Medicine Dispenser Design Review 1

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Subsystem Designs:

Housing

The housing system will include several CAD components. A funnel wide enough that all three conveyor belts tip over into it. The tube or slide to the bottom of the funnel will need to be smooth to prevent pills being stuck in place. The housing will have a way to manage the wires inside the containers. Another part of the housing system is the tray which the medications will be dispensed into. This tray will have the sensors embedded to determine whether or not the medications are present and will be rounded in the corners to allow for the medication to be easier to pick up if the patient is lacking dexterity. There will be a screen mounted in the face of the housing above the tray which will display important information about the medication. Surrounding the tray will be a cover which can be removed for our ability to access the sensors and wiring throughout the process. The entire housing will be 3D printed. Figure 1 shows a rough sketch of the housing. The top of figure one shows the funnel and tube running down to the tray. The bottom two images show that the conveyors will be in a second block of housing behind the main housing and that they will be suspended by the rolling pins and motors inside the belt. Figure 2 shows a rough sketch of the tray which includes an array of sensors around the outside as well as a button on the side for manual override. There are also screws which will hold down the lid around the tray so that we can access the sensors but a patient would not accidentally mess with them. The tray will likely be in the center of the housing not off to the left as is shown in Figure 1.

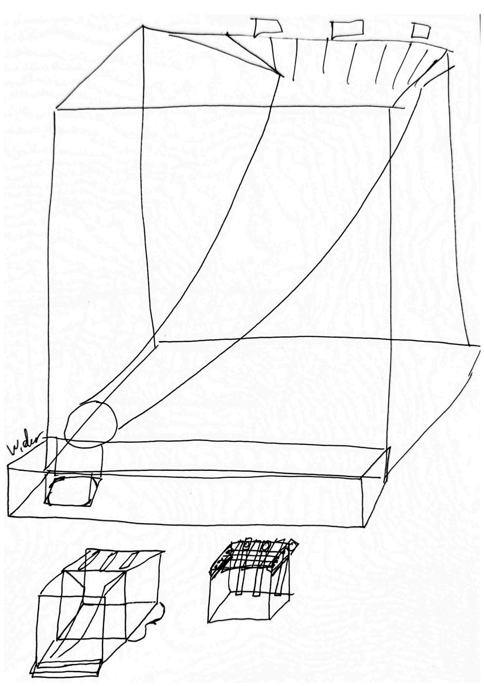

Figure 1: Housing Sketch

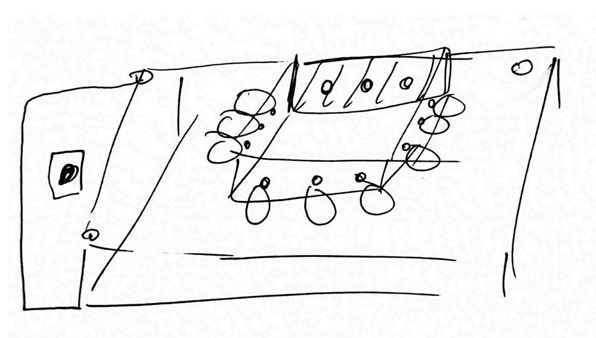

Figure 2: Tray Sketch

Conveyor Belts

The conveyor belts will be 3D printed. The belt itself will be comprised of interlocking pieces with a hinge between each. Figure 3 below shows a detailed schematic of those pieces including dimensions. Once the conveyor belt is printed and put together the spacing necessary between the pill boxes which will be mounted on the conveyor belt will be determined. There will be three conveyor belts and each belt will hold seven pill boxes. At first, only a few conveyor belt pieces will be printed to ensure that they will interlock well and if there needs to be any changes to the dimensions due to tolerance issues it can be fixed before we print a large quantity of them. Once the pieces are built in SolidWorks a more clear schematic will be available. In addition to the hinges on either side of each conveyor belt piece there will also be a hole in the bottom which the prongs of the gear will fit in to move the belt using the motor.

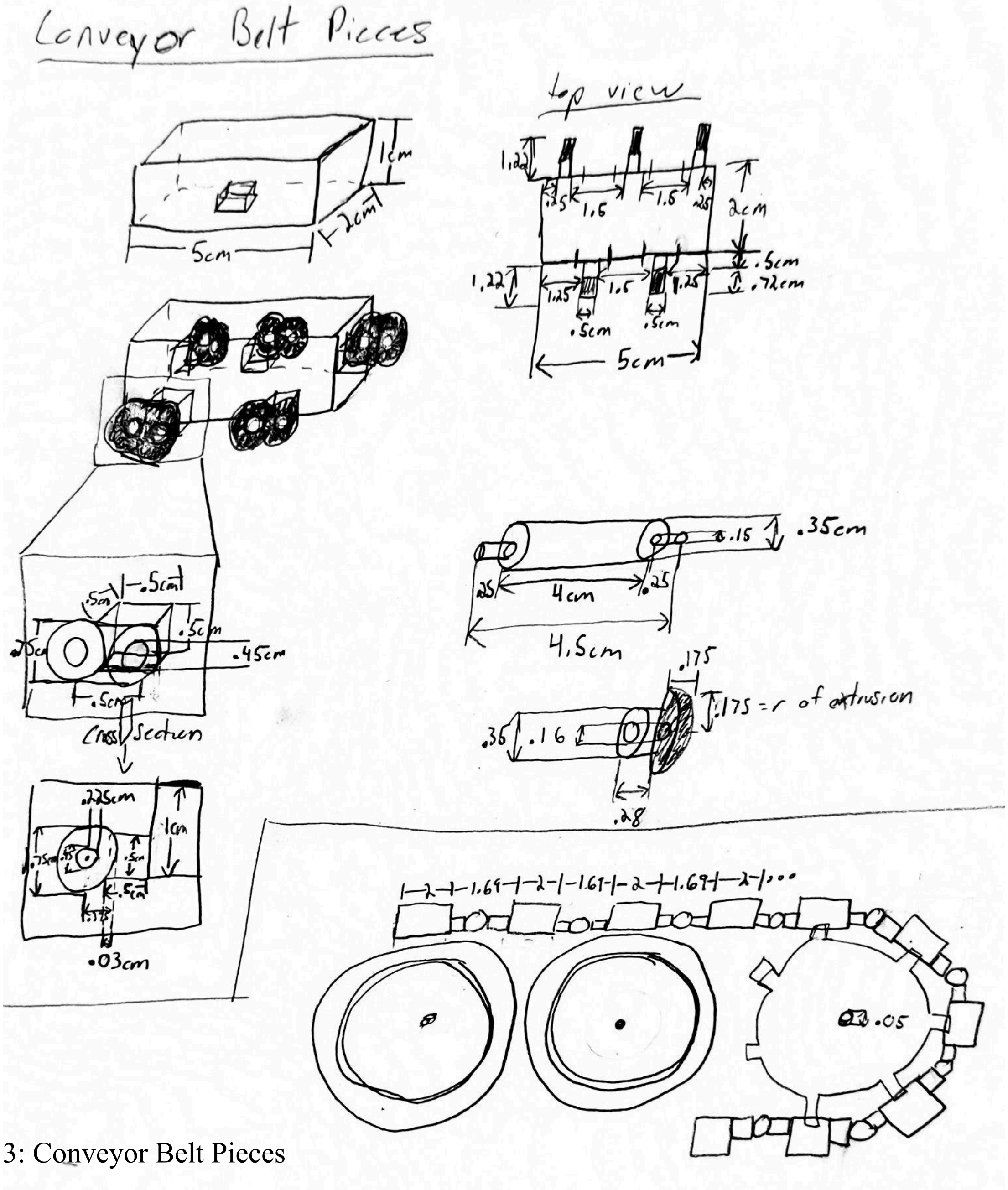

Figure 3: Conveyor Belt Pieces

Network

The network subsystem provides connectivity from the microcontroller to other components. This subsystem incorporates an interface designed specifically for prescription-related interactions. It provides input and reminder overrides, prompting users to modify and customize their prescription details as needed. Users also have the ability to adjust basic settings, ensuring a personalized experience tailored to their medical needs. The system further supports multiple repetitive reminder functions, ensuring that users receive timely notifications for medication intake. Additionally, the subsystem is equipped to dispense medicine on time, enhancing adherence to prescribed schedules. Also, the network subsystem will assist with the display of comprehensive drug information at the time of medicine intake, providing users with essential details about their medications. Importantly, the network subsystem ensures the timely conclusion of reminders following medicine intake, contributing to a seamless and effective prescription management experience. This subsystem will aid in achieving all general system requirements as it creates the connectivity between all parts of the system. The current testing can be done with the ESP32-WROOM-32E's bluetooth capabilities. While the WROOM-32e has bluetooth, we will be employing the ESP-NOW communication protocol instead due to its ease of implementation. The ESP-NOW protocol has good range and latency, however it has poor power consumption and barrier effect, but given the system being connected to wall power and being placed just inside a home, we are expecting the communication protocol to function well.

Auxiliaries

This subsystem integrates light (LED) to serve as a visual indicator for repetitive reminders. The use of LEDs allows for clear and noticeable signals, ensuring that users receive timely and distinct notifications for recurring reminders associated with medication intake. Simultaneously, audio elements, presented by speakers, enhance the reminder system's effectiveness. The speaker produces audible alerts that reinforce the visual cues provided by the LED indicators, catering to users with varying preferences. The speakers will be connected to the microcontroller using the I2S protocol. We will design and use a different microcontroller board for this subsystem. More specifically, we will be using the ESP32-C3. Furthermore, Computer-Aided Design (CAD) will be used to create a housing for the speaker and LED. This subsystem will require ordering LEDs, a speaker component, and an I2S amplifier. All of which are readily available through multiple sites.

Website

This subsystem will include the following components and functionalities: design and settings of user interface (UI), backend integration, and react components development. The design will include the development of visually appealing and user-friendly UIs such as forms and input fields for prescription input and settings adjustment pages. It will also be interactive and include clear navigation menus and controls. The backend integration will establish secure connectivity and transmission to backend services for storing and retrieving sensitive user data, such as medical information. The react components would ensure seamless integration of the interactive elements and dynamic functionality into the website and its UI. The modularity and reusability of this last implementation would allow flexibility for future enhancements and updates.

Sensing and Controls
This subsystem includes the pad sensor system, the display, and the button. The pad sensor system will determine if medicines are on the pad or not at the appropriate times. This system will consist of either IR sensors or beam break sensors which will function by covering a grid area within which any medication will be sensed. The details of the sensor will be discussed in the following section. The only signal it will have to return to the microcontroller will be if there are medicines detected or not. In further integration, the microcontroller will take that information and coordinate with the time of day to determine if the state of the pad sensor system is correct. That is to say, there will be four states: medicine should be detected and is, medicine should be detected and is not, medicine should not be detected and is, and medicine should not be detected and is not. These states will determine the software that is implemented and which subsequent subsystems are activated. The second portion of this subsystem is the display which will have to display the information on the medications. Further description of the display used is discussed in the following section. In further integration, this will display information that the microcontroller received from the website and it will display information at given times of the day corresponding to when the medicine is dispensed. The final aspect of this subsystem will be the button which will be used to turn off the notifications for taking medications.

Major Components:

Connection Diagram

ESP32 WROOM 32E
We chose this board to increase the number of available GPIO pins for our main housing unit. The auxiliary systems have separate ESP32 boards which will be discussed below. This ESP32 unit has around 19 GPIO pins which we will use for our sensors, LCD, motor driver boards, and others. The other requirements for the controller were that it needed to be able to work with WiFi, bluetooth, and ESP-NOW, all of which this board is capable of.

Housing
The conveyor belts will be 3D printed. The belt itself will consist of interlocking pieces with a hinge between each as discussed above. There will be no required connections for this or the main housing which will include: a funnel, a slide to the bottom of the funnel, an interior cavity for the wires, and the tray which the medications will be dispensed into.

The motors will be Fielect DC motors rated for 5.5V power and 80mA. The primary function of these motors will be to turn the conveyor belt. The motors will be turned on and off with two motor driver boards from Bojack. More specifically, the motor driver boards will use the L298N to drive 2 motors per each board at 5V power and 36mA. The motors will only go one direction so one input pin will always be high which allows us to use only three input GPIO pins as shown in the connections document. We are also only using three motors so one half of the second driver board will be left unconnected or grounded. The GPIO outputs will turn the motors on and off for a duration of time which will allow the conveyor to turn a certain distance and tip only the medication needed for that particular time period into the main housing and to the sensor pad.

This section will also include the power source which will be a USB connection to wall power to support 5V at 2A. This will be a general wall power adapter from USB to USBC on the board. This will cover the power for the microcontroller and all its connected components including driver boards for the motors. This connection is also shown on the connections sheet.

Network

The network subsystem will employ a dual-protocol approach to optimize communication efficiency and reliability. ESP-NOW is utilized for controller-to-controller communication within the system, ensuring seamless interaction between various components such as auditory and visual reminder modules. This protocol offers low latency and good range support, making it ideal for real-time data exchange between controllers. By leveraging ESP-NOW, we're hoping that auditory and visual reminders are delivered promptly and accurately, enhancing the user's medication adherence experience.

On the other hand, WIFI is employed for controller-to-internet communication, facilitating connectivity to external sources such as our website where prescription details are stored. Utilizing WIFI enables us to access up-to-dare prescription information, allowing users to customize their medication schedules and reminders as needed. This connection also enables the system to receive updates or additional information related to medication management, ensuring that users have access to accurate data to support their healthcare needs.

Auxiliaries

The auxiliary system will have several speakers and LED indicators. The speakers serve as an auditory reminder for users to take the pills on time, while the LED also will be lit when medications remain in the tray. The speaker is rated as 3W 8 ohm, the maximum voltage drive would be 4.9V and maximum current is 0.612A. We will be using the I2S protocol to drive the speaker. The MAX98357A I2S amplifier has an output power of 3.2W at 4 ohms, and 1.8W at 8 ohms. Meaning it has a maximum current rating of 0.89A and a minimum current rating of 0.474A. A minimum voltage rating of 3.3V. The speakers and LEDs will be integrated onto a 3D printed housing.

The auxiliary system will be driven by the ESP32-C3 microcontroller. This microcontroller provides I2S protocol for the audio output while also providing enough general purpose input output pins for the LEDs. This section will also include the power source which will be a USB connection to wall power to support 5V at 2A. This will be a general wall power adapter from USB to USBC on the board. This will power each of the individual auxiliaries. This connection is also shown on the connections sheet.

Website

The website would include a data input module that would allow users to input medication details and settings preferences into the system. The module provides user-friendly input fields and facilitation of data entry, validation, and submission, ensuring accurate input of prescription information. After submission, backend integration would handle the integration of backend services with the frontend UI, ensuring that data transmission and storage is seamless and secure. Both of these components would need internet connectivity to be able to access external resources and effectively communicate with backend systems.

Sensing and Controls
There are two types of sensors that are being examined at this time for final product use. The first is a beam break sensor from Adafruit and the second is an IR sensor from HiLetGo. In the design there would be 6 pairs of either sensor in a grid to create a drop area within which medication will be detected to be present or absent. Each sensor will have a pin on the microcontroller which will report a value for present or absent and the microcontroller will check each sensor output to determine if medication is in the drop area. The IR sensor acts as a distance sensor; it will change values if something is within a distance from it. In other words, we will create a standard grid size within which any sensor which determines something is closer than the standard distance will determine something as present. The beam break sensors will work in a similar grid fashion and will check if any of the grid sensor beams are broken. If they are, this would indicate a present condition. The connections sheet indicates which pins the sensors will be inputs for. The IR sensors require 3.3V or 5V and 20mA each. The beam break sensors use 10mA each at 3.3V.

This product will be using a Hosyond 3.5 inch LCD screen module with an ILI9341 driver chip. This chip runs on a 4 wire SPI interface and has touchscreen capabilities. At this time we are not going to design for the touchscreen capabilities, but it is a potential feature we could include later. In the design the LCD screen will serve to deliver all the major information regarding the medication to the user at the time the medicine is dispensed. This device at the most basic level will be able to read out to the user the names of medication and additional instructions for the medication in basic text. The device will receive the display information over SPI from the microcontroller at the appropriate time. The connections spreadsheet includes the exact connections over which the data will be sent. The LCD screen will require a VCC Power Supply Voltage of 3.3V~5V and a maximum current of 160mA. The button will function at the 3.3V output of the GPIO pins and the current draw is negligible.

Demo Plans for Design Review 2
Housing
The conveyor belt pieces will be printed and connected to each other as well as having the motor connected to the printed gear which will slot into the conveyor belt pieces to move the belt. The center pieces which hold the belt in the correct shape will also be printed. Hopefully all three types of pieces will work together but it is possible that tolerances could limit the functionality of this first version.

Network
Using the ESP-NOW communication protocol, we will be demoing the network subsystem. Through the communication protocol, we will be connecting an ESP32-WROOM-32E module, which will be our main controller, to an ESP32-C3 module, which we will be employing for our auxiliaries. To show successful communication we will be sending data from the WROOM to the C3 which will be denoted as lighting an LED. Then we will sending a successful return message from the C3 to the WROOM to show that both pathways are working properly. To show the WIFI connection functions properly, we will attempt to grab data from a web browser and communicate that to the WROOM, showing successful connection with a blinking LED.

Auxiliaries
For Design Review 2, we will be demonstrating a working auxiliary system without the 3-D printed housing. The system should be able to output specific audio reminders while receiving communication from the main controller. Demonstrating a working I2S protocol using the ESP32 Dev Kits. Showing a lighting LED as the microcontroller receives communication from the main controller.

Website
Website demonstration will showcase a user-friendly interface for inputting medication information. It utilizes Back4App as a storage solution for user data. This will be accessible via a pop-out browser in Visual Studio Code, the demo aims to eventually deploy on Netlify through Github for wider accessibility.

Sensing and Controls
For Design Review 2, the sensing and controls subsystem will demonstrate the use of the LCD screen as well as the sensor which was determined to be the best option for the project between the laser break sensors and the IR sensors. The demonstration will look like generating four generic medicine descriptions on the LCD screen in a large font one after another. It will also display the time. The sensor set up will demonstrate in an enclosed area (catch zone) the sensors can determine whether the medicine is there or not and a value of present or absent to the serial monitor.

Any problems and Plan of Action

The camera sensor upon plug in begins to heat up. At this time, with two other options available for sensors we will plan to pursue those options instead. We will look into returning the camera sensor.