



Biometric Authentication for Vehicle Security System Using Raspberry pi

Sudarshan T B Ramana¹, Rohini H N², Priyanka N³, Ankitha V⁴, Rashmi M Hullamani⁵

Research Student, Dept. of ETE, J N N C E, Shimoga, India¹⁻⁴

Assistant Professor, Dept. of ETE, J N N C E, Shimoga, India⁵

Abstract: This project presents an innovative approach to a comprehensive Vehicle Security System leveraging advanced technologies for enhanced protection. The system integrates Keypad Password, Face Recognition, and Fingerprint sensor mechanisms, ensuring multi-layered access control. Raspberry Pi serves as the central processing unit, adapt these security features seamlessly. Additionally, a Servo Motor Unlocking System is implemented, utilizing fingerprint verification to activate the motor, enhancing security further. To prevent theft attempts, an Anti-Lift feature employs a Ultrasonic Sensor, triggering alarms and immobilizing the vehicle if unauthorized movement is detected. This union of biometric authentication, innovative motor unlocking, and anti-lift measures establishes a robust and intelligent security for vehicles, addressing modern challenges in vehicular safety and theft prevention.

Keywords: Raspberry Pi, Keypad Password, Face Recognition, Fingerprint sensor, Ultrasonic Sensor, Servo Motor.

I. INTRODUCTION

Automobile security is one of the growing concerns in India. In a world where automotive technology is rapidly evolving, these key less vehicle security systems have become more and more popular. They are characterized by their use of advanced features such as biometric authentication methods, which replace The traditional physical key. Safeguarding of vehicle against theft is one of the major issues confronting developing countries. one of the most widely used systems is face recognition and finger print based system. The foundation of this security system lies in its multi-layered authentication mechanism. By integrating face recognition, keypad password, and fingerprint-based unlocking, the system ensures heightened security by requiring multiple forms of authentication before granting access. This approach not only enhances security but also offers flexibility, catering to diverse user preferences and scenarios. The Face Recognition feature employs advanced image processing algorithms to authenticate the user's identity through facial biometrics, adding an extra layer of security. Simultaneously, the Keypad Password functionality allows users to input a unique code for access, providing an alternative authentication method for increased flexibility. Furthermore, the Fingerprint-Based Servo Motor Unlocking System enhances security by incorporating biometric data for verification. The servo motor, controlled by the Raspberry Pi, ensures precise and secure unlocking mechanisms based on the authorized fingerprint. To fortify the system against theft and unauthorized towing, a ultrasonic Sensor has been integrated, acting as an anti-lift mechanism. This sensor detects any abnormal tilting or lifting of the vehicle, triggering an immediate alert and preventing potential theft scenarios. The seamless integration of these authentication methods and security features into a unified Vehicle Security System provides a robust solution for safeguarding vehicles against unauthorized access and potential theft.

The use of Raspberry Pi as the central processing unit ensures the system's efficiency, flexibility, and adaptability to evolving security needs in the dynamic realm of vehicular protection. At the heart of this system is the Raspberry Pi, a versatile single-board computer renowned for its functionality and ease of integration. Leveraging the computational power of the Raspberry Pi, the security system orchestrates the authentication processes, sensor interactions, and control mechanisms seamlessly. Its compact form factor and extensive community support make it an ideal choice for this application, offering scalability and customization options. The integration of face recognition technology adds an additional layer of security by authenticating users based on unique facial features. Utilizing a camera module connected to the Raspberry Pi, the system captures and analyzes facial images to verify the identity of the user. Advanced algorithms process these images, comparing them against stored templates to authenticate the user's identity accurately. This biometric authentication method provides a high level of security while offering user convenience and efficiency. In parallel, the keypad password serves as a reliable fallback authentication method, ensuring access in scenarios where facial recognition may be hindered, such as low light

conditions or occluded faces. Users can input a predefined password using the keypad interface, which is then validated by the system. In 2013, Radio frequency Identification (RFID) cards were designed for ignition start of automobile. However, the chances of losing the card or it being stolen led to the failure of the system. To address this concern, we introduce an advanced vehicle Security System this innovative system provides multi-layered security to safeguard your



vehicle from theft. This advanced vehicle Security System offers comprehensive protection for your vehicle and you can have peace of mind knowing that your vehicle is safeguarded against theft.

II OBJECTIVES OF OUR PROJECT WORK

1. Implement a robust system that requires successful verification through all three methods to grant access to the vehicle, enhancing security and preventing unauthorized access.
2. Integrate and synchronize the face recognition, keypad password, and fingerprint scanning modules continuously with the Raspberry Pi, ensuring efficient and reliable performance.
3. Implement logging functionality to record and store access attempts, successful or unsuccessful, providing users with a history of access and security administrators with valuable information for monitoring and troubleshooting.

III. LITERATURE SURVEY HISTORY

The integration of advanced technologies in vehicle security systems has become imperative in combating the rising instances of vehicle theft. A comprehensive literature survey reveals the efficacy of employing multifactor authentication mechanisms such as face recognition, keypad password, and fingerprint-based unlocking systems to fortify vehicular security. Leveraging the computational power of Raspberry Pi, coupled with ultrasonic sensors, presents a robust solution to counter unauthorized access and prevent vehicle theft. Face recognition technology, a subset of biometric authentication, has garnered considerable attention due to its accuracy and non-intrusive nature. By analyzing unique facial features, such as facial contours and landmarks, vehicles equipped with face recognition systems can grant access only to authorized individuals, thereby minimizing the risk of theft. Complementing this, the integration of a keypad password adds an additional layer of security, requiring users to input a predefined code for access. Furthermore, incorporating fingerprint-based unlocking systems enhances security measures by relying on the distinct patterns of an individual's fingerprints. This biometric authentication method offers unparalleled accuracy and tamper resistance, ensuring that only registered users can gain entry to the vehicle. The utilization of Raspberry Pi as a central processing unit facilitates seamless integration and efficient management of these authentication mechanisms. In addition to access control, the implementation of an ultrasonic sensor serves as a deterrent against vehicle lifting. By detecting any sudden changes in the vehicle's height, the sensor can trigger an alarm or initiate protective measures to thwart theft attempts. Moreover, integrating a servo motor for wheel locking further fortifies security by immobilizing the vehicle in case of unauthorized access. The amalgamation of these technologies not only enhances the security of vehicles but also provides a comprehensive anti-theft solution. Through the utilization of multifactor authentication, ultrasonic sensors, and servo motors, the proposed system offers a robust defense mechanism against unauthorized access and theft, thereby safeguarding valuable assets and ensuring peace of mind for vehicle owners.

IV. METHODOLOGY

The methodology for a comprehensive vehicle security system involves integrating face recognition, keypad password, fingerprint-based servo motor unlocking, ultrasonic sensor, and GPS module using a Raspberry Pi. The system begins with face recognition, employing a camera module interfaced with the Raspberry Pi. Simultaneously, a keypad is integrated to allow manual entry through a secure password. For an additional layer of authentication, a fingerprint sensor is incorporated. The user's fingerprint is scanned, and the data is compared for validation. Successful authentication triggers the servo motor mechanism, unlocking the vehicle. To prevent theft or unauthorized towing, a tilt sensor is implemented. The sensor detects any tilt or movement, activating an alarm and notifying the owner if the vehicle is being lifted or towed without authorization. Furthermore, a GPS module enhances the system with anti-theft capabilities. The module continuously tracks the vehicle's location, and if an unauthorized movement is detected, the system alerts the owner and relevant authorities. This feature aids in quick recovery in case of theft. The Raspberry Pi serves as the central processing unit, managing all the input from the sensors and implementing the security protocols. It also facilitates communication between the security system and the owner through notifications or alerts on a mobile device.

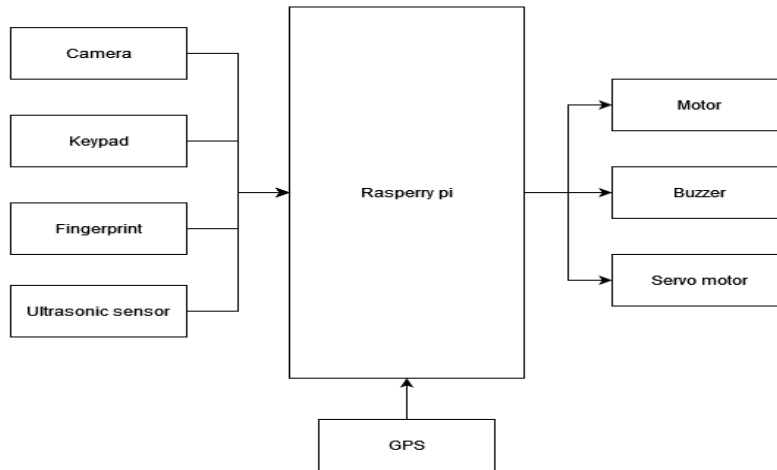


FIG 1:BLOCK DIAGRAM

V. WORKING PRINCIPLE

The Vehicle Security System employs cutting-edge technology for comprehensive protection. Integrated with face recognition, keypad password, and fingerprint authentication, the Raspberry Pi-based system ensures robust security. A servo motor enables secure unlocking, controlled by the unique user inputs. ultrasonic sensors and a GPS module add an extra layer of defense against theft, providing an anti-lift feature. This advanced system combines biometrics, user authentication, and innovative sensors to create a formidable defense mechanism for vehicle security. If the owner approaches the vehicle and press the push switch, the Raspberry Pi captures a live image and processes it, detecting faces using deep learning-based library like Open CV. Once a face is detected the image is converted into a feature vector using algorithms like Local Binary Patterns (LBP). These feature vectors serve as unique identifiers for each face. Then, the Raspberry Pi compares the feature vector of the detected face with a database of known faces. If a match is found, the system can processed to the second step. A fingerprint is scanned using a sensor, which captures the unique fingers on the fingertip. This sensor is usually capacitive and can convert the fingerprint's details into a digital image. The captured image is then processed by the Raspberry Pi. When a owner wants to unlock the vehicle, they place their fingertip on the sensor again. The Raspberry Pi compares the newly scanned fingerprint with the stored template and checks for a match. If a match is found, the system can processed to the third step.

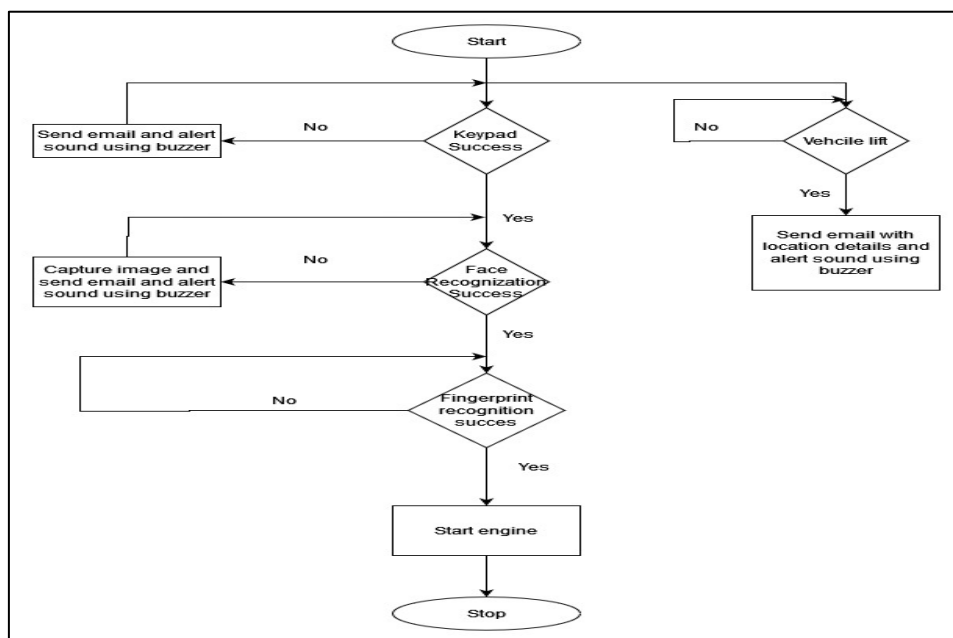


FIG 2: FLOW DIAGRAM



Then the owner is prompted to enter a password using a keypad. The Raspberry Pi, which acts as the brain of the system, monitors the keypad for input. The entered password is compared with a predefined password stored in the Raspberry Pi's memory. If the entered password matches the stored password, the system trigger actions like vehicle unlocking or granting access to a owner. Otherwise, it keeps track of incorrect attempts. If the password is incorrect, the system allows a limited number of retry attempts (e.g., two times) before taking further action. After two incorrect password attempts, the system triggers an action to Email the owner and also send a current location to the owner through GPS module.

Upon successful authentication, the Raspberry Pi sends a signal to the servo motor. The servo motor will physically unlocked the vehicle. When the vehicle is in a stationary position, the mercury switch is at rest, and electrical connections are either open or closed based on the design. If the vehicle is tilted or lifted, the internal mechanism responds to the change in orientation. The system interprets this change as an unauthorized movement or an attempt to lift the vehicle. Then alarm may include audible alerts, flashing lights, or other deterrents to discourage theft.

VI. HARDWARE DISCUSSION

1. RASPBERRY PI 4



Fig -3: RASPBERRY PI 4

The Raspberry Pi 4 stands as a hallmark in the evolution of single-board computers. Released by the Raspberry Pi Foundation, it boasts significant enhancements over its predecessors. Sporting a quad-core ARM Cortex-A72 processor running at up to 1.5GHz, it offers remarkable performance improvements, making it adept at handling diverse computing tasks. Its memory options range from 2GB to 8GB of LPDDR4 RAM, providing ample room for multitasking and memory-intensive applications. The Pi 4 also introduces support for dual 4K display via micro HDMI ports, expanding its utility in multimedia and display-intensive projects. Its gigabit Ethernet, USB 3.0 ports, and onboard Wi-Fi and Bluetooth further augment connectivity options, facilitating seamless integration into various projects and networks. Moreover, the inclusion of USB-C for power enhances its usability and compatibility with modern peripherals. With its versatile GPIO (General Purpose Input/Output) pins, it remains a favorite for makers and enthusiasts, enabling interfacing with a wide array of sensors, actuators, and electronic components. The Raspberry Pi 4 continues to empower innovation across fields such as education, IoT (Internet of Things), home automation, and hobbyist projects, serving as a catalyst for creativity and experimentation in the realm of computing.

2. FINGERPRINT SENSOR



Fig -4 FINGERPRINT SENSOR

A fingerprint sensor, also known as a fingerprint reader or fingerprint scanner, It is a biometric security technology that scans and identifies unique patterns on a person's fingertip. It captures and analyzes the ridges and valleys of the fingerprint, converting them into a digital template for authentication purposes. Commonly used in smartphones, laptops, and access control systems for secure user verification.



3. NEO-6M GPS MODULE



Fig -5 NEO-6M GPS MODULE

The NEO-6M GPS module is a compact and affordable Global Positioning System (GPS) module that is widely used in various applications, including navigation, tracking, and location-based services. It operates by receiving signals transmitted by a network of satellites orbiting the Earth. The module typically includes a small antenna to capture these signals. It provides data such as latitude, longitude, altitude, speed, and time, which can be used for a wide range of applications, from vehicle tracking to geotagging photos.

4. USB CAMERA



Fig -6 USB CAMERA

A USB camera, also known as a webcam, is a digital camera that connects to a computer via a USB port. It is primarily used for video conferencing, live streaming and facial recognition. Webcam typically have a small lens and sensor, along with electronics for capturing and processing video data. They can vary in quality, resolution, and additional features such as autofocus, zoom, and built-in microphones for audio capture.

5. SERVO MOTOR



Fig 7: SERVO MOTOR

SG90 servo motor is a popular micro servo motor commonly used in hobbyist and DIY projects. It is a small, low-cost servo motor that can rotate 00 to 180 degrees with a maximum torque of 1.8 kg-cm. It operates at 4.8-6V battery and has a weight of approximately 9 grams, making it ideal for small-scale robotics and model control applications. Controlled by pulse-width modulation signals, it features three wires: power, ground, and signal. Despite its modest size, the SG90 offers relatively precise positioning and quick response times. Its simplicity and ease of use make it a popular choice for beginners and experienced



6. HC-SR04 ULTRASONIC SENSOR



Fig 8: HC-SR04 ULTRASONIC SENSOR

The HC-SR04 ultrasonic sensor is a popular module used for measuring distance with ultrasonic waves. It consists of a transmitter and a receiver. The transmitter emits ultrasonic pulses, which bounce off objects and return to the receiver. This process is based on the principle of echolocation. The time taken for the ultrasonic pulses to return to the sensor is used to calculate the distance to the object. The sensor typically operates at a frequency of around 40 kHz. It has a range of about 2 cm to 400 cm, depending on the object's size, shape, and surface characteristics.

7. Battery Operated Motor



Fig 9: Battery Operated Motor

A Brushless Outrunner (B O) motor is a type of electric motor commonly used in various applications, including drones, RC vehicles, and electric bicycles. Unlike traditional brushed motors, B O motors feature an external rotor and a stationary stator, resulting in increased efficiency and power-to-weight ratio. They operate using electronic commutation, where the current direction in the motor windings is controlled by an external sensor or the motor's built-in electronics. This design eliminates the need for brushes, reducing maintenance and increasing longevity. B O motors offer high torque, smooth operation, and precise speed control, making them popular in hobbyist and industrial settings.

VII. RESULT AND DISCUSSION

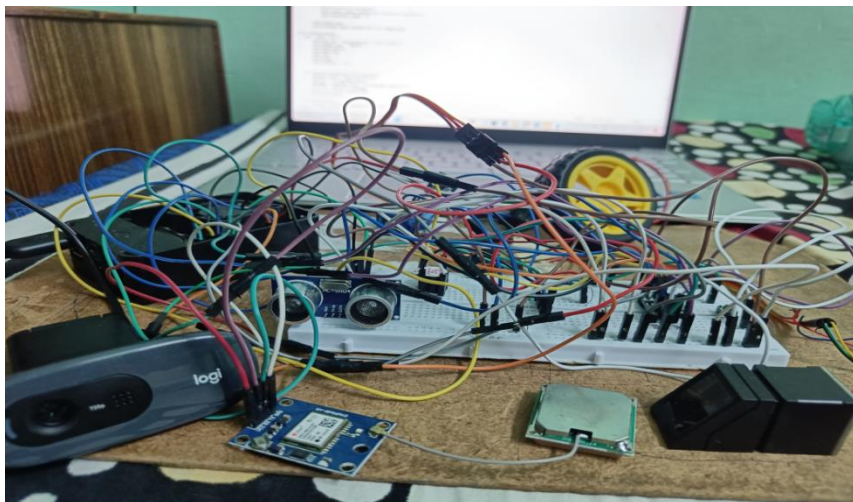


Fig 10: final project output



The integration of face recognition, keypad password, and fingerprint-based unlocking systems in a vehicle security setup, coupled with Raspberry Pi and ultrasonic sensor technology, offers a robust defense against unauthorized access. The Raspberry Pi acts as the central processing unit, orchestrating the various security layers seamlessly. Face recognition enhances security by allowing only authorized individuals access to the vehicle. Keypad password adds an additional layer of authentication, ensuring entry even in scenarios where facial recognition may not be viable. Moreover, the fingerprint-based unlocking system provides a highly secure method of access, as fingerprints are unique to each individual. The inclusion of an ultrasonic sensor adds an anti-lift feature, detecting any attempt to elevate the vehicle and triggering an alarm or deterrent mechanism. Furthermore, the servo motor-operated wheel locking system adds another level of security by immobilizing the vehicle when unauthorized access is detected. Overall, this comprehensive security system offers multi-factor authentication, anti-lift protection, and physical deterrents, significantly enhancing vehicle security and peace of mind for the owner. Through the integration of cutting-edge technologies, it provides a robust defense against theft or unauthorized use.

VIII. CONCLUSION

In conclusion, the integration of face recognition, keypad password, and fingerprint-based unlocking systems, alongside advanced technologies like Raspberry Pi and ultrasonic sensors, presents a robust vehicle security solution.

By combining multiple layers of authentication, including biometric and traditional methods, the system ensures a high level of security while also offering convenience and accessibility to authorized users. The inclusion of an anti-lift feature through the ultrasonic sensor adds an extra layer of protection against theft, detecting any unauthorized attempts to tamper with the vehicle. Moreover, the servo motor-operated wheel locking system enhances security by immobilizing the vehicle when unauthorized access is detected, further deterring potential theft or unauthorized use. Overall, this comprehensive security system offers a sophisticated defense against vehicle theft and unauthorized access, leveraging cutting-edge technologies to provide both security and peace of mind to vehicle owners. With its multifaceted approach and innovative features, it sets a new standard for vehicle security systems, ensuring the safety and protection of valuable assets in an increasingly connected world.

IX. FUTURE SCOPE

The future scope for a Vehicle Security System integrating face recognition, keypad password, fingerprint-based unlocking, and advanced features like anti-lift detection using Raspberry Pi, ultrasonic sensors, and servo motors is promising.

This holistic approach ensures robust protection against theft and unauthorized access. Face recognition technology offers seamless and secure authentication, enhancing user convenience while ensuring high-level security.

Keypad passwords provide an additional layer of access control, allowing users to input a unique code for entry. Fingerprint-based unlocking adds yet another level of security, leveraging biometric data for precise identification. Integrating these technologies with Raspberry Pi enables efficient processing and control, making the system intelligent and responsive. Ultrasonic sensors serve as a reliable anti-lift mechanism, detecting any attempt to raise the vehicle illicitly and triggering alerts or countermeasures. The servo motor-driven wheel locking system further fortifies security by immobilizing the vehicle when unauthorized access is detected, thwarting theft attempts effectively.

Additionally, the scalability and adaptability of this system pave the way for future enhancements and integrations with emerging technologies, ensuring continuous evolution and relevance in the rapidly advancing field of vehicle security. Overall, this comprehensive solution offers a glimpse into the future of sophisticated, multifaceted vehicle protection systems.

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