A Safe Driving System based on STM32 and Raspberry-pi

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Abstract :

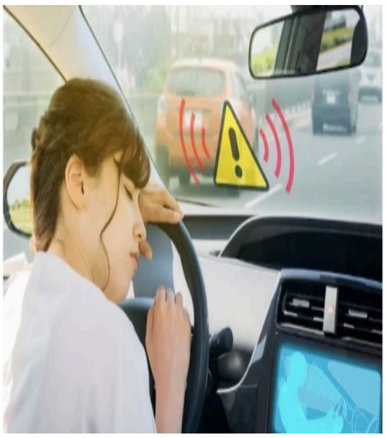
This project introduces a smart driving system designed to improve road safety by including three important features: anti-collision, anti-drunk driving, and anti-fatigue driving. It is built around the STM32 microcontroller, using an HC-SR04 ultrasonic sensor to detect obstacles, an MQ-3 alcohol sensor to prevent drunk driving, and a face recognition module powered by Raspberry Pi to monitor driver fatigue. By tackling key human factors behind traffic accidents, this system aims to make driving safer and reduce the number of accidents.

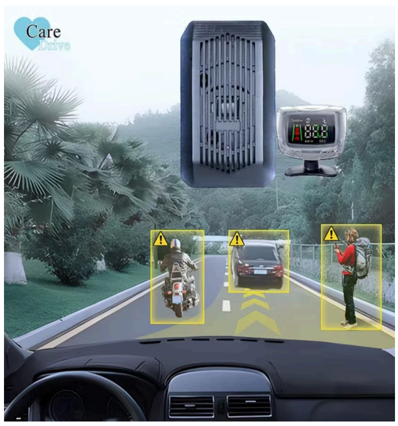
Introduction :

Road accidents are a major problem worldwide, causing many deaths, injuries, and economic losses. According to statistics, more than half of all road accidents are caused by drivers who are not qualified, drive badly, drive drunk, or drive when they are tired.

Current methods for preventing drunk driving are not effective. A better approach would be to detect drunk driving when the driver gets into the car. Similarly, driving when tired is a major cause of road accidents, but there are no good solutions to this problem.

This project proposes a new safe driving system that aims to prevent road accidents caused by drunk driving, tired driving, and other human factors. The system uses advanced technologies such as face recognition, alcohol detection, and ultrasonic sensors to make roads safer and reduce accidents.





The increasing number of road accidents worldwide is a major concern, with a significant proportion of these accidents attributed to human factors such as drunk driving, fatigue driving, and distracted driving. Existing solutions to prevent drunk driving and fatigue driving are inadequate, and there is a need for a comprehensive system that can detect and prevent these hazards.

Specifically, the problems addressed by this project are:

1. Drunk driving: Current methods for detecting drunk driving are limited to testing drivers at fixed locations, which is not effective in preventing drunk driving.
2. Fatigue driving: There is no reliable solution to detect and prevent fatigue driving, which is a major contributor to road accidents.
3. Distracted driving: Existing solutions to prevent distracted driving are limited, and there is a need for a system that can detect and alert drivers to potential hazards.

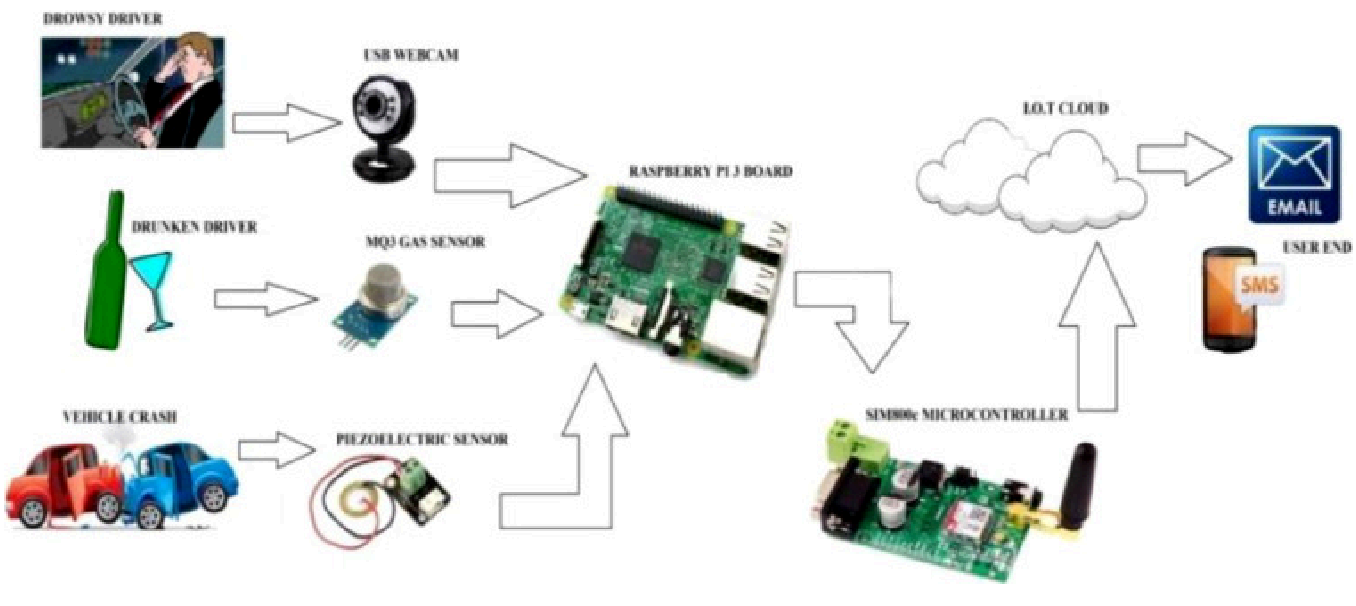
Proposed Solution :

Our proposed solution is a cutting-edge Safe Driving System that integrates advanced technologies to detect and prevent drunk driving, fatigue driving, and distracted driving. This system has the potential to revolutionize road safety, saving countless lives and preventing devastating accidents.

A Safe Driving System that integrates the following features:

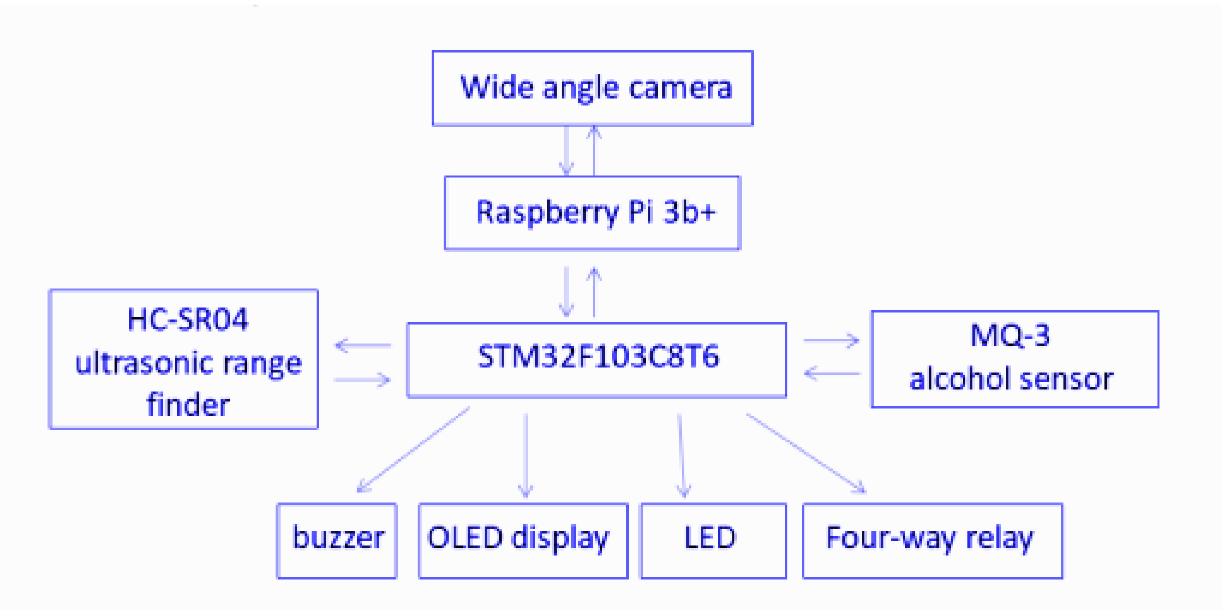
1. **Anti-Collision System** using Ultrasonic Sensors
2. **Anti-Drunk Driving System** using Alcohol Sensors
3. **Anti-Fatigue Driving System** using Face Recognition Technology

By implementing our Comprehensive Safe Driving System, we can create a safer and more responsible driving environment, ultimately saving lives and reducing the economic burden of accidents.



The overall block diagram of the Safe Driving System consists of the **STM32F103C8T6 microcontroller** as the main control unit, which interfaces with the HC-SR04 ultrasonic range finder, MQ-3 alcohol sensor, and the Raspberry Pi 3b+ development board for fatigue driving detection.

The process begins with the ultrasonic sensor detecting obstacles and sending signals to the microcontroller, which then triggers the alarm if an obstacle is detected. Simultaneously, the alcohol sensor detects the driver's blood alcohol level and sends signals to the microcontroller, which prevents the vehicle from starting if the level exceeds the legal limit. The Raspberry Pi 3b+ development board processes images from the camera to detect signs of fatigue in the driver, and alerts the driver if fatigue is detected. The system also includes output devices such as an alarm/buzzer and a display screen, and is powered by a battery or power adapter.



A. Anti-collision module :

The anti-collision module mainly uses an ultrasonic range finder based on STM32 single-chip microcomputer to monitor the distance between the car and the front obstacle in real time,and set buzzer alarms of different frequencies according to different distances to remind the driver to avoid obstacles and achieve the purpose of collision avoidance.

B. Anti-drunk driving module :

It is prescribed that the alcohol content in the driver's blood is greater than (equal to)20 mg / 100 ml and less than 80 mg /100 ml, which belongs to drunk driving. According to the actual situation, it can be approximated that in the case of drinking slowly, driving within 8.6 hours after drinking 3 bottles of beer will violate the standard[4].

In anti-drinking driving module, we mainly use the alcohol sensor based on STM32 single-chip microcomputer. When the door is opened, the sensor device enters the working state to detect the air alcohol concentration in the car. If the drunken driving concentration standard is reached, the power supply of the car ignition device will be cut off, and the car can not be started to prevent the drunk driving.

C. Anti-fatigue driving module :

According to the Traffic Safety Law, the driver shall notdrive continuously for more than 4 hours without a break.When the driver drives continuously for more than four hours,the mental function and physiological function will change, the driver's attention will be difficult to concentrate, the reaction speed will slow down, there will be deviation when judging the road conditions, and there will be various problems such as blurred vision.

Therefore, the anti-fatigue driving module adopts the method of face recognition, uses the raspberry pi wide-angle camera to collect and recognize the face data, and collects the face information every 20 minutes for comparison. When it is judged that the same driver drives continuously for up to four hours, an alert is issued to alert the driver to drive carefully or to stop as soon as possible to have a rest.

System Hardware Design & Implementation :

Four-way relay, ultrasonic sensor, alcohol sensor, OLED display, LED light and buzzer are controlled by STM32F103C8T6 single-chip microcomputer; face recognition module is achieved by Raspberry pi 3b+ and wide-angle camera. Fig.2 shows the control circuit diagram of the STM32 microcontroller and ultrasonic range finder and alcohol sensor.

The system consists of the following hardware components:

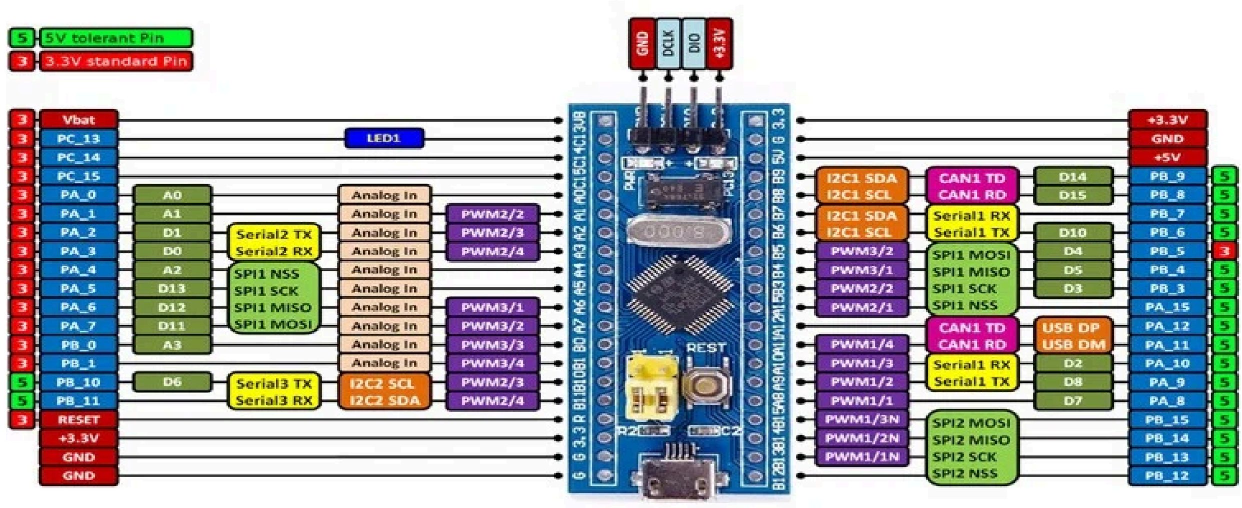
1. STM32F103C8T6 Microcontroller
2. HC-SR04 Ultrasonic Range Finder
3. MQ3 Alcohol Sensor
4. OLED Display
5. LED Light and Buzzer
6. Raspberry Pi 3B+ and Wide-Angle Camera.

As the main control CPU, STM32 is connected to the minimum system, and then directly connected to the A0 output of the alcohol sensor through the GPIO port to exchange information of analog signals; the Trig end and Echo end of the ultrasonic range finder are connected with the corresponding IO port of the main control chip to achieve the
transmission and reception of ultrasonic signals.

A. STM32F103C8T6 Microcontroller :

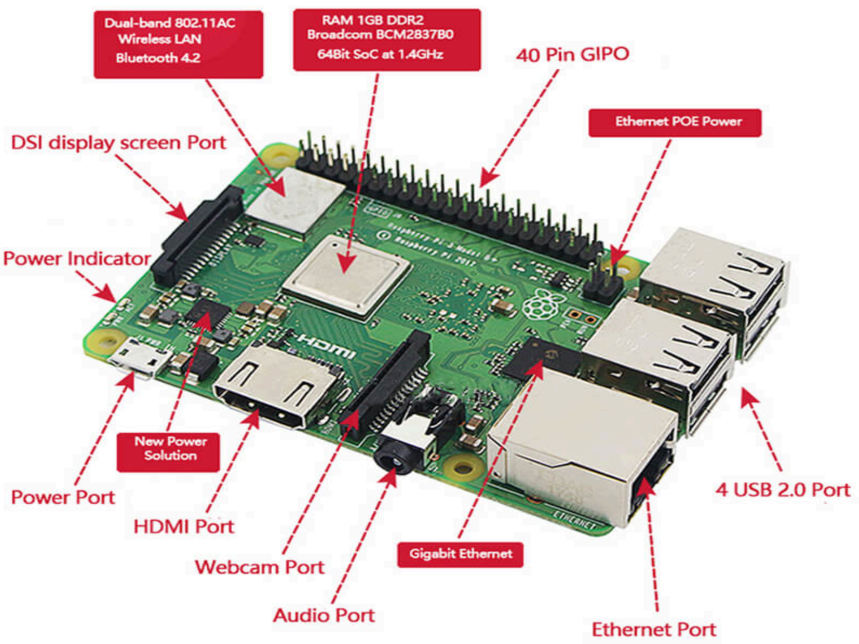
The STM32F103C8T6 is a 32-bit microcontroller from the STM32F1 series, developed by STMicroelectronics. Based on the ARM Cortex-M3 processor, it provides a high-performance, low-power platform for various applications. With 64 KB of flash memory, 20 KB of static RAM, and 37 GPIO pins, this microcontroller offers ample resources for connecting peripherals and external devices.

It also features a 12-bit ADC, multiple timers, and serial communication interfaces, including UART, I2C, SPI, and USB. In this project, the STM32F103C8T6 serves as the main processing unit, reading sensor data, processing information, controlling system outputs, and communicating with external devices.



B. Raspberry Pi 3B+ :

The Raspberry Pi 3B+ is a single-board computer developed by the Raspberry Pi Foundation.Released in 2018, it's an upgraded version of the Raspberry Pi 3B, offering improved performance, new features, and enhanced connectivity. With a quad-core 1.4 GHz Cortex-A53 CPU, 1 GB RAM, and dual-band 802.11ac wireless LAN, the Raspberry Pi 3B+ provides a robust platform for various applications.
In this project, the Raspberry Pi 3B+ is utilized specifically for detecting driver fatigue. It processes data from various sensors to monitor the driver's condition, helping to prevent accidents caused by drowsy driving.



C. Ultrasonic ranging :

This system uses the **HC-SR04 ultrasonic range** finder. The HC-SR04 ultrasonic ranging module provides 2cm-400cm non-contact distance sensing capability with a range accuracy of 3mm. The module includes ultrasonic transmitter, receiver, and control circuit.

The working principle of HC-SR04:

1. The STM32 microcontroller sends a 10µs high-level trigger signal to the EM78P153 microcontroller.
2. The EM78P153 emits a 40 kHz square wave, amplified and converted into a 40 kHz sound wave by the ultrasonic probe.

3. The sound wave is reflected by the object, received by the probe, and processed by the EM78P153.
4. A high-level signal is sent back to the STM32 MCU, which calculates the time interval between the signals to determine the propagation time of the ultrasonic wave.

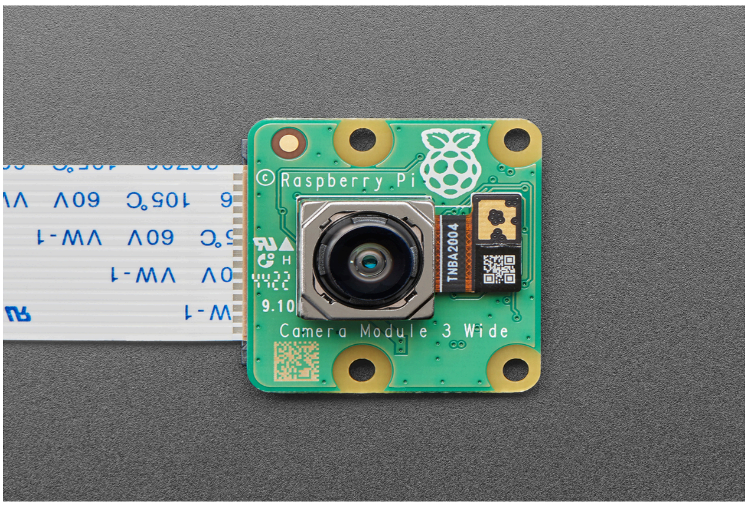
D. Alcohol sensor :

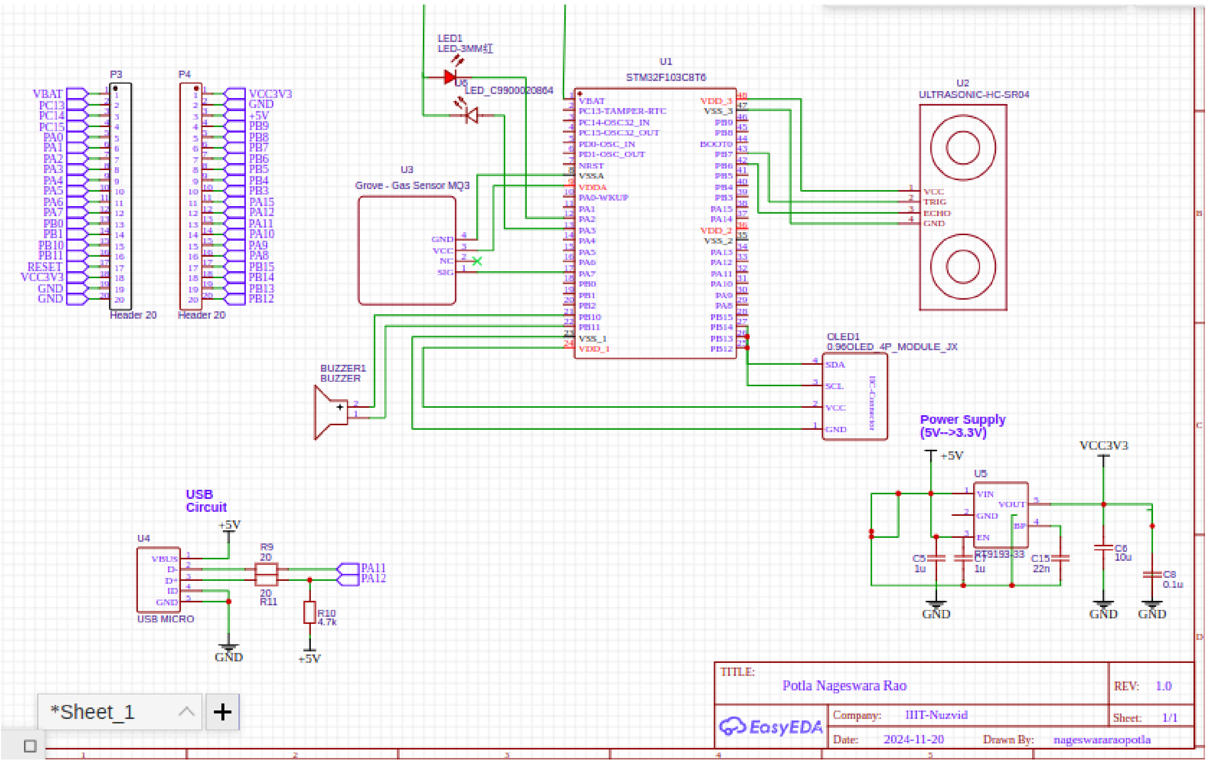
The MQ3 Alcohol Sensor is used in this system due to its high sensitivity and good selectivity to ethanol vapor, making it an ideal choice for **detecting alcohol concentrations.** The sensor is used to convert the alcohol concentration in the air into a level signal, which is then transmitted to the STM32F103C8T6 microcontroller for processing. By using the MQ3 sensor, the system can accurately detect and measure alcohol concentrations, enabling it to prevent drunk driving and ensure road safety.

E. Raspberry Pi and Wide Angle Camera :

The Raspberry Pi is a Linux 32-bit operating system based on Debian. It uses a Micro SD card as a memory hard disk. It is small in size but has the basic functions of a personal computer. It brings up 96 GPIO interfaces which can be used to connect multiple underlying layers. And it has SATA and HDMI interfaces for high-definition output[9].

The Raspberry Pi wide-angle camera provides 2592×1944 static picture resolution, using the photosensitive chip OV5647. It supports 1080p30, 720p60 and 640×480p60/90 video recording. Insert the wide-angle camera into the camera interface on the Raspberry Pi 3B+ board to enable the camera Function.




USB Circuit
USB MICRO
Power Supply (5V-->3.3V)
Grove - Gas Sensor MQ3
ULTRASONIC-HC-SR04
STM32F103C8T6
BUZZER1
TITLE:
Potla Nageswara Rao
REV: 1.0
Company: IIIT-Nuzvid
Sheet: 1/1
EasyEDA
Date: 2024-11-20
Drawn By: nageswararaopotla
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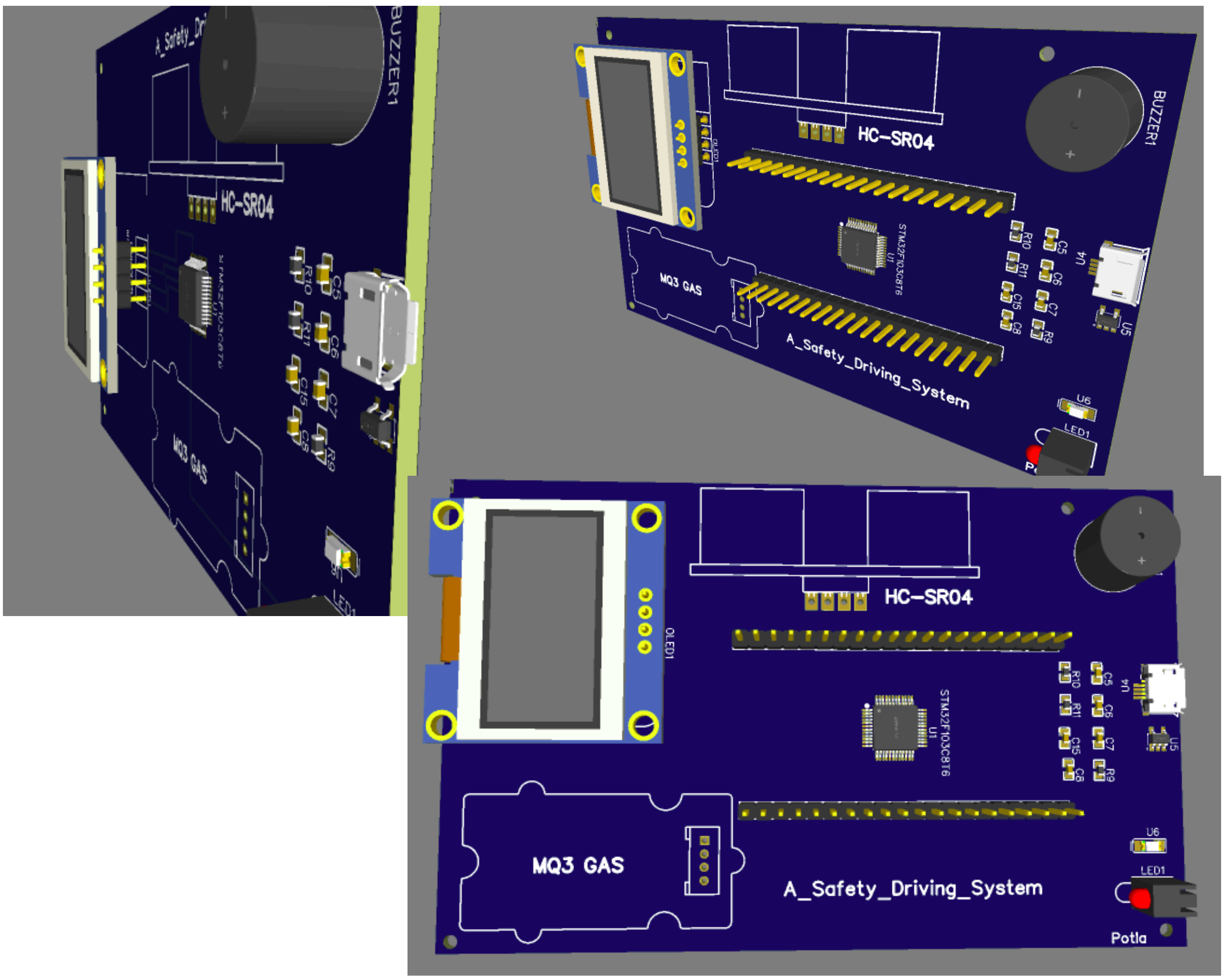
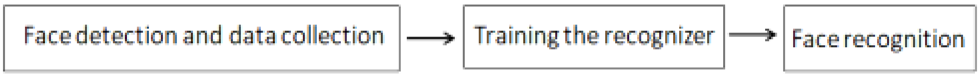

HC-SR04
BUZZER1
MQ3 GAS
A_Safety_Driving_System
OLED1
STM32F103C8T6
Potla

Face Recognition Module :

The software development environment needs to prepare OpenCV and Python 3. Use the command $ source ~/.profile to open a new terminal to run the source to ensure that the system variables have been set up correctly, then enter on the virtual environment, open the python compiler, and run version 3.5 or above. Afterwards, have OpenCV library installed in the Raspberry pi, test to confirm that camera is working properly, and then write in the code of face recognition.

A complete face recognition project needs to go through three stages: first, create a dataset, where we will store for each ID, a group of photos in gray with the portion that was used for face detecting. Second, train all user data directly by a specific OpenCV function, so that the recognizer is able to recognize each person's face and their respective ids. Finally, capture a fresh face on the camera and if this person had his face captured and trained before, the recognizer will make a prediction returning its id and an index, shown how confident the recognizer is with this match. The process block diagram is



After identifying successfully, a command is sent to the relay, and the face information is collected every 20 minutes for comparison.
If the detection judges that the driver is the same one for 12 consecutive times (that is, the driver has been driving for 4 hours continuously), the information will be returned to the Raspberry Pi voice module, prompting the driver to drive carefully and rest in time.

Conclusion :

Finally, This project presents a comprehensive safe driving system that integrates anti-collision, anti-drunk driving, and anti-fatigue driving functionalities. Leveraging the STM32F103C8T6 microcontroller and Raspberry Pi 3B+, the system utilizes ultrasonic ranging, alcohol sensing, and face recognition to detect potential driving hazards. The system's effectiveness in preventing drunk driving, fatigue driving, and collisions has been demonstrated, showcasing its potential to significantly reduce traffic accidents. Overall, this project contributes to the development of intelligent transportation systems, promoting safer and more responsible driving practices.

Future Scope :

The safe driving system presented in this project has demonstrated its potential in preventing traffic accidents. However, there are several avenues for future research and development:

1. **Integration with Existing Vehicle Systems:** Future work can focus on integrating the safe driving system with existing vehicle systems, such as the anti-lock braking system (ABS) and electronic stability control (ESC).
2. **Advanced Driver Monitoring:** The system can be enhanced to monitor the driver's vital signs, such as heart rate and blood pressure, to detect fatigue and stress.
3. **Machine Learning-based Accident Prediction:** Machine learning algorithms can be employed to analyze data from various sensors and predict the likelihood of an accident.