPS Module, GSM Module, RF transmitter and Receiver, Encoder and Decoder, etc. ATMega32 microcontrollers are used to enable the functioning of the system. The whole proposed system is divided into two major parts:

1. Crash detection and Locating Section
2. Traffic management for the Rescue Vehicle

The first section is all about finding the location of the crash site and obtaining the life status of the passenger, and sending the information to a rescue team using GSM Service. The Sensors are triggered by a Variation in the Vibration sensor which identifies the impact and correspondingly the other sensors like GPS and Pulse Sensors collect respective data which are sent serially via a GSM Module to a predefined rescue team mobile number. The Second Section consists of the further part of the system where the rescue vehicle needs to reach the target within the least possible time frame. Hence an RF Transmitter in the Rescue Vehicle transmits the information about the lane through which it arrives to the upcoming traffic junction, which has a RF Receiver that enables the reception of the lane information from the Operator.

1.1 Research Objective

Through this project we aimed to decrease death or injuries caused due to time anomalies occurring in rescue operations. The main objectives of the project are listed below:

- To provide immediate rescue and services when an accident occurs.
- To provide data regarding location and passenger's life after crash has occurred.
- To clear road blocks for faster arrival and rescue of the crashed

2. LITERATURE REVIEW

Automotive electronics plays a significant role in the automobile industry and provides luxurious features and more importantly addresses the safety and security concerns [1]. Several works that aim at providing a cost effective solution to the design and development of an event data recorder that has been basically adopted from the aviation

sector considering the need and the correlated benefits. An integrated design of the black box with the basic features of the data recorder which could be very useful for domestic vehicles and at the same time also hosts several additional features that could assist in mitigating the number of accidents, or at bare minimum, will serve as an analysis tool to prevent future accidents by analyzing the previous accidents is a field undergoing much research and development. Incorporating several other features like CAN compatibility, attractive user console and advanced web tracking anytime and from anywhere is also being researched. This leads to a system in which the overall cost is highly optimized by integrating such multiple features.. Today, technology has been repetitively subjected to changes. So with the inception of technology and improvisation of the same, developments in embedded systems have sky rocketed and are fast approaching the zenith. As an effect of such change over the past several years NHTSA (National Highway Traffic Safety Administration) has been actively involved in using Event Data Recorders (EDR) in high end automobiles like flights, cars and some two wheelers like Kawasakis Ninja. EDRs collect crash information which assists in real world data collection and also helps in understanding specific aspects of the crash. India ranks first in road accidents, for every 3.7 minutes road mishap snuck out a life. The proposed work addresses the causes and faults, and aims to collect the information which aids investigations of causes of accident and helps in improvement of motorcycle standards. Information from this device can be collected to determine the condition of motorcycle before the time of accident [2][3]. An embedded system is mounted on two wheelers which records the events like brake, gear, speed, stand and congestion. The results of analysis show that the recorders can report real world crash data and therefore be a powerful tool by providing useful information to crash reconstruction experts.

Vehicular applications are typically classified in [4]-

1. Active road safety applications-

The first category aims to avoid the risk of car accidents and make safer driving by distributing information about hazards and obstacles. The basic idea is to broaden the drivers range of perception, allowing him/her to react much quicker, thanks to alerts reception through wireless communications.

2. Traffic efficiency and management applications-

The second category focus on optimizing owes of vehicles by reducing travel time and avoiding traffic jam situations. Applications like enhanced route guidance/navigation, traffic light optimal scheduling, and lane merging assistance, are intended to optimize routes, while also providing a reduction of gas emissions and fuel consumption.

3. Comfort and infotainment applications-

Finally, although the primary purpose of VANETs is to enable safety applications, non-safety applications are expected to create commercial opportunities by increasing the number of vehicles equipped with on- board wireless devices. Comfort and infotainment applications aim to provide the road traveler with information support and entertainment to make the journey more pleasant.

3. CRASH DETECTION AND LOCATION

The whole system is initiated only if there is a trigger caused by the crash of a vehicle. Once the trigger has occurred, the rest of the system starts to get implemented. From obtaining location and pulse information of the passenger, sending it to the officials, to, issuing a rescue vehicle and managing the traffic so as to help the rescue vehicle reach the location.

When a Vehicle crashes, the vibration sensor senses a vibration exceeding the predefined threshold. Hence, the Pull down Resistor is pulled down and it is understood by the Microcontroller that a severe crash has occurred. Now the GPS, Pulse and GSM comes into play. The TX of the GPS is connected to the RX of the Microcontroller so that it receives data from the GPS, which is in DMS format. It needs to converted to DD format which is done by certain programming logic.

Now, the Pulse Sensor comes into effect, which was initially placed to understand the details regarding the life status of the passengers. This information will provide the urgency for the need of rescue. Pulse sensor is connected to a timer pin of the microcontroller which works according to the previously defined clock. The Heart beat relative to the clock is understood and is stored in the memory.

Once all the information are received, GSM comes into effect. The RX pin of the GSM is connected to the TX pin of the microcontroller. The obtained GPS value along with the pulse reading is sent as a string to the predefined Operator Number of a central agency assigns and dispatches rescue vehicles in closer proximity to the crash location. Thus, a crash exceeding injury threshold is detected and the corresponding site is located accurately using this technology.

4. TRAFFIC JUNCTION MANAGEMENT

After the first part of the proposed system has been implemented, the focus is shifted on the latter part of the project which basically aims at reducing traffic anomalies and delays at traffic junctions caused by inefficient traffic light switching system. An RFID based traffic management is planned for the same. The Traffic management is perfectly

done only if it is further divided into two parts individually controlled by two different ICs. The two parts are:

- Rescue Vehicle
- Traffic Junction

4.1 Rescue Vehicle

The Rescue Vehicle is controlled by an operator who arriving through a particular lane can manually switch the traffic signals according to his preference so that the delay caused by decelerating of his vehicle can be reduced. The lane information is sent using RF technology. Here an RF transmitter is installed in the Vehicle which will send the corresponding information. Each lane corresponds to a particular push button on the panel of the rescue vehicle. The 4 bit information obtained using the push buttons is first encoded into a single bit data which is sent through the RF transmitter and its antenna. A high span antenna can be used in practical applications to increase efficiency. However, in this project a low cost spiral antenna has been used.

4.2 Traffic Junction

A typical junction has traffic signals oscillating in a particular uniform order. After the implementation of this proposed system, a rescue vehicle operator can manipulate the working of a traffic signal accordingly so that the lane in which it is coming can be made free thus minimise any form of delay caused. The single bit data obtained via the RF Receiver is now given to a decoder which uses the same algorithm used to encode to obtain a 4 bit information corresponding to the lane. This is given to a microcontroller interfaced with the traffic lights and thus lights are manipulated using this information to favour the rescue mission.

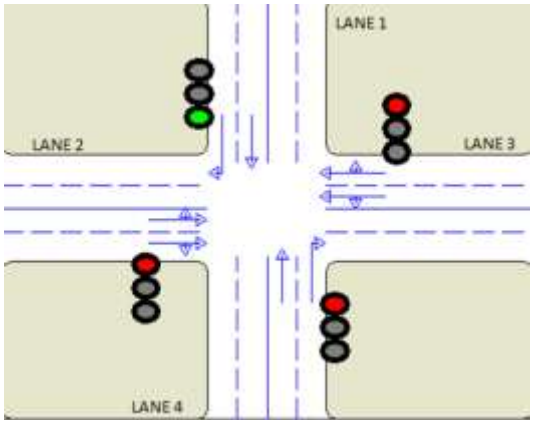

Figure 4.1: Traffic Junction after manipulation

Figure 4.1 shows a traffic junction where the rescue vehicle is coming through Lane 1 and the traffic lights have been manipulated by the operator so that his lane is always green until he has passed.

5. WORKING PRINCIPLE

The important developments in managing road traffic and creating a much more rapid rescue system had a simple beginning. A small motive to limit the time delay caused by traffic junctions to come closer to an ideal case.

Let **d** be the distance from nearest Emergency Vehicle to the location.
Let **t** be the time delay at a particular traffic junction.
Let **n** be the number of traffic junctions to come across.
Let **v** be the velocity of Emergency vehicle.

Ideally, the time required by the rescue vehicle to reach the crash site is given by:

$$T(v) = \frac{d}{v}$$

If the vehicle comes across n traffic junctions having t delay at every junction, the total time required to reach the crash site would further increase by a delay factor.
The Total time required, T, is now a factor of the delay at each junction t and it is given by the following relation:

$$T(t, v) = \frac{d}{v} + nt$$

The main aim of this project is to minimize the delay time, t caused by each junction and limit it to value tending to zero. Thus the relation now becomes:

$$T(t, v) = \frac{d}{v} + n \lim_{t \to 0} t$$

Now, the Total time required by the rescue vehicle to reach the crash site is made as low as possible by limiting the delay caused at junctions which tends to zero. Thereby nearing the ideal condition where the only time is the one that the vehicle takes according to the velocity it travels and how far it has to travel to reach the crash site.

6. CIRCUIT DESCRIPTION

The main objective of the proposed system is to facilitate higher faster rescues. It requires accurate locating capability and quick traffic manipulation. Hence, the system has been divided so that each can work independently. The two systems are classified as follows.

- Crash detection and Locating Section
- Efficient Traffic management for the Rescue Vehicle

6.1 CIRCUIT DIAGRAMS

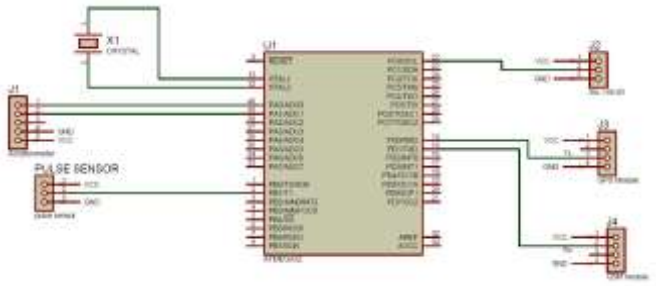

Figure 6.1: Crash detection and Locating Section

Crash detection and Locating Section consists of a Vibration Sensor, Pulse Sensor, an Accelerometer, a GPS Module and A GSM Module. ATMega32 is the Micro controller used.

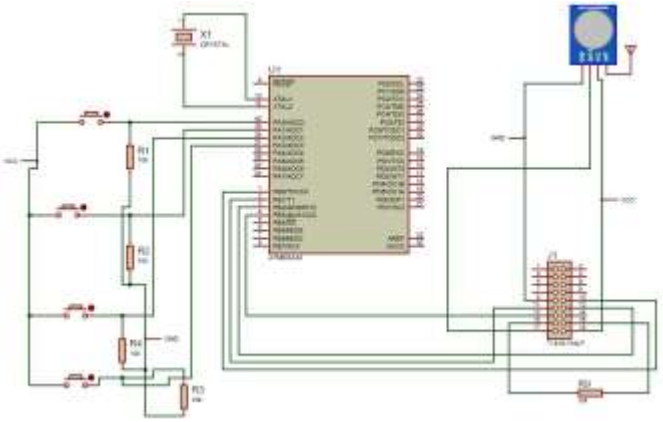

Figure 6.2: RF Transmitter Section in the Rescue Vehicle

Now, the traffic management part has two separate parts. One is shown in Figure 6.2 where the Transmitter section is shown. It is embedded in the Rescue Vehicle and the operator has the freedom of choosing which lane should turn green via push buttons. The respective data is first encoded and sent using a RF Transmitter.

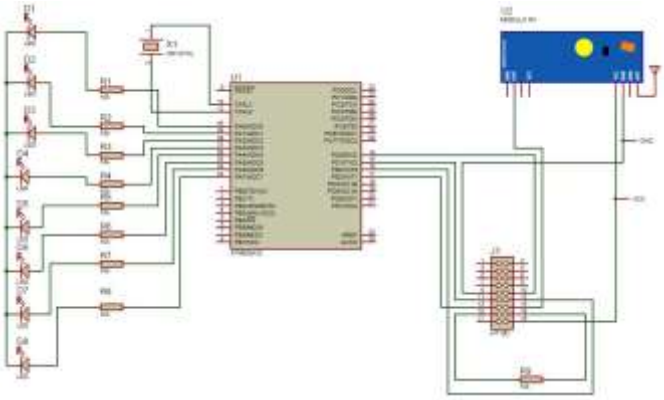

Figure 6.3: RF Receiver Section in the Traffic Junction

Figure 6.3 exhibits the receiver part of the System. It has the RF Receiver which directly acquires the sent data and is decoded using the same algorithm as that used in the encoder in the other part. The encoded data is given to LEDs such that the it glows in the Required format of a traffic signal.

7. HARDWARE DESCRIPTION

All the components used in this project are low cost and high efficiency products. The complete functioning of the system required the implementation of 3 individually programmed ICs. The antenna required by the RF modules were self wound using a wire to minimize economic calamities. In practical implementation a more sophisticated antenna is preferred regardless of its cost. The other major hardware used are explained below.

7.1 ATmega32

ATmega32 is an 8-bit high performance microcontroller of Atmels Mega AVR family. Atmega32 is based on enhanced RISC (Reduced Instruction Set Computing) architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle.

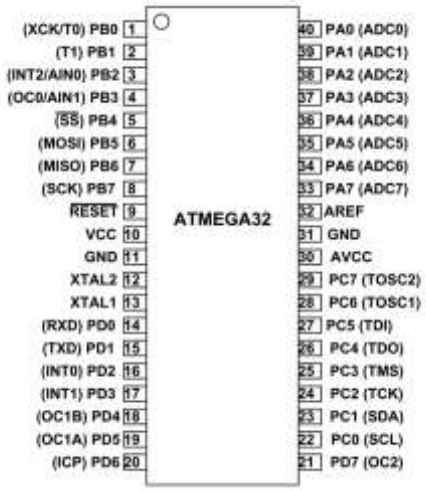

Figure 7.1: Pinout ATmega32

Atmega32 can work on a maximum frequency of 16MHz. combines 32 kB ISP ash memory with read-while-write capabilities, 1 kB EEPROM, 2 kB SRAM, 23 general purpose

I/O lines, 32 general purpose working registers, three flexible timer/-counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz.

7.2 GPS Module

GPS receivers use a constellation of satellites and ground stations to compute position and time almost anywhere on earth. At any given time, there are at least 24 active satellites orbiting over 12,000 miles above earth. The positions of the satellites are constructed in a way that the sky above your location will always contain at most 12 satellites. The primary purpose of the 12 visible satellites is to transmit information back to earth over radio frequency (ranging from 1.1 to 1.5 GHz). With this information and some math, a ground based receiver or GPS module can calculate its position and time.

7.3 Vibration Sensor

Vibration sensors, also known as piezoelectric sensors, are versatile tools for the measurement of various processes. These sensors use the piezoelectric effect, which measure changes in pressure, acceleration, temperature, strain or force by converting them to an electrical charge. A vibration sensor can also be used to determine aromas in the air by simultaneously measuring resonance and capacitance. Here it is used to detect impact of the vehicle and thus trigger all the other sensors and modules to do its functioning. Accident can be detected using fluctuations in the Vibration sensor reading.

7.4 Pulse Sensor

The working of the Pulse/Heart beat sensor is very simple. The sensor has two sides, on one side the LED is placed along with an ambient light sensor and on the other side we have some circuitry. This circuitry is responsible for the amplification and noise cancellation work. The LED on the front side of the sensor is placed over a vein in our human body. This can either be your Finger tip or you ear tips, but it should be placed directly on top of a vein.

Now the LED emits light which will fall on the vein directly. The veins will have blood flow inside them only when the heart is pumping, so if we monitor the flow of blood we can monitor the heart beats as well. If the flow of blood is detected then the ambient light sensor will pick up more light since they will be reflected by the blood, this minor change in received light is analysed over time to determine our heart beats.

7.5 GSM Module

GSM module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer. GSM MODEM is a class of wireless MODEM devices that are designed for communication of a computer

with the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Here, the number of an emergency center is given in the GSM Module.

7.6 RF Modules

The RF module, as the name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK).

Transmission through RF is better than IR (infrared) because of many reasons. Firstly, signals through RF can travel through larger distances making it suitable for long range applications. Also, while IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter & receiver. Next, RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources.

This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

The RF module is often used alongwith a pair of encoder/ decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs.

7.7 Encoder and Decoder

HT12E is an encoder integrated circuit of 212 series of encoders. They are paired with 212 series of decoders for use in remote control system applications. It is mainly used in interfacing RF and infrared circuits. The chosen pair of encoder/decoder should have same number of addresses and data format.

Figure 7.2: HT12E - Encoder IC

Simply put, HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits.

HT12E has a transmission enable pin which is active low. When a trigger signal is received on TE pin, the programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium. HT12E begins a 4-word transmission cycle upon receipt of a transmission enable. This cycle is repeated as long as TE is kept low. As soon as TE returns to high, the encoder output completes its final cycle and then stops.

Figure 7.3: HT12D - Decoder IC

HT12D is a decoder integrated circuit that belongs to 212 series of decoders. This series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. They are paired with 212 series of encoders. The chosen pair of encoder/decoder should have same number of addresses and data format.

In simple terms, HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by, say, an RF receiver, into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously. The input data code is decoded when no error or unmatched codes are found. A valid transmission in indicated by a high signal at VT pin.

HT12D is capable of decoding 12 bits, of which 8 are address bits and 4 are data bits. The data on 4 bit latch type output pins remain unchanged until new is received.

8. RESULTS AND INFERENCES

A system for emergency rescue and dispatch with efficient traffic control when road accident occurs was proposed, designed and made. The literature review for similar technologies that are being currently researched by the Vehicle Safety Commission was studied. Project smart vehicle and emergency rescue dispatch with efficient traffic control system was completely designed and demonstrated. Data was stored and messages for emergency medical services were successfully sent to the predefined mobile phone number.

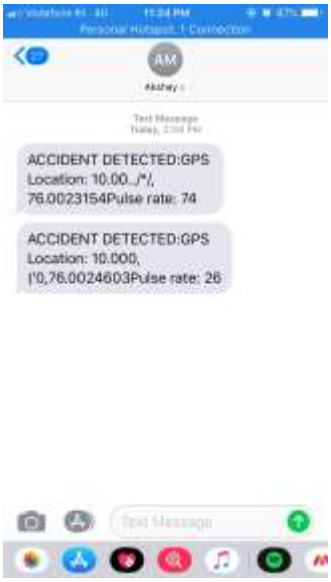

Figure 8.1: Message Displayed on the Phone

8.1 ADVANTAGES

1. The system is easy to design and implement.

2. Power consumption is low.

3. The system-user interface is easy and without complications.

4. The system has very fast response time with messages being sent within seconds of collision detection.

8.2 DISADVANTAGES

1. GPS signal reception depends on location.

2. Difficult to bring effect in certain traffic conditions in India.

3. GSM Signal Strength fluctuations in various locations.

4. RF Interference should not affect data.

9. CONCLUSION

Smart vehicle and emergency rescue dispatch system has been developed with the aim to make road transportation accident free. The objective of this project was to develop a system that can provide emergency rescue and analyze the reason behind the accident. For this various sensors have been incorporated with ATmea32 IC. Whenever a collision is detected a message will be sent to rescue team with the location of the vehicle. We believe that this system can be implemented in any vehicle of the current day and age, and hence can help provide assistance to those in need without any delay. However there is still a great deal of work and several significant problems that must be overcome before such a system can completely rid the world of vehicular accidents. Yet we strongly believe that we have made a relevant step in order to achieve this future.

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