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A Data-Driven Engine Starter System Using ESP32 With Multi-Layer Authentication and Alerts

Parunandhi Amareshwari[1*], Susmitha Reddy Karnati[2], Sahithi Nakirtha[3], Vasudha[4], Sai Swetha[5]

[1,2,3,4,5] Vignan's Institute of Management and Technology for Women (VUMTW), India

Email: amareshwari.parunandi@gmail.com[1*], sangarisusmita1122@gmail.com[2], sahithinakirtha2003@gmail.com[3], Vasudha2278@gmail.com[4], swayampakalasai@gmail.com[5]

Abstract

The Data-Driven Engine Starter System using ESP32 is designed to enhance engine security by integrating multi-layer authentication mechanisms, including password input, fingerprint recognition, and RFID/NFC technology. This system prevents unauthorized engine access, ensuring only authenticated users can operate it. In addition to robust authentication, the system leverages IoT connectivity to provide real-time alerts and monitoring, allowing users to control and oversee engine activity through a mobile app or web interface. By incorporating failsafe mechanisms and cloud-based logging, the system guarantees operational reliability and security, making it suitable for automotive, industrial, and fleet management applications. The system further enhances reliability through IoT connectivity, allowing remote monitoring, control, and alerts via a dedicated mobile app or web interface.

Keywords

Arduino IDE, Fingerprint Sensor Module, Relay Module Control, User Authentication

Introduction

Because of automated assimilation and access control systems, many companies have managed to defeat their security problems. Nowadays, anything connected to the system allows people to access data from anywhere worldwide. That's why hacking your data is an important concern. For this reason, you need to have some form of ID so you can access your info. Different technologies are used at different times to keep tabs on a person's location and prevent them from entering secure zones. Individual identification is most often done using passwords or ID cards. Secret passwords and ID cards are often not difficult to compromise, which means these techniques have a lot of doubt surrounding them.

Smile detection and facial expression recognition have evolved significantly with the

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advent of machine learning and computer vision. Early methods focused on handcrafted features like Local Binary Patterns (LBP) and Haar cascades for smile recognition (Shan et al., 2009), which, while lightweight, were sensitive to variations in lighting, pose, and occlusions.

More recent approaches have leveraged deep convolutional neural networks (CNNs) for robust smile and facial expression classification. For instance, GENKI-4K, a widely used smile detection dataset, has enabled models to train on spontaneous and posed smile images in natural settings (Whitehill et al., 2009). The CelebA dataset has also been instrumental in training classifiers on facial attributes, including smiles, under a wide variety of real-world conditions (Liu et al., 2015). Real-time smile detection has found applications in accessibility tools and consumer electronics. Some commercial implementations, such as the Smile Shutter in Sony cameras, employ proprietary algorithms to automatically capture photos when a smile is detected (Sony Corporation, n.d.).

However, these systems are often closed source, limiting extensibility and research validation. Gesture-based and voice-triggered selfie systems have been explored in the context of human-computer interaction. Research in this domain suggests that while gestures and voice commands are effective, smile detection offers a more intuitive and universally understood trigger mechanism (Turker & Alpaydin, 2013). In terms of model efficiency, lightweight CNN architectures such as MobileNet and SqueezeNet have been proposed for mobile expression recognition systems (Swamy et al., 2023). These architectures balance accuracy and inference speed, making them suitable for edge devices. Our system builds on this foundation, using a compact CNN tailored for smile detection that achieves high accuracy with low computational overhead.

Additionally, works on real-time video processing frameworks such as MediaPipe (Sirisati et al., 2021a) and OpenCV's DNN module (Sirisati et al., 2021b) have shown reliable performance for face and landmark detection, serving as strong foundations for smile-triggered event systems. Integration with Flask has also been popular in academic and prototype systems for deploying lightweight, interactive ML interfaces (Swamy et al., 2021). Despite these advancements, few open-source systems offer an integrated solution for hands-free selfie capture triggered by smile detection. Our work addresses this gap by combining deep learning-based smile recognition with real-time web-based interaction, optimized for both desktop and embedded environments.

Attempts have been made to work with both RFID and biometric methods at once to make sure access to the automatic sensing of the entity is safe and secure. A person places his card with an RFID tag and then scans his fingerprint with the sensor to check against what is stored, so his card entry is more convenient than the old-fashioned key. Instead of a key, the door will open when you show the RFID tag and your fingerprint. Should someone with an RFID card try to use their fingerprint at the door, it will not match. Even using a fingerprint sensor is not possible until an RFID card is punched, and efforts have been made to use both technologies at the same time for stronger security. Swipe the RFID-tagged punch card near the sensor and put your finger on the fingerprint reader to make sure the process matches to help you enter rather than using just a key. In its place, laying the RFID tag and placing your finger on the fingerprint pad will instantly open the door. If anyone tries to open the door with their fingerprint after possessing an RFID

tagging card, they won’t be able to because they don't match. No fingerprint sensor will be used until the RFID card has been punched.

Materials and Methods

A data-driven Engine Starter System using the ESP32 microcontroller incorporates advanced multilayer authentication and alert mechanisms to enhance security and functionality. This system ensures that only authorized users can start the engine by implementing multiple layers of authentication, such as RFID, biometric verification, or password protection. The ESP32 serves as the central controller, enabling connectivity through Wi-Fi or Bluetooth for real-time monitoring and control. Additionally, the system is integrated with an alert feature that notifies the user via SMS, email, or mobile application in case of unauthorized access attempts, system tampering, or unexpected failures. These features make the system highly reliable, secure, and suitable for modern vehicles or industrial machinery, providing enhanced safety and user convenience.

The proposed Data-Driven Engine Starter System using ESP32 introduces a highly secure and efficient solution for vehicle or machinery ignition control. This system leverages the ESP32 microcontroller for its robust processing capabilities and connectivity options, enabling a seamless integration of multilayer authentication and alert features. The authentication process includes multiple security layers, such as password entry, biometric verification (fingerprint or face recognition), and RFID-based access. These layers ensure that only authorized users can initiate the engine. Furthermore, the system incorporates real-time alerts via SMS, email, or a mobile application to notify the owner of unauthorized access attempts or any anomalies. The proposed design enhances both security and usability, making it suitable for modern applications where safety and convenience are paramount. For example, Table 1 is an example of a table format. The proposed Data-Driven engine starter system leverages the ESP32 microcontroller to deliver advanced security and monitoring features for vehicles. This system utilizes multilayer authentication methods, including passwords, OTPs, and potentially biometrics, to ensure only authorized users can access and control the engine.

Results and Discussion

The existing system contains some issues like slow manual checks causing queuing of needers, inconvenience of real-time data, and misinformation concerning vehicle owners. To get rid of the issues, we advise vehicle authentication with sensitive tag mistreatment RFID so that we can manage time intense throughout vehicle scrutiny.

A data-driven engine starter system using an ESP32 microcontroller integrates multilayer authentication and alerts to enhance vehicle security and monitoring. This system employs various sensors, GPS, and GSM modules to provide real-time tracking, engine start/stop control via a mobile app, and alerts for critical events like low fuel, over-speeding, or unauthorized access. The multilayer authentication ensures secure access, while the alerts keep the vehicle owner informed about any potential issues.

The proposed Data-Driven engine starter system leverages the ESP32 microcontroller to

deliver advanced security and monitoring features for vehicles. This system utilizes multilayer authentication methods, including passwords, OTPs, and potentially biometrics, to ensure only authorized users can access and control the engine. It integrates GPS for real-time location tracking and a GSM module to send alerts for events such as low fuel, over-speeding, or unauthorized access. Sensors monitor various parameters, providing the user with comprehensive data and control via a mobile app, enhancing both the security and convenience of vehicle management. It integrates GPS for real-time location tracking and a GSM module to send alerts for events such as low fuel, over-speeding, unauthorized access attempts, or any anomalies. The proposed design enhances both security and usability, making it suitable for modern applications where safety and convenience are paramount.

By tradition, it was in China where fingerprint records began. At this stage, records of teckneck use included clay with thumbprints to identify them. Several records from the 14th century in Persia displayed an impression of a finger. Research has found that every person's fingerprints are different from anyone else's. Henry Faulds recommended in 1880 that friction ridges be used widely on crime scene evidence to identify the criminals. For example, soot on a white wall showed that an accused was innocent, and grease on a cup showed who had drunk some alcohol. No matter what the ignition system, all vehicles today depend on the computer-controlled battery ignition circuit, using the battery, switch, coil, switching device, and spark plug (Delmar, 2008). Yet now that biometrics is part of modern technology, it is applied for Ignition and security processes (as mentioned by: Omidiora et al., 2011, Sasi and Nair, 2013, Karthikeyan, A. and Sowndharya, J, 2012, Pingat et al., 2013).

The aim of the Data-Driven Engine Starter System using ESP32 is to develop a secure, efficient, and technologically advanced system for controlling engine ignition. This project seeks to enhance the safety of vehicles or machinery by incorporating multilayer authentication mechanisms, such as password protection, biometric verification, and RFID access, to prevent unauthorized usage. Additionally, the system aims to provide real-time alerts and notifications to users in case of unauthorized access attempts or system malfunctions. By leveraging the versatile capabilities of the ESP32 microcontroller, the project aspires to deliver a reliable and user-friendly solution that combines enhanced security, convenience, and modern connectivity features.

The domain of the Data-Driven Engine Starter System using ESP32 falls under the categories of Embedded Systems, Automotive Electronics, and IoT-based Security Solutions. This project combines the principles of embedded system design with advanced security protocols to develop a smart and secure engine control system. Leveraging the capabilities of the ESP32 microcontroller, it integrates Internet of Things (IoT) connectivity, enabling real-time monitoring and notifications. The project also incorporates multilayer authentication techniques to ensure robust access control, making it highly relevant in the domains of smart vehicle systems, industrial automation, and secure IoT applications

The scope of the Data-Driven Engine Starter System using ESP32 encompasses the development of a secure and versatile engine ignition system suitable for modern vehicles, industrial machinery, and other motorized equipment. The project aims to enhance security through multilayer authentication, including password protection, biometric verification, and RFID access, ensuring that only authorized users can start the engine.

The Data-Driven Engine Starter System using ESP32 involves the collection of various data points to ensure secure and efficient operation. Authentication data, such as user credentials (passwords, RFID tags, or biometric scans), is gathered and securely stored or verified against a database to allow authorized access. The system also collects real-time data from sensors (data-driven) and the ESP32 microcontroller to monitor engine status, access attempts, and system integrity. In cases of unauthorized access or system anomalies, data is logged and used to trigger alerts via SMS, email, or a mobile application. This collected data is critical for ensuring robust security, analyzing system performance, and providing insights for future improvements or troubleshooting. The overall system prototype is depicted in Figure 1 below.

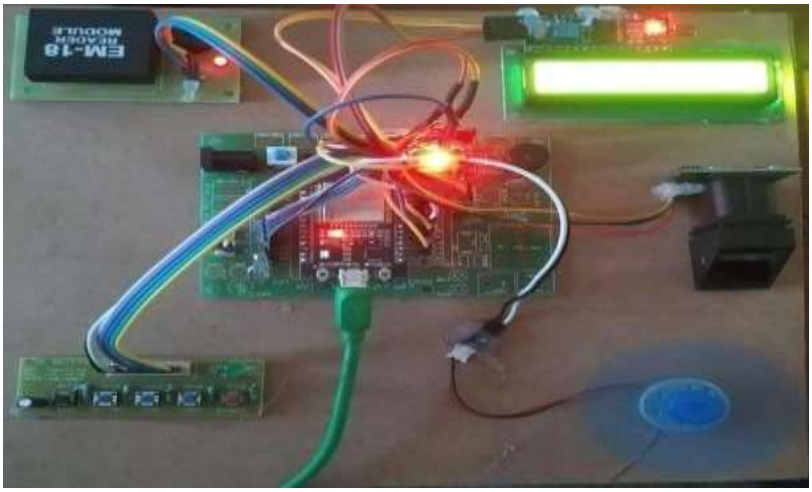

Figure 1. Data-Driven Engine-Data Starter

Conclusion

The world is being modernized day by day, and it needs technological backup with stronger protection and security of valuable secret code, hiding data, and items. This research work has the very purpose of providing robust security systems with automatic sensing and operating action to access or decline. It is a developed safety security and impermeable to baffle this security system. Security is maintained with sequential operation of the RFID and fingerprint sensor, and without the loss of one, access is denied. This security system is cheaper, flexible, less time-consuming, and also does not require committing any code or password to access. Fingerprint scanning and sensing can also be used to protect computer files and data. It is a very reliable security system and can provide the highest security. This project showcases a modern and secure vehicle engine starting system based on the ESP32 microcontroller with advanced multi-layered authentication as well as instant notification features. Decision-making based on data and multi-layered password entry, RFID, and fingerprint systems strengthens access control and security for the vehicle. The ESP32's utilization of mobile and web technologies permits the alerting system to issue mobile or web alerts, thus ensuring users are instantly notified of any unauthorized access.

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