

An AIoT based smart locking solutions to doors and lockers

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Abstract

Smart Door Lock System leverages the use of IoT and application of smartphone communication technology to open or close the door locks remotely through authentication. Several examples of digital door lock systems have already existed, such as camera-based door security systems, doors with digital keypads for password authentication, fingerprint detection, smart card, and proximity or location detection. Smart locks provide users the ability for locking and unlocking their door without a key, without geographical restrictions, as well as distribute virtual keys to visitors.

IoT-enabled smart locks provide sensors to operate keyless entry devices that allow users to access doors remotely, through a smartphone or other Internet connection compatible devices. In the broadest definition, a sensor is a device, module, or a sub-system whose purpose is to detect motion or changes in its surroundings and send the information to other electronics, mostly a computer processor. More than one such sensors can be manufactured as micro sensors using Micro- Electromechanical System (MEMS) technology. MEMS is a miniature machine that has both electronic and mechanical components. They usually consist of a central unit in the form of integrated chip like microprocessors, that processes data and several components that interact with the surroundings.

Keywords: IoT, Artificial Intelligence, Biometrics, Locks

1. Introduction

Humans have invented locks since ancient times, to use them to protect their privacy and personal belongings. they are constantly evolving over the ages for better protection. But the problem is that locking the door these days is not safe and can be easily bypassed. Our doors can be forgotten, and this is a common occurrence for most people. Locks are trying these days to depends on technology by using a code or phone or by card to make our things safer. But there are limits, which are the lack of features to be combined in one place. also, the lack of high-security features. To solve this problem, we need to combine all the modern security features into one lock as well as monitoring features. Thus, we have high security, comfortable opening, and closing systems, and features that help us easier and faster, all requirements do not conflict and help to make our homes safer than before.

The smart or intelligent door lock controls the opening of a workplace and home. The intelligent lock should handle heavy flows and maintain solid functionality in the given environment. It is important for authorized person to access the door in the room and must have a precise sense of user standing location [1]. The lock and the application have a separate channel of communication that controls by Application Programming Interface (API) such as to control the lock door and to give messages to the users through WiFi [2]. Android Based Smart door locking system is invented to address the security breach issues of unauthorized access, trespassing and intrusion. Banks, corporate offices, financial organization, jewellery shops, and government organization are some of the places where unauthorized access, trespassing and intrusion take place [3-4]. In recent days, the network based centralized electronic access control system developed for security gate control and door access control in smart buildings with different user authorization interfaces like near-field communication (NFC), radio-frequency identification (RFID), fingerprint

recognizer, and face recognizer, etc. [5-8] to limit the physical access of the people in the buildings or assets. The building facility localized electronic access control system receives the user specific authentication and authorization information from a centralized access control system server and performs the automatic gate or door lock open or close control for the specific individuals to access building facility area using NFC or RFID Tag or fingerprint features or facial features, etc. The most available access control system user authentication interfaces are subject to the security compromising by exposing the password or digital keys to strangers. Also, the RF-based available user interfaces are vulnerable to security threats [9]. However, the cost of the access control system installation is high, and the network interface has the weakness with access distance, security and network access efficiency issue.

The following are the different objectives of the proposed system:

- It is expected to provide a security toolkit to people of the society.
- The idea behind the modern days smart locks is to unify the functionality provided by convenient and secure access control methods with the convenience of internet connectivity.
- Security to confidential things, properties, and life is very important we should provide proper attention to these things to avoid unnecessary damage to them.
- These smart locks are expected to provide multiple options to lock or unlock your property.
- With the help of this smart lock one can manage their properties across the country from the single place.
- *Smart keys let you grant access to multiple people and track who comes in and out of your home any time of the day or night.*
- This smart lock provide lot more convenient for elderly and physical challenged people since it can be opened with smart phones a senior citizen are disabled don't have to struggle with keys go inner the door to open it.
- The main components of a smart lock include the physical lock, the key (which can be electronic, digitally encrypted, or a virtual key to provide keyless entry), a secure Bluetooth or Wi-Fi connection, and a management mobile app.
- Smart home security locks are not only well known for providing undaunted and unflinching security but also add grace to your spaces and premises with a large number of designs and styles.
- Smart door locking system is to provide a smart solution to overcome these challenges and provide a feasible solution.

2. System Architecture

The proposed smart locks solution is integrated with GPS. In this Such a door lock system is automated and does not need manual input for locking and unlocking, while also being secure. The door lock works like a switch, taking into account the user's proximity from the door. A Central Control Module is embedded in the door for a more secure coordination of the system and for providing a robust mechanism for locking and unlocking the system. Two separate programs are required to operate the lock, the one inside the microcontroller and the android software on user smart phone to transmit GPS coordinate of the user to the system at door. The system can embed itself in the local area network of the home surroundings, which enables extra security layers and restricts access to the system only through the network. The detailed architecture is depicted in Figure 1.

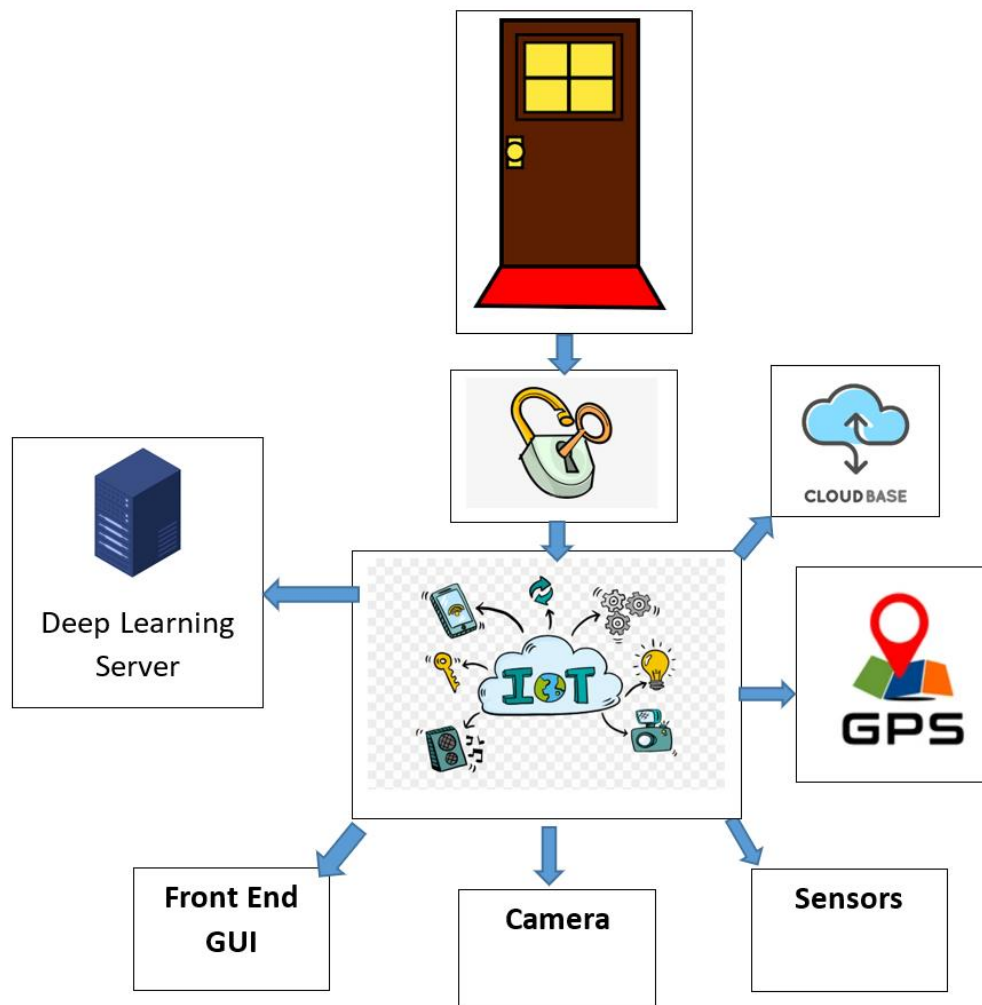


Figure 1: Proposed System architecture

The central processing unit controls the overall system. It is responsible for handling inputs from various sensors, processing data, and triggering actions. HC-05 Bluetooth Module enables wireless communication between the smart door lock and a paired device (e.g., a smartphone). This module allows users to send commands, such as lock/unlock signals, via Bluetooth. Fingerprint Sensor is used to capture and process fingerprint data for biometric authentication. Biometric module typically uses algorithms to compare stored fingerprint templates with the provided fingerprint to grant access. Relay is used as an electromechanical switch to be controlled by the Arduino. It manages the connection between the Arduino and the solenoid lock. Solenoid Lock is an electrically controlled lock mechanism. This lock engages or disengages the physical locking mechanism based on signals received from the relay.

3. Implementation

Hardware and user interfaces has been implemented as part of this system. Hardware architecture is depicted in Figures 2 and 3. Use of Arduino with various sensors is shown and solenoid lock as actuators is depicted in Figure 2. The system is flexible with plethora of options to the end user to use locking and unlocking mechanisms. Biometric based authentication, Internet based authentication, Face recognition based authentication and Voice based authentication is provided as shown in Figure 3.

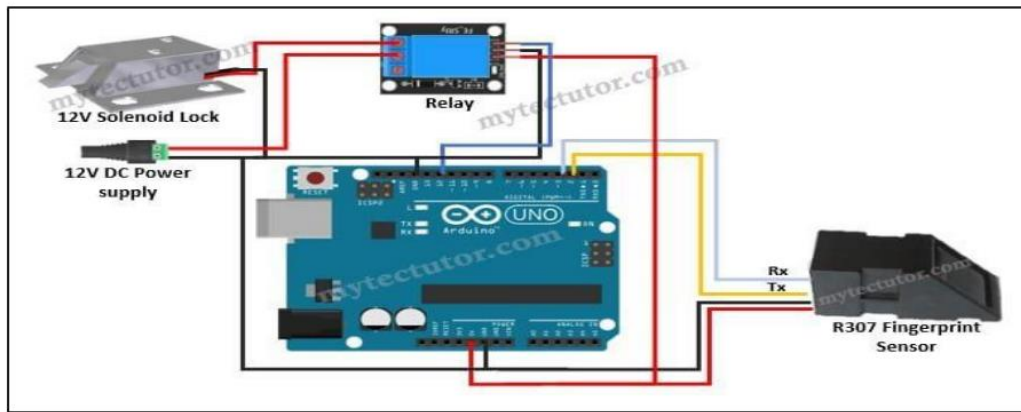


Figure 2: Hardware Architecture

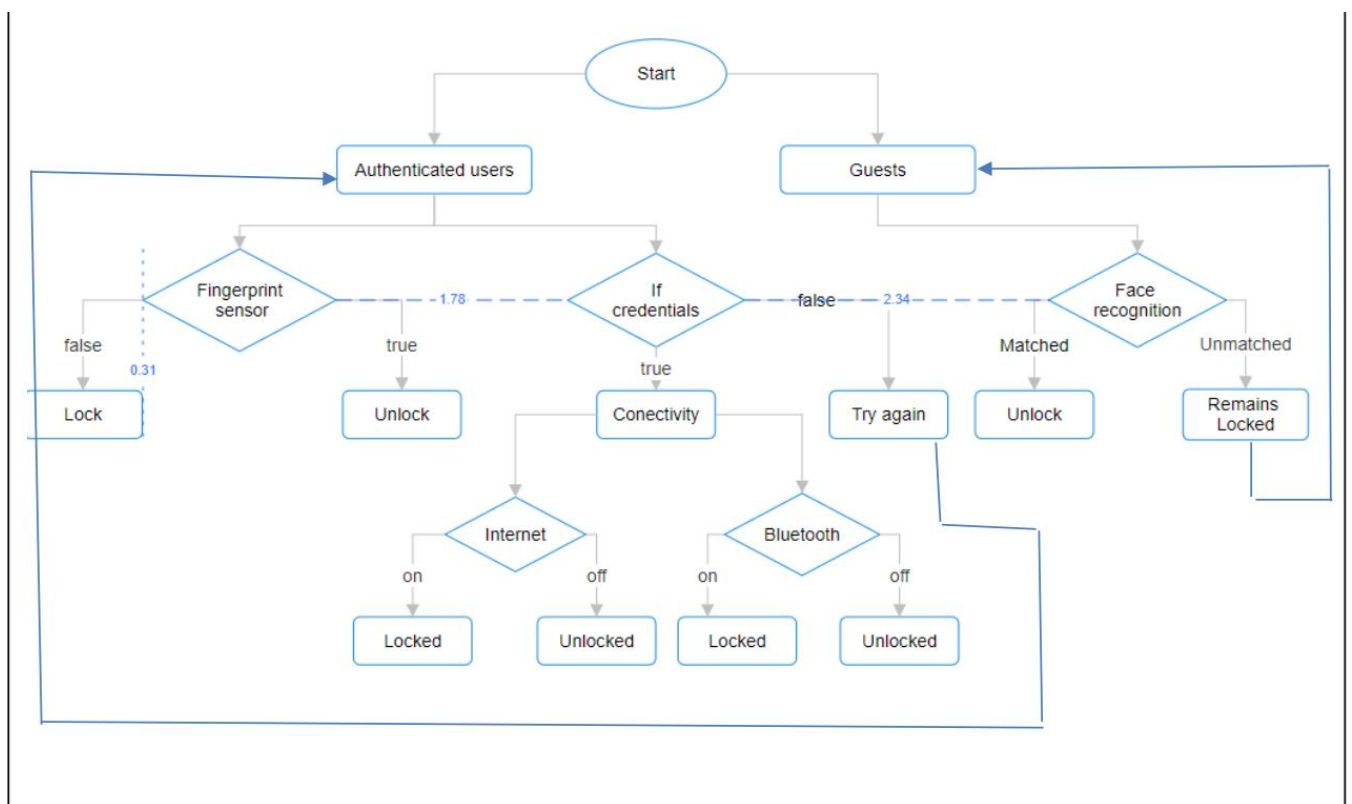


Figure 3: User Interface flow chart

4. Results and Analysis

Arduino based locking system setup is shown in Figure 4. The backend processing of Arduino is depicted in Figure 5. A compact device has been developed and fabricated as a PCB. It has been integrated with Bluetooth, relay, fingerprint sensor, solenoid lock and Arduino UNO WiFi Rev2 device. Few snapshots of the product is depicted in Figure 5:

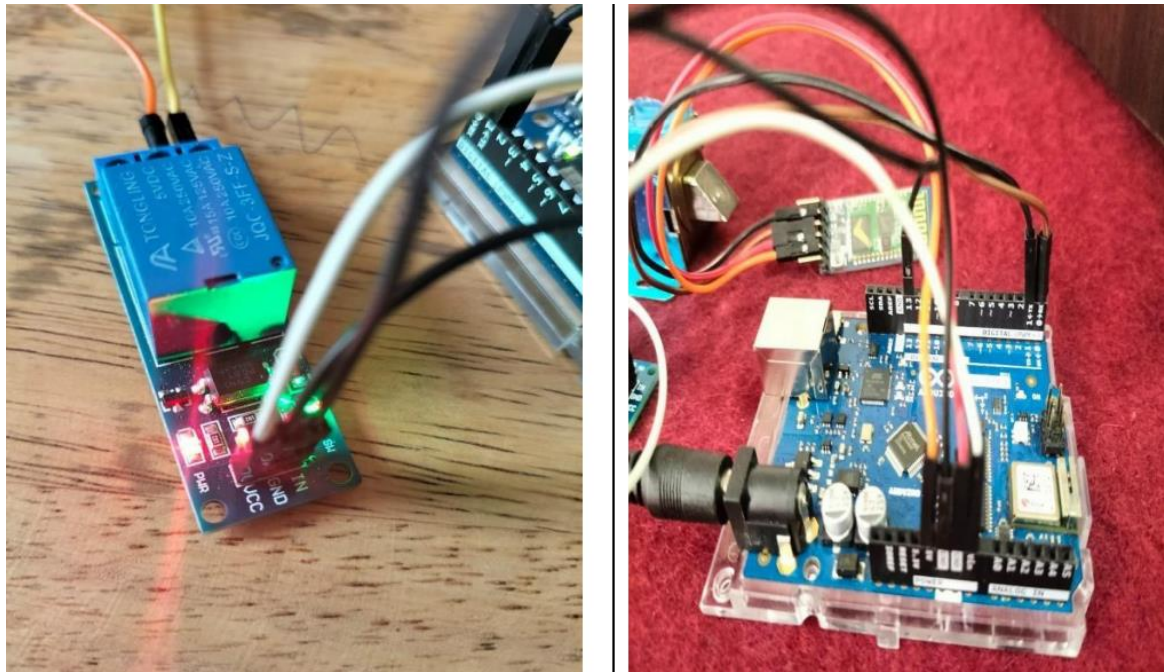


Figure 4: Set up of locking system

```
CODE #00
185 Serial.print(data);
186 Serial.begin(9600);
187 delay(500);
188 if(strcmp(data,"OFF")==0)
189 {
190 // Serial.print("Door Unlocked");
191 digitalWrite(RELAY_PIN, HIGH); // unlock the door
192 delay(2000);
193 //return;
194 }
195 else{
196 // Serial.print("Door Locked");
197 digitalWrite(RELAY_PIN, LOW); // lock the door
198 delay(2000);
199 //return;
200 }
201 }
202 }
203 //return 0;
204 }
```

Output Serial Monitor x

Message (Enter to send message to 'Arduino Uno WiFi Rev2' on 'COM7')

Attempting to connect to SSID: 4CWIFI_23013
Attempting to connect to SSID: 4CWIFI_23013
Connected to wifi
SSID: 4CWIFI_23013
IP Address: 192.168.43.51
signal strength (RSSI):-30 dbm

Starting connection to server...
connected to server
ONONONOFFOFF

Figure 5: Backend processing results

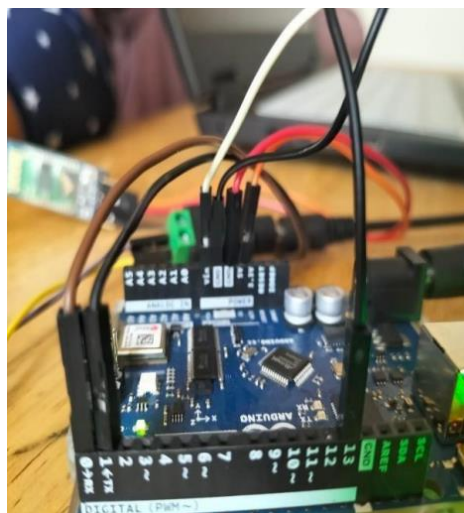


Figure 6: PCB based locking system board

The data of solenoid lock being locked and unlocked is recorded in firebase as shown in Figure 7.

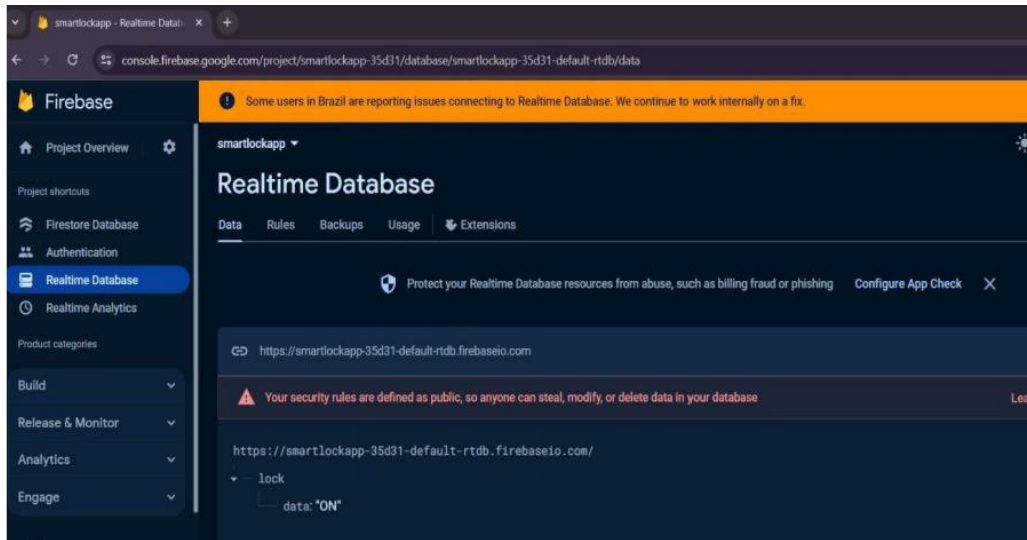


Figure 7: Use of internet cloud storage with Firebase

An APP has been developed in Android for operating this locking system. The authentication with username and password, voice authentication and in case of guest, capturing the face and authentication is shown in Figure 8.

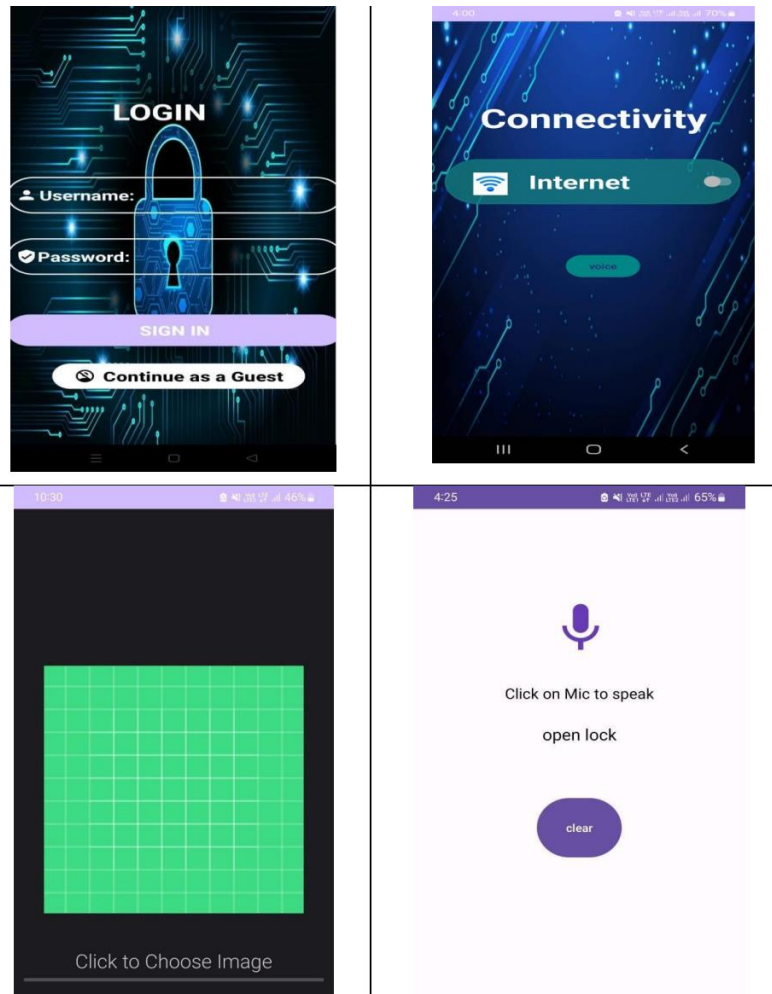


Figure 8: Front-end snapshots

The analysis of accuracy for various faces scanned for locking and unlocking is done and results are tabulated in Table 1. The corresponding graph is plot in Figure 9. It can be observed that an accuracy of more than 97% is obtained from the system and accuracy does not change much with number of students together. Further, the voice recognition analysis is also done and results are shown in Figure 10 and tabulated in Table 2. It is inferred that accuracy of more than 98% is observed. Hence this provides more flexibility to the users for locking and unlocking their precious property.

Table 1: Face Recognition Accuracy

Number of face image scanned	Accuracy (in %)
30	98.1
40	98.0
50	97.9
60	97.9
70	97.7
80	97.7

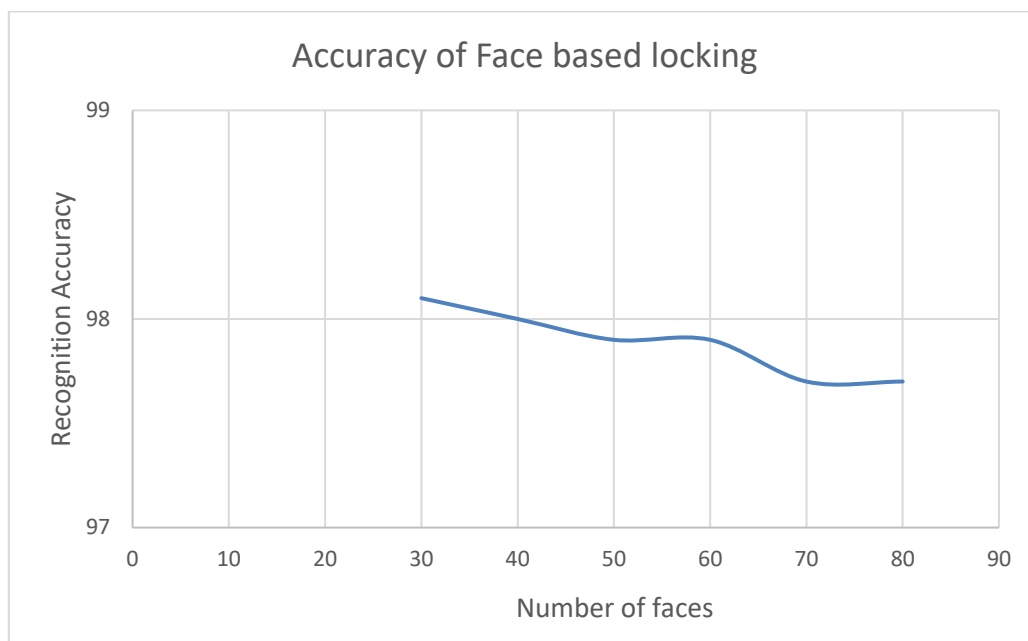


Figure 9: Plot of Face based recognition performance

Table 2: Voice Recognition Accuracy

Number of times voice input given	Accuracy (in %)
30	99.2
40	99.1
50	98.9
60	98.8
70	98.5
80	98.5

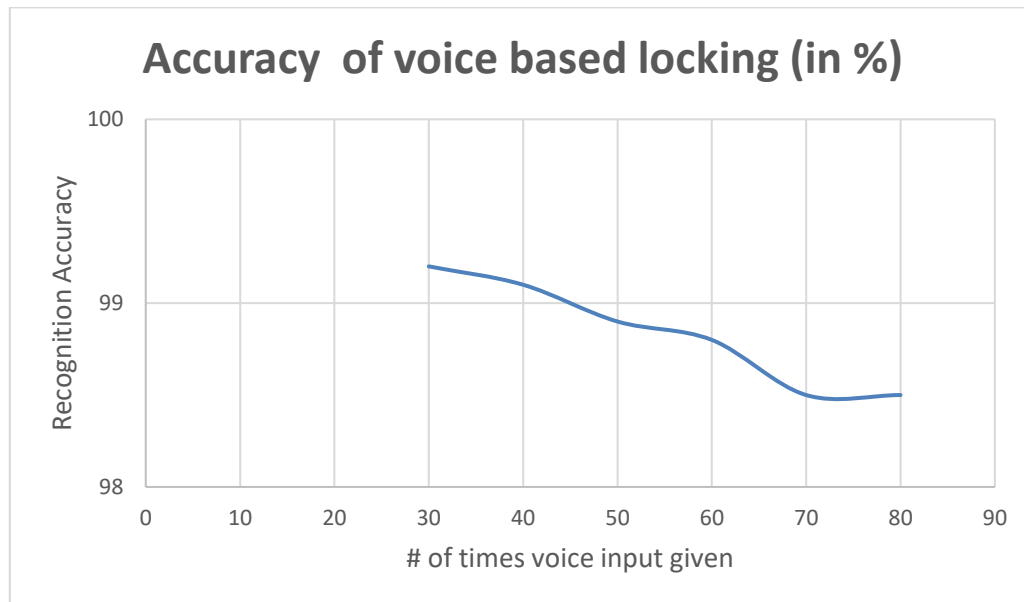


Figure 10: Plot of Voice based recognition performance

5. Conclusion and Future Scope

The smart lock project using Arduino represents a successful integration of technology to enhance security and convenience. The implementation effectively combines door sensing, user authentication, and automated unlocking mechanisms to provide a reliable and efficient access control system. The project's versatility allows for various authentication methods, accommodating user preferences. As we navigate the realms of IoT and smart home technology, this smart lock serves as a testament to the potential for creating intelligent, connected solutions that prioritize both safety and user experience. The modular design of the project allows for future expansions and improvements, ensuring adaptability to emerging technologies and security standards. By fostering a balance between accessibility and robust security measures, this smart lock project demonstrates the practical application of Arduino based systems in real-world scenarios. The project's success lies not only in its technical functionality but also in its user-friendly interface, making it a viable and user-centric solution for modern security challenges.

6. Authors' Biography

Dr. Chetan K R is working as a Professor and Head in the department of Artificial Intelligence and Machine Learning at an engineering college. He has an experience of more than 20 years. He has received project funding of around 15 lakhs in various projects. He has published more than 30 journals and book chapters in scopus indexed journals. His research areas and interest include Vision AI, Emotional AI, AIoT, Conversational AI and Generative AI.

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