AMBIENT INTELLIGENCE

ALAMEDA

GROUP 05

Smart Pill Organizer

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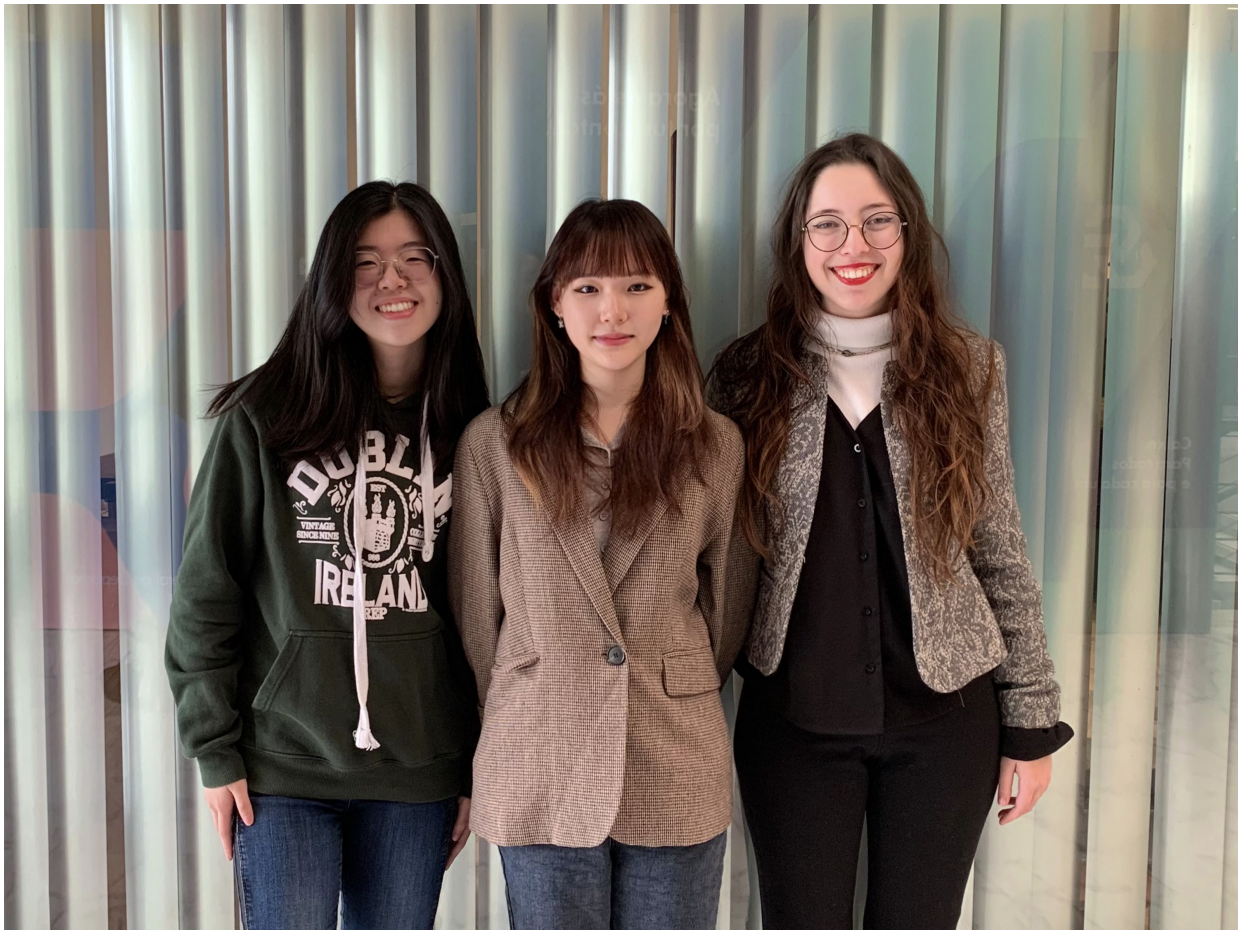

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I. Introduction

All over the globe, many individuals often encounter challenges in adhering to their prescribed medication schedules, due to factors such as age, stress, memory loss or even neurodevelopmental disorders. This struggle with medication adherence can lead to detrimental consequences, including ineffective treatments, deteriorating health conditions, and, in severe cases, death.

In response to this growing concern, we propose the development of a Smart Pill Organizer that autonomously notifies users when it's time to take their medication, according to their prescribed schedule. The pillbox features multiple compartments and each one is designated for a different type of pill.

The Smart Pill Organizer utilizes an Arduino Nano ESP32 microcontroller, an Arduino Uno microcontroller, and a Pixy2 camera, alongside network communication with the Ubidots STEM platform. Leveraging the platform's IoT and Cloud tools, we efficiently store data and create a user-friendly interface, ensuring effortless monitoring of treatment adherence.

Additionally, we enhance the functionality of the Smart Pill Organizer by integrating the Ubidots STEM platform with the Zapier platform. This integration automates the process of sending email alerts, providing users with timely notifications about their pill organizer status. By seamlessly connecting these platforms, we ensure efficient communication and streamline the user experience, ultimately promoting better medication adherence and healthcare management.

This solution aims to not only improve medication adherence but also enhance overall health outcomes and quality of life for users and potentially their caregivers.

II. Literature Review

A. A Smart Medicine Box for Medication Management Using IoT

In the scientific paper titled "A Smart Medicine Box for Medication Management Using IoT" [1], the team proposed a smart medicine box with an Internet of Things platform along with vital parameter measurements by using the sensor system. The focus of this solution is patients who encounter challenges in adhering to their medication schedules due to factors such as work stress, carelessness, or short-term memory loss.

This solution incorporates an IoT platform and a sensor system for monitoring vital parameters. It encompasses various features, including a buzzer system, medication intake tracking, GSM modules for SMS communication, cloud storage, a web interface, and battery-powered operation. Development is facilitated using the Arduino Mega platform. Notably, the box also integrates vital sign measurements, such as heart rate and body temperature, with heartbeat detected through an LED and temperature measured using an LM35 sensor.

The system operates by issuing alerts to remind patients of their medication schedule and notifying caregivers or neighbors when medication is due. Upon medication intake, the system records the time and uploads this information to the cloud via IoT. In instances where medication is missed, an alarm is triggered, and a notification is sent to the designated caregiver. Furthermore, the system continuously monitors the user's heart rate and temperature, uploading this data to the cloud for further analysis.

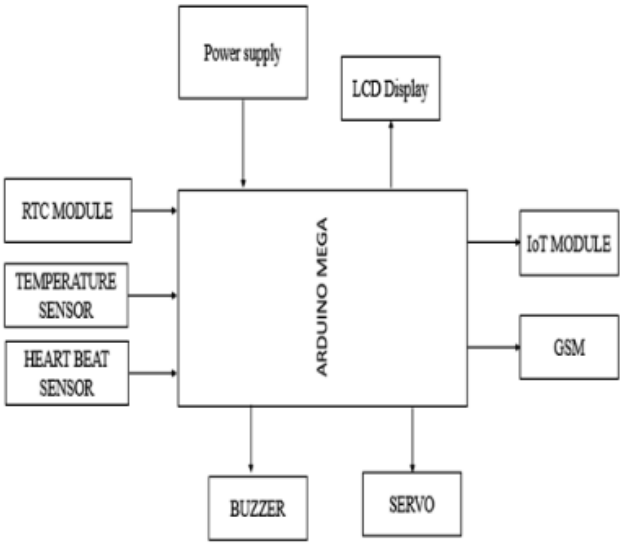

Fig. 1. Block diagram of [1].

B. Smart Pill Box With Reminder To Consume and Auto-Filling Process Using IoT

In the scientific paper titled "Smart Pill Box With Reminder To Consume and Auto-Filling Process Using IoT" [2], the team introduces a Smart Pill Box designed to address the challenges associated with an aging population all over the globe. As birth rates decline, the proportion of elderly individuals increases, requiring greater attention from family members to manage their care and medication needs. This pillbox aims to alleviate some of the burdens associated with caregiving responsibilities.

This solution is implemented with an Arduino Uno, an LM35 temperature and humidity sensor, an LED alert

system, an LCD Display, an IR sensor, a Buzzer, a battery power supply, and a Node MCU for mobile communication. Additionally, it also supports a dedicated app for remote monitoring of medication adherence and pillbox status.

The IR Sensor is utilized to measure the number of tablets in each compartment of the pillbox. When it's time for medicine intake, the buzzer sounds, the LED glows and the LCD Display indicates the medicine name and the time. If the pill count in a compartment is low and there is a need for a refill, the pillbox will indicate that it's time to refill by giving a notification in the LCD Display and sending alerts to both a selected medical shop and the app using Node MCU. The temperature and humidity sensor will continuously monitor the room temperature.

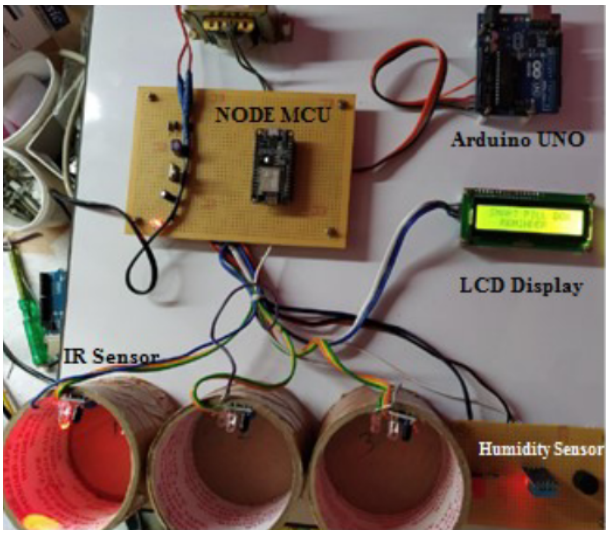

Fig. 2. Real-time connections and setup of [2].

Our project draws significant inspiration from the methodologies outlined in the aforementioned papers, aiming to approach the current state-of-the-art in Smart Pill Organizers. Like the referenced papers, our solution will integrate various hardware components such as buzzers, LED Alerts and microcontrollers. However, we have deliberately omitted humidity and heartbeat sensors from our design, prioritizing the safe storage of pills and focusing on essential requirements. Instead of using an IR Sensor to count the number of pills per compartment, our approach incorporates the use of a Pixy2 camera.

To address the prevalent issue of users inadvertently consuming the wrong medication, we have chosen to place an LED Alert near each compartment. When the scheduled time for medication consumption arrives, the LED will light up and signalize the correct medicine to consume. This design feature enhances medication adherence and minimizes the risk of errors in pill consumption.

III. Problem

The Smart Pill Organizer addresses the critical issue of medication adherence by providing a solution to the dangerous and persistent struggle many individuals face.

The proposed solution offers significant value by relieving users and their caregivers, if applicable, of the burden of remembering medication schedules. This not only reduces stress but also mitigates the risk of missed doses. Since regular monitoring by nurses and doctors is often an unrealistic situation, our Smart Pill Organizer serves as a reliable alternative. Additionally, our device caters to individuals managing multiple medications, a common scenario among older adults with multiple health conditions requiring polypharmacy. Through its compartmentalized design, our solution ensures scalability and organization for efficient medication management.

The stakeholders involved in our solution include the primary users, who are individuals managing their medication schedules, and their caregivers, if applicable. Additionally, healthcare professionals such as doctors and nurses can also be considered stakeholders since our device provides them with valuable insights into patient adherence through the information available in the accompanying web interface. Furthermore, the pharmaceutical and medical industries are significant stakeholders, as they contribute to the development and distribution of the medications utilized in our solution.

A. Solution Requirements

R1. The pillbox will alarm the user when it's time to take the medication.

R1.1: The alarm will cease upon confirmation of medication intake.

R1.2: The alarm will stop after a set duration if medication is not taken.

R2. The pillbox will identify the pills by their type.

R3. The pillbox will detect the quantity of each type of pill.

R4: The pillbox will provide a visual indication of the compartment containing the medication to be taken.

R4.1: The indicator will turn off after a set duration if medication is not taken.

R4.2: The indicator will turn off upon confirmation of medication intake.

R5: The pillbox will send a notification indicating when it's time to take a medication.

R6: The pillbox will detect the exact time when a pill is removed.

R6.1: The pillbox will send a notification indicating if the pill was taken at the wrong or correct time.

R7: The pillbox will alert the user when a certain type of pill has a low inventory.

R8: The pillbox will allow the user to insert or modify the medication's prescriptions in a user-friendly interface.

R8.1: If the interface is down, the pillbox will notify the user and provide a visual indication.

R9: The pillbox will notify the user if they miss a dosage.

B. Assumptions

A1. The pillbox assumes that each compartment has only a type of medication/pill.

A2. The pillbox assumes that each medication is distinguishable from the others solely by its color.

A3. The pillbox assumes that the pills are not stacked on top of each other.

A4. The pillbox assumes that each medication can have a maximum inventory of 4 pills.

A5. The pillbox assumes that each medication is taken one time per day, always at the same hour, and only consumes 1 pill at the time.

A6. The pillbox assumes that the user or the caregiver, if applicable, are able to operate the web interface to insert the medication information (prescription time) corresponding to each compartment.

A7. The pillbox assumes Internet access is available.

A8. The pillbox assumes a stable and horizontal surface for its operation, such as a table, desk, or counter, to ensure proper functioning.

A9. The pillbox assumes that it will be stored in a safe and dry location, away from extreme temperatures and direct sunlight.

A10. The pillbox assumes that the user will not attempt to falsify medication adherence by removing pills from the compartment and then returning them without actually taking them.

A11. The pillbox assumes that the Pixy2 camera won't face any obstructions to its utilization.

IV. Proposed Solution

A. Overview

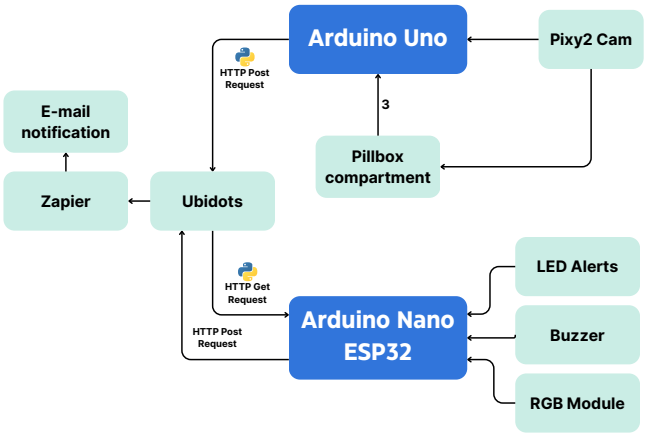

Fig. 3. Block diagram of smart pill organizer.

Arduino Uno

The Arduino Uno is responsible for interacting with the Pixy2 camera, fetching the inventory data for each compartment captured by the camera at intervals of 60 seconds.

Subsequently, it transfers this data to the Ubidots STEM cloud. To enable communication with the cloud without a network communication shield, the Arduino Uno transmits the recorded inventories to the terminal. A Python script is then employed to read this data from the terminal and transmit it to the Ubidots STEM Cloud via an HTTP Post Request, facilitating smooth integration and data transmission.

Arduino Nano ESP32

The Arduino Nano ESP32 functions as the primary controller for managing the Smart Pill Organizer functions. It is responsible for handling LED alerts, activating the buzzer, and overseeing the email notification system.

To retrieve information from the Ubidots STEM cloud, we employ a reverse mechanism similar to that used with the Arduino Uno: a Python script receives the data via an HTTP Get Request and outputs it to the terminal. The Arduino Nano ESP32 then reads this information from the terminal and takes appropriate actions based on the received data.

For the email notification system, the Arduino Nano ESP32 sends the email content via an HTTP Post Request to Ubidots STEM. This action triggers an event on the Zapier platform, which is integrated with Ubidots STEM, prompting the sending of the email to the user, or their caretaker if applicable, ensuring timely alerts regarding the pill organizer's status.

Pixy2 Camera

A Pixy2 Camera is strategically positioned above our compartments to detect the pills and monitor changes in inventory levels. This mechanism enables precise tracking of inventory fluctuations, facilitating accurate medication management within the smart pillbox system. The Pixy2 Camera is connected to the Arduino Uno through a Pixy IO to Arduino ISP Cable.

Ubidots STEM

The Ubidots STEM platform is a specialized environment for IoT projects, offering essential features such as cloud storage for sensor data captured by the Pixy2 camera and prescription times. Moreover, it provides a real-time dashboard serving as a user interface, facilitating the input of prescription times and monitoring medication adherence.

For students, Ubidots STEM offers a free plan, making it accessible for educational purposes. Additionally, we integrated Ubidots STEM with Zapier, enabling email alert notifications.

Zapier

Utilizing Zapier's integrated capabilities with Ubidots, we automated the process of sending emails to users efficiently. By leveraging this integration, emails are streamlined and automated, enhancing the functionality and effectiveness of the Smart Pill Organizer system.

Buzzer

The buzzer acts as an auditory signaling device for our solution, designed to notify the user when it's time to take their medication. Its persistent beeping serves as a reliable reminder, ceasing only when the user either takes their medication at the designated time or if 5 minutes elapse without action.

LED Alert and RGB Module

LED Alerts positioned adjacent to each compartment serve as visual indicators, aiding users during medication consumption. When it's time to take a medication, the corresponding LED will emit a green light to highlight the correct compartment, simplifying access to the required medication. The LED remains illuminated until the user takes their medication promptly at the scheduled time or within a 5-minute grace period.

If the Cloud system is offline, the user is alerted by the RGB Module. During this offline period, the RGB Module turns on illuminating a red light, signaling the system's status. This visual cue ensures users are promptly informed of any disruptions, enabling them to take necessary actions to ensure medication adherence.

Power Supply

Each Arduino is powered by a computer: the Arduino Uno is connected via a USB cable, while the Arduino Nano ESP32 is connected using a USB-C cable. Similarly, the Pixy2 camera is powered by a computer through a Micro-USB cable. This setup ensures continuous power supply to the components.

Pillbox compartment

The compartments are vertical columns within a container. When used correctly, each compartment contains only one type of medication, and its inventory is managed using the Pixy2 camera.

B. Logical design

R1. The Arduino Nano ESP32 activates the piezzo buzzer when it's time to take the medication.

R1.1: The Arduino Nano ESP32 deactivates the piezzo buzzer upon confirmation of medication intake.

R1.2: The Arduino Nano ESP32 deactivates the piezzo buzzer after a set duration if medication is not taken.

R2. When Ubidots STEM platform is offline the Arduino Nano ESP32 turns on the RGB Module illuminating it with a red light,

R2.1: The Arduino Nano ESP32 turns off the RGB Module when the Ubidots STEM platform is online again.

R3. The Pixy2 Camera identifies the different types of pills by their color.

R4. The Pixy2 Camera detects the quantity of every type of pill and sends the current inventory of each type to the Arduino Uno.

R4.1: The Arduino Uno sends the current inventory received from the Pixy2 Camera to the Ubidots STEM platform.

R5: When it's time to take a medication, the Arduino Nano ESP32 turns on the LED Alert correspondent to the compartment containing the medication to be taken.

R5.1: The Arduino Nano ESP32 turns off the LED Alert after a set duration if medication is not taken.

R5.2: The Arduino Nano ESP32 turns off the LED Alert upon confirmation of medication intake.

R6: The Pixy2 Camera data sent to the Ubidots Cloud has a timestamp in it.

R6.1: The Arduino Nano ESP32 receives the timestamp of each inventory update.

R7: The web interface available on Ubidots STEM allows the user to insert or modify the medication's prescriptions in a user-friendly interface.

R8: The Arduino Nano ESP32 sends a message through the context of a variable to the Ubidots STEM Cloud when it's time to take a medication.

R8.1: The Zapier automation is triggered with that variable update in the Ubidots STEM Cloud and sends an email with the message.

R9: The Arduino Nano ESP32 verifies if the inventory of every medication is equal or less than 1.

R9.1: If it is, the Arduino Nano ESP32 sends that notification message through the context of a variable to the Ubidots STEM Cloud.

R9.2: The Zapier automation is triggered with that variable update in the Ubidots STEM Cloud and sends an email with the message.

R9.3: If ten minutes elapse and the inventory remains categorized as low, the system dispatches another email notification. This cycles persists until the inventory is no longer deemed low.

R10: The Arduino Nano ESP32 sends a message through the context of a variable to the Ubidots STEM Cloud when the user misses a dosage.

R10.1: The Zapier automation is triggered with that variable update in the Ubidots STEM Cloud and sends an email with the message.

R11: The Arduino Nano ESP32 sends a message through the context of a variable to the Ubidots STEM Cloud when the user takes a dosage correctly.

R11.1: The Zapier automation is triggered with that variable update in the Ubidots STEM Cloud and sends an email with the message.

R12: The Arduino Nano ESP32 sends a message through the context of a variable to the Ubidots STEM Cloud when the user takes a dosage incorrectly.

R12.1: The Zapier automation is triggered with that variable update in the Ubidots STEM Cloud and sends an email with the message.

R13: If the Ubidots STEM Cloud goes offline, when it goes online again the Arduino Nano ESP32 sends a message through the context of a variable to the Ubidots STEM Cloud.

R13.1: The Zapier automation is triggered with that variable update in the Ubidots STEM Cloud and sends an email with the message.

C. Technology selection

We've opted for Arduino IDE as our development environment for programming the Arduino Uno and the Arduino Nano ESP32, implementing the code with the Arduino programming language. Concurrently, we utilize Python scripts to connect the Arduinos to the Ubidots STEM Cloud.

The buzzer and LED alerts are connected to the Arduino Nano ESP32, and the Pixy2 Camera is connected to the Arduino Uno.

V. BILL-OF-MATERIALS

A. Hardware

- **1 Arduino Nano ESP32 with Headers:** Development board for interacting with Ubidots STEM Cloud and to interact with the Piezo Buzzer, LEDs and RGB Module.
- **1 Arduino Uno:** Development board for interacting with the Pixy2 Camera and to send data to the Ubidots STEM Cloud.
- **1 Pixy2 Camera:** Vision sensor that can detect and track objects based on their color, used to detect the flunctuation of medication inventory.
- **1 Piezzo Buzzer:** Electronic component connected to the Arduino Nano ESP32 development board, used to provide auditory feedback to the user when it's time to take their medication.
- **3 LED Alerts:** Green light-emitting diode (LED) connected to the Arduino Nano ESP32 development board used to provide visual feedback to the user when it's time to take their medication.
- **1 RGB Module:** Electronic component connected to the Arduino Nano ESP32 development board, used to provide visual feedback to the user when the Cloud Platform is offline.
- **3 Resistors:** Electronic components used to limit the flow of electric current to the LED Alerts.
- **Jumper Wires:** Used to establish electrical connections between various components on the breadboard or between the components and the Arduino boards.
- **1 USB Cable:** Connects the Arduino Uno development board to the computer that supplies its' power.
- **1 USB-C Cable:** Connects the Arduino Nano ESP32 development board to the computer that supplies its' power.
- **1 Micro-USB Cable:** Connects the Pixy2 Camera to the computer that supplies its' power.

- **1 Pixy IO to Arduino ISP Cable:** Connects the Pixy2 camera to the Arduino Uno development board so they can communicate.

B. Software

- **PixyMon:** Software that enables parameterising the camera.
- **Ubidots STEM:** Platform that provides tools and resources for IoT projects, used in our solution for Cloud Storage and Web Interface. It's a free but limited free plan of Ubidots, targeted for students.
- **Zapier:** Web-based automation tool that can automate tasks that connect two or more apps together.
- **Pixy2 Library:** Software package that provides a set of functions and tools to interact with the Pixy2 Camera, making it easy to integrate in projects.
- **HttpClient Library:** Library to easily make HTTP GET, POST and PUT requests to a web server.
- **Ubidots API Documentation:** Provides information and references for using the Ubidots API.

VI. Conclusion

The goal of this project is to develop an advanced smart pill organizer designed to address the challenges associated with medication adherence. Our aim is to create a solution that not only enhances medication management but also improves overall health outcomes and quality of life for users.

A. Satisfied Requirements

The solution effectively satisfies several critical requirements.

R1: The pillbox promptly alerts users with a buzzer when it's time to take their medication, and it ceases upon confirmation of intake or after five minutes if medication is not taken. This feature ensures adherence to medication schedules.

R2: With Pixy2, the pillbox successfully identifies pills by their color, facilitating accurate medication management.

R3: The pillbox effectively detects the quantity of each type of pill, enabling seamless inventory management and checking.

R4: LEDs are installed in each compartment to provide clear medication guidance, offering visual cues that streamline intake and reduce the chance of errors.

R5: The system correctly identifies instances when pills are removed, promptly notifying users via email if they were taken outside or inside of the prescribed schedule or designated time.

R6: The system accurately identifies low inventory levels and notifies the user via email to restock, ensuring uninterrupted medication supply.

R7: By integrating the Ubidots STEM platform, the pillbox successfully allows users to insert or modify the medication's prescription.

R8: The system correctly sends a notification via email to the user when they miss a dosage.

Our solution admirably fulfills the vast majority of both functional and quality requirements envisioned during the planning stage. Regrettably, the sole unmet requirement pertains to the integration of an LCD display for presenting time and medication details. This shortfall arises from the voltage disparity between the Arduino Nano ESP32 (functioning at 3.3V) and the 5V-powered LCD display, posing a barrier to timely implementation within our project schedule. In response to this challenge, we opted to incorporate a digital clock into our web interface as a workaround. Nevertheless, exploring other display options harmonious with the system's voltage specifications holds promise for enhancing the user interface and overall interaction experience. While we successfully implemented the requirements concerning the mobile app, we made the strategic decision to transition to a web interface using Ubidots STEM instead of implementing our own mobile app.

B. Strengths

Our smart pill organizer boasts several compelling advantages:

- **Timely Medication Reminders:** Leveraging advanced technology, the system delivers timely alerts to users when it's time to take their medication, ensuring adherence to prescribed schedules and fostering better health outcomes.
- **Real-time Medication Monitoring:** Integration with the Ubidots STEM platform enables users to monitor their medication schedules in real time. This feature allows users to stay updated on their medication intake, ensuring they adhere to prescribed schedules.
- **Inventory Management Notifications:** The system promptly notifies users via email of any deviations from prescribed schedules or low inventory levels. This proactive notification system ensures users maintain a continuous supply of medications, facilitating effective medication management and promoting optimal health outcomes.
- **Low Chance of Error:** The combination of buzzer alerts, email, and LED indicators for accurate medication identification significantly reduces the chance

of medication errors. Additionally, the ability to track inventory allows users to verify if medication has been taken as prescribed, further enhancing user confidence and peace of mind while minimizing the risk of errors in medication management.

- **Rapid Response to Service Disruptions:** Through the integration of an emergency LED indicator, the system swiftly notifies users when Ubidots experiences service disruptions, ensuring timely awareness of the issue. Moreover, upon restoration of Ubidots services, the system automatically sends an email alert detailing the duration of the downtime, providing users with valuable insights into system performance and reliability. This rapid response mechanism enhances user confidence in the system's ability to maintain seamless operation, even in the face of external service interruptions.
- **Potential for Expansion:** While our current solution focuses on basic medication management functionalities, it has the potential for future expansion and enhancement. With the addition of new sensors, features, and integrations, our Smart Pill Organizer can evolve into a comprehensive health monitoring and management platform, offering a wide range of capabilities to meet the evolving needs of users.
- **Enhanced Pill Count Accuracy:** A mechanism was implemented to improve the accuracy of pill counting, particularly in scenarios where the Pixy2 camera detects multiple pills as a single block due to their close proximity. By computing the area of each detected block, the system establishes a reference for the expected area occupied by a single pill. Consequently, it accurately estimates the actual number of pills within each cluster with a high degree of precision. This method enhances inventory management by allowing users to arrange their pills freely, with the exception of stacking them, while ensuring an accurate count of medical stock. Additionally, this mechanism aligns seamlessly with the official maximum inventory limit of 4 pills per compartment, optimizing the system's functionality and reliability.
- **Accessible and Intuitive User Interface:** Our solution prioritizes accessibility and user-friendliness, ensuring inclusivity for individuals with diverse needs. The intuitive interface, complemented by audible and visual alerts, simplifies medication management for users with varying abilities. This design facilitates easy prescription input and modification, promoting user engagement and satisfaction with a positive overall experience.

C. Weaknesses

Despite its strengths, our solution faces several challenges that necessitate attention and refinement:

- **Internet Access Dependency:** The system's reliance on a stable internet connection for communication with the Ubidots STEM platform may pose challenges in environments with limited connectivity, potentially affecting system reliability and user experience.
- **Power Dependency:** The system relies on continuous power sources for both the Pixy2 camera and both the Arduino controllers. In the event of a power outage, the system may become non-functional, potentially leading to missed medication reminders or inaccurate inventory tracking.
- **Platform Limitations:** The constraints of the Ubidots STEM platform limit our system's scalability. With a maximum of 10 variables per device, our system, requiring 3 variables per compartment and 1 for email notifications, can only accommodate 3 compartments. This restriction on variables hampers our system's ability to support additional compartments or medications. Furthermore, our system's single-user support further restricts scalability and its capacity to cater to diverse user needs.
- **Sensor Limitations:** While the Pixy2 camera serves as a critical component for medication identification, its capabilities are inherently limited. The Pixy2 detects pills solely based on color, which may pose challenges in accurately identifying pills with complex color patterns or compositions. Furthermore, for Pixy2 to accurately detect pills, each compartment is restricted to a maximum of four pills, limiting the system's scalability and versatility.
- **Maintenance Complexity:** Regular maintenance and calibration of the Pixy2 camera parameters are essential to ensure accurate pill detection over time. The Pixy2 camera requires users to identify and associate specific pills with unique signatures, which adds an extra layer of complexity to the setup process and may increase the likelihood of errors if maintenance tasks are neglected.
- **Delays in Data Transmission:** The system's reliability relies on external services like Ubidots and Zapier, making it vulnerable to disruptions or outages that could affect functionality and lead to missed alerts or inaccurate data transmission. Moreover, to prevent system overload, there are delays in transmitting information from the Pixy2 camera to the ESP32 controller, ensuring stability by limiting data processing to once per minute. However,

during peak demand or service interruptions, email automation via Zapier may cause further delays in alert delivery.

D. Final Results and Future Work

Although our smart pill organizer exhibits notable strengths in bolstering medication management and adherence, addressing identified weaknesses in future work is pivotal for optimizing system performance and user satisfaction. It is necessary to conduct user testing sessions to solicit feedback directly from target users, as to achieve continuous improvement initiatives aimed at refining the solution's functionality and usability.

A critical consideration lies in the choice of platform for data management and communication. While Ubidots STEM serves the current solution, exploring alternative IoT platforms boasting broader capabilities and fewer constraints could significantly elevate the system's functionality and scalability.

Tailoring communication methods to suit the user demographic is imperative. Incorporating SMS alerts alongside emails would augment accessibility and usability, especially for older individuals lacking email accounts or not regularly checking their emails. SMS notifications offer a familiar and user-friendly mode of communication, widening the system's reach.

Moreover, for enhanced portability and convenience, exploring alternative power supply options is crucial. Detaching the system's reliance on a computer for power would enable users to deploy the smart pill organizer in diverse locations, unrestricted by desktop or laptop connections, thereby enriching flexibility and usability.

Investigating integration opportunities with the SNS24 mobile app is extremely promising. This integration would streamline communication between the smart pill organizer and the app, automating pill identification for users. This automation eliminates manual input, improving user convenience and experience. Additionally, enabling direct data transmission from the smart pill organizer to SNS24 could provide doctors with easy access to comprehensive medication-taking histories, enhancing medical monitoring and patient care.

We can confidently assert that our results were objectively positive, as we successfully achieved all the essential features required for our Smart Pill Organizer to operate effectively.

Following, you'll find visual representations of our solution:

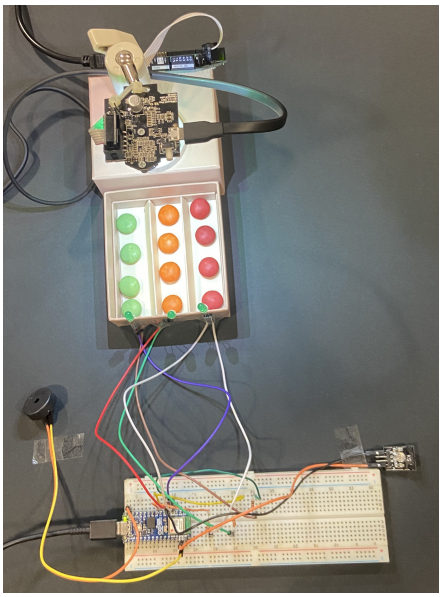

Fig. 4. Smart Pill Organizer Assembly

Fig. 5. Pixy2 Camera in action detecting the different types of pills

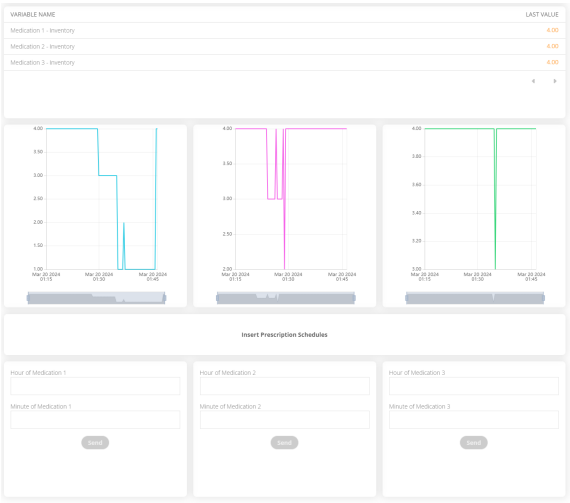

Fig. 6. Ubidots STEM Web Interface

Fig. 7. ”Cloud is back online” email example

Fig. 8. ”Correct dosage taken” email example

Fig. 9. ”Incorrect dosage taken” email example

Fig. 10. ”Low inventory” email example

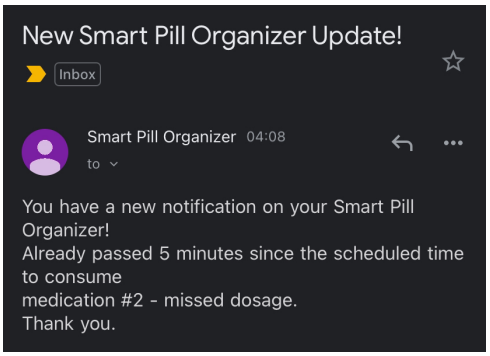

Fig. 11. ”Missed dosage” email example

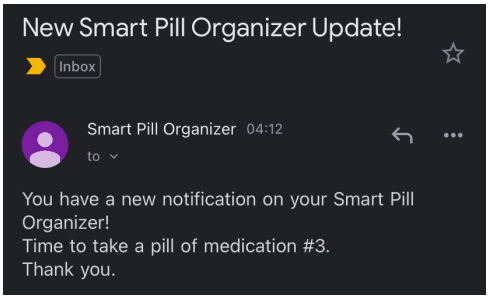

Fig. 12. ”Prescription time” email example

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