RFID and Keypad based door lock using Arduino

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Abstract **- *This project presents the design and implementation of a secure and user-friendly RFID and keypad-based door lock system using Arduino. The system integrates two authentication methods: RFID (Radio Frequency Identification) and a numeric keypad, ensuring enhanced security for residential, commercial, or office spaces. The primary goal of this project is to provide a convenient and reliable access control solution by combining the robustness of RFID technology with the versatility of a keypad interface.***

Keyword: Arduino Uno, Door lock, RFID, Keypad, integrating RFID and numeric keypad, dual-factor authentication.

I. INTRODUCTION

In today's world, security is a primary concern for homes, offices, and other facilities. Traditional key-based locks are prone to theft, duplication, and unauthorized access, making them less reliable in the face of modern security challenges. To address these concerns, electronic access control systems have become increasingly popular, offering more secure and convenient solutions for entry management.

One such system is the **RFID and Keypad-based Door Lock** using **Arduino UNO**, which combines two authentication methods—RFID (Radio Frequency Identification) and a numeric keypad. RFID technology enables contactless identification of authorized users by reading unique RFID tags or cards, while the keypad allows for additional security through a personal identification number (PIN) entry. By integrating these two methods, the system enhances security by providing dual-factor authentication, requiring both an RFID tag and a correct PIN code for access.

At the core of this system is the **Arduino UNO**, an open-source microcontroller that offers easy integration with a variety of sensors and modules. It serves as the control unit, processing inputs from the RFID reader and the keypad, and managing the operation of a locking mechanism, such as a servo motor or solenoid. The system ensures that only users with authorized credentials can unlock the door, thereby improving the safety of the premises.

RFID is Radio Frequency Identification which is a fundamental and cheapest technology to enables wireless data transmission. Radio frequency Identification i.e., RFID is a non- contact technique applied in industries for personal tracking, supply chain management, management of books in libraries and at tollgate. RFID technology has a lack of standardization and hence it has not been very often among the manufacturing companies earlier. RFID technologies are more proficient and more secure as compare to other networks. RFID technology is used in many areas such as public transport, industrial automation, animal identification, ticketing, inventory detection, electronic immobilization, access control, asset and people tracking, and many more. Gyanendra and Pawan proposed a security system using a passive type of RFID contains a door locking system using an actuator.

This project provides a cost-effective, flexible, and scalable solution for secure access control. It can be further enhanced with additional features such as remote monitoring, logging of access attempts, and time-based access restrictions, making it suitable for various applications in residential, commercial, or institutional environments.

II. LITERACY SURVEY

(a) Electronic door lock using RFID and password based on Arduino

In this system, the electronic door lock using RFID and

password based on Arduino UNO. It uses in doors and cupboards as electronic lock and so on. The security system is important at homes, schools, offices and industries in real life. The purpose of this paper is to develop a smart home security system using RFID and keypad. RFID is ID card reader to read ID card's value and Arduino UNO. If ID card reader is true, Arduino permits to press password on keypad. If password is true, lock style solenoid is unlock. If password is false, solenoid is lock. The electronic door lock system for home automation is able to interact with security management system for users and smart cards. Smart card is easy to use and accept more secure in real life. And then password is traditional but that is more impressive and more secure for human life. The Arduino microcontroller is used to control the whole system.

(b) RFID and Finger print Based Dual Security System: A robust secured control to access through the door lock operation

RFID reader and fingerprint sensing device work as a locker of the security and RFID tag and a validly ratified finger is considered as the key of the locker. In case of access granted entity, door bar gets opened with a servo mechanism system connected with door bar. On the contrary, no action is taken as cavalcade if the entity is considered invalid in the sensing system. These knock out the necessity for keeping track of keys or remembering a combination of password or pin. A prototype of the security system is also designed and the performance of it is tested. The satisfactory results of its performance show the validity of the system and indicate a better solution for the future security system.

(c) The automatic door lock to enhance security in RFID system

Providing the security system for a room is a crucial in terms of protecting the valuable things and preventing the unauthorized access. Therefore, the security must be enhanced in order to keep off losing goods or important data [1]. In order to improve the security and authentication, an electronic locking system is designed. The implementation of this research is limited to the automation of door lock security system. The prototype device of door lock security system in the classroom by using RFID card would be forwarded to the control circuit by Arduino mega as the microcontroller then activated the magnetic solenoid to open the door. Only user which has been registered could access the classroom. Otherwise, the new user which has not been registered yet in database was not given right to enter the room. Based on the research and implementation of the device, showed that the device can run efficiently and effectively. This system helps the lectures improve the authentication approach to enhance the security, comfortability and privacy requirement.

(d) Performance Analysis of RFID-Based Smart Door Lock Controlled by Arduino

Traditional door lock systems that usually use mechanical locks are now starting to be replaced with electrical and control-based lock systems that have more capabilities than traditional door lock systems. These techniques are an integration of mechanical devices, electronics, and intelligent control devices. One of the important features of this innovative lock system is its simplicity and high efficiency. In this research, an automatic lock system was constructed by combining mechanical and electrical components into a device. A microcontroller Arduino was used to control the whole functions of the system. The input component for this system is an RFID card or RFID Tag. We can also use college personal RFID tag to replicate. An RFID reader is installed on the device to detect the RFID card used when accessing the door whether a registered card or not. A solenoid door lock is used as an output that will function as a door lock mechanism. The door lock system developed in this study is integrated with the attendance system database. The result of this research shows that the system can recognize the identity of the door accessor and is also able to store data in form of identity and time the door is accessed. The solenoid door lock will retract to unlock the door if the door is accessed with a registered RFID card and vice versa solenoid door lock will continue in the push position to lock the door if the door is accessed with a not registered RFID card. Some of the main performances of this system are that RFID read range from 0 - 20mm, RFID sensor can detect the presence of an RFID card even if it is blocked by objects such as papers, plastics, glass, and cloths. When objects such as aluminum or iron are present in between the RFID sensor and the RFID card, it will interfere with the signal so that the RFID sensor cannot detect the presence of the RFID Arduino.

(e) Fingerprint Based Door Access System using Arduino

From earlier times, security was and also till now is an issue of concern in our households and also in office, shops, etc. Everyone has a fear of unauthorized person entering to their home or office without their knowledge. The normal door can be fitted with locks which are capable of breaking with the use of an alternate key. Alternatives to this system can be found like the password or pattern system in the locks which again has the possibility of getting exposed and opening the lock. So, a solution to such problems can be by combining door lock with biometrics. Biometric verification is any means by which a person can be uniquely identified by evaluating one or more distinguishing biological traits. Unique identifiers include fingerprints, hand geometry, earlobe geometry, retina and iris patterns, voice waves, DNA, and signatures. Here we will use fingerprint for biometric verification as it is one such thing which is unique to every individual and the use of fingerprint as the key to door locks can overcome the security problem of unauthorized people trespassing to our homes, shops, offices, etc to a great extent as duplicacy in such key is not possible. Also, this system will not lead to problems like losing keys because we do not require carrying keys if this system is used instead of traditional locks. So, using Arduino we will try to implement the system with features which will increase the security level.

III. SOFTWARE SPECIFICATION

a) Arduino UNO

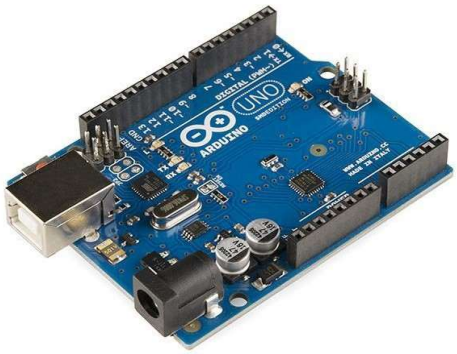


Figure 1:Arduino UNO

An Arduino Uno can control an RFID and keypad-based door lock, adding security with dual authentication. The RFID module verifies the user's tag, then the keypad prompts for a PIN. If both are correct, the Arduino triggers a servo or relay to unlock the door briefly. This setup combines RFID and PIN for enhanced access control, ideal for DIY secure entry systems.

b) I2C LED

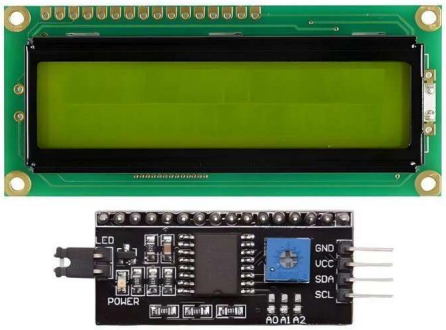


Figure 2:I2C LED

An I2C LCD can be added to an RFID and keypad-based door lock system to display status messages (e.g., "Enter PIN," "Access Granted," "Access Denied"). It connects easily to the Arduino via the I2C protocol, saving pins and simplifying wiring. This enhances user experience by providing real-time feedback during the authentication process.

c) MFRC522 RFID reader

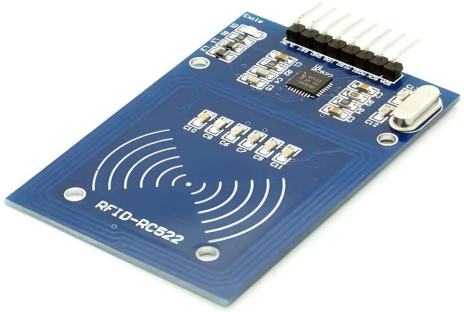


Figure 3:MFRC522 Reader

The MFRC522 RFID reader is used in an RFID and keypad-based door lock system to read RFID tags. When a tag is scanned, the MFRC522 module checks if it's authorized. If valid, the system then prompts for a PIN on the keypad. This reader enables secure tag-based authentication as part of the dual-authentication setup with the Arduino.

d) SG90 Micro-servo motor

Figure 4: SG90 Servo Motor

The SG90 Micro-servo motor in an Arduino-based RFID and keypad door lock acts as the locking mechanism. When a valid RFID card is scanned or a correct password is entered via the keypad, the Arduino signals the servo to rotate, unlocking the door. After a set time, it rotates back to lock the door again. This setup provides a simple, automated locking solution using servo control with Arduino.

e) 4X4 Keypad

Figure 5:4X4 Keypad

In an Arduino-based RFID and keypad door lock, the 4x4 keypad allows users to enter a PIN code as an additional layer of security. The Arduino checks if the entered PIN is correct; if so, and/or if a valid RFID card is scanned, the lock is released by the servo motor. This dual authentication enhances the security of the door lock system.

f) LED

Figure 6:LED

In an Arduino RFID and keypad door lock system, LEDs provide visual feedback. A green LED lights up when access is granted (e.g., after a valid RFID scan or correct PIN), indicating that the door is unlocked. A red LED lights up when access is denied, signaling an incorrect PIN or unauthorized RFID card. LEDs make the system user-friendly by clearly showing status and access outcomes.

g) Resistor 220 Ohm

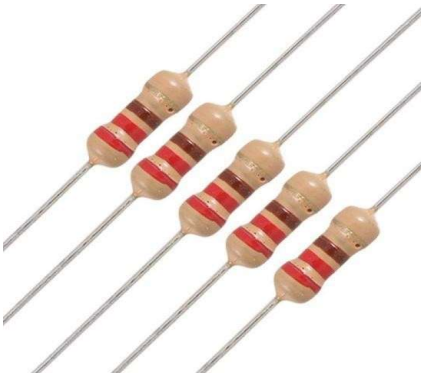


Figure 7: Resistor 220 Ohm

In an Arduino-based RFID and keypad door lock, a 220-ohm resistor is typically used with LEDs to limit current, preventing the LEDs from drawing too much power and burning out. It ensures the LEDs operate safely and extends their lifespan.

h) 6 to 12V Power Source

Figure 8: Power Source

In an Arduino RFID and keypad door lock system, a 6-12V power supply provides consistent power to the Arduino, servo motor, RFID module, and keypad. This external power source is necessary to ensure reliable operation, especia #include <MFRC522.h> #include <LiquidCrystal_I2C.h> #include <Keypad.h>

#include <Servo.h> #include <SPI.h>

// Create instances LiquidCrystal_I2C lcd(0x27, 16, 2);

MFRC522 mfrc522(10, 9); // MFRC522 mfrc522(SS_PIN, RST_PIN)

Servo sg90;

// Initialize Pins for led's, servo and buzzerlly for power-hungry components like the servo, which may not function well if powered solely through the USB connection.

IV. SOFTWARE SPECIFICATION

a) Arduino IDE

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting, and anyone interested in creating interactive objects or environments. Arduino can interact with buttons, LEDs, motors, speakers, GPS units, cameras, the internet, and even your smart-phone or your TV! This flexibility combined with the fact that the Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a huge variety of Arduino-based projects.

There are many varieties of Arduino boards (explained on the next page) that can be used for different purposes. Some boards look a bit different from the one below, but most Arduinos have the majority of these components in common.

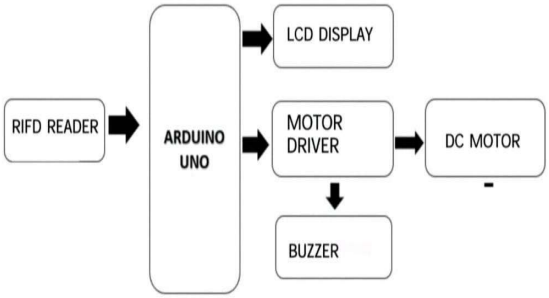
Figure 9: Arduino UNO

b) Arduino code:

```
#include <MFRC522.h>
#include <LiquidCrystal_I2C.h>
#include <Keypad.h>
#include <Servo.h>
#include <SPI.h>
// Create instances
LiquidCrystal_I2C lcd(0x27, 16, 2);
MFRC522 mfrc522(10, 9); // MFRC522 mfrc522(SS_PIN, RST_PIN)
Servo sg90;
// Initialize Pins for led's, servo and buzzer
// Blue LED is connected to 5V
constexpr uint8_t greenLed = 7;
constexpr uint8_t redLed = 6;
constexpr uint8_t servoPin = 8;
constexpr uint8_t buzzerPin = 5;
char initial_password[4] = {'1', '1', '1', '1'};  // Variable to store initial password
String tagUID = "49 A4 92 65"; // String to store UID of tag. Change it with your tag's UID
char password[4];   // Variable to store users password
boolean RFIDMode = true; // boolean to change modes
char key_pressed = 0; // Variable to store incoming keys
uint8_t i = 0;  // Variable used for counter
// defining how many rows and columns our keypad have
const byte rows = 4;
const byte columns = 4;
// Keypad pin map
char hexaKeys[rows][columns] = {
  {'1', '2', '3', 'A'},
  {'4', '5', '6', 'B'},
  {'7', '8', '9', 'C'},
  {'*', '0', '#', 'D'}
};
// Initializing pins for keypad
byte row_pins[rows] = {A0, A1, A2, A3};
byte column_pins[columns] = {2, 1, 0};
// Create instance for keypad
Keypad keypad_key = Keypad( makeKeymap(hexaKeys), row_pins, column_pins, rows, columns);
void setup() {
  // Arduino Pin configuration
  pinMode(buzzerPin, OUTPUT);
  pinMode(redLed, OUTPUT);
  pinMode(greenLed, OUTPUT);
  sg90.attach(servoPin);  //Declare pin 8 for servo
  sg90.write(0); // Set initial position at 90 degrees
  lcd.begin();   // LCD screen
  lcd.backlight();
  SPI.begin();      // Init SPI bus
  mfrc522.PCD_Init();   // Init MFRC522
  lcd.clear(); // Clear LCD screen
}
void loop() {
  // System will first look for mode
  if (RFIDMode == true) {
    lcd.setCursor(0, 0);
    lcd.print("   Door Lock");
    lcd.setCursor(0, 1);
    lcd.print(" Scan Your Tag ");
    // Look for new cards
    if ( ! mfrc522.PICC_IsNewCardPresent()) {
      return;
    }
    // Select one of the cards
    if ( ! mfrc522.PICC_ReadCardSerial()) {
      return;
    }
    //Reading from the card
    String tag = "";
    for (byte j = 0; j < mfrc522.uid.size; j++)
    {
      tag.concat(String(mfrc522.uid.uidByte[j] < 0x10 ? " 0" : " "));
      tag.concat(String(mfrc522.uid.uidByte[j], HEX));
```

```
  }
  tag.toUpperCase();
  //Checking the card
  if (tag.substring(1) == tagUID)
  {
   // If UID of tag is matched.
   lcd.clear();
   lcd.print("Tag Matched");
   digitalWrite(greenLed, HIGH);
   delay(3000);
   digitalWrite(greenLed, LOW);
   lcd.clear();
   lcd.print("Enter Password:");
   lcd.setCursor(0, 1);
   RFIDMode = false; // Make RFID mode false
  }
  else
  {
   // If UID of tag is not matched.
   lcd.clear();
   lcd.setCursor(0, 0);
   lcd.print("Wrong Tag Shown");
   lcd.setCursor(0, 1);
   lcd.print("Access Denied");
   digitalWrite(buzzerPin, HIGH);
   digitalWrite(redLed, HIGH);
   delay(5000);
   digitalWrite(buzzerPin, LOW);
   digitalWrite(redLed, LOW);
   lcd.clear();
  }
 }
 // If RFID mode is false, it will look for keys from keypad
 if (RFIDMode == false) {
  key_pressed = keypad_key.getKey(); // Storing keys
  if (key_pressed)
  {
   password[i++] = key_pressed; // Storing in password variable
   lcd.print("*");
  }
  if (i == 4) // If 4 keys are completed
  {
   delay(0);
   if (!(strncmp(password, initial_password, 4))) // If password is matched
   {
    lcd.clear();
    lcd.print("Pass Accepted");
    sg90.write(90); // Door Opened
    digitalWrite(greenLed, HIGH);
    delay(3000);
    digitalWrite(greenLed, LOW);
    sg90.write(0); // Door Closed
    lcd.clear();
    i = 0;
    RFIDMode = true; // Make RFID mode true
   }
   else    // If password is not matched
   {
    lcd.clear();
    lcd.print("Wrong Password");
    digitalWrite(buzzerPin, HIGH);
    digitalWrite(redLed, HIGH);
    delay(3000);
    digitalWrite(buzzerPin, LOW);
    digitalWrite(redLed, LOW);
    lcd.clear();
    i = 0;
    RFIDMode = true;  // Make RFID mode true
   }
  }
 }
```

V. BLOCK DIAGRAM



Power supply: A DC power supply (often 5V or 12V, depending on the hardware) powers the Arduino, RFID reader, and other components.

Arduino UNO: Arduino (e.g., Arduino Uno) controls the flow of the entire system by receiving input from the RFID reader and keypad, processing the data, and then sending signals to actuators (servo/motor) to lock or unlock the door.

RFID Reader: An RFID module (e.g., RC522) communicates with the Arduino to read the unique ID of RFID tags/cards when they are brought near the reader. The Arduino compares this data with pre- stored values to verify whether access should be granted or denied.

Keypad: A 4x4 or 4x3 matrix keypad is used to enter a passcode. The keypad sends the entered digits to the Arduino, where the input is processed and compared with a stored passcode for verification.

Buzzer: A buzzer can be used to indicate successful or failed authentication attempts. It can also serve as an alert for invalid access or an error in the system.

LCD Display: An LCD display for an RFID door lock is a small, typically backlit screen used to provide visual feedback to users during the authentication process. It displays information such as welcome messages, authentication status and system alerts like Door Locked or Error.

b)

VI. METHILOGY

Step1: Identify the functional and security needs, including dual-factor authentication (RFID + PIN), control of a locking mechanism, and optional features like alarms for unauthorized access.

Step2: Connect the RFID reader to the Arduino's SPI pins (SDA, SCK, MOSI, MISO, RST, and GND). Interface the keypad with Arduino using digital pins, which will capture user input.

Step3: Use an RFID library (such as the MFRC522 library) to read and process RFID tags. Store the authorized RFID tag IDs in the code. Implement keypad input handling to capture the PIN entered by the user. Use the keypad library for easier interaction.

Step4: Test the individual components (RFID, keypad, lock, and feedback mechanisms) to ensure they work as expected. Test the full system by scanning RFID tags and entering PINs, ensuring the system correctly identifies authorized users and denies unauthorized access.

Step5: Add a feature to log access attempts, including time, RFID, and PIN data, for monitoring purposes. Enable Wi-Fi or Bluetooth modules for remote control via a smartphone app or web interface.

Step6: Design a suitable enclosure to house the Arduino and components, ensuring durability and ease of use. Mount the RFID reader, keypad, and lock mechanism on the door.

Step7: Install the system in a real-world setting and test its performance over time to ensure reliability and robustness. Adjust parameters like lock activation time, feedback duration, and system responsiveness based on user needs.

a) Software model development

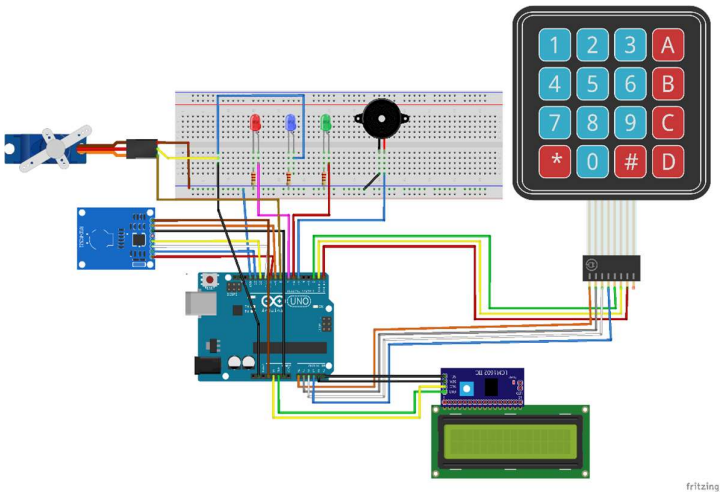


Figure 10: Software Model

b) Hardware model development

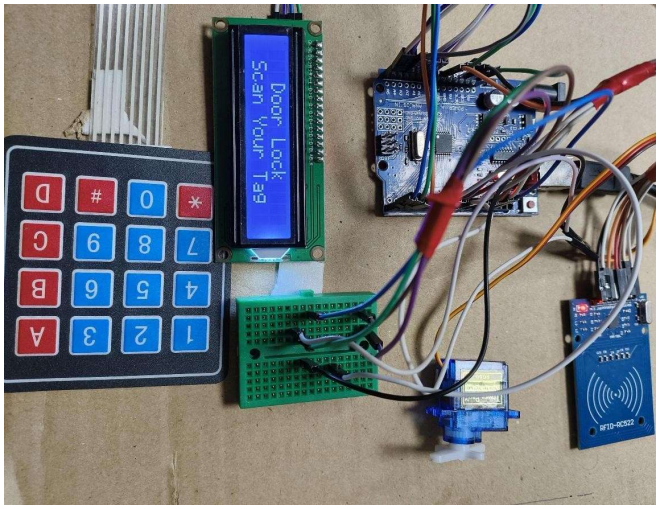


Figure 11: Hardware Model

VII. CONCLUSION

The implementation of an RFID and keypad-based door lock system using Arduino offers a practical, cost-effective, and secure solution for access control. This paper highlights the integration of RFID technology and a numerical keypad, which provides dual-layer authentication for enhanced security. The system leverages Arduino's versatility and ease of programming, making it accessible for educational, residential, and small-scale commercial applications.

The use of RFID enables convenient, contactless access, while the keypad adds an extra layer of security by requiring a PIN. The combination of these technologies reduces vulnerabilities associated with single-factor authentication. Moreover, the modularity and scalability of the Arduino platform allow for future enhancements, such as integrating IoT features, remote monitoring, or biometric authentication.

The experimental results demonstrate that the system is reliable and responsive, with minimal delays in authentication. It effectively restricts unauthorized access and logs entry attempts, providing both security and accountability. Overall, the RFID and keypad-based door lock system is a viable and efficient solution for modern access control needs. Future work could focus on improving the system's robustness against advanced hacking techniques and exploring the integration of cloud-based functionalities for real-time monitoring.

VIII. REFERENCE

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