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Mini Project Report on

TELECARE SMART DOOR ASSISTANCE FOR BED-RIDDEN PATIENTS

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

ELECTRONICS AND COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the mini project report entitled ***"TELECARE SMART DOOR ASSISTANCE FOR BED-RIDDEN PATIENTS"*** *is a bonafide record of the work done by* ***SREENESH K.S (UID: U2201199)*** *submitted to the Rajagiri School of Engineering & Technology (Autonomous) in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B.Tech.) in* ***ELECTRONICS AND COMMUNICATION ENGINEERING*** *during the academic year 2024–2025.*

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ABSTRACT

In today's fast-paced society, individuals who are differently abled or bedridden often face challenges in managing daily activities such as answering the door, which can compromise their safety and independence. Our mini-project aims to address this issue by using technology to create a smart door system that enhances both accessibility and security.

The system allows users to remotely monitor and control door access through a mobile application. When a visitor presses the doorbell, a photo is captured and sent to the user in real time, enabling them to make informed decisions about unlocking the door. The system also includes features such as identity verification, tamper detection,and emergency alert capabilities to caregivers through automated voice calls.

By integrating user-friendly interfaces and practical functionality, our solution ensures that users can securely interact with visitors without physical movement. This not only reduces their dependence on others but also improves their safety and quality of life, making it a reliable and accessible solution for modern caregiving.

Contents

List of Abbreviations

Abbreviation	Full Form
API	Application Programming Interface
BMS	Battery Management System
CAM	Camera
EEPROM	Electrically Erasable Programmable Read-Only Memory
ESP32	Espressif Systems Microcontroller (Wi-Fi + Bluetooth)
GPIO	General Purpose Input Output
GND	Ground
GSM	Global System for Mobile Communication
HTTP	Hypertext Transfer Protocol
IDE	Integrated Development Environment
IoT	Internet of Things
IR	Infrared
LCD	Liquid Crystal Display
Li-ion	Lithium-ion
MLX90614	Infrared Thermopile Temperature Sensor
MQTT	Message Queuing Telemetry Transport
NLP	Natural Language Processing
OLED	Organic Light Emitting Diode
PCB	Printed Circuit Board
PWM	Pulse Width Modulation
RFID	Radio Frequency Identification
SPI	Serial Peripheral Interface
TIP122	NPN Darlington Power Transistor
TwiML	Twilio Markup Language
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus
VoIP	Voice over Internet Protocol
WROOM	Wi-Fi + Bluetooth Module (by Espressif)

List of Symbols

Symbol	Description
V_{in}	Input Voltage
V_{out}	Output Voltage
I	Current (Amperes)
R	Resistance (Ohms)
P	Power (Watts)
T	Temperature (Celsius or Kelvin)
f	Frequency (Hz)
t	Time (seconds)
μ	Micro (10^{-6}) prefix
mAh	Milliampere-hour – unit of battery capacity
k	Kilo (10^3) prefix
M	Mega (10^6) prefix

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CHAPTER 1

Introduction

The Smart Door project is a highly developed, integrated access control and monitoring system tailored to a variety of bedridden needs. Developed with the latest IoT technology, it uses ESP32 Wroom-32 and ESP32 CAM microcontrollers to provide a safe, health-oriented smart door solution. The project integrates several extensions, including RFID-based authentication, visitor temperature screening using the MLX90614 sensor, emergency calls via Twilio-API, real-time image absorption via Telegram,and warnings. This comprehensive system has been carefully developed to provide an intuitive and seamless experience that minimizes physical interactions and improves safety, accessibility and convenience. It is the perfect blend of modern technology and delicate design, aimed at improving the quality of life for users in their home, healthcare and living environments.

1.1 Background

With the rise of IoT and the growing demand for intelligent, contactless systems, access control solutions have become essential—especially in healthcare, elder care,and assisted living settings. Traditional door mechanisms often fail to meet the needs of bedridden or differently-abled individuals who require remote and hygienic entry solutions. The availability of low-cost microcontrollers and real-time communication tools has made it feasible to build scalable, user-friendly systems that prioritize safety, convenience,and independence. The Smart Door Project was conceived in this context, integrating ESP32-based IoT technologies with features like RFID authentication, temperature screening, real-time image transmission,and emergency calling—delivering a reliable, accessible,and health-conscious smart door system.

1.2 Problem Definition

The Smart Door Project aims to resolve several key issues found in traditional access systems, especially for differently-abled and bedridden individuals. These users often face limited accessibility, making it difficult to physically verify visitors or unlock doors, which leads to dependency on caregivers. Traditional locking mechanisms do not support real-time monitoring or remote access, raising significant security concerns. Additionally, commercial smart door solutions are typically expensive and rely heavily on cloud services, which may suffer from reliability or privacy issues. Another critical gap is the lack of automated emergency handling in conventional systems, leaving users vulnerable in urgent situations.

1.3 Scope and Motivation

The scope of the smart door project includes real-time image capture using ESP32-CAM, access control via RFID, temperature-based visitor screening, Telegram integration for user commands,and emergency call functionality using Twilio API. The system can be customized for various environments, including homes, healthcare centers,and eldercare facilities.

Motivation for this project arises from the increasing demand for smart accessibility solutions, especially in the healthcare and caregiving sector. With the growing need for contactless and remote-controlled systems, this smart door provides an effective solution that is user-friendly and technologically robust. It highlights how embedded systems and IoT can be used to create safer, more inclusive environments.

1.4 Objectives

- **Remote Visitor Monitoring**: Allows bedridden individuals to see visitors in real-time using ESP32-CAM and receive images via Telegram for verification.
- **Cost Effective**
- **Secure Access Control**: Implements RFID authentication for trusted caregivers and uses a solenoid lock to ensure secure entry.
- **Health Safety & Emergency Alerts**: Integrates the MLX90614 temperature sensor for visitor screening and triggers automatic emergency calls in case of security breaches.

- **Reliable Power Management**: Operates on a 12V Li-ion battery, ensuring uninterrupted functionality even during power failures.

1.5 Challenges

- **Power Management**: Difficulty in handling 12V, 5V,and 3.3V levels without instability.
- **ESP32-CAM Setup**: Faced issues with Telegram integration due to Wi-Fi instability.
- **RFID Detection**: Inconsistent tag reading, requiring placement adjustments.
- **Twilio Integration**: Unreliable emergency call triggers needing debugging.
- **Circuit Assembly**: Ensuring compact, interference-free PCB connections.
- **Tamper Detection**: Vibration sensor triggered false alarms; sensitivity tuned.

1.6 Assumptions

- The system operates with stable Wi-Fi and power supply.
- Users are familiar with RFID tag usage and system interaction.
- Environmental conditions allow accurate sensor performance.
- Caregivers or emergency contacts can be reached via internet-based platforms (Telegram, Twilio).
- All components used are compatible with ESP32 microcontrollers.
- A person with physical differences who is mostly bed-restricted but has functional hand movement.

1.7 Societal / Industrial Relevance

This project holds significant relevance for both societal and industrial applications. Its primary goal is to address practical challenges through a smart, accessible,and cost-effective solution.

Societal Relevance: The project is designed with a focus on accessibility and safety, making it especially beneficial for differently-abled individuals, elderly citizens,and bedridden patients. It provides enhanced security and convenience by allowing remote access control, real-time monitoring,and emergency alerts, thereby improving the quality of life and independence for users. The integration of smart technology ensures a more inclusive and user-friendly living environment.

Industrial Relevance: Industrially, the project showcases the practical implementation of IoT-based smart security systems. It can be adapted for use in offices, healthcare facilities, assisted living centers,and secure areas, where automated access control and real-time monitoring are essential. The modular and scalable nature of the design allows easy customization for various professional settings, offering a reliable and efficient solution for modern access control systems.

1.8 Organization of the Report

Chapter 2 provides a detailed review of the major literature papers that were taken as references for this project. It highlights existing works, methodologies,and technologies relevant to our project domain.

Chapter 3 explains the methodology followed in the project. It includes the block diagram, circuit diagram, flowchart,and the experimental setup that guided the development process.

Chapter 4 describes the components used in the project, categorized into hardware components and software tools. Each component's role and functionality within the system are clearly outlined.

Chapter 5 presents the results and outputs obtained from the experimental setup. It discusses the performance, accuracy,and effectiveness of the implemented system.

Chapter 6 concludes the report by summarizing the project outcomes and highlighting the potential future scope for further development and enhancements.

CHAPTER 2

Literature Survey

With the rapid growth of Internet of Things (IoT) technologies, smart home security systems have become increasingly popular for ensuring safety and convenience. Among them, smart door systems based on microcontrollers such as the ESP32 are gaining attention for their real-time monitoring, remote access and integration with messaging platforms. This literature survey outlines recent developments in smart door systems, with a focus on image-based monitoring, RFID authentication and cloud communication using Telegram.

2.1 Smart Door Monitoring and Control

Manjunath and Kumar designed a home security system using the ESP32-CAM and Telegram application. The system captures images when motion is detected and sends them to the user via Telegram. The study highlights how Telegram bot integration allows for real-time alerts and remote interaction with the system. This approach reduces dependency on traditional hardware components and enhances user convenience through smartphone-based control [1].

Sudaryanto and Handayani implemented a Telegram-controlled ESP32-based camera system, further extending its capability with command-based interactions. Users can control the camera via specific commands such as capture, flash on/off, or even unlock functionalities. Their system demonstrates the practical integration of Telegram bots with the ESP32-CAM for interactive surveillance and automation [2].

Patel and Mehta proposed a similar door surveillance system using ESP32-CAM, emphasizing the low-cost setup and integration with Telegram bot services. Their model allows image capture and real-time visitor notifications, making it an accessible solution for smart home security [6].

2.2 Smart Locking with RFID and IoT

Ziad and Noor developed a smart door lock system using the ESP32 microcontroller integrated with RFID and fingerprint sensors, connected via the Internet of Things. The system authenticates users through RFID and biometric verification, providing access control and tracking capabilities. This method adds a layer of physical security and is useful for limiting door access to authorized individuals. The project effectively leverages IoT-based monitoring and provides future scalability for smart homes [3].

Sharma and Sinha extended this concept by incorporating facial recognition alongside RFID authentication to build a highly secure smart door access control system. Their implementation showcased improved authentication reliability and provided multi-modal security for sensitive environments like laboratories or server rooms [5].

2.3 Emergency Communication Using Twilio API

In a different but relevant domain, Raj and Priya developed a real-time customer interaction system using Twilio API and Assembly AI, capable of handling queries through calls and Natural Language Processing (NLP). Though originally built for customer service, this architecture supports integration into smart home security projects for emergency voice call alerts. For instance, the Twilio API can be adapted in a smart door system to initiate automated emergency calls in case of tampering or unauthorized access [4].

Joshi and Gupta proposed an IoT-based smart home automation system that also included emergency alert mechanisms. Their system emphasized timely notifications during security breaches or fire hazards and could be adapted with VoIP or call APIs to improve real-time emergency response [7].

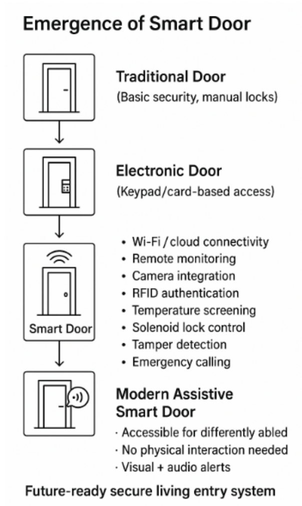

Figure 2.1: Emergence of Smart door.

2.4 Summary and Gaps Identified

Summary

Various smart door security systems have been explored in the literature, each with unique technologies and features. RFID-based systems offer simple and low-power solutions but lack advanced features like camera integration. IoT-enabled systems using ESP32 provide remote access and real-time monitoring but pose potential security risks due to cloud dependency. Face recognition systems using ESP32-CAM ensure contactless entry and are cost-effective, though their performance drops in low-light conditions. Temperature screening setups using MLX90614 enable accurate, non-contact health checks but are often isolated features with no integration into access control systems.

Gaps Identified

- Lack of integration between multiple technologies such as RFID, camera,and temperature sensor in a unified system.
- Inadequate consideration of accessibility features for differently-abled or bedridden users.
- Absence of built-in emergency response systems like automated calling or alert notifications.
- Commercial smart locks are expensive and dependent on cloud services, which may be unreliable.

CHAPTER 3

Methodology

In this chapter, we discuss the various stages involved in the development of the Smart Door System for Bed-Ridden Individuals. This includes the block diagrams, circuit implementation, flowcharts,and experimental setup that form the base of our project.

3.1 Problem Statement

Differently abled and bedridden individuals often face significant challenges in managing basic household activities, such as opening or monitoring the main door. Conventional door systems require physical interaction, which may not be feasible for individuals with limited mobility. Furthermore, existing smart door solutions lack critical features such as real-time image capture, secure authentication, emergency alert systems,and caregiver integration — all of which are essential for ensuring safety, independence,and convenience for these users.

There is a pressing need for an intelligent, accessible,and secure smart door system that can be controlled remotely, monitors visitor activity, ensures only authorized access,and alerts caregivers in case of emergencies. The system should provide a user-friendly interface for patients, while integrating multiple technologies like IoT, RFID, camera modules,and wireless communication.

This project aims to design and implement a comprehensive smart door solution that addresses these issues through seamless hardware and software integration, promoting safety, autonomy,and improved quality of life for differently abled individuals.

3.2 Block Diagram

ESP32 Cam Block Diagram

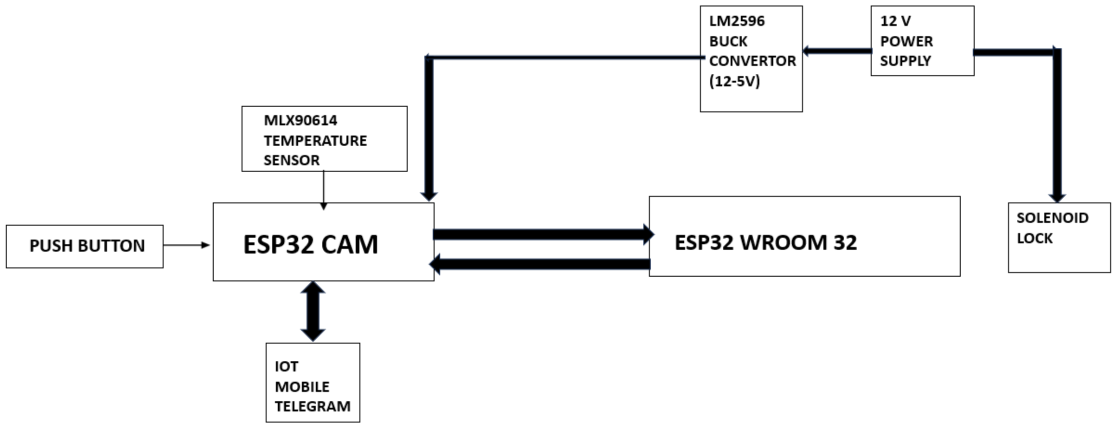

Figure 3.1: ESP32 Camera Module Block Diagram.

The ESP32-CAM module serves as a core component in the smart door security system, responsible for visitor identification, temperature screening,and long-distance communication. It is a Wi-Fi-enabled microcontroller with an integrated camera, enabling it to capture images of visitors and transmit them over the internet to a connected device.

Upon activation via a push button installed at the entrance, the ESP32-CAM captures a real-time image of the visitor. Simultaneously, it receives input from the MLX90614 non-contact temperature sensor, which records the visitor's body temperature. Both the captured image and the temperature data are transmitted to a Telegram bot configured on a mobile device using IoT communication protocols. This setup ensures that caretakers or residents are instantly notified and can make informed decisions regarding access control.

The ESP32-CAM communicates with the ESP32-WROOM-32 module using UART serial communication. This interface allows for the transmission of essential commands such as **/flash /unflash /temp /unlock and /photo**, which are triggered based on the responses received through the Telegram bot. In this project, the ESP32-CAM functions as both a data acquisition unit and a communication interface.

Power is supplied to the ESP32-CAM through a 5V regulated line, derived from a 12V power source using an LM2596 buck converter. This voltage regulation ensures safe and stable operation of the module within its specified limits.

ESP32 Wroom 32 Block Diagram

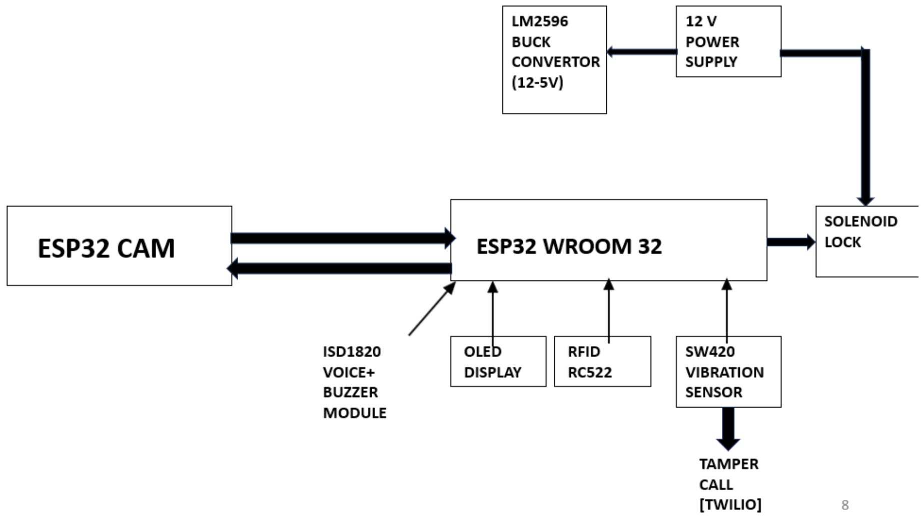

Figure 3.2: ESP32 Wroom 32 Module Block Diagram.

The ESP32-WROOM-32 module functions as the central control unit in the smart door security system. It is a highly integrated microcontroller with built-in Wi-Fi and Bluetooth capabilities, responsible for managing peripheral components, executing control logic,and enabling secure communication with the ESP32-CAM and external devices.

In this system, the ESP32-WROOM-32 communicates bi-directionally with the ESP32-CAM through UART serial communication. It receives image and temperature data captured by the ESP32-CAM and relays appropriate control commands based on the user's input via the Telegram bot, such as /unlock or /photo.

The ESP32-WROOM-32 interfaces with multiple peripheral modules:

- **RFID Module (RC522)**: Used for secure access control by authenticating pre-registered RFID cards. Upon successful authentication, the module signals the ESP32-WROOM-32 to unlock the door.
- **OLED Display**: Provides real-time status updates, such as lock status, authentication results,and visitor information, ensuring local monitoring of the system.
- **ISD1820 Voice + Buzzer Module**: Plays pre-recorded voice messages or alerts when triggered. This enhances visitor interaction by delivering audio feedback at the door.

- **SW-420 Vibration Sensor**: Detects tampering or physical impact on the door. If tampering is detected, the ESP32-WROOM-32 initiates an emergency call to a designated caretaker using the Twilio API, ensuring rapid response to security breaches.

  The ESP32-WROOM-32 also controls the solenoid lock, which is activated or deactivated based on verified access commands as well as RFID Based Autentication. The solenoid lock is powered directly from a 12V supply,and its switching is managed via the ESP32's output.

  Power is supplied to the ESP32-WROOM-32 through a 5V regulated output from an LM2596 buck converter, which steps down the input from a 12V power supply. This ensures stable and safe operation of the microcontroller and connected modules.

Overall Block Diagram

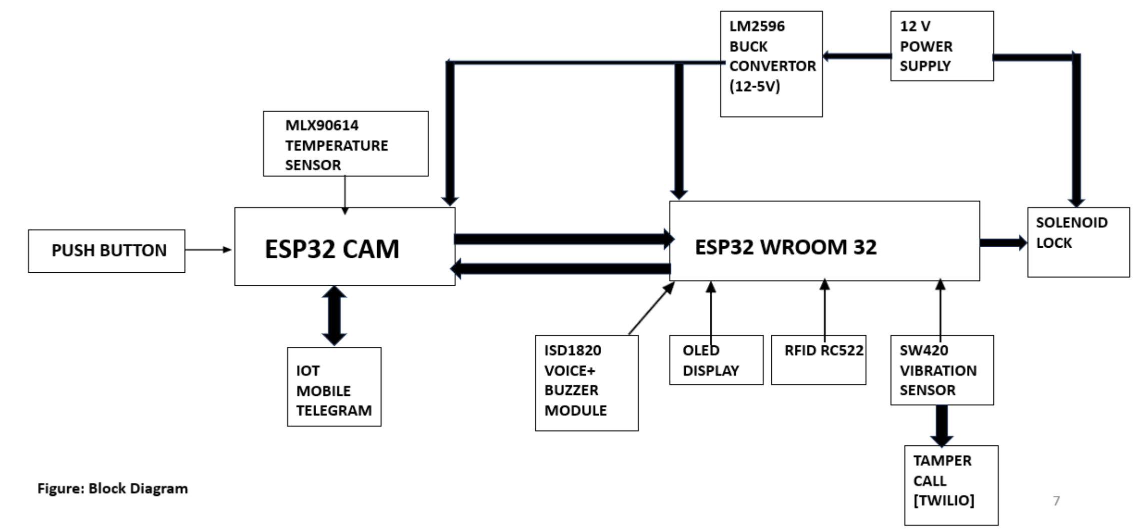

Figure 3.3: Overall Block Diagram.

3.3 Circuit diagram

The circuit diagram of the Smart Door System for Bedridden Patients integrates multiple modules and sensors to enable a secure, contactless,and accessible door control solution. The design combines health monitoring, authentication, real-time alerts,and automation using two microcontrollers: the ESP32-CAM and the ESP32-WROOM-32. The system is powered by a 12V Li-ion battery, which is stepped down using a buck converter to meet the voltage requirements of individual modules.

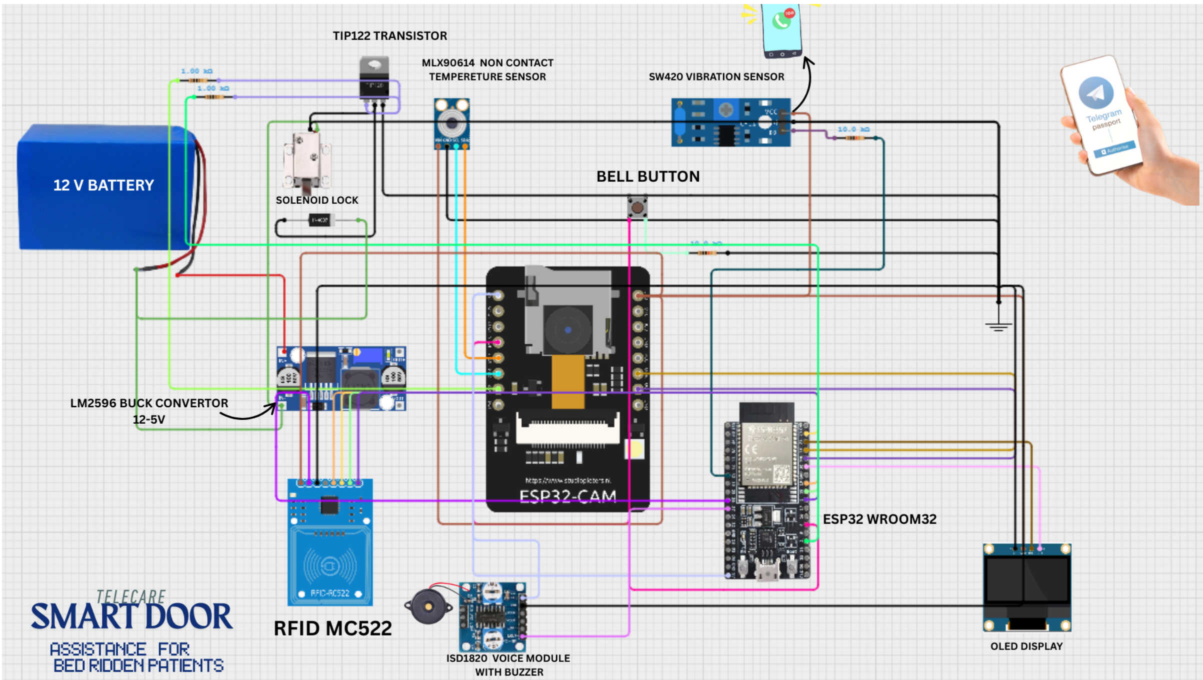

Figure 3.4: Circuit Diagram.

3.3.1 Connection Details

Table 3.1: Smart Door Circuit Connection Details

Component	**Connected To**	**ESP32 CAM & WROOM Module Pin**	**Voltage Supply**
Solenoid Lock	Collector of TIP122	–	12V
TIP122 Transistor	Base from ESP32 via 1k Ωresistor, Emitter to GND & Collector to Solenoid lock	GPIO2 → Base	–
Flyback Diode (1N4007)	Across solenoid terminals	–	–
ESP32-CAM	UART Communication to ESP32-WROOM-32	TX to RX, RX to TX	5V
ESP32-WROOM-32	Central controller	Multiple I/O pins	5V
RFID Module (RC522)	SPI Communication with ESP32-WROOM-32	SDA → GPIO5, SCK → GPIO18, MOSI → GPIO23, MISO → GPIO19, RST → GPIO26	3.3V
MLX90614 Temperature Sensor	I2C Communication with ESP32 Cam	SDA → GPIO15, SCL → GPIO14	3.3V
SW420 Vibration Sensor	Digital Output to ESP32-WROOM 32	D0 → GPIO32 via 10K Ωresistor	3.3V
Bell Push Button	One end to GND, other to ESP32 cam and ESP32-WROOM-32 input	GPIO4 of ESP32 CAM & GPIO 13 of ESP32-WROOM 32	–
ISD1820 Voice Module	Trigger via Bell Push Button & connected to ESP32-WROOM 32	P-E → GPIO32	5V
OLED Display (I2C)	ESP32-WROOM 32 GPIO	SDA → GPIO21, SCL → GPIO22	3.3V
LM2596 Buck Converter	Input: 12V Battery, Output: 5V to circuit	–	12V In → 5V Out
12V Battery	Main Power Source	–	12V
Common Ground	All modules share ground	GND	–

3.4 System Workflow-Flowchart

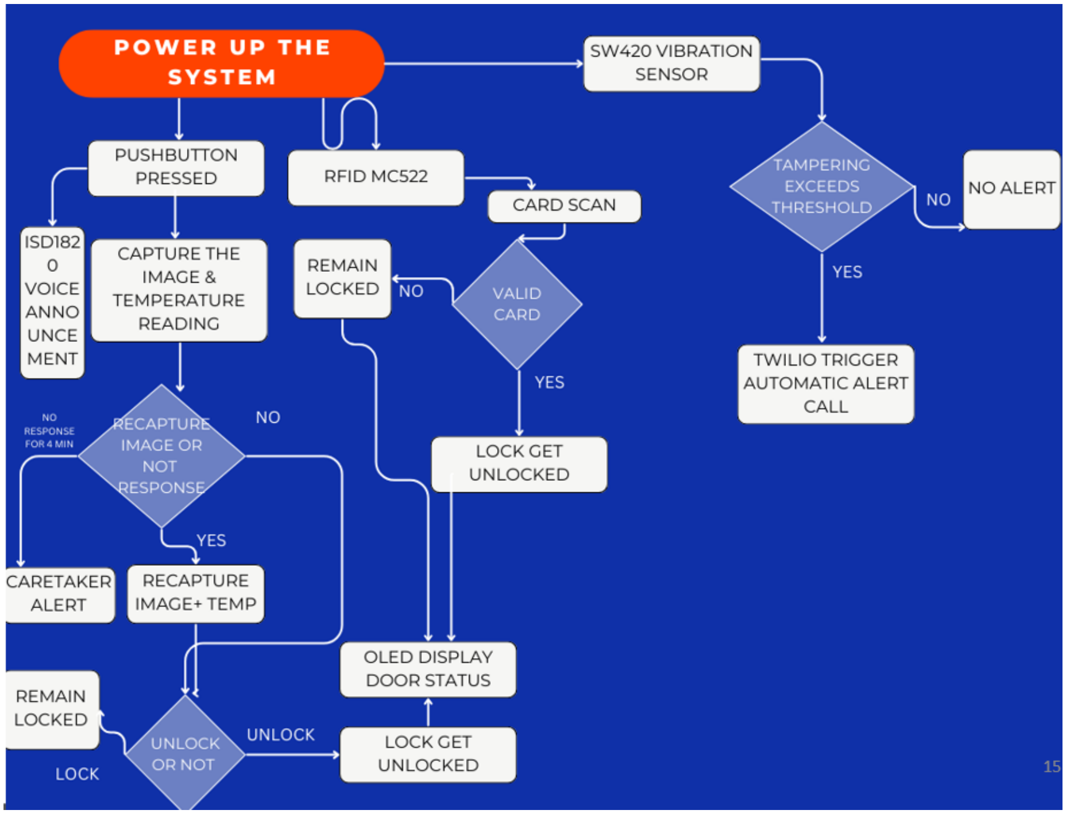

Figure 3.5: Flow chart.

- **System Initialization:** Upon powering up the system, all modules are activated including the ESP32-CAM, RFID reader (RC522), temperature sensor (MLX90614), vibration sensor (SW420),and the ISD1820 voice module.
- **Visitor Detection:** When the push button is pressed by a visitor, the ESP32-CAM captures the image and simultaneously the temperature sensor records the visitor's temperature. A voice announcement is played through the ISD1820 module, prompting the visitor for further action.
- **No Response Scenario:** If the system does not receive any input or response from the visitor within 4 minutes, a caretaker alert is triggered. The system remains in the locked state until a valid interaction occurs.
- **RFID Authentication:** If the visitor scans a card using the RFID module, the system checks the validity of the card. If the card is not valid, the door remains locked. A valid

card prompts the system to unlock the door,and the OLED display shows the updated door lock status.

- **Tamper Detection:** Independently, the SW420 vibration sensor monitors for any abnormal vibrations. If the tampering activity crosses a predefined threshold, an automatic emergency alert is triggered using the Twilio API, which initiates a call to the designated emergency contact.
- **Final Output:** If all validation conditions are met—either via RFID authentication or manual unlocking after verification—the solenoid lock is activated to open the door,and the updated status is shown on the OLED display. Otherwise, the system stays in a locked and monitored state.

3.5 Overall Working

When a visitor presses the door button, the ESP32-CAM captures their image and sends it to a Telegram bot for real-time remote monitoring. The user can interact using Telegram commands like /photo (retake photo), /flash or /unflash (control camera flash),and /unlock (control the solenoid lock). Secure access is provided through RFID authentication for trusted visitors or caregivers. The MLX90614 sensor screens the visitor's body temperature to ensure health safety. The system features an OLED display that shows the real-time lock status (Locked/Unlocked) for quick local identification. If any tampering or forceful attempt is detected, the system immediately triggers an emergency call using Twilio to notify family or security personnel. Powered by a 12V Li-ion battery, the system remains operational during power failures, offering a reliable, health-aware,and smart access control solution.

3.6 Software Development and Implementation

3.6.1 Software Design

The software design phase focuses on outlining the requirements and functional specifications of the smart door system. This includes determining the programming platform (Arduino IDE with C/C++ language), selecting appropriate libraries,and defining the software architecture. In this project, the software design involves modular development for:

- Visitor identification via ESP32-CAM and image capture.

- Temperature measurement using the MLX90614 sensor.
- RFID authentication using the RC522 module.
- Voice playback with the ISD1820 voice module.
- Real-time Telegram bot communication for door control and notifications.
- Solenoid lock activation using unlock command / RFID via TIP122 transistor control.
- Tamper detection using a vibration sensor (SW420).
- OLED-based door lock status indication.

3.7 Experimental Setup

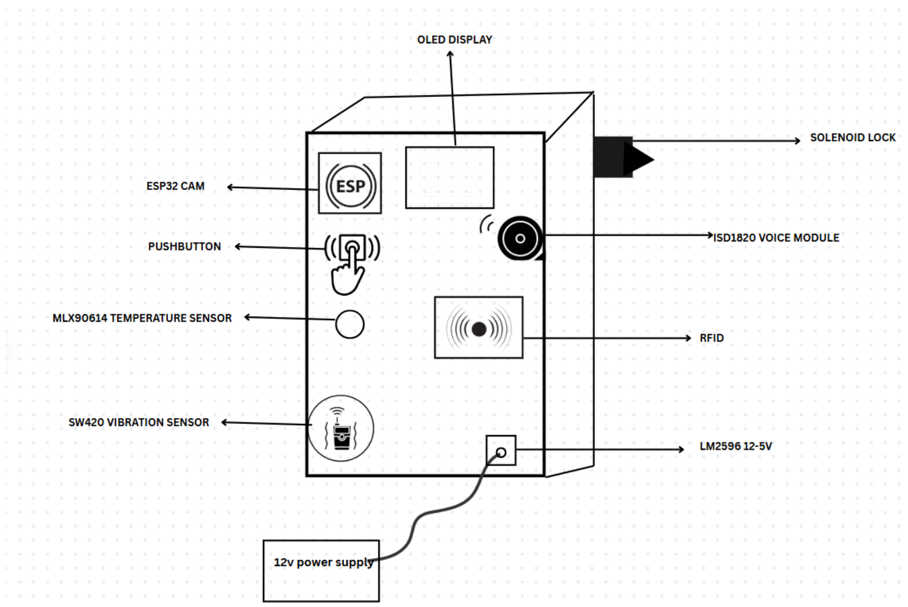

Figure 3.6: Experimental Setup.

The Smart Door System is mounted on a stable tabletop for organized testing and accessibility. The core controller, ESP32-WROOM-32, manages all operations, interfacing with input/output modules. The ESP32-CAM, positioned to face the entrance, captures visitor images in real-time. An adjacent MLX90614 sensor performs non-contact temperature checks, both triggered via a pushbutton, suitable for bedridden users.

A user-friendly RFID RC522 module allows authenticated entry for caregivers, while a solenoid lock, driven by a TIP122 transistor, controls the door mechanism. An OLED display shows lock status updates (“Locked”/“Unlocked”),and the ISD1820 voice module delivers audio prompts at the door. For tamper detection, a SW420 vibration sensor monitors shock levels and triggers an emergency Twilio API call if interference is detected.

All modules are powered by a 12V Li-ion battery, with buck converters supplying 5V and 3.3V to specific components. Wiring is safely organized to ensure system reliability.

Once powered on, the ESP32 continuously monitors for events. When triggered, it captures an image, measures temperature, plays voice instructions,and processes RFID scans for access. In case of no response within 4 minutes, a Telegram alert is sent. If tampering is detected, Twilio immediately places a call to a caretaker or security contact.

This compact and functional setup enables secure, accessible smart door operation tailored for differently abled individuals.

3.7.1 Testing Environment

- The complete system was first assembled on a breadboard to test individual module functionality.Then shifted to PCB
- A multimeter was used to verify voltage levels at different circuit points.
- USB and serial connections via CP2102 were used to upload and debug the code for ESP32 modules.
- Twilio credentials were integrated into the software to test emergency calling features.
- Telegram bot was tested for real-time image reception and remote unlocking commands.

3.7.2 Procedure

1. Power was supplied to the entire system using the 12V Li-ion battery.
2. When the pushbutton was pressed, the ESP32-CAM captured an image and the MLX90614 read the visitor's temperature.
3. ISD1820 played a voice prompt for visitor instructions.
4. If no response was received within 4 minutes, the system notified the caretaker and remained locked.
5. RFID cards were scanned to test authentication logic.
6. The OLED display updated lock status in real-time after card verification or caretaker input.

7. The vibration sensor was tested by simulating tampering. If vibration exceeded the threshold, the Twilio API triggered an emergency call.

3.7.3 Observations

- The system successfully captured and transmitted images to Telegram within 5 seconds.
- Temperature values were reliably detected within ±0.2°C accuracy.
- The RFID module correctly differentiated between valid and invalid cards.
- Tampering alerts via Twilio were triggered within 2–3 seconds after threshold breach.
- The system remained stable for long durations with the battery and power conversion circuits.

3.8 Individual Contribution

As a key contributor to the hardware and software integration of the smart door system, I was responsible for designing and implementing the major embedded features of the project. I independently handled the setup and synchronization of the ESP32-WROOM-32 and ESP32-CAM modules. I established a stable communication interface between both boards and successfully integrated the Telegram Bot to enable real-time remote access and control of the door.

I configured the RFID module to authenticate trusted visitors and programmed the solenoid lock control logic. I also incorporated the MLX90614 infrared temperature sensor, allowing health screening at the entry point, ensuring visitor safety. Moreover, I integrated Twilio API support to trigger emergency voice calls, enhancing the system's responsiveness during tamper or emergency conditions. I ensured that all modules, from sensors to actuators, operated in sync through robust programming and testing.

CHAPTER 4

Hardware and Software Details

Working Principle

The Smart Door System operates on the principle of **sensor-based automation and remote control using IoT**. When a user interacts with the system (e.g., by pressing a button), sensors collect data such as temperature or presence, which is processed by a microcontroller. Based on this input, actions such as unlocking the door, capturing images, or sending alerts are automatically performed. The system ensures security and accessibility through real-time monitoring and remote communication via internet-connected platforms.

4.1 System Level Design

4.1.1 Components Used

1. ESP32-WROOM-32
2. ESP32-CAM
3. MLX90614 Infrared Temperature Sensor
4. Push Button
5. TIP122 Transistor
6. Solenoid Lock
7. ISD1820 Voice Module
8. OLED Display
9. RFID Module (RC522)

10. SW 420 Vibration Sensor
11. 12V Lithium-ion Battery
12. LM2596 Buck Converter
13. PCB Board
14. Resistor-10k Ω & 1k Ω
15. Arduino IDE
16. Telegram Bot
17. Twilio API

4.1.2 Function of Each Component

- **ESP32-WROOM-32**

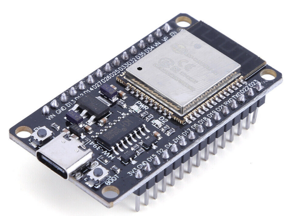

Figure 4.1: ESP32 WROOM 32.

The ESP32-WROOM-32 is a versatile Wi-Fi + Bluetooth module built around the ESP32 chip, offering dual-core processing and ultra-low power consumption. It comes in a compact form factor with a 38-pin layout, although not all pins are broken out on some development boards. This module includes interfaces for SPI, I2C, UART, CAN, ADC (12-bit), DAC (2 channels), touch sensors (up to 10),and PWM outputs. It provides up to 25 usable GPIOs, making it highly adaptable for diverse applications such as IoT devices, smart appliances,and connected industrial systems. Its solid wireless performance and deep sleep modes further support battery-powered or low-power designs.

- **ESP32-CAMERA**

Figure 4.2: ESP 32 Camera Module.

The ESP32-CAM is a compact, low-cost module that integrates the ESP32-S chip with an OV2640 camera, offering Wi-Fi and Bluetooth connectivity along with camera functionality. It features a 24-pin header with 10–12 usable GPIOs, depending on camera usage and SD card interface configuration. Despite its small size, it supports UART, SPI, I2C, PWM, ADC,and microSD storage. Key components include the OV2640 2MP camera, a microSD slot,and an onboard antenna (or external antenna option). The ESP32-CAM is ideal for image streaming, surveillance, smart door systems,and edge AI projects like face recognition. With its low power needs and growing ecosystem, it's a standout board for camera-based IoT innovation.

- **MLX90614 Infrared Temperature Sensor**

Figure 4.3: MLX90614 Infrared Temperature Sensor

The MLX90614 is a non-contact infrared (IR) temperature sensor designed for precise and hygienic temperature measurements. It uses thermopile technology to detect IR radiation emitted by objects and converts it into a temperature reading. The sensor outputs both ambient and object temperatures in digital format over I2C or PWM interface. Because it doesn't require physical contact, the MLX90614 is ideal for applications like body temperature screening, industrial monitoring,and environmental sensing.

With high accuracy, fast response time,and low power consumption, it is widely used in health monitoring systems, especially for detecting fever or abnormal temperature in access control systems.

- **Push Button**

Figure 4.4: Push Button

A push button is a simple mechanical switch that initiates an action when pressed. In microcontroller-based projects, push buttons are commonly used to trigger specific functions such as capturing a photo, toggling a lock, or resetting a device. When pressed, the button completes an electrical circuit, allowing current to flow and be detected by the microcontroller.

- **TIP122 Transistor**

Figure 4.5: TIP122 Transistor

The TIP122 is a high-power NPN Darlington transistor known for its ability to switch high currents using low input signals. It acts as an electronic switch in circuits, commonly used to control high-power devices like motors and solenoid locks. With its high current gain and built-in base resistor, the TIP122 is easy to interface with microcontrollers such as the ESP32. It enables low-power control logic to manage devices requiring higher voltages or currents

- **Solenoid Lock**

Figure 4.6: Solenoid Lock

A solenoid lock is an electromechanical device that uses an electromagnetic solenoid to control a mechanical locking mechanism. When energized, it retracts the bolt, unlocking the door; when power is removed, it automatically locks again. These locks are commonly used in access control systems due to their reliability and security. When integrated with microcontrollers like the ESP32, solenoid locks provide automated door control in smart security systems.

- **ISD1820 Voice Module**

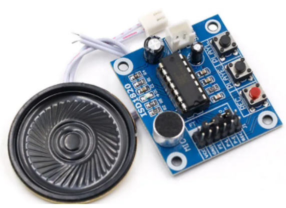

Figure 4.7: ISD1820 Voice Module

The ISD1820 is a standalone voice recording and playback module, capable of recording short audio messages (typically up to 10 seconds). With built-in microphone and speaker connections, it allows easy integration into projects requiring sound prompts, alerts, or voice responses. Used in smart doors, it can play pre-recorded greetings or warnings to visitors, enhancing interactivity and accessibility for the differently-abled.

- **OLED Display**

Figure 4.8: OLED Display

The 0.96 OLED (Organic Light-Emitting Diode) display is a miniature yet powerful dis play module known for its vibrant colors, high contrast ratio,and low power consumption. With a resolution of 128x64 pixels packed into a compact form factor, this display offers crisp and clear graphics, making it suitable for various applications where space is limited. This display typically interfaces with microcontrollers through standard protocols like I2C or SPI, allowing for easy integration into projects such as wearable devices, portable instru ments,and IoT gadgets. Its low power consumption makes it particularly well-suited for battery-operated applications, while its fast response time ensures smooth animations and scrolling.

- **RFID Module (RC522)**

Figure 4.9: RFID Module (RC522) & RFID Tags

The RC522 is a widely-used RFID (Radio Frequency Identification) module that operates at 13.56 MHz and communicates over SPI protocol with microcontrollers. It reads data from compatible RFID tags and cards, allowing for secure authentication in smart systems. The RFID reader emits radio waves that interact with the RFID tags within its range. These tags consist of a microchip and an antenna, which together store and transmit data when activated by the reader's signal.

- **SW-420 Vibration Sensor**

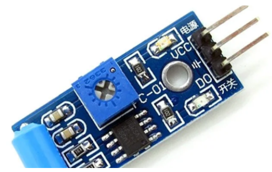

Figure 4.10: SW-420 Vibration Sensor

The SW-420 vibration sensor is a simple yet effective device designed to detect vibrations, shocks, or any physical disturbances in its surroundings. It contains a spring-loaded mechanical switch inside a sealed cylinder. When the sensor experiences any movement or shaking, the spring makes contact with an internal conductor, creating a temporary electrical signal. This change in signal is captured and interpreted by a connected microcontroller (such as the ESP32) to trigger an event.

- **12V Lithium-ion Battery**

Figure 4.11: 12V Lithium-ion Battery

12V Lithium-ion battery is a compact, high-efficiency rechargeable power source widely used in electronics, robotics,and embedded systems projects. Comprising typically of three 3.7V lithium-ion cells connected in series, this battery pack delivers a nominal voltage of 11.1V, which is commonly referred to as 12V in practical applications. Known for its high energy density, lightweight design,and long cycle life, the 12V lithium-ion battery is ideal for portable and battery-powered devices that require consistent voltage and current delivery. It supports continuous current output and is often protected by an inbuilt Battery Management System (BMS) that prevents overcharging, over-discharging,and short circuits, ensuring safety and reliability.Its rechargeable nature, availability in various capacities (mAh),and compatibility with USB charging modules make it a go-to power source in modern embedded and IoT projects.

- **LM2596 Buck Converter**

Figure 4.12: LM2596 Buck Converter

The LM2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. It is used for lowering the voltage level from 12V to 5V because the voltage requirement for a microcontroller is 5V

- **PCB Board**

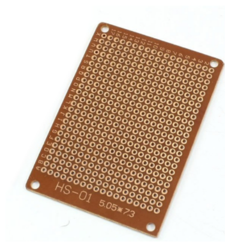

Figure 4.13: PCB Board

A Printed Circuit Board (PCB) is used to mount and connect electronic components using copper tracks etched on a non-conductive substrate. PCBs offer a reliable, professional,and space-efficient way to assemble and deploy embedded systems. For large projects like smart doors, custom PCBs can streamline wiring, reduce errors,and enhance durability compared to breadboard setups .

- **Resistors – 10k Ω & 1k Ω**

Resistors are passive components that limit current and divide voltage in a circuit. In this project, 10k Ω and 1k Ω resistors are commonly used in pull-up/pull-down configurations for buttons and sensors. They ensure signal integrity and protect components from excess current, playing a foundational role in circuit design.

Figure 4.14: PCB Board

4.1.3 Software Used

- **Arduino IDE**

Figure 4.15: Arduino IDE

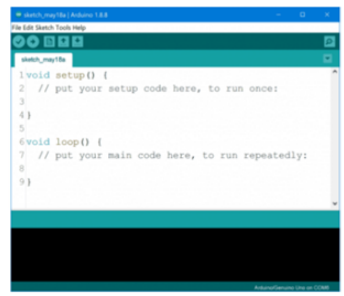

Figure 4.16: Serial Interface

The **Arduino Integrated Development Environment (IDE)** is a powerful and user-friendly open-source platform used to write, compile,and upload code to microcontrollers like the **ESP32-WROOM-32** and **ESP32-CAM**. It supports programming in a simplified version of **C/C++**, allowing both beginners and experienced developers to build and deploy firmware for embedded systems and IoT applications. The IDE features a built-in code editor, serial monitor,and extensive library support, enabling seamless interaction with a wide range of sensors, actuators,and communication modules.

In this project, the Arduino IDE is used to write firmware that handles sensor inputs (such as from the **MLX90614**, **RFID module**,and **SW-420 vibration sensor**), controls output devices like the **TIP122-driven solenoid lock**,and integrates with external services through APIs like **Telegram Bot** and **Twilio**. The programming involves setting up Wi-Fi connectivity, managing serial communication, handling interrupts,and sending or receiving HTTP requests.

- **Telegram API**

The **Telegram Bot API** is a powerful interface that allows developers to build bots that can interact with users, groups,and channels on Telegram. In this project, the

Figure 4.17: Telegram API

API is integrated with the **ESP32-CAM** to create a seamless and user-friendly remote monitoring system for the smart door.It's secure platform with cloud storage integration.

- **Twilio API**

Figure 4.18: Twilio API

The **Twilio Voice API** is used in the smart door project to provide an emergency communication feature. When tampering or unauthorized access is detected (e.g., through the **SW-420 vibration sensor**), the ESP32 triggers a **voice call** to a predefined contact, such as a family member, security guard, or caregiver.

The ESP32 uses the `HTTPClient.h` library to send a RESTful API request to Twilio's servers, which then initiate the voice call. Twilio allows the customization of call content using either:

- **TwiML (Twilio Markup Language)** – to define call behavior and speech content.
- **Programmable Voice** – to dynamically generate spoken alerts using text-to-speech.

This feature ensures that critical alerts are not missed, even when the user is not checking messages on Telegram. It provides an additional layer of security and reliability by using voice calls over traditional data messages. Twilio's robust cloud infrastructure guarantees high availability, making it ideal for real-time emergency notifications.

4.2 My Implementation Tasks

I took charge of designing the complete circuit connection, starting from breadboard testing to final soldering on PCB. I also created real-time test environments to verify the reliability of each component during operation, such as testing the image-capturing functionality of ESP32-CAM and validating RFID access through secure logic.

I wrote the Arduino codebase for multiple modules, ensured UART communication worked flawlessly between ESP32 boards,and debugged issues related to signal interference and power drops. Through iterative testing, I optimized timing delays, managed GPIO assignments,and enhanced response time for door unlock commands.

CHAPTER 5

Results and Discussions

5.1 Working Model

Figure 5.1& 5.2 represents the working model of the Smart Door System. The setup includes the ESP32-CAM module for image capturing, RFID module for caregiver authentication, solenoid lock for door control,and various integrated sensors for tamper detection, temperature measurement,and voice playback. The system is powered using a 12V lithium-ion battery and controlled via Telegram and Twilio APIs.

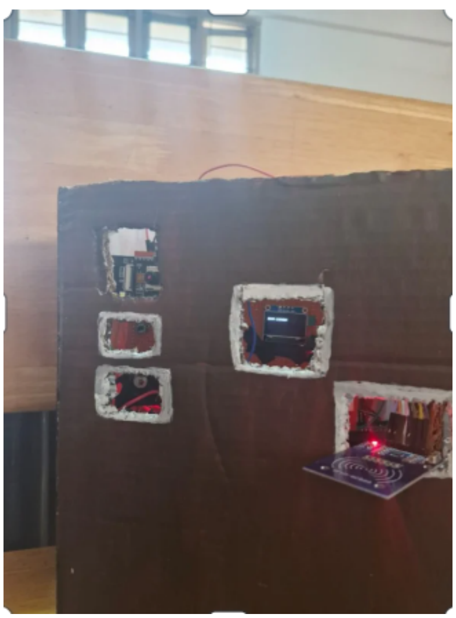

Figure 5.1: Prototype front view

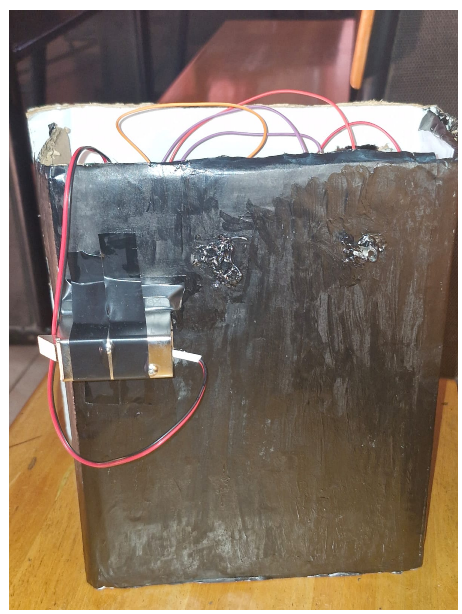

Figure 5.2: prototype back view

5.2 Telegram Bot Interface and Commands

Figure 5.3 & 5.4 depicts the notifications received via Telegram when a visitor presses the door button. The ESP32-CAM captures an image and sends it to the registered user, who can then respond with commands such as `/unlock`, `/flash`, `/unflash` ,`/temp` or `/photo`. This enables remote access and control over the smart door. Figure 5.5 depicts alert forwarded to Caregiver when Patient is not responding for more than 4 minutes

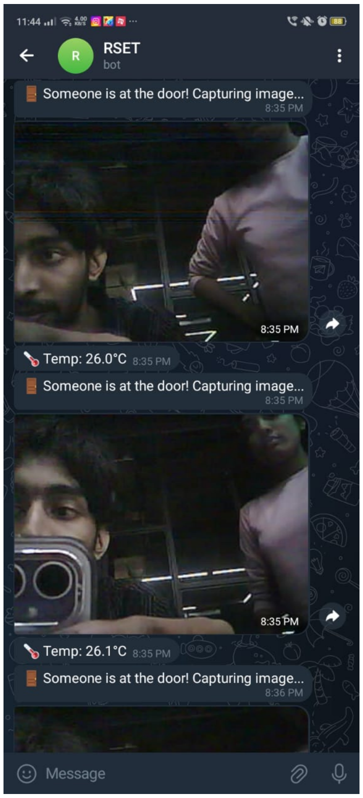

Figure 5.3: Door Notification

Figure 5.4: Command interface

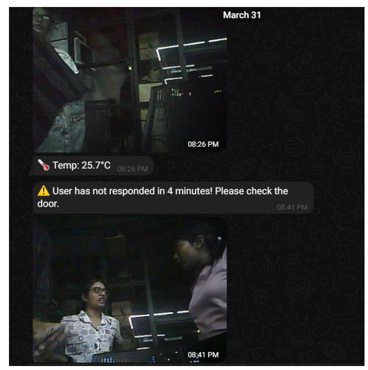

Figure 5.5: Caregiver Alert

5.3 Emergency Call via Twilio API

Figure 5.6 shows the emergency phone call alert received when the vibration sensor detects potential tampering. The ESP32 sends a REST API request to Twilio's server, which triggers an automated voice call to a predefined contact number. This adds an extra layer of security to the system.

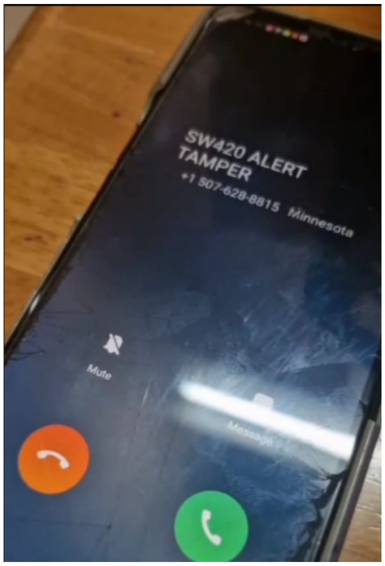

Figure 5.6: Twilio Emergency Call Alert

5.4 Solenoid Lock Position and Door status Indicator

Figure 5.7 illustrates the display generated when a caregiver or trusted person uses the RFID card to unlock the door or when unlock command pressed via telegram.

Figure 5.8 & 5.9 illustrates the solenoid locks unlock and locked state positions

Figure 5.7: Door Status

Figure 5.8: Solenoid lock's Initial Locked position

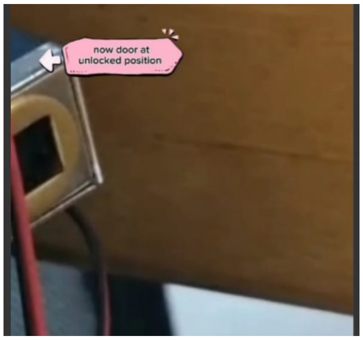

Figure 5.9: Solenoid lock's unlocked state after Verification

5.5 Advantages

1. **Accessibility:** Designed for differently-abled and bedridden individuals.
2. **Remote Control:** Unlock and monitor the door remotely via Telegram.
3. **Security:** RFID authentication, tamper detection,and image logging.
4. **Emergency Communication:** Auto-calling via Twilio API.
5. **Visitor Logging:** Captures and stores images of every visitor.
6. **Temperature Screening:** MLX90614 detects visitor body temperature.
7. **Voice Feedback:** ISD1820 provides audio messages at the door.
8. **Low Power Consumption:** Powered by a 12V battery with regulated output.
9. **Custom Commands:** User-defined bot commands enable personalized interaction.
10. **User-Friendly Interface:** No app installation required—only Telegram.

5.6 Disadvantages

1. **Internet Dependency:** Requires a stable internet connection for Telegram and Twilio APIs.
2. **Security Concerns:** Improper access management could lead to unauthorized entry.
3. **Battery Maintenance:** Requires periodic charging of the battery.
4. **Initial Setup Complexity:** Requires programming, wiring,and cloud API integration.
5. **Hardware Sensitivity:** Sensors may trigger false positives in noisy or unstable environments.

CHAPTER 6

Conclusion and Future Scope

6.1 Conclusion

The developed smart door system offers a secure, efficient,and accessible solution for remote door monitoring and control. By integrating the ESP32-CAM module, RFID authentication, solenoid lock, vibration-based tamper detection,and real-time notification systems via Telegram and Twilio Call API, the project addresses critical needs for the differently-abled and elderly. Users can visually verify visitors, grant or deny access,and receive immediate alerts in case of unusual activity. The inclusion of a voice module for basic responses and an OLED display for real-time lock status enhances user interaction. The system is both cost-effective and compact, making it suitable for real-world home automation deployments.

6.2 Future Scope

- **Face Recognition Integration:** Incorporating AI-based face recognition for automatic authentication and personalized responses.
- **Mobile App Development:** Designing a dedicated Android/iOS app for better user interface, notifications,and voice control.
- **Cloud Data Logging:** Implementing cloud storage to maintain logs of door activity for enhanced security tracking and audit.
- **Battery Backup & Solar Integration:** Enhancing power reliability through advanced battery management or renewable energy sources.
- **Voice Command Support:** Adding support for virtual assistants like Google Assistant or Alexa for hands-free operation.

- **Multilingual Audio Support:** Improving accessibility with multilingual voice prompts in local languages.
- **Emergency Protocol Automation:** Integrating fire, gas,and medical alert systems for broader smart home safety.
- **Multiple Entry Management:** Extending the system to manage multiple entry points using a centralized control unit.

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Appendix A: Presentation

TELECARE SMART DOOR ASSISTANCE FOR BEDRIDDEN PATIENTS

PROJECT GUIDE : MS.ANCY BRIGIT

TEAM MEMBERS:

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INTRODUCTION

BACKGROUND CONTEXT

Need for Accessible and Secure Home Entry:
- Bedridden individuals need secure, convenient, and emergency-responsive home entry solutions.

Challenges:
- Conventional doors require physical interaction, which is difficult for bedridden individuals.
- Caregivers may not always be available.

Limitations of Existing Solutions:
- Expensive and cloud-based, not tailored for differently-abled individuals.

Project Aim:
- Provide a locally controlled, cost-effective, and accessible smart door system.

INTRODUCTION

PROBLEM/GAP

•**Limited Accessibility**: Bedridden individuals struggle with physically verifying visitors and unlocking doors.
•**Security Concerns**: Traditional locks lack real-time visitor verification and remote access control.
•**High Cost of Alternatives**: Commercial smart locks are expensive and dependent on cloud services, which may be unreliable.
•**Lack of Emergency Handling**: Conventional systems do not provide an automated response during security threats.

Project Solution to Bridge the Gap:
•**ESP32-CAM for Visitor Monitoring**: Captures images and sends them to the patient's Telegram app.
•**Remote Unlocking**: Enables door control via a mobile application.
•**Tamper Detection & Emergency Calling**: Detects unauthorized access attempts and triggers an emergency call to caregivers.
•**RFID Authentication & Temperature Screening**: Ensures secure and health-conscious visitor access.
•Power Backup System: Operates on a 12V Li-ion battery, ensuring continuous functionality during power failures.

INTRODUCTION

SIGNIFICANCE

•Tailored for Differently-Abled Individuals: Enhances independence and security for bedridden users.

•Comprehensive Security System: Integrates multiple security layers, including visitor verification, RFID authentication, and emergency handling.

•Cost-Effective & Privacy-Focused: Eliminates reliance on cloud services, reducing costs and privacy concerns.

•Uninterrupted Operation: Battery-powered system ensures reliability even during power outages.

OBJECTIVES

- **Remote Visitor Monitoring**: Allows bedridden individuals to see visitors in real-time using ESP32-CAM and receive images via Telegram for verification.
- **Cost Effective**
- **Secure Access Control**: Implements RFID authentication for trusted caregivers and uses a solenoid lock to ensure secure entry.
- **Health Safety & Emergency Alerts**: Integrates the MLX90614 temperature sensor for visitor screening and triggers automatic emergency calls in case of security breaches.
- **Reliable Power Management**: Operates on a 12V Li-ion battery, ensuring uninterrupted functionality even during power failures.

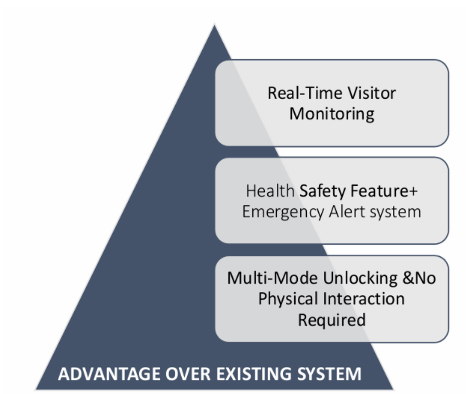

Figure: Advantage over existing

BLOCK DIAGRAM

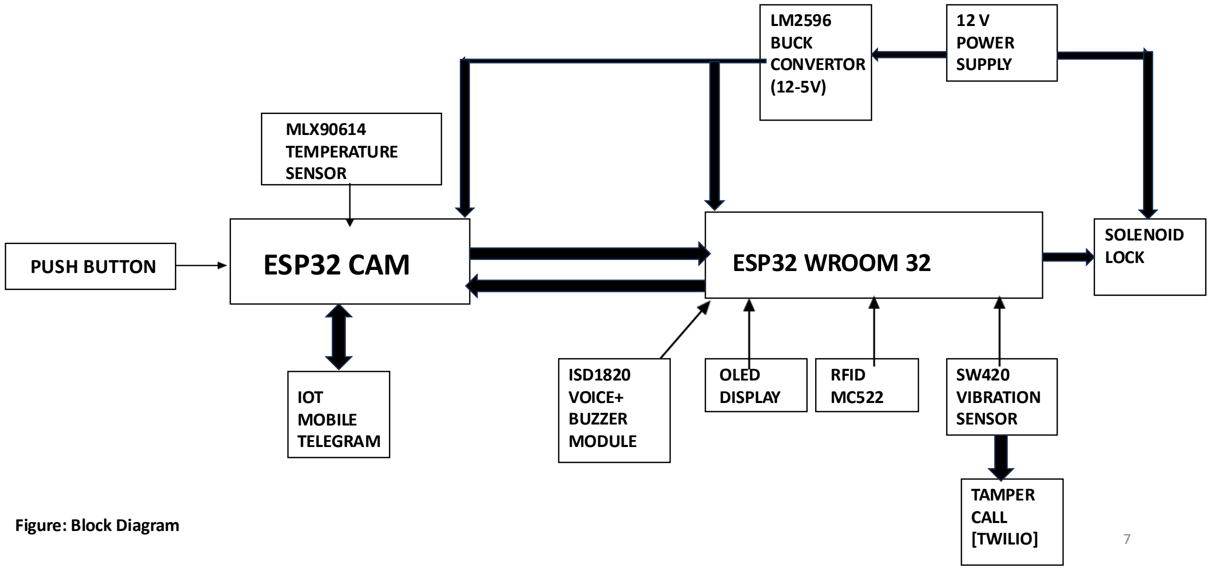

Figure: Block Diagram

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CIRCUIT DIAGRAM

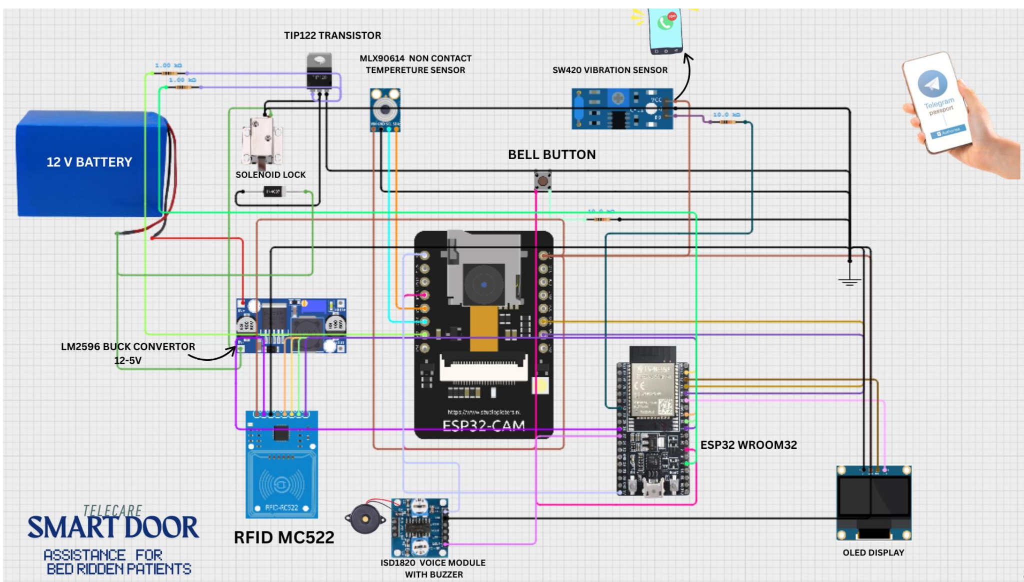

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Figure: Circuit Diagram

METHODOLOGY

1. ESP32-WROOM-32 (Main Controller)

•Acts as the central processing unit for the smart door system.

•Controls communication between all connected components, including ESP32-CAM, RFID, solenoid lock, and sensors.

•Sends and receives data through Wi-Fi, integrating with Telegram for remote access and Call for emergency alerts.

2. ESP32-CAM (Visitor Monitoring & Authentication)

•Captures images of visitors when the doorbell is pressed.

•Sends live images to the user's Telegram app for remote verification.

3.RFID Module (RC522) (Caregiver & Trusted Visitor Access)

•Allows registered caregivers or trusted visitors to unlock the door using RFID cards

•Communicates with ESP32-WROOM-32 to verify authentication and trigger the solenoid lock.

METHODOLOGY

4. Solenoid Lock & TIP122 Transistor (Door Lock Mechanism)
•The solenoid lock physically secures the door and unlocks only after proper authentication.
•TIP122 transistor is used to control the 12V solenoid lock using a signal from ESP32-WROOM-32.

5. MLX90614 Temperature Sensor (Health Screening)
•Measures the body temperature of visitors without physical contact.
•The measured temperature is then sent to the patient via Telegram as a precautionary alert before they decide to unlock the door.

6. OLED Display & Audio Announcement (Door Status & Accessibility)
•The OLED screen displays whether the door is locked or unlocked.
•An audio announcement informs users about door status, assisting those who cannot read the display,like please wait

7. SW420 Vibration Sensor (Tamper Detection & Security Alert)
•Detects forced entry attempts or unauthorized tampering with the door.
•Triggers an emergency call via Twilio API to the caregiver or security personnel.

METHODOLOGY

8.Twilio API (Emergency Call Feature)
•Automatically calls the registered caregiver or security staff in case of tampering or security threats.
•Ensures quick response in case of emergencies.

9. Power Management System (Reliable Operation)
•The system runs on a 12V Li-ion battery for reliable power supply.
•Step-down converters regulate voltage to 5V and 3.3V for different components.
•Ensures the system remains operational even during power failures.

10. Telegram Bot API (Remote Monitoring & Control)
•Sends visitor images to the user via Telegram when the doorbell is pressed.
•Allows the user to remotely unlock the door by sending a command.
•Notifies the user in case of temperature alerts or tampering incidents.

OVERALL WORKING

• A visitor presses the doorbell button, triggering the ESP32-CAM to capture an image.

• The image is sent in real-time to the user's Telegram bot, allowing them to verify the visitor.

•When the visitor presses the push button , the MLX90614 infrared temperature sensor automatically measures their body temperature without any physical contact [from palm].

•The measured temperature is then sent to the patient via Telegram as a precautionary alert before they decide to unlock the door.

• If the visitor is authorized, the user can remotely unlock the door using a Telegram command.

•Trusted caregivers and family members can use an RFID card for direct access.

•When an authorized RFID tag is scanned, the ESP32-WROOM-32 verifies it and automatically unlocks the solenoid lock.

OVERALL WORKING

- A vibration sensor detects unauthorized tampering with the door.
- If tampering is detected, an emergency alert is triggered, and the system sends a warning to the user's Telegram.
- Additionally, the system initiates an automatic emergency voice call using Twilio API to notify caregivers or security personnel.
- If the patient fails to respond within a set time, the system automatically sends an alert message to the caregiver or a trusted contact via Telegram.
- An OLED display shows whether the door is locked or unlocked along with verification announcement from ISD1820

FLOW CHART

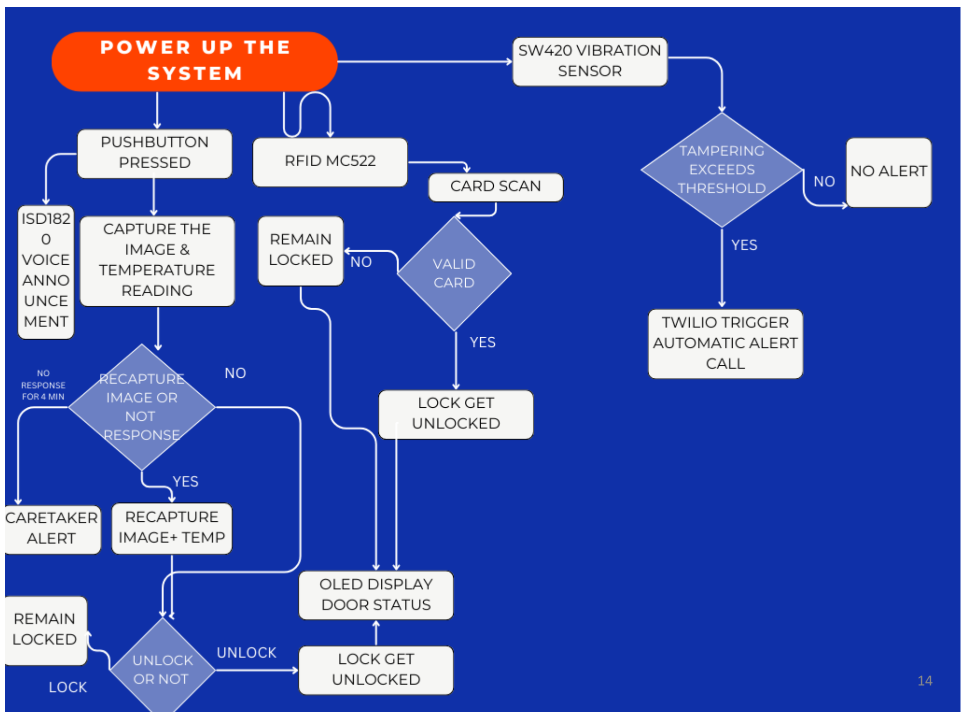


Figure: Flowchart

TOOLS AND EQUIPMENTS

MAIN COMPONENTS

•**ESP32-WROOM-32** – The central microcontroller that controls door operations, processes RFID authentication, and manages alerts.
•**ESP32-CAM** – Captures visitor images and sends them to Telegram for verification •Wi-Fi/Bluetooth module with OV2640 camera with resolution 2MP for image capture and face detection.

•**RFID Module (RC522)** – Allows authenticated users (caregivers/trusted visitors) to unlock the door.

•**Solenoid Lock (12V)** – Secures the door, controlled via the ESP32-WROOM-32 and TIP122 transistor.

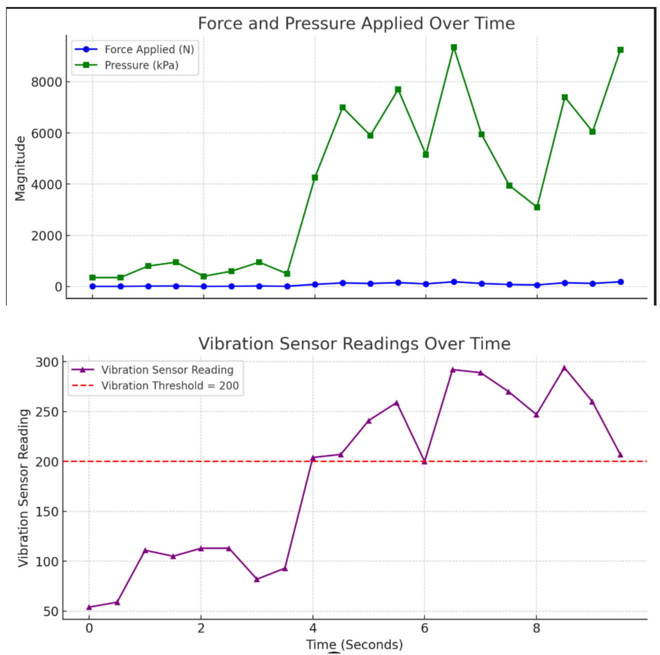
- **MLX90614 Temperature Sensor** – Measures the visitor's temperature when they press the push button
- **SW 420 Vibration Sensor** – Detects tampering attempts and triggers an emergency alert.
- **OLED Display & ISD 1820 Audio Announcement** – Displays the door lock status and announces it for those who cannot read.
- **Twilio API & Telegram Integration** – Sends alerts, visitor images, and emergency notifications to the patient and caregiver.
- **12V Li-ion Battery** – Powers the entire system with step-down converters for stable voltage supply.

TOOLS AND EQUIPMENTS

SUB COMPONENTS

- **Push Button :** Used as a doorbell to trigger the camera.
- **IN4007 Diode:** Protects the circuit from voltage spikes during lock operation.
- **TIP122 Transistor:** Controls the solenoid lock as a high-power switch.
- **Resistors and Capacitors:** Manage current, voltage, and noise filtering in the circuit.

INFERENCE GRAPH



OUTPUTS

- CLICK HERE FOR CODE
- CLICK HERE FOR BREADBOARD IMPLEMENTED VIDEO
- CLICK HERE FOR DEMO VIDEO

CHALLENGES FACED

•**Power Distribution Complexity** – Managing multiple voltage levels (12V, 5V, 3.3V) for different components without instability was challenging.
•**ESP32-CAM Setup Issues** – Initially faced difficulties in configuring the ESP32-CAM with Telegram due to unstable Wi-Fi connections.
•**RFID Module Interferenc**e – The RFID reader sometimes failed to detect tags properly, requiring careful placement and fine-tuning.
•**Twilio API Delays** – Faced issues with inconsistent emergency call triggers, which needed debugging and proper request handling.
•**Soldering & Circuit Assembly** – Ensuring compact and reliable PCB connections without signal interference was difficult.
•**Temperature Sensor Calibration** – The MLX90614 sensor needed proper positioning to accurately detect temperature without false readings.
•**Tamper Detection False Alarms** – The vibration sensor initially triggered alarms too easily, requiring sensitivity adjustments.
•**Time Constraint**s – Balancing the project workload with academic commitments made timely completion challenging.

FUTURE SCOPES & UPGRADES

- **AI-Powered Face Recognition** – Replace RFID with ESP32-CAM + TensorFlow Lite for local AI-based authentication.
- **OTP-Based Secure Unlocking** – Use Twilio for OTP-based door unlocking via SMS/WhatsApp.

- **Battery Backup with Smart Power Switching** – Implement TP4056 + Power Path Management IC for seamless switching between battery and main supply.
- **Voice Assistant Integration** – Control door via Google Assistant/Alexa
- **Intrusion Detection with AI & Motion Sensor**s – Use PIR + AI anomaly detection for identifying suspicious movements.
- **Biometric Fingerprint Scanner** – Integrate fingerprint sensor (R307/GT511C3) as an alternative to RFID for enhanced security.

WORK DIVISION

SREENESH K.S	**1. TELEGRAM BOT INTEGRATION & TWILIO API DEVELOPMENT** **2. ESP32-WROOM-32 & ESP32 CAM Programming along with Circuit design and Component Selection** **3. RFID Integration & Door controlling**
SREELAKSHMI R	**1. OLED Display & Audio Announcement Setup** **2. Prototype Integration** **3. PCB Soldering of Components**
RAHUL V MENON	**1. PCB Soldering of Components** **2. Prototype Integration** **3. Power Management & Voltage Regulation**
VARADHA K VIPIN	**1. MLX90614 Temperature Sensor Integration & Alert System** **2. Final Hardware Testing & Debugging** **3. Prototype integration**

TIMELINE

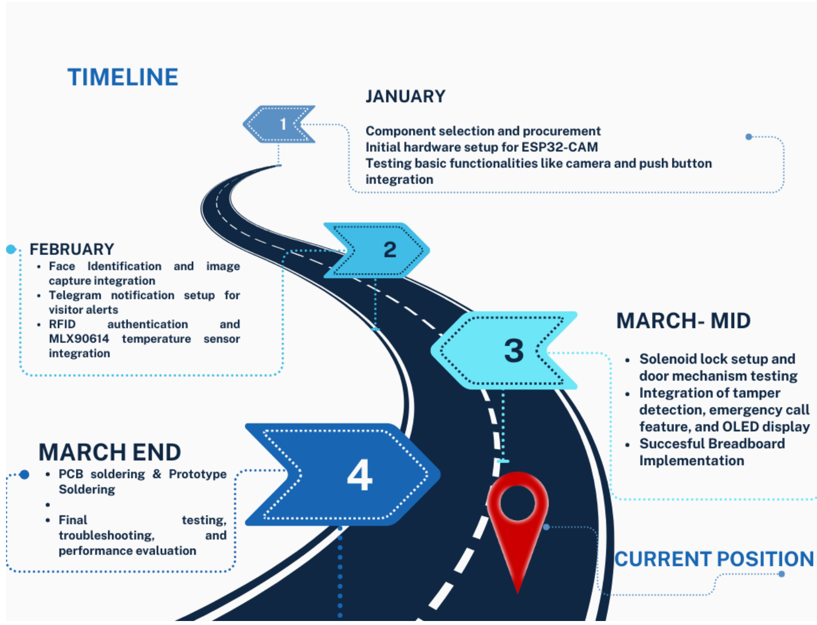


Figure: Timeline of Project

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THANK YOU

CODE

ESP32 WROOM 32 CODE

```
#include <Wire.h>
#include <Adafruit_SSD1306.h>
#include <WiFi.h>
#include <WiFiClientSecure.h>
#include <MFRC522.h>

#define RST_PIN 22
#define SS_PIN  21
#define BUZZER_PIN 2
#define VIBRATION_PIN 35
#define LOCK_PIN 4

const char* ssid = "Your_SSID";
const char* password = "Your_PASSWORD";

WiFiClientSecure client;

MFRC522 rfid(SS_PIN, RST_PIN);

void setup() {
  Serial.begin(115200);
  pinMode(LOCK_PIN, OUTPUT);
  pinMode(VIBRATION_PIN, INPUT);
  pinMode(BUZZER_PIN, OUTPUT);
  SPI.begin();
  rfid.PCD_Init();
  WiFi.begin(ssid, password);
}

void loop() {
  if (digitalRead(VIBRATION_PIN) == HIGH) {
    // send emergency call via Twilio
  }

  if (rfid.PICC_IsNewCardPresent() && rfid.PICC_ReadCardSerial()) {
    if (isAuthorizedUID(rfid.uid.uidByte)) {
      digitalWrite(LOCK_PIN, HIGH);
      delay(3000);
      digitalWrite(LOCK_PIN, LOW);
    }
    rfid.PICC_HaltA();
    rfid.PCD_StopCrypto1();
  }
}

bool isAuthorizedUID(byte *uid) {
  byte authorizedUID[4] = {0xDE, 0xAD, 0xBE, 0xEF};
  for (int i = 0; i < 4; i++) {
    if (uid[i] != authorizedUID[i]) return false;
  }
  return true;
}
```

ESP32 CAM CODE

```
#include <WiFi.h>
#include <WiFiClientSecure.h>
#include <UniversalTelegramBot.h>
#include <Adafruit_MLX90614.h>
```

```
#include "esp_camera.h"

#define BOTtoken "Your_Telegram_Bot_Token"
#define CHAT_ID  "Your_Chat_ID"

const char* ssid = "Your_SSID";
const char* password = "Your_PASSWORD"; //CANT SHARE ITS PRIVATE

WiFiClientSecure client;
UniversalTelegramBot bot(BOTtoken, client);
Adafruit_MLX90614 mlx = Adafruit_MLX90614();

void setup() {
  Serial.begin(115200);
  WiFi.begin(ssid, password);
  mlx.begin();
  bot.sendMessage(CHAT_ID, "ESP32-CAM Ready", "");
}

void loop() {
  int numNewMessages = bot.getUpdates(bot.last_message_received + 1);
  while (numNewMessages) {
    handleNewMessages(numNewMessages);
    numNewMessages = bot.getUpdates(bot.last_message_received + 1);
  }
}

void handleNewMessages(int numNewMessages) {
  for (int i = 0; i < numNewMessages; i++) {
    String text = bot.messages[i].text;
    if (text == "/photo") {
      captureAndSendPhoto();
    } else if (text == "/temp") {
      float temp = mlx.readObjectTempC();
      bot.sendMessage(CHAT_ID, "Visitor Temp: " + String(temp) + "°C", "");
    }
  }
}

void captureAndSendPhoto() {
  camera_fb_t *fb = esp_camera_fb_get();
  bot.sendPhotoByBinary(CHAT_ID, "image/jpeg", fb->len, fb->buf, false, "visitor.jpg");
  esp_camera_fb_return(fb);
}
```

Appendix B: Questions & Answers

Questions & Answers

1. **Why did you choose ESP32-CAM instead of Raspberry Pi or other boards with a camera?**

   ESP32-CAM is compact, cost-effective,and provides built-in WiFi and camera features, making it ideal for IoT-based surveillance applications. It consumes less power compared to Raspberry Pi and fits well into low-resource embedded systems like the smart door.

2. **What are the limitations of using ESP32-CAM,and how did you handle them?**

   ESP32-CAM has limited GPIOs, lacks a USB port,and heats up under continuous usage. We used CP2102 for programming, implemented sleep intervals,and avoided simultaneous heavy operations like camera streaming and data transmission.

3. **How did you ensure the system works reliably during a power failure?**

   A 12V Li-ion battery powers the entire system. Voltage regulators convert 12V to 5V and 3.3V for components. Capacitor filters were used to handle voltage fluctuations and ensure stability during battery operation.

4. **How did you handle UART communication between ESP32 boards?**

   We used hardware UART channels available on the ESP32. Proper level matching and shared GND were ensured. Data buffers were cleared after each communication cycle to prevent overflow and ensure smooth serial data exchange.

5. **How does the RFID system differentiate between trusted and unknown visitors?**

   Each RFID tag has a unique UID which is matched with predefined UIDs stored in the EEPROM. Access is granted only to recognized UIDs; otherwise, access is denied and a notification is triggered.

6. **How is the emergency calling system implemented without GSM?**

   We used Twilio API to make VoIP calls via WiFi. On detecting abnormal temperature or tampering, ESP32 sends an HTTP request to Twilio's server, which then makes an automated call to the caregiver or family member.

7. **What would happen if Telegram or Twilio services fail or go offline?**

The RFID-based local access remains functional. A buzzer alerts the nearby caregiver. A manual override button allows emergency door unlocking as a fail-safe mechanism.

8. **How secure is your system against RFID spoofing or replay attacks?**
   The system logs UID access with timestamps and restricts repeated use within a short interval. For added security, it can be extended to use encrypted RFID protocols or two-factor authentication.

9. **Can your system be adapted to a mobile app interface for easier control?**
   Yes. Since the system already uses WiFi and APIs, it can be extended to mobile apps using Blynk, MIT App Inventor, or custom apps via HTTP/MQTT protocols.

10. **How is real-time performance ensured for capturing and sending images?**
    We optimized the ESP32-CAM by lowering resolution to reduce transmission time, used non-blocking Telegram functions,and managed memory efficiently to prevent system crashes or watchdog resets.

Appendix C: Vision, Mission, Programme Outcomes and Course Outcomes

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill,and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To evolve into a centre of excellence in electronics and communication engineering, moulding professionals having inquisitive, innovative and creative minds with sound prac tical skills who can strive for the betterment of mankind

Department Mission

To impart state-of-the-art knowledge to students in electronics and communication engineering and to inculcate in them a high degree of social consciousness and a sense of human values, thereby enabling them to face challenges with courage and conviction

Programme Outcomes (PO)

Engineering Graduates will be able to:

- **PO 1. Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals,and an engineering specialization to the solution of complex engineering problems.

- **PO 2. Problem analysis**: Identify, formulate, review research literature,and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences,and engineering sciences.

- **PO 3. Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal,and environmental considerations.

- **PO 4. Conduct investigations of complex problems**: Use research-based knowledge including design of experiments, analysis and interpretation of data,and synthesis of the information to provide valid conclusions.

- **PO 5. Modern Tool Usage**: Create, select,and apply appropriate techniques, resources,and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

- **PO 6. The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal,and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

- **PO 7. Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts,and demonstrate the knowledge of,and need for sustainable development.

- **PO 8. Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

- **PO 9. Individual and Team work**: Function effectively as an individual,and as a member or leader in teams,and in multidisciplinary settings.

- **PO 10. Communication**: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations,and give and receive clear instructions.

- **PO 11. Project management and finance**: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

- **PO 12. Life-long learning**: Recognize the need for,and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

Engineering students will be able to:

- **PSO 1:** Demonstrate their skills in designing, implementing and testing analogue and digital electronic circuits, including microprocessor systems, for signal processing, communication, networking, VLSI and embedded systems applications;
- **PSO 2:** Apply their knowledge and skills to conduct experiments and develop applications using electronic design automation (EDA) tools;
- **PSO 3:** Demonstrate a sense of professional ethics, recognize the importance of continued learning,and be able to carry out their professional and entrepreneurial responsibilities in electronics engineering field giving due consideration to environment protection and sustainability

Program Educational Objectives (PEOs)

- **PEO 1:** Graduates shall have sound knowledge of the fundamental and advanced concepts of Electronics and Communication Engineering to analyze, design, develop,and implement electronic systems or equipment.
- **PEO 2:** Graduates shall apply their knowledge and skills in industrial, academic, or research careers with creativity, commitment,and social consciousness.
- **PEO 3:** Graduates shall work in a team as a member or leader and adapt to the changes taking place in their field through sustained learning.

Appendix D: CO-PO-PSO Mapping

Course Outcomes (CO)

CO1	**Students will be able to practice acquired knowledge within the selected area of technology for project development.**
CO2	**Students will be able to Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.**
CO3	**Students will be able to Reproduce, improve and refine technical aspects for engineering projects.**
CO4	**Work as a team in development of technical projects.**
CO5	**Communicate and report effectively project related activities and findings**.

Mapping

The mapping specification is as follows: **1 - Low, 2 - Medium, 3 - High**

Mapping of Course Outcomes with Programme Outcomes

height	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	3	3	2	3	3	2					2
CO 2	3	3	3	2	3	3	2			3	2	2
CO 3	3	3	3	2	3	3	2			3	2	2
CO 4					2			3	3	3	2	2
CO 5					2			3	3	3	2	2

Table D.1:Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

CO–PSO Mapping

	Programme-specific Outcomes (PSOs)		
	PSO 1	**PSO 2**	**PSO 3**
CO1	3	3	2
CO2	3	3	2
CO3	3	3	2
CO4	2	2	3
CO5	2	2	3

Table D.2: Mapping of Course Outcomes (COs) with Programme-specific Outcomes (PSOs)

Mini Project Outcomes

P1	We were able to practice acquired knowledge within the selected area of IoT and embedded systems for smart door project development.
P2	We were able to identify, discuss,and justify the technical and design aspects of the smart door project with a systematic approach.
P3	We were able to reproduce, improve,and refine technical aspects for the smart door project using ESP32-CAM and ESP32-WROOM-32.
P4	We were able to work as a team in the development of the smart door project for differently abled individuals.
P5	We were able to communicate and report smart door project-related activities and findings effectively.

Table D.3: Mini Project Outcomes

Mapping of Mini Project Outcomes with Programme Outcomes (POs)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
P1	3	3	3	2	2	3	2					1
P2	3	2	2	2	2	2	2			2	2	2
P3	3	2	2	1	3	3	1			3	2	1
P4					2			3	3	3	2	2
P5					2			2	3	3	2	2

Table D.4:Mapping of Mini Project Outcomes (P1–P5) with Programme Outcomes (POs)

Mapping of Mini Project Outcomes with Program Specific Outcomes(PSOs)

	Programme-specific Outcomes (PSOs)		
	PSO 1	**PSO 2**	**PSO 3**
P1	3	2	2
P2	3	2	2
P3	3	2	2
P4	2	2	3
P5	2	2	3

Table D.5:Mapping of Mini Project Outcomes (P1–P5) with Programme-specific Outcomes (PSOs)

Justification for Mini Project Outcome & Programme Outcome Mapping

MAPPING	LEVEL	JUSTIFICATION
P1–PO1	3	Applied engineering and electronics knowledge to develop a secure smart door system integrating sensors, actuators,and communication protocols.
P1–PO2	3	Identified real-world access control and health safety issues, analyzed user-specific needs,and formulated a solution using engineering principles.
P1–PO3	3	Designed an intelligent and accessible system that ensures security, user health,and public safety through customized door automation.
P1–PO4	2	Conducted experiments to fine-tune system behavior by analyzing sensor readings and validating data responses for performance.
P1–PO5	2	Used Arduino IDE, Wokwi simulation tools to model, implement,and test the functionality of hardware and software components.
P1–PO6	3	Considered health, safety,and social needs of bedridden/differently-abled individuals in the development and application of the smart door system.
P1–PO7	2	Emphasized low power consumption and reusable components to promote sustainability and eco-friendly design.
P1–PO12	2	Engaged in independent research and learning to explore embedded systems and IoT-based automation.
P2–PO1	3	Applied fundamental knowledge in electronics, embedded C programming,and sensor integration for smart door automation.
P2–PO2	2	Analyzed challenges like security breaches, temperature screening,and unauthorized access,and offered validated solutions.
P2–PO3	2	Designed system components to automate visitor handling, using ESP32-CAM, RFID,and solenoid lock mechanisms.
P2–PO4	2	Collected and interpreted sensor data (MLX90614, RFID, vibration sensor) for decision-making in the smart door logic.
P2–PO5	2	Integrated modern IT tools such as Telegram Bot API and VoIP calling services for remote monitoring and control.
P2–PO6	2	Addressed health and accessibility concerns for differently-abled individuals with emergency calling and real-time monitoring.

P2–PO7	2	Incorporated features that reduce energy waste and allow efficient battery-based operation.
P2–PO10	2	Created proper documentation, maintained logs of system activity,and communicated project progress with stakeholders.
P2–PO11	2	Managed project timelines, hardware assembly,and testing phases within a group setting.
P2–PO12	2	Learned new APIs and tools independently to enhance the system and respond to changing requirements.
P3–PO1	3	Used fundamental knowledge of embedded systems to build an integrated IoT-based access control solution.
P3–PO2	2	Formulated and tested several iterations of the smart lock mechanism and automated features based on analyzed needs.
P3–PO3	2	Developed a user-friendly solution with voice alerts, temperature scanning,and emergency options to meet health and security needs.
P3–PO4	1	Interpreted sensor outputs and experimental feedback to optimize sensor placement and detection accuracy.
P3–PO5	3	Deployed modern tools like Arduino serial monitor, Telegram bot,and Twilio to control and debug the smart door system.
P3–PO6	3	Integrated tamper detection and emergency communication considering legal and personal safety responsibilities.
P3–PO7	1	Chose components that are durable and energy-efficient to align with sustainable engineering practices.
P3–PO10	3	Explained and presented system operation and features clearly through demonstration and reporting.
P3–PO11	2	Coordinated among group members for tasks like component interfacing, soldering,and power optimization.
P3–PO12	1	Adapted to new tools and protocols during the project, ensuring continuous learning and system improvement.
P4–PO5	2	Applied circuit design and simulation tools to test module interactions like RFID,ESP32WROOM-32 & SW 420 Vibration Sensor.
P4–PO8	3	Prioritized ethical use of user data (temperature, access logs) and ensured secure communication via Telegram.
P4–PO9	3	Functioned effectively within a team to develop, test,and troubleshoot subsystems and final integration.

P4–PO10	3	Created clear technical documentation and communicated effectively with peers and faculty during evaluations.
P4–PO11	2	Practiced teamwork and resource planning during the PCB fabrication and integration stages.
P4–PO12	2	Learned how to debug complex interactions and apply feedback to refine the project.
P5–PO5	2	Used tools like WOKWI and multimeters to test voltage levels, current flow,and signal responses.
P5–PO8	2	Upheld professional and ethical standards in project design, especially in safety-critical scenarios.
P5–PO9	3	Collaborated with team members during final assembly, testing,and public demonstration.
P5–PO10	3	Explained system working through presentations, report writing,and practical walkthroughs.
P5–PO11	2	Balanced task distribution and hardware management during the mini project lifecycle.
P5–PO12	2	Took initiative to self-learn integrations like Twilio API, MLX90614 interfacing,and Telegram bot configuration.

Table D.6:Justification of Mapping of Mini Project Outcomes (P1–P5) with Programme Outcomes (POs)

Justification for Mini Project Outcome & Programme Specific Outcome Mapping

MAPPING	LEVEL	JUSTIFICATION
P1–PSO1	3	Implemented embedded system concepts to design an integrated smart door using ESP32, RFID, solenoid lock,and temperature sensors.
P1–PSO2	2	Used IoT tools like Telegram and Twilio to achieve real-time communication and automation for user interaction and monitoring.
P1–PSO3	2	Considered accessibility for differently abled individuals while designing hardware placement, notification systems,and ease of use.
P2–PSO1	3	Applied microcontroller programming and interfacing techniques to implement RFID-based authentication and camera-based monitoring.

P2–PSO2	2	Integrated cloud communication tools like Telegram Bot API and voice call APIs to enhance functionality and responsiveness.
P2–PSO3	2	Addressed social impact through features like emergency calling and temperature screening, especially for elderly and differently abled users.
P3–PSO1	3	Developed and tested subsystems including RFID, MLX90614,and solenoid control using Embedded C and Arduino IDE.
P3–PSO2	2	Enabled IoT-based alert mechanisms that send messages and images over the internet to ensure remote access and control.
P3–PSO3	2	Ensured ethical and safe design by avoiding data misuse and maintaining user privacy in monitoring applications.
P4–PSO1	2	Practiced real-time troubleshooting and debugging to ensure component coordination and accurate logic-based control.
P4–PSO2	2	Configured API integrations for health safety (Twilio call on tampering), enabling proactive safety notifications.
P4–PSO3	3	Promoted inclusive design by integrating emergency features and easy user interaction mechanisms for non-technical users.
P5–PSO1	2	Finalized PCB soldering,and integration of system hardware for real-time deployment and testing.
P5–PSO2	2	Enabled smart automation features by linking multiple sensor systems with ESP32's cloud-enabled communication stack.
P5–PSO3	3	Encouraged responsible design through efficient power usage and low-cost, reliable components to promote sustainability.

Table D.7:Justification of Mapping of Mini Project Outcomes (P1–P5) with Programme-specific Outcomes (PSOs)