An-Najah National University

Faculty of Engineering & Information Technology

Computer Engineering Department

Graduation Project 2

Smart HealthMed

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Sincerely,
Ahmad Abu Shams
Abdul Rahman Yahya

Disclaimer

This report was prepared by Ahmad Abu shams and Abdul Rahman Yahya from the Computer Engineering Department at the Faculty of Engineering, An-Najah National University. The content of this report reflects the authors' own work and opinions. While minor editorial revisions have been made, the report may still contain some language or content inaccuracies.

All findings, conclusions, and recommendations presented in this report are solely those of the authors. An-Najah National University does not assume any responsibility for the use of this report beyond its intended academic purpose.

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Abstract

This project presents the design and implementation of a smart medication management system developed using an Arduino and ESP8266 microcontroller platform. The system is designed to assist elderly patients in adhering to their prescribed medication schedules by automatically dispensing medication doses at predefined times, while also supporting manual dispensing requests. In addition, the solution integrates a wearable device attached to the patient’s arm, built with vital sign monitoring sensors (such as heart rate, temperature, and fall detection sensors), which continuously track the patient’s health status and generate alerts in emergency situations, such as falls. A mobile application, connected via the ESP8266’s Wi-Fi , allows caregivers to remotely configure and monitor the system. Furthermore, the system provides options to send SMS notifications or make emergency calls when dangerous conditions are detected. By combining IoT connectivity, real-time health monitoring, and automated medication dispensing, the proposed system enhances patient safety, ensures medication adherence, and reduces the risk of health complications among elderly individuals.

Chapter 1

Introduction

1.1 General background

Elderly patients often struggle to follow their prescribed medication schedules, which can lead to severe health complications. Traditional methods, such as relying on caregivers or manual reminders, are not always reliable and can result in missed doses. There is a clear need for smart systems that automate medication dispensing, continuously monitor patient health, and provide timely alerts in case of emergencies, thereby ensuring patient safety and adherence to treatment plans.

1.2 Objectives

The main objective of this project is to design and implement a smart medication management system that automatically dispenses medication according to a predefined schedule. The system also supports manual dispensing. In addition, it continuously monitors patients' vital signs, including heart rate, temperature, and fall detection, and provides timely alerts in case of emergencies. The project aims to improve patient safety, ensure medication adherence, and reduce the risk of health complications among elderly individuals.

1.3 Significance

This project is significant as it offers an innovative solution to improve medication adherence and patient safety among elderly individuals. By integrating automated medication dispensing, continuous health monitoring, and real-time alerts, the system ensures that patients take their medications on time while providing caregivers with remote monitoring capabilities. This reduces the risk of health complications, enhances the overall quality of care, and minimizes reliance on constant human supervision.

1.4 Organization of the report

The report is organized into five main chapters. Chapter 1 provides an introduction, outlining the general background, objectives, significance, and organization of the report. Chapter 2 presents the theoretical background and previous work related to smart medication systems and health monitoring technologies. Chapter 3 details the methodology, including the hardware components, system design, and programming of the microcontrollers. Chapter 4 discusses the mechanical, electrical, and software challenges encountered during implementation. Finally, Chapter 5 concludes the report with a summary of the work, conclusions, recommendations, lessons learned, and potential directions for future wor

Chapter 2

Theoretical Background and Previous Work

2.1 Historical Context

Proper medication management has been a critical concern in healthcare, particularly for elderly patients who often struggle to adhere to their prescribed schedules. Traditionally, caregivers and family members manually reminded patients to take their medications, but such methods were prone to errors and missed doses. Over time, digital reminders, mobile applications, and smart pillboxes have been introduced to improve adherence. Recent advances in IoT, wearable sensors, and automated dispensing systems have enabled the development of intelligent solutions that can monitor patient health, dispense medication automatically, and provide real-time alerts. The Smart Medication Management System presented in this project represents the latest step in this evolution, combining automated dispensing, vital sign monitoring, and IoT connectivity to enhance patient safety and treatment compliance.

2.2 Existing Literature

Over the past decade, various smart medication management systems have been developed to improve patient adherence and safety. Early solutions relied on manual reminders, simple electronic pillboxes, or caregiver supervision, which often proved insufficient for elderly patients. More recent studies have introduced automated pill dispensers integrated with IoT technologies, allowing remote monitoring and real-time alerts. Several academic projects have focused on combining medication dispensing with health monitoring, using sensors for heart rate, temperature, and fall detection. Compared to previous systems, the Smart Medication Management System developed in this project integrates automated dispensing, continuous vital sign monitoring, and IoT-based alert mechanisms, providing a more comprehensive and reliable solution to ensure patient safety and adherence.

2.3 Evolution of Agricultural Technology and Related Work

Smart medication management systems have evolved significantly over the past decade, from simple reminder devices and electronic pillboxes to automated dispensing solutions integrated with health monitoring sensors. While earlier systems improved adherence, many lacked continuous monitoring of vital signs or real-time alerts, limiting their effectiveness in preventing health complications.

The system developed in this project addresses these limitations by combining automated medication dispensing with continuous monitoring of heart rate, body temperature, and fall detection. Medication is dispensed through organized slots controlled by DC motors and an electromagnetic lock, while caregivers receive timely SMS in case of emergencies. The integration of Arduino and ESP8266 microcontrollers ensures reliable control, real-time communication, and flexible system operation. This combination of features represents a more comprehensive and practical solution compared to existing approaches, improving patient safety and treatment compliance.

Chapter 3

Methodology

In this chapter, we provide a detailed explanation of the hardware, software, and standards used in designing and implementing the Smart Medication Management System. The methodology covers the systematic integration of microcontrollers, sensors, actuators, power supply, and user interfaces to ensure reliable medication dispensing and real-time health monitoring. Detailed descriptions of component selection, mechanical design of medication slots, programming of Arduino and ESP8266, communication protocols, and alert mechanisms are included to illustrate how these elements work together to achieve the project's objectives.

3.1 Standards and Specifications

The design of the Smart Medication Management System adheres to established engineering standards to ensure reliability, safety, and compatibility. The ESP8266 microcontroller employs the IEEE 802.11 standard for Wi-Fi communication, enabling seamless connectivity with mobile applications and remote monitoring. Electrical components, including batteries, DC-DC converters, and regulators, are selected and configured according to safety and performance standards to prevent malfunctions or hazards. Mechanically, the medication dispensing slots are designed to prevent jamming or incorrect dosage release. Overall, strict adherence to these standards ensures the system operates safely and effectively for end-users.

3.2 Hardware Components

3.2.1 Microcontrollers

The Smart Medication Management System uses an **Arduino Mega 2560 connected to an ESP8266** to control medication dispensing and various actuators, while another **ESP8266** is used on the vital signs monitoring device to provide wireless connectivity and data exchange with the main system. The **Arduino Mega 2560**, based on the **ATmega2560** chip, features 54 digital input/output pins, 16 analog inputs, and multiple UART ports, making it ideal for interfacing with numerous sensors and actuators, including DC motors, the electromagnetic lock, and medication dispensing slots.

The **ESP8266** serves as a wireless communication module with the Arduino to facilitate data transmission and reception, allowing caregivers to connect via a mobile application to remotely monitor the system, receive alerts, and send commands. Upon receiving a command, the Arduino Mega executes the corresponding action, such as dispensing medication or triggering an alert, ensuring seamless integration and timely responses.

The choice of these microcontrollers allows for **flexible system expansion and reliable operation**, as additional sensors or actuators can be easily integrated. Moreover, the separation of roles—Arduino for hardware control and ESP8266 for wireless communication—enhances system efficiency and reduces the risk of processing delays, making the solution robust and suitable for real-time healthcare applications.

Additionally, the use of microcontrollers in this system **ensures a high level of safety and reliability**, as critical operations such as medication dispensing and alert notifications are precisely controlled. Built-in fault tolerance, error handling, and real-time processing capabilities of these controllers help prevent malfunctions, minimize human error, and maintain continuous patient monitoring, which is crucial for elderly or chronically ill patients.

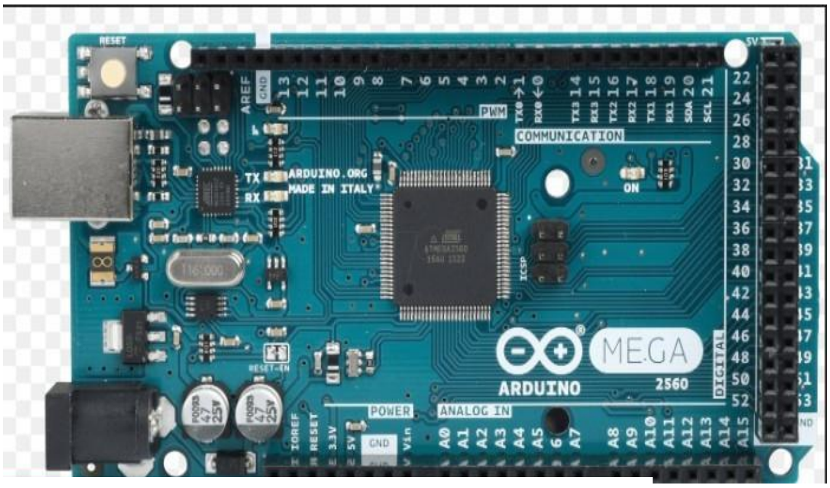

Figure 4 ***Arduino Mega***

Figure 5 Esp8266

3.2.2 Actuators , Motors and control component

DC Motor with H-Bridge Driver

The system uses a DC motor controlled through an H-Bridge driver to manage the internal medication dispensing mechanism. The DC motor is responsible for moving the medication slots located inside the storage box. Each slot contains a specific dose of medicine, and the controlled rotation of the motor allows precise alignment and release of the correct medication at the scheduled time.

The H-Bridge driver enables bidirectional control of the DC motor, allowing it to rotate both clockwise and counterclockwise. This capability is essential for accurately positioning the slots and returning them to their original state after dispensing. The motor control process is fully automated and managed by the Arduino microcontroller, ensuring reliable and repeatable operation while minimizing mechanical errors.

Figure 6 Gear Dc Motor

Figure 7 H-Bridge

Electromagnetic Lock

The electromagnetic lock is a fundamental component of the medication storage system, with its primary function being **to prevent unauthorized access to the contents of the box**. The lock can be controlled and operated exclusively through the **mobile application** linked to the system, ensuring that access to the medications is restricted to authorized users only, thereby enhancing the safety and management of the storage process.

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Figure 8 Electromagnetic Lock

SIM800L

The **SIM800L** modem is used in the system to enable cellular network communication and send SMS alerts to caregivers in case of emergencies, such as a patient fall or delayed medication dispensing, ensuring remote monitoring and prompt response.

Figure 9 SIM800L

Buzzer

The **buzzer** provides audible alerts, such as notifying caregivers in case of a patient fall, enhancing user awareness and ensuring prompt response in emergencies.

Figure 10 Buzzer

Slot

The medication dispensing slots organize and store individual doses for each scheduled time with precision.DC motors control each slot to ensure accurate dispensing and prevent any errors or missed doses.

Figure 11 Slot

3.2.3 Sensors

In the **Smart HealthMed** medication management system, a variety of sensors are employed to ensure accurate medication dispensing and continuous monitoring of the patient's health. Each sensor has a specific and well-defined role:

1. **Infrared (IR) Sensor:**

The dispensing of medication is scheduled through the mobile application.When the scheduled time arrives, the motors are activated to release a single medication pill. A sensor detects whether the pill has been successfully dispensed. Once the pill is released, the motors stop automatically, ensuring accurate and controlled dispensing.

Figure 12 IR Sensor

2. **Temperature Sensor:**

Continuously measures the patient's body temperature **and displays the reading on the mobile application**.

Figure 13 Temperature Sensor

3. Gyroscope / Accelerometer (MPU6050):

This sensor is responsible for measuring the patient’s body movement and acceleration along three axes using a gyroscope. The readings are analyzed to determine whether a fall has occurred. If a fall is detected, the system immediately sends an SMS alert to the caregiver.

Figure 14 Gyroscope

4. Real Time Clock (RTC):

The system maintains accurate timing for medication schedules, ensuring that medications are dispensed at precise, predetermined times.

Figure 15 RTC

5. Max 30 100

The MAX 30100 sensor is used to measure the patient's heart rate and blood oxygen saturation (SpO_2). The collected readings are continuously monitored and displayed on the mobile application, allowing real-time tracking of the patient's vital signs.

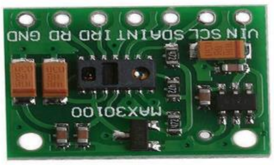


Figure 16 Max 30 100

System Integration:

- All sensors work together with the Arduino Mega and ESP8266 to control the opening of the medication box, dispense the correct dosage, and trigger alerts when necessary.
- This integration guarantees patient safety, adherence to medication schedules, and reduces the risk of missed or incorrect doses.

3.2.4 Power devices

The vital signs monitoring device is powered by two lithium batteries. A DC–DC voltage regulator steps down the battery voltage to a safe level for operating the ESP8266 and other sensitive electronic components. In addition, a 12 V power supply is used to power the overall system, motors requires 12v and for other parts we used voltage regulators to provide appropriate operating voltages for the Arduino, LCD, and other peripherals.

Figure 14 Regulator

Figure 15 Lithium Batteries

3.2.5 Input and Output

LCD Display

The system uses a **20×4 LCD** screen (20 characters per line, 4 lines) to display the current date and day, as well as the types and names of medications, facilitating clear and organized tracking of the patient’s medication schedule.

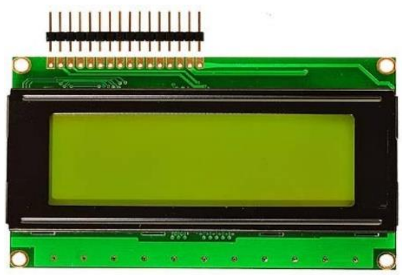


Figure 16 LCD

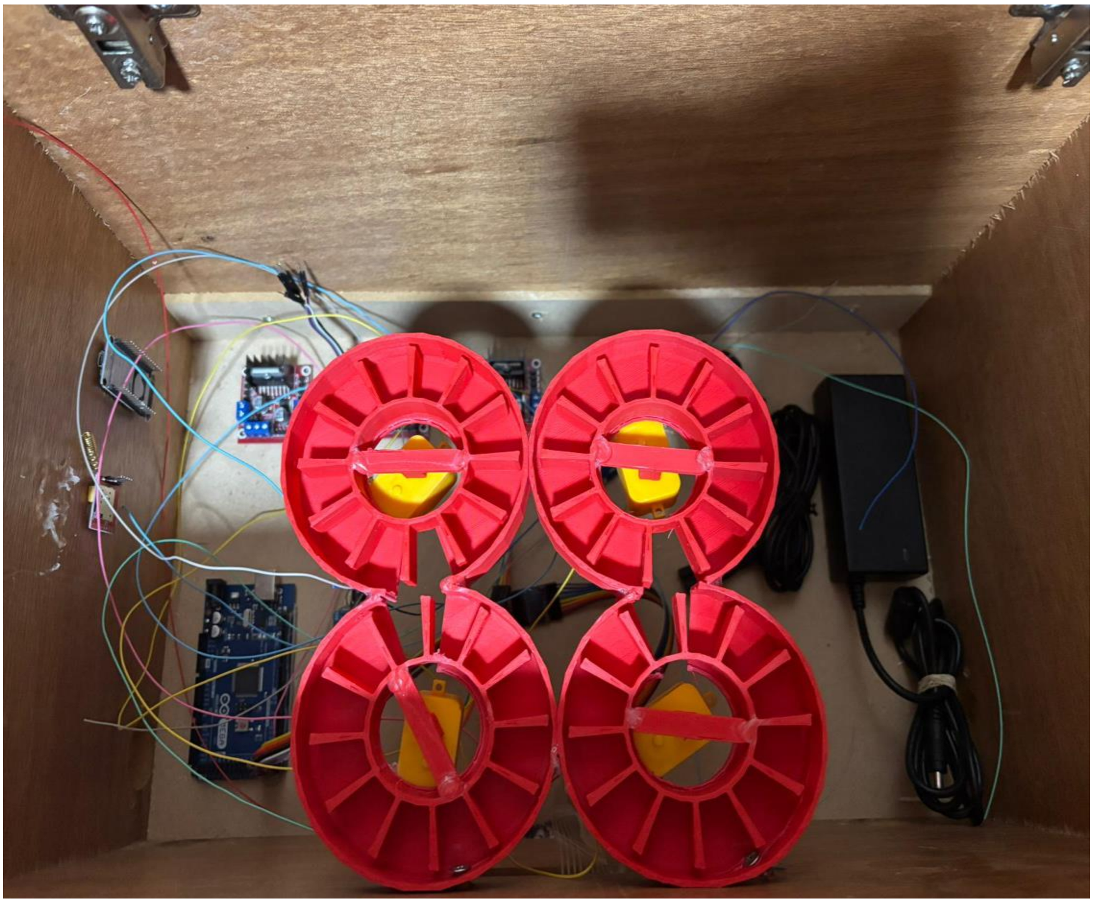
Keypad

The **Keypad** is used in the system as a means of controlling and interacting with the device, allowing the user to input commands, thereby ensuring safe and precise control over medication dispensing operations.

Figure 17 Keypad

Medication Slots and Mechanism:

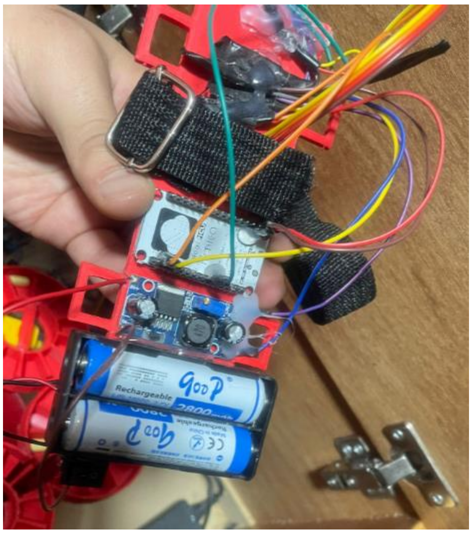
The medication is stored in organized slots inside a secured box.DC motors controlled via H-Bridge drivers move the slots precisely to release the correct dosage at the scheduled time.



External Structure:

- The system's casing is designed to securely house all electronic components, motors, and medication slots.

- Materials are chosen to be lightweight yet durable, ensuring stability and protection of the internal mechanisms.



3.3 Experimental Procedures

In the **Smart Medication Management System**, experimental procedures were conducted to test the functionality, accuracy, and safety of the medication dispensing and monitoring mechanisms. The main procedures are described as follows:

1. **Medication Slot Dispensing:**

- The DC motors controlled via H-Bridge drivers continue to rotate until a command from the infrared (IR) sensor signals them to stop.
- The system can operate automatically according to the preset schedule or manually via the mobile application.

2. **Electromagnetic Lock Operation:**

- The electromagnetic lock is controlled through the mobile application to ensure that it cannot be operated by unauthorized individuals.

3. **User Presence Detection (IR Sensor):**

The IR sensor in our system is specifically used to detect when a medication pill has been successfully dispensed from the slot. Once the pill passes the sensor, it sends a signal to the microcontroller to immediately stop the rotation of the slot mechanism.

4. **Temperature Monitoring:**

The temperature sensor continuously monitors the patient's body temperature.

5. **Fall Detection (MPU6050 Gyroscope/Accelerometer):**

The system takes readings from the gyroscope, which measures the patient's body movement and acceleration. By analyzing these readings, it determines whether a fall has occurred. In the event of a detected fall, the buzzer is activated, and an immediate alert is sent to caregivers either via SMS or through the mobile application.

6. **Real-Time Clock (RTC) Functionality:**

The RTC is used to maintain the current time and date, which can be set through the mobile application. The operation of the motors and the medication dispensing system relies on readings from the RTC. It also ensures that the time and date are preserved in the event of a power outage, maintaining the accuracy of the medication schedule.

7. **Live Feedback via Mobile Application:**

The ESP8266 module enables communication with the mobile application, allowing users and caregivers **to** control the electromagnetic lock, set medication schedules and names, and view sensor readings for vital signs. The application also allows specifying phone numbers for alerts and composing the messages to be sent**,** ensuring precise and prompt monitoring of missed doses and emergency situations.

8. **Manual Control Testing:**

Data is transmitted from the mobile application to the Arduino controller, and the Keypad is used to select the command to be executed. This functionality is tested to ensure secure, accurate, and responsive operation in scenarios that require manual intervention.

These experimental procedures ensure the **accuracy, safety, and reliability** of the Smart Medication Management System, confirming that the system can autonomously dispense medications, monitor health parameters, and provide timely alerts in real-world conditions.

3.4 Software Implementation

The software component of the **Smart HealthMed** system was developed to ensure precise and reliable control of all system components. The system relies on Arduino and ESP8266 microcontrollers to process data from various sensors, including the infrared (IR) sensor, motion and gyroscope sensor (MPU6050), vital signs sensor (MAX30100), and the Real-Time Clock (RTC). The software controls the motors via H-Bridge drivers to rotate the medication slots and deliver the correct doses at scheduled times, while also managing the electromagnetic lock to prevent unauthorized access.

The Arduino communicates with the ESP8266 module via Serial Communication (UART)**,** with the ESP8266 transmitting commands from the mobile application to the Arduino and sending sensor readings back to the app for real-time monitoring. Additionally, the ESP8266 is connected to **the** SIM800L module via UART to send emergency alerts or SMS messages to users or caregivers in events such as patient falls or missed doses. The system incorporates two ESP8266 modules: one inside the medication box for controlling motors, slots, and sensors, and another worn on the wrist to monitor patient activity and collect vital signs. These modules communicate wirelessly via Wi-Fi or TCP/IP protocol, ensuring continuous, accurate data exchange and enabling secure and efficient remote control and monitoring through the mobile application.

3.5 Mechanical Implementation

The mechanical design of the **Smart HealthMed** system ensures precise, reliable, and secure medication dispensing while maintaining user safety. The system features a structured medication storage box with individual slots for each type of pill. DC motors, controlled through H-Bridge drivers, rotate the slots to align the correct dose with the dispensing mechanism. An infrared (IR) sensor immediately detects the passage of a pill, stopping the motor to prevent multiple pills from being dispensed accidentally.

The electromagnetic lock is securely installed to prevent unauthorized access, while the 20×4 LCD display and keypad (**Keypad**) provide clear interaction for manual control and configuration. All mechanical components, including the motor mounts, slot guides, and structural frame, are firmly fixed within a robust chassis to minimize vibration, maintain proper alignment, and ensure consistent operation. The design also allows easy maintenance and accessibility for refilling medications or adjusting mechanical elements, providing a balance between safety, durability, and operational efficiency.

Chapter 4

Discussion

The **Smart HealthMed** system is designed to improve medication management accuracy and enhance patient safety. Experimental results show that the system successfully dispenses medications at scheduled times using the Real-Time Clock (RTC), while the infrared (IR) sensor ensures that only a single pill is released by stopping the motors immediately after dispensing.

In terms of safety, the electromagnetic lock controlled through the mobile application effectively prevents unauthorized access. Additionally, the MPU6050 sensor enables reliable fall detection and sends immediate alerts via SMS or the mobile application, while the MAX30100 sensor allows continuous monitoring of vital signs. Overall, the system demonstrates good reliability and efficiency, making it suitable for home healthcare applications.

4.1 Mobile App

Application Description

This is a mobile application designed to help patients and caregivers manage treatment and monitor health conditions in a safe and effective way.

The application provides the following features:

- **Electronic System Control**: The ability to remotely control the opening and closing of an electromagnetic lock through the application.

- **Medication Scheduling**: Organizing medication intake schedules by day and time, with the ability to manage each medication separately.
- **Vital Signs Monitoring**: Monitoring the patient's vital signs such as **body temperature, blood oxygen level, and heart rate**, and displaying them in real time within the application.

- **Emergency Alert System**: In the event of a patient fall, the application automatically sends an alert message to a pre-selected contact number (family member or caregiver).

The application aims to improve patient safety, reduce medication scheduling errors, and ensure rapid response in emergency situations.

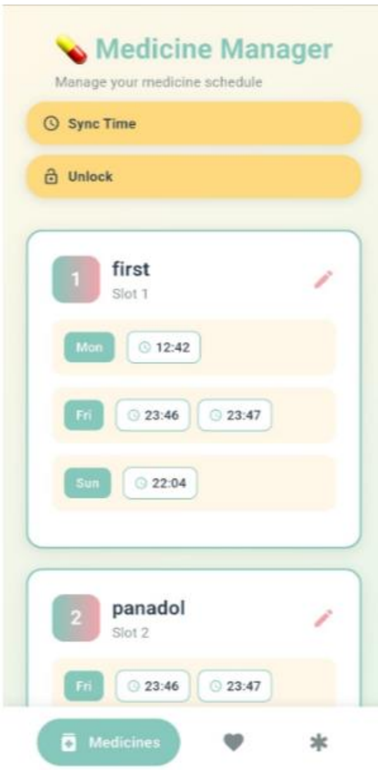


Figure 17 Mobile App

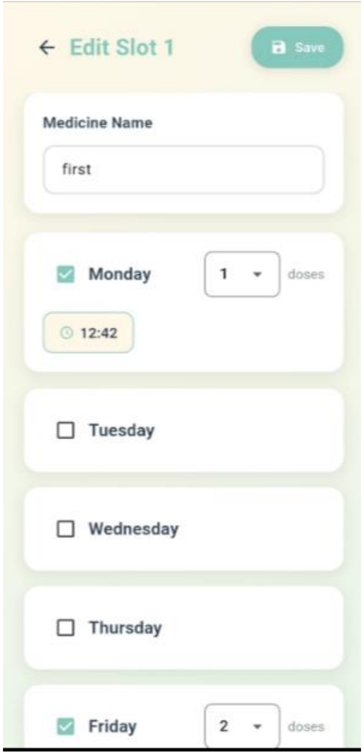


Figure 18 Mobile App

Figure 19 Mobile App

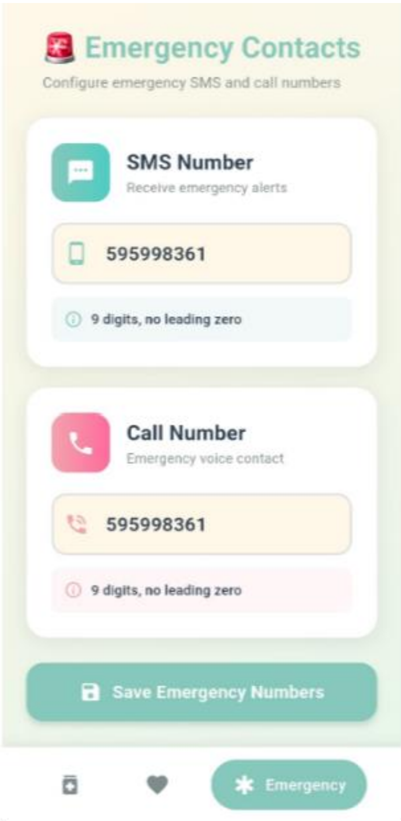


Figure 20 Mobile App

Chapter 5

Conclusion and Future Work

5.1 Summary

The Smart Medication Management System project aims to develop a smart, semi-autonomous system capable of accurately dispensing medications, monitoring patient health parameters, and providing timely alerts in emergency situations. The system is equipped with a variety of electronic and mechanical components, including an Arduino Mega, ESP8266, DC motors, electromagnetic locks, IR sensors, RTC modules, temperature sensors, and a gyroscope/accelerometer (MPU6050).

A key feature of the system is its integration with a Flutter-based mobile application, which enables manual control over medication dispensing, real-time monitoring of health data, and access to alerts and notifications for both patients and caregivers.

The dispensing mechanism uses DC motors to rotate medication slots, while the IR sensor detects when a pill has passed to ensure precise stopping. The electromagnetic lock secures the medication box, allowing safe and controlled access. The RTC module ensures accurate timing for automatic dispensing according to the prescribed schedule. Additional sensors continuously monitor the patient's vital signs and detect falls or other emergencies, triggering alerts as necessary.

This project provides a strong foundation for future development in automated medication management, improving patient safety, ensuring adherence to prescriptions, and reducing risks associated with human error in medication administration.

5.2 Conclusion

In conclusion, this project demonstrates the feasibility of building a smart, semi-autonomous medication management system that improves patient safety and ensures adherence to prescribed medication schedules. By integrating DC motors, electromagnetic locks, IR sensors, RTC modules, temperature and motion sensors, and a real-time control system via a Flutter-based mobile application, the system can accurately dispense medications, monitor patient health, and send alerts in emergency situations.

This solution enhances both safety and efficiency in medication administration and showcases how combining automation, sensors, and mobile applications can provide practical solutions to real-world healthcare challenges. The successful implementation confirms the effectiveness of the system's design and highlights its potential for deployment in home care, hospitals, or other medical environments.

5.3 Recommendations

Improving Medication Dispensing Accuracy
It is recommended to enhance the rotary slot mechanism and the infrared (IR) sensor to ensure that only one pill is dispensed at a time, especially when handling different pill sizes and types.

Enhancing Power Supply Reliability
Using separate and stable power sources for motors and the electromagnetic lock is advised, along with appropriate protection circuits, to ensure reliable operation during power fluctuations or outages.

Strengthening Security and Access Control
The security of the electromagnetic lock should be further reinforced by fully integrating it with the mobile application and restricting access to authorized users only.

Improving Fall Detection Accuracy
Proper calibration of the MPU6050 sensor and optimization of motion analysis algorithms are recommended to reduce false alerts and improve fall detection accuracy.

Enhancing the Mobile Application Interface
The mobile application interface should be improved to simplify medication

scheduling, display vital sign readings, and manage alerts more effectively for users and caregivers.

Testing in Real-World Environments
The system should be tested in real-life scenarios and with actual users to ensure suitability for home healthcare and to enhance long-term reliability.

Future System Expansion
Future enhancements may include cloud-based data storage, support for multiple patients, and integration with smart healthcare platforms.

5.4 What We Have Learned

Through the development and implementation of the **Smart HealthMed** system, we gained practical experience in integrating hardware and software components to build a reliable healthcare solution. We learned how to interface various sensors, including vital sign and motion sensors, with microcontrollers to collect and process real-time data.

The project also improved our understanding of motor control using H-Bridge drivers, secure access mechanisms through electromagnetic locks, and accurate time management using a Real-Time Clock (RTC). In addition, we developed skills in mobile application communication, enabling remote monitoring, control, and alert management.

Overall, this project strengthened our problem-solving abilities, enhanced our system integration skills, and provided valuable insight into designing safe, accurate, and user-friendly smart healthcare systems.

5.5 Future Work

Medication Supply Monitoring
Incorporate sensors to monitor remaining pills in each slot and alert caregivers or patients before depletion to ensure continuous medication adherence.

Energy Efficiency Optimization
Implement battery management algorithms or alternative energy sources, such as solar panels, to increase operational time and reduce maintenance.

Multi-Pill Handling
Develop a mechanism to dispense different types of pills (tablets, capsules, powders) within the same device without the need to manually change the slots.

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