

## DESIGN AND IMPLEMENTATION OF A SMART COMBINATION LOCK

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### ABSTRACT

There is an increase in the number of mobile phone users and the availability of Bluetooth application in virtually all mobile phones in existence today at a simple and low cost. This has made the possibility of developing a secure solution for wirelessly connecting our mobile phones to our home automation system a reality. Hence, this project aims at designing a smart combination lock by exploiting Bluetooth as a wireless connection protocol on android mobile devices to control a door via a solenoid lock. The user will have to install the door lock application on his/her android device and register a password that will enable him/her open and close the door. The main improvement in this system is the introduction of auto-lock key which makes it possible for the door to be left open in case many users wants to access the door at the same time thereby eliminating repeated password entry, provision of dual access to the door using Bluetooth and Short Message Sending (SMS) as well as notification of the house owner when a user accesses the door as well as when the wrong user tries to access the door.

**Keywords** – *Smart Phone, Android, Solenoid Lock, Bluetooth, Arduino*

### 1. INTRODUCTION

The design of a home security system is of great importance in our today's world with the increasing demand for the security and protection of life and property from various forms of threat and vulnerabilities [1]. Locks and keys have been around for centuries now, they are installed in doors and stimulated mechanically by the right keys [2].

The security sector is undergoing a transformation from mechanical to electronic (digital) systems. This has

brought about the need to review existing systems and look into the possibility of creating better systems that are smarter and more secured [3]. Recently, the internet was improved and many things were connected to it (phones, laptops, cars, television, tablets, etc.) This was done because of our need for a smarter and more productive system [2]. Today, the number of mobile phone users including smartphones is rapidly increasing worldwide and various convenient and useful applications have been developed [4]. Now smartphones are not only used to send and receive phone calls, send text messages, and perform mobile banking operations but are used to control various other devices in our everyday life. Through a mobile operating system and internal applications, varieties of external devices such as cars, televisions, computers, projectors, etc. can be remotely controlled [2].

Virtually all mobile phones in existence today contain the Bluetooth application, which is a simple, low cost and secure solution for wirelessly connecting a mobile phone to our home automation system [5]. For this reason, this project work is to develop a smart combination door lock system by exploiting Bluetooth as a wireless connection protocol on android mobile devices to control a door via a solenoid door lock. In order to achieve the aim the following objectives were pursued; first an Arduino application was developed that will provide a Graphical User Interface (GUI) for entering of passwords into the system. Then the microcontroller was coded to enable it interface with the Bluetooth module for connection with android smartphone and also to enable the GSM module send SMS (Short Message Service). Finally a program was developed that will enable the microcontroller to open/lock the door via the solenoid lock under predefined conditions.

A smart combination door lock system is a keyless entry system that enables a user to operate a door using his/her android smartphone. With this system, the use of keys and the stress of moving around with them are eliminated because it is easier to carry our phones around than keys. Also some phones are now more secured than ever, it is possible to use a standard AES encryption that is very hard to penetrate [6]. For this reason theft or loss of phone will not be an issue.

The home door is an important aspect of home security system which must be adequately secured and easily accessible to authorized persons. This project seeks to address this issue by enhancing the door security level, such that only authorized persons with the correct passwords can gain access to a house or a restricted area. With this design, even if a phone is misplaced or stolen the security of the door is guaranteed because an enemy must have the right password in order to gain entrance. Loss of phone will not incur any additional cost as to ensuring the security of the door because the door lock application can be easily installed on any android device and the passwords can also be easily changed or modified by users. Also with this system, the house owner will be instantly notified in case of security breach (password manipulation) and whenever the door is opened by an authorized person. The house owner is also at the liberty of changing the password of any member at any time, with this temporary passwords can be given to visitors and anticipated threat from any member can be avoided. The home owner can also open the door from any remote location in case a user encounters any challenge in operating the door and also when a visitor without password visits the house while he is away from home.

## 2. RELATED WORKS

In [7], a Microcontroller-controlled Security Door System which enables the control of a door via a smart card was designed. However the drawback of this system is that anyone can easily open the door as long as he/she has the right smart card.

A Digital Security System with Door Lock System using RFID Technology was proposed in [8]. Though the aim of this design was achieved but the security of the door solely depends on the tag, such that even in the hands of the wrong person the door can still be opened.

In [9], a motion based home security system which uses a microcontroller was developed. The owner only gets notification via SMS whenever the light falling on the photodiode is obstructed by an obstacle. However, this obstruction cannot only be caused by the finger of a

burglar; insects and birds can also cause it which will result in unnecessary disturbance and tension.

A door locking security system using GSM was considered in [3]. The challenge of this system is that to open the door a call has to be made and for a call to be made, a communication network is required. It therefore means that if there is network failure, the user can't gain entrance to the room which can be a bit frustrating.

Lia et al [10] implemented a door locks automation system using Bluetooth-based Android Smartphone. Despite the fact that the right password must be entered to open the door, the house owner doesn't get notification of any security breach or successful opening of the door. Provision was not also made to enable a user reset or change his/her password at regular intervals in order to eliminate any anticipated threat.

A password based security lock system which enables a user to enter a password through a keypad in order to unlock a door introduced in [11]. The downside of this design is that the keypad in this case is incorporated on the door; a person can stand to observe closely and figure out the password that the user enters or even capture the keypad in the process with a camera.

The design of an android-based home door locks application via Bluetooth for disabled people was carried out in [5]. The design targeted only a particular set of people (the disabled) and anyone that has the application installed on his/her phone can easily open the door as no password is required.

Most of the existing models actually serve the purpose for which they were designed it was observed made that the models are limited in their areas of application because the door was designed to lock automatically after being opened by a user. With this arrangement, using the door on special occasions where a large number of people are to enter/leave the house and password/tag cannot be provided for all of them will require repeated entering of password or insertion of tags which will be stressful and time consuming. Also the use of tag or smart card in order to open the door has some security risk as they can be easily stolen by an enemy and as such giving them no difference from the conventional lock because once a person has the right key he can also open a lock.

Hence, we have proposed a model that is simple to implement and cost effective but provides adequate security. In order to make the door suitable for all occasions, we have introduced an auto-lock key in our model. The door will only lock automatically if this key is triggered; else it will remain opened in other to suit the occasion at hand. Our proposed model intends to make up for the issue of network failure as a rightful

user will only need a Bluetooth enabled android smartphone which requires no communication network for connection to the system. In order to have peace of mind as regard to the security of his home whenever he is away, the owner requires a constant notification of the state of the door. In our proposed model, the owner gets an SMS alert each time the door is opened and also when a wrong password is entered. He gets to know the person that enters into the house and the time at which he/she entered. In case of network failure, an alarm system is included in the design which is automatically triggered whenever a wrong password is entered repeatedly for three times.

### 3. MATERIALS AND METHODS

The block diagram of the design is shown in fig. 1 below;

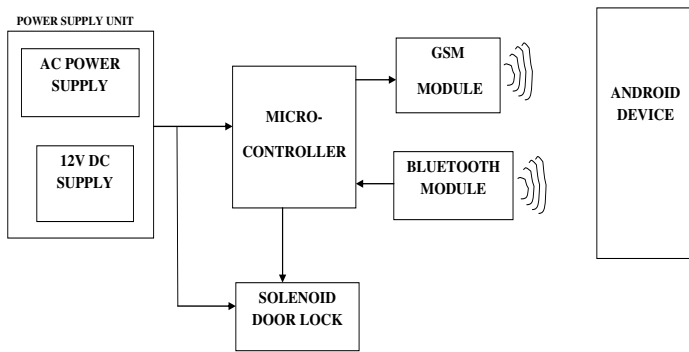


Figure 1: Block Diagram of a Smart Combination Lock

The smart lock unit consists of the microcontroller, the GSM module, Bluetooth module, solenoid lock and the android device. The android device serves as the medium of entering passwords into the system. It has a graphical user interface which contains a keypad through which password can be entered and also a key for resetting passwords.

The microcontroller is programmed to carry out the following tasks:

- To accept passwords from the android device via the Bluetooth module and confirm if it is correct or not.
- To send SMS alert to the house owner via the GSM module whenever the door is opened and also when an incorrect password is entered into the system.

- To open the door via the solenoid lock whenever a correct password is entered by a user.

The Bluetooth module serves as an interface between the microcontroller and the android device, it aids the connection of the android device to the system and serves as a medium through which passwords are sent to the system.

The GSM module simply serves the purpose of sending SMS alert to the house owner whenever the door is opened and also when a wrong password is entered into the system. It also enables him to open the door from any location by sending an SMS to the microcontroller. The complete circuit diagram of the smart combination lock is shown in fig. 2 below.

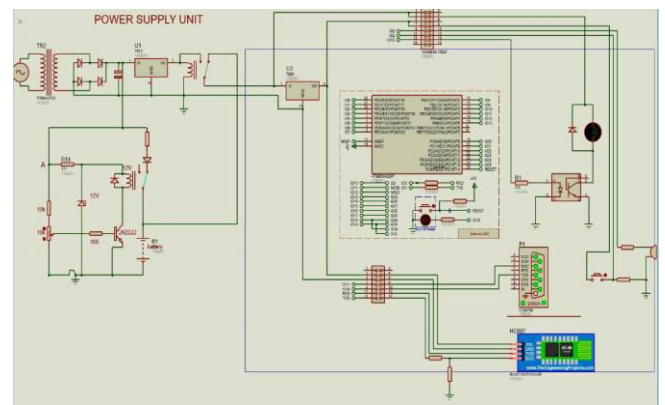


Figure 2: The circuit diagram of a smart combination lock

Fig. 3 shows the flowchart, which is the step by step approach that was followed in writing of the smart combination lock program, which enables the execution of command from the android application.

### 4. RESULTS AND DISCUSSIONS

At the end of the construction, the design was subjected to different tests to ensure that it meets the design specifications. This testing was necessary in order to ensure that the aim of the project was achieved. And android device was connected to the system via the Bluetooth module, passwords were entered into the system and user registration was also carried out.

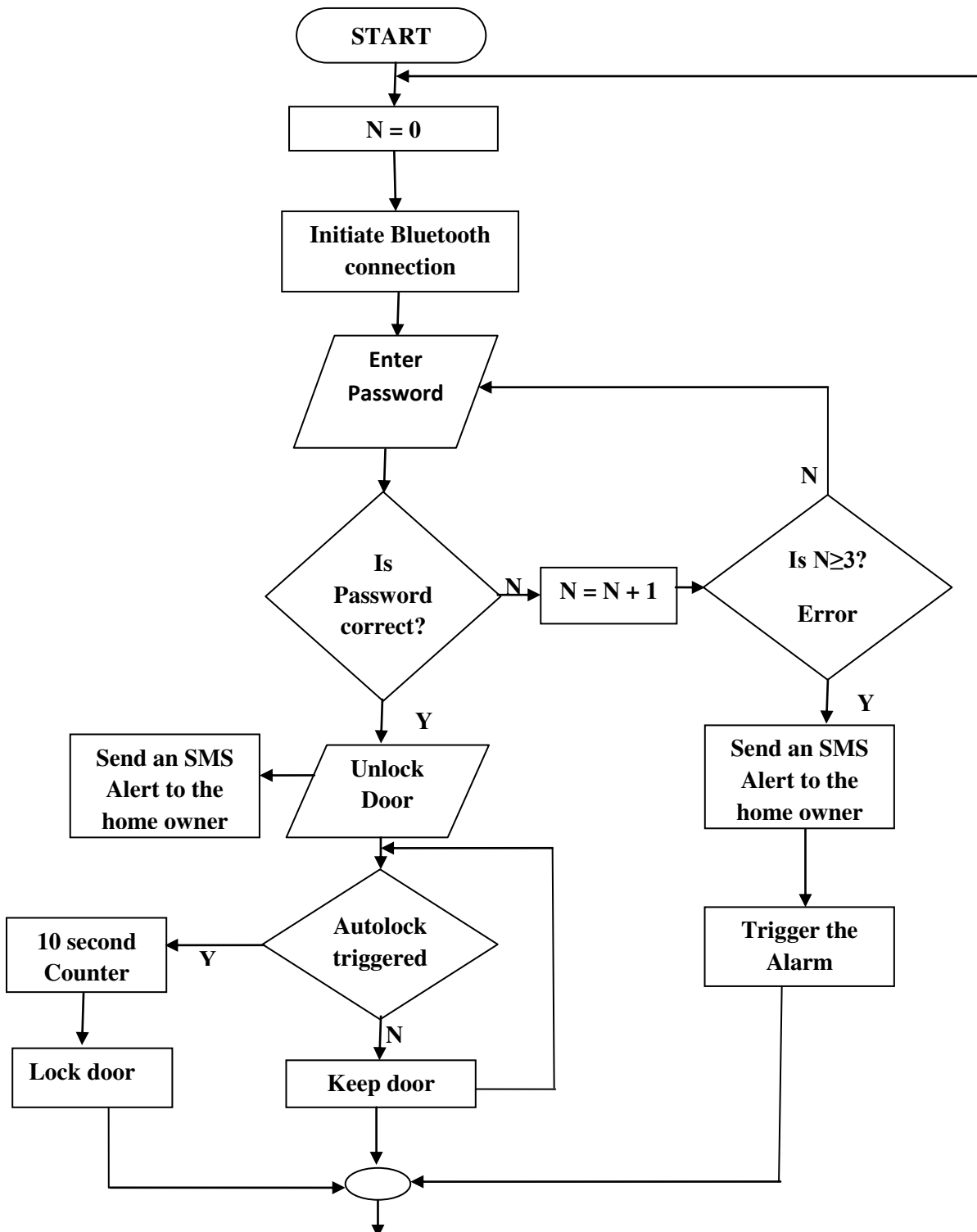


Figure 3: flow chart of the smart combination lock

When the door lock application was opened, the user was prompted to allow a Bluetooth connection between the android device and the Bluetooth module. When the user clicked on “Allow” a connection was successfully established between both devices but when the user clicked “Deny” the process was terminated. After a successful connection has been established, a registration form will open up for the user to register his/her name and password. This password is unique for every phone that has the application installed on it and serves as the key for opening the application (its aim is to prevent unauthorized users). Immediately after a successful registration, the application will open and the user will be required to enter the password he/she has registered and then click on ‘enter’. When the password entered was correct, the application opened and a feedback message “successful” was displayed on the screen but when the password is incorrect the application remains locked and a feedback message “unsuccessful” is displayed on the screen. After the application was opened with the right password, the user was required to enter another password to enable him/her open the door. This password was different from the one that granted him/her access to the application; therefore he/she had to register another password. To do this the user had to click on the menu button at the top right hand corner of the application and select “Registration”. The registration form opened and the user was required to enter his/her name, phone number and password and then click on register. The user then entered the registered password and clicked on “Log in”, the solenoid lock was stimulated granting the user access to the home and a message was sent to the home owner. When a wrong password was entered, the door remained in its lock position and a feedback message “unsuccessful” was displayed on the screen. After the third attempt to open the door with the wrong password, the alarm was triggered, a message was sent to the home owner and the interface closed automatically. Attempt was also made to open the door by SMS and this was also successful but could only be done by the Admin (home owner). When the auto-lock key was triggered, the door closed exactly ten seconds after it was opened but the door remained open when the auto-lock was not triggered. Same result was obtained when the push button was pressed after opening the door. From the results obtained during the testing of the device, the aim as well objectives of the project were achieved because users could open/close the door using their android devices; this was possible because of the door lock application installed on the android devices and the program that were written to guide the operation

of the microcontroller. The following interfaces are required to initialize and to operate the smart combination lock system

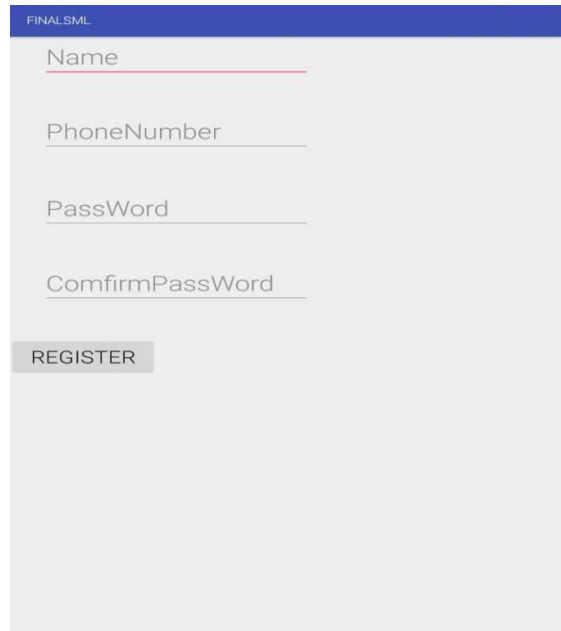


Figure 4: Register a password to open the application

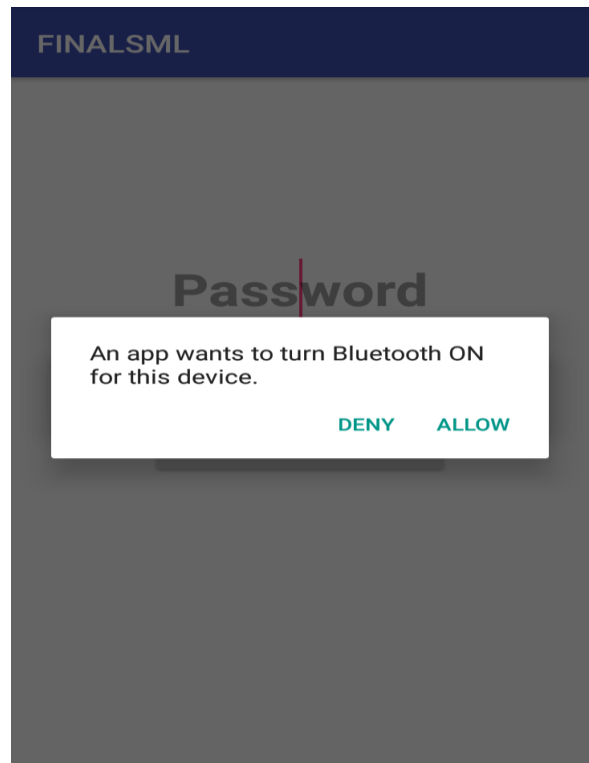


Figure 5: Application prompting user to enable Bluetooth connection

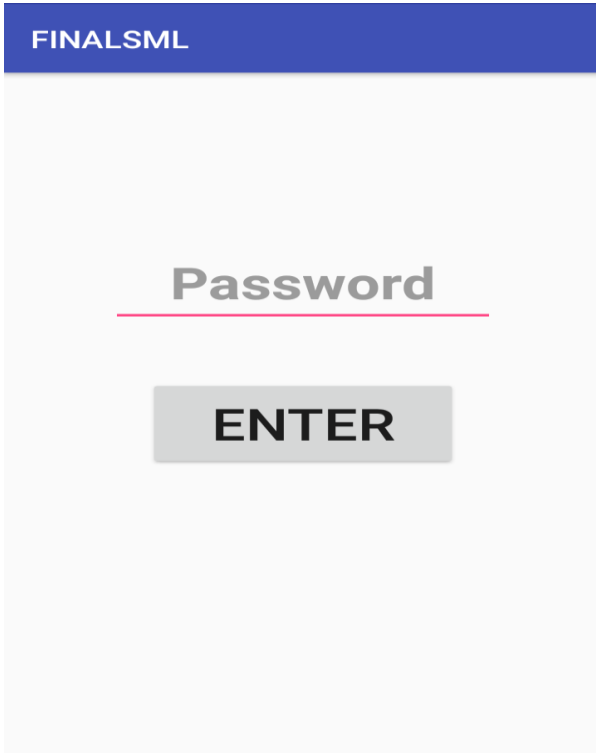


Figure 6: Enter password to open application

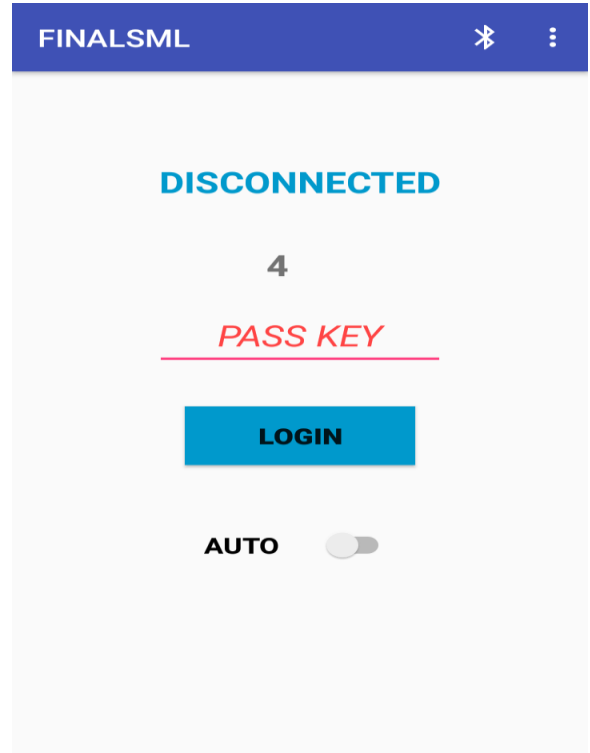


Figure 9: Enter password to open door

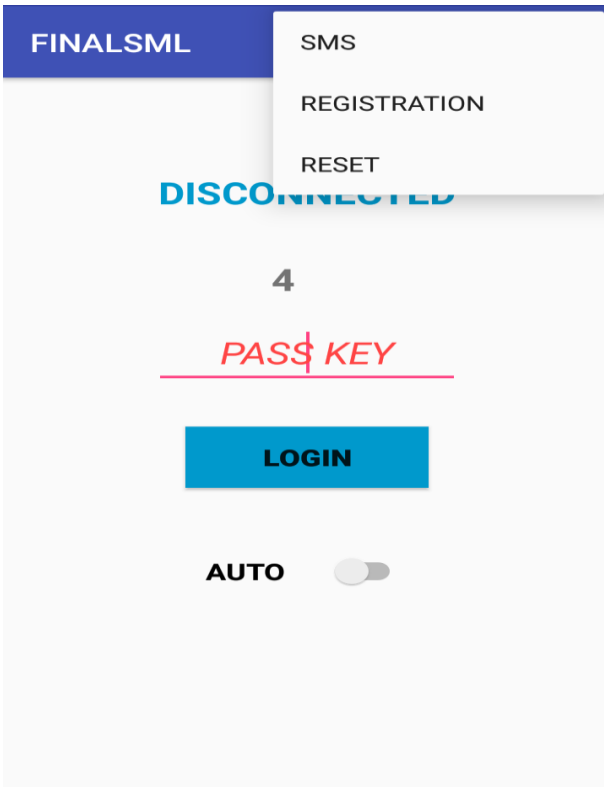


Figure 7: Content of the menu button

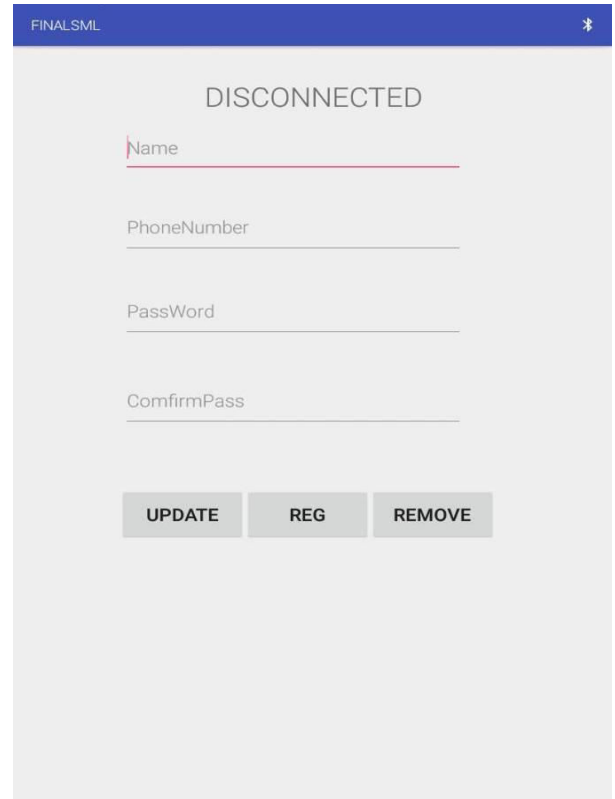


Figure 8: Register a password to open the door

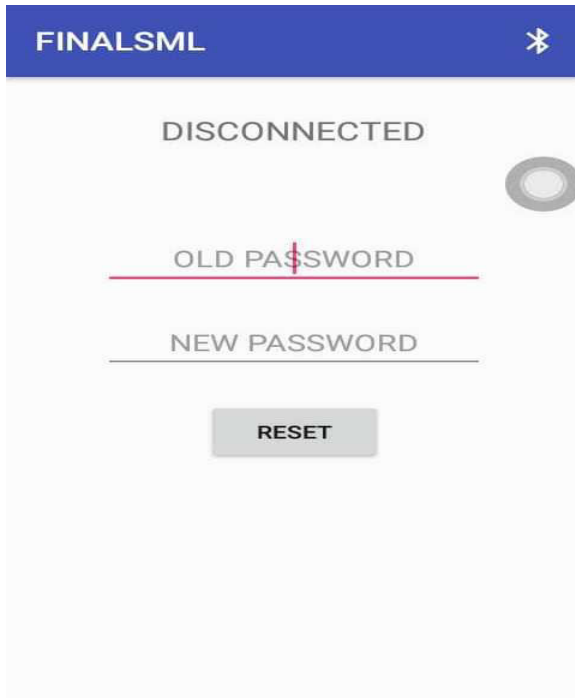


Figure 10: Password reset



5(h). Send password to open door via SMS

Figure 11: Implementation results of android app

## 5. CONCLUSION

A Smart combination lock was designed and implemented successfully. Relevant tests were carried

out of the constructed work and it worked according to the design specifications. The smart lock can be used in residential buildings, offices as well as industrial settings. The economic gains of this project work cannot be overemphasized as it is a perfect substitution for conventional locks and also of great importance in a time like this when we are faced with so many security challenges. The aim of this study was to design a system that can enable users open/close a door wirelessly using an android smartphone. The range and security aspect were considered through the use of Bluetooth technology that is embedded in the mobile device. At the end of the construction the system was installed on small wooden door and was tested to work appropriately according to the design specifications. With its ease of installation and use, minimum complexity, wide applicability options and strong feasibility, the smart combination lock guarantees a huge step forward in the world of locks systems.

There is no project work that is perfect and will not allow for any form of modification in the future. Though this project has fulfilled the purpose for which it was carried out, further research can also be made in order to improve its performance in the future. The project was designed for a limited number of users but can be modified to have a large number of users in order to enable its use in offices, hotels, schools, etc where many users are required. It can also be integrated with the internet such that with the aid of the internet and security cameras the user can monitor his home from any remote location.

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