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Development of Voice Recognition Door Lock with Keypad

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Abstract: Significant advances in wireless sensor networks, telecommunications, and informatics have enabled pervasive intelligence, which envisions the future Internet of things (IoT). A door access system's development includes a wide range of features, from a simple keypad to the complex use of and biometrics. The door access system was developed to address the issue of burglary by increasing the security of the access system. The study concentrated on residents of standard homes. As a result, voice recognition door locks with keypad have been developed to address the issue of a vulnerable access control system. The goal of this research is to create a prototype of a voice recognition door lock with a keypad, code the prototype, and then test the prototype for accuracy. The prototype was created using the Arduino microcontroller, which comes with its own programming language and electronic development and testing platform. A keypad and voice recognition were used as inputs for the project, and a solenoid door lock and an LCD display were used as outputs. The prototypes were subjected to functional and accuracy tests in order to collect data and determine their proper function. Through the use of a simple Arduino approach, this project provides a dependable solution for improving door access security. The prototype had a 86.67% successful rate of recognising the first command and a 93.33% successful rate of recognising the second command, according to the results of the accuracy testing performed on 10 different individuals in this study.

Keywords: Voice Recognition, Security, Arduino

1. Introduction

The Internet of Things (IoT) is a technology that connects physical objects and allows them to communicate with one another. Pervasive intelligence, the future of IoT, is now a reality thanks to advancements in wireless sensor networks, telecommunications, and informatics [1]. In the 1980s, the concept of ubiquitous computing, which aims to integrate technology into everyday life, emerged. Individually, IoT contributes significantly to higher living standards through e-health, smart homes, and smart learning[2]. It is estimated that 75.44 billion smart devices will be connected globally by 2025 [3]. Biometric recognition, which is widely used in IoT security, is a technique for identifying a person

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based on physiological and behavioural characteristics [4]. Voice recognition is an important aspect of this because it helps to determine who is speaking. This field's innovations have made a wide range of information easily accessible.

In Malaysia, property crime, such as burglary, is more common than violent crime. This results not only in property loss, but also in psychological consequences [5]. Break-ins are common in residential areas, with single-family homes being the most frequently targeted. In gated high-rise apartment complexes with 24-hour guards and electronic access control systems, burglary is less common [6]. The goal of this study is to develop an alternative door access system that uses an Arduino-based voice recognition system with a keypad as a backup to prevent home burglary and make the access system more difficult to access, only for authorized personnel.

1.1 Objective of the study

The project's objective is to develop a prototype voice-activated door lock with a keypad as a backup option. The Arduino programming software and C language will be used to code the prototype. The developed prototype will be tested for accuracy by measuring the recognition rate of the lock and unlock commands with ten different people.

2. Literature Review

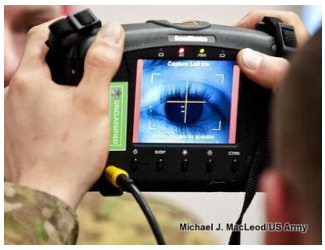
The use of technology to automate various aspects of the home, such as lighting, heating, and security, is referred to as home automation. It has expanded significantly in recent years as a result of technological advancements. Home automation can be traced back to the early twentieth century, but it didn't really take off until the 1970s, with the introduction of microprocessors and other electronic devices [7]. By 2023, the global home automation market is expected to be worth $74 billion [8]. There is a growing trend toward "smart homes," which are fully integrated and controlled by a single device, such as a smartphone. Furthermore, artificial intelligence and machine learning are expected to become more common in-home automation systems, allowing them to learn and adapt to the habits and preferences of individual users [9].

2.1 Biometric Door Lock

Voice recognition, fingerprint scanning, facial recognition, iris recognition, and hand geometry are examples of these technologies. Individual utterances are analyzed and recognized, and a template or model is created for each user. Fingerprint scanning identifies people by using their unique fingerprints. Patterns based on a person's facial textures and shape are used in facial recognition. To identify individuals, iris recognition employs mathematical pattern recognition techniques. Hand geometry identifies people based on the shape of their hands. Each technology has a unique method of capturing and recognizing unique characteristics, such as recording a person's voice or taking hand measurements. These technologies have been enhanced to improve the security and usability of door access control systems.

Table 1: List of Biometric Security System

NO	BIOMETRIC	DESCRIPTION	PICTURE
1	Voice recognition	A door access control system hears and analyses an individual's voice to provide appropriate access. During the enrollment stage, the system creates a template or model of the person's voice. The system compares a sample speech utterance to the stored templates during the verification step to determine the best match and grant access.	 Figure Voice recognition

		Figure 1 depicts the visual aid of a voice recognition door lock [10].	
2	Fingerprint scan	Fingerprint scanning is a technique used in security systems to identify people by their fingerprints. It is used to open doors, laptop computers, and cell phones, among other things. Individuals must first register their fingerprints with an optical or thermal scanner before using fingerprint scanning in door access control systems. To gain access, the individual must place their registered fingerprint on the scanner, and the device will recognise their distinctive features [11]. A fingerprint scanner with a keypad is depicted in Figure 2.	 Figure Fingerprint scanner
3	Facial recognition	Facial recognition is a technology that employs artificial intelligence to identify people based on their facial characteristics. It works by comparing a scan's facial features to a database of faces. During the enrollment stage, the system records an individual's facial characteristics, and during the testing stage, the system compares the scanned face to the stored faces to grant access [12]. Figure 3 shows how the system can recognise up to 500 faces to keep out intruders and unwanted guests.	 Figure Facial Recognition
4	Iris recognition	Iris recognition, a technology that identifies individuals based on the unique patterns in their irises using mathematical pattern recognition techniques. It uses video camera technology and subtle near-infrared illumination to photograph the iris [13]. Individuals can be recognised by computerised security systems by decoding the unique patterns in their irises, as shown in Figure 4.	 Figure Iris Recognition
5	Hand geometry	Hand geometry is a technology that identifies people based on the shape of their hands. Hand geometry readers measure the hand multiple times and compare the results to measurements stored in a file. It is not as unique as other biometric identification methods like fingerprints or iris recognition, but it is still commonly used for high-security applications [14]. Figure 5 depicts a person scanning their hand on a hand geometry reader.	 Figure Hand geometry

2.2 Voice Recognition Phases

To function properly, a voice recognition system must go through two stages. The first stage is enrollment, also known as training, in which the system records and analyses a speaker's unique voice features and stores them in a database. The second stage is verification, also known as testing, which

involves comparing a sample speech utterance to the stored models to determine a match. Some systems necessitate training, whereas others do not.

2.3 Microcontroller

Table 2: List of Microcontroller

NO	TYPE	DESCRIPTION	PICTURE
1	Raspbeerry Pi	The Raspberry Pi board is a microcontroller with an ARM processor, a graphics chip, RAM, and connectors for external devices like a keyboard, mouse, and display unit. It also has USB ports, Ethernet for internet connectivity, and can support open source operating systems based on Linux. The Raspberry Pi Foundation also sells add-on hardware modules as accessories. When a full-fledged computer is required, such as when driving complex robots, performing multiple tasks, or performing intensive calculations, it is best used. Figure 6 shows the Raspberry Pi microcontroller	 Figure Raspberry Pi
2	Arduino	The Arduino platform is an open-source physical computing platform that interacts with various types of extension boards via microcontroller boards. It includes a development environment, which enables users to write software for the microcontroller and interact with various devices. The Arduino platform is ideal for simple repetitive tasks and is frequently used for prototype development. The Raspberry Pi, like the Arduino, is a microcontroller board, but it is a more powerful and full-fledged computer that is best suited for more complex tasks and applications. Figure 7 shows the Arduino microcontroller.	 figure Arduino Uno

Based on studies, the best analogy is used to create the prototype of a Voice Recognition Door Lock with Keypad. The microcontroller Arduino Uno was chosen to implement the wireless system. This is because the Arduino Uno is a popular and widely used microcontroller known for its ease of use and versatility. It is well-suited for this project because it can be programmed in a variety of programming languages, including C. Furthermore, because it is a low-cost and open-source platform, it can reduce the design of this prototype and make it more affordable.

3. Methodology

The prototype is designed with the completion of the project objectives in mind. The prototype is constructed with low-cost components such as a voice recognition module, a single channel relay, and a keypad. All of these components are linked to the Arduino Uno, which serves as the prototype's microcontroller. The Arduino IDE software is used to control and monitor the operation. The process flow is depicted in the flowchart in Figure 8 below.

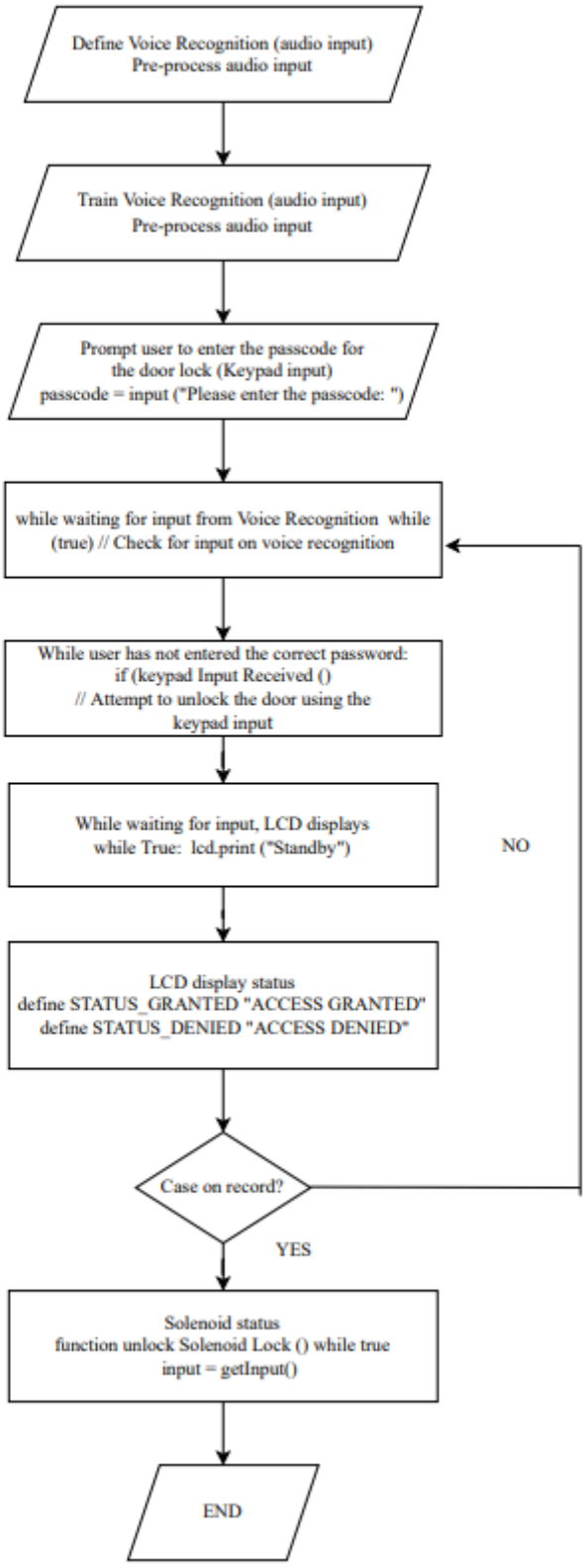


Figure 8: Workflow of the prototype

3.1 Block Diagram

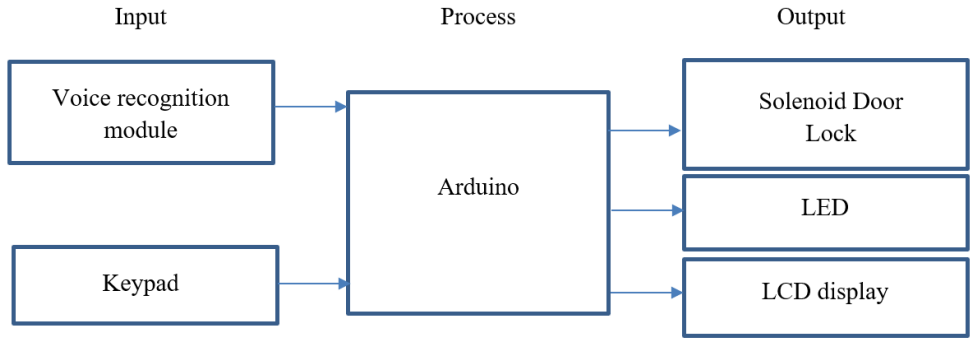


Figure 9: Block Diagram of the prototype

Shown in the figure 9 above is the voice recognition door lock with a keypad block diagram . The keypad is an input device for manual code entry, allowing users to enter a code using buttons or keys, which is then processed by the microcontroller. The Voice Recognition Module functions as an alternative voice recognition input device, capturing the user's voice and processing it to match it against pre-stored voiceprints.

The microcontroller, in this case an Arduino Uno, acts as the central processing unit, controlling the overall operation of the lock. It receives input from both the keypad and the voice recognition module and controls output devices such as the LCD and solenoid based on that input. The LCD acts as an output device, displaying the lock's status and providing feedback to the user, displaying messages such as "Access granted" or "Access denied" depending on the input received. The solenoid, on the other hand, oversees the door's locking mechanism and is controlled by the microcontroller to open or close the lock.

3.2 List of Materials

The microcontroller Arduino Uno serves as the central processing unit in the Voice Recognition Door Lock with Keypad prototype, connecting and communicating with various components to control the overall operation of the lock. The keypad and voice recognition module serve as the lock's inputs, where users can enter their code or voiceprint. These inputs are connected to the microcontroller via digital pins, and the microcontroller processes the input and controls the LCD output devices. Based on the input received, the microcontroller sends a signal to the solenoid to open or close the lock. The LCD is used to show the lock's status and provide feedback to the user. Communication between the microcontroller and the components takes place via the protocols such as UART and I2C.. The materials used in the development of this prototype are listed in Table 3 below.

Table 3: List of materials required in developing the prototype

NO	COMPONENT	FUNCTION	SPECIFICATION
1	Voice Recognition Module V3	A device that enables voice recognition and voice command in electronic projects and systems. It is compatible with microcontrollers such as the Arduino and Raspberry Pi. This module can perform voice recording, recognition, comparison, trigger, and control functions.	It operates in a temperature range of -20°C to 60°C and is powered by a voltage range of 3.3V-5V. It has a current consumption of 35mA-40mA. It has an 8kHz audio sampling rate, 32Mbit audio storage, and can recognise up to 15 voice commands.
2	4×4 Keypad	By pressing the buttons, users can enter numerical and/or character	5V operating voltage, 25mA current consumption Temperature

		data. Each button represents a different number or character, and pressing it sends a signal to the microcontroller, which can then be used to control other devices or perform specific actions.	range: -20°C to 60°C Connectivity option include digital pins. Compatibility with a variety of microcontroller platforms
3	Liquid Crystal I2c	On the screen, display text and/or numerical data. It can be used to display a system's status or to provide feedback to the user. The i2c protocol enables simple communication between the LCD and the microcontroller, reducing the number of communication pins required and making it simple to interface with the microcontroller.	5V operating voltage, 20mA current consumption Temperature range: -20°C to 60°C 16x2 display size Option for connectivity include i2c. Compatibility with a variety of microcontroller platforms
4	Arduino Uno Board	In electronic projects and systems, act as the central processing unit. It can be programmed in a variety of programming languages, including C and C++, and it can control a wide range of devices, including motors, sensors, and actuators. It has numerous input and output capabilities and can be connected to various components via digital and analogue pins.	The ATmega328P microcontroller is used in this microcontroller board. It has 14 digital input/output pins, 6 analogue inputs, a quartz crystal with a frequency of 16 MHz, a USB connection, a power jack, an ICSP header, and a reset button.
5	Arduino IDE	Provide a simple and intuitive interface for users to write, upload, and debug code for Arduino boards. It includes a code editor, a library manager, and a serial monitor, allowing users to easily write, upload, and debug code. The IDE also includes a library of pre-written code known as "sketches" that can be used to get a project up and running quickly.	Users can use this software to write, upload, and debug code for Arduino boards. It is a multi-platform app that works on Windows, macOS, and Linux. It provides a straightforward interface for writing, uploading, and debugging code.

3.3 Software Development

The development of code for a Voice Recognition Door Lock with Keypad using Arduino entails writing a code that controls the behavior of the lock based on input from the keypad and voice recognition module. The programming is done in the Arduino programming language, which is based on C. The first step in the development process is to install any required libraries or software that the code will use. This could include libraries for the keypad, voice recognition module, and LCD. Once the hardware and software are in place, the program can be written. The code should include instructions for reading input from the keypad and voice recognition module, processing the input, and controlling output devices such as the LCD and solenoid. Figure 10 below shows the coding in Arduino IDE.

voice_door_lock | Arduino 1.8.19

File Edit Sketch Tools Help

voice_door_lock

```
#include <Adafruit_CircuitPlayground.h>
#include <Adafruit_Circuit_Playground.h>
#include <Keypad.h>
#include <EEPROM.h>
#include <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>
#include "VoiceRecognitionV3.h"



#define I2C_ADDR 0x27           //I2C adress,use the code to scan the adress first (0x27) here
#define BACKLIGHT_PIN 5         // Declaring LCD Pins
#define En_pin 4
#define Rw_pin 1
#define Rs_pin 0
#define D4_pin 6
#define D5_pin 7
#define D6_pin 8
#define D7_pin 9


const byte numRows= 4;          //number of rows on the keypad
const byte numCols= 4;          //number of columns on the keypad

char keymap[numRows][numCols]=
{
{'1', '2', '3', 'A'},
{'4', '5', '6', 'B'},
{'7', '8', '9', 'C'},
{'*', '0', '#', 'D'}
};
```

Figure 10: Coding using Arduino IDE

4. Result and Discussion

After the design has been finalized, the lock's prototype will be created. Assembling the various components and connecting them in accordance with the circuit design would be required. Soldering, wiring, and other types of assembly work may be required. After assembling the prototype, it would be tested to ensure that it functions as expected. This could include testing the voice recognition module to ensure that it can recognize different voices accurately, testing the keypad to ensure that it can accept and process input correctly, and testing the overall operation of the lock to ensure that it opens and closes when it should. When the prototype performs as expected, it is ready for further use or development. It can be used for real-world testing or to make further improvements. Figure 11 below shows the hardware design of the prototype.

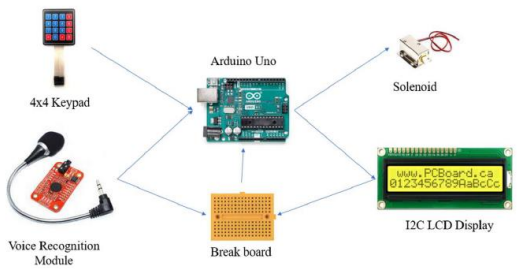


Figure 11: The final design of the Hardware

Once the code has been written, it should be uploaded to the prototype's microcontroller for testing. This would entail connecting the prototype to a computer via a USB cable and uploading the code via the Arduino IDE. After uploading, the prototype should be tested to ensure that it works properly. This could include testing the voice recognition module to ensure that it can recognize different voices accurately, testing the keypad to ensure that it can accept and process input correctly, and testing the overall operation of the lock to ensure that it opens and closes when it should.

The accuracy and overall time delay of a Voice Recognition Door Lock with Keypad prototype have been tested. A group of ten people were chosen to participate in the testing, and the results showed that the prototype had a lock command accuracy rate of 86.67% and an unlock command accuracy rate of 93.33%. The overall time delay for the test was 2.5 seconds, with the shortest delay being 1 second and the longest delay being 4 seconds. While the prototype's accuracy rate is relatively low, it is important to remember that this is a prototype and that the results should be regarded as a rough estimate rather than a final product. The accuracy can be increased by fine-tuning.

Table 4: Accuracy testing result

Person	Command 1 (lock)				Command 2 (unlock)				Average delay (s)
1 (owner)	✓	✓	✓	3	✓	✓	✓	3	3
2	✓	✓	✓	0	✓	✓	✓	0	4
3	✓	✓	✓	0	✓	✓	✓	0	1
4	✓	✓	✓	0	✗	✓	✓	1	4
5	✗	✓	✓	1	✓	✓	✓	0	3
6	✓	✓	✓	0	✓	✓	✓	0	1
7	✓	✗	✗	2	✓	✓	✓	0	3
8	✗	✓	✓	0	✗	✓	✓	1	4
9	✗	✓	✓	1	✓	✓	✓	0	1
10	✓	✓	✓	0	✓	✓	✓	0	1
Success rate (%)	86.67				93.33				2.5

The prototype's accuracy can be improved by fine-tuning the voice recognition algorithms and increasing the number of people involved in the testing. The prototype can also be trained on a larger variety of voices, enhancing its ability to recognize different accents, dialects, and languages. A user-friendly interface can be created as a front-end to the prototype to make it more accessible to a wider range of users. This could be a mobile app or a web interface that allows users to easily set up and configure the prototype, as well as manage and monitor access to their doors.

5. Conclusion

A voice recognition door lock with keypad system powered by Arduino could provide a convenient and secure method of unlocking a door. The voice recognition component would allow the user to unlock the door by simply speaking a predetermined phrase, whereas the keypad would provide an alternative method of unlocking the door by entering a numerical code. Multiple voice phrases and key codes could be programmed into the system, allowing multiple people to access the door. Overall, this type of system could be an asset to any home or business looking to improve security and convenience.

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