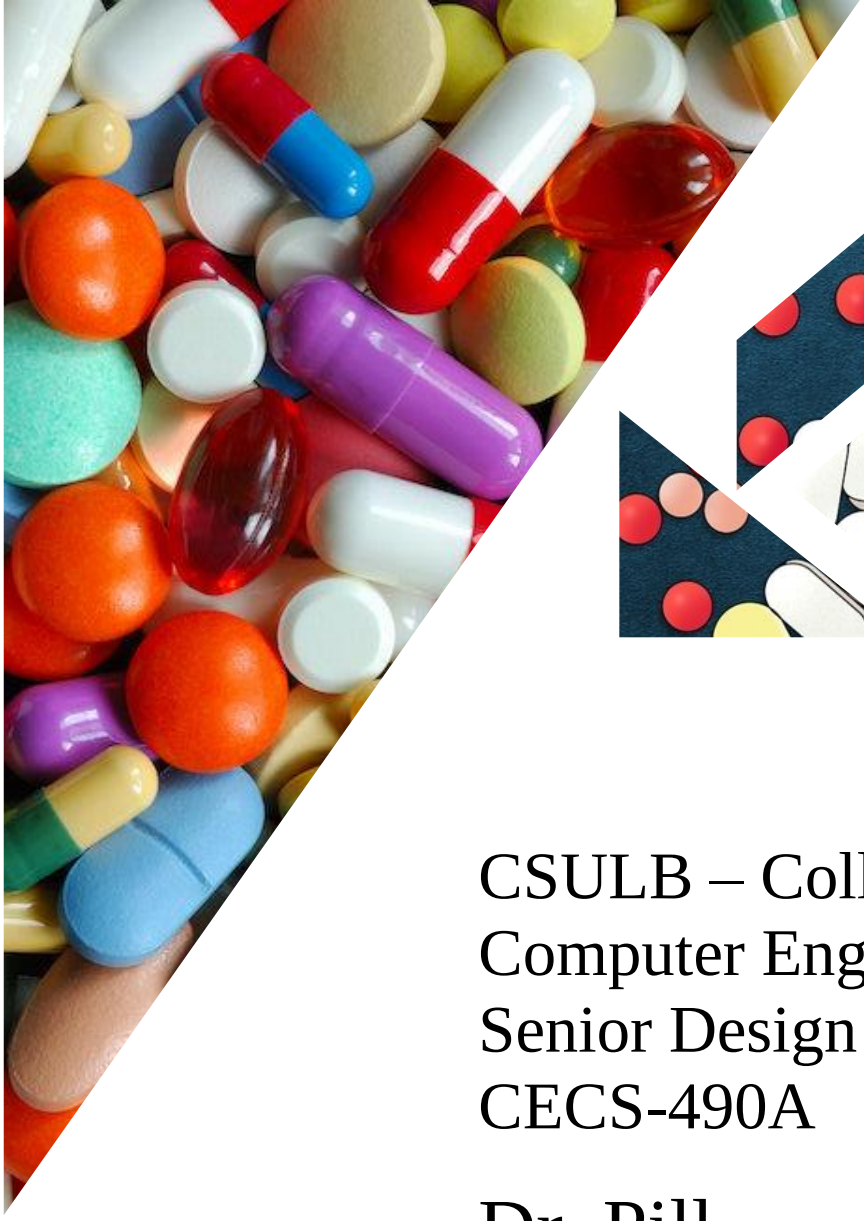

CSULB – College of Engineering
Computer Engineering
Senior Design Project
CECS-490A

Dr. Pill

Jonathan Cerniaz
Jehmel Espiritu
Jeremy Espiritu
Joseph Guzman
Afzal Hakim
Lee Roger Ordinario

Prof:
Dan Cregg

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Executive Summary

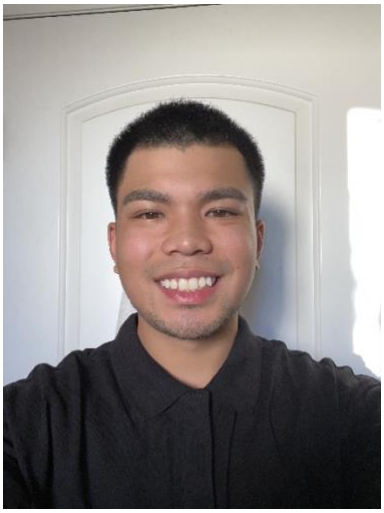
Dr. Pill will be our interpretation of an Automatic Pill Dispenser. Our device aims to facilitate the process by freeing up more time for physicians and allowing patients to take their medication accurately. This device is perfect for doctors and physicians with a range of patients to attend to. Dr. 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.

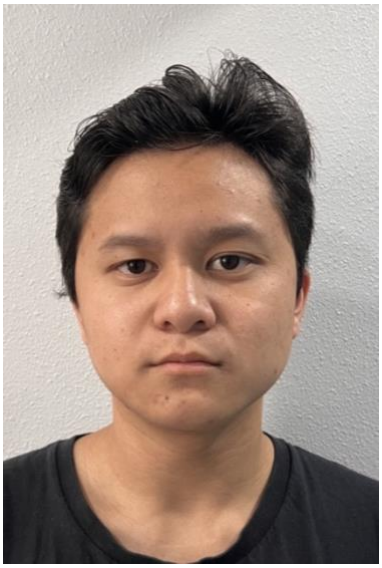
Jehmel Espiritu, a fourth-year student interested in the inner workings of the computer. He is determined to further his knowledge of computing technologies and use this expertise to innovate and contribute to his chosen field. His passion for problem-solving and understanding complex systems drives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

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.



Joseph Guzman, a fifth-year 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.

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.



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.

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
- User interface program
- Power supply

Joseph Guzman

- Enclosure and Framework
- GitHub Manager
- 3D Design
- Raspberry Pi

Team 2:

Jehmel Espiritu

- Launchpad (TM4C123G)
- Motor movement
- Hardware setup for motors

Jeremy Espiritu

- Pill tracking and dispensing
- Screen display
- Dispense history

Team 3:

Afzal Hakim

- Facial Recognition
- Number pad
- Fingerprint scanner
- App (optional)

Lee Roger Ordinario

- Dispense Design
- Motor development
- Storage Development/Design

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

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.

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
- Multiple pill storage compartments for different medications
- User interface with screen display
- Pill tracking and dispensing system
- Dispense history logging
- Security features:
    - Facial recognition
    - Number pad access
    - Fingerprint scanner
- Customizable medication schedules
- Reminders and alarms for medication times
- Secure enclosure to protect medications
- Circuitry for accurate pill counting and dispensing

- User authentication system
- Drop pivot mechanism for precise single-pill dispensing
- 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

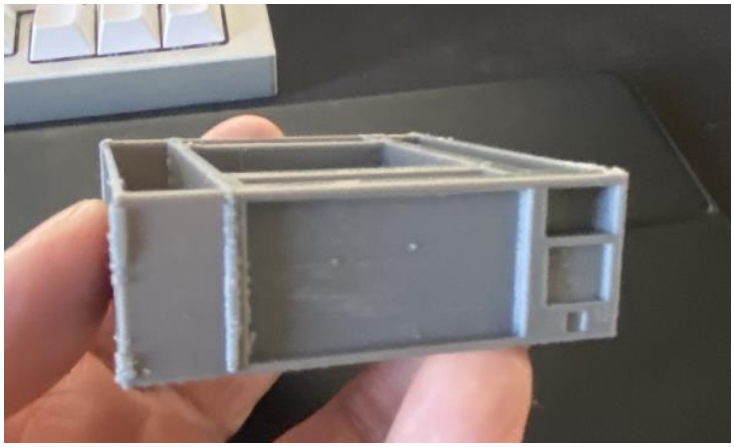


Figure 1 (Prototype)

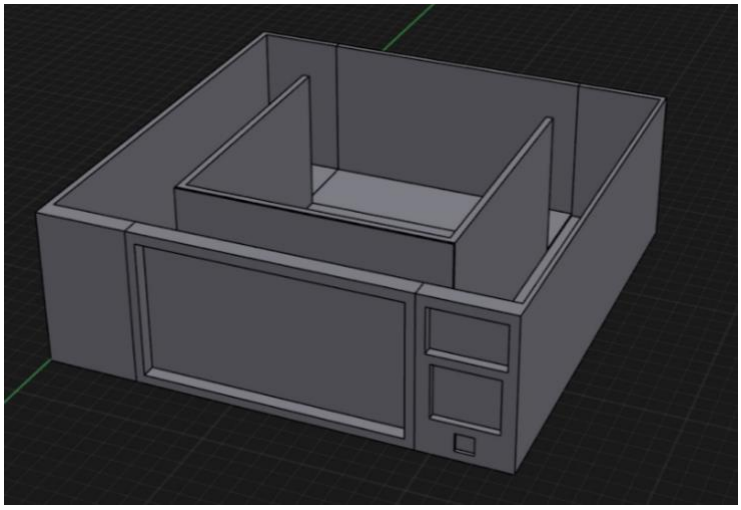


Figure 2 (First 3D Design)

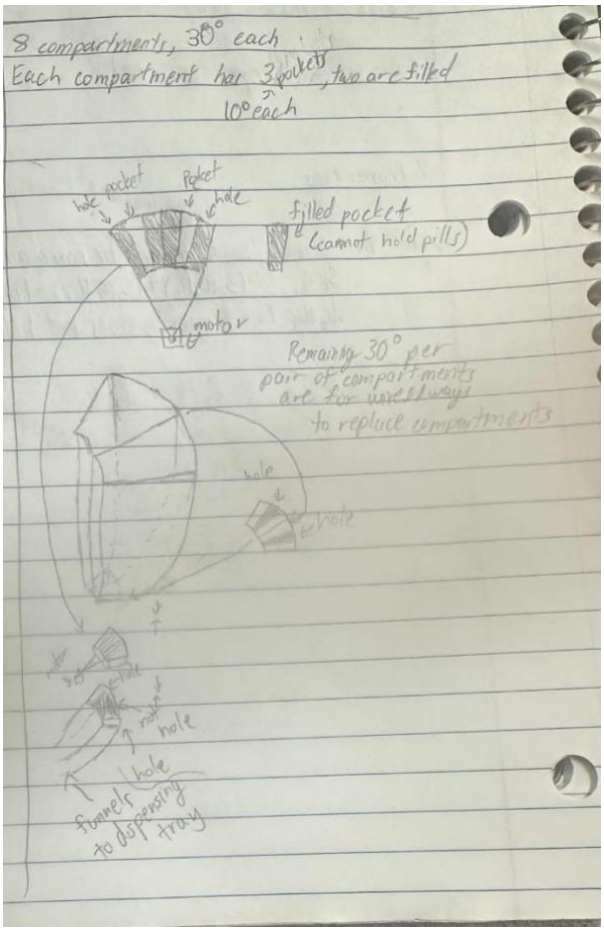


Figure 3 (Sketch of storage/dispense)

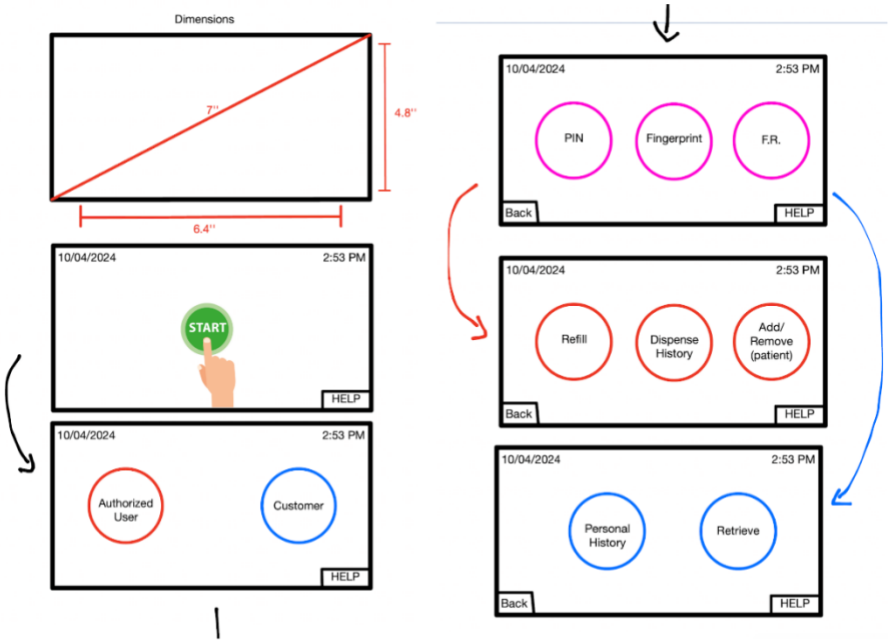


Figure 4 (Rough sketch of user interface)

Design

Block Diagram

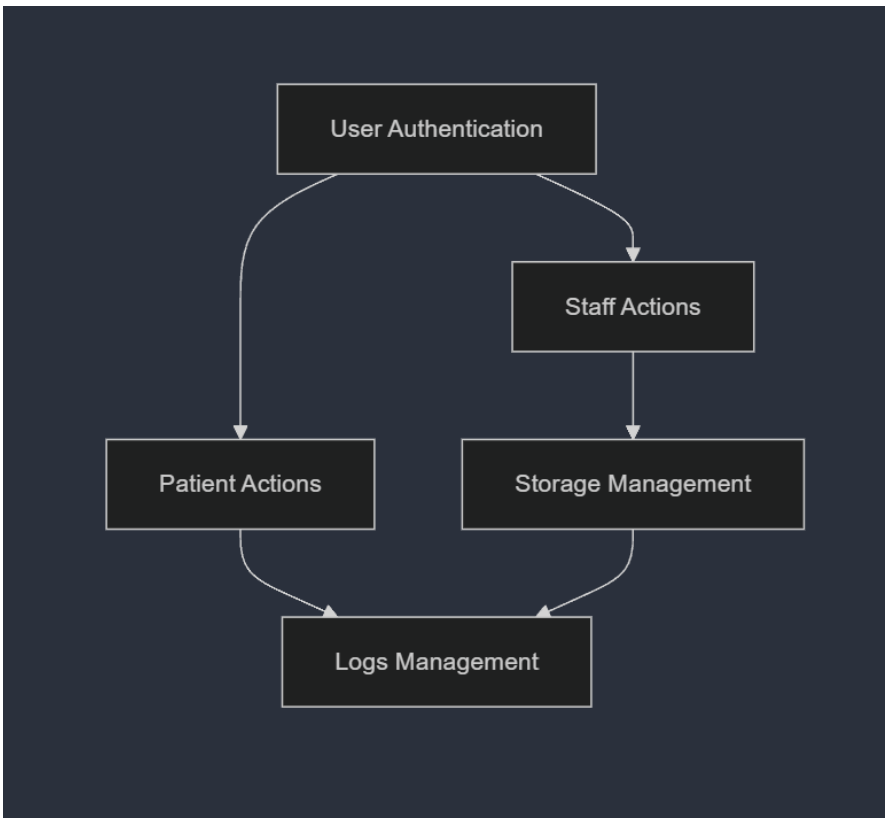


Figure 5 (General block diagram for interface)

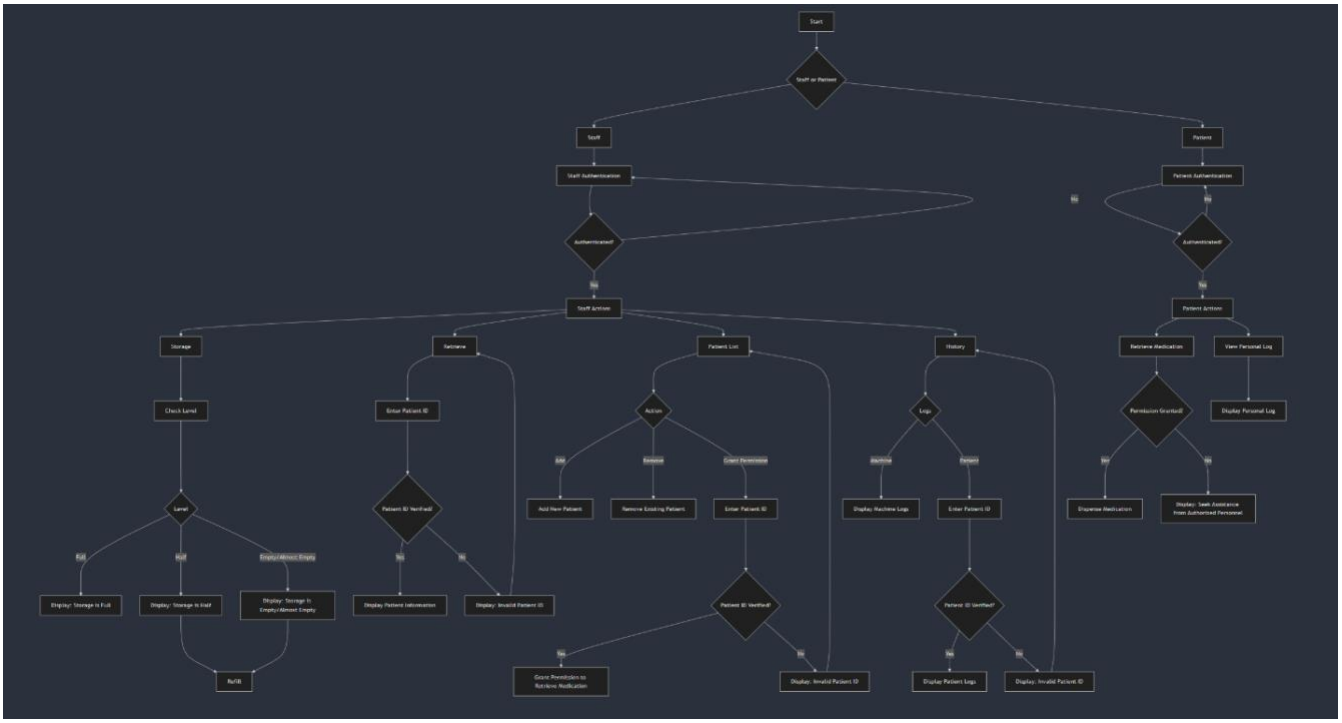


Figure 6 (Full block diagram for interface)

Block Description

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.

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.

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 at least 10 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.

Special Circuit:

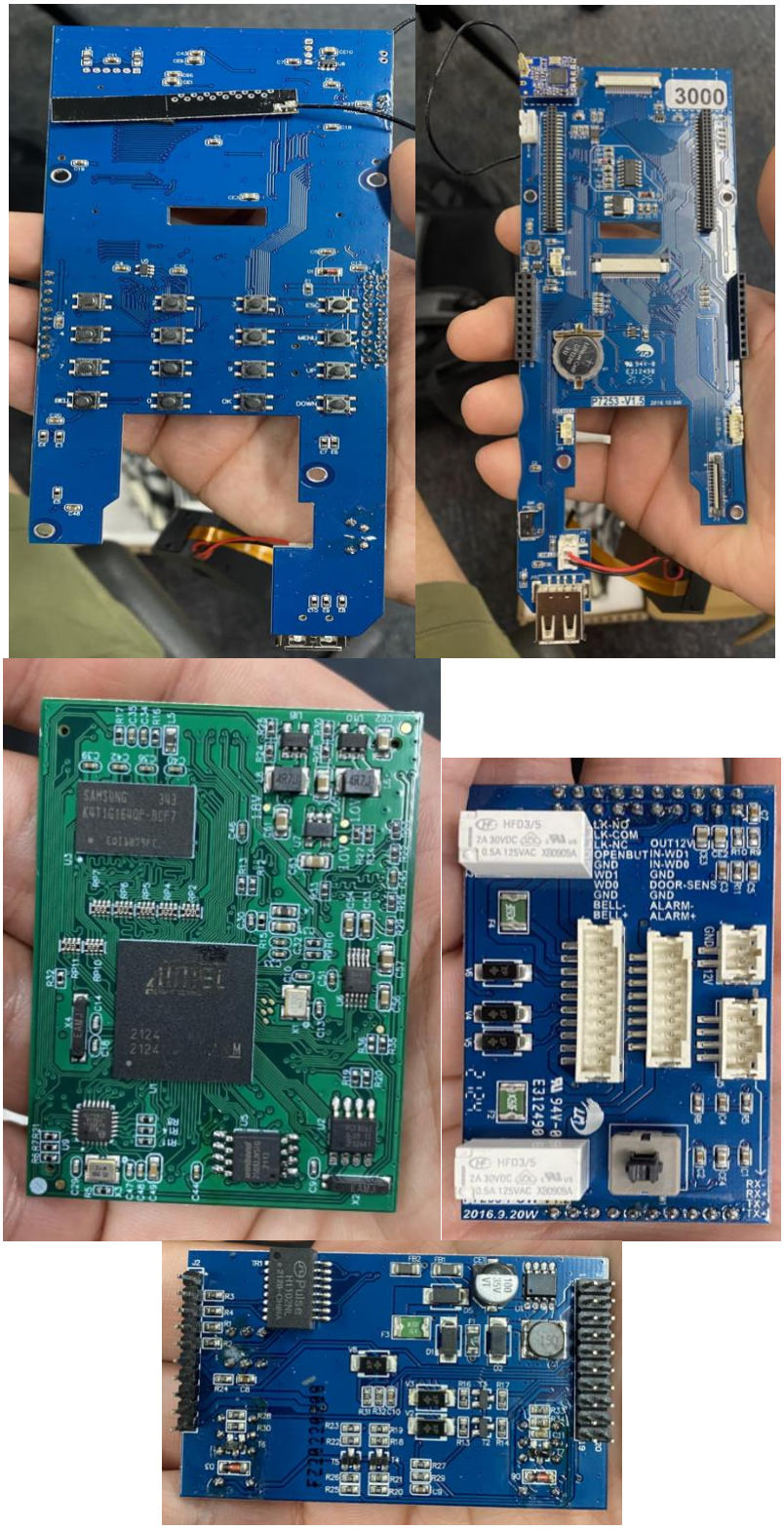


Figure 7 (Security Circuit/Board

Physical Interfaces:

- Raspberry pi
- Launchpad
- Fingerprint recognition
- Pin pad
- Facial Recognition

Mechanical Requirements:

- Stepper motors

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:

- Target weight < 2 kg for portability
- Even weight distribution to prevent tipping

Electronics Packaging and Protections:

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

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 TMC 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.

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
Microcontroller (e.g., Raspberry Pi 4)	$100	High	1-2weeks	Amazon, DigiKey
Touch Screen Display	$40	Medium	2-3 weeks	Amazon, DigiKey
Servo Motors	$30	High	1 week	Amazon
Pill Compartments and Mechanisms	$50	Custom	3-4 weeks	3D Printing
Power Supply	$20	High	1 week	Amazon, Store

Camera Module	$30	High	1 week	Amazon
Enclosure Materials	$75	High	1 week	Home Depot, Amazon
Miscellaneous Electronics	$75	High	1 week	DigiKey, Amazon
Sensors	$20	High	1 week	Adafruit, DigiKey, Amazon
Fingerprint Scanner	$20	High	2 weeks	Amazon

Total Parts Cost (Estimate): $460

Grand Total: $225,460

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, 202	Oct 7, 2024	• Designing and planning (Aug 26 - Dec 18) • Complete prototype design (Sep 27) • Pill Storage Mechanism (Sep 17)
Hardware Development	Oct 1, 2024	Mar 1, 2025	• User Interface Hardware Integration (Mid-November 2024) • Security Hardware Implementation (December 2024) • Connectivity and Remote Access (January 2025) • Final Hardware Assembly and Security Testing (February 2025)
Software development	Oct 1, 2024	Mar 1, 2025	• Start Software Development (Oct 7, 2024) • Development (November 2024) • Security Features Implementation (January 2025)

			• Dispense History and Tracking System (February 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	• Final demonstration

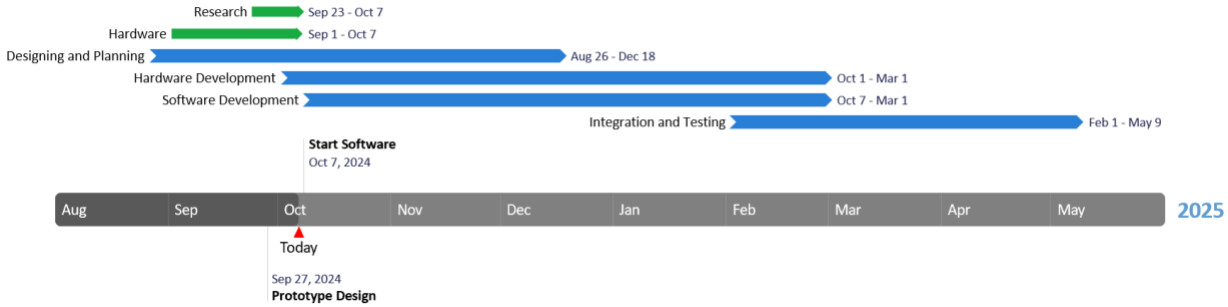


Figure 8 (Blue = plan for phases; Green = Progress)

As of the current date, the project is progressing according to schedule. The Research and Hardware planning phases are mostly completed, running from September 23 to October 7 and September 1 to October 7, respectively. The Designing and Planning phase, which started on August 26, is still ongoing and will continue until December 18. The project has just reached a significant milestone with the completion of the Prototype Design on September 27, 2024. The team is now at the cusp of beginning the Software Development phase, scheduled to start on October 7, 2024. Hardware Development and Software Development are both set to run concurrently from their start dates until March 1, 2025. The Integration and Testing phase is scheduled to begin on February 1, 2025, overlapping with the final month of development, and will continue until the project's completion on May 9, 2025. Overall, the project appears to be on track, with key initial phases completed and the team poised to move into the core development stages.

Technical Data

Current 3D Design Prototype:

Figure 9 (Front Interface)

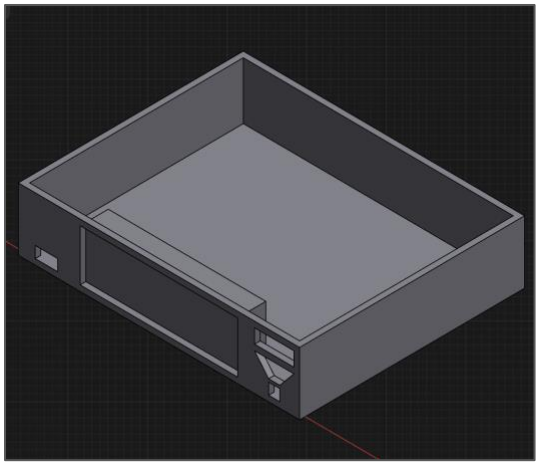


Figure 10 (Top View)

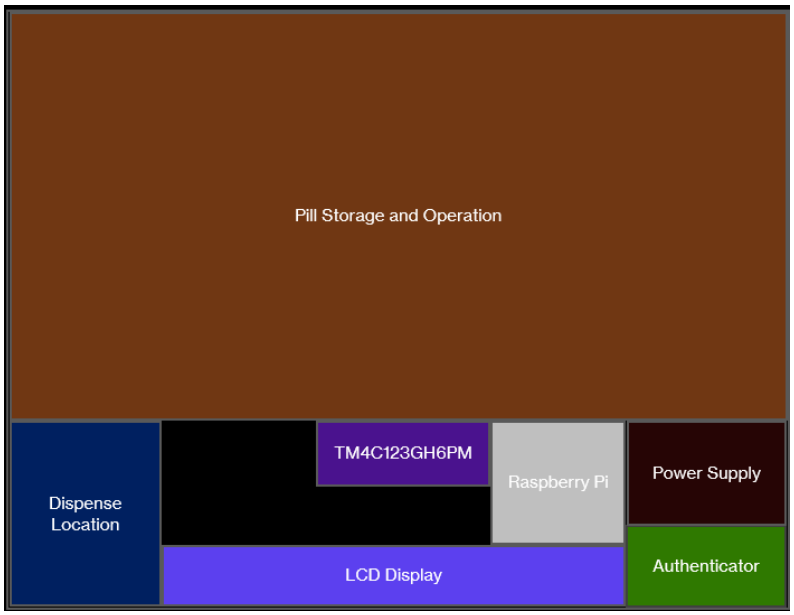


Figure x (Blueprint Layout)

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. The diverse range of pill shapes and dimensions posed a considerable obstacle to creating a universal dispensing mechanism. To address this issue, we thought of a drop pivot mechanism powered by a motor. We hope that this solution allows for controlled, one-at-a-time pill dispensing, regardless of the medication's physical characteristics. Additionally, we implemented a modular storage system with compartments of different sizes to accommodate various pill dimensions. This approach allows us to effectively manage and dispense a wide array of medications, from small tablets to larger capsules, without compromising accuracy or reliability. Our current challenge is figuring out how to create a sanitary environment where there would not be cross-

contamination. We are currently in the process of finding a way to solve this issue, but there are no other issues or concerns other than this.

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

Appendix

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