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EV Secure – Multifactor Smart Safety and Security System for Electric Vehicles

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Abstract: — *With the increment in Electric vehicles, the safety of rider and security of vehicle has been one of the prime concern, in Electric 2 wheels. The rider safety rules are not being followed by most of the riders, and various cases of theft of vehicle are happening due to inefficient security system. To overcome this, a smart safety-security system, for Electric 2 Wheels named as "EV Secure" is proposed. Multiple authentication approaches are integrated into the system, to ensure rider safety as well as vehicle security. An IR sensor detects whether the rider is wearing a helmet or not, face recognition and fingerprint authentication authenticates the right rider. The vehicle is only then ignited, after all the authentication processes are done successfully, otherwise the ignition is not turned on. Apart from the authentication, GPS tracking and GSM communication are also implemented, to serve as the vehicle tracker and theft detector. The GPS module continuously track the vehicle, whereas the SMS alerts are sent by the GSM module to the user in case of any illegal activity or emergency. The whole system is controlled by an ESP32, which provides communication to all the hardware modules integrated in the system, efficiently. This system is designed to be cheap, compact and reliable and can be practically applied in Electric vehicles. To summarize, the proposed project "EV Secure" tackles the issues of helmet non-wearing and vehicle theft in an integrated smart way. This project can help in reducing the accidents caused by helmet negligence, and also increase the security of vehicles*

Keywords: EV Security, Smart Helmet, ESP32, Face Detection, Fingerprint Authentication, GPS Tracking, GSM Module, Electric Vehicle Safety, IoT

I. INTRODUCTION

Electric vehicles are a very fast growing mode of transportation because they help in curtailing air pollution and conserve fuel. But the safety and security issues of electric bikes are still a major concern in the field. Many road accidents are caused due to failure of helmet usage due to lack of a system that can detect whether rider is using a helmet or not. Unauthorized access t o vehicle increases the number of theft cases. The normal ignition systems of vehicles only have keys and simple electronic lock systems which cannot differentiate between valid/invalid user and rider wears helmet or not. Existing systems do not have real time monitoring and tracking capabilities. Due to the growth of embedded systems and IoT technology, hybrid safety systems can be designed using sensor, camera, biometric authentication systems and wireless modules that would help in reducing the road accidents and Theft problems. In this project “EV Secure”, is a multi-factor authentication and vehicle tracking system using the GPS and GSM modules. It detects the helmet usage with ESP32-CAM, verifies the face, authenticates the fingerprints with R307 and provides ignition to the vehicle with the help of relay module. It provides tracking with the help of GPS module and alert messages using GSM module. The proposed system aims in providing a simplified, reliable, and low cost smart security system for electric vehicles for the safety of rider along with vehicle security. ([RJPN Research Journal][2])

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II. LITERATURE REVIEW

A. Existing Systems

Different types of smart helmet and vehicle security systems have been developed by using embedded system and IoT technologies. Most of the developed systems have helmet detection sensor to prevent user from riding without helmet, and some systems have accident detection and emergency button alert systems with help of GPS and GSM module. ([ResearchGate][1]) Modern smart helmet systems have used biometric authentication like fingerprint detection method for secure login and wireless communication between engine and helmet module. These systems enhance security and prevent third party intrusion. ([EBSCO OpenURL][3]) Vehicles security systems using IoT technologies have various other features like GPS tracking, remote monitoring and alarm booking, and emergency notification through mobile apps. These systems have excellent vehicle monitoring ability but they will increase system cost and complexity.([IJERT][4])Advanced smart helmet systems have used various technologies like alcohol detection, emergency accident detection, GPS tracking and ignition control to improve rider safety and avoid accidents.([OpenRGate][5])

B. Limitations of Existing Systems

- Only one-factor authentication in most system
- Limit security against unauthorized use.
- Some system only check whether you are wearing a helmet or not. Do not check the identity of user.
- Very high system complexity & cost.
- Do not have face recognition & fingerprint authentication. Not have real time tracking function & remote control.
- Not focus on electrical vehicle.

C. Research Gap

Requirements for a smart and integrated system. The system should be able to:

- Confirm the rider is wearing a helmet through camera based detection.
- Authenticate the rider through face recognition and fingerprint identification.
- Block any illegitimate vehicle ignition. Enable GPS tracking and GSM messages.
- Ensure rider's safety as well as vehicle protection at the same time.
- Function efficiently while providing low cost for electric vehicles.

To address it the new EV Secure system will integrate helmet detection, face recognitions, fingerprint authentication, GPS tracking and ignition control features in one intelligent and secure safety platform.

III. PROBLEM STATEMENT

The number of two wheeler road accidents is increasing day by day through negligence in helmet wearing and riding in a careless way. Simultaneously, the number of vehicle thefts and unauthorized vehicles is also increasing rapidly. The current vehicle ignition system cannot verify that the vehicle is being driven by a responsible person, and that the rider wears a helmet. Many smart helmet systems use a basic set of sensors, and do not offer complete authentication and tracking features. Some systems are expensive and difficult to implement in small scale electric vehicles. To ad dress the above problems, the proposed EV Secure system gives a single multifactor smart safety and security system for electric bikes. The system employs helmet detection, face recognition, fingerprint authentication, GPS tracking, and GMS communication that allows only the authorized persons with the helmet to operate the vehicle. The system also enhances road safety and monitoring. ([Atlantis Press][6])

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IV. PROPOSED SYSTEM OVERVIEW

The proposed EV Secure is a smart vehicle security and safety system for electric bikes. It utilizes the ESP32-microcontroller, ESP32-CAM, R307 fingerprint sensor, GPS module, GSM module and relay module to provide secure vehicle access and rider safety.Currently, the system utilizes the ESP32 - CAM to check for helmets and face detection, as well as for rider identification using fingerprint authentication. The vehicle is only initiated on determination of all correct conditions. Both GPS tracking and GSM communication are achieved through Blynk mobile application, providing real-time monitoring and alerts.The system increases the safety of the rider and intelligence of the vehicle security system.

V. SYSTEM ARCHITECTURE

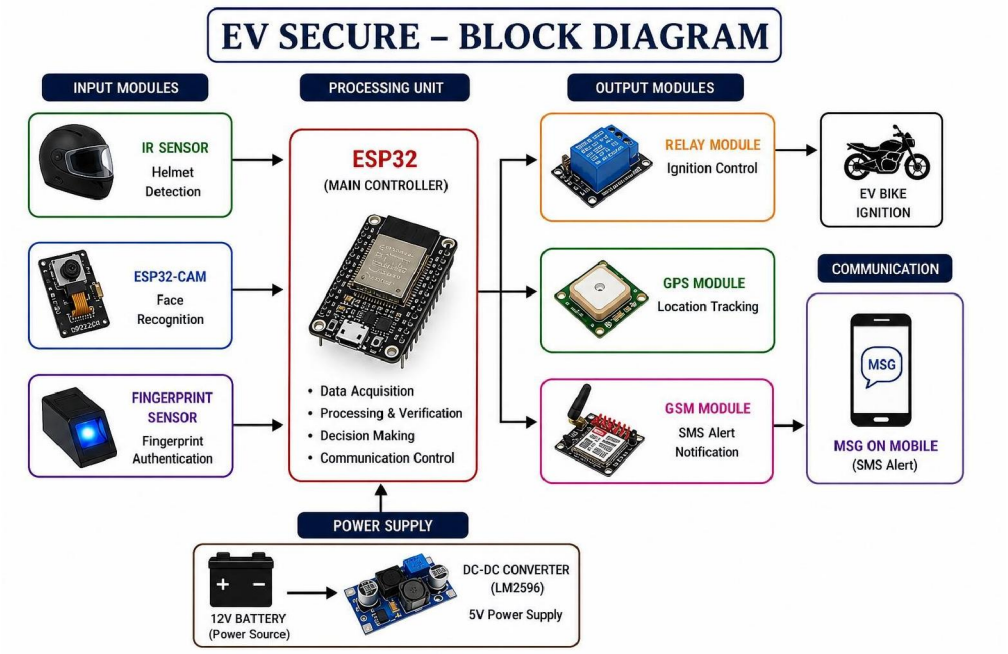

Fig. 1. System Architecture of EV SEcure

VI. SYSTEM ARCHITECTURE OVERVIEW

The system architecture of proposed "EV Secure" to ensure a smart ride and the security of electric vehicle is designed with numerous authentication and monitoring modules. The entire system architecture is broadly categorized into 4 sections: input modules, processing module, output modules and communication system. The input modules are intended with the ESP32-CAM Module, which captures the image of the faces for face detection and Helmet detection and also the R307 fingerprint sensor, for user identification. These modules are responsible to fetch rider details and transmit them to the main controller. The main controller used in our proposed system is the ESP32 microcontroller, which receives data from the input modules and the condition of the user authentication is done based on the received data a nd the decision to the vehicle ignition and monitoring operation is accomplished accordingly. The output modules contains the relay module connected with the ignition of the EV bike, which can be turned ON only after the helmet detection, face detection and the fingerprint authentication, which is provided by the fingerprint sensor. The GPS module can constantly identify the moving direction of the vehicle. The communication system is built-in with the

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SIM800L GSM Module, which communicates via the SMS service, to obtain the alerts to the user mobile in respect to the vehicle locations and the other notifications.

The entire system is powered using a 12V EV battery and a LM2596 DC-DC buck converter, which offers the stabilized 5V power source to the entire electronic modules.

VII. IMPLEMENTATION DETAILS

The hardware and software implementation of the EV Secure system can be explained separately. The aim of the hardware implementation is to develop a smart electric vehicle safety and security system that performs helmet detection, face recognition, fingerprint authentication, GPS tracking and ignition control.

A. Hardware Implementation

All the electronic components used to assemble the EV Secure system are included in this hardware setup. The main controller unit is the ESP32 Dev Kit which is connected to and controls the other modules. The helmet detection and face recognition is achieved using the ESP32-CAM module which captures rider image and verifies safety condition before ignition. The biometric authentication module used is the R307 fingerprint sensor which checks whether the rider is an authorized user. The ignition system of the electric bike is controlled using a 5V relay module which is activated only when helmet, face and fingerprint authentication are verified. The vehicle location tracking system is achieved by using the NEO-6M GPS module while the SMS alerts are generated using the GSM Module, SIM800.L.The system is powered by a 12V EV Battery which supplies the voltage and the regulated voltage is supplied by LM2596 buck converter. All the electronic components are properly wired and mounted on the electric vehicle prototype.

B. Software Implementation

The software part is developed using Arduino IDE with Embedded C language. The ESP32 constantly checks the Arduino ID data coming from the ESP32-CAM and the fingerprint sensor to establish that helmet is detected, face is recognized and fingerprint matches .Once all the above mentioned conditions are encountered, the EV comes into action and the relay module is activated to start the electric vehicle. The GPS module keeps updating vehicle location and the GSM Module keeps sending the notifications and alerts to the user over message to mobile. Helmet status is checked even during riding and if helmet is removed after start then the system runs for a limited distance before stopping the ignition.

C. Working Algorithm

Modules available and required

- Read and detect helmet using IR sensor
- Using ESP32- Perform face detection
- Scan fingerprint R307 sensor. Authenticate both fingerprint and face.
- If success all authentications – open relay, then start the EV bike.
- Else keep ignition off
- Using GPS to continuously monitor the vehicle location
- Trigger the alert through GSM.

D. Implementation Outcome

The final EV Secure system successfully achieved the following results:

- Provenance helmet detection
- Speedy face recognition
- Secured fingerprint authentication

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- Automated EV ignition system
- Tracking vehicle location through GPS. Notifying with alert message through GSM

Controller	ESP32-Main control unit for processing and decision making
Camera Module	ESP32-CAM face detection
IR Sensor	For helmet detection
Authentication	R307 fingerprint sensor- user authentication
Ignition Control	5V relay module-control EV bike ignition
Tracking	NEO-6M GPS Module- Real time Location tracking
Communication	SIM900L GSM Module-SMS Alerts and communication
Power Supply	12V Battery Provides power to entire system
Software	Arduino IDE - Used for programming and control logic
Programming	Embedded C – Used for coding and logic implementation
Functionality	Helmet detection, Face detection, Fingerprint authentication , GPS Tracking , ignition control

XIII. EXPERIMENTAL RESULTS AND ANALYSIS

The developed EV Secure: Multifactor Smart Safety and Security System for Electric Bikes was tested in actual operating conditions. The aim of testing was to measure the authentication performance, helmet detection, response time, GPS position tracking, security efficiency of the system..

A. Experimental Setup

The robot was placed in an area with obstacles such as small objects and walls to simulate real farm conditions. The system was powered using a battery, and the robot was controlled using a mobile device through Bluetooth. Multiple test runs were conducted to observe its behavior under different conditions.

B. Results

During The EV Secure system were fitted on an electric bike prototype. The system integrated an ESP32 microcontroller, ESP32-CAM for face and helmet detection, R307 fingerprint sensor, GPS module, GSM module, relay circuit, and Blynk Mobile Application.The system were tested under varied scenarios such as:

- Unauthorized and authorized user access
- Helmet worn and no-helmet riding
- GPS location tracking
- Fingerprint authentication
- Relay intelligent ignition control

The system was powered from an EV type 12V battery, and a buck converter was used to regulate the power supply to appropriate levels

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C. Comparative Analysis

Compared to existing conventional security systems available for two-wheelers, the proposed EV Secure system would add/serve the purpose of: 1. Better security system due to multi-factor authentication. 2. Higher rider safety due to helmet detection. 3. Improved mobility performance due to GPS. 4.Enhanced monitoring system due to mobile application.5.Better security than keys Based on the developed prototype, for now the system is more sophisticated but the only disadvantage would be environmental factors like low light or faces covered up by some object, which might diminish the detection rate slightly

D. Summary

The experimental program carried out in the course of this study clearly demonstrated that the proposed EV secure system could be used as a practical method to effectively handle electric bike security and rider safety issues.The system to be introduced as a smart system by including various modules such as face detection, helmet detection, fingerprint authentication, GPS and GSM modules successfully. The project guarantees vehicle security as well as proposes safety by use of electric (power assisted) vehicles which based on the distance covered. Overall the solutions built in this project could be utilized to build functional working security system suitable for smart transport system.

IX. RESULTS AND ANALYSIS

:X RESULTS AND ANALYSIS

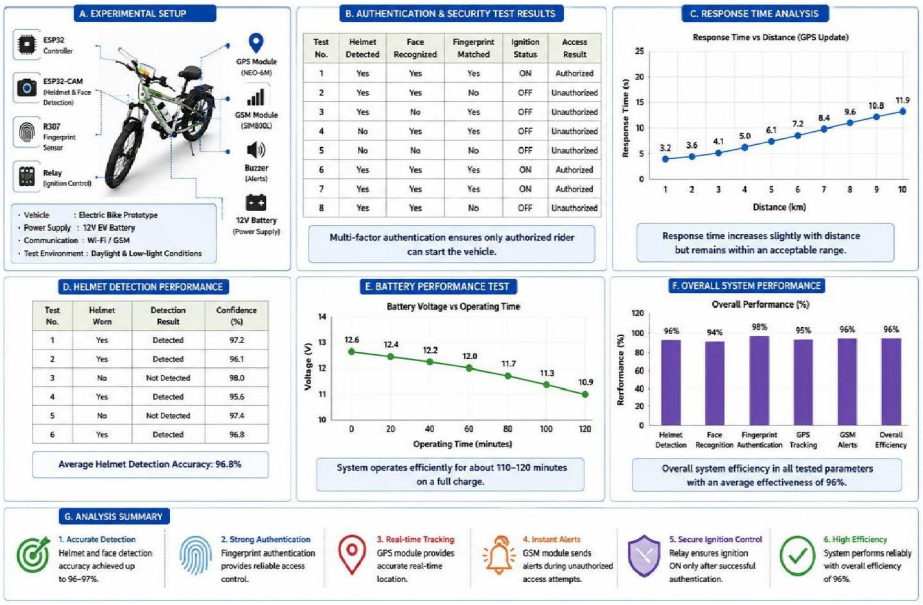

Fig. Result and Analysis

X. DISCUSSION

The development and testing of the EV Secure system demonstrate that smart authentication and monitoring technologies can significantly improve electric bike security and rider safety. The integration of helmet detection, face recognition, fingerprint authentication, GPS tracking, and GSM communication creates a powerful multifunctional security system. The ESP32 microcontroller effectively coordinated all modules and ensured smooth operation. Experimental testing confirmed that the system can prevent unauthorized vehicle usage while also promoting helmet safety compliance. The GPS and GSM features enhance security by enabling real -time tracking and emergency alerts.

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The project provides a cost-effective and practical solution for modern EV security applications and can be furt her improved using AI-based recognition and cloud connectivity in future developments.

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