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SafeDrive Pro IoT Based Driver Verification System

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Abstract: *SafeDrive Pro is an IoT-based Driver Verification System designed to address the rise in vehicular accidents involving underage and unlicensed drivers. By integrating multi-factor authentication, including age verification, facial recognition, and driver license validation, SafeDrive Pro ensures only authorized individuals can operate vehicles. The system aims to improve vehicle security, reduce unauthorized usage, and enhance road safety. The proposed system leverages IoT technology, machine learning for facial recognition, and RFID for license validation. Initial results indicate that the system can effectively prevent unauthorized access, offering a robust approach to reducing road accidents and promoting vehicle security*

Keywords: ECP32 microcontroller, Face Recognition, ESP32 Camera, Vehicle Accident ,GPS

I. INTRODUCTION

In recent years, the number of vehicular accidents involving underage drivers has been on the rise, often with serious consequences and inadequate legal repercussions. To address this critical issue, we introduce SafeDrive Pro - an IoT Based Driver Verification System. SafeDrive Pro leverages advanced IoT technology to ensure that only drivers who are legally permitted to drive can start the vehicle. The system integrates multiple verification steps:

1. Age Verification: The system checks the driver's age using their ID proof. If the driver is below 18 years old, the vehicle will not start.
2. Identity Verification: For drivers above 18, the system performs a face scanning process to ensure the driver matches the verified ID proof.

By implementing SafeDrive Pro, we aim to significantly reduce the incidence of accidents caused by underage drivers and enhance road safety. In May 2024, a tragic accident occurred in Kalyani Nagar, Pune, when a 17-year-old boy, driving a Porsche Taycan at high speed, crashed into a motorbike, killing two techies, Aneesh Awadhiya and Ashwini Koshta. The incident drew significant attention due to the minor's age and the involvement of alcohol. It was reported that the car was moving at over 200 km/h when it collided with the bike, causing both victims to be thrown from their vehicle, with Koshta dying on the spot and Awadhiya succumbing to injuries later in the hospital. The case also involved legal action against the pubs that served alcohol to the underage driver. SafeDrive Pro is an IoT-based driver verification system aimed at enhancing vehicle security by ensuring that only authorized and competent individuals can operate a vehicle. With the increasing number of road accidents, often caused by unverified or underqualified drivers, systems like SafeDrive Pro can play a crucial role in improving safety standards. This system is particularly useful for high-performance vehicles, such as luxury or commercial vehicles, where unauthorized access can lead to dangerous situations. SafeDrive Pro uses various technologies like Convolutional Neural Networks (CNN), Haar Cascades, OpenCV, and Optical Character Recognition (OCR) to create a robust, real-time system for driver authentication and behavior monitoring.[1] To improve the performance and simplicity of the SafeDrive Pro system, an Android application has been developed. The mobile app serves as an interface between the driver, vehicle, and the cloud system, allowing for easy management and monitoring of vehicle access in real-time.

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II. COMPONENTS AND TECHNOLOGIES USED

A. ESP32 Microcontroller in SafeDrive Pro:

ESP32 is a powerful, low-cost microcontroller with integrated Wi-Fi and Bluetooth, making it ideal for IoT applications like SafeDrive Pro. The ESP32 is responsible for managing wireless communication between the vehicle and remote servers, allowing real-time data transmission, such as vehicle status, driver verification results, and alerts.

Wi-Fi/Bluetooth Connectivity:

ESP32 ensures seamless connectivity with the cloud, allowing the system to send and receive data in real-time. This enables fleet managers or vehicle owners to monitor driver status, track vehicle movement, and access verification logs remotely.

Peripheral Contro:

The ESP32 can also manage various sensors used in the system, such as temperature, proximity, or speed sensors, enhancing the overall functionality of SafeDrive Pro by integrating additional safety features.

Low Power Consumption:

The ESP32 is known for its energy efficiency, making it ideal for continuous monitoring in vehicle environments, where power resources may be limited.

B. Convolutional Neural Networks (CNN):

CNN is a type of deep learning algorithm that excels in image processing tasks. In the SafeDrive Pro system, CNN is used to analyze facial images for driver identification and authentication. It is highly effective in recognizing patterns in visual data, such as facial features, even in varying lighting conditions. By training a CNN with a dataset of authorized drivers' faces, the system can accurately verify whether the person attempting to drive the vehicle is authorized.[2]

C. Haar Cascade Classifier

Haar Cascade is an object detection algorithm that identifies faces in real-time from video frames. OpenCV provides pre-trained Haar Cascade models for face detection, which are used in SafeDrive Pro to quickly locate the driver's face in the input image. The face is then passed to the CNN for further analysis and verification. Haar Cascades are lightweight and efficient, making them ideal for real-time applications like this.[3]

D. OpenCV (Open Source Computer Vision Library):

OpenCV is a powerful library of programming functions primarily aimed at real-time computer vision tasks. It provides the tools necessary for image processing, video analysis, and object detection. In this project, OpenCV is used to process video feed from the camera, detect faces, and assist with real-time monitoring of driver behavior. It also helps with preprocessing the images that are fed into the CNN for verification.[4]

E. Optical Character Recognition (OCR):

OCR is used to read and interpret text, such as driver license numbers or other identification documents, directly from images. In SafeDrive Pro, OCR technology can be implemented to verify the driver's license or other credentials before allowing access to the vehicle. This adds an extra layer of security by ensuring that the driver’s identity is not only verified by face recognition but also by official documents.[5]

By combining these technologies, SafeDrive Pro creates a multi-layered driver verification system that can significantly reduce unauthorized vehicle use and enhance overall road safety. The system is scalable, meaning it can be deployed across different vehicle fleets, ensuring that only verified and authorized individuals can operate vehicles, thus mitigating the risks of accidents and theft.

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III. MOTIVATION AND OBJECTIVE

3.1 Motivation

The motivation behind the SafeDrive Pro - IoT Based Driver Verification System stems from the growing need to enhance vehicle security in an increasingly connected world. As vehicle theft, unauthorized use, and safety concerns rise, there is a clear demand for more secure and reliable driver authentication systems.[6] Existing solutions often fall short due to their reliance on single-factor authentication or their primary focus on fleet management rather than security. By integrating IoT technology with multi-factor authentication, SafeDrive Pro aims to fill this gap, providing a comprehensive solution that not only prevents unauthorized access but also offers real-time monitoring, data analytics, and seamless integration. This project is driven by the goal of improving road safety, reducing theft, and providing peace of mind to vehicle owners and fleet managers alike.

3.2 Objective

Develop a Multi-Factor Authentication System:

Create a secure, reliable driver verification process that integrates Licence Verification using ESP32, and Image verification.

Enhance Vehicle Security:

Prevent unauthorized access and operation of vehicles by ensuring only verified drivers can start and operate the vehicle.

Ensure Data Security and Privacy:

Design the system to handle sensitive data securely, addressing privacy concerns related to biometric and personal information.

Improve Road Safety:

Contribute to reducing accidents and liability by ensuring that only authorized and verified drivers can operate the vehicle.

IV. METHODOLOGY

Existing System:

Existing driver verification systems primarily rely on manual license checks or basic biometric methods. These systems often involve physical document verification or simplistic identity matching, lacking real-time monitoring and comprehensive security features. Consequently, they may be prone to fraud and inefficiencies, highlighting the need for more advanced, automated solutions.[7]

Proposed System:

1. We define system architecture, including hardware (ESP32, camera) and software components (server, database).\
2. We try to Implement a mechanism to check the driver's age using a database of registered users.
3. Use the camera to capture the driver's image for facial recognition using CNN algorithm.
4. Create and maintain a database for storing verified driver information and license details using OCR and HAAR cascading'
5. If verification is successful, send a signal to the ESP32 to start the engine; if not, implement a delay for re-capture attempts.

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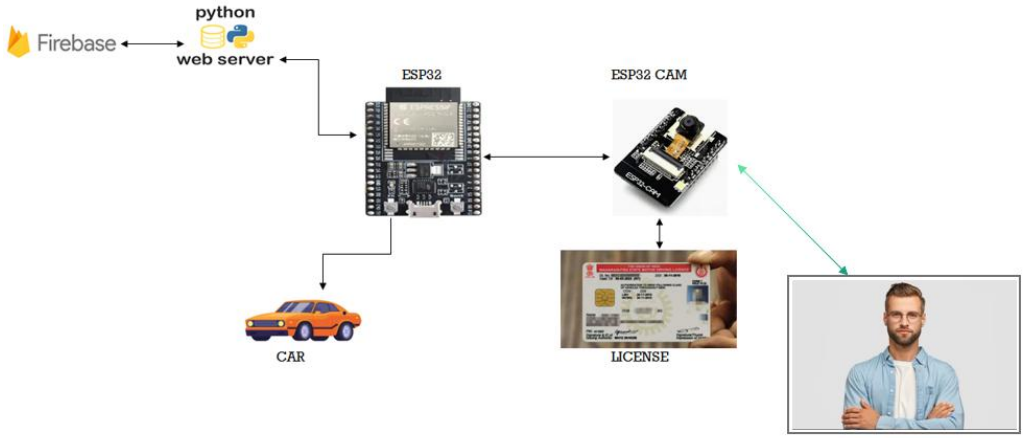

Fig 1. Circuit flow Diagram

Here's a breakdown of the components and their functions:

A. ESP32 Microcontroller:

Role: The ESP32 microcontroller is the central component that connects all other devices in the system. It handles data from the ESP32-CAM and communicates with external systems like Firebase and a web server.

Task: It transmits data (like facial recognition and license information) and sends control commands to unlock or lock the car.

B. ESP32-CAM (Camera Module):

Role: This camera module is connected to the ESP32 microcontroller. Its primary function is to capture live images of the driver's face and the license.

Task: The ESP32-CAM takes images of both the driver and their license, feeding this visual data to the ESP32 for further analysis.

C. License and Face Verification:

The system captures an image of the driver's face and their license using the ESP32-CAM.

Using OCR (Optical Character Recognition), the system reads the license details, such as the driver's name and identification number.

Simultaneously, facial recognition is performed by comparing the captured face image with a pre-stored dataset (hosted on Firebase).

D. Communication with Firebase and Web Server:

Firebase: The ESP32 communicates with a Firebase server, where driver data (like facial images and license details) is stored and verified. It also stores the driver's access logs.

Web Server (Python): A Python-based web server processes the information from the ESP32, analyzing the driver's data for authentication and performing real-time checks to validate the driver's identity.

E. Car Access Control:

Role: Once the driver's identity is verified (both their face and license), the ESP32 microcontroller sends a signal to unlock the vehicle.

Outcome: If the verification fails, the vehicle remains locked. If the verification is successful, the system grants access and unlocks the car for the driver.[8]

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F. Flow of Operation:

Capture: The ESP32-CAM captures images of the driver's face and the license

Data Transmission: The ESP32 microcontroller sends this data to Firebase and the Python web server for verification.

Verification:

The system compares the captured face with pre-stored authorized driver images using a facial recognition algorithm (like CNN).

OCR is used to extract details from the license, ensuring the person is authorized to drive.[9]

Response:

If the verification is successful, the ESP32 sends a command to unlock the vehicle.

If it fails, an alert can be sent, and the vehicle remains locked.

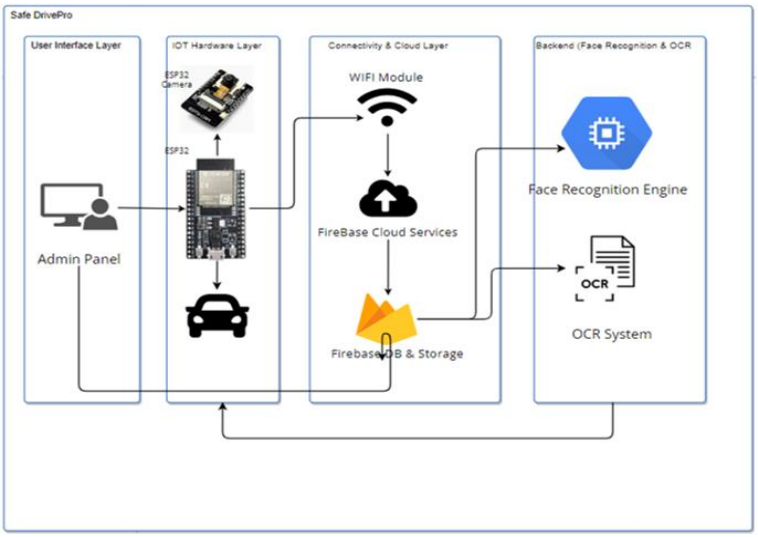

Fig2. Architectural Diagram

User Interface Layer:

Admin Panel: This is where administrators manage the system. It allows them to add or remove users, view reports, and monitor the system's performance. Think of it as the control center for managing who can drive the cars.

IoT Hardware Layer:

ESP32 Microcontroller and Camera: This small device acts like the brain of the system. It has a built-in camera that captures images of the driver and the vehicle. Whenever someone tries to start the car, the camera takes their picture. This is similar to how facial recognition works on smartphones.

Connectivity & Cloud Layer:

WiFi Module: The ESP32 uses a Wi-Fi connection to send the captured images to the cloud. This means that the data doesn't have to be stored on the device itself, but instead can be accessed from anywhere with an internet connection.

Firebase Cloud Services: This is a cloud platform where all the data (like images and user information) is stored. It allows for real-time access and management of the data. When the images are sent from the ESP32, they go to Firebase, where they can be processed and analyzed.

Backend (Face Recognition & OCR):

Face Recognition Engine: After the images are sent to Firebase, they are processed by the face recognition system. This technology checks if the person in the image matches any authorized drivers stored in the database. If the match is found, it means that the driver is allowed to start the car.

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OCR System: In addition to facial recognition, the system also checks the driver's license. The OCR (Optical Character Recognition) scans the license image to extract text, verifying details like the driver's name and age. This ensures that the driver is not only authorized but also meets age requirements.

V. LITERATURE SURVEY

Real-Time Driving License Verification System Using Face Recognition (2024):

Traditional methods of driver license verification often face challenges in terms of efficiency, accuracy, and real-time capabilities. To address these limitations, we propose a novel Driving License Verification System (DLVS) that leverages advanced facial recognition and optical flow techniques to revolutionize driver license verification. The DLVS seamlessly integrates with traffic management systems, enabling real-time verification of driver licenses, enhancing traffic communication, and promoting overall public safety.[1]

License Detection and Accident Prevention System with IoT:

The research paper titled "License Detection and Accident Prevention System" proposes an IoT-based system for validating driver's licenses and preventing accidents through various monitoring techniques. It includes features like RFID license verification, face recognition for driver identification, drowsiness detection, and intoxication detection using deep learning algorithms. Additionally, the system integrates a real-time emergency alert mechanism to notify authorities upon detecting an accident.[2]

License Verification System With Face Recognition Using IOT(2021):

A Driving license identification system as a part of smart city development. Driving license system is a huge task for the government to monitor. Whenever the person gets the license that time, the face of the person is stored in the database. Haar-Cascade Classifier algorithm is used for face detection and Local Binary Pattern algorithm for recognition technology. The hardware components are cost effective, small in size and has sufficient computational power for application-oriented components. The frivolous nature of licence owners makes it hard to take care of the documents they hold and brings the job of police officers to critical state when verifying the details. This project prevails in the way for replacing the usage of hard copies with digital footprint. To overcome this problem face detection and finger print based license authentication system using IOT will be implemented. Raspberry pi is the brain of this system, which helps for face detection and face recognition. The USB camera gets interfaced with raspberry pi to get the data from user.All these data are uploaded to the cloud (IOT) through NodeMCU It is used to find the person having license or not and also get the validation of the license. Whenever the person doesn't have a legitimate license or if the license is already expired, the display indicates it is invalid and vice versa.

Authenticated Access Control for Vehicle Ignition System by Drivers License using IOT:

This research presents a vehicle ignition system that enhances security through a multi-layer authentication process, specifically focusing on verifying the driver's identity via a driver's license and biometric data (fingerprint recognition). The proposed system integrates several technologies, including RFID for license validation and a fingerprint module to ensure that only authorized users can start the vehicle.

Face Recognition Based on Convolutional Neural Network:

The paper explores a face recognition method utilizing convolutional neural networks (CNNs). It details a CNN architecture comprising three convolutional layers, two pooling layers, and fully connected layers, concluding with a Softmax layer for classification. The research emphasizes the improved accuracy and efficiency of CNNs over traditional methods in facial feature extraction and recognition.

VI. PROJECT FEASIBILITY AND SCOPE

Project Feasibility

Although securing a vehicle completely is not possible, this project aims to shorten the gap between flexibility and security of the vehicle. This project provides a sensible thought to accomplish and improve security and to prevent the

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events of thefts and accidents. IoT while still in its beginner stage has gigantic potential to automate variety of functions to a certain level and ensure that the processes continue to work without human intervention. This project also tries to better the existing security systems which though provide sensible security but have certain drawbacks.

The SafeDrive Pro IoT-Based Driver Verification System demonstrates high feasibility across technical, economic, operational, legal, and social dimensions. The integration of established technologies, potential for significant cost savings, compliance with legal standards, and increasing public awareness of road safety issues collectively indicate that this project has the potential to succeed.

The implementation of such a system could significantly contribute to reducing road accidents caused by unauthorized drivers, thereby enhancing public safety and vehicle security. As technologies continue to advance, the system can adapt and evolve, making it a forward-looking solution for the challenges of modern transportation.

Scope

Enhanced Vehicle Security: Improves driver authentication to prevent unauthorized access.

1. Real-time Face Recognition: Provides instant driver verification.
2. IoT Integration: Enables seamless communication between the vehicle and authentication sys tem.
3. Data Accuracy: Uses OCR for precise extraction of driver license details.
4. Scalable Solution: Can be expanded for use in commercial fleets or individual vehicles.
5. Cloud-based Data Storage: Secures driver information using Firebase.
6. Customizable Verification Levels: Allows multi-factor authentication with face recognition and license validation.
7. Potential for Industry Adoption: Suitable for logistics, public transportation, and personal vehicles.
8. Cost-Effective Security: Offers an affordable alternative to current vehicle security systems.

VII. CONCLUSION

SafeDrive Pro presents an innovative solution to address the growing problem of underage and unauthorized drivers. By integrating IoT technology with advanced multi-factor authentication systems, including age and identity verification through face scanning and license checks, the system ensures that only authorized, licensed drivers can start and operate vehicles. This preventive approach not only enhances vehicle security but also significantly reduces the risk of accidents caused by underage or unlicensed drivers, ultimately contributing to improved road safety and legal compliance. In today's world, road accidents caused by unqualified or unauthorized drivers have become a growing concern. Many of these incidents involve underage drivers who lack the experience and training required to handle vehicles safely. Furthermore, unauthorized drivers, including those without a valid driver’s license, can also put themselves and others at risk. In response to these pressing issues, SafeDrive Pro has been designed as a proactive and intelligent solution that leverages the latest advancements in IoT and machine learning to prevent unauthorized vehicle usage.

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