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KEYPAD AND SMARTPHONE BASED DIGITAL DOOR LOCK

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ABSTRACT
This paper presents a low-cost digital door lock system that is controlled by a microcontroller. There is a need for a secure system that is hard to tamper within these times where robberies and thefts are increasing in homes and shops. The proposed door lock can be accessed by both a keypad and an Android smartphone. The microcontroller used is the Atmega328P (found in Arduino UNO) and interfaced with the smartphone via a Bluetooth module. The door lock can be operated through keypad if Bluetooth module is not working. A double lock system consisting of a solenoid lock and a servo motor has been used in the system, which adds to the security. A buzzer is added to alert the person accessing the door and the nearby people if the input password is incorrect. The simulation of the complete system has been performed on Autodesk Tinkercad.

Keywords: Digital, Smartphone, Bluetooth, Keypad.

INTRODUCTION
The security systems in domestic and commercial buildings are so old and outdated that they can be easily compromised. In areas where people "live under a rock," such as rural areas, they tend to use conventional methods of security. They rely on mechanical door locks and doors with inbuilt handles and latches. Although they are effective in warding off outsiders, they are not effective from a security perspective of security.

So, to enhance the security of the doors, people are opting for digital door locks, as they cannot be easily compromised since they are operated electrically. Such door locks have a lot of options to unlock. Some of these options are password entry by keypads, fingerprint scanners, face recognition, barcode scanners, etc. The digital door locks can also be accessed with a smartphone, provided a proper interface is established between the phone and the door lock.

In this project, a digital door lock system prototype has been made that can unlock a door using either a keypad or smartphone. This is done so that there is versatility in accessing the door, and in the event of the failure of one option, another option can be used to unlock the door, which makes the system more reliable. The system can be modified to unlock the door with both the keypad and the smartphone simultaneously.

The smartphone is connected to the door lock via Bluetooth, and a display is provided for the user to determine the state of the door lock. A buzzer is also connected to alert the user in situations where the input password is incorrect. A solenoid lock and a servo motor are used for the lock.

Section one of the paper gives a brief introduction to the topic; next section discusses the literature survey; after that the design and simulation of the system has been described; hardware implementation and its working is explained in further section. The last section concludes the paper.

DIGITAL DOOR LOCK

The Conventional Lock
The concept of security existed in ancient times, when people used wooden locks to tightly shut their doors. The wooden locks were quickly replaced by metal door locks since wood can easily be cut down with sharp objects and erodes quickly over time. The metal door locks were used with chains. These chains are unbreakable with sharp objects like knives, blades, etc. But the mechanism of unlocking a chain lock was fairly simple; it uses a latch that holds the lock in place and can be unlatched easily, so it was not a good choice for long-term protection (Italia, 2018).

The Mechanical Door Lock

Then came the mechanical door lock. It was an enclosed box-like item that contained mechanical gears that turned in order to unlock and lock when a certain key was inserted into it. This 'key' was built specifically for a particular type of lock (Italia, 2018). But the mechanical lock had some disadvantages of its own, one of which was duplication of keys, meaning the key with the specific pattern could be duplicated and used for unlocking the door lock without the original.

Present Applications

The digital door lock is currently used in several applications worldwide. They are used in hotels, where each hotel room has a magnetic key specifically coded for the lock so that only that key can open the door.

In offices: Only employees are allowed to enter the premises, so a specific barcode is provided on their ID card for each employee. For guests, a guest ID is issued, although in some offices, they do not even have a bar code for scanning.

In banks: Although they are not exactly used in door applications, similar technology is used in bank safes and vaults, where money and valuables are stored.

Military: Military safe rooms and secret storage rooms utilize digital door locks to keep their ammunition, weaponry, and important documents safe. They also use digital door locks with monitoring systems in their secret rooms to conduct top-secret meetings or military strategies so that they do not leak out into enemy territory.

Homes: Residents in high-rise buildings are opting for digital door locks due to their additional security and complex structure, which makes lock breaking a difficult job for the thieves.

DESIGN AND SIMULATION

Design of Door Lock

The main objective of the door lock is to unlock the door with either a keypad or smartphone. To achieve the objective, the following components have been utilized, as seen in Fig. 1.

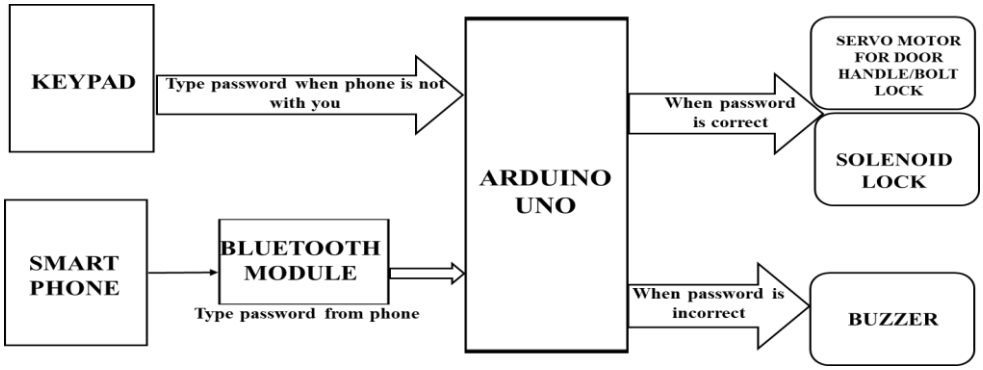

Fig. 1: System block diagram

Arduino UNO

This is a development board that houses the Atmega328P microprocessor for this project. It is the most widely used development board. It is simple to program and comes with an integrated development environment (EZ Orji, 2019) (Chattoraj, 2016)

4x4 Keypad

The keypad has the following numbers, letters, and special characters: 1, 2, 3, 4, 5, 6, 7, 8, 9, *,0, #, A, B, C, and D. With such a diverse set of keys at your disposal, a more secure passcode can be generated throughout the microcontroller coding process. Furthermore, the keys may be programmed to execute tasks such as clearing typed input, backspacing, and so on (Ray, 2022) (Roopchandka, 2019) (Amanullah, 2013) (Jain, 2016).

LCD Display

The LCD display is utilized to show whether the password entered is accurate. In the project, a 16x2 LCD display has been utilized (so-called because it has two rows of sixteen parts each). The text is displayed in both rows. These displays require a steady 5V power source to function, and the necessary pins are linked to the microcontroller to show the text. (Ray, 2022) (Roopchandka, 2019) (Saxena, 2022) (Alkhazali, 2023).

Solenoid Lock

A solenoid lock is an electrical lock that activates when the solenoid present inside the lock is powered. They are powered by 9V and 12V supplies, which Arduino cannot supply; thus, they are connected to an external source, which is connected to the lock through a 5V channel relay. In most cases, it is in the locked position. When the supply is provided, the lock is unlocked (Goswami, 2017) (Ha, 2015).

5V Relay Module

It typically has two modes: normally closed (NC) and normally open (NO). When a signal is applied to the relay, it will change from the NC area to the NO area, completing the NO circuit (Goswami, 2017) (Ha, 2015).

Servo Motor

This is employed as a door handle lock in the project. The servo motor used is a Tower Pro MG995, with a stall torque of 9.4 kg/cm at 4.8 V input. The servo mechanism, along with the solenoid lock, results in a double lock mechanism (Pandurang, 2016) (Doshi, 2022).

Piezo Buzzer

This component is configured to make a sound if the password is entered incorrectly. This may be used to notify everyone around if an unauthorized person tries to unlock the door lock (EZ Orji, 2019) (Chattoraj, 2016) (Neelam, 2016) (Ankit, 2016).

Bluetooth Module

The Bluetooth module is used to connect the system to the Arduino wirelessly through Bluetooth. The module utilized is an HC-05 module with a range of ten meters and Bluetooth 2.0 compatibility. The Bluetooth module supports Android smartphones and PCs. (Saxena, 2022) (Alkhazali, 2023) (RA Ramlee, 2012) (Islam, 2015).

Power Supply

For powering both the Arduino and the solenoid lock, a regulated power supply is made. The schematic diagram of the power supply made on Easy EDA software is shown in figure 2. The input power is taken from the AC mains, stepped down to 12 volts AC, and converted to almost pure DC by means of a rectifier and a C filter. It is further rectified into pure DC with the help of a voltage regulator.

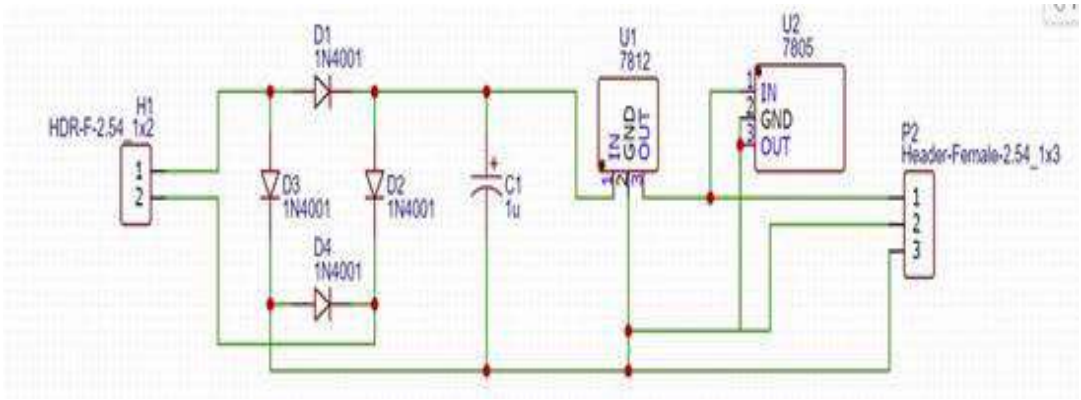

Fig. 2: The schematic of power supply

Fig. 3 shows the schematic of the system. The Arduino is interfaced to an LCD display, Bluetooth module, servo motor, and keypad as described below

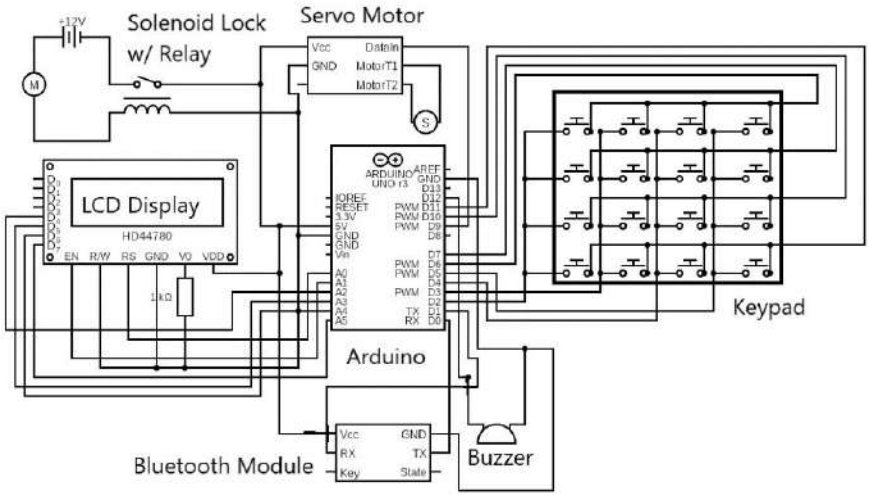

Fig. 3: The schematic for the digital door lock circuit

Digital pins 2, 3, 4, 5, 6, 7, 10, and 11 are linked to the keypad. The R/W, GND, LED2, and V0 (connected to a 1 k resistor) connections of the LCD are linked to the Arduino's GND pin, VDD and LED1 to 5V, and RS, EN, D4, D5, D6, and D7 to the analogue pins A0, A1, A2, A3, A4, and A5 of the Arduino.

The TX pin of the HC-05 is linked to digital pin zero of the Arduino, the RX pin of the HC-05 is connected to digital pin one of the Arduino, and VCC and GND are connected to 3.3V and GND of the Arduino, respectively.

The Arduino's 5V pin and seventeen linked to the GND pin provide power to the servo and the 5V relay. The servo control pin (data) is attached to digital pin 9 (which is also a PWM pin since servo control is done with PWM), while the relay activation pin is connected to Arduino pin thirteen.

The piezo buzzer is attached to the Arduino's pin twelve and GND. The NO relay output is coupled to the solenoid lock.

- **Simulation of the Circuit**

This circuit was simulated using Autodesk Tinkercad, an online simulation software, as shown in Fig. 4.

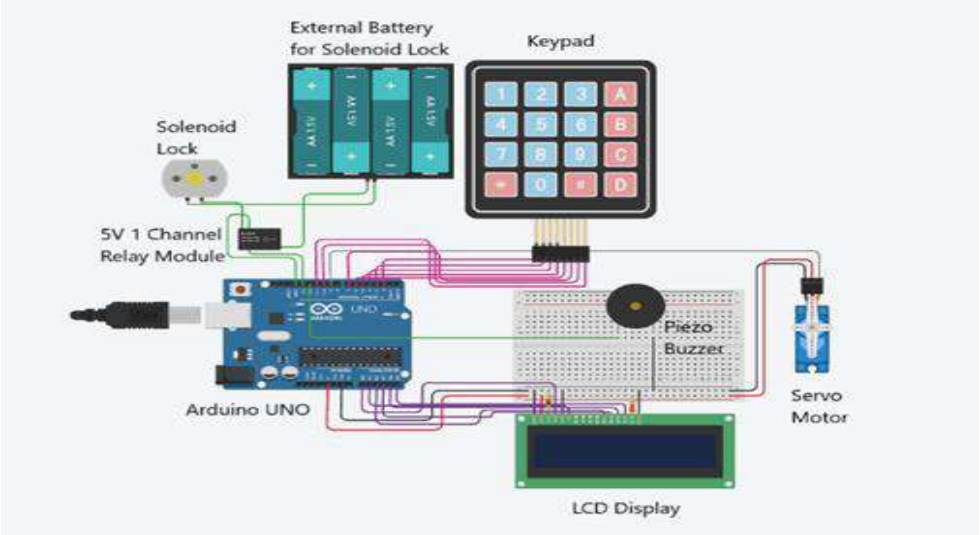

Fig. 4 The digital door lock Tinker cad simulation

The Arduino board must be powered in order to power the circuit. There are three options for doing so.

- By making use of the 12V DC adapter pin
- By using the 5V USB cord (this is used for uploading the code too),
- Using the Arduino's Vin pin (it requires an uncontrolled DC supply of 7–12V or a regulated DC supply of 5V through a jumper connection) (Neelam, 2016) (Ankit, 2016)

HARDWARE IMPLEMENTATION

The functioning of the prototype is dependent on the microcontroller. There are two ways the password can be typed.

- Using the Keypad
- Using the serial monitor

Using the Keypad

A certain password is set on the microcontroller, and if the correct password is typed, the solenoid lock will unlock and the servo motor will unlock or turn the door handle. The password is a string function, meaning characters other than numbers can also be set in the passcode. The other characters in the keypad other than numbers are *, #, A, B, C, and D. These keys can also be used for distinct functions; they must be coded accordingly (EZ Orji, 2019) (Chattoraj, 2016). Once the door lock unlocks, a timer of 10 seconds will start; within that time, we must open and close the door. Once the timer ends, the" Door Closed" sign appears on the LCD display, and the locks will immediately be activated and the door will be locked.

Using the Serial Monitor

The serial monitor serves as a "tether" between the computer and Arduino, allowing the user to send and receive text messages, which is useful for debugging and controlling the Arduino using a keyboard.

The same code (used for unlocking via the keypad) is used, except the input is taken from the serial monitor and displayed on both the LCD and the serial monitor. This serial monitor of the Arduino is accessed by the Android smartphone via Bluetooth. This way, we can unlock the door with our smartphone. Before using the smartphone to unlock the door, a few things need to be done, as mentioned below.

The first step is to connect an Android phone to the HC-05 module. To pair these devices successfully, a passkey needs to be typed; the passkey is either 0000 or 1234 (Sarno, 2018) (Javale, 2013) (Lia Kamelia, 2014) (Bhattacharya, 2022). Then a suitable terminal app is used to access the serial monitor from the smartphone. An Android app can also be developed to connect the serial monitor and smart phone (RA Ramlee, 2012) (Islam, 2015) (Abdulsalam, 2023) (Nasirruddin, 2018).

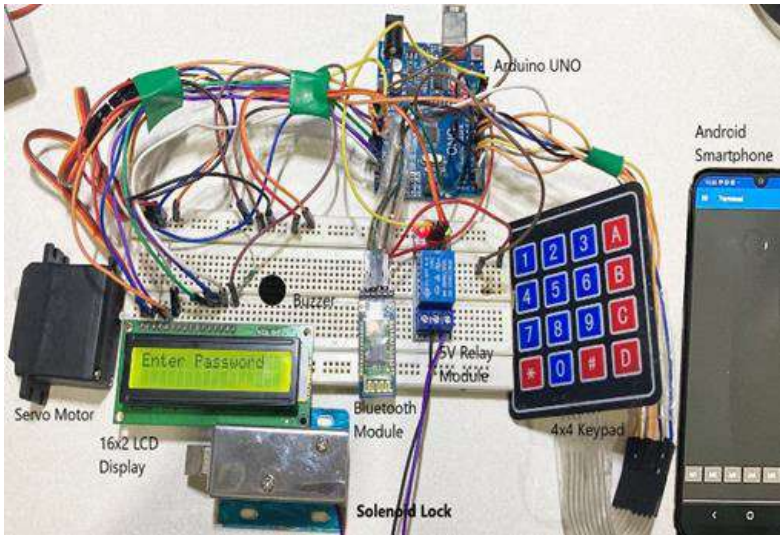

Fig. 5 Hardware implementation

The circuit's output is depicted in Fig. 6. The servo motor is initially in the rest position, and the solenoid lock is locked.

Fig. 6 Stages of operation of the digital door lock

The microcontroller starts when the power is turned on, and the screen shows "Enter Password," as seen in Fig. 6a. To prevent the password from being revealed, we coded it to display the '*' sign on the display, as illustrated in Fig. 6b (Mishra, 2014).

The character limit for the code is kept at five. So once the password reaches the character limit, the process based on the typed password begins. When the typed password matches the preset password, the lock unlocks. The display shows" Door is Open (Fig. 6c), the servo motor rotates 90 degrees, and the solenoid lock unlocks. After the door is unlocked, it can be operated. An instruction will pop up on the display, showing how to close the door (Fig. 6d).

The door should be operated within the period the" close door" screen is displayed. Once the time is up, the screen will show lock activated" (Fig. 6e), the servo motor will go back to the rest position, and the solenoid lock will be deactivated.

If the typed password does not match the preset password, the screen will show" Wrong Password" (Fig. 6f), and the buzzer will start beeping five times.

If the wrong character key is pressed, the "*" key on the keypad can be used to clear the data (Mishra, 2014). The password must be retyped after it has been cleared. The process of opening the door with the smartphone is identical to that of unlocking the door with the keypad (Abdulsalam, 2023) (Nasirruddin, 2018), but the door lock can be accessed with the smartphone anywhere, while with the keypad, you must be next to the system.

Fig. 7 Unlocking the door with the smartphone

Fig. 7 shows the unlocking of the door lock with a smart phone. For the project, an application called Serial Bluetooth Terminal (available on the Google Play Store) has been used for accessing the Arduino Serial Monitor on the Android device (Abdulsalam, 2023) (Nasirruddin, 2018) (O Agbo David, 2017) (Rathod, 2017). To access it, we need to pair the phone with the HC-05 module and connect the Arduino within the application. Once it is connected, we can go ahead with unlocking the door by typing our password, as seen in Fig. 7.

The serial monitor has also been programmed so that it displays the same text as on the LCD screen. So, whether the password typed is correct or incorrect can be seen on the smartphone screen (Srinivasan, 2022) (Bhute, 2017).

Conclusion and Future Scope

This paper has proposed a low-cost digital door lock system that provides a two-in-one solution for unlocking the door by using either the keypad or the smartphone. The interfacing of the smartphone with the door lock via Bluetooth was successfully implemented. In case of failure of Bluetooth module, the door lock can be operated by keypad. The prototype double lock system works as per the proposed plan, and the system responds to the correct passcode typed either from the keypad or smartphone.

- As technology is evolving and every aspect of life is being upgraded or digitised, the old methods of security are not reliable. We need to make sure that the present security system can keep ourselves and our belongings safe. This is one of the primary reasons for our security systems digitalization. It is also one of the fields that can be upgraded with the coming technologies. A few of them are listed below.

- Use of fingerprint and face recognition in providing enhanced security.
- The addition of a detection system to detect any unwanted or unauthorised person entering the premises
- This detection system can include security alarms, CCTV cameras, automatic locking mechanisms, deadlocks, etc.

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