Pill Popper Pro

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Use Case

Problem with Existing Methods:

- No way to easily verify if a daily pill was taken at the correct time or quantity
- Insecure access for unintended users
- Often inaccessible for individuals with poor hand mobility
- No easy prompting for the patient to know when to seek a refill of the prescription
- General disorganization due to multiple separate bottles

Solution: Automated pill dispenser with a connected app

- Pill Popper Pro allows users to easily enter their daily pills and dispense them
- App records whenever a user takes their medication and alerts them when a refill is due

ECE Areas: Web-App Development, Embedded Systems, Robotics, Control Systems, and Signal Processing

Design Requirements

Requirement	Metric	Justification
Correct pill dispensed	95% of the time	Ensures patients receive the right medication at the correct time to prevent adverse effects
Correct dose dispensed	95% of the time	Ensures correct number of pills per dose based on the prescription to prevent overdose or underdose
No. of compartments	6	Based on medication intake statistics, ensuring sufficient storage for the average elderly patient (5+ medications)
Pills per compartment	<30 pills	Reduces refill frequency, ensuring a 30-day supply for most prescriptions
Notification timing	<60s of scheduled time	Ensures timely medication reminders, but allows for user mobility
Dispensing delay	<10s of user activation	Users should quickly access medication once near the device
Pill dimensions	1mm-22mm	Considers size of most standard prescription pills

Solution Approach - Software

*Changes highlighted in pink

Software Design Requirements	Technologies Used
Web App page structure and functionality	HTML, Javascript, Django, CSS
Account and pill management	mySQL, OAuth
Reminder and notification system	Javascript, Celery*, Celery-beat*, redis*, Google Calendar API
Web App deployment & SSL	AWS EC2, daphne*, nginx*, certbot
Device communication	Web sockets, redis*
Website domain	GoDaddy

* These programs are daemonized

Solution Approach - Hardware

*Changes highlighted in pink

Processing & Control

Raspberry Pi 5

- ➔ Receives dispense commands from web app
- ➔ Controls servo motors and sensors

Dispensing Mechanism

MG996R Servo Motor

- ➔ Rotate the gate to release the pill

Rotating Disc/Gate

- ➔ Allows for pills to release when dispensed

Funnel & pipes

- ➔ Directs pill into dispensing mechanism
- ➔ Pipes to prevent jamming

Verification & Tracking

HX711 & 100g Load Cell

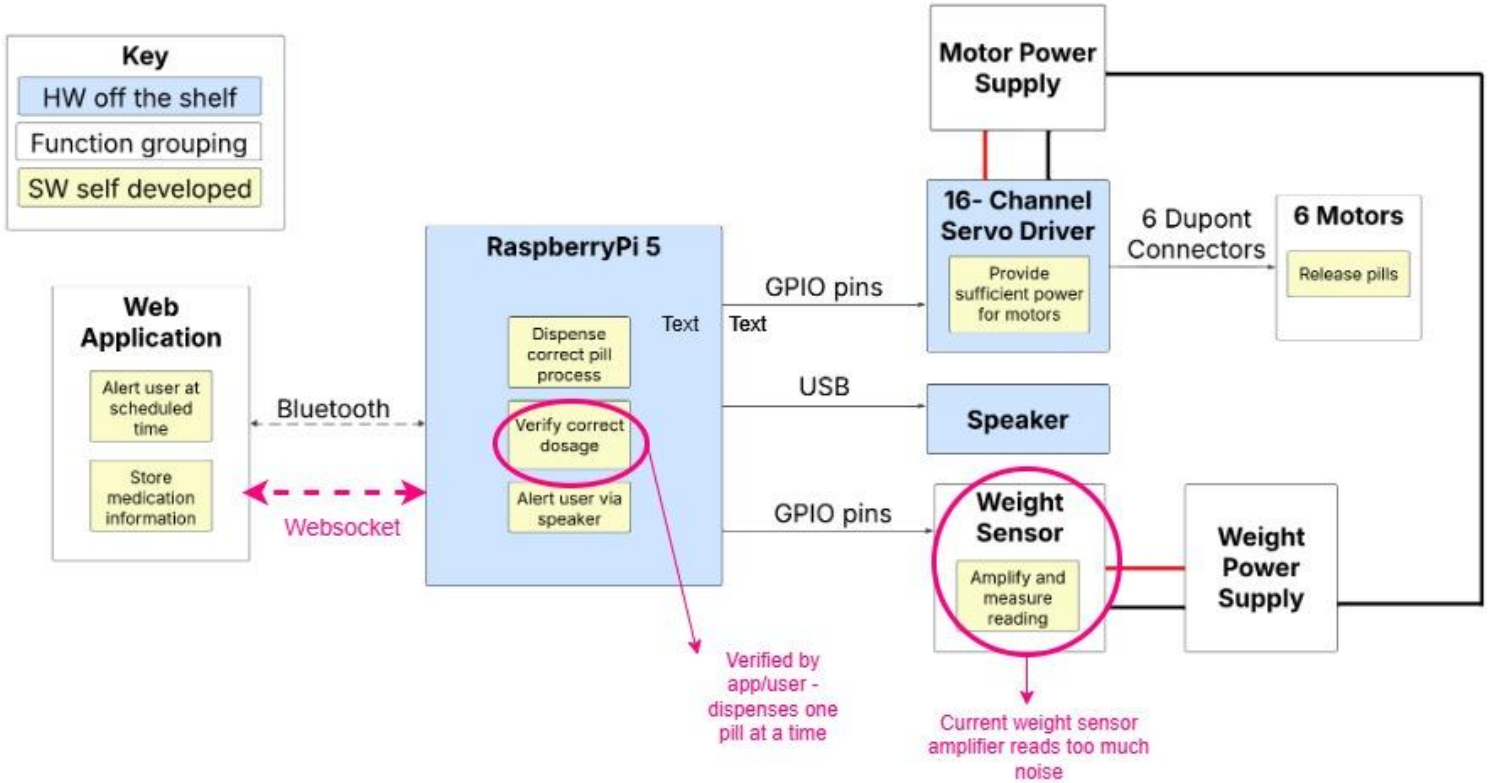
- ➔ Precision weight sensor to detect pill dispensing/ user consumption
- ➔ Currently still testing, will omit if inaccurate readings

Speaker

- ➔ Alert user of pill dispensing actions

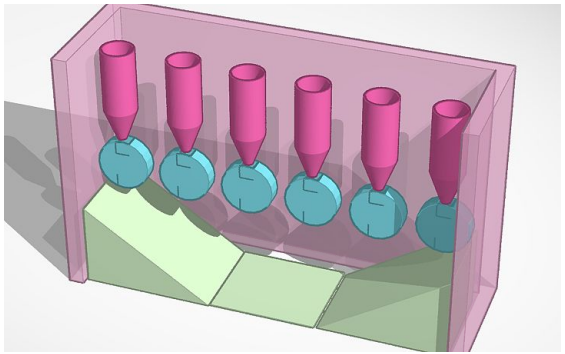
High-Level Diagram

*Changes highlighted in pink

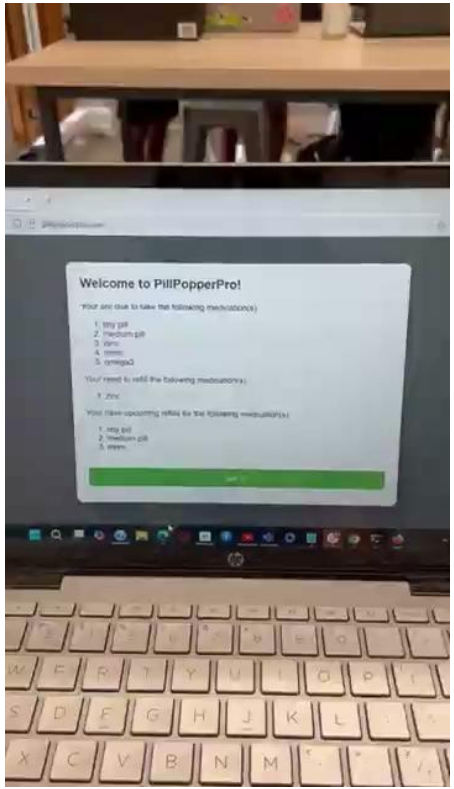


Complete Solution - Device

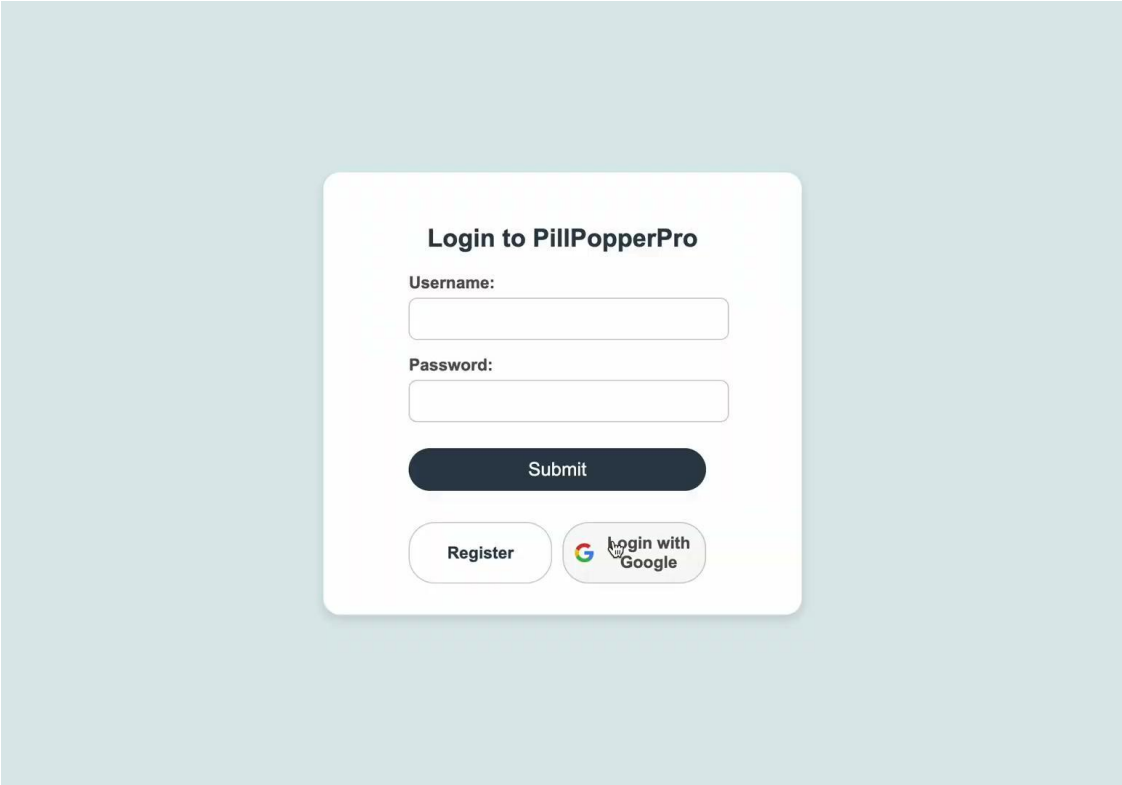
Initial design



What we have built thus far



Complete Solution - Software Walkthrough



Testing Verification Metrics

Requirement	Method	Target
Correct Pill + Correct Dosage + Correct Time	Repeatedly dispense a specific pill and dosage	95% success rate across all trials
Adaptable UI	Adjust web browser viewport to specific phone model dimensions	Complete all web app tasks successfully with accurate displays
Product Ease-of-Use	Simulating limited hand mobility with tape and opening the device	Average ease-of-use score of ≥3.5, given 1 is unable to complete and 5 is complete with no discomfort
Connectivity between Devices	Unit test across pairs of components	Motors moving at specified intervals, receiving “Hello World”, etc.
Weight sensors	Weighing each pill, in 4 different dosages, 19 times	Distinct weight ranges among the different dosages

Testing Verification - Pill Dispensing

Pill Compartment	Pill Type	Dispensing Accuracy	Average Time for Pill Dispensing	Main Issues
1	Omega-3 Capsule	100%	5.84 s	No major issues
2	Zinc Capsule	96.67%	5.84 s	Pills can occasionally get stuck in gaps
3	Zinc Capsule	100%	5.84 s	No major issues
4	5mm Bead	96.67%	5.84 s	Two pills released at once, disc hits funnel
5	5mm Bead	96.67%	5.84 s	Two pills released at once, disc hits funnel
6	4mm Bead	(still testing/ adjusting)	5.84 s	Wrong dose released, position of disc not consistent

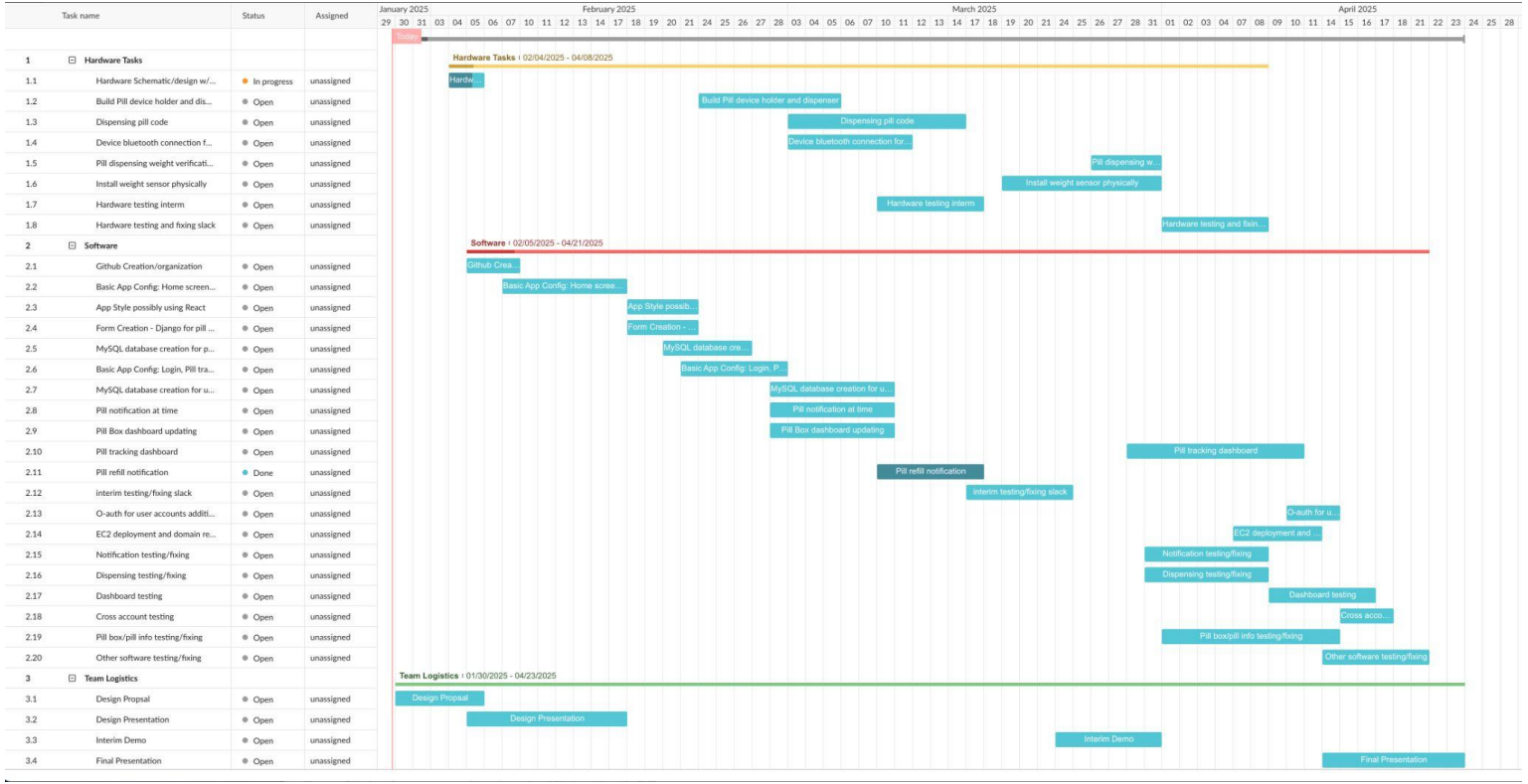
Testing Verification- Software & Connectivity

Component	Testing Method	KPI's
User Interface	Rendered six common screen sizes using (360 x 740, 375 x 812, 390 x 844, 412 x 732, 414 x 896, 480 x 853) using chrome's developer settings. Checked if all page components rendered at reasonably large and clearly visible sizes.	All components rendered on screen with a minimum text size for 14px.
Cross Account Testing/Caretaker access	Logged in on multiple accounts at the same time ensured user's could only access pill information linked to their account. Also tested that Caretaker's could only access patient's dashboard when added.	All user information was associated with account and Caretaker's permissions correct.
Pill Information and Times	Tested 3 different pills in each time slot with different information including time, and time zone. Ensured information was stored correctly and all time logic including dashboard and notifications occurred at the correct time,	All Pill information and time zone logic was correct in each trial.
Web Browser and Device	Tested dispensing from three devices(windows computer, macbook, and phone) and three browsers (chrome, firefox, safari)	Dispensing worked from all devices on all browsers

Testing Verification - Design Tradeoffs

Issues	Fixes
Funnel design causes pills to jam	Added a tube to feed the pills into the disc one at a time
For small pill, disc hole too big	3D printed inserts/foam padding to make the disc hole smaller to prevent wrong dose falling
Weight sensor too much noise	Removed them as a verification tool
Notifications only in Browser	Adding API's (Google Calendar, emails) to notify user outside browser
Bluetooth support in browsers is limited (i.e. not safari)	Websockets work across all browsers

Project Management - Gantt Chart



	Task name	Status	Assigned
1	**Hardware Tasks**		
1.1	Hardware Schematic/design w/...	In progress	unassigned
1.2	Build Pill device holder and dis...	Open	unassigned
1.3	Dispensing pill code	Open	unassigned
1.4	Device bluetooth connection f...	Open	unassigned
1.5	Pill dispensing weight verificati...	Open	unassigned
1.6	Install weight sensor physically	Open	unassigned
1.7	Hardware testing interm	Open	unassigned
1.8	Hardware testing and fixing slack	Open	unassigned
2	**Software**		
2.1	Github Creation/organization	Open	unassigned
2.2	Basic App Config: Home screen...	Open	unassigned
2.3	App Style possibly using React	Open	unassigned
2.4	Form Creation - Django for pill ...	Open	unassigned
2.5	MySQL database creation for p...	Open	unassigned
2.6	Basic App Config: Login, Pill tra...	Open	unassigned
2.7	MySQL database creation for u...	Open	unassigned
2.8	Pill notification at time	Open	unassigned
2.9	Pill Box dashboard updating	Open	unassigned
2.10	Pill tracking dashboard	Open	unassigned
2.11	Pill refill notification	Done	unassigned
2.12	interim testing/fixing slack	Open	unassigned
2.13	O-auth for user accounts additi...	Open	unassigned
2.14	EC2 deployment and domain re...	Open	unassigned
2.15	Notification testing/fixing	Open	unassigned
2.16	Dispensing testing/fixing	Open	unassigned
2.17	Dashboard testing	Open	unassigned
2.18	Cross account testing	Open	unassigned
2.19	Pill box/pill info testing/fixing	Open	unassigned
2.20	Other software testing/fixing	Open	unassigned
3	**Team Logistics**		
3.1	Design Propsal	Open	unassigned
3.2	Design Presentation	Open	unassigned
3.3	Interim Demo	Open	unassigned
3.4	Final Presentation	Open	unassigned