Smart Home Security Gate System Based Arduino Uno

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Abstract. Today's home safety has become a challenge due to advanced techniques used by burglars. To offer complete security solution to lives and properties at home, schools, offices, etc., in this research paper, a smart gate lock security system-based Arduino Uno with DTMF (Dual Tone Multi Frequency) polyphonic tone sensor has been developed and simulated in Proteus platform. The keypad unit is used to enter the password whereas an LCD (Liquid Crystal Display) for visual information display. After a password has been entered, the system compares it with the stored password for a match. If there is a match 'Access Granted' is displayed on the LCD and the gate will be unlocked but after being in idle state for five seconds, the gate will be automatically locked again (protection system). If there is no match in the password, 'Access Denied' is displayed on the LCD and the gate remains closed. If wrong passwords have been entered three times in the row, the alarm system will be triggered to alert people around. For more safety, a CCD (Charge-Coupled-Device) Camera will take the photos of visitors regardless the entered password status. To reset the password, the '###' button is entered followed by the 'reset key' known by the system's owner. If the reset key is confirmed, the system's owner will enter twice the new password. The system has recorded 100% success rate (SR) in granting access for registered users and 100% failure rate (FR) for non-registered users. Finally, the system has also been 100% successful for password reset.

Keyword: Smart gate; Arduino UNO Atmega328; LCD; Keypad; Security; password.

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1. INTRODUCTION

The advent of modern technology is a cornerstone of societal development and global economic growth. Many people spend more time away of their homes due to work, study and other duties. Consequently, homes become more vulnerable for several threats particularly being burgled (Hussein et al., 2017). Therefore, the need for upgrading the current security systems in homes, schools, offices and other buildings for the protection of lives and properties (Afroz, 2022). Nowadays, electronic door lock systems are one of the most popular security systems being used in many residential and business places. The vital characteristic behind the wide use of such systems is their reliability while authorizing or denying the door access to persons with a correct or wrong password (Park et al., 2009). A door lock system called Near Field Communication (NFC) door lock system has been proposed in (Hung et al., 2015). In this pattern recognition technology system, persons' faces are analyzed for their authentication (Jiang et al., 2013). Furthermore, a digital door lock system using PIC platform was proposed in (Ibrahim et al., 2015). Here, 5-digit password is used to lock/unlock the door. When the user enters an incorrect password, the system alerts the owner via the incorporated GSM module. In (kale et al., 2014) an intelligent system for home security using illumination sensitive background model is presented. The system utilizes a face recognition technique to track, detect and identify intruders. For more reliable security, an image of the intruder is sent on the owner mail id for further actions. An android-based home door locks using Bluetooth technology was developed in (Ismail et al., 2014). User's key is sent as radio frequency (RF) signal to the Arduino Uno for authentication and eventual decision for releasing the electromagnetic (EM) lock or not.

Therefore, in this research, a smart gate lock security system-based Arduino uno Atmega328 with DTMF (Dual Tone Multi Frequency) polyphonic tone sensor was developed. 6-digit password is used to unlock and open the gate (Islam et al., 2014). A CCD Camera is used to take photos of visitors. If the entered password is valid, the gate will be opened, else the door will remain locked (Dash et al., 2023). For more safety, if wrong passwords have been entered three times continuous, the alarm system will be triggered to alert surrounding people. Finally, for more convenience, the system owner can reset the password at any time.

2. SYSTEM ARCHITECTURE AND OPERATION

2.1 System Working Mechanism

Fig. 1 depicts the working mechanism of the proposed smart gate lock security system. The Arduino Uno Arduino UNO ATMega328 receives and processes polyphonic tone signal in order to operate the gate. The keypad unit is used to enter the password whereas an LCD for visual information display. DTMF polyphonic tone sensor will capture user's password and send it to the Arduino Uno for authentication (Rangkuti et al., 2015). While the CCD camera captures and stores user's photos, the LED/Buzzer will be triggered for any suspicious person. L298N Motor Driver Module opens/closes the gate according to instructions from the Arduino Uno (Shabani et al., 2017).

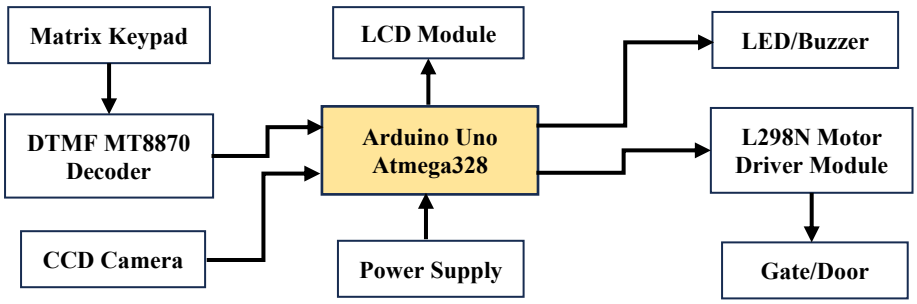

Fig. 1. System Block Diagram.

2.2 Decision Making Algorithm

This algorithm was designed and installed into the microcontroller that instructs the solenoid to automatically lock or unlock the gate based on the password status. The programming of the gate lock security system and password reset is shown in Fig. 2.

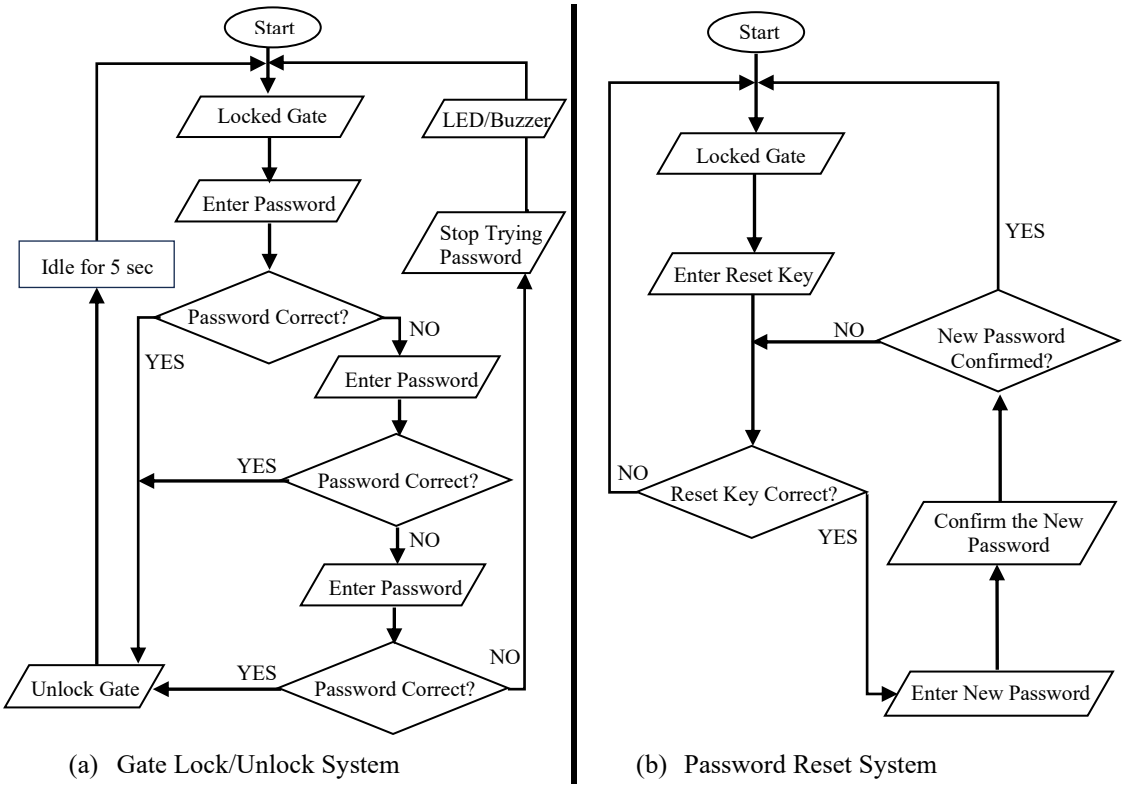

Fig. 2. System Flow Chart.

3. SYSTEM OPERATION

3.1 Simulation Tool

Proteus Design Suite was chosen to run this project. In fact, this software suite contains schematics, simulation and printed circuit board (PCB) designs (Shabani et al., 2021). Intelligent Schematic Input System (ISIS) is the software to draw schematics and simulate the circuit in real time. It consists of several components such as Arduino UNO ATMega328 microcontroller, VSM DLL model (keypad), 16x2 Alphanumeric LCD display, PWM servo motor, LED bulb, resistors, and virtual oscilloscope (Singh, 2015). The compiled C++ codes are saved as .hex type file, in Proteus, to allow their updates or calibrations based on the user preference (Sun et al., 2015). The schematic diagram of the developed smart gate lock security system is depicted in Fig. 3.

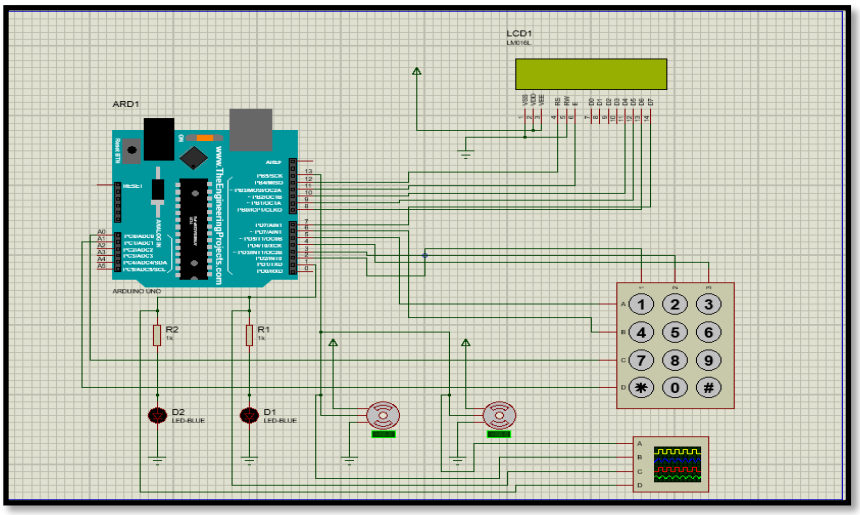

Fig. 3. Schematic Diagram.

3.2 Running Mechanism

The 3x4 keypad is the input module to type in passwords at the gate lock security system (Singh et al., 2025). The received signal is sent to Arduino Uno microcontroller via DTMF decoder module for processing. Then, the microcontroller checks the entered password for authentication. Once the authentication is complete, the microcontroller instructs the solenoid to lock or unlock the gate according to password status and instantly, the camera snapshots the person at the door. Fig. 4 shows the declaration codes to connect the keypad pins to the Arduino board pins.

FYP_PROJECT_FINAL_CODE | Arduino 1.7.11

File Edit Sketch Tools Help

FYP_PROJECT_FINAL_CODE

```
#include<LiquidCrystal.h>
#include<Servo.h>

/*LCD rs=12, en=11, D4=10, D5=9
D6=8,  D7=7
*/

LiquidCrystal lcd(12,11,10,9,8,7);
Servo Servo1;

//defining pins used for rows and columns
int servoPin=13;
int c1=2;
int c2=3;
int c3=4;
int r1=5;
int r2=6;
int r3=A0;
int r4=A1;
```

Fig. 4. Declaration Codes for Keypad Pins Connection.

The first stage of this system is the pop-up instruction “Enter Password”. Thus, its declaration code has been written in the ‘void setup’ function. Fig. 5 shows the coding for the ‘Enter Password’ function.

```
void setup()
{
  lcd.begin(16,2); // lcd initialized 16*2
  lcd.print("Enter Password:");
  lcd.setCursor(0,1);
  Servo1.attach(servoPin);
  pinMode(r1,OUTPUT);
  pinMode(r2,OUTPUT);
  pinMode(r3,OUTPUT);
  pinMode(r4,OUTPUT);
  pinMode(c1,INPUT);
  pinMode(c2,INPUT);
  pinMode(c3,INPUT);
  pinMode(1,OUTPUT); //led connectd to pin 1
  pinMode(13,OUTPUT); //servo connected to pin 13

}
```

Fig. 5. Declaration Codes for 'Enter Password' message.

Fig. 6 shows "Enter Password" message that will be called each time a keypad button is pressed.

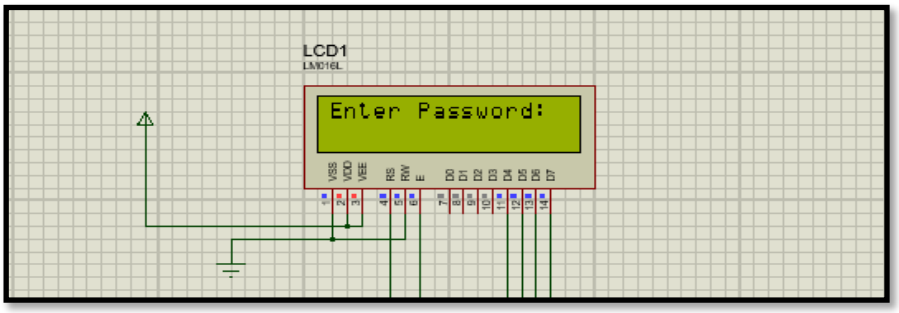

Fig. 6. Form of Message 'Enter Password.'

If a correct password is entered, the microcontroller will construct the servo motor to open the door. The coding to open the door has been written in 'void loop' function as shown in Fig. 7.

```
void loop()
{


for(m=0;m<3;m++)
{
  scan_choice();
}

if(temp[0]=='0' && temp[1]=='0' && temp[2]=='0') // correct password to open door 000
{
  Servo1.write(90);
  delay(1000);
  Servo1.write(180);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("OPEN DOOR");
  digitalWrite(1,HIGH); // led on
  delay(1000); // delay of 3 seconds
  digitalWrite(1,LOW); // led off
  return setup();

}
```

Fig. 7. Declaration Codes for 'Open Door' message.

Fig. 8 displays “Open Door” message that is called each time a correct password is entered.

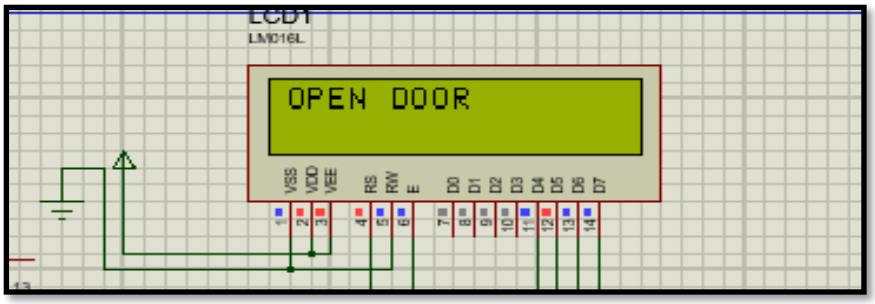

Fig. 8. Form of Message ‘Open Door.’

Fig. 9 shows “Wrong Password” message that is called each time a wrong password is entered.

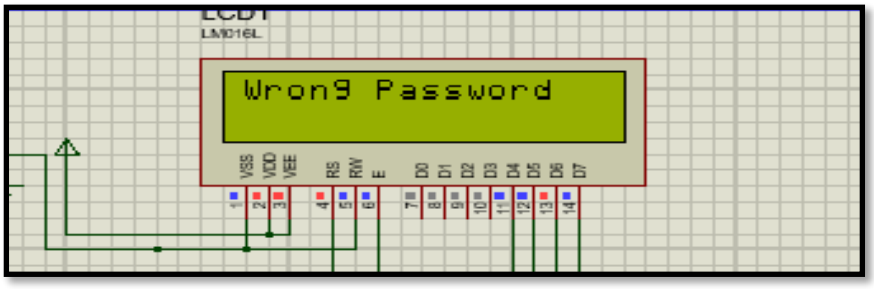

Fig. 9. Form of Message ‘Wrong Password.’

After a wrong password has been entered three times consecutively, the microcontroller will, simultaneously, trigger the buzzer/Alarm and display the message ‘Stop Try.’ The coding is shown in Fig. 10.

```
attempt=attempt+1; // variable increment by 1 on entering wrong password
if(attempt==3) // if 3 wrong passwords entered consecutively
{
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Stop Try");
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Reset System");
  return reset();
}
```

Fig. 10. Declaration Codes for ‘Stop Try’ and ‘Reset System’ messages.

Fig. 11 shows “Stop Try” message that is called each time a wrong password has been entered consecutively three times.

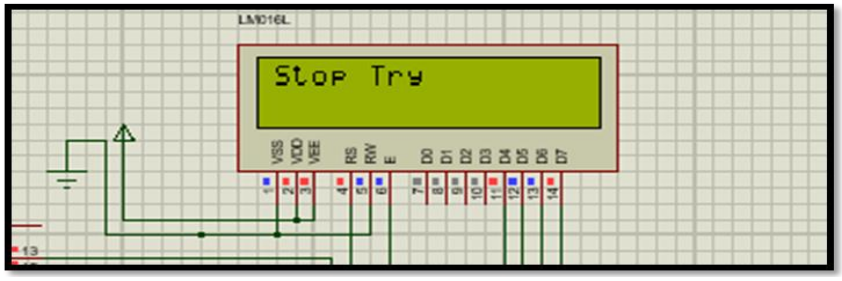

Fig. 11. Instruction ‘Stop Try.’

3.3 System Password Reset

Changing the system password from time to time is required to strengthen the security of any system. After the 'Reset Pass' (known by the system owner) has been entered and validated, the LCD will display the message 'Enter New Password' and afterward the message 'Confirm the New Password' to re-enter the new Password. If the confirmation is approved, the system password is reset to the new password. Fig. 12 shows "Enter Reset Pass" message that is displayed on the LCD.

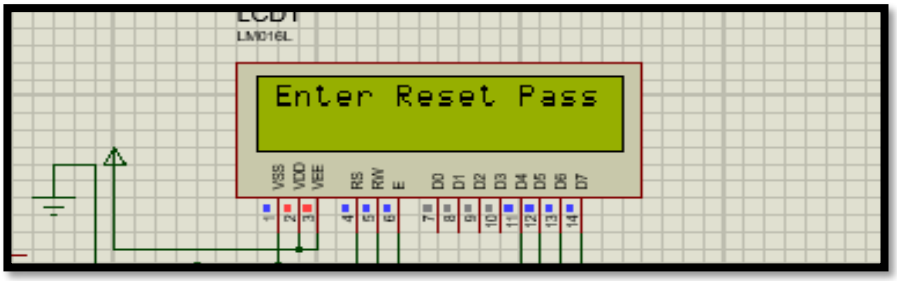

Fig. 12. Instruction 'Enter Reset Pass.'

If the confirmation is approved, the system password is reset to the new password and the message 'Reset Success' is shown on the LCD. The coding is shown in Fig. 13.

```
if(temp[0]=='#' && temp[1]=='#' && temp[2]=='#') // correct password to reset system ###
{

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Reset Success");
  delay(1000);
  return setup();

}
```

Fig. 13. Declaration Codes for 'Reset Success' messages

Fig. 14 shows "Reset Success" message after verification and confirmation of the new password.

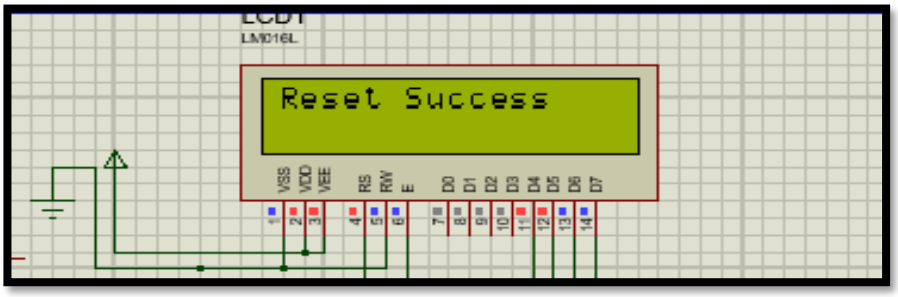

Fig. 14 Print Out Statement 'Reset Success.'

4. SIMULATION RESULTS AND DISCUSSION

To validate the developed smart gate lock security system, ten passwords have been created and tested with varying number of trials. The system success rate (SR) and failure rate (FR) have been used to evaluate the performance of the proposed system [2]. The success rate (SR) and failure rate (FR) are, respectively, obtained using the Eq. (1) and Eq. (2) [2].

$$SR = \left(\frac{S_{\mathrm{r}}+S_{\mathrm{nr}}}{T_{\mathrm{r}}+T_{\mathrm{nr}}}\right) \times 100\% \quad (1)$$

$$FR = \left(\frac{F_{\mathrm{r}}+F_{\mathrm{nr}}}{T_{\mathrm{r}}+T_{\mathrm{nr}}}\right) \times 100\% \quad (2)$$

Where:

S_{r}: Successful system access by registered passwords.
S_{nr}: Successful system access by non-registered passwords.
F_{r}: Failure system access by registered passwords.
F_{nr}: Failure system access by non-registered passwords.
T_{r}: Total system transactions by registered passwords.
T_{nr}: Total system transactions by non-registered passwords.

Table 1 presents the simulation results of ten conducted tests amongst them five registered passwords and five non-registered passwords.

Table 1. Test Results

Passwords	Registered	Number of Trials	Succeed Trials	Fail Trials
158973	Yes	3	3	0
258967	Yes	5	5	0
356201	Yes	4	4	0
781003	Yes	9	9	0
681233	Yes	7	7	0
250020	No	1	0	1
894122	No	2	0	2
602215	No	2	0	2
302545	No	3	0	3
835876	No	3	0	3

The test results from Table 1 confirms the success of the developed smart gate lock security system. In fact, all five registered passwords were 100% granted system access while the five non-registered passwords 100% failed to gain system access.

5. CONCLUSION AND RECOMMENDATIONS

To guarantee security to lives and properties, a more secure and cost-effective smart gate lock security system-based Arduino uno Atmega328 with DTMF (Dual Tone Multi Frequency) polyphonic tone sensor was developed. This is a simulation project due to the lack of the DTMF hardware. The code was written in Arduino 1.7.11 version while the circuit was drawn in Proteus 8 Professional platform. The system verifies the entered password and then opens the door (Fig. 8), else it will display 'Wrong Password' message (Fig. 9) while the door remains locked. After unlocking the door, the system waits for 5 seconds and if the door is not opened, it will automatically be locked. Changing of the system's Password can be triggered when the rest button is pressed and the 'Reset Password' is entered. After validation of the 'Reset Password,' the new Password is entered.

In future, the android application should be implemented whereby the house owner will be notified by SMS, calls and snaps of any suspicious person at the gate house and an auto trigger report of the attempt to theft to be sent to nearest police station along with domestic address. A prototype should be built to complete this project.

6. ACKNOWLEDGMENTS

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