



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 6, June 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

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# Design and Implementation of Smart Control Elevator Based on Biometric Recognition System for People with Special Needs

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**ABSTRACT:** The elevators have been developed to serve the requested passenger's floors with efficient vertical transportation. However, it presents permanent difficulties for people with special needs. They can't manipulate easily those elevators and usually make them feel uncomfortable. Many researches propose an efficient solution for those peoples based on biometric technology. The main purpose of this research is to investigate the effectiveness and accuracy of the biometric recognition technology in the development of a smart elevator for people with special needs and how to help them to use elevators easily based on multimodal biometric systems?

In this paper, we developed a prototype of an efficient three floors smart elevator through programmable electronic devices such as microcontroller and programmable logic controller. The proposed smart elevator allow handicapped peoples to control the elevator easily and comfortably, especially people with speechless, visual, hearing, and physical impairments that have daily challenges with elevator. An average performance rate more than 98% has been stored with an efficient control of the proposed smart elevator. The proposed smart elevator permits to facilitate the daily life of people with special needs making them more independent by using biometric recognition modalities.

**KEYWORDS:** Smart control elevator, multimodal biometric recognition, people with special needs, Programmable Logic Controller.

## I. INTRODUCTION

Nowadays, we will find all building with an elevator in the tallest skyscrapers of cities. The elevator serves as an important lifeline for all users and anyone can move easily to any building floor [1], [2], [3], [9]. At the same time, it is also important to consider the control of elevator [5] as well as consider the flexible use of it [4] [6]. Many researches presented a recent development projects to apply intelligent technologies to elevator control problems. Some researchers proposed intelligent algorithm for expected users to operate elevators without any special training and obtained comparable performances with regular elevators [12]. The implementation is realized with mobile application part and microcontroller is used as the core of hardware part [10]. However, [8] detailed a touch less interface for the control of an elevator based on gesture recognition. A user can select and confirm the desired floor without touching any physical device. However, elevators are used by many people especially those with special needs and elderly persons which have a daily challenge with elevators [13]. In fact, they often lack the dexterity required to operate them properly [15]. This can be especially true for person who suffers from cerebral palsy, autism or other developmental disabilities [21] [22]. People who use wheelchairs or walkers may also have difficulties on pressing elevator buttons [16]. Therefore, it is necessary to use a biometric recognition which allows people with special needs to operate it easily and independently [14]. In consequence, a biometric recognition elevator can help people with disabilities to feel safer, more secure and less stressed. As requirement, biometric recognition reader must be installed inside the cabin of elevator such as: fingerprint scanner, acoustic voice recorder [7], face detection, etc. Users can also get authorized based on RFID or Bluetooth reader inside mobile phone [17] [18]. After a positive verification of credentials, the button of the particular floor will get activated only for authorized user and enable after to move until desired floor. All readers installed inside the elevator should be connected to the master programmable logic controller. Smart elevators represent a fusion section between electrical and computing engineering that involves incorporating smartness into elevators for comfort, safety, security, and power conservation [19]. They permit also to identify automatically the resident users and predict the desired floor [20]. Typically, people think of biometrics as using purely physical factors and the most senses that a human can be use easily and comfortably are: fingerprinting, retina scan, speech recognition and facial recognition [11]. The objective of this paper is to use a biological recognition to control the proposed elevator based on biometric recognition system. This smart elevator provides more security and helps many people, including those with special needs, to use the elevator with more comfort and luxury.

## II. CONTROL OF ELEVATOR BASED ON BIOMETRIC RECOGNITION SYSTEM

Biometric recognition technology is method of identifying and authenticating individuals based on their physical and biological features, such as face and speech recognition, finger recognition, iris and DNA recognition. The use of this technology has become increasingly important due to the growing trend of digitalization and the need for authentication and identification of users in a secure and reliable manner. It can be used in a variety of applications, such as access control, user authentication, identity management, and surveillance. With the advancement of technology, biometric recognition systems become more reliable and efficient.

### II.1. Fingerprint Recognition System

Among the many biometric features, the fingerprint is considered one of the most practical ones. Our fingerprints are unique, at least on certain points: called minutiae or lines, bifurcations, points which represent the termination of ridges. The specific arrangements of all the elements forming the papillary lines which are found on our fingers make possible infinity of combinations. Moreover, the design formed by these lines on our fingers never evolves. Depending on the level of security desired, it is estimated that it takes between 10 and 20 match points to certify a fingerprint. For this reason, the fingerprint recognition systems received more attention during the last period due to the need for security in a wide range of applications. They require a minimal effort from the user and provide relatively good performance based on low price fingerprint sensors.

### II.2. Speech Recognition System

Speech recognition software on computers requires that analog audio be converted into digital signals called (A/D) conversion. For a computer, to decipher a signal, it must have a digital database of word vocabulary or syllables, as well as a speedy means for comparing this data to acoustic signals. For pattern recognition, a comparator checks these stored patterns against the output of the converter. When a user pronounces a word, acoustic vibrations are created in the air. The mentioned converter is applied to convert the analog wave to a digital data. In fact, sampling process is applied for the acoustic wave by taking precise measurements. The unwanted noise is removed by filters that separate also different frequency bands. It also adjusts the volume to a constant value. This type of biometric recognition can be used comfortably specially by people with impaired physical mobility. However, these users don't always speak at the same speed, so the voice need to be modified to match the speed of the voice models already stored in the data base.

## III. DESIGN AND IMPLEMENTATION OF PROTOTYPE

The design and implementation of the proposed smart control elevator system requires the consideration of several technical and non-technical factors. From the technical side, it must be capable of accurately recognizing users and providing safe and secure access to the elevator. In addition, it must be able to recognize different types of users, such as pedestrians and wheelchair users, in order to provide an appropriate level of service. On the non-technical side, the elevator system must be able to meet the needs of the users and be easy to use. The flowchart illustrated in figure 1, describe the interconnection block diagrams of the proposed smart control elevator.

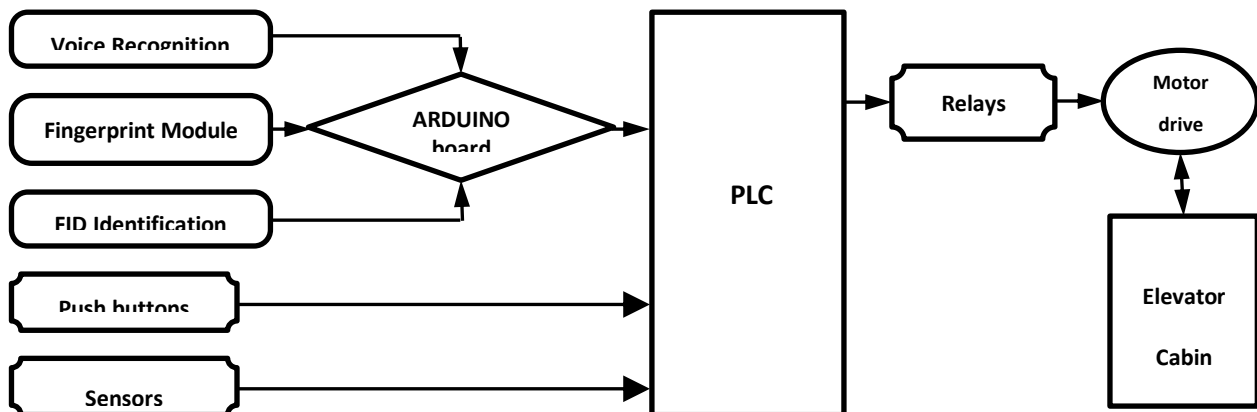


Figure 1: Flowchart of the proposed smart control elevator



The proposed elevator is divided into three floors. It constructed with various mechanical components that mainly include: cabin, traction rope, shaft, doors, chain and pulley, guide rails and safety device. It is composed by three floors. Each user can press any outside call button to call the elevator cabin. This call button is placed on front of each floor. However, the cabin buttons are used for floor selection (from 1 to 3) placed inside the cabin. This elevator is operated by a motor drive. It represents a Siemens SINAMICS G110 Series AC Frequency Inverter for 0.25 kW. It's simple to set-up and converts single phase 230V input to 230V three phases for a standard AC induction motor. For moving cabin, It will be able to develop very high starting torque with lowest starting current. To concept an automated smart control elevator, we divided our work into two parts: Hardware and software. For the first part, we used several automation components such as sensors, motor drive, biometric modules, microcontroller and PLC to permit to control the elevator process along three mentioned floors. In each floor, we will use two types of sensors: a limit switch to detect the presence of cabin and a proximity sensor to sense the opening and closing door of cabin. For the second part, we will develop an efficient Sequential Functional Chart (SFC) program implemented by S7-Simatic Manager into Siemens PLC with reference (S7-315).

### III.1. HARDWARE Description

#### III.1.1. Multimodal Biometric Recognition based on Arduino Board

Multimodal biometric recognition system, specifically based on Arduino microcontroller board, is a technology that allows for multiple forms of biometric data to be collected and processed together. It is a complex system that offers a more secure and reliable way to identify people based on their physical characteristics. This Arduino board was created as interaction design. It began to revolve in response to new requirements and problems, transitioning from simple 8-bit boards to devices for IoT applications, 3D printing, wearable, and embedded systems [15]. It represents a printed circuit board that contains microcontrollers, LEDs, and several types of I/O interfaces. All types of Arduino boards are completely open source, allowing users to create individually codes corresponding to specific programming projects. However, the Arduino software is easy to use for novices while being versatile enough for expert users. It is compatible with Windows, Linux, and Mac. Based on this Arduino microcontroller board, a multi biometric recognition system can be done by combining different types of biometrics in a variety of ways including fingerprint scanning, voice identification, and facial recognition among other methods. The multimodality biometric recognition permits to increase the accuracy of the system and make it more secure and can easily handle the data from multiple sources. It is also programmable, allowing for custom algorithms and code to be used to process the data. In this work we present a multimodal biometric system that exploits multiple biometric traits. It is privacy-aware as it ensures privacy protection and allows the extraction of secure identifiers. In fact, a control post is designed as a visual guide to be able used specially by person with special needs. The recognition system reads input patterns from fingerprint scanners or acoustic signal from speaker and turns it into an output pattern. A set of instructions can be used to perform input and output activities for controlling elevator.

#### a. Fingerprint recognition module

In our work, we choice the optical fingerprint scanner due to its accuracy and low cost. It uses tiny capacitor array circuits that track the detail of a fingerprint. In fact, every user has a specific fingerprint that cannot be removed or changed. These features are characterized by a pattern or scanned image called fingerprint extracted from the biometric sensor. The emitted sensitive light from microchip of sensor makes a digital image by separating ridges and valleys from the fingerprint. This image is converted after to 1's and 0's to create a user's own personal code. When we want to identify a user before access to elevator, an identification stage is applied corresponding to a variable security level of sensor. The connection between fingerprint sensor and Arduino board is illustrated in figure 2.

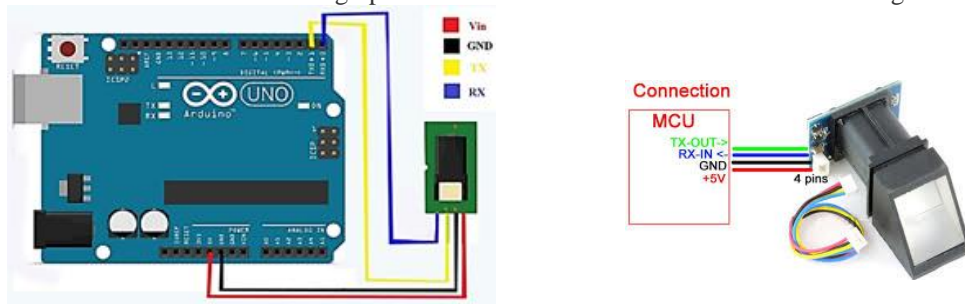


Figure 2: Connection between used fingerprint sensor and Arduino board

A (16x2) liquid crystal display screen is also used to validate the correct authentication of each fingerprint by writing the name of each identified user: “Welcome (Name of user)” on LCD screen. It is able to display 16 characters on 2 lines, white characters on blue background. Usually, we connect with the (16x2) LCD screen an I2C with (I2C) communication interface. It means that we need only four pins connected directly with the LCD display: VCC, GND, SDA, and SCL as demonstrated in figure 3.

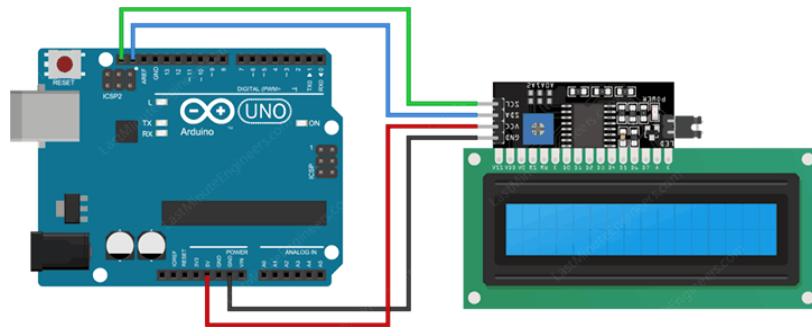


Figure 3: Connection between I2C LCD screen and Arduino board

#### b. Voice recognition module

Voice or speech recognition offers significant advantages to a several variety of potential users. Today, it is extremely useful for specific users with a physical disability. This technique consists to make able any machine or program to receive and interpret dictation or to understand and carry outspoken commands. In fact, voice recognition software enables user to feed data in Arduino board using his proper voice comfortably. So, specific user can speak into a voice recognition system in order to convert the acoustic signal into a text. After searching, we decide to choose the voice recognition device V3 (Figure 4).

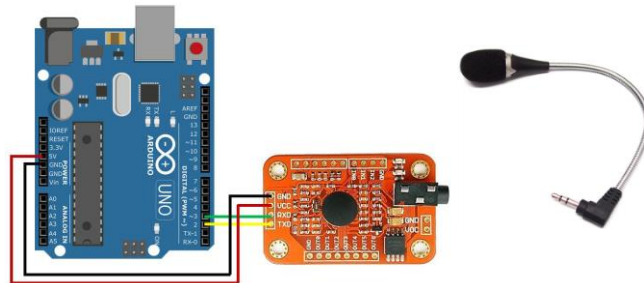


Figure 4: Connection between voice recognition module (V3) and Arduino board

This module can work with 99% recognition accuracy used under ideal conditions. It is equipped with a microphone to convert sound into an electrical signal which could be trained as a voice command. An IDE program is applied to develop the biometric control system of elevator.

#### III.1.2. Control of Elevator based on Programmable Logic Controller

Programmable Logic Controller (PLC) is used to control all input/output (I/O) interfaces of elevator. PLC is generally used to reduce the human intervention and complexity with increasing the automation process and safety. The modular PLC system will provide a great deal of applications in the field of automation. The programming of PLC is flexible, quickly and easily done. It can be exploited for automation of control elevator which requires a PLC to read the states of input interfaces, such as push buttons, sensors and biometric modules and produce a corresponding output according to the stored program. The PLC must be handling any fault conditions. The input interface of PLC converts signals into logic signals which analyzed by Central Processor Unit. This CPU evaluates the status of input, output sections and other variables during the execution of the stored program and sends signals to update the status of all outputs. The output modules convert control signals from CPU into digital or analog values used to control various output devices. In our work, we used a Siemens PLC with reference (S7-315) to control automatically the proposed elevator. As mentioned, fingerprint recognition module and V3 voice module are both used with PLC respectively for perfect identification/matching fingerprint recognition and efficient easy-control voice recognition. Figure 5 explained the interconnections between PLC and biometric recognition modules.

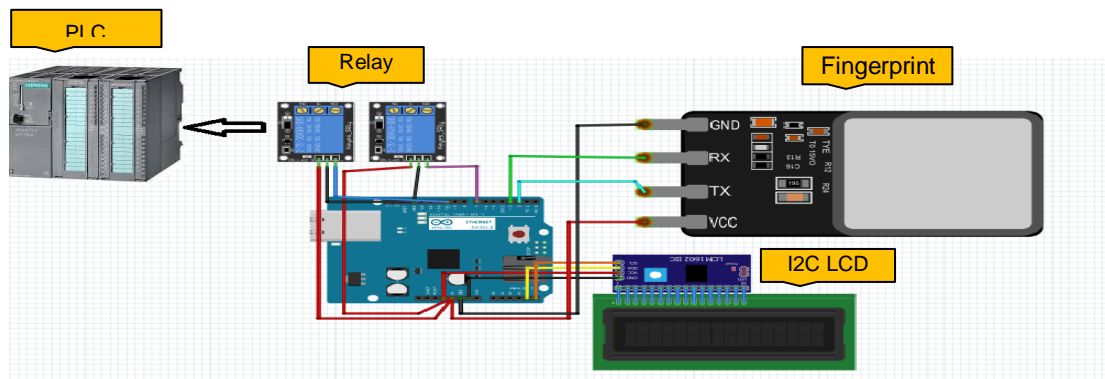


Figure 5: Interconnection between fingerprint recognition module and PLC

To detect the presence of cabin in each floor, we use three inductive proximity sensors. They enable to detect, without contact, all metal objects at detection distance up to 30 mm. This type of sensor comprises an oscillator whose windings constitute the sensing face. An alternating magnetic field is generated in front of these windings. These sensors provide an output electrical signal (24V) when the cabin reached the appropriate floor. Upon arrived, the inductive detects the metal attached on the outside of cabin. To sense the state of opening or closing door of cabin, we placed three other proximity sensors. When a metal object is placed within the magnetic field generated by the sensor, the resulting currents induced form an additional load and the oscillation increases. This causes the output driver to operate and, depending on the sensor type (NO or NC), output electrical signal is produced to determine the state of cabin door. The performance of elevator can be improved due to PLC which offers stability and efficiency. PLC represents the major element to control the proposed elevator. The voltage of 24 VDC is supplied by PLC and a specific PLC address is attributed to each I/O interfaces.

### III.2. SOFTWARE Implementation

At each floor, we placed a sensor for detecting the presence of cabin and we insert also a proximity sensor to validate the state of cabin door (opening or closing). Initially, the elevator cabin must be in motion only after checking the closing door as safety condition. After pressing on call button, the elevator moves until the desired floor. Upon arrived, the cabin door will be open during 7 seconds. The respective floor will be indicated by a 7-segment display. Then, the user -actually inside the cabin- will operate the elevator to move till the desired floor by pressing normally on the corresponding push button inside the cabin or by a biometric system after recognition process. We distinguish three different cases:

a. *Standing at floor 1:* The user is presents at the first floor which detected by sensor (S1) and he will call the cabin by pressing call buttons to move up.

- If the cabin was initially at first floor, the door will directly open, and the cabin will move to the desired floor after closing door (CD).
- If the cabin was at second floor (S2) or at third floor (S3), M+ will operate to move down until first floor. Upon arrived, the door will open, and the cabin will move up to the desired floor after closing door.
- When the user with special needs now is inside the cabin at Floor 1:
  - If he presses the push button “2” or “3” or uses the voice commands by saying: “TOW” or “THREE”, the cabin will move up to the desired floor.
  - But if he puts directly his finger on sensor or presents his RFID card, the cabin will move up to specific floor where this person lives (Floor 2 or 3).
  - However, if he presses accidentally the push button “1” or he says “ONE” as voice command, the alarm will be trigger and create a warning sound to indicate his presence at floor 1.

b. *Standing at floor 2:* The user is presents in the second floor detected by sensor (S2) and he will call the cabin by pushing call buttons (up or down).

- If the cabin was initially at second floor, the door will open directly, and the cabin will move to the desired floor after closing door (CD).
- If the cabin was at first floor (S1) or at third floor (S3), the drive motor will operate respectively to move (M-) or (M+) to second floor. Upon arrived, the door will open, and the cabin will move to the desired floor after closing door.
- When the user with special needs now is inside the cabin at Floor 2:

- If he presses the push button “1” or “3” or uses the voice commands by saying: “ONE” or “THREE”, the cabin will move to the desired floor.
  - But if he puts directly his finger on sensor or presents his RFID card, the cabin will move to the specific floor where this person lives (Floor 1 or 3).
  - However, if he presses accidentally the push button “2” or he says “TWO” as voice command, the alarm will be trigger and create a warning sound to indicate his presence at floor 2.
  - c. *Standing at floor 3:* The user is present in the third floor (S3) and he will call the cabin by pushing call button (down).
    - If the cabin was initially at third floor, the door will open (OD) directly, and the cabin will move to the desired floor after closing door (CD).
    - If the cabin was at second floor (S2) or at first floor (S1), the drive motor will operate (M-) to the existing cabin floor. Upon arrived, the door will open and the cabin will move to the desired floor after closing door.
    - When the user with special needs now is inside the cabin at Floor 3:
      - If he presses the push button “1” or “2” or use the voice command by saying: “ONE” or “TWO”, the cabin will move to desired floor.
      - But if he puts directly his finger on sensor or presents his RFID card, the cabin will move to the specific floor where this person lives.
      - However, if he presses accidentally the push button “3” or he says “THREE” as voice command, the alarm will be trigger and create a warning sound to indicate his presence at floor 3.
- All previous three cases are implemented into PLC based on Sequential Function Chart (SFC) language. The SFC represents a graphical programming language that displays the process flow as a diagram to allow programmers to control the sequential processes based on actions and transitions according to each step. All steps activate those associated actions after validation of previous transitions. The main features of SFC language is constantly changing sequences which expressed by progression of operations. All interlock circuits or redundant outputs didn’t to be designed. As example, we draw the corresponding SFC GRAPH to the last case when the user stands at floor 3.

#### IV. EXPERIMENT RESULTS AND DISCUSSION

S7-Simatic Manager is used as software for Programmable Logic Controller. It permits to realize easily the requirement automation tasks. Based on its integrated S7-GRAPH language, the equivalent Sequential Functional Chart of smart elevator is programmed into Siemens PLC with reference S7-315. Table 1 resumes the performance of the proposed elevator in terms of recognition rate for each type of impairment people.

Table 1: Performances of proposed smart elevator

Type of impairment	Recognition used technique	Recognition rate (%)
Visual impairment	Speech	96
Resident person with Speechless and hearing impairment	Fingerprint	98
Resident person with physical impairment	Speech / RFID Detection	99
Non-disabled person	-	100
<b>Average</b>		<b>98.25</b>

From table 1, we obtained a 98.25% as performance rate of the proposed prototype. For impairment people, the average recognition rate is (97.67%):

- For persons with visual impairment, speech recognition technique has been used to help them to operate elevator based on voice commands (“ONE”, “TWO”, and “THREE”). However, this technique has the potential to misidentify words, especially when used in noisy environments. It can lead to misunderstandings and confusion. Furthermore, voice recognition technology is not always accurate. It can be fooled by accents and dialects, and it can also misinterpret intent. As a result, speech recognition technique relies on large amounts of data to work properly. In fact, in training phase, we used 50 repetitions for each voice command and we stored a recognition rate =96% in testing phase.
- For resident persons with speechless and hearing impairment, fingerprint recognition technique and RFID detection card has been used to identify them easily based on fingerprint scanner or RFID reader. However, the accuracy of fingerprint recognition can be impacted by environmental conditions. If a person’s finger is dirty, wet,



or dry, the scanner may not be able to accurately read the print. Additionally, if the scanner's resolution is not set at a high enough level, it may not be able to pick up all of the details of the fingerprint. This can lead to false positives or false negatives, resulting in an improperly authenticated user. As a result, fingerprint recognition technique relies on large amounts of data to work properly. In our work, we used 20 templates of each individual's fingerprint and we stored a recognition rate =98% in matching stage.

- For resident persons with physical impairment, speech recognition and RFID detection card has been used to help them to operate elevator based on and RFID reader. By combining both voice recognition and RFID detection, we increase the performance rate that will be equal 99%. Due to RFID, the signal emitted by the card can be detected automatically and used it to track the person's location or movements of those with physical impairment. However, RFID cards can be easily lost or stolen and can be also vulnerable to interference from other signals and lead to potential health problems due to emitting of radio waves.  
In the normal case when using the elevator by non-disabled persons, a perfect performance rate equal to 100% has been stored. Without need to use any biometric recognition technique, all users can operate the elevator efficiently.
- To control efficiently the proposed multimodal biometric elevator, we combine both fingerprint and voice recognition modalities especially for people with special needs. Inside the cabin of elevator, each available user can scan properly his fingerprint or after detecting his personal RFID (Radio Frequency Identification) card to move directly to the registered floor. RFID detection cards are becoming increasingly popular in everyday life, from credit cards to access control cards. While these cards are extremely popular and have their advantages, they also have some issues that should be addressed. The primary issue is security. As with any technology, RFID cards have the potential to be hacked or counterfeited. All it takes is a scanner that can read the RFID signal, and a hacker can make a duplicate of the card or access the information contained on it. This can lead to identity theft, financial loss, and other serious security issues. Another issue is privacy. Depending on the type of card, the information contained within it can be accessed remotely without the knowledge of the user. This means that the user's personal data can be accessed without their knowledge or consent, which can be a major violation of privacy. Finally, RFID cards can be easily lost or stolen. By using the "Sigtrain" command, we are storing a voice command in to a specific address, so you should specify the address in the command.

## V. CONCLUSION

In this paper, we proposed a design of prototype for three-floor elevator based on PLC control. This elevator used biometric recognition systems which become increasingly popular in the modern world. By combining biometric recognition technologies, the prototype allows users to manipulate luxury the elevator with efficiency, especially for elderly people with special needs. In fact, living independently can be a challenge for those people with disabilities when they used elevators which often designed with the assumption that all users will be able-bodied individuals. This means that the control of the elevator is often focused on convenience and speed, without taking in account the needs of disability users. The proposed smart elevator offers an efficient solution for these persons by using a multimodal biometric recognition system. It uses a biometric control to identify the user and helps him to move to the destination floor. In order to reduce the risk of accidents, the smart elevator is programmed to allow only authorized users to use it and prevent also unauthorized access after fingerprint recognition or RFID card detection. The used speech recognition module represents a compact and easy-control speaking recognition board for a speaker-dependent voice recognition module. It allows the elevator to move automatically between floors without the need to press any button. In fact, the voice recognition modality permits to recognize voice commands allowing a hands-free operation and eliminating the need of buttons. Finally, this smart control elevator is a viable engineering solution for improving the efficiency and safety of elevators based on innovative technology. The system is able to recognize and respond to multiple types of input, including combination physical recognition techniques. This allows for a more personalized experience for the user, as well as improved safety and security. The system is also able to integrate with existing elevator systems, allowing for a seamless transition to the new system based on advanced algorithms. Furthermore, to increase the performance of elevator used by disable persons, we need to use an efficient control system, well-maintained and properly functioning components with understanding of the user's needs. The designed control system must be able to minimize energy consumption, minimize wait time, and maximize safety. Additionally, elevator should be regularly maintained to ensure the correct functionality of all components with safety features. Finally, understanding the needs of the users is important to providing an optimal experience with the elevator. This includes factors such as the number of people using the elevator, the weight of items being carried in the elevator, and any special requirements of the users. As a future work, facial recognition technology can be used also to recognize a person's particular facial features with disability's degree.



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