IAA Journal of Scientific Research 10(1):36-48, 2023. ISSN: 2736-7319

Automated Hybrid Smart Door Control System

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ABSTRACT

This research paper successfully designed, developed and implemented an automated hybrid smart door control system which has the ability to secure a home up to 92% electronically. This smart door system is designed and implemented by building a hardware made up of the Bluetooth module and fingerprint scanner which are interfaced with the Microcontroller system that uses +5V power supply. The written programs were interfaced into the microcontroller chips by plugging the Arduino USB cable into the laptop and upload the codes. The microcontroller chips helped in enrolling the users fingerprint into the fingerprint scanner and it automatically administers and saves the users fingerprint after enrollment. Furthermore, after all the processes the user places the enrolled or registered finger into the fingerprint scanner which either accepts or denies the user by triggering the solenoid lock to either unlock, lock or deny access. This process of unlocking and locking requires using Bluetooth and fingerprint to either lock or unlock the door smartly without stress and it can be done within one second that is why the Solenoid lock is used in building this security system. This automated hybrid smart door control system developed has curbed the problem of door breaking theft for about 92%, strengthened security and as well made it so easy for the physically challenged people to have access to their homes without third party assistance.

Keywords: Smart Door System, Fingerprint, Bluetooth, Security, Arduino, Microcontroller.

INTRODUCTION

Smart Home System (SHS) is a dwelling incorporating a communications network that connects the electrical appliances and services allowing them to be remotely controlled, monitored and accessed [1, 2, 3, 4, 5, 6, 7]. SHS includes different approaches to achieve multiple objectives range from enhancing comfort in daily life to enabling a more independent life for elderly and handicapped people [8, 9, 10, 11, 12, 13]. Security has become a very challenging concern in the twenty first century where everybody wants to feel safe at every point in time more especially at home, workplace and its environs at large [5, 14, 15, 16]. To feel safe and guarded to a certain extent at home there are many electronic and artificial intelligent gargets that were mainly designed to facilitate it [17, 18, 19, 20]. Those designed gargets such as metal dictator, automatic door alert and so on does not still provide sufficient security in this twenty first century. Due to this security threats and high rate of crime being recorded on daily bases at home, there calls for a need to improve home securities electronically. One of these artificial intelligent and electronic door securities systems used in Smart door security system are Bluetooth based smart door, image break based smart door, retina based smart door, remote control based smart door, finger print based smart door and Radio frequency identification (RFID) smart doors [21, 22, 23, 24].

The RFID and biometric systems of lock is an excellent method to make a door smart, due to its ability to use artificial intelligent and electronic mechanism to operate [25, 26, 27, 28]. The use of

Bluetooth and smartphone is much easier to adopt and use because of its simplicity [29, 30, 31]. This proposed automated hybrid smart door system gives the user more access to communicate with the door and as well offers a diverse opportunity for the physically challenged persons that might not have a finger or the crippled to use RFID or biometric lock respectively. Furthermore, with the design and implementation of automated hybrid smart door system the physically challenged can simply access their doors either with finger or by single click in device [32, 33, 34, 35, 36].

A researcher in [6] did a very extensive work on Design and Implementation of a Reliable Wireless Real-Time Home Automation System Based on Arduino Uno Single-Board Microcontroller. The researcher's design and implementation concepts for a wireless real-time home automation system based on Arduino Uno microcontroller as central controllers. The proposed designed system has two operational modes. The first operational mode is manually-automated mode where the user can monitor and control the appliances at home from anywhere using the cellular phone through Wi-Fi communication technology [37, 38]. The second operating mode is the self-automated mode which makes the controllers to be capable of monitoring and controlling different appliances at home automatically in response to the signals that comes from the related sensors. The hardware was implemented using Matlab-GUI platform for reliability and effectiveness. The advantage of this design is its simplicity, cost effectiveness and flexibility but the disadvantage is that it has only one system of operation which is internet based and secondly its durability is not feasible.

In [1], the author focused mainly on four fields for SHS which are, home automation and remote monitoring, environmental monitoring, including humidity, temperature, fault tracking and management and finally health monitoring. The system design is based on the Microcontroller MIKRO C software; multiple passive and active sensors and also a wireless internet services which is used in different monitoring and control processes. This paper presents the hardware implementation of a multiplatform control system for house automation and combines both hardware and software technologies. The system results showed that it can be classified as a comfortable, secure, private, economic and safe system in addition to its great flexibility and reliability. The disadvantage of this SHS is that it is not robust, its circuit complexity and never considered the handicapped ones. Due to this disadvantage, it has not solved the problem of robustness and ease of implementation.

There are many other smart door systems designed in different area by different authors as in [7,8,9,10,11] which curbed the problems of theft and insecurity to a certain level but never eradicated it. From the extensive review we were above to find out that there are many problems associated with smart door system such as: (1) they lack robustness and has complex circuit. (2) It lacks versatility: it does not consider the handicapped and disables (3) It lacks durability: it easily got spoilt and most at times abandoned due to its fragile and hybridized nature. There are also problems of unsteady power supply in African and for effective and efficient utilization of this smart door system there must be a steady power supply. The effectiveness and robustness of this smart door design will be well felt when renewable sources of Energy (Solar photovoltaic) is incorporated in it [12, 13]. Author in [14,15,16,17] reviewed, developed, fabricated and optimized solar photovoltaic panels and from that it can be drawn that solar photovoltaic sources of energy will be best used as an alternative/supplementary sources of power supply to the smart door system. This proposed design and implementation of automated smart door system will be more user friendly, has less circuit complexity and has alternative power supply in case of power failure. This project will also consider and admit the physically challenged people by giving them the privilege to access the door while sitting on their wheel chairs, resting sofas or sleeping bed through Bluetooth.

The main objective of this research is to construct a two-way access control system using fingerprint sensor and Bluetooth Module.

MATERIALS AND METHODS

1. Arduino Uno

This is a microcontroller board based on the ATmega328p. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, and a reset button. It contains everything needed to support the microcontroller. We either need to connect it to a computer using a USB cable or power it with an AC-to-DC adapter [17][18][19]. The Arduino circuit acts as an interface between the software part and the hardware part of the project.

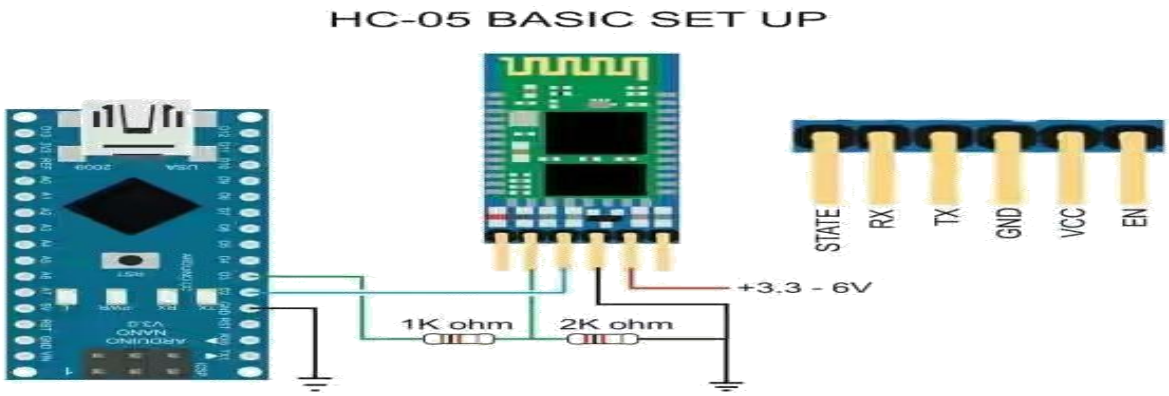

Figure 1: Arduino Uno

2. Bluetooth module

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices and building Personal Area Networks (PANs). The Bluetooth module being used allows us to transmit and receive signals. It receives the text from the Android phone and transmits it to the serial port of the Arduino Uno.

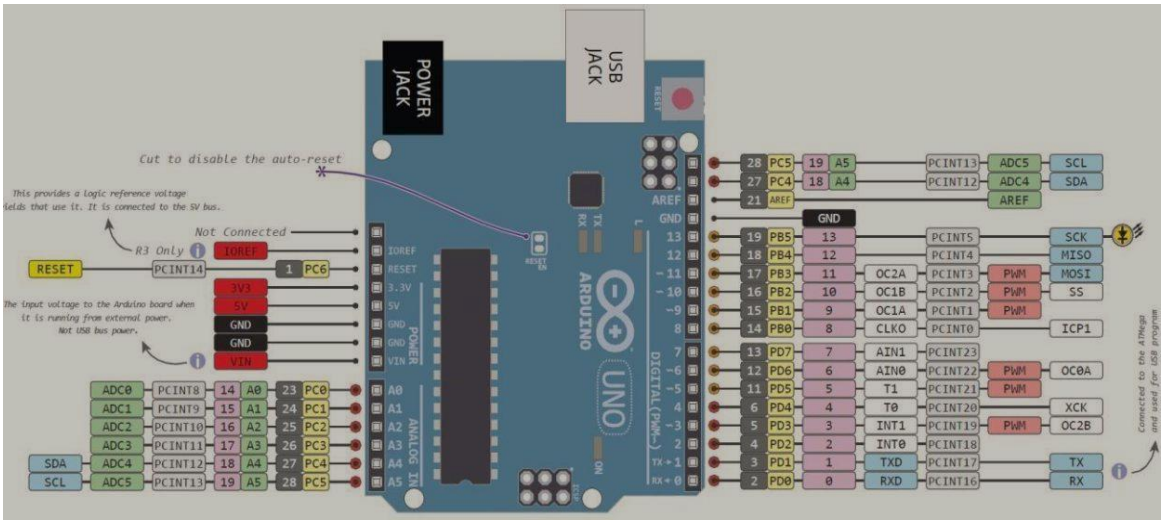

Figure 2: Bluetooth Module HC-05

Table1: Bluetooth Module functional keys

Pin Number	Pin Name	Description
1	Enable/key	This pin is used to toggle between data mode (set low) and AT command mode (set high) by default it is in data Mode
2	Vcc	Powers the module. Connect to +5v supply voltage
3	Ground	Ground pi to module, connect to system ground
4	TX-transmitter	Transmit serial data and everything received via Bluetooth will be given out by this pin as serial data
5	RX-Transmitter	Receive serial data. Every serial data given to this pin will be broadcasted via Bluetooth
6	State	The state pin is connected to on board LED it can be used as feedback to check if Bluetooth is working properly.
7	LED	Indicate module status.

3. Solenoid Lock

Solenoids are basically electromagnets: they are made of a big coil of copper wire with an armature (a slug of metal) in the middle. It is basically used for electronic lock and when 9-12VDC is applied, the slug pulls and the door opens. The solenoids come with the slanted slug as shown in figure 3 and it enables user to configure it to any angle (90, 180 or 270 degrees) so that it matches the door configuration position

.

Figure 3: Solenoid Lock

4. Liquid-Crystal Display (LCD)

it is an electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers to display results/output. Figure 4 is the LCD module that will be used to display the output of this proposed prototype. The display has 8

pins which are connected directly into the microcontroller. It displays 16 characters by 2 lines; the characters are black against a green background [20].

Figure 4: Liquid-Crystal Display (LCD)

5. Fingerprint scanner

A fingerprint scanner is a type of technology that identifies and authenticates the fingerprints of an individual in order to grant or deny access to a computer system or a physical facility.

Figure 5: Fingerprint Scanner

Working Principles of the Proposed Automated Hybrid Smart Door Control System (AHSDCS). The working mechanism and principals of AHSDCS is represented in the flowchart as shown in figure 6. Each unit of the flowchart will be explained extensively as we unfold its functions. The AHSDCS is made up of some important units which will be detailed together with its circuit connections and programing.

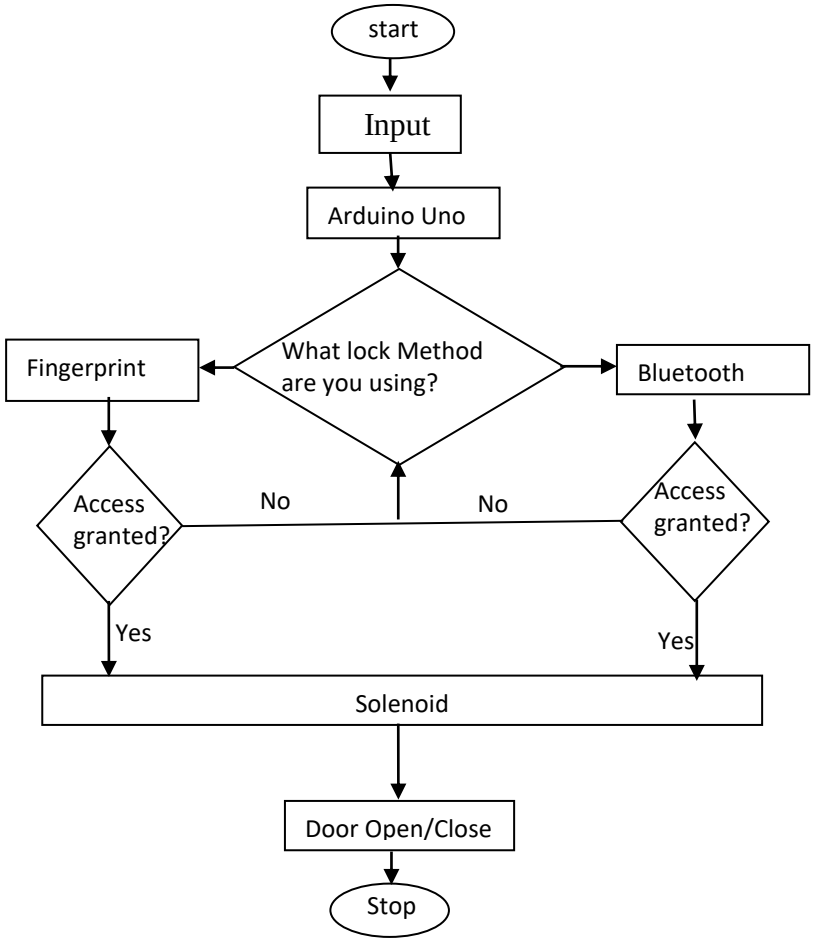

Figure 6: Flowchart of AHSDCS

This is the unit in which command is given to start the execution of a program and in this project the smartphone and Fingerprint Scanner are the devices that serve the purpose of sending command as input. The mobile smartphone sends signal when connection is established between the devices (Bluetooth module (HC-05) and the fingerprint scanner). The Devices send the input commands through a developed application to the device modules with respect to the devices the user is using at that particular time. The device through the written applications gives the user access to try the other module (alternative) when the first one fails. The input command can only be executed when and only when a Bluetooth connection is established between the device and the module and be operated within Bluetooth range limit or when the finger image saved in the system is scanned by the fingerprint scanner [21,22].

Receiver Unit

This unit deals primarily with the receiving of command signals sent from the input. The command sent by the mobile smartphone or fingerprint scanner is received in this unit with the help of a Bluetooth module (HC-05) and fingerprint module respectively. The Bluetooth module also serves as a link to establish connection between the mobile device and the Arduino microcontroller.

Processing Unit

This is a unit where command to execute, how to execute it, when to execute it and where to execute were determined. The Arduino microcontroller serves the purpose of processing the command of this project. The Arduino receives the command from the mobile smartphone on what command to execute via the Bluetooth module or fingerprint module and then the microcontroller determines what function to perform and how to perform the particular task and give the required output of the given task. The Arduino that serves as the main processing unit has two units the hardware (which is the microcontroller) and the Integrated Development Environment (IDE) which comprises of software program that runs the whole operating system.

Smartphone Application

The Android phone used in this research design and implementation was programed to select any home appliance from the options that appear in the App which gives the user access to select either open or close. The user cannot run the App from outside the house unless within the Bluetooth range related with the Bluetooth module. It allows establishing point-to-point connection with Bluetooth support devices. The Android Software Development Kit (SDK) provides all necessary tools to develop Android Application (API). The Android uses apk file to install the application and the code was written in Android Studio IDE

Output Unit

This is the stage at which the output is being displayed where the Solenoid lock is the device used to either open or close the door through the help of the commands. When the Solenoid lock receives the command from the microcontroller to open it moves its position to ninety degrees which moves up and opens the slider while when the command is to close the servo motor moves to one hundred and eighty degrees which moves the slider to lock position which closes the door.

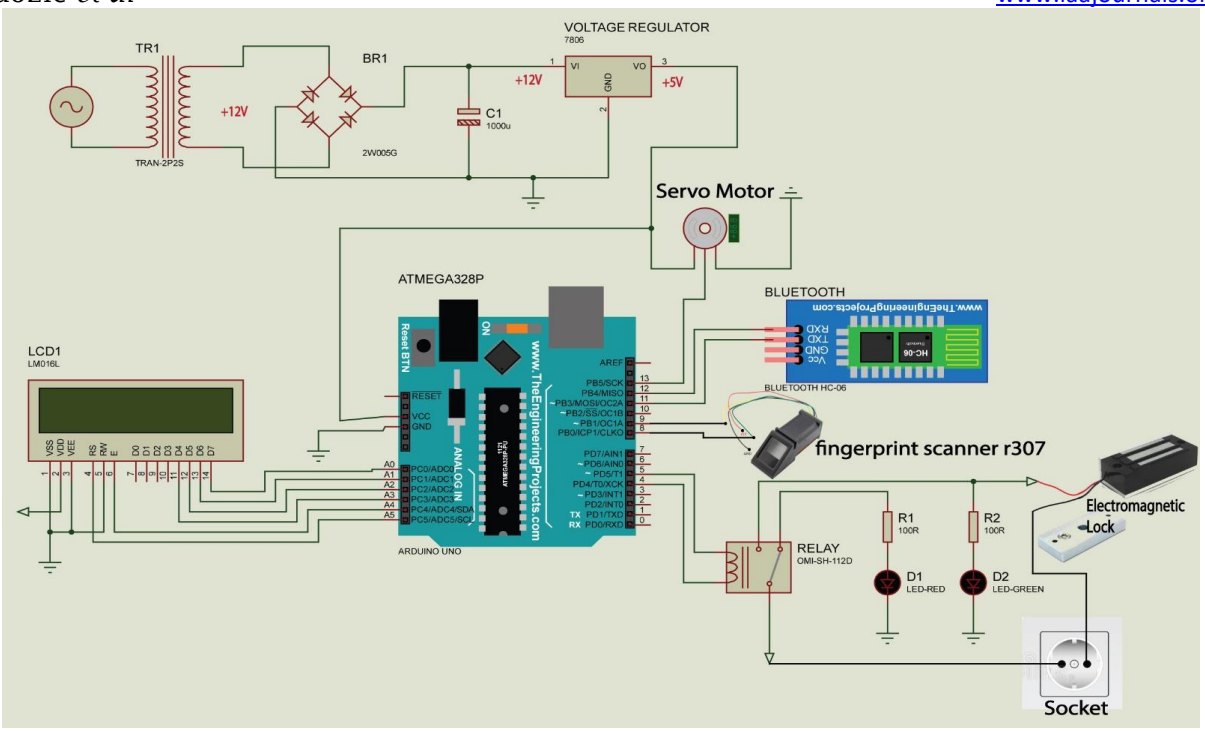

Figure 7: Circuit Diagram of AHSDCS

Circuit diagram is the final circuit where the whole components are combined and tested for efficiency and effectiveness. All the components used in this system was Programmed and tested separately for safety measures and matching with the right driver. Each component was programmed separately with Arduino UNO using different Arduino IDE. Also, they were run in different computers. Later on, all were combined in a single Arduino IDE and implemented for real life application.

RESULTS

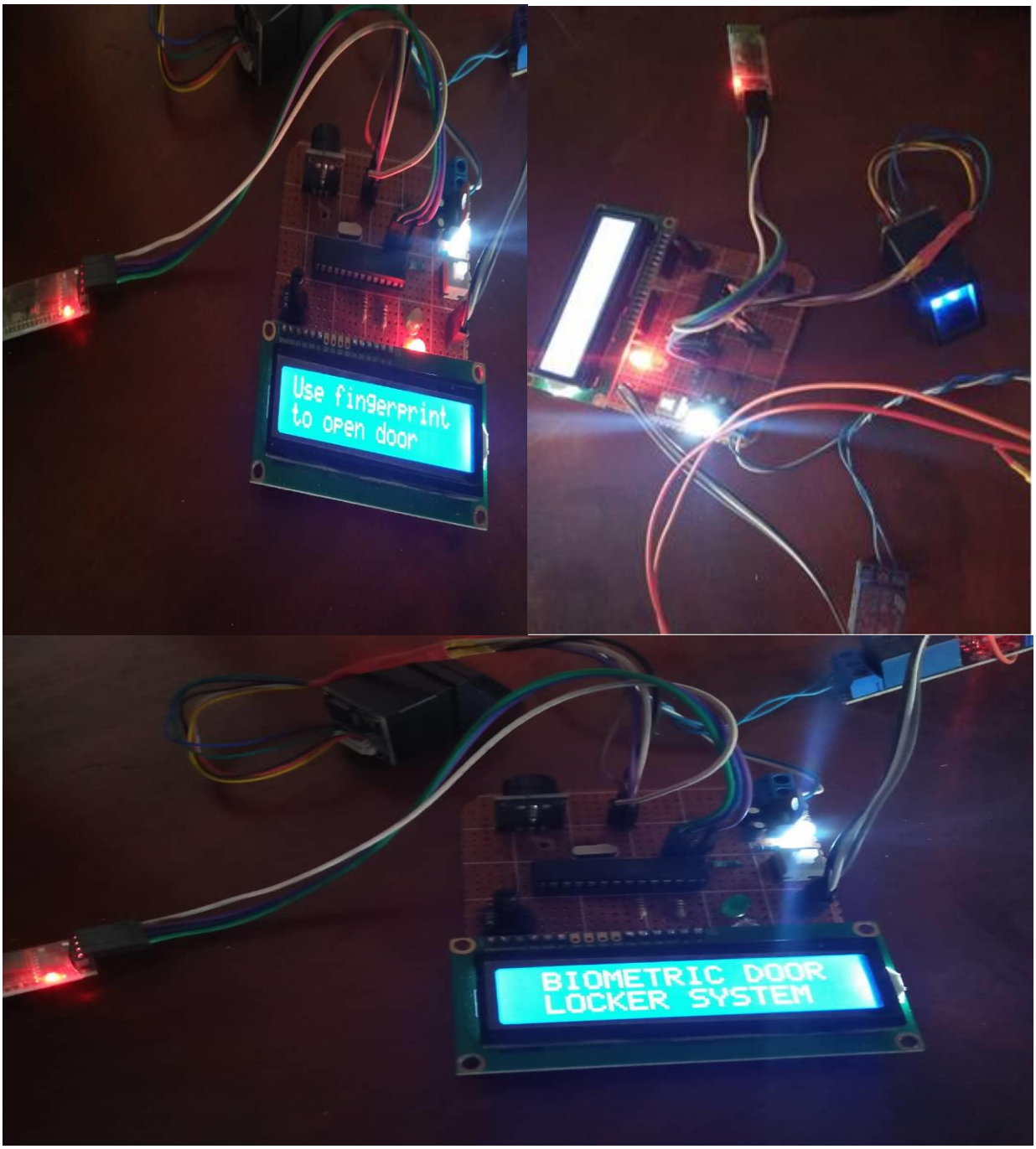

Figure 8: The Working Diagram of the Implemented AHSDCS

DISCUSSION

This research is based on improving the home security system which will identifies the Bluetooth App and register the owner's fingerprint into the microcontroller using the fingerprint scanner or sensor. The Bluetooth module and fingerprint scanner are interfaced with the Microcontroller system that uses +5V power supply. The first thing to do after connecting the circuit diagram is to

plug the Arduino USB cable to the laptop and upload the code into the microcontroller chips. This microcontroller chips will help in enrolling the fingerprint into the fingerprint scanner and it automatically administers and saves the users fingerprint after enrollment. This fingerprint scanner has the capacity of saving up to 137 different fingerprints of different individuals. The downloaded and installed Apk (Bluetooth app) will be connected to the hardware as shown in figure 8. The next step is for the user to turn on the smartphone Bluetooth and pair it with the HC06 Bluetooth module which will permit interactions between the devices. After these processes, the app will be ready for use and the user will be required to click on the Bluetooth icon on his/her smartphone and then connect with the Bluetooth module HC06. Furthermore, immediately the phone is connected, the app will grant the user access to press unlock to access the door or lock to lock the door because there is embedded interaction between the user's smart phone and the smart door to prevent unauthorized person from accessing the door.

Now when you place your thumb on fingerprint scanner after enrollment or registering process has been done, when access is granted the solenoid lock will be unlocked and when denied the access will not be granted. This process of unlocking and locking requires less than one minute for the processes to be completed that's why the Solenoid lock is used in building this security system.

CONCLUSION

This research paper has successfully developed, designed and implemented an Automated Hybrid Smart Door Control System using Arduino, fingerprint scanner and Bluetooth applications for a better household security and to as well allow the eligible disabled people access. Automated Hybrid Smart Door Control System was successfully design using Arduino applications and coding was done using Arduino IDE platform. This developed research project has curbed the problems of door breaking thefts, given easy access to opening and closing of doors by the eligible people and finally offered the eligible physically challenged people privilege to access the doors without assistance by the third party. This project will help the world at large more especially Africans to curb door breaking thefts and as well offer easy access to the eligible users. This project will also help to reduce cost for the house owners as security guard responsible for assisting in opening/closings doors and gates for their employers will not be necessary anymore as the technology has taken over the duty as the eligible users can access the door comfortably without any assistance from the gateman. It is safe to say that the main objectives and the aim of this research project were achieved at very affordable cost which should be the earnest desire of any engineer.

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