CSULB – College of Engineering
Computer Engineering
Senior Design Project
CECS-490B

Dr. Pill

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Jehmel Espiritu
Jeremy Espiritu
Joseph Guzman
Afzal Hakim
Lee Roger Ordinario

Prof:
Dan Cregg

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Executive Summary

Dr. Pill will be our interpretation of an Automatic Pill Dispenser. Our device aims to facilitate the process by freeing up more time for physicians and allowing patients to take their medication accurately. This device is perfect for doctors and physicians with a range of patients to attend to. Dr. Pill is also designed for the elderly, providing a device that assists them with taking medication at the right time and dosage. Our product aims to simplify the process, reduce human error, and enhance medication adherence through innovative features. This idea was sparked by our excitement to work in the health field, especially with many options to work on tech-driven healthcare solutions, and we are excited to work on a hands-on project that can simplify and speed up the prescription process.

Team Members

Jonathan Cerniaz is a fourth-year student interested in the intricacies of technology. He thrives on hands-on projects and practical problem-solving when not immersed in tech. With a passion for innovation, he often engages in collaborative projects that challenge conventional thinking. His curiosity drives him to explore emerging technologies and their applications, aiming to bridge the gap between theory and real-world solutions.

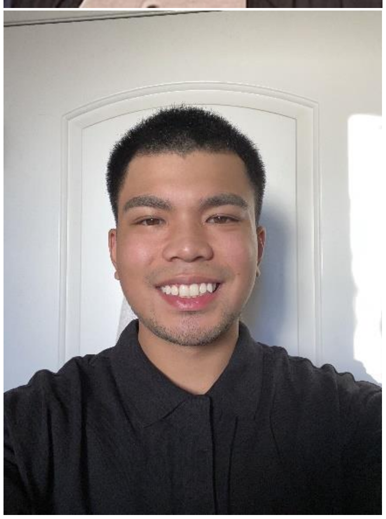
Contact: Jonathan.Cerniaz01@student.csulb.edu

Jehmel Espiritu, a fourth-year student interested in the inner workings of the computer. He is determined to further his knowledge of computing technologies and use this expertise to innovate and contribute to his chosen field. His passion for problem-solving and understanding complex systems drives him to explore emerging trends and advancements in technology.

Contact: Jehmel.Espiritu01@student.csulb.edu

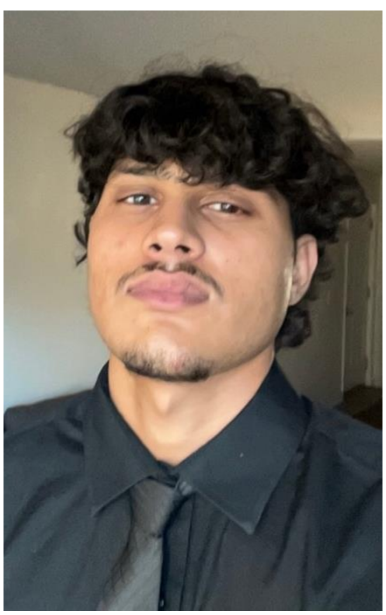
Jeremy Espiritu is a fourth-year student interested in computer hardware and the development of said hardware. He plans on using their knowledge to further himself in any career/project he is involved in. He is also passionate about staying current with emerging technologies and enjoys exploring new innovations in the field.

Contact: Jeremy.Espiritu01@student.csulb.edu



Joseph Guzman, a fifth-year who is interested in the electrical and hardware side of the field. His goals are to leverage his passion for electrical and hardware engineering to create innovative solutions that can allow for advancements within technology thus benefiting society. Joseph also holds a strong interest in space, in hopes of one day being able to pursue a career within the space industry and collaborate with space-related projects and missions.

Contact: joseph.guzman@student.csulb.edu



Afzal Hakim is a fourth-year student with a passion for learning modern technology. He enjoys tackling hands-on challenges to repair and improve systems. He enjoys solving difficult problems and likes fixing things to make them work better. He is highly motivated by opportunities to connect with experienced and knowledgeable individuals. He is eager to learn from their insights and is committed to continuously expanding his expertise in the field.

Contact: Afzal.Hakim01@student.csulb.edu

Lee Roger Ordinario is a fifth-year student whose goal is to learn from existing technology and designs. Due to the increase of the implementation of new technology in various fields, he plans to incorporate what he has learned into other fields that may benefit from it. Lee's interests lie in problem solving and hardware engineering, which he uses for simple designs that can be incorporated into more complex designs.

Contact: LeeRoger.Ordinario@student.csulb.edu

Team Roles and Responsibilities

We plan to split into three groups of two, with each team assigned to a different aspect of the project based on our location, interests, and preferred roles.

Team 1:

Jonathan Cerniaz

- Circuitry
- Team Management
- Touch screen display
- Enclosure & Framework
- Power Supply & Regulation
- Conveyor Belt
- Storage design

Joseph Guzman

- Enclosure & Framework
- GitHub Manager
- 3D Design and Build
- Motor Testing
- Dispensing Mechanism
- Board to board communication
- Conveyer Belt

Team 2:

Jehmel Espiritu

- User interface implementation
- Display menu programming

Jeremy Espiritu

- Pill tracking and dispensing
- Screen display
- Dispense history

Team 3:

Afzal Hakim

- Facial Recognition
- Number pad
- Fingerprint scanner
- Log Tracking Management and Storage

Lee Roger Ordinario

- Dispense and Storage Design
- Soldering
- Object Recognition

Team Communication and Progress Tracking Method

Meeting Schedules

- Weekly Recap Team Meetings: Every Friday at 3 PM via Microsoft Teams
- Every Mon-Fri in other classes as well as our Senior Design Class
- Monthly Progress/Team Building Meetup Off-Campus
- Daily check ins with designated teams

Tools (Communication, Repository, Documentation)

- Microsoft Teams: For video meetings, collaborative document editing, ideas, links, organization, and most importantly our tasks and to-do list.
- GitHub: For version control of software code and documentation
- Google Docs: For weekly progress reports
- Microsoft Word: Big progress update reports with newest updates and major changes
- Microsoft PowerPoint: For progress presentations to show achievement, next steps and challenges
- Microsoft Excel: To track funds, supplies, and who bought what.
- Shapr3D and SolidWorks: For 3D building and designing

Progress Tracking

- Microsoft Teams: Individual and Group tasks in our "Task" tab.
- Weekly Status Reports: The team submits brief reports on their area's progress
- Progress Presentations: Presents achievements, challenges, and next steps.

Project Details

Objectives:

Dr. Pill aims to revolutionize medication management with the primary goal of addressing the common challenges associated with medication adherence, particularly for elderly patients and those with complex medication regimens. The project seeks to develop a user-friendly, technologically advanced solution that simplifies the process of taking medications, reduces human error, and enhances overall medication compliance. By incorporating features such as biometric security and remote monitoring capabilities, Dr. Pill aspires to set a new standard in the field of medication management devices, improving patient outcomes and quality of life.

Our design will perform a range of sophisticated functions to ensure accurate and timely medication dispensing. The device will automatically dispense the correct pills, utilizing a precise drop pivot mechanism to handle various pill sizes and shapes. It will feature multiple storage compartments to accommodate different medications, along with a tracking system to monitor dispensing history. The integrated user interface will provide clear instructions and reminders, while advanced security measures—including facial recognition, fingerprint scanning, and a number pad—will safeguard against unauthorized access.

Benefits:

- Improved medication adherence
- Accurate dosing
- Enhanced medication safety and security
- Reduced medication errors
- Timely reminders and alarms
- Increased independence for patients
- Easier management of complex medication regimens
- Safe storage of medications away from children and pets
- Automatic refill reminders
- Real-time adjustments to medication schedules
- Reduced workload for caregivers
- Improved quality of life for patients
- Potential cost savings by preventing medication-related complications
- Integration with mobile apps for comprehensive health management (optional)
- Customizable medication schedules
- Ability to track medication adherence history
- Reduced risk of accidental overdose or underdose
- Simplified medication organization process
- Potential for integration with electronic health records
- Improved communication between patients and healthcare providers
- Support for managing multiple medications simultaneously
- Reduced anxiety about medication management
- Potential for early intervention in case of missed doses

Features:

- Automatic pill dispensing mechanism
    - Two Modes: Refill and On-Demand
        1. Refill: continuous dispensing of multiple pills of the same type
        2. On-demand: Needed number of dosages dispensed at scheduled time
- Multiple pill storage compartments for different medications
- User interface with 7’’ screen display
- Pill tracking and dispensing system
    - Object Recognition
        1. Pill verification of markings, color, size, and shape

2. Multiple verification checks to ensure accuracy

- Dispense history logging
- Security features:
  - Facial recognition
  - Number pad access
  - Fingerprint scanner
- Secure enclosure to protect medications
- Circuitry for accurate pill counting and dispensing
- User authentication system
- Drop pivot mechanism for precise single-pill dispensing
- Conveyor to open compartment for easier pill accessibility
- Modular storage system to accommodate various pill sizes
- Potential for remote access by authorized personnel (stretch goal)
- Potential mobile app integration (optional)
- Compatibility with different pill shapes and sizes
- Real-time adjustments to medication schedules
- Secure data storage for patient information
- Potential integration with electronic health records
- Alert system for missed doses or low medication supply

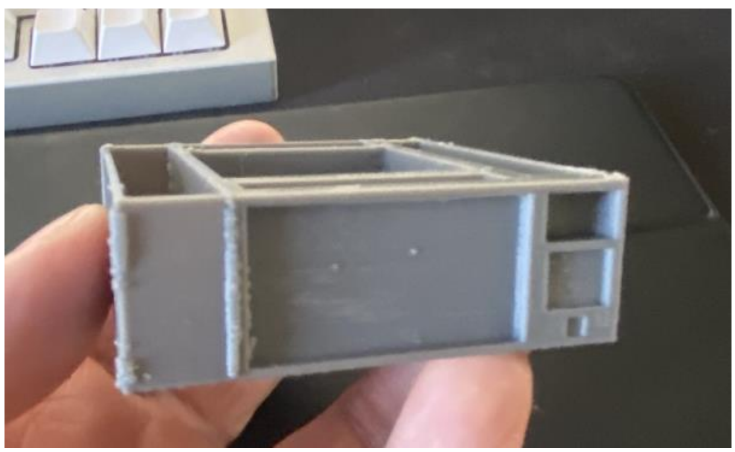


Figure 1 (Prototype)

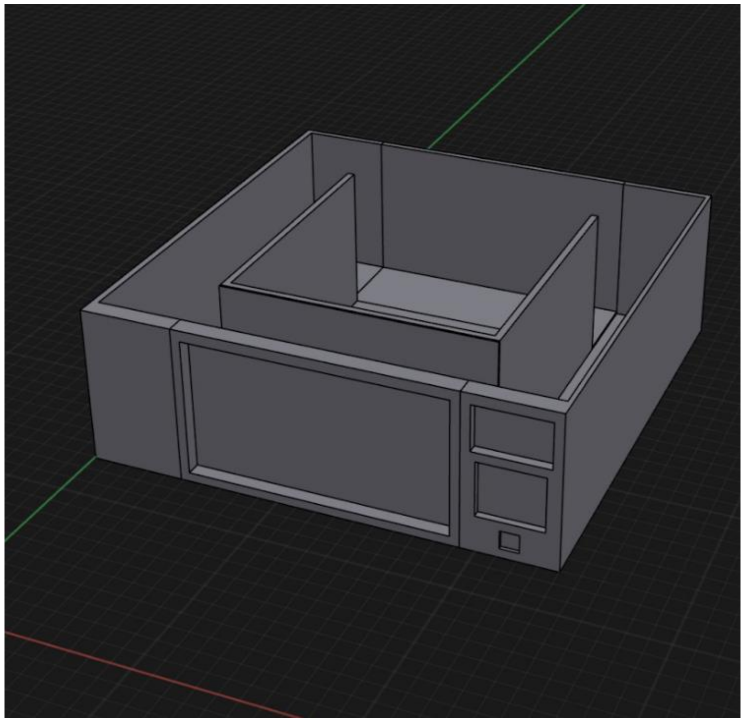


Figure 2 (First 3D Design)

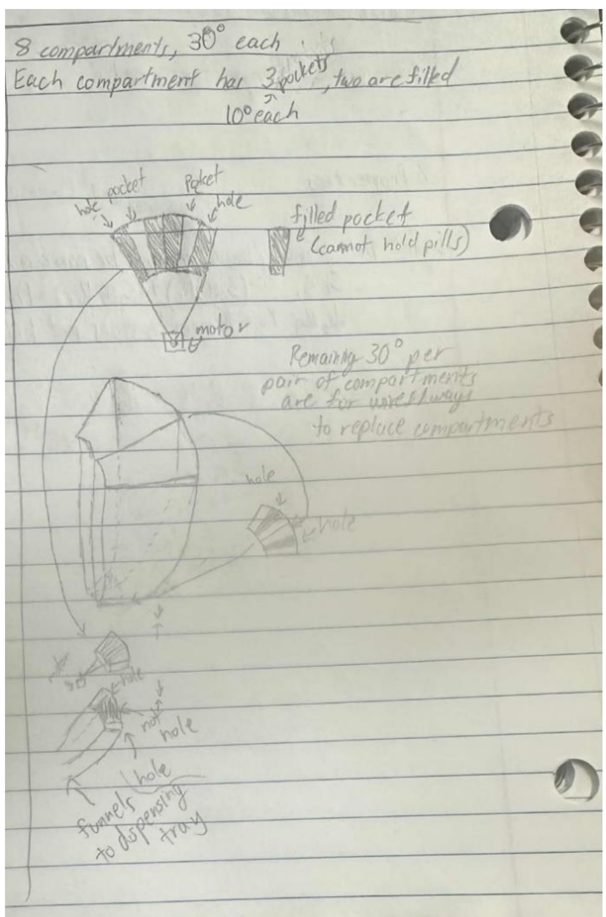


Figure 3 (Sketch of storage/dispense)

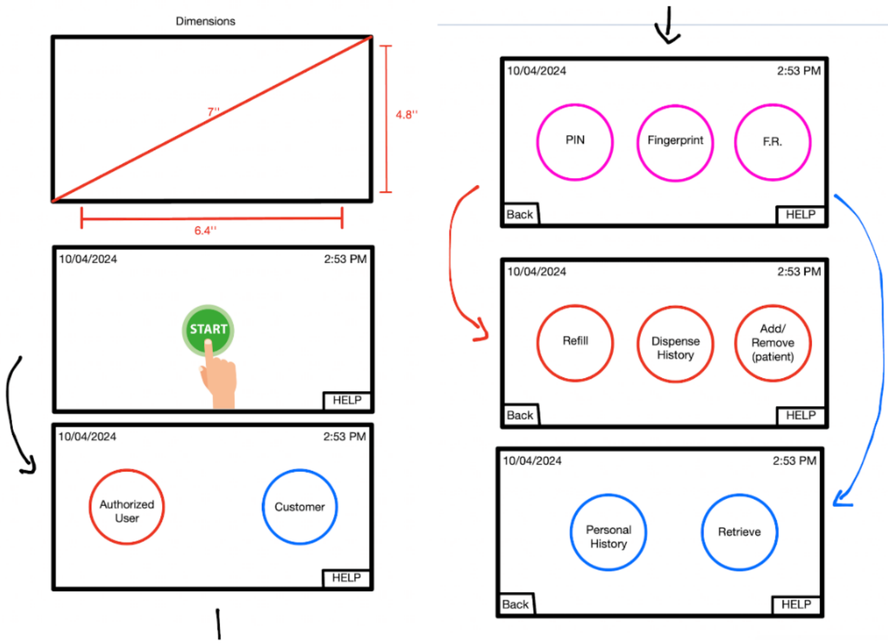


Figure 4 (Rough sketch of user interface)

Design

1.) <u>Block Diagram</u>

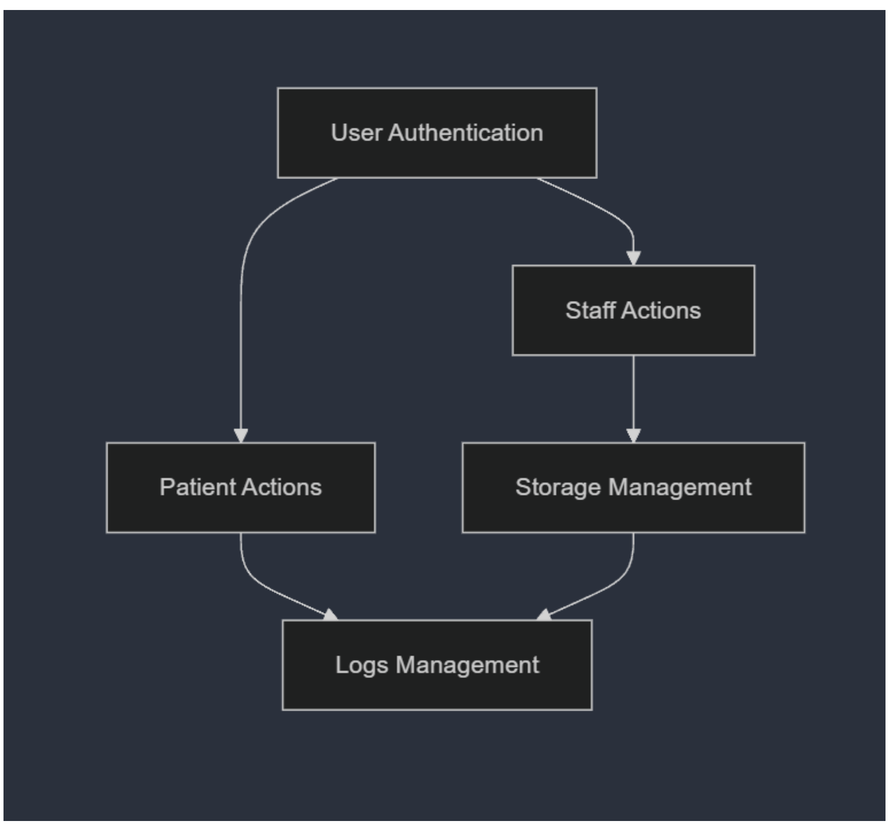


Figure 5 (General block diagram for interface)

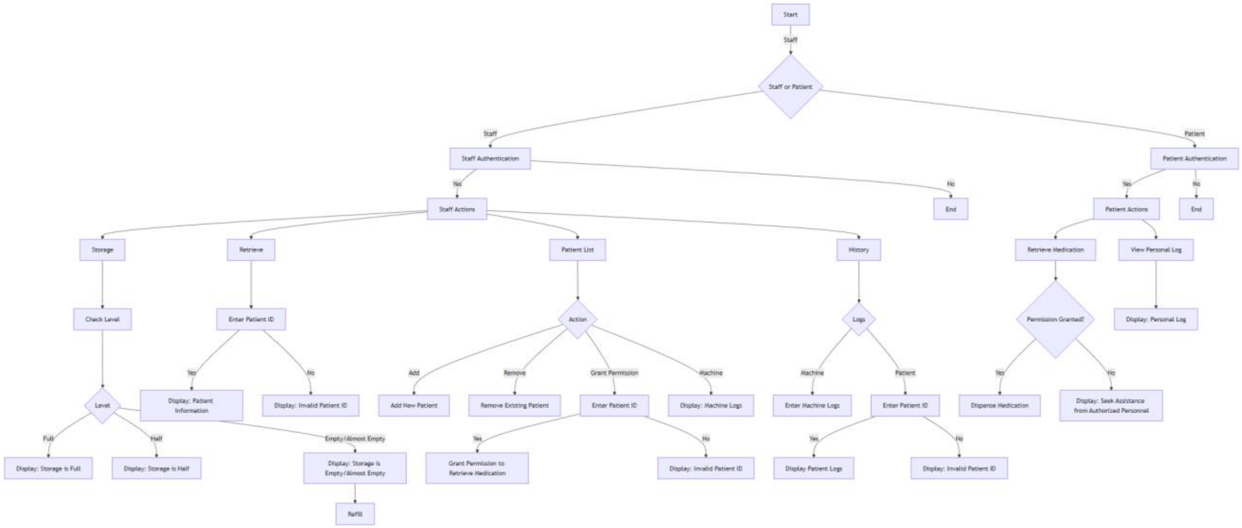


Figure 6 (Full block diagram for interface)

2.) <u>Block Description</u>

Start Block: Begins process flow

- Users select staff or patient

Staff or Patient decision: Directs flow based on user type (staff or patient)

- Ensures appropriate authentication and actions for each user role

Staff Authentication: Verifies staff credentials

- Prevents unauthorized access to staff functions
- Loops back if authentication fails

Staff Actions: Central hub for all staff capabilities

- Directs flow to storage, retrieve, patient list, and history functions

Storage: Allows staff to check medication storage levels

- Displays if storage is full, half-full, or almost empty
- Ability to refill storage if not full

Retrieve (staff): Allows staff to look up patient information

- Requires entering and verifying patient ID
- Displays patient details if ID is valid
- Loops back to re-enter ID is invalid

Patient List: Options to add patient, remove patient, or grant medication retrieval permission

- Adding/removing patients maintains up-to-date records
- Granting permission interfaces with patient Retrieve Medication block

History (staff): Provides a choice of machine logs or patient-specific logs

- Machine logs show the overall device history

- Patient logs require ID and only show entries for that patient
- Invalid patient ID loops back to the History block

Patient Authentication: Verifies patient credentials

- Prevents unauthorized access to patient functions
- Loops back if authentication fails

Patient Actions: Central hub for authenticated patients

- Routes to either Retrieve Medication or View Personal Log

Retrieve Medication (patient): Allows patient to request their medication

- Only dispenses if permission was granted by staff
- If there is no permission, display a message to seek staff assistance

View Personal Log: Shows history log for authenticated patient only

- Allows patients to review their medication retrieval record.

MySQL Block Diagram:

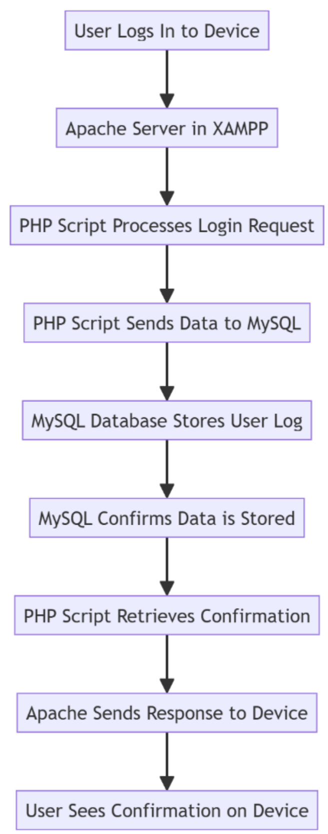


Figure 7 (MySQL Database and also a log tracking application)

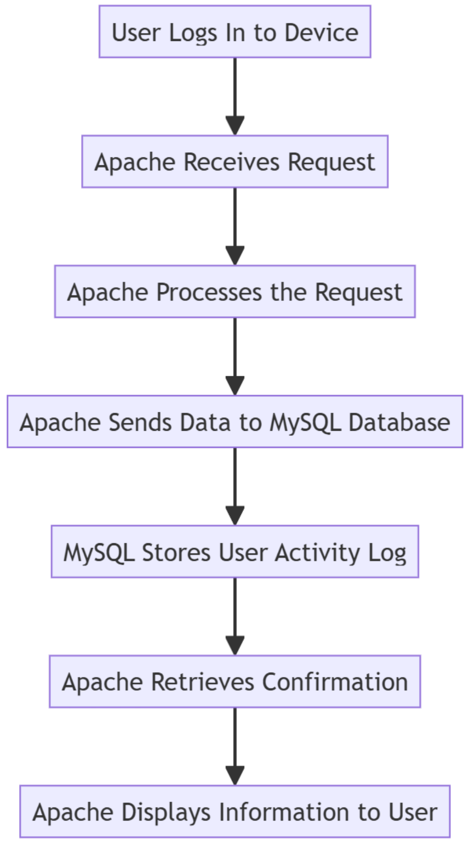


Figure 8 (Apache is used to send / retrieve data from MySQL database)

3.) Performance Requirement:
Dispensing Accuracy: 99.9% accuracy in dispensing the correct medication and dosage.

Response Time: < 500ms response time for user interface interactions and < 2 seconds for pill dispensing after authentication.

Motor Performance: Must operate efficiently between 50-100% of rated load with at max 2 pounds of weight.

Authentication Speed:

- Facial recognition: < 3 seconds
- Fingerprint scanning: < 1 second
- Number pad entry: < 5 seconds for complete code entry

Storage Capacity: Ability to store and manage 8 different types of medications simultaneously.

Battery Life: Minimum 24-hour battery backup in case of power outage. (Stretch Goal)

Remote Access Latency: < 2 seconds for authorized personnel to access and update medication schedules remotely. (Stretch Goal)

User Interface Responsiveness: Screen refresh rate of at least 30 Hz for smooth interactions.

Data Synchronization: < 5 minutes to fully sync medication schedules and dispensing history with cloud services.

Error Rate: < 0.1% error rate in overall system operation, including dispensing, scheduling, and user authentication.

Noise Level: < 40 dB noise level during operation to ensure quiet dispensing, especially for nighttime doses.

Environmental Tolerance: Operate effectively in temperatures ranging.

Power Systems:

The power system of the Automatic Pill Dispenser is a crucial component that requires careful planning to ensure reliable and efficient operation. The primary power source for the device is a universal AC power supply, typically a 120VAC wall outlet. However, to enhance reliability, a 24-hour battery backup system is envisioned as a stretch goal to provide continuous operation during power outages.

The device requires multiple voltage levels to power its various components. The Raspberry Pi 5, which serves as the central processing unit, operates on 5V DC and draws up to 3A, consuming around 10W. The motor systems, including stepper motors and servo motors, require 12V DC and 5V DC respectively, with current draws ranging from 1-2A per motor depending on the load. The 7-inch touchscreen display and other sensor systems also operate on 5V DC, with combined current draws of approximately 500mA.

To manage these power requirements, the system will incorporate step-down converters for voltage regulation and a power distribution board to ensure stable power supply to all components. Overcurrent protection, short circuit protection, and thermal management are also essential to prevent damage and maintain optimal performance. The estimated total continuous power draw during active operation is between 15-20W.

In terms of energy sources and longevity, the battery backup system, if implemented, should provide enough capacity to maintain critical functions for at least 24 hours. This would involve selecting batteries with appropriate Ah ratings, such as 5VDC 3AH or equivalent, to ensure the device remains operational during extended power outages.

The power management system must also include features like sleep, idle, and deep sleep modes to conserve power when the device is not in active use. Proper EMI filtering and power status monitoring are additional considerations to ensure the device operates reliably and efficiently.

Special Circuit:

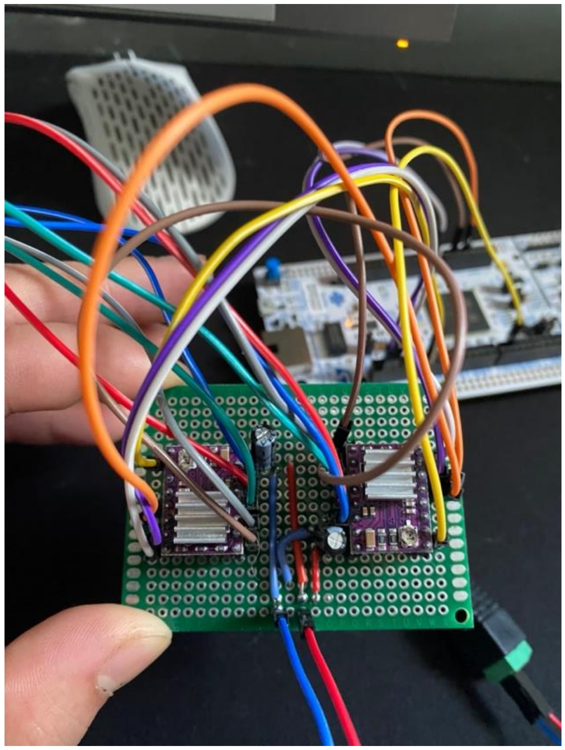


Figure 9 (DRV8825 Motor Driver Circuit)

Main Sub-systems:

- **Pill Dispenser**:
  - Mechanism: Motorized drop pivot system for accurate pill dispensing and conveyor belt for easy pick-up
  - Storage: Multiple compartments for different pill types and sizes

- **User Interface:**
  - Display: 7-inch touchscreen for user controls and information display

- **Security Features:**
  - Authentication: Facial recognition, fingerprint scanner, and keypad for restricted access
  - Authority Hierarchy: Different roles are granted different options

- **CPU and Processing Unit:**
  - Processor: Raspberry Pi 5 with ARM Cortex-A72, 64-bit quad-core processor
  - Clock Speed: Operates at 1.5 GHz

Physical Interfaces:

- **Connection Types:**
  - Wired: I2C, SPI for internal data transfer between components
  - Wireless: Bluetooth and Wi-Fi for device communication and remote access

Protocol Transport and Information Exchange:

- **Bluetooth and Wi-Fi:**
  - Purpose: Enable short-range communication and remote access features.

- **I2C/SPI:**
  - Utilized for: Internal communication between sensors, display modules, and peripheral components.

- **UART:**
  - Used for: Serial communication, potential Bluetooth integration, and debugging.

API for Interface Communications:

- **Commands Sent:**
  - Functions: Pill dispensing instructions, authentication requests, and medication schedule updates.

- **Commands Received:**
  - Feedback: Authentication responses, pill count updates, and activity logs.

- **Communication Method:**
  - Primary: Interrupt-based for quick response during interactions.
  - Secondary: Polling for background tasks like monitoring storage levels.

Physical Interfaces:

- Raspberry pi
- STM32 Microcontroller
- Fingerprint recognition
- Pin pad
- Facial Recognition

Mechanical Requirements:

- Stepper Motors
- Hobby Servo Motors
- Timing Belts
- Timing Pulleys
- Ball Bearings

Mechanical Stresses:

- The enclosure must withstand daily use and potential drops
- Vibration resistance for the pill dispensing mechanism
- Impact resistance for the outer casing
- Pill compartment stability with weight of motors

Motor Load Requirements:

- Precision stepper motors for the pill dispensing mechanism

- Motors must handle various pill sizes and weights

Overall System Weight/Size:

- Target weight < 4 kg for portability
- Even weight distribution to prevent tipping
- Project will fit within a 50 cm by 50 cm space

Electronics Packaging and Protections:

- IP54-rated enclosure for dust and splash resistance
- Proper ventilation to prevent overheating
- Shock-absorbing mounts for sensitive components

CPU Processing Requirements:
Processor Type and Architecture:

- Microcontroller: Raspberry Pi 5 known for its ARM Cortex-A72 architecture
- Cores: Quad-core processor
- Clock Speed: Operates at 1.5 GHz
- Bit Size: 64-bit architecture

Memory Specifications:

- RAM: Options for 2GB,4GB or GB of LPDDR4-3200 SDRAM to handle multitasking and complex processes
- **Storage:** MicroSD card for booting and data storage, supporting up to 128 GB or more
- Flash Memory: No built-in Flash, relying on external MicroSD for storage

Input/Output Interfaces:

- GPIO Requirements: Utilizes the Raspberry Pi's 40-Pin GPIO header for interfacing with peripheral devices such as motors, display modules, and user input components (e.g. keypad and sensors)
- ADC: Not available natively; an externa; ADC module can be used if needed for sensor inputs
- DAC: Can be implemented through external DAC modules or using PWM for audio alerts

Peripheral and Communication Needs:

- I2C/SPI: Utilized for communication with connected sensors, display, and peripheral components
- UART: Available for serial communication, potentially for Bluetooth integration or debugging
- USB Ports: Multiple USB 3.0 and 2.0 ports for connecting external devices or communication interfaces
- Ethernet and Wireless Communication: Built-in Gigabit Ethernet and 802.11ac Wi-Fi for network connectivity

Additional Features:

- Timers and PWM channels: available for controlling motors and generating signals for alarms
- HDMI and Audio Outputs: Dual micro-HDMI for display needs and 3.5mm jack for audio alerts

Verification

Tolerance Analysis:

- To ensure optimal system performance, comprehensive testing will be conducted across the full range of operational tolerances for the motor, Raspberry Pi, and TMC boards and motors. The goal is to achieve a fast response time that meets or exceeds our target.

Testing Procedures:

- Component Testing: Each component will be tested individually to ensure it functions correctly. This includes measuring the motor's torque and speed under load, testing the Raspberry Pi for processing speed and connectivity with other components and assessing STM32 boards and motors for their response under various voltage conditions.
- Integration Testing: After individual checks, all components will be integrated to evaluate how they work together. This involves running simulations to see how each part communicates and responds within the system.
- Real-World Scenarios: We will conduct tests in real-world conditions to assess performance in practical applications, including the timed dispensing of pills to evaluate speed and efficiency.

Performance Metrics:

- Response Time: The time taken from user input (button press) to action (pill dispensing), measured in seconds.
- Throughput: The number of pills dispensed in a given time period.
- Error Rate: The frequency of errors during dispensing, such as jams or misfeeds.
- User Interface Response: The delay between user interactions and the system's visual feedback.

Worst-Case Scenario Testing:

- We will also test worst-case scenarios by simulating delays in the dispensing mechanism and artificially inducing delays in the user interface response. This includes slow pill dispensing, delayed user interface response, and running tests that combine both slow dispensing and delayed interface response to assess how the overall system handles multiple stress factors simultaneously.

Demonstration

Demo 1:

What was planned?

This demo we planned to show how pills are dispensed and stored using a step motor to control the dispensing mechanism. The audience would be able to choose which pill and how many pills to dispense. The technical aspects included 3D design, motorized drop pivot system, as well as the storage compartments. One of the stretch goals that we were aiming for was to integrate an XY grid that would be able to transport the pills from the dispense location to the retrieve location.

What were the measurable outcomes?
The main measurement of success for this demo was the ability to dispense the correct type of pill and amount. We also would like to see the efficiency of motors, the storage capacity and fluidity of the dispensing.

Did the Demo show positive results? If not, why?
The demo did show positive as well as negative results. The positive was that during our demonstration our code implementation was functional and worked as intended, we were able to select the correct motor, pill, and amount of pill. The negative of the demonstration was that the dispensing was not accurate due to the jamming of pills and ultimately the degrading condition of the motor stem mount, which resulted in a loose rotation of the dispensing pocket.

Demo 2:

What was planned?
For this demo, we plan on demonstrating our UI using our 7-inch touchscreen LCD that incorporates a Raspberry Pi 5 as the brains. This demo will be an extension to our first demo as we are transitioning our terminal to the LCD and implementing a number pad application to access the terminal.

What is the measure of success for this demo?
For this demo, we want the touchscreen interface to respond accurately and consistently upon user input. We also want the terminal to be displayed correctly on the LCD when in use.

Demo 3:

What was planned?
For this demo, we will be demonstrating how the authentication device communicates with XAMPP, Apache, and our MySQL server to create users and data logs. The goal is to ensure that the authentication system properly registers user interactions and stores them in the database. We also want to verify that the admin has the ability to create user profiles and view logs.

What is the measure of success for this demo?
The demonstration will be considered successful if:

- When a user is authenticated using fingerprint or face recognition, a log entry is created in our MySQL server.
- Only the admin can access and view all the logs.
- Only the admin has the ability to create user profiles.

Once the user profile is created, they should be able to log in smoothly using fingerprint or facial recognition. After authentication, the system should allow them to request their prescribed pills. The request is then processed, and the dispensing mechanism releases the correct medication while creating a log entry in the MySQL server.

Final Demo:

For our final demonstration we plan to implement all 3 demonstrations into one, creating a device that utilizes all implementation seamlessly without flaws. An automated pill dispenser that is not only efficient in pill delivery, but also user-friendly and practical. Our device will be able to hold 8 different types of medications and be able to dispense each one accurately. This is controlled via 4 motors each responsible for 2 types of pills. The pills being dispensed will be dropped onto a conveyor belt that will only move when the number of pills are equal to the amount requested. The delivery of the medication is efficient as it allows for users to quickly retrieve their medication with just a few simple taps.

Dr. Pill will be able to be controlled via a touchscreen device with an intuitive interface. User Interface should show a unique display with various kinds of input options. We have three unique user inputs: admin, staff, and patient; all of them having different options based on who is using the device. An example is admins can refill the pill dispenser, staff are able to retrieve pills as well as add/remove patient from the database, and patients are able to view their personal history and retrieve their pills.

Our device also utilizes a MySQL server to manage user authentication and pill dispensing records. Once a user is authenticated, they should be able to request their prescribed pills, which will then be dispensed by the system. Each dispensing action will be recorded in our MySQL server, ensuring that all transactions are logged for tracking and security purposes.

Additionally, the logs will include images of the dispensed pills captured by our object recognition device. This feature provides an added layer of verification, allowing admins to review the dispensing history and confirm that the correct medication was delivered to the user. These logs will be accessible only to the admin, maintaining data security while ensuring transparency in the system's operations.

Cost

Assuming a dream salary of $50/hour for each team member and an estimated 300 hours of work per person:

Labor Cost

Team Member	Calculation	Total
Jonathan Cerniaz	$50 x 2.5 x 300	$37,500
Jehmel Espiritu	$50 x 2.5 x 300	$37,500
Jeremy Espiritu	$50 x 2.5 x 300	$37,500
Joseph Guzman	$50 x 2.5 x 300	$37,500
Afzal Hakim	$50 x 2.5 x 300	$37,500
Lee Roger Ordinario	$50 x 2.5 x 300	$37,500

Total Labor Cost: $225,000

Parts Costs (Estimate)

Component	Estimated Cost	Availability	Lead Time	Source
Raspberry Pi 5	$80	High	1-2weeks	CanaKit
7'' Touch Screen Display	$35.99	Medium	2-3 weeks	Amazon
Wood	~$20	High	1 week	Home Depot
Pill Compartments	$23.99	Custom	3-4 weeks	3D Printing/Amazon

120W Universal Power Supply	$26.99	High	1 week	Amazon
Camera Module 2	~$30	High	1 week	Amazon
Adafruit Fingerprint Scanner	~$75	High	1 week	Home Depot, Amazon
RaspberryPi Fan	~$75	High	1 week	Amazon, DigiKey
pixy2 Sensors	$69.90	High	1 week	Amazon
MicroSD	~$20	High	2 weeks	Amazon, DigiKey
Motor Driver				
USB C Power Supply	$11.99	High	1 week	Amazon
STM32 Microcontroller	$10.98	High	1-2 weeks	ElectroMaker
Other (wires, capacitors, adapters, etc.)	~$20	High	2 weeks	Amazon, DigiKey

Total Parts Cost (Estimate): $489.84

Grand Total: $225,489.84

Subsystem Demonstration

1. ***Subsystem 1: Dispensing Mechanism and Storage - Precise Pill Dispensing System***

   Description:
   This subsystem ensures accurate storage and dispensing of pills through a motor pivot system.

   Function:
   To store and retrieve pills efficiently and accurately based on user requests.

   Goals:
   - Validate that the storage system securely holds pills.
   - Ensure smooth mechanical operation without jams.

   Validation:
   Test dispensing with various pill sizes and shapes, ensuring alignment with user input and successful delivery.

2. ***Subsystem 2: Display User Interface - Interactive Touchscreen Interface***

   Description:
   The touchscreen UI provides users with an intuitive interface for interacting with the pill dispenser.

   Function:

To enable users to input requests, confirm actions, and view logs or device status seamlessly.

Goals:
- Validate responsiveness and accuracy of touch controls.
- Test integration with backend systems including the dispensing mechanism and MySQL in a future demo.
- Ensure user-friendly navigation and clear feedback.

Validation:
Perform multiple user tests to confirm touch accuracy, app flow clarity, and seamless connectivity with other subsystems.

3. *Subsystem 3: Authentication System - Secure Access and Logging System*

Description:
This subsystem secures user interactions via fingerprint scanning and facial recognition, logging all actions in the database.

Function:
To prevent unauthorized access and maintain a log of all user interactions with the system.

Goals:
- Validate that fingerprint and facial recognition systems authenticate accurately.
- Confirm proper logging of interactions in the MySQL database.
- Test that unauthorized access attempts are blocked.

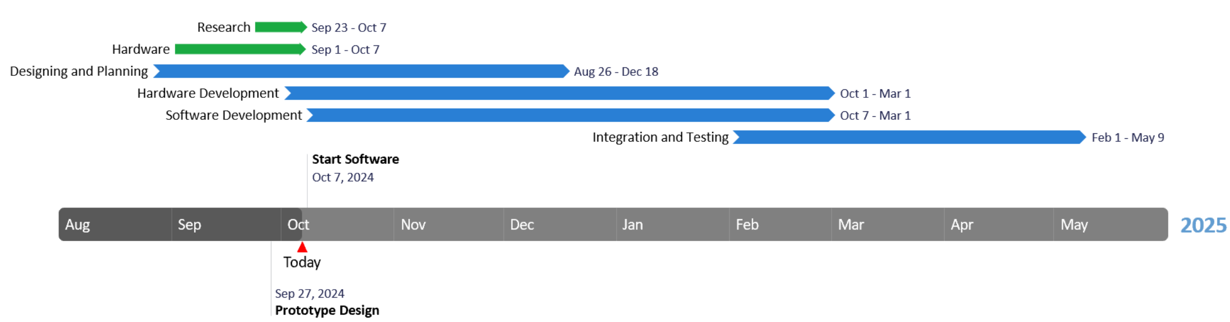
Validation:
Conduct tests with multiple users, ensuring high success rates in authentication and verifying that logs are stored correctly for each action.

Schedule

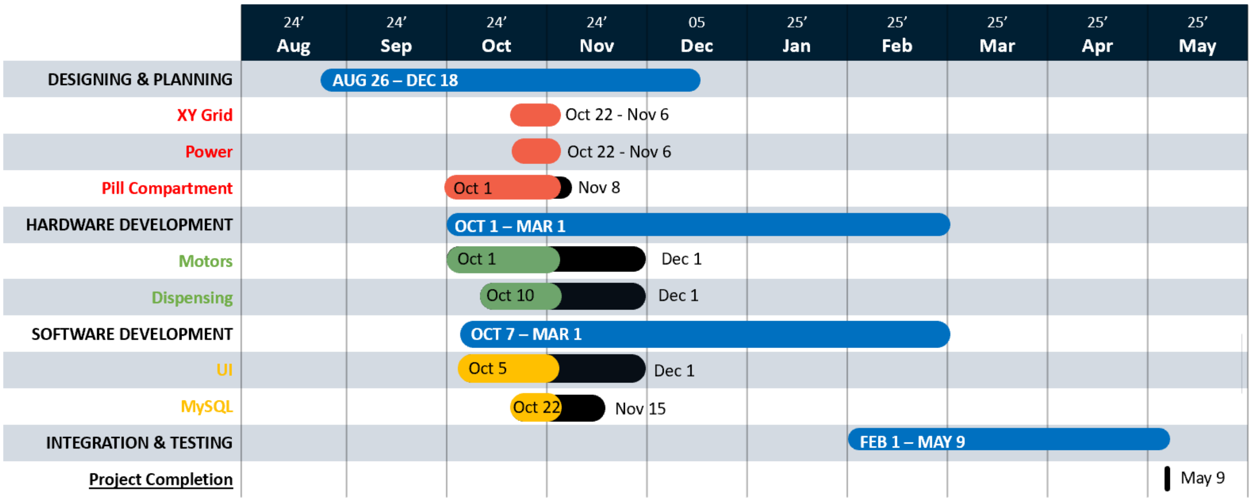
This table overviews the planned project timeline, highlighting the major phases and their corresponding dates. It includes key milestones like the completion of our prototype design and the start of facial recognition development. The integration and testing phase overlaps with the end of the development phase, allowing for a smooth transition between these stages. Below our table is a timeline version of the general phases and current progress from our table.

Phase	Start Date	End Date	Key Activities
Research & Planning	Aug 26, 2024	Oct 7, 2024	• Complete prototype design (Sep 27th) • Pill Storage Mechanism (Sep 17th)

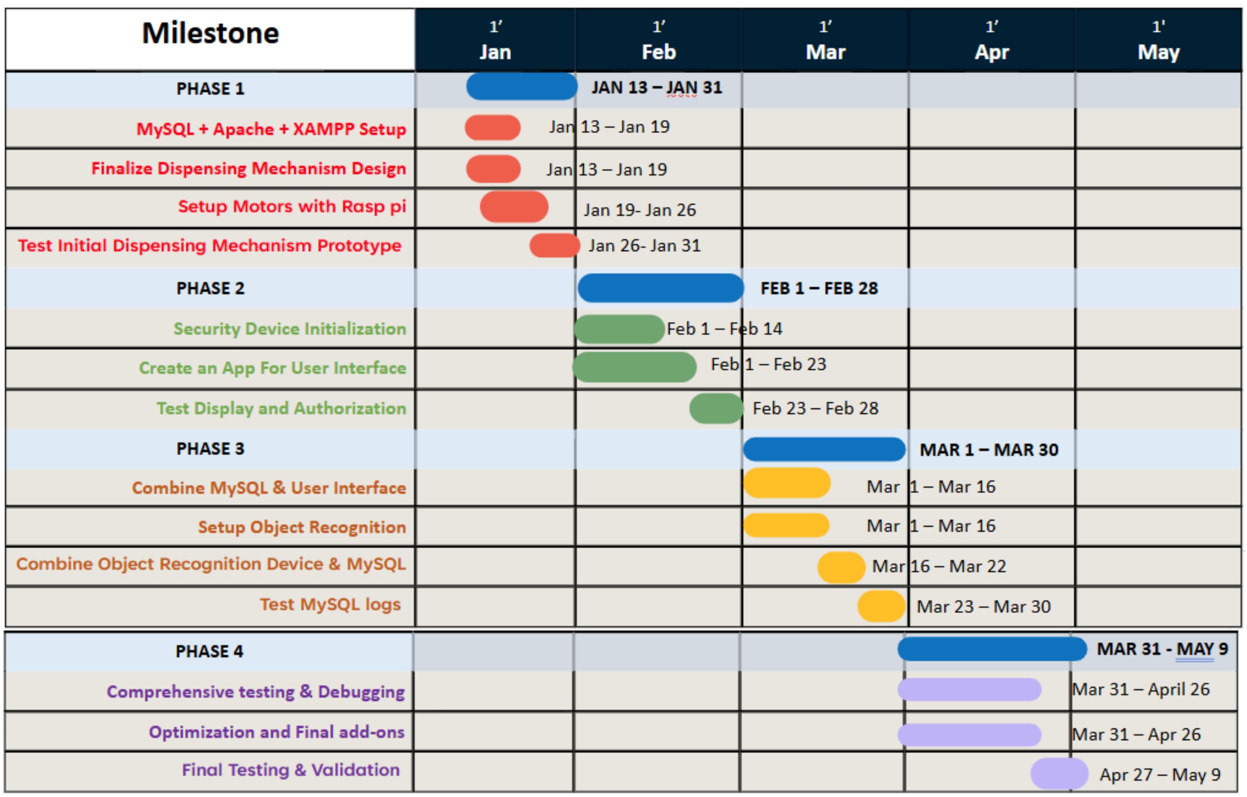
			• Power Supply and Estimate (Oct 22nd - Nov 4th) • Pill Compartment Measurements (Nov 10th)
Hardware Development	Oct 1, 2024	Mar 1, 2025	• User Interface Hardware Integration (Mid-Dec) • Order and test initial components (Nov 30th) • Security Hardware Implementation (Dec 30th) • Motor control system (Dec 30th) • Connectivity and Remote Access (Jan 2025) • Final Hardware Assembly and Security Testing (Feb 2025)
Software development	Oct 1, 2024	Mar 1, 2025	• Start Software Development (Oct 7th) • UI Development (Nov) • Security Features Implementation (Jan 2025) • Dispense History and Tracking System (Feb 2025) • Software Completion and Integration (Mar 1, 2025)
Integration & Testing	Feb 1, 2025	May 9, 2025	• Initial integration • Comprehensive testing • Refinement and final testing
Project Completion	May 9, 2025	May 9, 2025	• Preparation for expo • Final demonstration



Timeline 1 (Blue = plan for phases; Green = Progress)



Timeline 2 (Blue = plan for phases; Colored = current topics in progress; Black = deadline)



Timeline 3 (Blue = plan for phases; Colored = start and end by date)

Schedule Plan for Spring 2025

Phase	Start Date	End Date	Key Activities
MySQL + Apache + XAMPP Setup	Jan 13	Jan 19	Connecting MySQL to Appache software and setup altogether in Xampp software

Finalize Dispensing Mechanism Design	Jan 13	Jan 19	Design and finalize dispensing layout.
Setup Motors with Rasp pi	Jan 19	Jan 26	Configure and program motors for dispensing.
Test Initial Prototype	Jan 26	Jan 31	Test the initial dispensing functionality.
Security Device (Fingerprint + Facial Recognition)	Feb 1	Feb 14	Integrate security authentication features.
Creation of App for UI	Feb 1	Feb 23	Develop the application interface for user interaction.
Setup Touchscreen Display UI	Feb 16	Feb 23	Configure and design the touchscreen interface.
Motor Setup for Dispensing	Feb 17	Feb 23	Program and test motor control for dispensing.
Test Display UI and Security Device	Feb 23	Feb 28	Validate the display functionality and security integration.
Combine MySQL and UI	Mar 1	Mar 16	Link the database with the user interface.
Object Recognition Integration	Mar 1	Mar 16	Implement and test object detection features.
Combine Object Recognition and MySQL	Mar 16	Mar 22	Link object recognition with database functionality.
Test MySQL log tracking	Mar 23	Mar 30	Verify accurate data logging and retrieval.
Comprehensive Testing	Mar 31	Apr 26	Test all system components together.
Optimization + Final add-ons	Mar 31	Apr 26	Fine-tune the system and add extra features if necessary.
Final Testing & Validation	Apr 27	May 9	Conduct final checks to ensure system functionality and reliability.

As of the current date, the project is progressing according to schedule Timeline 2. It provides a detailed breakdown of the project phases, key activities, and deadlines for the Dr. Pill project. The blue bars represent the planned phases, showing the expected duration of each task. The colored bars indicate the current tasks in progress, allowing us to track real-time progress. Finally, the black markers represent critical deadlines for each task or phase. Timeline 3 outlines our planned schedule for the next semester, including the start and end dates for each phase to ensure the project is completed on time.

- The Designing & Planning phase (August 26 – December 18) is currently ongoing, with specific focus on the development of the XY Grid and Power System, both of which are scheduled to be completed by November 6. The design of the Pill Compartment is also in progress and is expected to be finalized by November 8.

- The Hardware Development phase (October 1 – March 1) has already started, with work on the motors and dispensing mechanisms. Both are expected to be completed by December 1.

- The Software Development phase (October 7 – March 1) has also begun, with work on the user interface (UI) and MySQL database integration. The UI is expected to be completed by December 1, while MySQL integration should be finished by November 15.

- The Integration & Testing phase will begin on February 1, overlapping with the final stages of hardware and software development. This phase will run until May 9, when the project is expected to be fully completed.

- Object Recognition Integration (March 1 – March 16): Implement and test object detection features to ensure accurate identification of pills.

- Combine Object Recognition and MySQL (March 16 – March 22): Link object recognition capabilities with the database for seamless data handling.

- Test MySQL Log Tracking (March 23 – March 30): Validate the accuracy of data logging and retrieval functionalities within the system.

- Comprehensive Testing (March 31 – April 26): Perform integrated testing of all system components to confirm proper functionality and interactions.

- Optimization + Final Add-ons (March 31 – April 26): Refine the system and incorporate additional features as needed to enhance functionality.

- Final Testing & Validation (April 27 – May 9): Conduct thorough final checks to ensure the system is reliable, functional, and ready for deployment.

Technical Data

Current 3D Design Prototype:

Figure 9 (Front Interface)

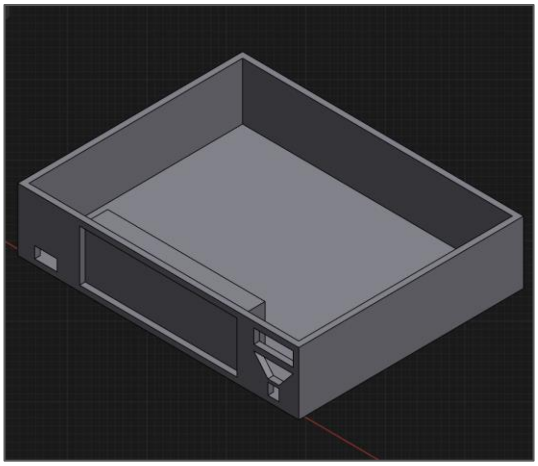


Figure 10 (Top View)

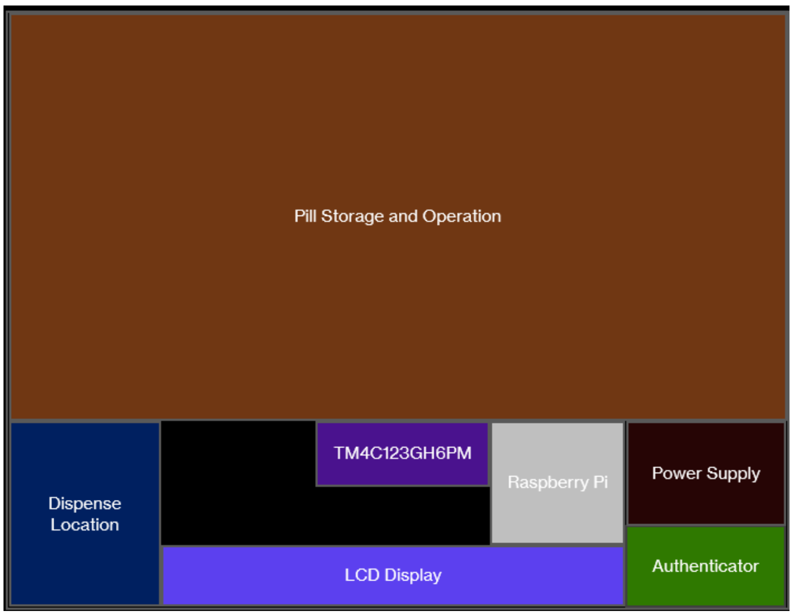


Figure 13 (1st Blueprint Layout)

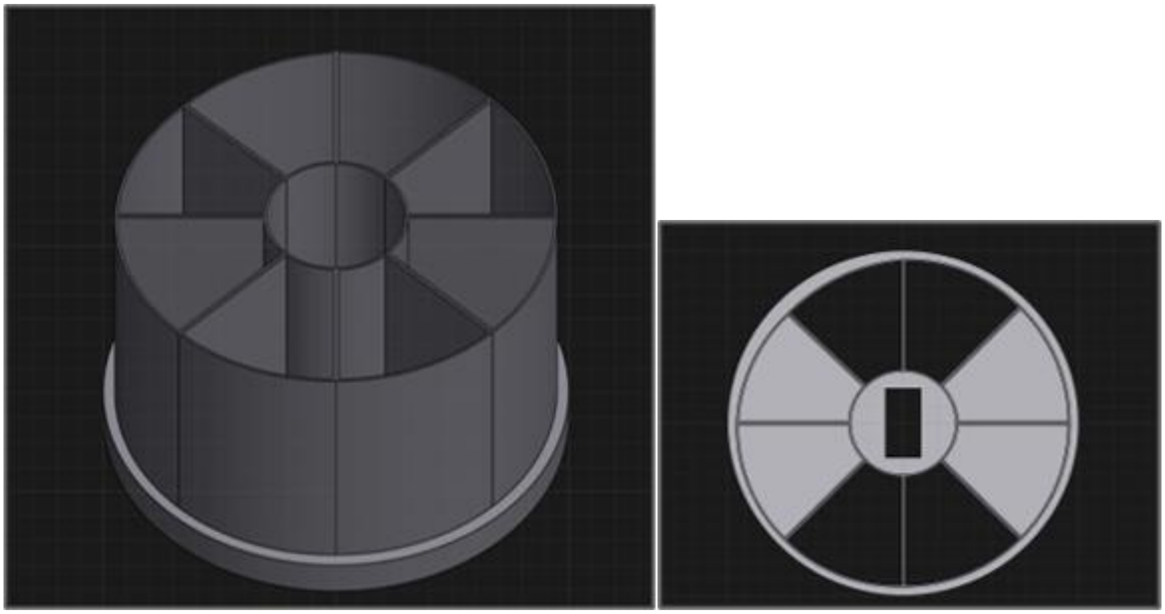


Figure 14 & 15 (Dispense Mechanism for motor)

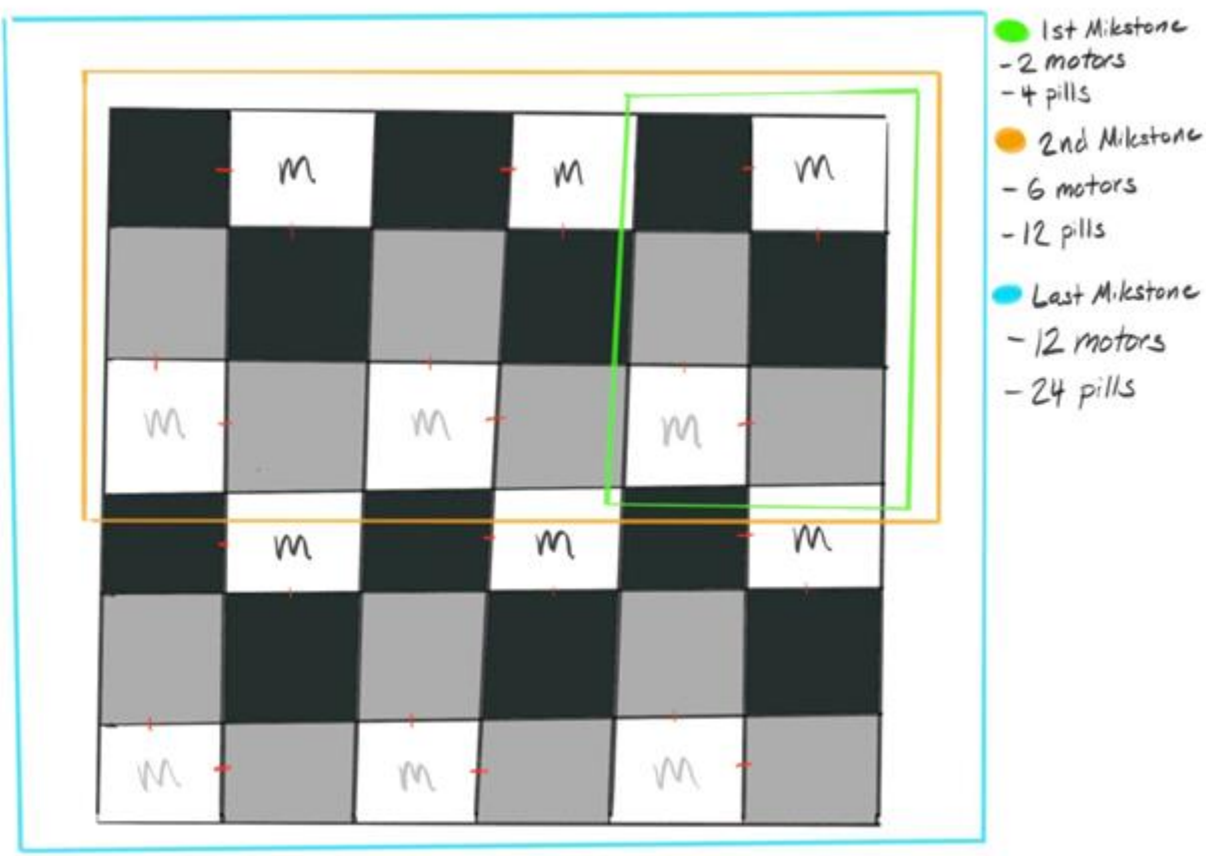


Figure 16 (Grid system for transporting dispensed medication)

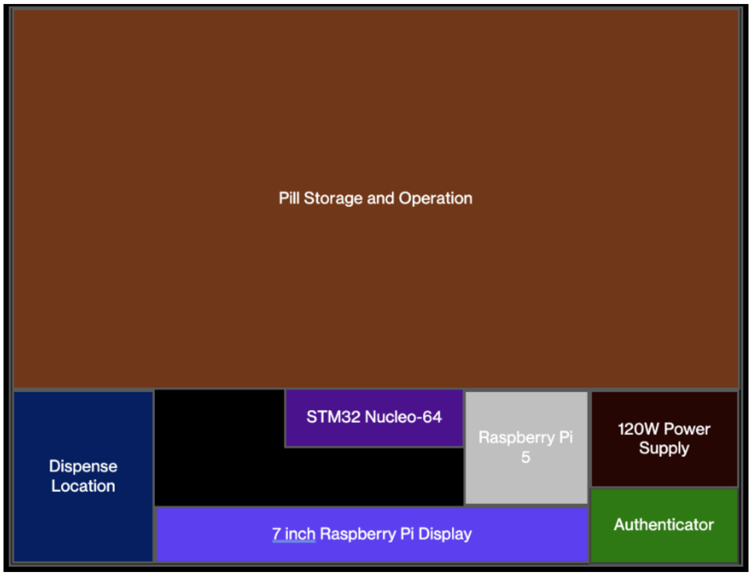


Figure 17 (2nd Blueprint Layout)

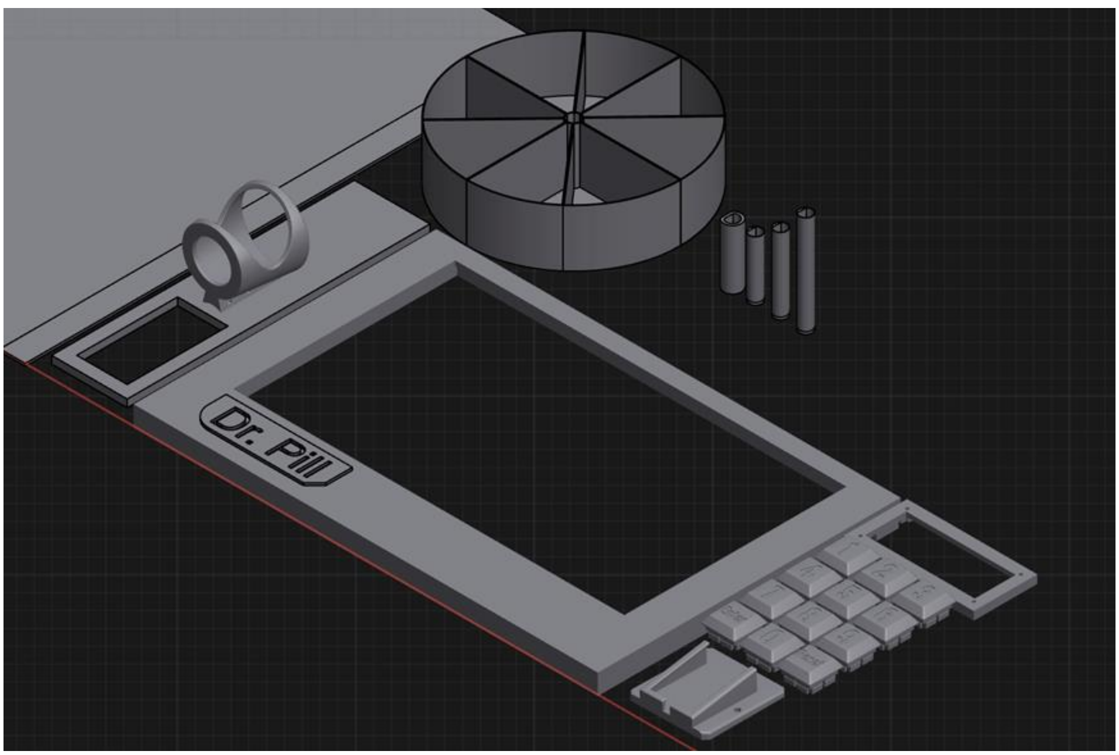


Figure 18 (Front Plate Design and Motor Dispense Mount)

Figure 19 (7" LCD Touchscreen Display)

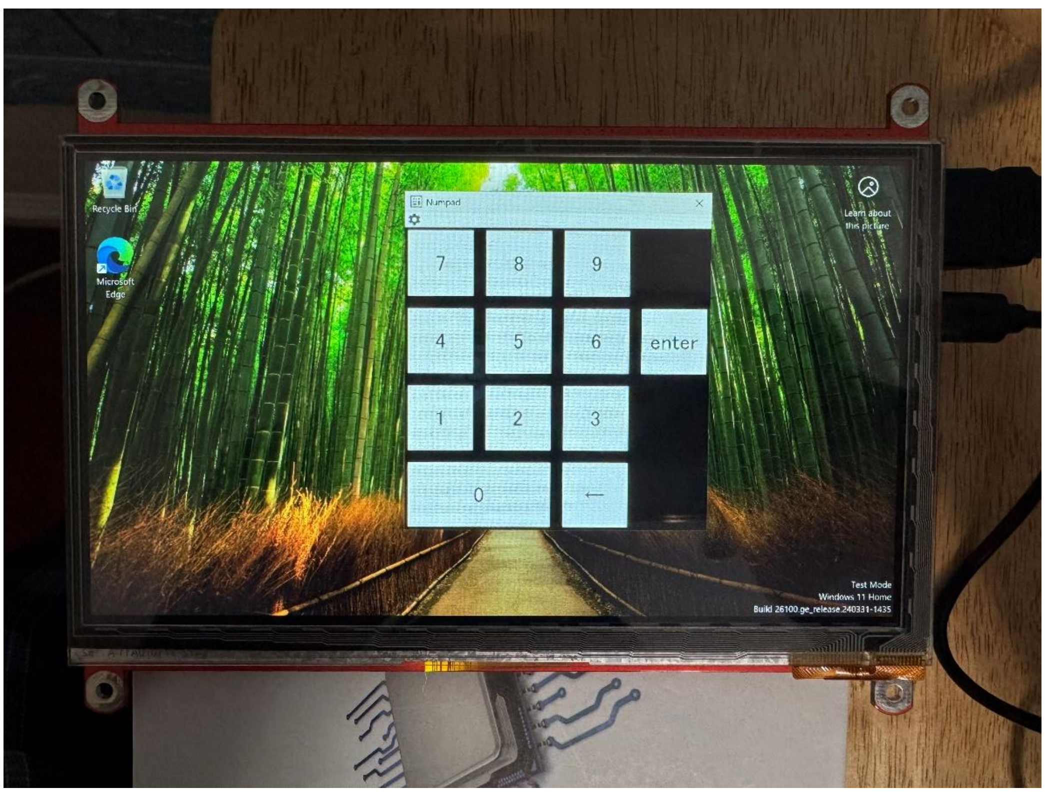


Figure 20 (Numpad Application)

Figure 21 (Demonstration 1 Build)

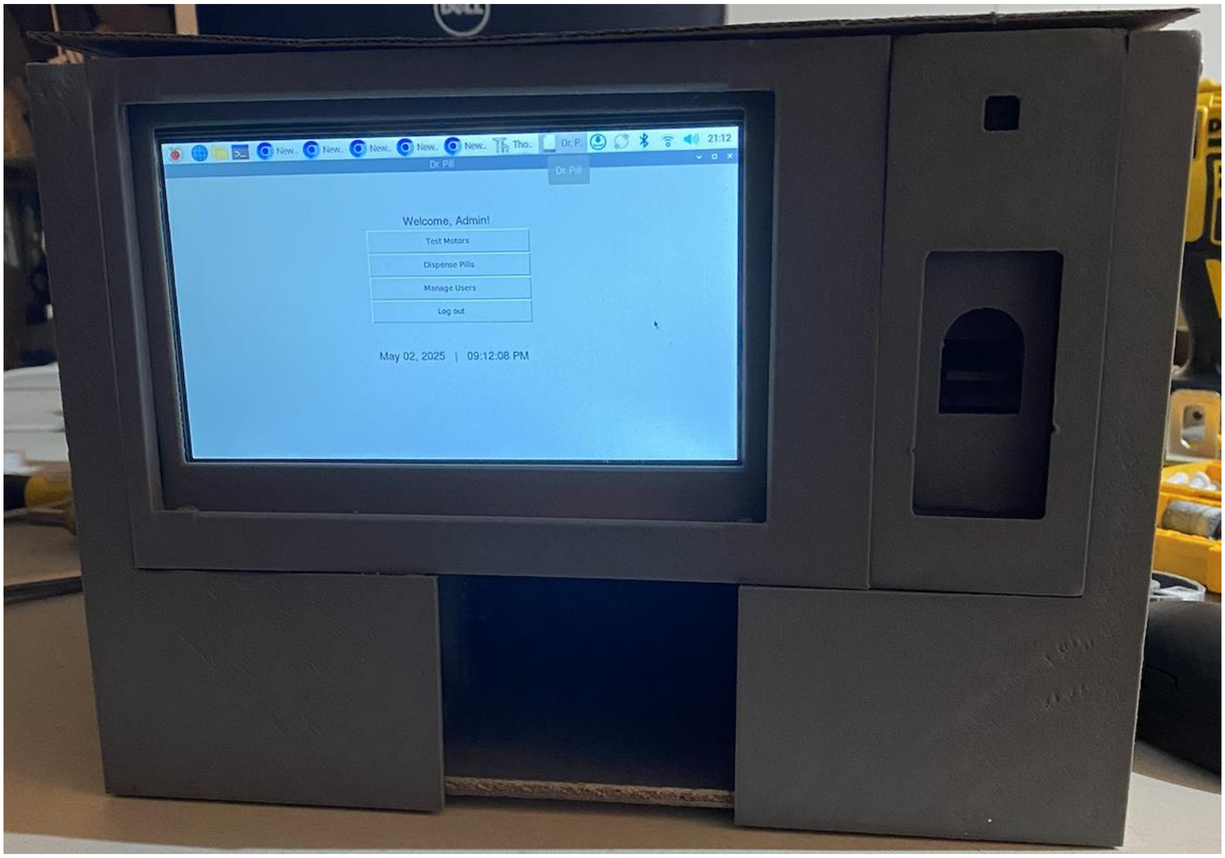


Figure 22 (Front View of Dr. Pill)

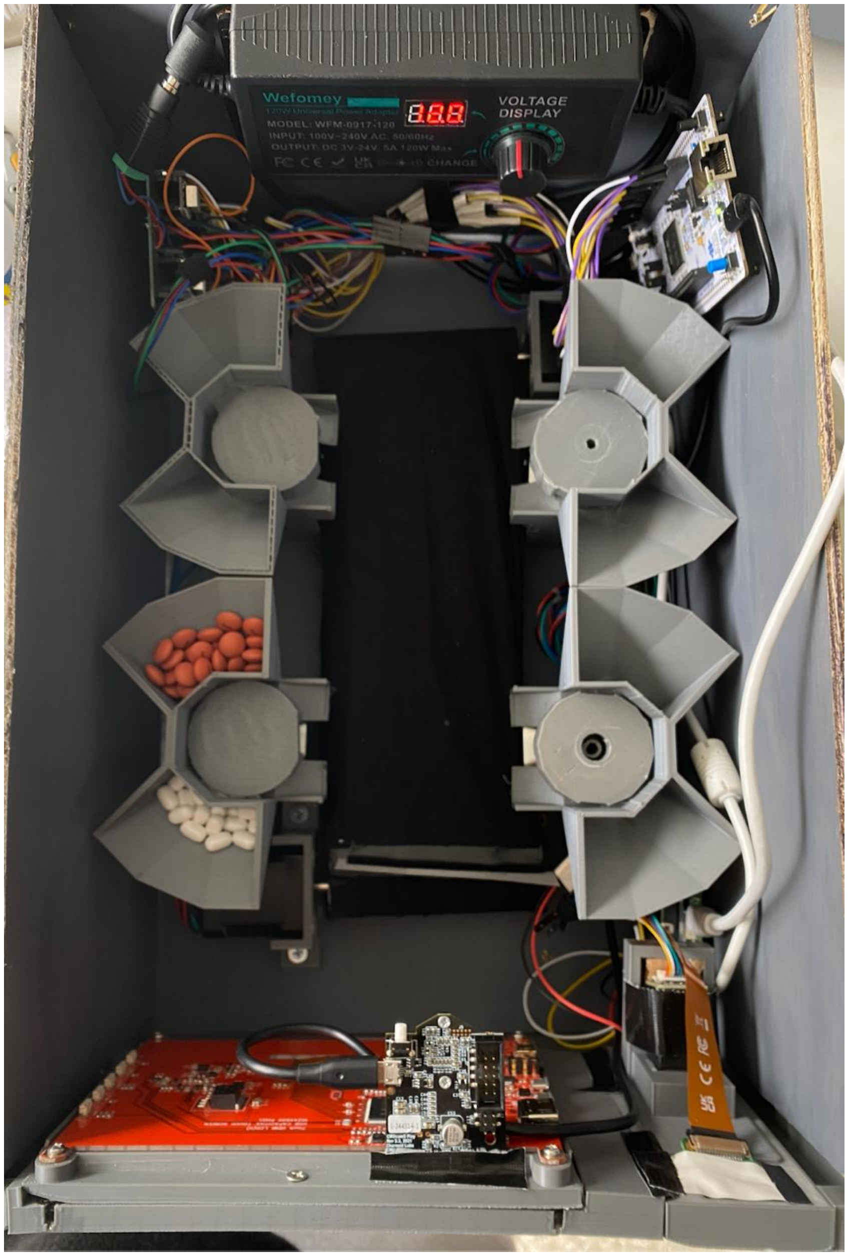


Figure 23 (Top View of Dr. Pill)

Schematics: N/A
Repository: GitHub

Significant Challenges and Solutions

One of the significant challenges we encountered during the design process of Dr. Pill was achieving precise, single pill dispensing across various medication types and sizes. To address this, we are attempting to implement an XY grid system to transport pills, which helps minimize the risk of cross-contamination by keeping different medications separated throughout the dispensing process. This is only to cover a wide variety of pills, so a conveyor may suffice if we work on a smaller scale. Additionally, we switched from using a TMC microcontroller to an STM32 microcontroller because it is easier to use and implement, providing us with more flexibility in integrating various system components.

However, we are still working on solving the problem of pills getting stuck during dispensing. This issue could be caused by pill shape or size, so we are considering different mechanical solutions such as vibration mechanisms or angled chutes to prevent jamming. Another concern is the temperature regulation within the dispenser, as excessive heat could damage certain medications or cause them to degrade faster. We also need to account for the risk of pills being crushed or producing excess powder during dispensing, which could lead to contamination or inaccurate doses.

In terms of power management, we decided on using a universal power supply with adjustable voltage settings, paired with step-down converters to regulate power for different components like motors and sensors. We are also considering adding a backup battery for uninterrupted operation in case of power outages. To conserve power and enhance efficiency, we plan to implement sleep modes, including idle and deep sleep modes, ensuring that components only draw power when necessary. This will help reduce overall energy consumption and extend the lifespan of our system.

Our dispensing mechanism, we ran into multiple problems. List: space management, motor weight load, 3d print sizing.

The dispensing mechanism encountered several significant challenges that required adjustments. Regarding space management, the primary issue stemmed from limited room for component placement, leading to overcrowding and potential interference between moving parts. A solution we came up with for better space utilization is to create stackable components. The motor weight load presented another crucial challenge, as excessive strain on the motor resulted in reduced efficiency and potential performance issues. Upgrading to higher torque motors or considering a dual motor setup could also effectively distribute the load, though this would need to be balanced against space constraints and power requirements. Lastly, the 3D printing sizing issues became troublesome, with concerns about dimensional accuracy, warping, and structural integrity. The use of stronger materials like PETG or ABS for critical components, along with implementing reinforcement structures could be a possible solution.

During Demo 1, our dispensing mechanism ran into issues. The pill delivery was not smooth, and the number of pills dispensed was inaccurate. To resolve this, we are making changes to the design and the stability of our motor mounts to achieve precise delivery. Using our object recognition device, we can also confirm the exact number of pills dispensed, ensuring accuracy and reducing errors. Additionally, we are addressing previous concerns such as space management, motor weight load, and 3D print sizing. Limited space led to component overcrowding, so we are exploring stackable designs to optimize placement. The weight load on the motor affected efficiency, requiring further adjustments.

Another issue we encountered was in the communication between our MySQL server and the biometric and facial recognition device. While the server successfully receives the signal from the device, it does not respond back. We want the server to communicate confirmation that the user has logged in and to create a log entry for tracking purposes. So far, the connection between Apache, MySQL, and XAMPP is functioning smoothly, but the response from the MySQL server to the device is not working as expected. We are currently troubleshooting this issue and expect to resolve it soon by thoroughly checking all connections to ensure a smooth, responsive system.

Stretch Goals

In addition to a remote access capability to authorized personnel (doctors, physicians, caretakers), that allows them to access the device without having to be there physically, we also have some bigger goals in mind that we can add in the future.

Mobile App

- Medication Logging and Tracking
- Smart Reminders and Alerts
- Prescription Renewal Reminders
- Medication Identifier
- Drug Interaction Checker

Modular / Portable

- Could be designed with modularity in mind, allowing for easy transportation.
- Can include features like a battery backup for power outages or travel.

Project Follow On

Based on the information we saw when researching our project appears to have potential for commercialization of the Dr. Pill automatic pill dispenser project beyond the senior project stage. Here are some key points that support this:

Technological Advancements:

- The industry is seeing constant technological developments to improve the efficacy of automatic pill dispensers. Dr. Pill's innovative features could potentially give it a competitive edge in this evolving market.

Home Healthcare Trend:

- There's a growing trend towards home healthcare solutions, which aligns well with Dr. Pill's design for personal use.

Mobile App Integration:

- Developing a companion mobile app for Dr. Pill could tap into the growing trend of health management apps and wearable technology integration.

Given these factors, there seems to be a strong potential for commercializing Dr. Pill beyond the senior project. However, to successfully bring it to market, you would need to consider factors such as regulatory compliance, manufacturing scalability, distribution channels, and ongoing product development to stay competitive in this rapidly evolving market.

Project Ethical Concerns

Patient knowledge and understanding: Since our device does aim to innovate the pill dispenser industry, consumers will be out of the loop and need to be taught the new functionalities of the device. Ensure that they are well-informed and capable of using the device properly and with ease. This can pose challenges, specifically with the elderly as they might not be familiar with the technology, causing more problems for them.

Privacy and Confidentiality:

- Our device will have access to a large array of data of the patients' information which will be kept confidential. This data will contain their medical history, which only authorized personnel should be able to access. We will have to ensure that only authorized personnel can see patients' information as well as the patient being able to view their own.

Removal of human interaction between patients and their physicians:

- The creation of this device aims to facilitate medication management but can also eliminate the need for patients to interact with their designated physicians. Obvious problems could sprout from this as automated pill dispensers can potentially erode the personal relationship and trust between patients and doctors. Open communication is important to maintain a strong relationship between the patient and physician even with Dr. Pill.

Device accuracy and dependability:

- We will ensure that our device is safe and ready to use, without the concern of malfunctioning. Any malfunctions or inaccuracies pose health risks. To catch malfunctions and alert the user along with authorized personnel we must implement multiple fail-safe mechanisms.

Intellectual Property

What makes our concept unique is that we aim to modernize the look and improve the functionality of pill dispensers. We find that existing pill dispensers are outdated and although they are 'automatic' and 'smart,' they still heavily rely on human intervention and manual operation. Dr. Pill will incorporate advanced technology to facilitate the process of daily medication use.

Patentable Ideas: N/A

Other devices/products that share similarities:

- Live Fine Automatic Pill Dispenser
- Hero Smart Dispenser
- MedReady Automatic Pill Dispenser

Future Path Implementation

In the future if we were to continue the implementation of 'Dr. Pill, The Automatic Pill Dispenser' we have many concerns and expected paths to resolution. Because our implementation is not complete, we can continue improving the functionality of a series of modules of our project. The main issue that we would focus on would be object recognition and having it control the movement of our motors, as this would greatly improve our module for our dispensing mechanism. In terms of our enclosure, we will aim to improve the build of the enclosure and make it more permanent as the existing 3D build, and wood is not perfect and could be improvement. This would be our next major step for implementation, and we would then continue to further improve our device accordingly.

Appendix

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