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DEVELOPMENT OF A PROTOTYPE FOR VEHICLE ACCIDENT AVOIDANCE, DETECTION AND RESCUE ALERTING SYSTEM

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***Abstract* — The growing demand for automobiles has resulted in an increase in traffic congestion and accidents. Traffic-related deaths in cities are on the rise due to a range of circumstances. By giving timely medical care, these death rates can be considerably lowered. As the ambulance takes longer to reach at the accident scene and hospital, the victim's odds of dying increase. To address this issue, an intelligent automatic ambulance rescue system based on Machine Learning can be utilized to reduce fatalities caused by accidents, either by preventing or detecting and reporting them. If an accident occurs for whatever cause, such as the driver being intoxicated and falling asleep unexpectedly, this embedded system will be able to send a spontaneous message to the police, ambulance, or rescue team to assist the victims. Sensors such as a vibrating sensor, an ultrasonic sensor, and a camera are used to create such a system. All of the devices are connected to the Jetson nano board, which allows for data analysis utilizing machine learning and deep neural networks, as well as parallel processing and edge computing.**

***Keywords*—Jetson Nano, ML, Sensors, Rescue system, Accident analysis, edge computing, parallel processing.**

I. INTRODUCTION

As a result of the high demand for vehicles, traffic congestion and road accidents have increased. The lives of people are at tremendous danger.

Our system includes a collision mitigation and accident detection system, as well as an autonomous automotive accident alert system.

The suggested system can prevent an accident by automatic steering control, recognize automotive accidents in a quarter of the time, and transmit information to the rescue team in seconds, including geographic locations, time, and the accident's impact on passengers.

A unique method of tracking the location of the nearest hotspot to which the system connects is used to determine the geographic location of the incident. In the unlikely event that there are no casualties, a switch is provided to prevent the message from being sent, sparing the rescue crew important time. The vibration sensor is capable of detecting the accident with pinpoint accuracy. In the event of a vehicle accident, this approach offers the greatest possible solution to poor emergency services. The components used in the proposed system's design are discussed in the sections below.

One method to combat accidents is to create self-driving cars, implement neural networks, and deploy them on the Jetson Nano. Messaging System for Vehicle Tracking and accident detection can optimize power consumption by eliminating unnecessary usage and one drawback of this is it does not support dynamic user interface.

The core objectives of this system are:

A. To create an accident mitigation system that will prevent collisions with obstacles and accidents.
B. To design an accident detection system
C. To design a rescue system that includes tracking of real time location of the vehicle and alerting the ambulance or rescue team to avoid the delay in medical assistance.
D. To integrate all the above systems in an efficient way to build our final prototype.

Our motivation is the outcome of this project that would be safety. Safety refers to protecting human's life and health in the first place and protecting other resources such as property, etc. in the second place. Our designed robot uses motor drivers and power supply and an RF module for wireless operation, the collision mitigation system was designed using three ultrasonic sensors for better accuracy and efficient results.

II. LITRETURE SURVEY

The paper "Automatic Messaging System for Vehicle Tracking and Accident Detection" uses an accelerometer to identify the accident and uses GSM, GPS modules to alter

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hospitals which are interfaced using an Arduino UNO. The accident is detected when there is change in the orientation of the vehicle such as the accelerometer. But the point where the project lacks is that it neither supports a user-friendly interface nor implements the feature of collision prevention. Contrary to this, our project performs accident detection using vibration sensors as the impact of vibration during an accident stands different from other vibrations of a vehicle, thus accurate detection is possible. The main board that coordinates all the functions in the project is the Jetson nano board along with the NodeMCU which was used to implement a unique way of communication.

The paper "Accident Alert and Tracking using Arduino" uses a vibration sensor module to identify the accidents. Furthermore, the system proposed in this paper utilizes the GPS and GSM modules to track the location and send an alert message to the rescue team. The research gap is that the loss of signal may lead to loss of life. This is a basic alert system without any advanced features like accident scene analysis.

The paper "Mobile Application for Automatic Accident Detection and Multimodal Alert" provides the user with a user interface on a smartphone. The smartphone data and the incoming data are used to determine the safety and traffic coming in the user's journey. It also includes the feature of utilizing the sensors within the smartphone of the user and also the OBD feature (On-Board Diagnosing) of the automobiles to detect the accidents. If the user forgets the phone, this system's efficiency seems to be reduced. Moreover, the phone gets damaged or the signal is unstable, it can be a problem in the operation of this system. The drawback of this project is overcome by installing the detection system inside the vehicle so that there is no risk for the user even if he forgets the smartphone.

The paper "Autonomous Vehicle Control Using a Deep Neural Network and Jetson Nano" provides insights about designing self-driving cars using Jetson Nano board. The system mentioned in this paper deployed a Machine Learning model and deep neural networks for its design. This paper provided us with ample knowledge on Jetson nano boards. The concept of self-driving cars was implemented using ultrasonic sensors. These concepts were used to draw significant insights regarding interfacing of various sensors with the Jetson nano board.

The paper "Intelligent Collision Avoidance and Safety Warning System for Car Driving" implements collision avoidance systems using ultrasonic sensors. Location updates are implemented analogous to any other system mentioned in the literature survey which is through GPS and GSM modules. The system proposed in this paper detects objects, alerts the driver, stops the car in case he does not respond to the alert buzzer and finally stops when brakes are not applied when necessary. This entire system is designed in perspective to provide assistance to drivers. It is a basic system developed using Arduino and does not implement any exceptional features.

III. ARCHITECTURE AND THE PROPOSED SYSTEM

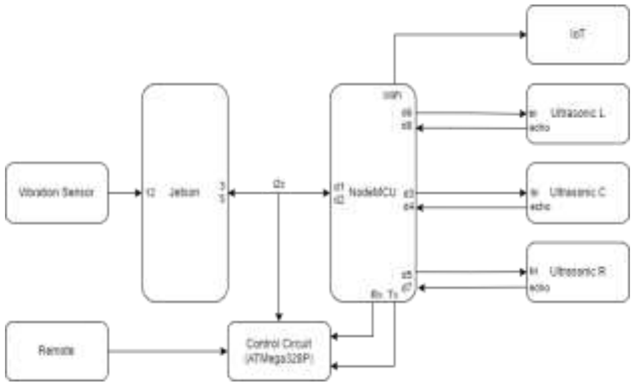

Figure 1 Architecture of proposed System

This architecture includes the design of various systems like accident mitigation system, accident detection system and rescue system whose integration constitutes the proposed system. The development board chosen was Jetson Nano.

IV. METHODOLOGY

A. ACCIDENT MITIGATION SYSTEM

The accident-avoidance system is being implemented using ultrasonic senor by performing proximity sensing. The term "proximity sensing" refers to the process of measuring the distance between a vehicle and an object. This distance can be used to predict whether or not a collision will occur. The conclusions reached are utilized to determine the threshold distance, which is employed to govern the vehicle's movements.

To expand the scope for estimating the risk of a collision, three ultrasonic sensors (HC SR04) were used in the development of this sub system. The operation of these sensors is depicted in the image below, with D1, D2, and D3 denoting ultrasonic sensors located in the vehicle's right, middle, and left foreparts, respectively, and 'th' denoting the sensors' threshold. When the D2 sensor detects an object, the prototype is unable to move ahead to avoid colliding with it; this restriction is maintained as long as the object is detected. The prototype can either go backwards or wait for the object to move out of the path before proceeding. When the D1 sensor identifies the thing on its own, the prototype makes a right turn to avoid the obstacle and continue on its way.

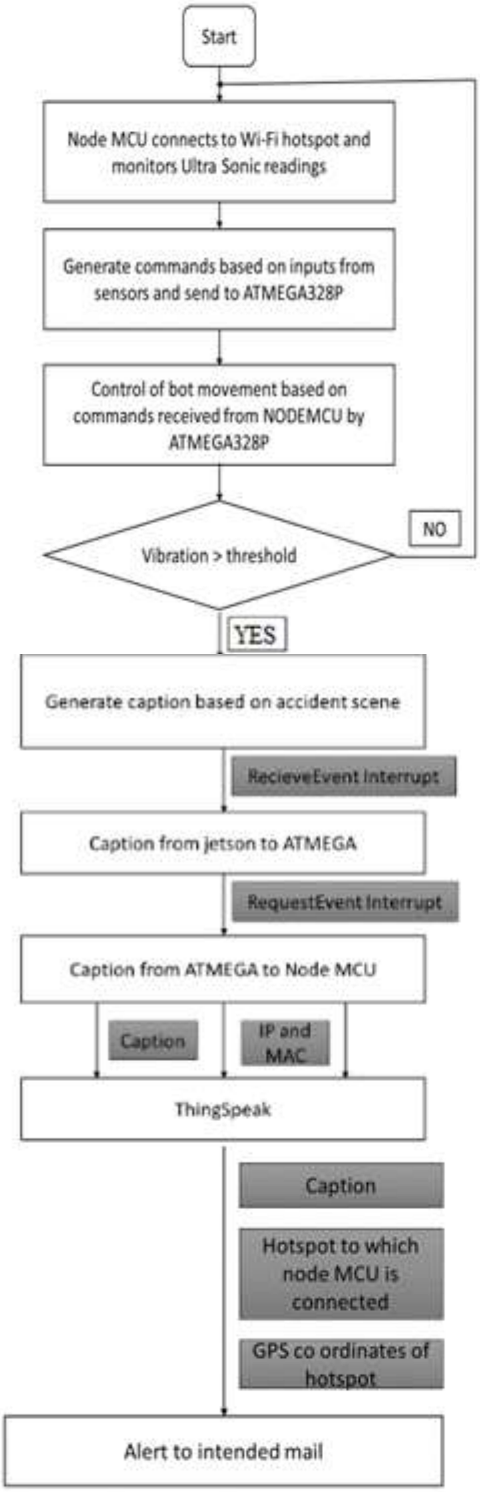

Figure 2 Flow Chart of complete system

Similarly, when the D3 sensor identifies an object on its own, the prototype makes a left turn to avoid it and continue on its own.

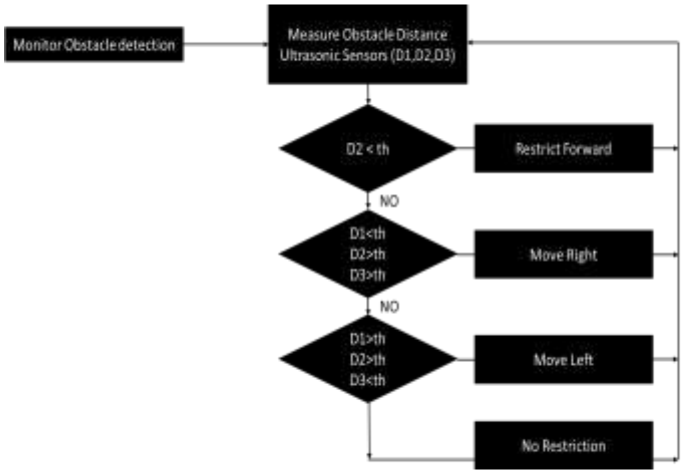

Figure 3 Collision Avoidance Block Diagram

B. ACCIDENT DETECTION

The sensor that is used for the accident detection is SW-420. It is a digital sensor with non-directional property and capability to sense a signal of range varying from 3.3V to 5V which is usually considered as high. There exists a potentiometer along with a comparator to set the threshold and to detect the vibrations that exceed the set threshold and provide a digital output, 1 or 0.

The comparator used in SW-420 is LM393. Initially, the output is high when the circuit is activated which indicates the stability of the module. Whenever the sensor is prone to any movement or vibration, the output is close to 0. According to the results, we can change the threshold using potentiometer along with the sensitivity to meet our specific requirements. On the board, two LEDs, each depicting power condition and the digital output from the sensor are available to ensure the correct functioning of the sensor module. The sensor will be powered by 5V in this project.

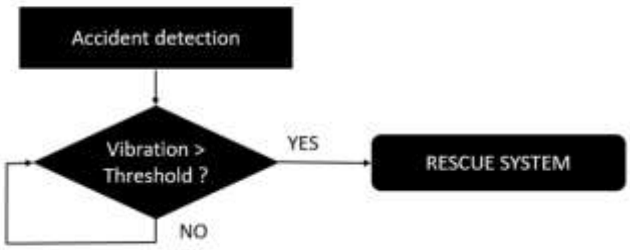

Figure 4 Accident Detection Block Diagram

C. Accident Scene Analysis

Accident scene analysis is performed in order to determine the severity of the victim's injuries. It also provides the count of injured people, which would be communicated to the rescue team so that necessary arrangements could be made. It also aids in identifying the cause of the event and its impact,

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prompting essential countermeasures to be made to avoid such accidents in the future.

This subsystem requires a camera for continuous monitoring of the passengers. The camera captures the entire scene in the vehicle after specified time in regular intervals that will be stored in the memory card. After a specific number of frames, the memory card would be cleared leaving place for further monitoring. This step is complicated yet necessary to acquire the count of passengers even if the camera is damaged during an accident.

The pictures thus obtained will run through an ML based system to generate a caption for the accident scene. This caption includes the count of passengers and their condition. The caption thus generated will be sent to the rescue team so that they can make necessary arrangements to save the victims.

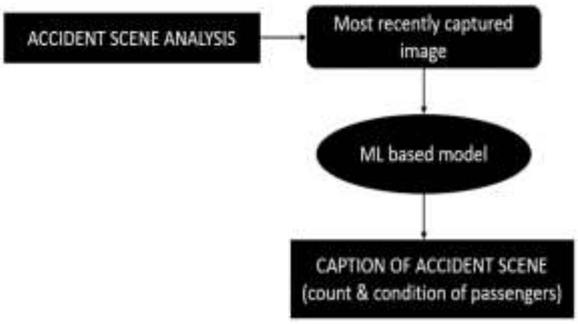

Figure 5 Accident Scene Analysis

D. RESCUE ALERTING SYSTEM

The term "location tracking" refers to the collecting of a vehicle's regional coordinates. This is done with the help of NodeMCU. The ESP8266 Wi-Fi module is used to connect the prototype to Wi-Fi, and the ESP8266WiFi.h module is used to connect it. This can be accomplished by placing hotspots in various locations and allowing the ESP8266 to connect to any of them. Using the ESP8266 Wi-Fi module of NodeMCU, the device thus connected to the hotspot can be used to retrieve the hotspot's MAC address. On ThingSpeak, all the MAC addresses that have been retrieved will be saved. When an accident occurs, the most recent MAC address is detected, and the hotspot's location can be determined using that information. This MAC address will be sent to the rescue crew as a message to assist the victims in their recovery.

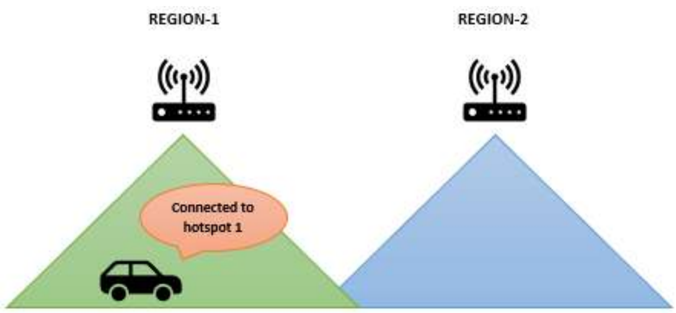

Figure 6 Prototype connected to Hotspot 1 in region 1

V. RESULTS AND OUTPUTS

Figure 7 Prototype of proposed system

A. Collision Avoidance system:

For greater precision and efficiency, the collision mitigation system was created using three ultrasonic sensors, as previously mentioned. For wireless operation, the bot was built with motor drivers, a power source, and an RF module. We run the prototype along a path while adjusting the position of the obstacles to test its collision avoidance functionality. The position of the obstacles for testing is depicted in Figure 8, and the reaction of the collision mitigation system is described in Table 1.

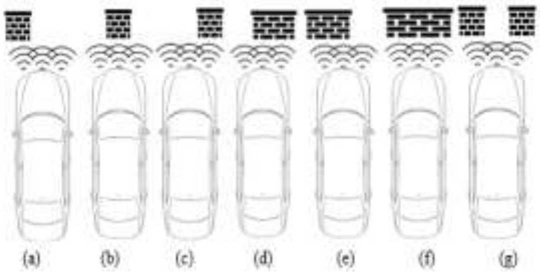

Figure 8 Position of obstacle

Table 1 Output/ Response when tested

Position of Obstacle	**Output/ Response**
Fig 8 (a)	Avoid Left Obstacle and Take Right Turn
Fig 8 (b)	Restrict Forward Motion
Fig 8 (c)	Avoid Right Obstacle and Take Left Turn
Fig 8 (d)	Restrict Forward Motion
Fig 8 (e)	Restrict Forward Motion
Fig 8 (f)	Restrict Forward Motion
Fig 8 (g)	Restrict Forward Motion

B. Accident Detection and Rescue System:

A vibration sensor was deployed to identify if an accident had occurred or not. When the vibration exceeds a threshold value, which was set to 100, the Jetson nano categorizes it as an accident. After the accident has been detected, the program to generate the caption for the accident scene.

To test the system first we disconnect the collision mitigation system from the prototype by disconnecting the trigger signal coming from the microcontroller to the ultrasonic sensors. Then we crash the prototype against a wall. This triggers the accident detection system and activates protocols post-accident such as accident scene analysis, location identification and alerting systems.

In the following Figure 9 depicts the output screenshot from the Jetson Nano that include accident detection, caption generation and caption delivery to the NodeMCU through i2c communication. It is displayed that the bot has started, and the vibration detection has been invoked.

The image also depicts the readings of the vibration sensor and a string "Accident Detected" which depicts that the reading of the vibration sensor has crossed the threshold set. After the detection of an accident, the program for accident scene analysis has been invoked and the caption has been generated. The generated caption will be sent to the NodeMCU through i2c after which the string "uploaded" is printed to confirm this action.

Figure 9 Jetson Nano output after Accident detection

Figure 10 depicts the data uploaded to ThingSpeak. In the image, field 1 represents the MAC address and field 2 represents the cation generated when accident has occurred.

A	B	C	D
created_at	entry_id	field1	field2
2022-06-19 21:56:19 UTC	126	E2:5C:90:87:70:9F	
2022-06-19 21:56:49 UTC	127	E2:5C:90:87:70:9F	
2022-06-19 21:57:16 UTC	128	E2:5C:90:87:70:9F	
2022-06-19 21:57:37 UTC	129	E2:5C:90:87:70:9F	
2022-06-19 21:57:53 UTC	130	E2:5C:90:87:70:9F	
2022-06-19 21:58:15 UTC	131	E2:5C:90:87:70:9F	
2022-06-19 21:58:49 UTC	132	E2:5C:90:87:70:9F	
2022-06-19 21:59:15 UTC	133	E2:5C:90:87:70:9F	
2022-06-19 21:59:43 UTC	134	E2:5C:90:87:70:9F	
2022-06-19 22:00:09 UTC	135	E2:5C:90:87:70:9F	
2022-06-19 22:00:33 UTC	136		1woman driving the car is injuri

Figure 10 Update of MAC address & Caption on ThingSpeak

The Figure 11 is the Matlab visualization in ThingSpeak that depicts Region, Coordinates, and the time at which upload has occurred.

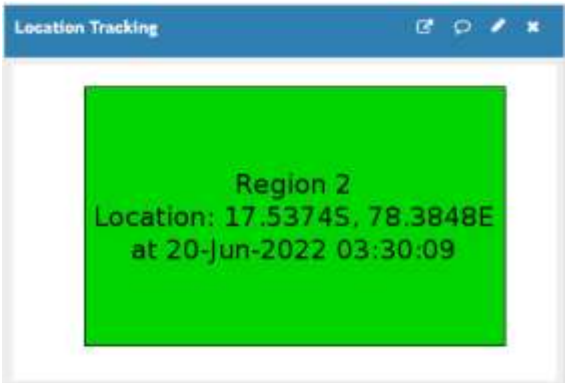

Figure 11 ThingSpeak Visualizations - 1

The Figure 12 depicts the alternate case if the NodeMCU is not connected to any router. In that case, the region was claimed to be Unknown region. But the image depicts the region and GPS coordinates of the router to which the NodeMCU was last connected along with the date and time of the connection.

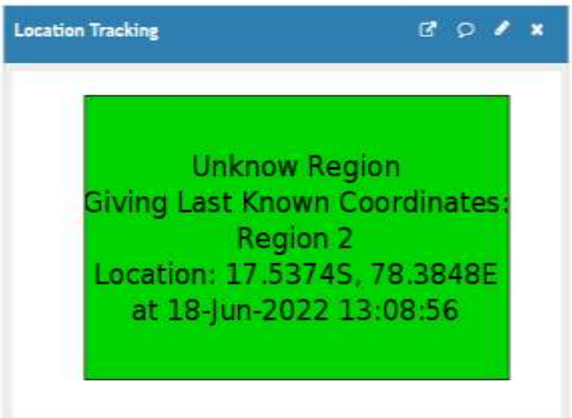

Figure 12 ThingSpeak Visualizations - 2

Figure 13 Alert Mails from ThingSpeak - 1

Figure 14 Alert Mails from ThingSpeak – 2

The Figures 13 and 14 depict the mail sent to the rescue team by the ThingSpeak platform for the above Figures 10 and 11. They represent the Alerting system developed using the data uploaded to ThingSpeak.

C. Accident scene Analysis:

The dataset (accident scene images of people being injured in a car) for accident scene analysis was acquired from multiple internet sources and tested against the machine learning model, which provided the following results.

Below Figure 15 represents the caption generated for the respective accident images.

Figure 15 Captions Generated for different images

The table 2 represent the maximum time delay taken by each sub system to perform their task.

Table 2 Performance Analysis

Event	Max Time Delay(sec)
NodeMCU Setup Time	0.106
Caption Setup Time	115.1876(100-150)
Caption Generation Time	2.962
I2C from Jetson to ATMEGA328P	0.0041
I2C from ATMEGA328P to NodeMCU	0.0056
NodeMCU to ThingSpeak	0.868
ThingSpeak to Mail	0.08
Successive Ultrasonic Readings	0.090
Successive Location uploads onto ThingSpeak	18

VI. CONCLUTION AND FUTURE SCOPE

It is clear that the accident avoidance and accident detection systems in a single system prove to be an effective way to save the victims of accidents. The additional features of this project like accident scene analysis and unique way of communication between two devices justify the novelty of the system. Thus, it can be concluded that the system proposed in this report is a novel design for effective accident prevention and detection along with an alerting system to inform the rescue team regarding the accident and related information. The proposed system is considered to be a novel design because:

→ The prominent hardware component used was a Jetson nano board whose capabilities are well explored and utilized appropriately to get effective results demonstrated in terms of time taken by the system to act on detection of an accident.

→ The communication system proposed in this system was chosen to overcome the drawback of utilizing GPS and GSM which would not work in the absence of proper signal.

→ The proposed system prototype was able to communicate the count of victims along with their condition to the rescue team to ease the process of saving them.

→ The results demonstrated depict the performance analysis of the individual subsystems of which the edge computing capability of jetson has been perceived.

Therefore, this novel system has been tested and proved to yield effective and adequate results.

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