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IOT BASED VEHICLE SAFETY AND SECURITY SYSTEM USING RASPBERRY PI

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ABSTRACT:

This proposal presents an advanced integrated vehicle safety and security system that addresses both aspects accurately. Existing systems typically focus on either safety or security measures, but not a combined solution. The proposed system incorporates a facial recognition-based authorization for security and an ultrasonic sensor to monitor vehicle movements for enhanced safety. By integrating these crucial components, the system aims to provide a comprehensive solution that enhances vehicle security through facial authentication while simultaneously reducing the risk of accidents through obstacle detection and speed control mechanisms. This integrated approach to vehicle safety and security distinguishes the proposed system, offering a holistic solution that tackles the critical challenges in this domain.

***Index Terms*-Internet of Things(IoT), Face Recognition, Raspberry Pi, MQTT, Twilio SMS alerts.**

I. INTRODUCTION

Vehicle safety and security are major concerns today due to increasing road accidents and vehicle thefts. According to recent stats, India saw over 400,000 road accidents in 2021 with many fatalities. Globally, millions of lives are lost annually in road accidents. Existing security systems like key duplications and biometric scanners like fingerprint and iris scanners have limitations and are costly.

This project proposes an integrated solution using facial recognition for vehicle access and ultrasonic sensors for obstacle detection and speed control. The aim is to provide an accurate, cost-effective system that enhances both security through facial authentication and safety by avoiding accidents. The scope covers developing these two components - facial recognition for security and ultrasonic sensing for safety - into one unified Internet of Things (IoT) system using a Raspberry Pi. This integrated approach tackles the key challenges of vehicle safety and security together.

II. LITERATURE SURVEY

Previous researchers have explored different techniques to enhance vehicle security and safety. One approach involved using facial recognition algorithms to identify authorized drivers and control the vehicle's ignition accordingly. These systems were built using affordable components like Raspberry Pi microprocessors and Pi cameras, making them cost-effective and easy to integrate into existing vehicles [1].

Another study focused on obstacle detection, where the system used cameras to identify moving or stationary objects in the vehicle's path and ultrasonic sensors to measure the distance to these obstacles. While the system could alert the driver about potential collisions, it did not take any preventive measures to avoid the obstacles automatically [2].

In an effort to control vehicle speeds in restricted areas, a project proposed an embedded system with an RF transmitter and receiver setup. The system used a microcontroller, DC motor, opto-coupler, and ultrasonic sensor. However, its implementation required installing RF transmitters in speed signs along the roads [3].

A different approach involved real-time image processing to detect speed limit signs and automatically adjust the vehicle's speed accordingly. The system used an Arduino UNO board to process the images, send data to the cloud, and transmit the vehicle's location via a GPRS module [4].

To combat vehicle theft, some researchers developed integrated anti-theft control systems that used advanced communication technologies like LTE Release 8 or 3.9G. These systems incorporated GSM modules with SIM cards to exchange messages with the owner, enabling location tracking and remote engine control [5].

Another anti-theft device utilized a microcontroller as the control core, along with GPS and GSM modules connected through an electronic switch. Upon detecting a theft, the device would trigger alarms and send the vehicle's location to the owner via SMS [6].

In the realm of autonomous driving, researchers proposed a real-time embedded system prototype that could detect speed bumps using a vision camera and adjust the vehicle's speed accordingly. This system employed Convolutional Neural Networks (CNN) for learning and demonstrated promising results with optimal power consumption and high detection accuracy [7].

For accurate face recognition, a study titled "Multiple Face Detection and Recognition through Viola-Jones and Artificial Neural Networks" developed a system that achieved an accuracy rate of 88.06%. The system performed best when the person was around 100 cm from the camera, under specific lighting conditions, and facing the camera directly [8].

To improve road safety, automatic traffic sign detection and recognition (TSDR) systems have been introduced. These systems can identify traffic signs from camera images, aiming to enhance robustness and efficiency, especially in adverse traffic conditions [9].

Another study compared the performance of face recognition algorithms based on Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) using a small training dataset. The results indicated that PCA outperformed LDA in terms of accuracy [10].

Leveraging the Internet of Things (IoT) and cloud technologies, an advanced vehicle system was proposed to provide automatic safety and theft control features with minimal delay. The system incorporated various components like infrared sensors, Bluetooth modules, limit switches, and a mobile app, enabling functionalities such as password-controlled door access, safety harness control, and remote engine management via GSM [11].

Additionally, researchers aimed to develop an autonomous car prototype using a monocular vision system with a Raspberry Pi processor, HD camera, and ultrasonic sensor. The car was designed to navigate safely and intelligently to its destination by combining techniques like lane detection and obstacle avoidance, minimizing the potential for human error [12].

In another study, a vehicle anti-theft system was built using an Arduino microcontroller, GPS module, and GSM module. The system could send SMS alerts to the owner and allow remote vehicle control and monitoring through SMS commands [13].

These studies showcase various approaches and technologies employed to enhance vehicle safety, security, and autonomous driving capabilities, addressing critical issues such as theft prevention, obstacle avoidance, speed control, and driver identification.

III. METHODOLOGY

A. FACE RECOGNITION:

The face recognition component was implemented using Python 3.8 on the Raspberry Pi platform. The face_recognition and OpenCV libraries were imported for computer vision and image processing tasks. Additionally, the NumPy library was incorporated to work with numerical data and arrays.The face_recognition library provides predefined functions and algorithms for detecting and recognizing faces in images or video streams. It utilizes deep learning models trained on extensive datasets of facial images to extract features and create face encodings, which are numerical representations of facial features.

To set up the face recognition system, the facial image of the authorized person was captured and encoded using the face_recognition library's functions. This encoded image was then saved as a NumPy file, serving as the trained model for the authorized user's face. During runtime, the camera continuously captured images, which were processed using the face detection and recognition algorithms from the face_recognition library. The captured face was encoded and compared with the trained model's encoding. If a match was found with a sufficient level of confidence, the system granted access to the vehicle.

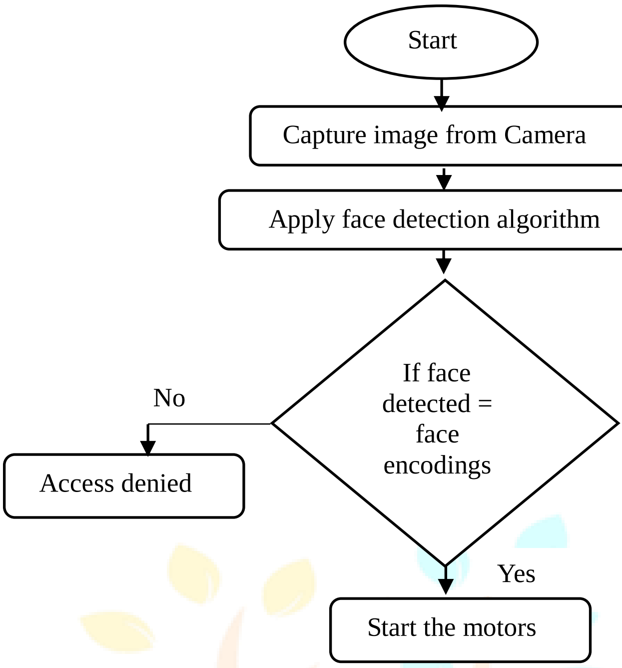

Fig.1 Face Recognition flowchart

B. OBSTACLE AVOIDANCE:

For obstacle avoidance, an ultrasonic sensor (HC-SR04) was employed. This sensor operates by emitting high-frequency sound waves and measuring the time taken for these waves to reflect back after hitting an obstacle. The distance to the obstacle is calculated using the speed of sound in air (343 m/s) and the time taken for the sound wave to travel back to the sensor.

The ultrasonic sensor was programmed to continuously monitor the surroundings, irrespective of any other concurrent processes running. This ensured that the system had up-to-date information about potential obstacles at all times. If the calculated distance was less than 30 centimeters, indicating the presence of an obstacle within close proximity, the system immediately sent a signal to the motor driver circuit, causing the vehicle to halt.

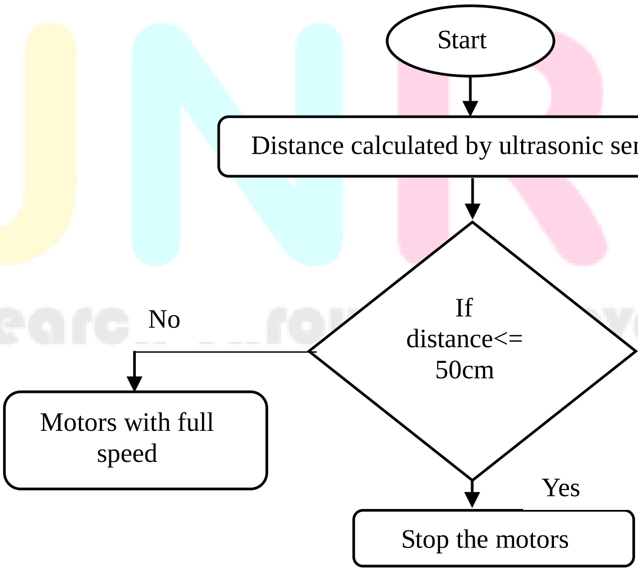

Fig.2 Obstacle Avoidance flowchart

C. SPEED CONTROL:

The speed control mechanism also utilized the ultrasonic sensor for distance calculation. As the vehicle moved, the sensor continuously measured the distance to any potential obstacles in its path. When the calculated distance fell within a range of 100 to 50 centimeters, indicating the presence of an obstacle at a moderate distance, the system automatically reduced the motor speed by 50%. This reduction in motor speed translated to a corresponding 50% decrease in the overall vehicle speed.

By slowing down the vehicle's approach towards the obstacle, the speed control mechanism allowed for safer operation and provided additional reaction time for the driver or the system to take further actions, such as stopping the vehicle or changing its course to avoid a collision.

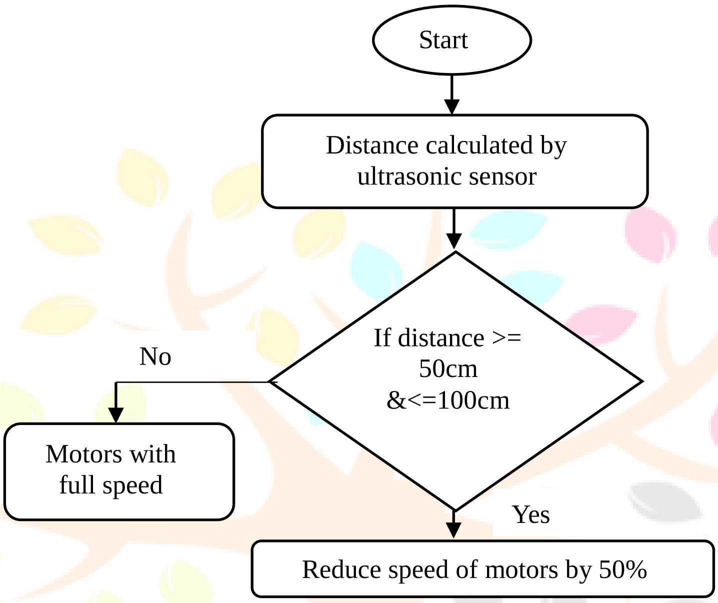

Fig.3 Speed Control flowchart

D. ALERTING SYSTEM

The alerting system was implemented using the Twilio cloud-based communication platform. Twilio allows developers to programmatically send and receive messages, including SMS, voice calls, and other communication channels, through its APIs.

The alerting system was designed to send SMS notifications to a designated phone number under specific conditions. These conditions included successful face recognition (granting access to the authorized user), failed face recognition attempt (potential unauthorized access), and the detection of an obstacle within a certain distance range.

When any of these conditions were met, the system triggered the Twilio API to send a predefined alert message via SMS to the specified phone number. This alert mechanism ensured that the relevant parties, such as the vehicle owner or authorities, were promptly notified in case of security breaches, unauthorized access attempts, or potential collision risks, allowing for timely intervention or response.

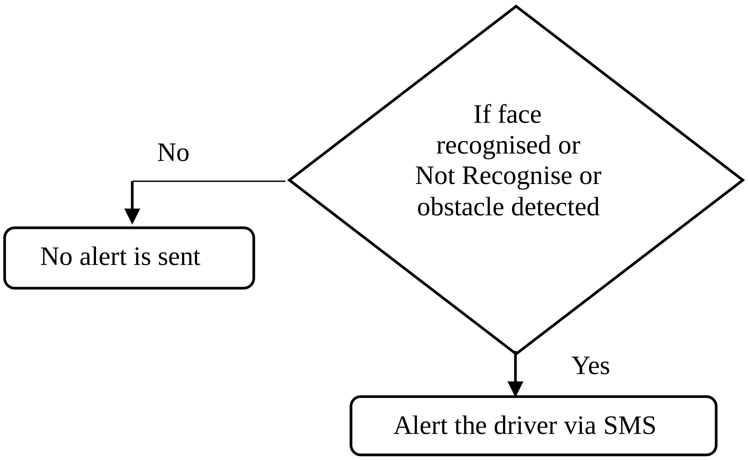

Fig.4 Alerting System flowchart

E. IOT INTEGRATION FOR SECURITY MONITORING

For the security aspect of the project, IoT (Internet of Things) technology was integrated to enable remote monitoring through facial recognition. The system was designed to capture images of unidentified individuals attempting to access the vehicle. These images are then transmitted over the MQTT (Message Queuing Telemetry Transport) protocol to a mobile application called MQTT Dash.

By leveraging the MQTT protocol, which is a lightweight messaging protocol commonly utilized in IoT applications, the captured facial images are seamlessly delivered to the authorized user's mobile device in real-time. This feature allows for remote monitoring and instant notification of potential security breaches. Upon receiving the images on the MQTT Dash application, the user can promptly assess the situation and take appropriate action if necessary, even when not physically present at the vehicle's location.

IV.RESULTS AND DISCUSSIONS

The proposed system was successfully implemented, integrating face recognition, obstacle avoidance, speed control, and an alerting mechanism. Fig. 1 shows the connections and interfacing of various components, including the Raspberry Pi, ultrasonic sensor, camera, and motor driver circuit.

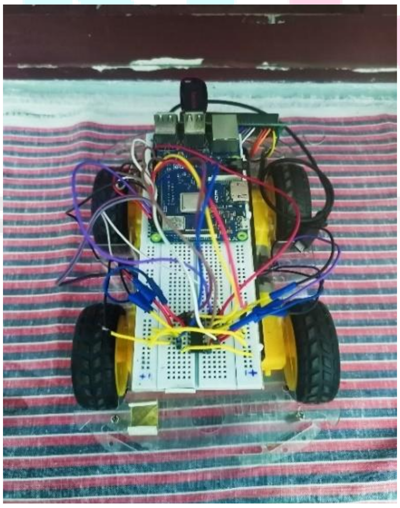

Fig.5 Connections and Interfacing of components

Fig. 2 represents the overall prototype of the developed system, showcasing the integration of hardware and software components.

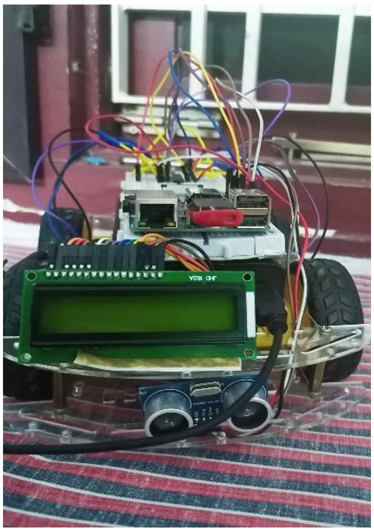

Fig.6 Prototype of the proposed system

The face recognition module accurately identified authorized individuals, granting access to the vehicle. The system exhibited reliable performance in detecting and responding to obstacles within the specified distance threshold. When an obstacle was detected within 30 centimeters, the vehicle promptly halted, preventing potential collisions.

The speed control mechanism effectively modulated the vehicle's speed based on the presence of obstacles within the range of 100 to 30 centimeters. This feature ensured a gradual reduction in speed, allowing for safer operation and increased reaction time for the driver or the system to take appropriate actions.

The alerting system successfully notified the designated parties via SMS using the Twilio platform. Alerts were triggered upon successful face recognition, failed recognition attempts, and obstacle detection within the specified distance range. This feature provided an additional layer of security and safety by enabling timely intervention or response.

V. CONCLUSION

The proposed system presents a comprehensive solution for enhancing vehicle security, safety, and autonomous capabilities. The integration of face recognition, obstacle avoidance, speed control, and an alerting mechanism addresses critical concerns related to vehicle theft, collision prevention, and timely notification.

The face recognition module ensures that only authorized individuals can operate the vehicle, mitigating the risk of theft or unauthorized access. The obstacle avoidance feature contributes to enhanced safety by automatically halting the vehicle when obstacles are detected within close proximity, reducing the likelihood of collisions.The speed control mechanism optimizes the vehicle's speed based on the presence of obstacles, allowing for safer operation and increased reaction time. The alerting system further enhances security and safety by promptly notifying relevant parties in case of security breaches, unauthorized access attempts, or potential collision risks.

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