

Literature Review on Smart Door Lock Using Keypad and GSM

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Abstract: Smart security systems are rapidly evolving as modern alternatives to conventional mechanical locks, offering enhanced safety, reliability, and flexibility. Among these, authentication methods that integrate embedded systems with communication technologies provide cost-effective yet secure solutions for access control. This paper presents a review and implementation of an OTP-based door lock system that combines a 4x4 keypad with a SIM800L GSM module for dynamic authentication. The system operates on a dual-layer verification mechanism: an initial password entry followed by a one-time password (OTP) sent to the registered mobile number in case of failed attempts. An Arduino Uno microcontroller is used to coordinate the process, while an LCD display provides real-time feedback to the user. This approach significantly reduces the vulnerabilities associated with static passwords, such as brute-force attacks or unauthorized sharing. The review also examines existing security mechanisms, identifies their limitations, and discusses how OTP-based GSM integration improves affordability, robustness, and usability. Future extensions may include biometric integration, IoT-based cloud monitoring, and mobile app support to further strengthen system performance and applicability.

Keywords: Smart Security, OTP Authentication, GSM Module, Arduino Uno, Access Control System, IoT-based Lock

I. INTRODUCTION

Security and access control are fundamental requirements in both residential and commercial environments. Traditional door lock systems, including mechanical key-based locks and static password mechanisms, have been widely used for decades. However, these conventional systems have increasingly shown weaknesses in terms of security and user convenience. Mechanical keys are vulnerable to duplication, theft, or loss, while static passwords are prone to brute-force attacks, guessing, and unauthorized sharing. These shortcomings have motivated researchers and engineers to explore modern alternatives that can provide more reliable, cost-effective, and intelligent security solutions.

In recent years, the rapid advancement of embedded systems, Internet of Things (IoT) technologies, and mobile communication has transformed the design of smart security systems. Among these, Arduino-based microcontroller platforms combined with communication modules such as SIM800L GSM have proven to be highly effective for creating intelligent, real-time, and affordable door lock systems. These solutions not only provide enhanced protection but also add features such as dynamic authentication, remote monitoring, and scalability for diverse applications.

One of the major challenges with existing smart locks is their reliance on either a single factor of authentication or expensive biometric systems. RFID-based locks, for instance, require physical cards or tags, which can be misplaced or cloned. Biometric systems, such as fingerprint and facial recognition, although secure, are costly to implement and require sophisticated hardware, making them less feasible for low-cost home or small-office security. Similarly, keypad-only locks with static passwords suffer from predictability and can be compromised if the password is shared. These issues clearly indicate the need for a security solution that is both cost-effective and resistant to common vulnerabilities.



The integration of One-Time Passwords (OTPs) into door lock systems has emerged as a practical solution to address these limitations. OTPs are dynamically generated codes that are valid for a single authentication session, ensuring that even if a password is compromised, it cannot be reused. By leveraging the GSM network, OTPs can be sent directly to the registered mobile number of the authorized user, thereby adding an additional layer of security. This two-step verification mechanism greatly reduces the risks of brute-force attacks and unauthorized access, making it a suitable approach for modern smart locks.

The Arduino Uno microcontroller plays a crucial role in managing this dual-authentication process. It coordinates input from the 4×4 matrix keypad, processes the authentication logic, communicates with the GSM module for OTP generation, and controls the relay module connected to the door lock actuator. To enhance usability, a 16×2 LCD display is incorporated, which provides real-time feedback to the user by displaying system prompts such as “Enter Password,” “OTP Sent,” or “Access Granted.” This combination of hardware and software creates a system that is secure, user-friendly, and reliable.

Globally, there has been a significant rise in the adoption of smart locks and IoT-enabled access control systems. Reports suggest that the smart lock market is expanding rapidly due to increasing demand for connected homes, smart offices, and institutional safety. However, many existing systems are either expensive, network-dependent, or lack scalability. In contrast, GSM-based OTP systems present a balanced solution by offering affordable and widely accessible mobile-based authentication. GSM networks are available even in rural areas, making this approach practical for deployment in diverse geographical regions.

Therefore, the proposed smart door lock system using keypad and GSM addresses the shortcomings of traditional and existing smart locks by providing dual-layer authentication in a cost-effective design. By combining the advantages of Arduino-based control, GSM-based OTP verification, and user interaction through LCD feedback, the system achieves enhanced security without requiring high-cost components. This review paper evaluates existing approaches, highlights their limitations, and presents the design of an OTP-based smart lock system that is practical, scalable, and well-suited for real-world applications in both urban and rural contexts.

II. LITERATURE SURVEY

Several researchers have worked on improving door lock security systems using microcontrollers, GSM modules, and one-time passwords (OTPs). The primary motivation behind these studies has been the need to overcome the limitations of traditional mechanical and password-based locks while keeping the solution cost-effective and user-friendly. The following section reviews some of the most relevant contributions in this area.

Gowtham et al. [1] designed an adaptive biometric smart door lock system with time-bound access using a GSM module. The system allowed temporary access control and remote unlocking but primarily relied on GSM communication, making it potentially vulnerable to network delays or interception for critical security.

Kale et al. [2] developed a smart door lock using face recognition and GSM modules. The system demonstrated effective facial authentication for mobile-based access; however, OTP mechanisms were not integrated, leaving the design susceptible to SIM card misuse or spoofed messages.

Sutar [3] implemented a smart door lock system controlled via SMS using mobile devices. The approach enabled remote unlocking through messages, but security was limited as there was no multi-factor authentication or encryption for SMS transmission.

Pandey et al. [4] proposed a generic smart door lock system integrating digital access methods. While the system automated access, it lacked advanced mobile or biometric authentication, reducing resistance to unauthorized entry.

Kumari et al. [5] presented a GSM-based wireless smart door lock. The solution validated GSM feasibility for security applications but did not incorporate OTP or biometric verification, making it vulnerable to SIM cloning or interception attacks.

Yadav et al. [6] introduced a smart door locking system using LoRa technology. The system offered long-range wireless control but had limited security mechanisms against unauthorized access or device tampering.



Mohamed et al. [7] developed an OTP-based door lock using Arduino and the SIM800L GSM module. The study emphasized secure access via OTP, reducing risks of message interception, but did not include biometric verification for enhanced security.

Leekongxue et al. [8] implemented a smart door monitoring and locking system with a SIM900 GSM shield and Arduino UNO. While efficient for remote control, the system lacked OTP or multi-factor authentication, increasing potential security vulnerabilities.

Clinton and Vetrichelvi [9] designed the C-Sey smart door lock system integrating basic digital access. Although it automated unlocking, the design did not implement GSM or OTP mechanisms, limiting remote control capabilities.

Anonymous [10] proposed an IoT-based door lock system controlled using Google Assistant. The solution allowed voice-based access but was susceptible to voice spoofing and required network connectivity for operation.

Sale et al. [11] presented a mobile application-based IoT smart door lock and unlock system. While enabling remote control, the system lacked OTP verification and robust encryption, making it vulnerable to unauthorized access if the app or network were compromised.

Hamas et al. [12] developed a smart security door system using SMS-based energy harvesting. The system focused on energy efficiency but did not integrate OTP or biometric authentication, limiting security against message interception.

Satti et al. [13] designed a smart visitors' notification system with automatic secure door lock using mobile communication. The system improved visitor management but relied on conventional mobile communication without OTP, raising security concerns.

Simon et al. [14] implemented an electronic doorbell system using a keypad and GSM module. The design enabled remote notifications and keypad access, but lacked OTP and biometric security layers.

Sai Krishna [15] explored remote accessing of door systems using GSM. While demonstrating GSM feasibility for control, the system had limited authentication methods, making it less secure against SIM-based attacks.

Divya and Rao [16] proposed a centralized authentication smart locking system integrating RFID, fingerprint, password, and GSM. This multi-factor approach improved security, though OTP was not implemented, limiting dynamic access control.

Nehete et al. [17] developed a wireless security system with digital code lock using RF and GSM. The design demonstrated effective wireless control but did not integrate OTP or biometric verification, leaving room for unauthorized entry.

Parveen and Mohan [18] created a smart receptionist system using a smart lock with wireless communication. While automating access in offices, the system lacked OTP or strong authentication, reducing security against external threats.

Murthy et al. [19] designed an advanced GSM-based home locker safety system using Arduino UNO. The system allowed remote alerts and unlocking but did not incorporate OTP or multi-factor authentication, exposing it to potential SIM misuse.

Srisha and Sandhya [20] implemented an Arduino-based password-protected door locking system. While simple and effective for local control, the system lacked remote access and OTP verification, limiting scalability and security.

Abraham et al. [21] developed an automatic portal lock security system using two-step verification via Bluetooth and GSM. The approach enhanced security through multi-step verification but did not integrate OTP over GSM for mobile-based control.

Borkar and Dasarwar [22] proposed a smart vehicle security system with accident detection, theft control, and battery charging using GSM and GPS. While robust for vehicular security, the system was not tailored for home door locks or OTP-based authentication.

Kumar et al. [23] developed an advanced multi-level security system using Raspberry Pi-3. The design supported multiple authentication levels but did not integrate GSM or OTP mechanisms for mobile-controlled access.

Raju et al. [24] presented a smart lock controlled via voice call. The system enabled remote unlocking but lacked OTP or multi-factor authentication, making it vulnerable to unauthorized calls or spoofing.

Nehete et al. [25] conducted a literature survey on door lock security systems. The study summarized existing technologies but highlighted gaps in dynamic OTP-based authentication and robust multi-factor security for smart locks.



Ravindra and Konda [26] designed a GSM-based security lock using a linear actuator. While demonstrating automated unlocking, the system did not implement OTP or biometric verification, leaving potential vulnerabilities. Mamatha et al. [27] proposed intrusion detection for smart home alarm systems. The focus was on alerting unauthorized entry but did not directly integrate door lock control or OTP authentication. Rakib et al. [28] developed a fingerprint-based smart home automation and security system. Biometric authentication improved security; however, remote GSM or OTP-based access was not included. Hussain et al. [29] designed an AI-based smart guard for home automation. The system incorporated intelligent monitoring but lacked practical OTP or GSM-based door unlocking mechanisms. Sahani et al. [30] implemented a web-based embedded door access control and home security system using face recognition. While supporting remote access through the web, the system did not integrate GSM or OTP-based authentication for dynamic mobile control.

III. PROPOSED METHODOLOGY

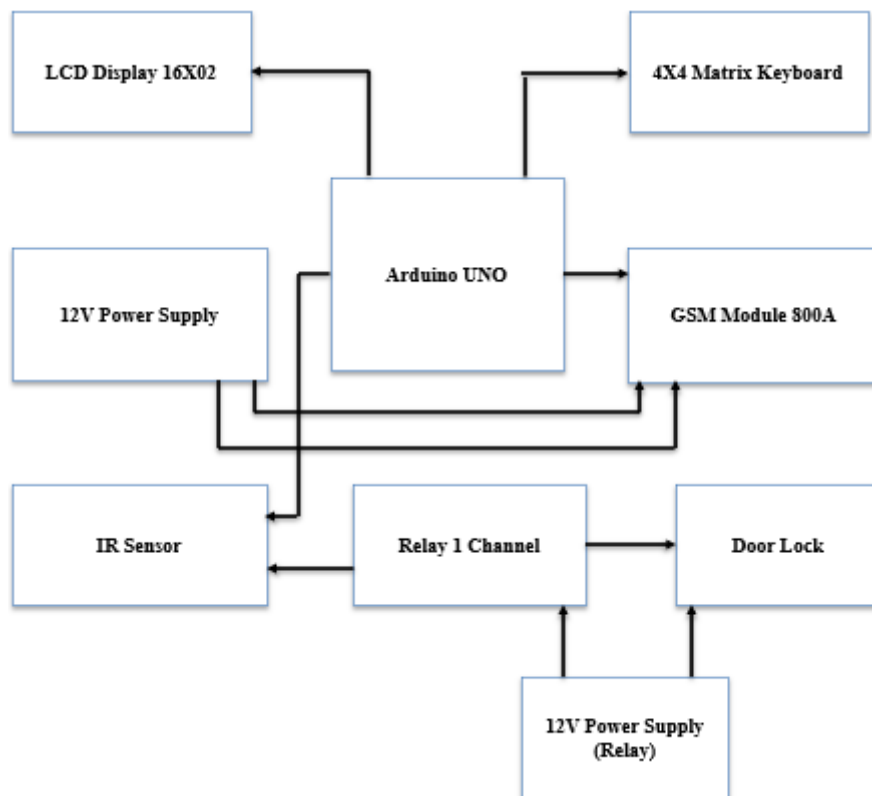


Fig. 1 Smart Door Lock Using Keypad & GSM

The proposed system, Smart Door Lock using Keypad and GSM, is designed to provide secure access control by combining password authentication with one-time password (OTP) verification. The methodology involves the coordinated functioning of various hardware modules such as Arduino UNO, GSM module, keypad, LCD display, relay, and door lock actuator. Together, these components establish a dual-layer security system that ensures only authorized users can gain access.

The system begins with the user entering a predefined password through the 4×4 matrix keypad. This input is transmitted to the Arduino UNO, which serves as the central processing unit. If the entered password matches the stored password in the Arduino's memory, the controller activates the relay module that powers the door lock and grants access. At the same time, the 16×2 LCD display provides feedback to the user by showing messages such as "Access Granted" or "Access Denied."



If the user fails to enter the correct password after a predefined number of attempts (e.g., three incorrect tries), the Arduino activates the GSM module (SIM800L). The GSM module generates a unique OTP and sends it via SMS to the registered mobile number of the authorized user. The system then prompts the user to enter this OTP on the keypad. Once the OTP is entered, the Arduino verifies it against the generated value. If the OTP is correct, the relay is energized and the door unlocks. If the OTP is incorrect, the system denies access and displays a warning on the LCD. This dual-layer verification ensures a balance between convenience and enhanced security.

To ensure stability and reliable functioning, a regulated 12V DC power supply is used to power the system. A dedicated supply line is provided for the relay and lock actuator to prevent voltage fluctuations that could disrupt the operation of the Arduino and GSM module. An optional IR sensor can also be integrated for detecting human presence, which may trigger the system to activate only when someone approaches the lock, thereby conserving power and increasing efficiency.

The overall methodology can be summarized as follows: the Arduino UNO manages input validation, OTP generation and verification, GSM communication, and control of the locking mechanism. The keypad acts as the primary input interface, the LCD display acts as the user guide, the relay operates as the switch for the actuator, and the door lock enforces the physical security mechanism. By combining hardware modules with embedded C programming on the Arduino IDE, the system achieves a secure and cost-effective solution for access control.

1. Arduino Nano

The Arduino Nano is a compact microcontroller unit (MCU) used in embedded system applications, based on the ATmega328P microcontroller. It operates at a clock speed of 16 MHz and features 14 digital input/output pins (of which 6 can provide PWM output), 8 analog input pins, a mini-USB connection, and a reset button. The board runs on an operating voltage of 5V, with a recommended input voltage range of 7–12V. In this project, the Arduino Nano performs essential functions such as reading user input from the keypad, controlling the LCD and relay, interfacing with the GSM module, and executing the authentication logic. Its small size makes it suitable for compact designs, while its low cost, wide availability, and compatibility with a variety of sensors and modules make it a practical choice for embedded system projects.

2. 4×4 Matrix Keypad

The 4×4 matrix keypad is used as the primary input device for entering both the password and OTP. It consists of 16 tactile push buttons arranged in a 4-row by 4-column matrix. This arrangement reduces the number of microcontroller pins required for interfacing, as Arduino can detect keypresses by scanning rows and columns. The keypad typically operates at 3.3V to 5V, making it fully compatible with Arduino UNO. It is durable, low-cost, and capable of handling multiple inputs, making it suitable for real-time user interaction in security applications.

3. LCD Display (16×2)

A 16×2 character LCD is used to provide real-time feedback and instructions to the user. It displays two lines with up to 16 characters per line. The LCD communicates with the Arduino through the I2C interface module, which minimizes wiring complexity by reducing the required pins from 16 to just 2 (SDA and SCL). This display shows prompts such as “Enter Password,” “OTP Sent,” “Access Granted,” or “Access Denied.” Its inclusion improves usability by guiding the user at each stage of the authentication process. The LCD typically operates at 5V and consumes very little power, making it an energy-efficient choice for the project.

4. GSM Module (SIM800A/SIM800L)

The SIM800L GSM module is the communication backbone of the system. It enables the Arduino to send and receive SMS messages by interfacing through UART serial communication and AT commands. Operating in the GSM 850/900/1800/1900 MHz bands, the module ensures wide network coverage in most regions. It requires a supply voltage of 3.7V to 4.2V and consumes around 0.2 A during transmission. In this project, the GSM module generates and delivers



OTPs to the registered user's mobile number. It eliminates the need for internet connectivity, thereby extending the system's usability to rural areas where GSM coverage is available but broadband connections may be limited.

5. Relay (1 Channel)

The relay module acts as an electrically operated switch that isolates the low-power control signals of the Arduino from the higher voltage required to drive the door lock actuator. A single-channel relay module is sufficient for this project, as only one load (the door lock) needs to be controlled. The relay coil is energized by a 5V signal from the Arduino, which allows the normally open (NO) contact to close and complete the circuit for the lock. This ensures safe switching without directly exposing the microcontroller to high voltages or currents.

6. Door Lock

The final actuator in the system is the electronic lock, which can be implemented using a solenoid lock or a servo motor. A solenoid lock operates on 12V DC and uses electromagnetic force to move a latch mechanism that locks or unlocks the door. Alternatively, a servo motor can rotate to operate a latch-based mechanism. The choice between solenoid and servo depends on application requirements: solenoids are preferred for direct locking mechanisms, while servo motors may be used for lightweight or prototype models. The actuator provides the final step in physically granting or denying access.

7. IR Sensor

The infrared (IR) sensor is used as an optional component to enhance the security and efficiency of the smart door lock system. It operates by emitting infrared light and detecting the reflection from nearby objects, thereby identifying the presence of a person near the lock. When a human presence is detected, the system can automatically activate and prompt the user to enter a password, thus conserving power when the lock is idle. Additionally, the IR sensor can act as a motion detector to generate alerts in case of unauthorized tampering or suspicious movement near the lock. Typical IR sensors operate at 3.3V–5V and provide digital output signals that are easily compatible with the Arduino UNO. By integrating this sensor, the system achieves an additional layer of monitoring and intrusion detection.

8. 12V Power Supply

The 12V DC power supply serves as the main source of energy for the system. It provides sufficient voltage and current to drive the relay, GSM module, Arduino UNO, and door lock actuator. A regulated supply is necessary to ensure that voltage fluctuations do not damage sensitive components. In this design, a dedicated line is provided to the relay and actuator to isolate their load from the control circuitry. This prevents sudden surges during lock operation from resetting or affecting the performance of the Arduino or GSM module. The supply can be derived from a 12V DC adapter connected to the mains or from a rechargeable 12V battery pack, depending on the application. For continuous and safe operation, the 12V supply is further regulated using a buck converter (LM2596) to step down the voltage for low-power components.

IV. CONCLUSION

The design and implementation of OTP-based smart door lock systems using Arduino and GSM technology provide a secure, practical, and affordable alternative to conventional locking mechanisms. Unlike static key or password-based approaches, the integration of dual-layer authentication—combining a fixed password with dynamically generated OTPs—offers stronger resistance against unauthorized access attempts. The literature reviewed, along with the proposed model, confirms that GSM-enabled OTP verification minimizes the vulnerabilities associated with traditional methods and ensures that access is granted only to authenticated users.

The system's architecture, built around the Arduino UNO microcontroller, effectively integrates essential components such as a 4×4 matrix keypad, LCD display, GSM module, and relay-controlled locking mechanism. This arrangement



results in a reliable yet user-friendly design that is adaptable for a wide range of applications, including residential, institutional, and commercial security. While its dependence on mobile network connectivity remains a limitation, the solution still demonstrates that low-cost IoT-enabled security systems can be implemented successfully without the need for expensive biometric devices.

Looking ahead, the system can be further enhanced by incorporating biometric authentication, mobile app control, and cloud-based data storage for access logging. Such improvements would pave the way for more advanced, multi-factor authentication systems that provide higher reliability and traceability. In conclusion, this work establishes a practical foundation for modern access control by combining affordability, simplicity, and improved security within a scalable design.

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