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A Mobile Communicative Prototype for Fatal Rate Reduction in Vehicle Accident: Development and Analysis

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Abstract: After 1970, road accidents were increased suddenly, mainly due to the increase in the number of vehicles on the road. The 11% of the world's accidents are happening in India, so we need to think more towards reducing the accidents and reducing the number of deaths for which the Mobile Communicative Prototype can play the important role. A survey on 100 peoples is carried out for checking the awareness and rating of the automobile safety devices. Mobile Communicative Prototype is designed and developed in the project lab and experimentally investigated the responses. Only after a few seconds of accident, the alert system delivered the message of the accident to the emergency number, so that the people injured in the accident can get medical help immediately. The cost of the retrofitting is approximately 100USD, which is very low 1-2% of the cost of the vehicle. It is also stated that the energy consumption of the retrofit is very low. This can also help in reducing the speed of vehicles.

Keywords: GSM, GPS, ESP, Mobile Communicative Prototype etc.

INTRODUCTION

The India contribute 11% fatal of global fatal accidents it means approximately 1.5 lakh peoples annually have been dead in Road accident in India. The road accident data from 2014 to 2020 are shown in table 1 (Ministry of Road Transport and Highways, 2018). It is observed that the accident rate is decreasing from 2015 to 2020 gradually but it is significantly decreasing in 2020 may be due to Lockdown of Covid-20. But the accidental death rate is normalizing to 1.5 lakh other than the Covid-20 period. The major reason of road accident is the higher speed of vehicle but the fatal cases may recover from timely providing the medical assistance. If the message of accident may reached within a short period to the emergency then medical assistance will provide to the injured peoples, in this criteria an Mobile Communicative Prototype will provide an important role to send the message within the seconds of accident.

Table 1. Scenario of Road Accident in India (Ministry of Road Transport and Highways, 2018)

Year	Total Accident	Death	Injured
2010	499628	119558	380070
2011	497686	121618	376068
2012	490000	138000	352000
2013	486000	138000	348000
2014	489400	139671	349729
2015	501423	146133	355290
2016	480652	150785	329867
2017	464910	147913	316997
2018	467044	151417	315627
2019	449002	151113	297889
2020	366138	131714	234424

Vangi *et al.* (2020) studied the coherence assessment of accident database kinematic data and observed that the maximum accidents occurred due high speed only and somewhere it is occurred due to the mistake of driver. The accidents is just like a collision and it can be mitigated by the collision detection mechanism using multi-layer laser scanner (Lee *et al.*, 2019).

The adaptive intervention logic for automated driving systems based on injury risk minimization have been designed by Vangi *et al.* (2020). Tan *et al.* (2021) studied the Evidence for the crash avoidance effectiveness of intelligent and connected vehicle technologies. The various studies have been carried out their studies based on the evidence, prediction, real-time crash detection, strategic control, algorithm development (Trigger algorithm), Global Positioning System (GPS) and Global System for Mobile communication (GSM) (Nishimoto *et al.*, 2019; Sharma *et al.*, 2016; Ge *et al.*, 2011; Wang *et al.*, 2021; Xiao *et al.*, 2016; Jia, 2015; Agrawal *et al.*, 2013; & Chaturvedi & Srivastava, 2018).

Vehicle accident detection system have been designed based on IoT and developed live tracking by using geo-coordinates by some researchers (Panwar, 2020; & Raut & Sachdev, 2014). Patel (2013) developed a smart accidental kit by Utilizing the Emergence of Android Smartphones for Public Welfare by Providing Advance Accident Detection and Remedy by 108 Ambulances. This type of system was developed at laboratory scale by some researchers (Shanthi *et al.*, 2018; Wakure *et al.*, 2014; Prasad & Aswani, 2012; Rajkiran & Anusha, 2014; Prabha *et al.*, 2014; & Kapri *et al.*, 2020). The type and selection of motor used in this type of laboratory scale systems have been studied and presented by researchers (Wikipedia, n.d.A). The application of GSM, Accelerometer, and GPS system in the vehicle Mobile Communicative Prototype can be understood from (Wikipedia, n.d.B; Wikipedia, n.d.C; Wikipedia, n.d.D; & Wikipedia, n.d.E).

The vehicle alert system is developed by various researchers and nobody has given the accidental time data or for which accuracy level their system was worked. This communication is presenting the design and development of vehicle Mobile Communicative Prototype with the time take in the messaging. It will also recommend that, how researchers can reduces the time interval of messaging. By this technology the vehicle accident can be reduced up to some extent.

MATERIAL AND METHODS

The vehicle Mobile Communicative Prototype is developed under the project in the department of mechanical engineering, Rajasthan technical University Kota, India in the month of March to May 2022. The system is programmed in the laboratory in the Arduino Programming language. This is hardware based programming and Python may also use because Python is a very good fit for use in conjunction with Arduino. The goal of the project firstly is to detect accidents and alert the rescue team in time and secondly the gap between the existing systems in place and the ideal system is that automated system is used once the accident occurs which can give latitude and longitude of accident occurred area without delay. More Human life can be saved using this system.

Survey on Vehicle Accident Alert System

A survey on the safety devices was carried out during the project and observed that highest number of peoples aware about the seat belt, head light, central locking and wheels & Tyres wherever lowest knowledge of Mobile Communicative Prototype and GPS system. The lowest knowledge of the safety devices is responsible for the higher accidents. The survey was carried out on 100 peoples in the Kota city of India and it is graphically represented in Figure 1.

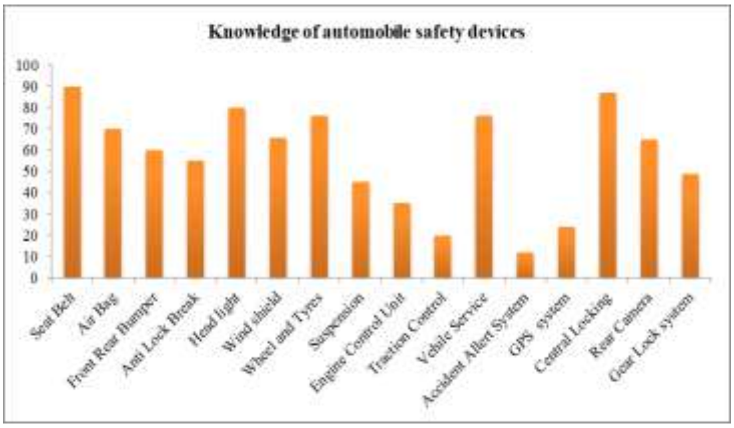

Figure 1: Survey for knowledge of automobile safety devices

The figure 2 shown the rating of the safety devices before and after the 1 hour training of 100 peoples. It indicates that the peoples rated the highest 4.5 and 4.2for seat belt and vehicle service respectively. After the training peoples have rated highest 5.0 for seat belt, accident alert system, GPS system, wind shield and wheel and tyres, it means safety devices training is required at the time of issuing the driving license or at the time of vehicle purchasing.

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Figure 2: Rating of automobiles safety devices before and after training of 100 persons

Hardware and Software Required

The hardware and software are required to develop the project is given in table 2 as follows:

Table 2. Hardware and Software Required Developing Accidental Alert System

Sl. No.	Name of Hardware	Qty.	Sl. No.	Name of Software	Qty.
1	ESP 32	1		Arduino IDE PRR	
2	12V DC motor	1		Fritzing Simulation	
3	Sim 900A GSM module	1		Fusion 360	
4	Neo 6m GPS module	1	Whereas 12V DC motor, 3 inch wheels, are not the part of vehicle alert system and these part are using to develop a model of car for experimental purpose.		
5	MPU6050 accelerometer and gyroscope sensor	1			
6	Breadboard	1			
7	Jumper wires	1			
8	6v 1500 mAH rechargeable batteries	1			
9	12v MPPT solar charger module	1			
10	Piezo shock sensor	1			
11	3 inch wheels	4			

Working of the System

The figure 3 is shown the working of vehicle alert system. The accelerometer and gyroscopic modules are the accident detection or input devices, by these sensors accidents of the car/ automobile is detected. The MPU6050 is a Micro Electro-Mechanical Systems (MEMS) which consists of a 3-axis Accelerometer as shown in figure 4(c) and 3-axis Gyroscope inside it which is shown in figure 4(a). This helps us to measure acceleration, velocity, orientation, displacement and many other motion related parameter of a system or object. It will detect any change in the velocity, orientation by just changing the force into the potential difference. Like if we gave an shock to the MPU 6050 it will detect the intensity and the change in orientation. The input data is to be processed in the processing control volume which consists with the GPS module, ESP32 microcontroller and abort/ cancel button as shown in Figure 3. GPS is global positioning system which is shown in figure 4(b). By using GPS, we can always obtain position and time information anywhere in the world. GPS works on trilateration technique. It is used to collect information about elevation, velocity and locations. To get output (information of location), trilateration collects signal from satellites. This signal is sent by orbiting satellites around earth. Then, with the help of these signals GPS device reads and interprets the position. ESP32 is shown in 4(e) is a compact integrated circuit designed which includes a processor, memory and input/output on a single chip. The company which manufactures ESP 32 is Espress if Systems a Shanghai- based Chinese company. It receives data from its input output peripheral and interprets this data. This data stores in data memory where the processor accesses it. Then, microcontroller uses the instruction which is stored in program memory. Then microcontroller uses the data which is received from input and output peripheral and enacts the approximate actions.

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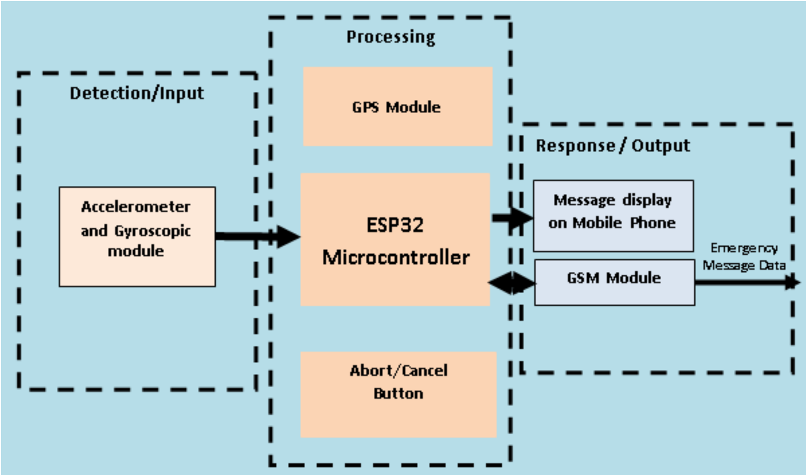
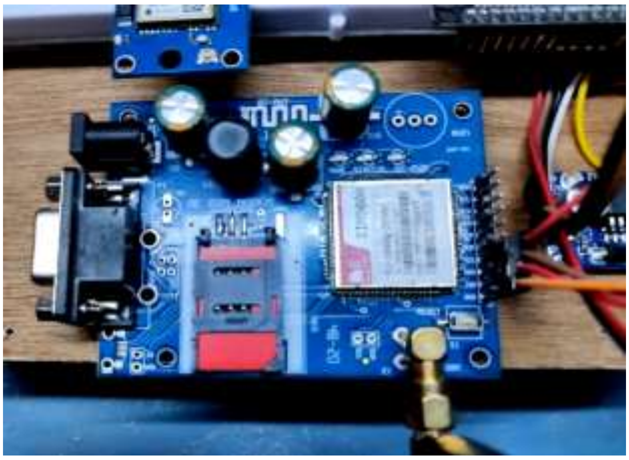


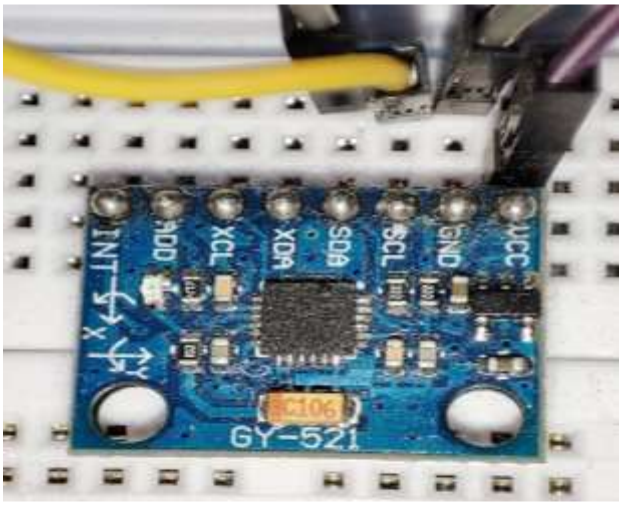
Figure 3: Working of Vehicle alert system

The third control volume in figure 3 indicates the Response/output which includes the GSM module and mobile display system on mobiles. LM 2596 is a voltage converter which converts the voltage from low value to high value as shown in figure 4(d). In the given image the N+ and N- shows the connections where the low voltage connection to be made and the OUT+ and OUT- are the connections from which high voltage will be passed. GSM Module is used to communicate between a computing system and GPRS system. GSM Module is powered by a power supply circuit. The module offers GPRS/GSM technology for communication with the uses of a mobile sim. It uses a 900 and 1800MHz frequency band and allows users to receive/send mobile calls and SMS.

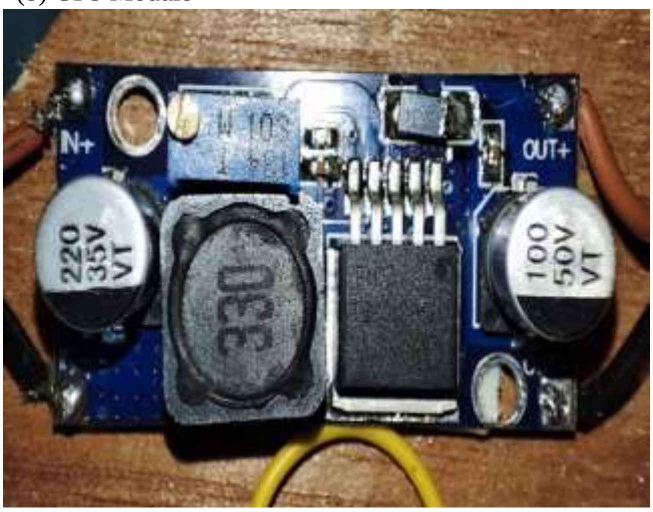


(a) GSM Module

(b) GPS Module



(a) Accelerometer



(b) step-up voltage converter

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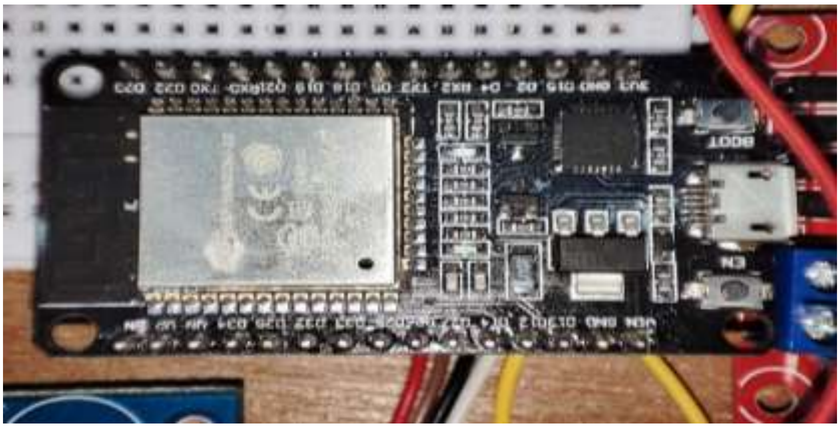

(e) ESP 32

Figure 4: Hardware Panels used in Vehicle Mobile Communicative Prototype

The integrated Connections of the Detection / input system, processing unit and output/display system have been completed and the connection configuration is shown in Table 3.

Table 3. Input Output Pins for designed connections

GSM MODULE			**Accelerometer**		
Pin No	**Input Pin**	**Output pin**	**Pin No**	**Input Pin**	**Output Pin**
1	Rx	D2 (ESP32)	1	VCC	3 VC (ESP32)
2	Tx	D4 (ESP32)	2	SCL	D22 (ESP32)
3	Vcc	GPS	3	SDA	D21 (ESP32)
4	Vcc	Charging Module			
5	Gnd	Switch			
	GPS		**Step-up voltage converter**		
Pin No	**Input Pin**	**Output Pin**	**Pin No**	**Input Pin**	**Output Pin**
1	GND	ESP GND	1	N-	B- (charging module)
2	GND	Accelerometer GND	2	N+	B+ (charging module)
3	Tx	Rx2 (ESP32)	3	Out-	GND (motor driver)
4	VCC	VIN (ESP32)	4	Out+	12v (motor driver)
			ESP32		
Pin No	**Input Pin**	**Output pin**	**Pin No**	**Input Pin**	**Output pin**
1	GPI012	N4 (motor driver)	4	D26	N1 (motor driver)
2	GPI014	N3 (motor driver)	5	GND	Switch
3	D27	N2 (motor driver)			

CAD Modeling of the Prototype

The CAD model of Car/automobile is develop by Sunil Yadav under this project which is shown in figure 5 with dimensions and the design is first tested under impact/crushing load in the mechanics software after that it was manufactured in the laboratory.

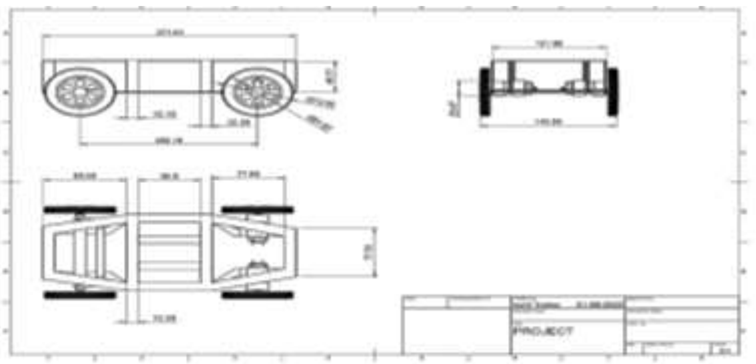

Figure 5: CAD model of the Prototype

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Design of Code and Code Testing

The code is developed in the laboratory and after completion of code it is required to simulate the code in the Fritzing simulation kit which is shown in figure 6.

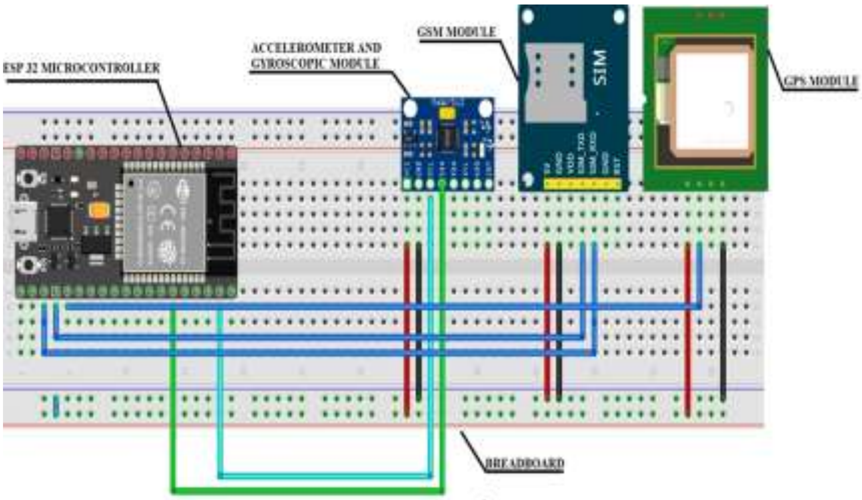

Figure 6: Fritzing simulation Kit

ESP32 is capable of functioning reliably in industrial environments, with an operating temperature ranging from –40°C to +125°C. Powered by advanced calibration circuitries, ESP32 can dynamically remove external circuit imperfections and adapt to changes in external conditions. A simulation prototype including ESP 32 Microcontroller, Accelerometer and Gyroscopic Module, GSM Module and GPS Module on simulation software called Fritzing Kit, in which we will code the program and also simulate the code in it. After the correct compilation of the code is done then we will insert the code in the real ESP 32 Microcontroller. When the Prototype meets with an Accident it will get a shock, and MPU- 6050 will identify the intensity of the shock and then it will send information to the ESP then the ESP will request the location of the accident point from the GPS Module. After getting the location from GPS, ESP will send this data to GSM Module and then the GSM module will send a default message which will contain the location, speed of the vehicle and the time of accident.

RESULT AND DISCUSSION

The prototype of Mobile Communicative Prototype is presented here can be used as alert and information sending to the emergence number. When the accident occurs, the vibration sensor would be activated and transfer the message for which GPS system finds the location of accident and GSM incorporate to send the messages. This type of system can be applied in the mobile network available areas. The figure 7 presented the complete prototype of accidental alert system. The all components (other than vehicle prototype) would be used in automobiles as per the required configuration.

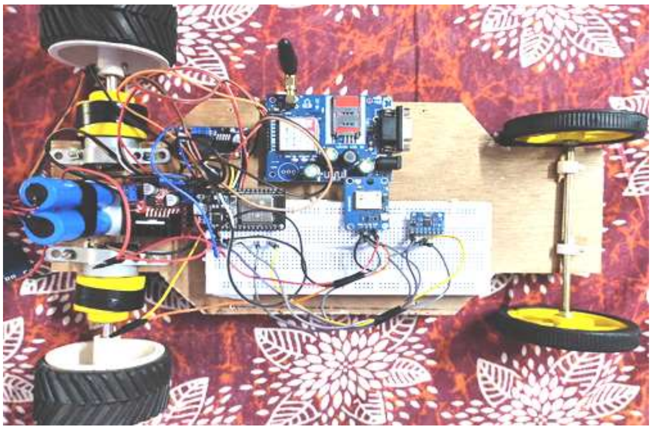

Figure 7: Prototype

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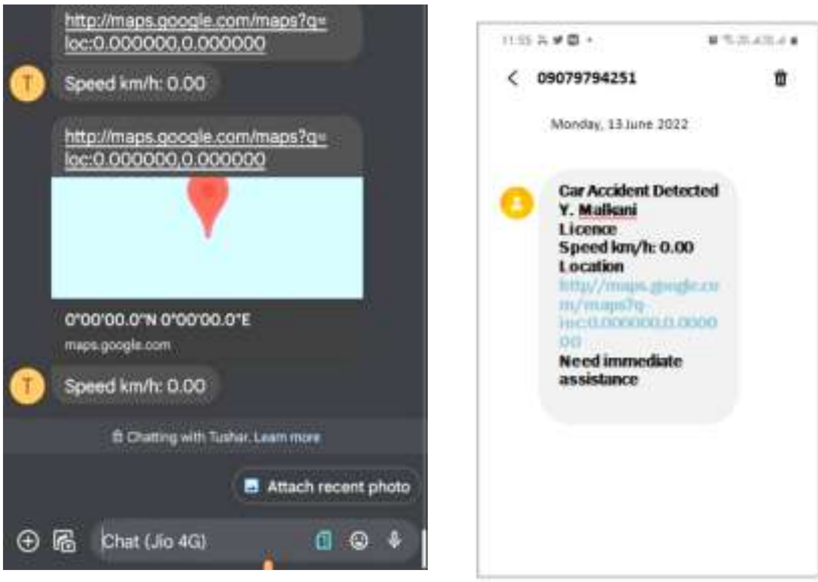

(a) Original designed message (b) Modified the Design of Response

Figure 8: Received alert message

The accident detection and reporting system was tested after implementation. The system sends the information to the emergency numbers which consist with the GPS position and time as well as the speed of vehicle at the time of accident. The GPS location integrated with Google maps helps to find out the exact location of the accident and possible help can be reached as soon as possible. Figure 8 depicts the display of the alert message. This information is received by the emergency contacts number through the mobile. By the help of this message the immediate assistance can be given to the rider/passengers with the immediate medical aid. The prototype of vehicle alert system is tested in three conditions such as: in the covered garage or hidden place, under the shadow of big tree or obstacle between sun and car, and on the high way at various speeds which are received in the message.

Table 4. Reaction Time of Designed Vehicle Accident Alarm System

S. No.	**Speed at the time of Accident**		**GPS Location Code**	**Time Taken**
Automobile/Car in the Mechanical Engineering Lab at RTU Kota				
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.143068, 75.803925	6.90
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.143050, 75.803877	6.90
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.143056, 75.803886	6.85
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.143062, 75.803898	6.88
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.143077, 75.803942	6.87
Automobile/Car in the in the Shadow of a Big Tree				
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.142936, 75.803848	4.50
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.142929, 75.803856	4.55
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.142916, 75.803873	4.55
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.142993, 75.803768	4.50
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.142910, 75.803877	4.49
Automobile/Car in the on the National Highway No. 76 near Nayagaon Kota				
	3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.123780, 75.801405	3.11

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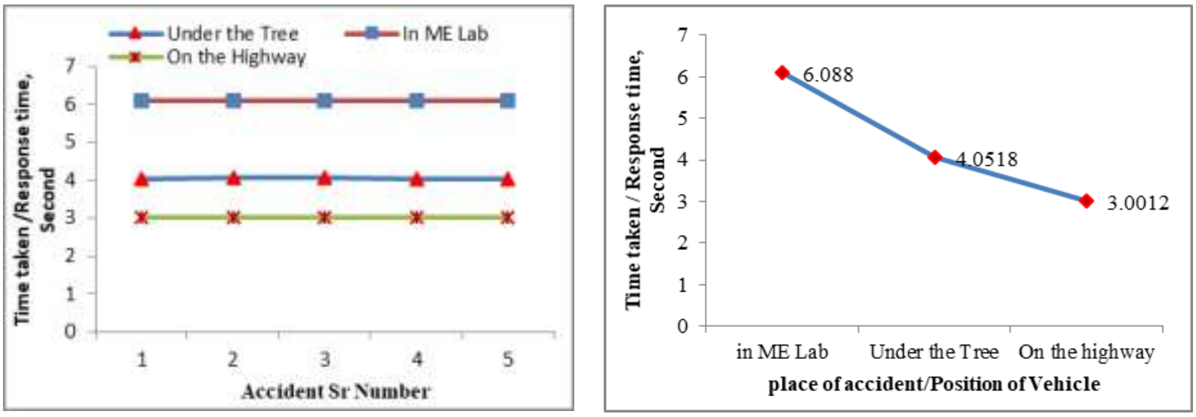
3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.123652, 75.801603	3.12
3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.123622, 75.801655	3.12
3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.123572, 75.801739	3.13
3 m/s	10.8 km/h	http//maps.google.com/maps?q-ioc: 25.123524, 75.801786	3.12

The experiment of the system was carried out on 13th June 2022 between 11AM to 2 PM and the response time and GPS message with the location of accidents is presented in table 4. The response time of the accident according to the number of accident and place is shown in figure 9 (a, b). It is observed that the time response is less than 10 second in all three criteria's such as: in the lab or covered area, under the tree and on the highway. The response time of message is measured at the time of accident and found that the minimum time taken at highway where proper signal of mobile is to observed and highest time taken in the ME lab where mobile signal is weak. It means the system is working efficiently in the proper availability of mobile and GPS signal. This time is to sense the accident and response integrated with GPS & Google map and after that it sends to the emergence number. The energy supplied to the system by three chargeable cells (1.5x3 V) of 4.5 V total. It is also observed that the accident can be reduced or fatal cases can be reduced by consumption of very small energy consumption. As considering the economic viability of the system is that the cost of the retrofit is very low appximately100USD. The cost is very small as compared to the cost of the Car/Vehicle and the cost of a human being.



(a) Time Taken in Accident (b) Time taken in Response According to the Place

Figure 9: Response time of the Accident according to the number of accident and place

CONCLUSIONS

The study is concluded that the Mobile Communicative Prototype must be fitted to the every vehicle either two wheeler to the cars and trucks etc. to reduce the fatal rate caused by road accident. The annual fatal rate and total accidents are presented introductory and observed that the lowest fatal rate Covid-20 year from consecutive years. The response time of the system is very low in seconds and it can be successfully used in the automobile and it is only way to reduce the accidental deaths. The retrofitting cost is very low approximately 100 USD and the energy consumption is very low. It is a viable option to reduce the fatal rate of the globe which is occurred due to the vehicle accidents.

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