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Research Paper

A HELMET GUARDIAN: SMART WAY TO LOCK

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ABSTRACT: The increasing rate of two-wheeler theft and helmet misplacement has created a need for secure, reliable, and user-friendly locking mechanisms. This project proposes the design and implementation of a Digital Helmet Lock that utilizes a scanner-based authentication system, such as RFID, QR code scanning. The digital lock integrates a microcontroller that processes authentication data from the scanner and activates an electromechanical locking unit. The system enhances security by ensuring that only authorized users can access or detach the helmet. Additionally, it eliminates the need for traditional keys, reducing the risk of duplication or loss. The prototype demonstrates improved convenience, faster access time, and higher security compared to conventional helmet locks. This technology can be integrated into motorcycles, smart parking facilities, and public helmet-rental systems, contributing to safer and more efficient urban mobility solutions. he system's operation is as follows: Authentication: When the rider attempts to start the vehicle, a scanner (e.g., fingerprint, QR code, or an AI-enabled camera for helmet detection) verifies the rider's identity and confirms the helmet is in use. Ignition Control: The vehicle's ignition is controlled by a microcontroller which receives data from the scanner module via a wireless link (like RF or Bluetooth).Mandatory Use: Ignition is only enabled if the authentication is successful and the helmet is detected as properly worn; otherwise, the engine remains locked, and an alert may be triggered. This integrated approach not only acts as an advanced anti-theft mechanism by ensuring only registered individuals can operate the bike, but it also mandates the use of safety gear, thereby significantly reducing the risk of fatal head injuries during accidents. The implementation demonstrates a reliable, cost-effective solution for promoting safer driving practices in real-time.

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I.INTRODUCTION

A digital helmet lock opened by a scanner is an advanced safety and security system for motorcyclists that utilizes wireless communication and sensor technology to ensure the rider is wearing the helmet before the vehicle's ignition can be activated. This system integrates a smart lock mechanism with a scanning method, such as RFID (Radio-Frequency Identification) tags or a smartphone application, to provide keyless convenience and enhanced security. Traditional helmet locks provide basic security against theft but do not enforce the use of the helmet for rider safety. In response to the high rate of head injuries in two-wheeler accidents, researchers and engineers have developed smart helmet systems that link the helmet's status directly to the motorcycle's ignition system. The integration of scanners, particularly the use of smartphones as a "scanner" via Bluetooth or an app, moves beyond simple mechanical locks to creat intelligent automated safety loop. The core principle is that the helmet acts as a secondary, mandatory "key" for the vehicle. The system typically involves a transmitter unit embedded in the helmet and a receiver unit connected to the bike's control unit, all managed by a microcontroller. In modern two-wheelers, securing a helmet safely and conveniently has become an important requirement. Traditional helmet locks use mechanical keys, which can be inconvenient, easy to lose, and vulnerable to tampering. To overcome these limitations, a Keyless Helmet Lock System using RFID technology provides a smarter and more secure solution.

RFID (Radio Frequency Identification) uses a unique tag and reader to enable contactless authentication. In this system, the user simply scans an RFID card or tag near the reader to lock or unlock the helmet. When the authorized RFID code is detected, the microcontroller activates a motor or solenoid to release the lock mechanism. Unauthorized tags are rejected, ensuring safety and

preventing theft. This project demonstrates how RFID can be used to improve vehicle security by offering fast, keyless access, higher reliability, and better user convenience. It also showcases practical applications of embedded systems, sensors, automation in smart transportation. In modern two-wheelers, securing a helmet safely and conveniently has become an important requirement. Traditional helmet locks use mechanical keys, which can be inconvenient, easy to lose, and vulnerable to tampering. To overcome these limitations, a Keyless Helmet Lock System using RFID technology provides a smarter and more secure solution. RFID (Radio Frequency Identification) uses a unique tag and reader to enable contactless authentication. In this system, the user simply scans an RFID card or tag near the reader to lock or unlock the helmet. When the authorized RFID code is detected, the microcontroller activates a motor or solenoid to release the lock mechanism. Unauthorized tags are rejected, ensuring safety and preventing theft.

II.LITERATURE REVIEW

RFID-Based Helmet Locks and Authentication Helmet as a Key Using RFID A particularly relevant work is "Helmet as A Key for Bike Using RFID". In their system, an RFID tag is integrated with the helmet; when the helmet is placed (or tapped) near a reader, the motorcycle's ignition or lock system verifies the tag and allows access. This shows how RFID can be directly applied to helmet-lock mechanisms rather than just door locks. Wearable RFID Systems Beyond lock control, there is research on wearable RFID systems [1].

A system where passive RFID tags are embedded in clothing, and a small RFID reader worn on the bodydetectspatterns for activity recognition. Though not directly a lock system, their work shows that RFID patterns can be used for wearable authentication, which could inspire helmet-mounted tags tied to identity [2].

Smart Helmet Projects (Security + Control): Smart Helmet System for Safety & Security It describe an "IoT-based Smart Helmet System" that integrates biometric authentication, helmet detection, vehicle ignition control, and real-time alerts. Although this is not a standalone helmet lock, it demonstrates how authentication (scanner) and control (ignition lock) can be combined in a helmet-based system to improve security [3].

Gaps and Opportunities for QR / Scanner-Based Helmet Locks: From the literature reviewed above, we can identify several gaps and areas for further research, particularly relevant to a digital helmet lock project: Lack of Helmet-Specific Lock Research Many "smart helmet" studies focus on accident detection, rider behavior, or vehicle ignition control—not on locking the helmet itself. There is limited research explicitly on helmet storage locks (i.e., locks that secure a helmet when parked or store Scanner Authentication for Helmet Locks While RFID is used in some helmet-ignition systems, applying scanner-based authentication (e.g., QR-code scanner, RFID reader) specifically to a helmet lock remains underexplored. There is potential to use QR-code scanning (camera-based) to authenticate users and unlock helmet compartments or locking mechanisms, but literature directly applying QR-based access to helmet locks is minimal. Security Model / Threat Analysis [4].

The existing works rarely provide a detailed threat model for a helmet lock (e.g., how an attacker might spoof an RFID helmet tag, or use replay attacks). Advanced security techniques (cryptography, challenge-response authentication) are not widely applied to helmet lock systems in the literature. Power / Form Factor Constraints A helmet lock must be physically small, lightweight, and possibly battery-powered. However, most studies on locks are door-based and assume a larger power budget or fixed power supply. Research is needed on low-power microcontrollers, efficient scanners, and compact locking mechanisms that fit the helmet lock use-case [5].

III. METHODOLOGY

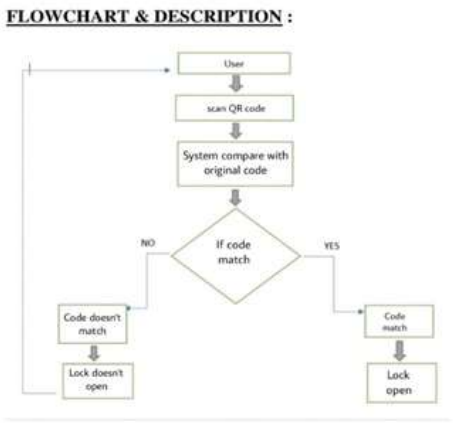

FIG 3.1 FLOW CHART

IV. Material Selection

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 ARDUINO UNO:

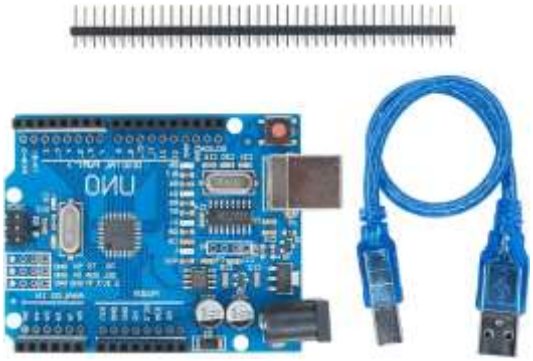

Fig 4.1 Arduino uno

The Arduino platform can be divided into two: Hardware and Software. Arduino uses hardware known as the Arduino development board. Arduino Software for developing the code is known as the Arduino IDE (Integrated Development Environment). Built-up with the 8-bitAtmel AVR microcontrollers that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be. Programmed easily using the C or C++ language in the Arduino IDE. The Arduino board can also be used to upload a new code to the Arduino board. By using a USB cable to upload. The Arduino IDE provides a simplified integrated platform that can run on almost all personal computers and users can write programs For Arduino using C or C++ programming language.

4.2 SERVO MOTOR:

Fig 4.2 servo motor

A servo motor is a precise, self-contained electrical device that uses a closed-loop control system with position feedback to accurately control angular or linear movement, speed, and torque. Unlike a conventional motor, a servo motor's position is continuously compared to a command signal by a sensor (like an encoder) and controller, allowing it to correct errors and stop at exact points

4.3 JUMPER WIRES

Fig4.3 jumper wires

Jumper wires are flexible electrical wires with connectors on each end, used to temporarily connect components on a breadboard or other prototyping tools without soldering. They are available in male-to-male, female-to-female, and male-to-female configurations and are essential for building, testing, and modifying electronic circuits

4.4 RFID

Fig4.4 RFID

RFID used in scanners refers to the process where an RFID reader (often called an RFID scanner) detects and reads data from RFID tags using radio waves. When the scanner is activated, it sends out a radio signal that powers nearby passive tags or communicates with active tags. The tag then transmits its stored information—such as an ID number, product details, or location—back to the scanner instantly and without requiring physical contact or direct alignment. This makes RFID scanners far more efficient than barcode scanners, as they can read multiple tags at once, work through packaging or obstacles, and operate from greater distances. RFID scanners are commonly used in retail stores, warehouses, hospitals, libraries, and security systems to quickly track inventory, authenticate access, or verify items.

V. Results and Discussion

5.1 Working Principle:

A digital helmet lock that opens using a scanner operates on the principle of electronic verification and controlled actuation. The lock is equipped with a scanner, which can be a QR code reader, RFID/NFC reader, or fingerprint sensor, depending on the design. When a user scans their authorized code, card, or fingerprint, the scanner reads the data and sends it to a microcontroller, which acts as the brain of the system. The microcontroller compares the scanned data with the stored authorized information. If the data matches, it sends an electric signal to the lock mechanism, typically a solenoid or motorized latch, which physically opens the helmet lock. If the data does not match, the lock remains closed, and an alert such as a beep or light may be triggered. The system is powered by either the vehicle's battery or a separate rechargeable battery, ensuring that the electronic components function reliably. Some advanced versions also incorporate features like Bluetooth connectivity, auto-locking, tamper alarms, and battery status indicators, making the lock both secure and convenient for everyday use.

Fig 5.1 Working model

VI. Conclusion

A digital helmet locker that opens using a QR code provides a secure, convenient, and user-friendly solution for protecting helmets. By using electronic verification through a QR code scanner and a controlled locking mechanism, it ensures that only authorized users can access the locker. This system eliminates the need for physical keys, reduces the risk of theft, and can be integrated with smart features like auto-locking and alerts. Overall, it combines security, efficiency, and modern technology to enhance safety and convenience for two-wheeler riders. The keyless helmet lock system using RFID provides a smart, secure, and user-friendly solution for two-wheeler safety. By replacing traditional mechanical locks with RFID-based authentication, the system eliminates the risk of key loss, duplication, and unauthorized access. It ensures quick locking and unlocking with a simple RFID tag, improving convenience for the rider. The system is reliable, cost-effective, and can be easily integrated into existing vehicles, making it a

practical advancement toward modern, technology-driven transportation safety.

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