National Institute of Technology Kurukshetra

BTech IoT Programming

Project Report

On

Safety and Accident Prevention System Using Multi-Sensor Integration

by

Group Leader:

Mohak Mittal (123102133)

Email-123102133@nitkkr.ac.in

Phone No-7017177659

Other Team Members:

Sanskar Kansal (123102134)
123102134@nitkkr.ac.in
Phone No-9755894106

Yash Gupta (123102135)
123102135@nitkkr.ac.in
Phone No-9034796750

Divya Dahiya (123102136)
123102136@nitkkr.ac.in
Phone No-7206307295

Vineet Kumar (123102129)
123102129@nitkkr.ac.in
Phone No-7892010546

Supporting Member :

Venkatesh Shukla (123108030)
123108030@nitkkr.ac.in
Phone No-9305795705

Branch: CS B(08)

Subject: IoT Programming (CSPC 209)

Abstract

With the increasing number of road accidents over the past decades, which continue to rise at an alarming rate, a significant portion of global GDP approximately 3 to 5 percent is lost due to these incidents. Our IoT project focuses on this issue by reducing accident occurrences and providing immediate alert to those who are about to get affected. The system consists of a network of sensors to enhance vehicle and passenger safety by monitoring both the vehicle's condition during driving. Key sensors such as temperature sensors, gas and smoke detectors, force sensors, and sound detectors will collect data to assess risks like overheating, gas leaks, or potential collisions by some excess force or pressure. After detecting such risks, the system will trigger a buzzer or alarm based on the magnitude of the detected threat.

Moreover, a novel feature which we are trying to integrate into the system to further enhance security is a driver authenticatio system based on face detection using driver's license. This system ensures that only the authenticated driver can access the vehicle. This will remove the risk of stealing of the vehicles and will promote the users to verify the person before driving any car.

Our system recognizes face with an accuracy of 96.38 %. This model has recall of 94.56 percentage and precision of 97.63 percentage.

Important Keywords- Internet of Things**,** Real-Time monitoring, Theft Protection, Facial Recognition, Alarm System, Buzzer Alerts, ESP32, Driver Authentication etc.

Introduction

Our team has chosen this topic because in the past decades there has been a regular rise or a significant acceleration in road accidents, which is still growing at an alarming rate. Our IOT project aims to reduce this and also give possible help to the person who got injured. In this we will be using a network of sensors to enhance passenger safety by monitoring the vehicle's and it's surroundings condition. The keys sensors include temperature sensor, gas and smoke detector, force sensor, and sound detectors, which collect data and informs regarding the possible risk like overheating, fire hazard, nearly collision. It will trigger the

buzzer in such situations. To do this it will take the data from various sensors, then will process the data and will activate the alarm if required.

Main Features of our Project:-

Multi Sensor System:

- Temperature Sensor: If the temperature exceeds critical thresholds, the system triggers an alert to notify the driver and help the driver to take the precautions for a safer drive.
- Gas and smoke detector: It will detect the concentration of toxic gases or smoke. If high, the system will activate emergency warning.
- Force sensor: When there is sudden rapid deceleration or a strong force impact, it will trigger alarm.

The system relies on a microcontroller-such as ESP32 for integrating sensor information and response operations. It can also utilize GSM modules to send live data and alerts to emergency services as well as to the driver.

Platforms Used:

- Proteus Professional: The circuit design and simulation of whole multi-sensor system and Arduino are integrated on a platform named Proteus. It gets the access of all the sensors by using their .hex files.
- Arduino IDE: The code for providing logic to the ESP32 and getting the desired output is done on a famous IDE named Arduino IDE. The .hex file required for providing logic to ESP32 is generated by it.

To further enhance the safety and security of vehicle, we are integrating a novel feature: Face detection integrated with a driver's identity verification system. Before giving access of the vehicle to the driver, the driver must present his/her identity using facial recognition technology the system will verify the driver authentication.

As there is high fatality rates linked to road accidents. This paper presents the analysis of existing accident detection and prevention technologies, with an innovative access feature to further enhance the safety.

Unique Functionality of the project

1) Preventing Unauthorized Drivers:
   The system limits access to the vehicle's controls by verifying the driver's identity using face recognition. Only authentic users are given access to vehicle. This prevents situations of theft and accident because people, such as thieves, teenagers without permission, can't get control of the vehicle. In this we are using a Machine learning model to achieve this

goal. In this the driver have to put his face in front of camera if his facial features match with the image captured at the driving seat then only driver will be get the access to the vehicle else vehicle will not start. For verifying t person at the driver seat, The database contains some pictures of the users friendly or known to the owner of the car and he has full access to add or remove anyone in the database.

2) Unregistered Drivers: In case the driver sitting at the driving seat is not registered in the database then the owner will get the image of that person. He will have the access to allow that person use his vehicle or not. If that person is allowed then his image will also get registered in the database for his future drives. This feature will help to prevent the thefts of the vehicle hence reduce crimes.

3) Our model is using ESP32 instead of Arduino as ESP32 offers
    - Higher Processing Speed : As ESP32 has faster processor as compared to Arduino, allowing the system to handle complex task and do multitasking in better way.
    - Better memory management : It has better memory resources in both RAM and storage. Hence it is better for handling complex programs.
    - Allows Wi-Fi and Bluetooth Inability : ESP32 have the ability to connect through Wi-Fi and Bluetooth to other devices and send the messages directly to them. This ability is not allowed in microcontrollers like Arduino.

Hence it allows our whole model to run with enhanced processing speed with better energy efficiency.

1. Related Work in Project

Author	Link of published work (Research Paper/ Patent)	Year	Features	Model/ Sensors/ Used	Drawback in their Project
Mc Win Prince M, Selvan S, Arun Kumar B	[1]	2021	• Accident detection using GSR sensor alerts the driver and can also stop the vehicle if needed. • System will automatically control the vehicle in critical zone.	GSR sensor , Heart rate sensor, transmitter and receiver.	• System needs to be lightweight • Too much load on the system • Complexity in sharing location after an accident

K R Navaneeth, Yashas A N	[2]	2023	• It provides real time health monitoring of driver. • Implementation is done using Arduino. • Real time vehicle state monitoring.	IR sensor , temperature sensor , heart rate sensor , alcohol sensor , ultrasonic sensor.	• High power Consumption • Cost and Maintenance is also high • This may give false Positives/Negatives as output.
Amruta Rajendra Chougule , K. Suganthi	[3]	2018	• It automatically shifts the head beam from low to high or low to high according to the requirement. • Smoke and alcohol detection sensor to prevent accident. • Sensor also detects the potential accident based on distance and speed.	Alcohol sensor, Smoke sensor , Rain sensor, Proximity sensor. GSM module , GPS module.	• No measures are there to prevent accident • Limited scope as it is not addressing the overall demands for the topic
Shivani Sharma, Shoney Sebastian	[4]	2019	• Accident detection using smart sensors. • Notification is sent in case of emergency situation. • Live location is tracked for faster response.	Accelerometer, vibrative sensor, hearth-rate sensor, GPS module ,GSM module.	• Algorithm works only for the area which has strong networks • Complex to implement and deploy
Mohanraj, E. Dakshnamoothy , M., & Karthikeyan, S	[5]	2022	• Alcohol detection using breathalyzer. • Notification will be sent in case of emergency situation. • Smart seatbelt system. Will not give access to vehicle without wearing seatbelt.	Alcohol sensor, vibration sensor, relay switch.	• Lack of preventive measures. • No driver verification facility available.
K. Chittithalli Reddy, R. Sathvik, V. Raju, O. Litin, CH. Sirisha	[6]	2024	• Alcohol detector measures the alcohol content in driver's breath. • Also to is detection for driver drowsiness by monitoring the eye blink.	Alcohol sensor , Eye-link sensor, Ultrasonic senor.	• Limited scope as it is not addressing the overall demands for the topic • Lack of Authentication Measures

			• Ultrasonic sensor to detach the obstacle in the path.		
Shohag Barman; Md. Ferdous Bin Hafiz; Niaz Ashraf Khan	[7]	2024	• GPS send the location of the person to the hospital • Alert regarding over-speeding is send.	Accelerometer sensor, vibration sensor, ultrasonic sensor, GPS module, control and limit switch.	• Low accuracy in sending alerts regarding danger area. • It takes long time(20-30min) to send the signal.
Dr. Fathima Jabeen, Sudhir Rao Rupanagudi, Varsha G Bhat.	[8]	2023	• User authentication using face recognition and fingerprint. • Checking of fuel level in the tank	Face recognition model, fingerprint scanner model, GSM module.	• Accuracy of the face recognition model is low(93%). • It focuses only on user authentication.

Drawbacks in these existing projects

- In most of the models Arduino is used as microcontroller which results in latency in response time which may result in delay in processing, decision making in real-time or in critical situation.
- Limited Processing Power for Complex Algorithms: As Arduino may not support the complex algorithms
- No proper management for Data Privacy, collecting and transmitting data like driver's health, vehicle conditions could raise privacy issues.
- Limited sensor range is there it may fail detect the any risk situation and may result in any error.
- The system is dependent on external environmental conditions such as weather, road conditions, which may result in false reading.
- There is very much complexity during integration combining various sensor may lead to integration challenges further may result in system malfunctions or inaccuracies.
- As most of the models are complex and there is continuous monitoring and data processing leads to higher power consumption, which is problematic for battery-operations.

2. Project Details

Our project focuses on showing the simulation of the sensors which will monitor the vehicle during its journey and alert the user if any problem had occurred in it. Another thing which is our unique functionality is a face recognition model which will confirm the owner of the car that the person driving his car is known to him or not.

For the simulation part, we used a simulator named **Proteus** in which we design the whole circuit of our project. In the circuit, we used the following components:-

1. ESP32 :- It is a microcontroller which provide the power to our whole circuit. We use it ahead of Arduino Uno as It enables Bluetooth and Wi-Fi enability which helps to send alert messages directly to our phone. It is also faster than Arduino Uno. It contains 18 analog-enabled pins, or analog-to-digital converter (ADC) channels which are used to take the input and output from the sensors.

2. Temperature Sensor(LM35):- It is used to monitor the temperature inside the vehicle. It takes the input as voltage and calculate the temperature. If the temperature exceeds a threshold value, then it sends alert and turns on the buzzer.

3. MQ-9 Gas Sensor:- It is used to detect whether there is any harmful gas inside the vehicle or not. It uses a toggle button which becomes 1 once it detected any gas.

4. Touch Pad(Force Sensor):- We used a touch pad for representing force applied on the engine. If the force exceeds a threshold value, then it sends alert and turns on the buzzer.

5. GSM Module:- It is a device which can send the messages to the phones directly. We connect the module with a virtual terminal in which the message sent by the gsm module is being displayed.

6. LCD:- We connected lcd's to show the current values of all the sensors used in our circuits which helps to monitor the car during whole journey.

After connecting the whole circuit the logic to the ESP32 is given by a code written in an IDE named as **Arduino IDE.** The whole code is written in C++ language and it is connected to the circuit using an .hex file generated by Arduino IDE.

Algorithm used for ESP32 is :-

1. INITIALIZE LCD displays for temperature (lcd1), gas detection (lcd2), and force (lcd3)

2. DEFINE tempSensorPin, gasSensorPin, forceSensorPin, redLED, greenLED, yellowLED

3. DEFINE sendSMS(message) to simulate sending an SMS alert

4. SETUP:

   a. BEGIN serial communication for GSM

   b. INITIALIZE lcd1, lcd2, lcd3 displays

   c. SET gasSensorPin as INPUT

   d. SET redLED, greenLED, yellowLED as OUTPUT

5. LOOP:

a. READ temperature from tempSensorPin

i. CONVERT temperature reading to voltage

ii. CALCULATE temperature in Celsius from voltage

b. READ gas detection value from gasSensorPin

c. READ force value from forceSensorPin

i. MAP force value to percentage

d. DISPLAY temperature on lcd1:

i. SET lcd1 cursor to (1, 0), DISPLAY "Temperature = "

ii. SET lcd1 cursor to (1, 1), DISPLAY temperature in Celsius

e. DISPLAY force on lcd3:

i. SET lcd3 cursor to (1, 0), DISPLAY "Force = "

ii. SET lcd3 cursor to (1, 1), DISPLAY force percentage in Newtons

f. TEMPERATURE ALERT CHECK:

i. IF temperature > 50.0°C THEN

- TURN ON redLED

- CALL sendSMS("Warning: High Temperature detected!")

ii. ELSE

- TURN OFF redLED

g. GAS DETECTION CHECK:

i. IF gas detected THEN

- CLEAR lcd2, SET lcd2 cursor to (1, 0), DISPLAY "Gas Detected"

- TURN ON greenLED

- CALL sendSMS("Warning: Gas detected!")

ii. ELSE

- CLEAR lcd2, SET lcd2 cursor to (1, 0), DISPLAY "No Gas Detected"

- TURN OFF greenLED

h. FORCE ALERT CHECK:

i. IF force percentage > 70 THEN

- TURN ON yellowLED

- CALL sendSMS("Warning: Excessive Force detected!")

ii. ELSE

- TURN OFF yellowLED

i. WAIT 2 seconds

Now the main part of our project is Face Recognition Model which is developed and trained using libraries of Python such as Numpy, Open CV etc.

This model plays a major role in preventing thefts and teens under 18 to get the control of a vehicle. The camera take the image of the person sitting at the driver seat. After that the machine learning model will check is that person's image is available in the database or not. The database will have the images of the owner of car and the person who are familiar to him. If the person is verified, he will get access of the car and if not then the image will be sent to the owner of the car who will have access to allow the person to drive his car or not. The small User interface of our model is made by using Tkinter library of python.

Algorithm used for Face Recognition System is :-

1. INITIALIZE necessary libraries and modules:

- os, datetime, pickle, subprocess, tkinter (tk), cv2, PIL (Image, ImageTk), face_recognition

2. CLASS App:

a. METHOD __init__():

i. INITIALIZE main application window with title, size, and layout

ii. ADD login button with callback to login method

iii. ADD register new user button with callback to register_new_user method

iv. ADD webcam display label

v. INITIALIZE webcam feed with add_webcam method

vi. SETUP database and log paths, creating the database directory if it doesn't exist

b. METHOD add_webcam(label):

i. CHECK if webcam capture is initialized; if not, initialize it

ii. ASSIGN provided label to self._label

iii. START webcam processing with process_webcam method

c. METHOD process_webcam():

i. CAPTURE frame from webcam

ii. CONVERT frame to RGB and create PIL image from the array

iii. DISPLAY webcam feed in tkinter window

iv. REPEAT after a short delay (20 ms) for continuous feed

d. METHOD login():

i. SAVE current webcam frame as an image file (unknown_img_path)

ii. RUN face recognition against the database with subprocess

iii. EXTRACT recognized name from the subprocess output

iv. CHECK name:

- IF name is "unknown_person" or "no_persons_found":

DISPLAY error message via util.msg_box

- ELSE:

DISPLAY welcome message via util.msg_box

LOG successful login with username and timestamp in log file

v. DELETE temporary image file (unknown_img_path)

e. METHOD logout():

i. CHECK if current user is authenticated via anti-spoofing module

ii. IF valid:

- RECOGNIZE user’s name

- DISPLAY goodbye message via util.msg_box

- LOG logout event in log file

iii. ELSE:

- DISPLAY alert message for spoofing attempt

f. METHOD register_new_user():

i. OPEN new window for user registration

ii. ADD accept button for new user registration, linked to accept_register_new_user method

iii. ADD try again button for retrying registration

iv. SETUP display area for captured image

v. CAPTURE webcam image and display it in registration window

vi. ADD entry field for entering username

g. METHOD try_again_register_new_user():

i. CLOSE current registration window

h. METHOD add_img_to_label(label):

i. SET image to provided label for live display

ii. SAVE current frame for later use during registration

i. METHOD start():

i. START main application loop

j. METHOD accept_register_new_user():

i. GET entered username

ii. SAVE the captured image to database with username as the file name

iii. DISPLAY success message via util.msg_box

iv. CLOSE registration window

3. MAIN FUNCTION:

a. CREATE App instance

b. CALL app.start() to begin the application loop

3.1 Conceptual Design Diagram

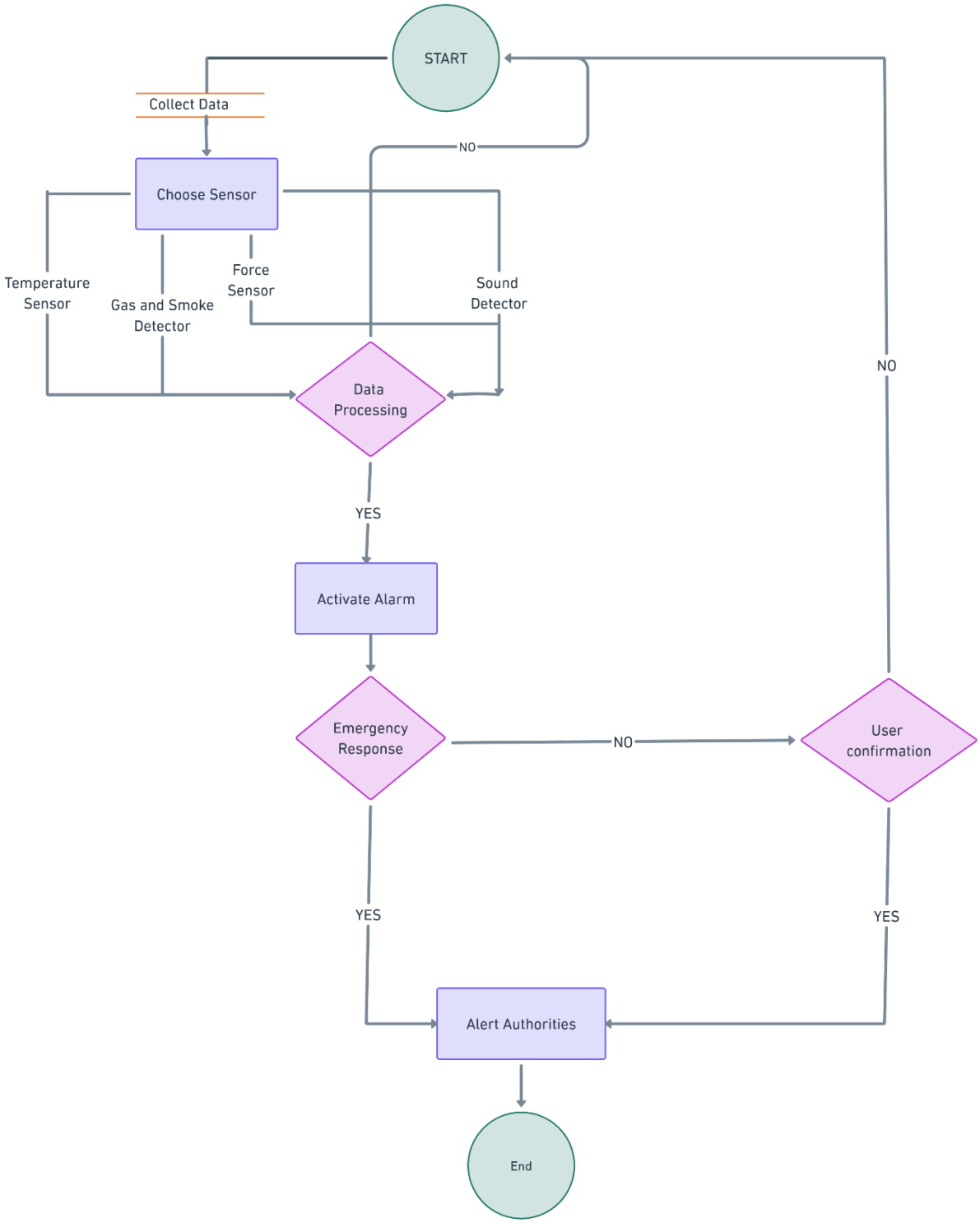

Fig-1: Data Flow Diagram (DFD)

Workflow

This flowchart represents the whole process of accident detection and prevention.

1. Data Collection: Data is collected through different sensors and then processed.

- Temperature Sensor: If the temperature rises above threshold temperature it triggers alarm.
- Gas and Smoke Detector: It detects any leakage of toxic gas or smoke and triggers alarm.
- Force Sensor: It senses sudden deceleration or a strong impact and sends a message to hospital in case of a crash.

2. Sensor Selection: Depending on the situation, different sensors will act accordingly. They will continuously collect data and process it.

3. Data Processing: The sensors will process the data to determine if there is a high risk of an accident. For example:

- If the Force Sensor detects rapid deceleration, it could send an alert.
- If the temperature is high, an alert will be sent to the user.

4. Alarm Activation: If the system identifies a potential accident risk, it will activate alarm. For example:

- If the car is braking suddenly, the Force Sensor will send an alert.
- If gas or smoke is detected, the Gas and Smoke Detector it will trigger alarm

5. Emergency Response Evaluation: After triggering the alarm, the user will follow the required actions and procedures to prevent any mishappening.

6. Alerting Authorities: If the system or driver confirms that an accident is inevitable such as sudden deceleration or sudden impact, the system can automatically send a message to the authorities.

3.2 Working Example

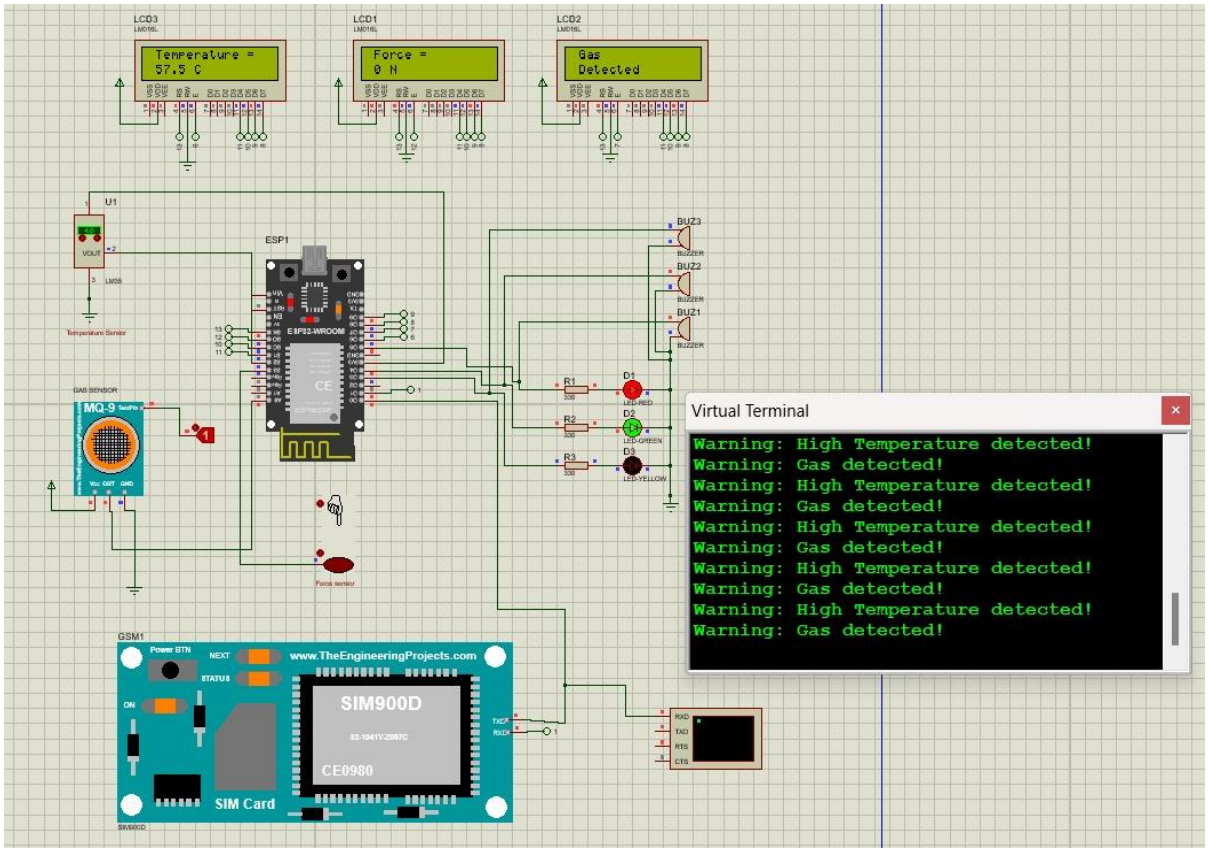

Fig-2: Photograph Of Working Project

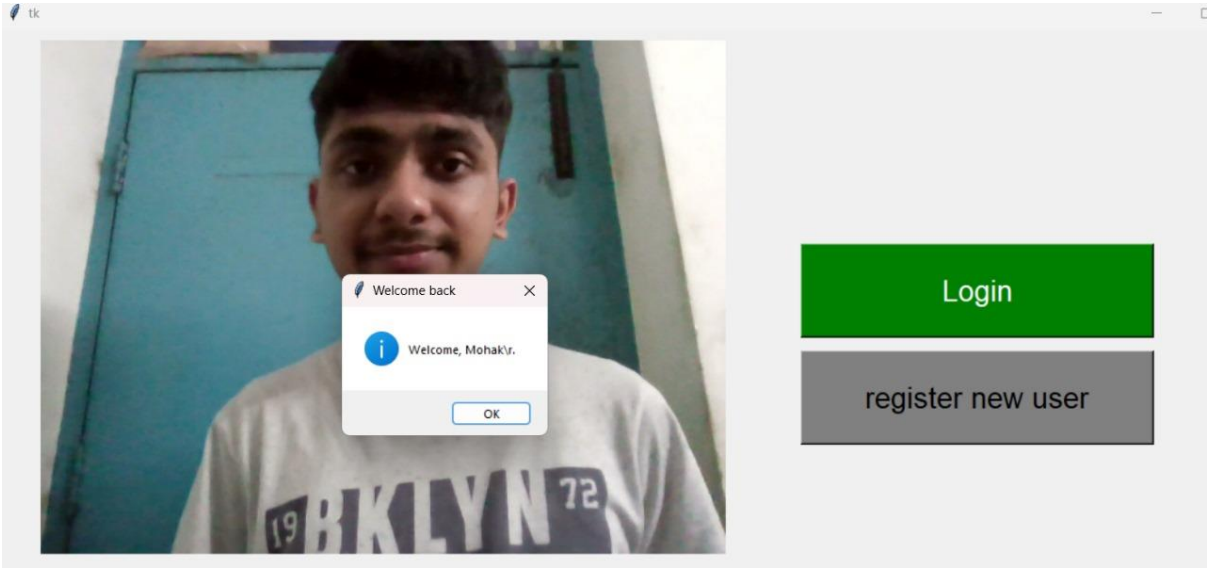

Fig-3: Face Recognition Model

4. Experimental Setup

4.1. Implementation Details

Sr. No.	Sensor/Model	Module Used	Description
1	Gas Sensor	MQ-9 Gas Sensor	It is used to check the presence of toxic gas or smoke. If present, it will send an alert to the user.
2	Temperature Sensor	LM35	If the temperature exceeds critical thresholds, the system will trigger an alert to notify the driver.
3	Force Sensor	TOUCHPAD	If there is sudden deceleration or a strong impact, a message will be sent to notify the authority.
4	GSM Module	SIM900D	It is used to send messages to the user or hospital.
5	Face Recognition model	ML Model	It will match the face with the database provided the owner and verify whether it is the same person or not.
6	Language	CPP Language	C++ language is used to write the logic for the simulation circuit in Arduino IDE.
7	Software	Proteus Stimulation	A app based simulator named Proteus Professional is used for designing the circuit consisting of ESP32, Sensors etc.

Table 4.1 Shows Implementation Details

4.2. Experimental Results

Sr. No	TEST SCENARIO	INPUT	OUTPUT
1	Gas Sensor	Toggle	If analog value=1, turn the buzzer and led on.

2	Temperature Sensor	Temperature	If temperature > threshold value, turn the led and buzzer on.
3	Force Sensor	Force Impact	If force > threshold value, turn the led and buzzer on.
4	GSM Module	Receiver	Send the alert message in the virtual terminal
5	Face Recognition model	Driver's image	Recognize face with 96.38 percentage accuracy. Recall of this model is 94.56 percentage. Precision of this model is 97.63 percentage.

Table 4.2 Shows Experimental Results

5. Comparison With Existing Work

- We use ESP32 ahead of Arduino Uno as It enables Bluetooth and Wi-Fi inability which helps to send alert messages directly to our phone. It is also faster than Arduino Uno and has more functionality, which proved to be an asset for our project.
- We integrated a Face Recognition Model which will prevent the theft of the vehicle. This functionality is not included in any other research paper, so it is our unique functionality.
- Our project is not based on a single problem as it covers multiple things like
  - It will remove the risk of accidents by alerting the person if any mishappening occurs by the simulation part.
  - It will prevent thefts of the vehicle by using Face Recognition model.

  These multiple problems are not covered in any single research paper.

6. Conclusion and Future Work

This project will allow the owner to manage who can have access to the vehicle and prevent unauthorized access of the vehicle. It will also help to manage the health of the vehicle with the help of different sensors such as temperature and gas sensors which will provide alert to the user in case of any leakage or overheating, thus preventing any mishappening. It will also trigger alarm and send alert message in case of any collision.

There are several advanced AI features that could be implemented to enhance the safety of the car for future works.AI model could be developed to analyze driver behavior and traffic patterns which could predict potential accident scenarios before they will occur. Provide warning to the driver about speed limit in a particular area using GPS integration. AI model

to continuously adapts and refines its risk model according to driving patterns, environmental factors, creating a personalized algorithm. A Real-Time Road condition mapping system to get current road condition like potholes, debris, etc. and provides a safe route to reach the destination. AI model that could navigate to the side road in case of driven becomes unconscious. traffic law system that ensures that the driver follows traffic rules like speed limits, stop sign recognition, and no-entry zones, etc. thereby reducing accidents.

7. References

[1] Mc Win Prince M, Selvan S, Arun Kumar B. An IOT based system for accident detection.

https://ijadst.com/ajradmin/certificates/132/IJADST_20210432.pdf

[2] K R Navaneeth, Yashas A N. Advanced Car Accident Prevention System.

https://www.researchsquare.com/article/rs-3205906/v1

[3] Amruta Rajendra Chougule , K. Suganthi. IoT Based Smart Car Monitoring System.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8939066

[4] Shivani Sharma, Shoney Sebastian. IoT based car accident detection and notification algorithm for general road accidents.

https://core.ac.uk/download/pdf/329119566.pdf

[5] Mohanraj, E., Dakshnamoorthy, M., & Karthikeyan, S. Accident prevention using IoT

https://media.neliti.com/media/publications/574362-accident-prevention-using-iot-90e8c4b9.pdf

[6] K. Chittithalli Reddy, R. Sathvik, V. Raju, O. Litin, CH. Sirisha. Car Accident Prevention System.

http://junikhyatjournal.in/no_1_Online_24/21_online_apr.pdf

[7] Shohag Barman; Md. Ferdous Bin Hafiz; Niaz Ashraf Khan. An IoT-Based Smart System for the Detection, Notification and Prevention of Vehicle Accidents.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10534370

[8] Dr. Fathima Jabeen, Sudhir Rao Rupanagudi, Varsha G Bhat. IoT based Smart Vehicle Ignition and Monitoring System.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9036809