International Journal of Science and Engineering Applications
Volume 10-Issue 09, 132 - 139, 2021, ISSN:- 2319 - 7560

Voice Recognition System for Door Access Control Using Mobile Phone

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Abstract: Security is one of the most important issues for any individual or organization, and as technology has advanced, numerous techniques to protecting lives and property have been deployed through door access control systems. The typical method of unlocking a door is to open it with a real key or by twisting the door knob. Physical keys that are used to open doors are subject to duplication and can be misplaced. Furthermore, typical biometric technologies and other technologies are vulnerable to a variety of failures, such as a person's finger being cut off to produce a fingerprint scan, a pin being hacked using various methods or permutations, and a person's photo being used for facial recognition. Furthermore, it is more difficult for people with physical disabilities to unlock a door system without the assistance or support of others. For example, it is difficult for a person in a wheelchair to open a door system without the assistance or support of another person. As a result, a speech recognition access control system that can accommodate both able-bodied and impaired people is unavoidable. This paper demonstrates how voice recognition may be used to access door systems by creating a door access control system that employs speech recognition to simplify the work of providing access to door systems via a mobile phone connected via Bluetooth. The system's performance is perfectly in line with its design.

Keywords-Door; Voice Recognition; Bluetooth; Arduino; Microcontroller.

1. INTRODUCTION

Voice recognition is just one of several biometrics applications that can be used in access control systems. Voice recognition (32%) is the most popular biometric measure, followed by fingerprints (27%), facial scan (20%), hand geometry (12%), and iris scan (12%), according to a Unisys poll (10 percent). Consumers prefer speech recognition biometric systems, according to this survey. By reading in the unlock phrase or password, voice recognition would be utilized to unlock many sorts of doors such as office doors, garage doors, and gates. The speech recognition system must first go through a training phase in order to understand and learn different voices from different people, and then go through a testing step to confirm that the system recognizes voices correctly. Different people would read in phrases to open a door system in this arrangement.

The voice is analyzed by the system, which extracts various features and intents from it. These qualities are recorded in a database so that the next time the system hears that voice, the properties in the database are matched and appropriate feedback is supplied. (2017, Cho et al.)

Security is one of the most important issues for any individual or organization, and as technology has advanced, numerous techniques to protecting lives and property have been deployed through door access control systems. The typical method of unlocking a door is to open it with a real key or by twisting the door knob. Physical keys that are used to open doors are subject to duplication and can be misplaced. Furthermore, typical biometric technologies and other technologies are vulnerable to a variety of failures, such as a person's finger being cut off to produce a fingerprint scan, a pin being hacked using various methods or permutations, and a person's photo being used for facial recognition. Furthermore, it is more difficult for people with physical disabilities to unlock a door system without the assistance or support of others. For example, it is difficult for a person in a wheelchair to open a door system without the assistance or support of another person. Hence, the need for a voice recognition access control system that can serve both abled-bodied and disabled individuals is inevitable.

The purpose of this study is to break the limitations of conventional door access control systems in ensuring safety of lives and properties. One limitation includes the inability of the current system to provide the best security due to different hacks on the system such as key duplication. It is also believed that it would serve as a stepping stone to the development of better voice recognition systems that would be aimed at providing better security and making life easier.

2. THEORECTICAL BACKGROUND

A system that restricts access to a location or resource selectively is known as an access control system. A door can be used as a physical means of preventing entry to specific people who do not have the appropriate access credentials, such as a key, keycard, fingerprint, voice password, RFID card, security token, or coin. In the remains of Nineveh, ancient Assyria's capital, the earliest known key and lock devices were uncovered. Since then, technology has progressed with the arrival of computers, which provide access control through the use of computer programs and software. One of the newest forms of access control is voice recognition, which entails decoding human speech and identifying the speaker.

There are two types of recognition: speaker recognition and speech recognition. Speaker recognition is the process of recognizing a person based on the features or characteristics of their speech. Speech recognition is the process of recognizing what the speaker has spoken. The act of confirming a speaker's identity in a system is known as speaker authentication. Enrollment (training phase) and verification are the two phases of a speech recognition system (testing phase). The speaker's voice is recorded as input signals, then features or qualities are extracted to create a template or model during the enrolment phase. A sample speech utterance is compared to models already stored in the system in the verification step to determine the best match (es) (De Vries *et al*, 1992).

3. REVIEW OF RELATED WORK

Both the industry and academics are making remarkable advancements in voice recognition systems. The structural and functional designs of speech recognition door access control systems have evolved over time, and research is ongoing to develop voice recognition algorithms that are flexible and capable of accurately detecting the voices of various individuals. Some major advancements in speech recognition door access control systems include:

Intelligent Voice-Based Door Access Control System using Adaptive-Network-Based Fuzzy Inference Systems (ANFIS) for Building Security. Wahyudi *et al* (2007). This study looked at how a number of technologies, such as PIN pads, keys (both traditional and electronic), identity cards, cryptography and dual control processes, are used to protect secure facilities from illegal access. Speaker verification, or the capacity to authenticate a speaker's identification by analyzing speech, is an appealing and generally inconspicuous method of providing security for access into a sensitive or secure location. The research paper went on to say that a person's voice cannot be accurately stolen, lost, forgotten, guessed, or impersonated. The study presented the design and development of a voice-based door access control system for building security because of these benefits.

Real Time Recognition based Building Automation System. G. Muthuselvi *et al* (2014). This research examined how technology was used in houses to respond to the demands and instructions of the occupants in order to improve daily life at home. The embedded system was designed to detect and understand human voice instructions, which were then utilized to toggle various workloads. A speech recognition system, as well as an 8051 microcontroller kit and relays, were used to create the design. The results of the processing were then presented on a Liquid Crystal Display (LCD), which was primarily used to show system states.

Door Automation System using Bluetooth-Based Android for Mobile Phone. L. Kamelia *et al*. (2014). This study examined at how Bluetooth on an Android phone was utilized to automate the process of opening a door. Home controllers that are connected to a Windows-based PC are the most popular. This research used Bluetooth, a component of smart home technology, on a mobile device to make the procedure easier and more efficient. The hardware for the door-lock system consists of an android smart phone acting as the task master, a Bluetooth module acting as the command agent, an Arduino microcontroller acting as the controller center / data processing center, and a solenoid acting as the door lock output.

Agbo David O et al., (2017) Designed and implemented a door locking system using

android app. The application was created with the help of an Android app that produces a password that is recognized by Bluetooth to control the opening and closing of a door that is located a long distance away from the user. The Bluetooth module put on the door receives commands from Android phones and sends them to the microcontroller, which controls the door's opening and closing. The hardware was created on experimental boards after the design was modelled in the Proteus integrated development environment. The system's performance is perfectly in line with its design. The method can be utilized in a variety of situations when access to a container must be restricted.

Kamoru et al., (2018) designed motion detector alarm and security system. The model was developed utilizing an embedded microcontroller system capable of detecting intruder movements in a restricted area and then triggering an alarm system, motion detector system. However, a passive infrared sensor was used to identify the person's mobility based on their body heat. The passive infrared (PIR) sensor, which was utilized as an alternative detector in this project, was connected to a microcontroller, which activated the alarm

system and any other output devices linked to warn the house owner. Given the amount of time and resources saved, the project's future development was excellent. This system can be used as a model for larger projects that include audio-visual cameras and send the collected image to an email in real time.

Zaid A. Mundher et al., (2019) build a Real-Time Home Security Alarm System Using a Kinect Sensor. Using the Kinect sensor and the Kinect SDK, this project aimed to build and execute a low-cost, smart, and small real-time monitoring home security system. The results reveal that using the Kinect device to develop the proposed system is both efficient and computationally simple.

However, in view of the different design done by previous researchers, they can be improved upon by incorporating the use of voice recognition through mobile phone application to access door control through Bluetooth connection, this will provide better and faster access.

4. METHODOLOGY

4.1 Principle of Operation

This microcontroller-based door access control system uses Google's open-source speech-to-text on the android application through the mobile phone to operate a door using voice input. The android application and the android mobile phone are connected via a wireless link using an HC-05 Bluetooth module. Serial communication is used to communicate between the microcontroller and other system components.

The android application connected through the Bluetooth module sends commands to the microcontroller (ATMEGA328P). It then makes a decision based on the command it has received. The device has been developed to work with a speech to text software, which will use the microcontroller to send an electrical signal to the door latch. The activity of the door latch is determined by the input command from the speech to text app on the Android mobile app: OPEN voice input will activate the door to open, and CLOSE voice input will activate the door to close, as programmed into the Bluetooth module.

LEDs are also used as visual feedback; the red LED indicates data exchange between the android and the Bluetooth module, while the yellow LED indicates the status of the door. A buzzer was utilized as a AUDIO feed back, producing a buzzing sound when the door was open or closed.

4.2 Materials Used for the Project

The following are the list of the materials used in this project;

1. Bluetooth module
2. Door latch
3. wire
4. Wood work
5. Buzzer
6. Microcontroller
7. Led
8. Mobile phone

4.3 Bluetooth Stage

The HC-05 Bluetooth module used in this project is a simple to use Bluetooth SPP (serial port protocol) module that allows for seamless wireless serial connection setup. In this project, the HC-05 Bluetooth module functions as a wireless bridge between the microcontroller and the mobile phone app, allowing serial communication between the two.

4.4 The Microcontroller Specifications

Various factors are considered in the choice of microcontroller to use for a particular purpose. These include:

1. The number of digital inputs, analogue inputs the system concerned requires; a factor which helps to determine the minimum number of inputs and outputs (I/O) that the chosen microcontroller must have and the extent of need of an internal analogue to digital converter module.
2. The size of program memory storage required
3. The magnitude of clock frequency; a factor which determines the execution rate of tasks by the microcontroller
4. The number of interrupts and timer circuits required.

In a project of this kind where the number of task that can be handled is largely dependent on the amount of memory available, a microcontroller with a large memory sufficient input/output ports and analogue/digital channels such as the ATMega328P is quite acceptable for use. The choice as to which pin will be used in a particular application is controlled by programming the various special functions registers. Figure 1 presented the block diagram of voice recognition for door access control while Figure 2 showed the circuit diagram for the voice recognition for door access control using mobile phone through Bluetooth connection.

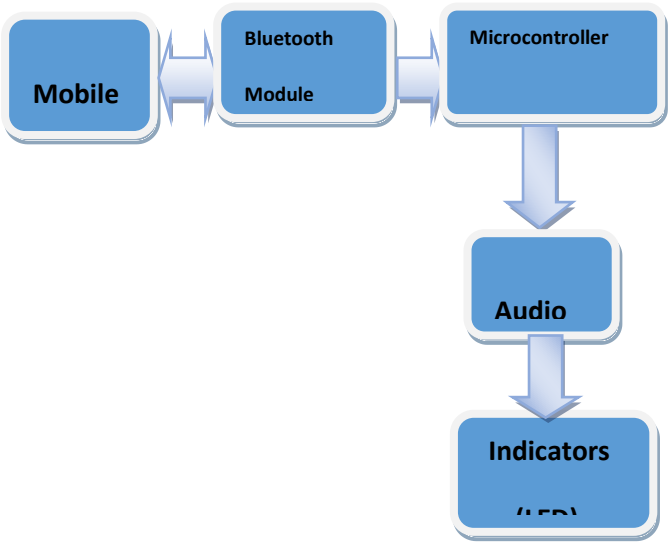

Figure 1: block diagram of voice recognition for door access control

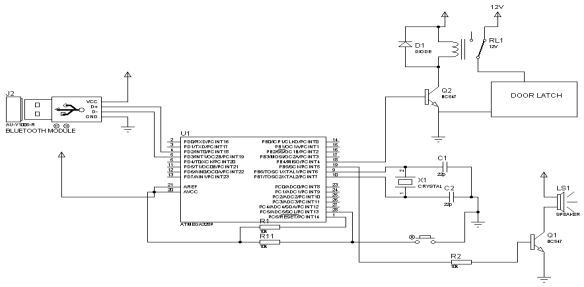

Figure 2: circuit diagram for the voice recognition for door access control using mobile phone through Bluetooth connection.

5. IMPLEMENTATION, TESTING AND RESULT

Construction

The physical realization of the project is very vital. Here the paper work is transformed into a finished hardware. After carrying out all the paper design and analysis, the project was implemented, constructed and tested to ensure its working ability. The construction of this project was done in three different stages.

1. The implementation of the whole project on a solder-less experiment board.
2. The soldering of the circuits on printed circuit boards.
3. The coupling of the entire project to the casing.

Figure 3 displayed the PCB artwork for the design of the android based voice controlled door.

Implementation

The implementation of this project was done on the breadboard. The power supply was first derived from a bench power supply in the school electronics lab. To confirm the workability of the circuits before the power supply stage was soldered. The implementation of the project on bread board was successful and it met the desired design aims with each stage performing as designed.

Soldering

The various circuits and stages of this project were soldered in tandem to meet desired workability of the project. The microcontroller stage was first soldered before the led indicator stages were done. The soldering of the project was done on a printed circuit board.

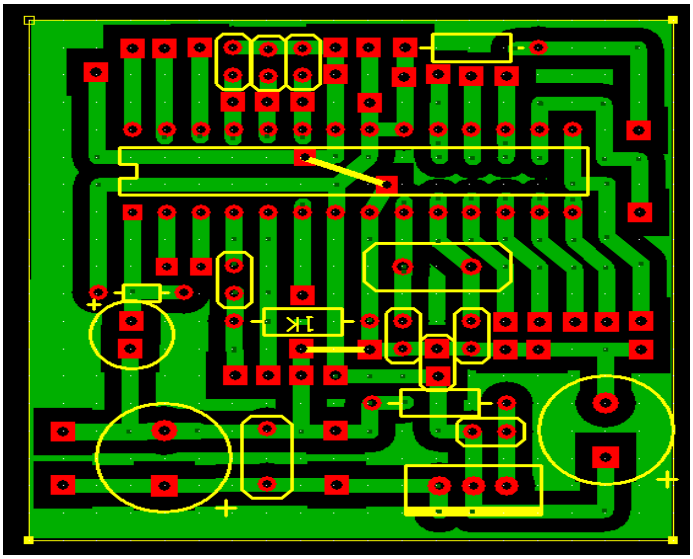

Figure 3: PCB artwork for the design of the android based voice controlled door.

Casing and boxing.

The third phase of the project construction is the casing of the project. This project was coupled and fixed to a model door for ease of demonstration.

Testing

Stage by stage testing was done according to the block representation on the breadboard, before soldering of circuit commenced on printed circuit board.

The process of testing and implementation involved the use of some test and measuring equipments stated below.

1. **Bench Power Supply**: This was used to supply voltage (5VDC) to the various stages of the circuit during the breadboard test before the power supply in the project was soldered. Also during the soldering of the project the power supply was still used to test various stages before they were finally soldered.
2. **Oscilloscope**: The oscilloscope was used to observe both the trigger and the echo signal waveforms and to ensure that all waveforms were correct and their frequencies accurate. The waveform of the oscillation of the crystal oscillator used was monitor to ensure proper oscillation at 16MHz.
3. **Digital Multi-meter**: The digital multi-meter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor h_{fe}. The process of implementation of the design on the board required the measurement of parameters like, voltage, continuity, current and resistance values of the components and in some cases frequency measurement. The digital multimeter was used to check the output of the voltage regulators used in this project.

Results

The result from the research work was presented as displayed in Figure 4, 5, 6, 7, 8, 9 and 10.

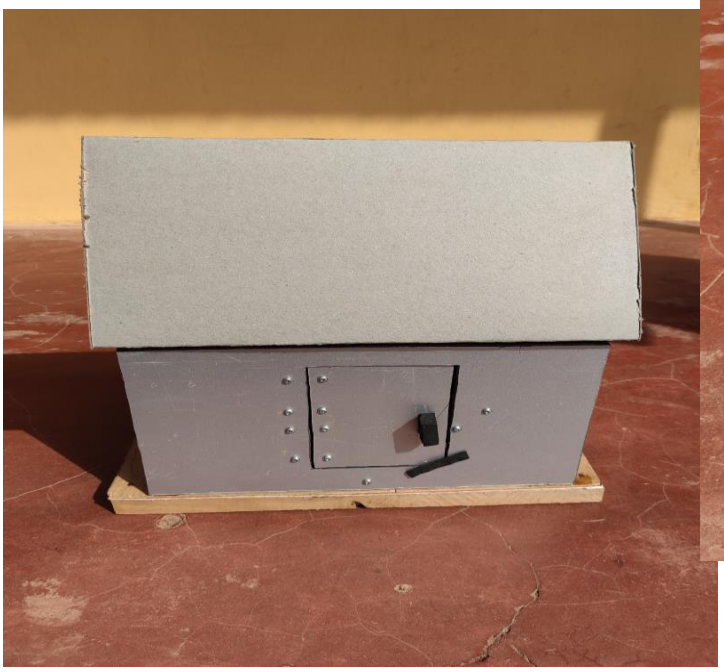

Figure 4: front view of the prototype

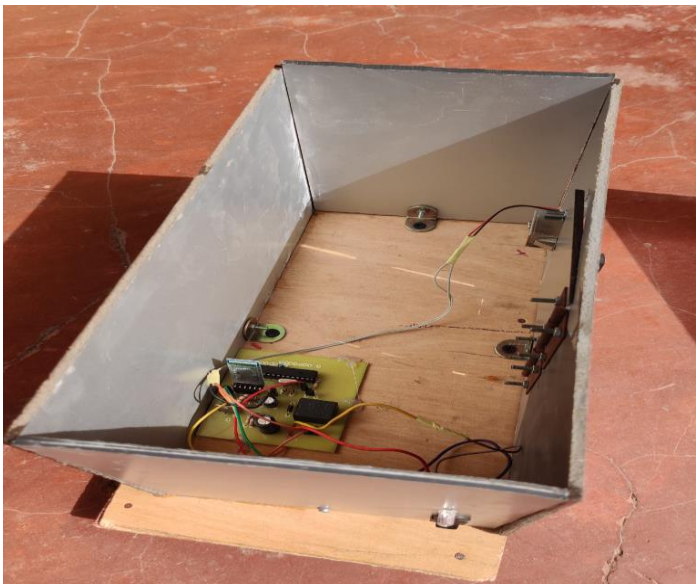

Figure 5: upward view

Figure 6: Side view of the prototype

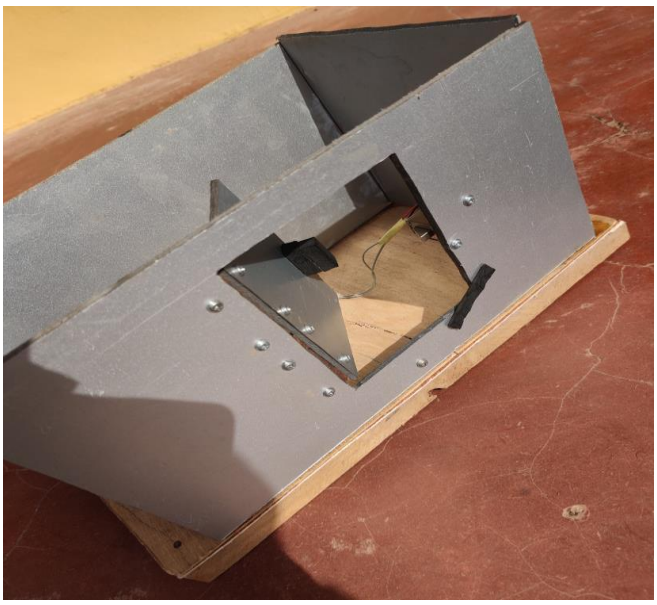

Figure 7: side of view of the prototype when opened

Figure 8: Shows interface of the Android application

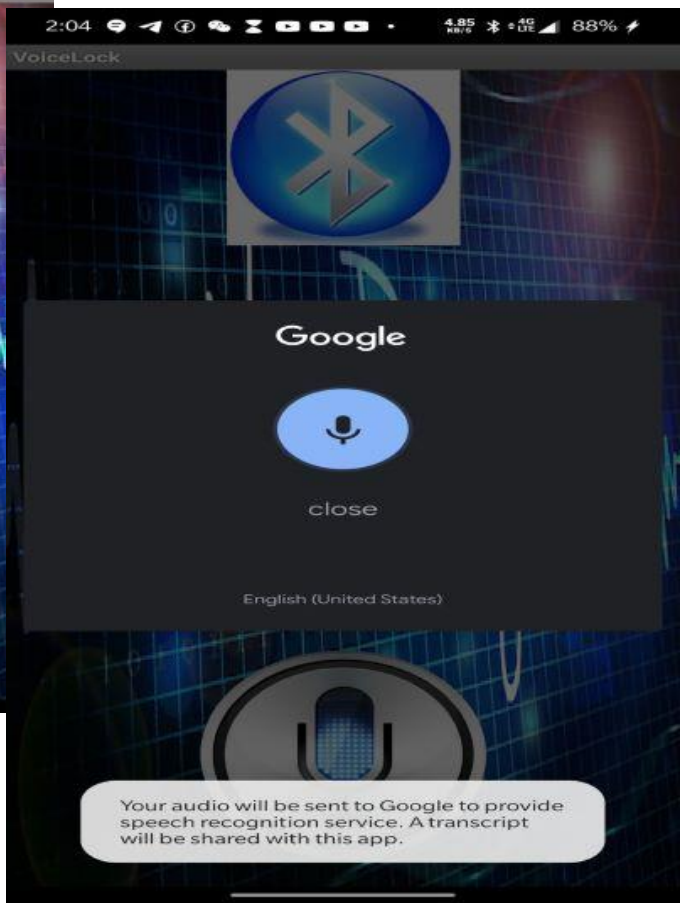

Figure 10: Show when the voice input is CLOSE

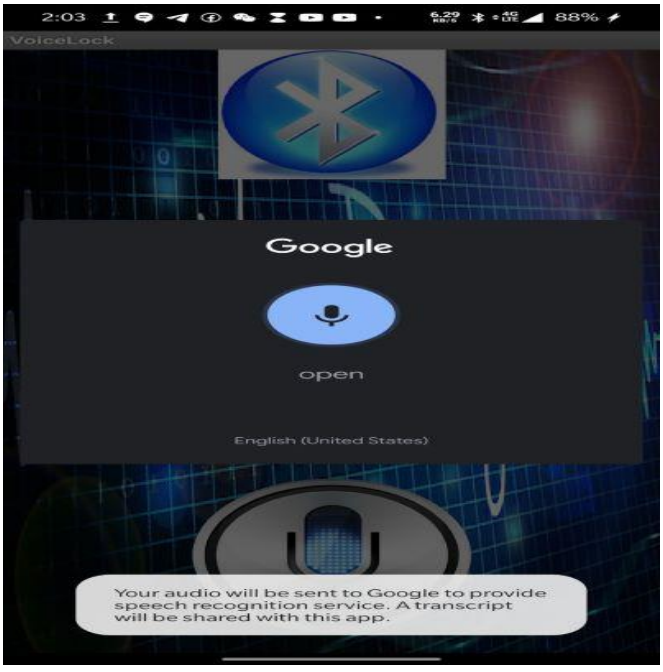

Figure 9: Shows when the voice input is OPEN

Problems Encountered

Like every research and practical engineering work, diverse kinds of problems are often encountered. The problems encountered in this project and how they were solved and maneuvered are listed below.

1. At the implementation stage of this project, the communication between the controller and the mobile used in this project was found failing. The problem was traced to both items not operating at the same frequency as designed. The oscillator was changed.
2. Network variation might cause delay in the delivery of the text message. However, the time delay was adjusted to balance the irregularities in the delivery of the message by network providers.

6. CONCLUSION AND RECOMMENDATIONS

The project which is the design and construction of the android based voice controlled door was designed considering some factors such as economic application, design economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the project after test met design specifications. However, the general operation of the project and performance is dependent on the user who is prone to human error such as entering wrong voice input.

Also the operation is dependent on how well the soldering is done, and the positioning of the components on the printed circuit board. If poor soldering lead is used the circuit might form dry joint early and in that case the project might fail. Also if logic elements are soldered near components that radiate heat, overheating might occur and affect the performance of the entire system. Other factors that might affect performance include transportation, packaging, ventilation, quality of components, handling and usage.

The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown. The project really gave a good exposure to digital and practical electronics generally which is one of the major challenges in this field now and in future. The design of the android based voice controlled door involved research in both digital and microelectronics. The project was quite challenging and tedious but eventually was a success. However, like every aspect of engineering there is still a room for improvement and further research on the project as suggested in the recommendations written out in the section that follows in the paragraph below

Recommendations.

For the purpose of the future research, the project work can be improved upon. The following areas were highlighted for this purpose.

1. The whole circuitry can be reduced by making use of integrated circuit with higher scale of integration.
2. A higher scale integrated circuit can be used so that other means of authentication could be used to cut across to the less privileged in the society (e. g. visually impaired individual).
3. Moreover, it is recommended that students should be enlightened on new areas of technology that are yet to be addressed in order to bring solution to the various problems faced by man in his day to day activities.
4. A lot of work has been put into place to ensure that the voice recognition system is able to recognize the owner's voice and grant access to the owner. There is still a lot of work that needs to be done to ensure that the voice recognition system is able to perform well and optimally. Some key areas that should be considered when making improvements on the voice recognition system include:

i. Native language: Major Nigerian native languages such as Igbo, Yoruba, and Hausa currently do not have speech to text engine. The ability of the voice recognition to recognize the native language of the user can be worked and improved upon by training speech models of those language.

ii. Security: The exchange of data between the various components of the hardware and the software should be encrypted to ensure that the system cannot be hacked and data integrity is maintained. The recommendation is further that a custom encryption algorithm should be implemented.

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