Med-I-Can - Project Proposal

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Introduction

Outline:

A common issue among the disabled and elderly communities, is the need for taking a wide variety of medications at least once a day. Some individuals rely on their caregivers to assist them in this task, and in situations where multiple people are depending on much fewer caregivers (i.e.: group homes), this becomes a tedious task, and can be detrimental if not completed correctly.

Our goal is to create a solution that will simplify the task for caregivers, allow patients to take a step closer to independence, and reduce the risk of incorrect administration of medication. Our idea is to create a physical system (similar concept to a vending machine) that can serve an individual, but is scalable to multiple people, and is controlled by an app. Our idea sets itself apart by allowing one caregiver to manage medication for multiple users, to create preset dosages/timing for each individual, and modify based on the well-being of each individual (for example, if an individual has a cold, add that preset of specific cold medication to the regular medication routine). This is especially crucial in settings such as Assisted Living spaces.

Background:

There exists a partial solution (https://www.amazon.com/GMS-Automatic-Dispenser-Alarms-Included/dp/B002B51358?th=1), which demonstrates the need for a solution to sorting medication, and how crucial it is to avoid overdose.

High-Level Requirements List:

- The device must be able to dispense the correct medications with the correct dosage
- The device must not dispense medication without completely pulling the user's identification card into the device, only returning the card after the user takes out the medication and replaces the cup

Design

Block Diagram:

Below is the block diagram for our solution; we've broken it into three sections: Mechanical, Power/Processing, and the App. These can be created independently, and then modified to work in conjunction with each other. This design will satisfy the high-level requirements; it incorporates systems that are scalable from an individual user to multiple, it allows for simple control/caregiver input via the app, and has safety features to protect users/patients (i.e.: locking card until empty cup, notifications to app (caregiver) if medicines are not retrieved, etc.).

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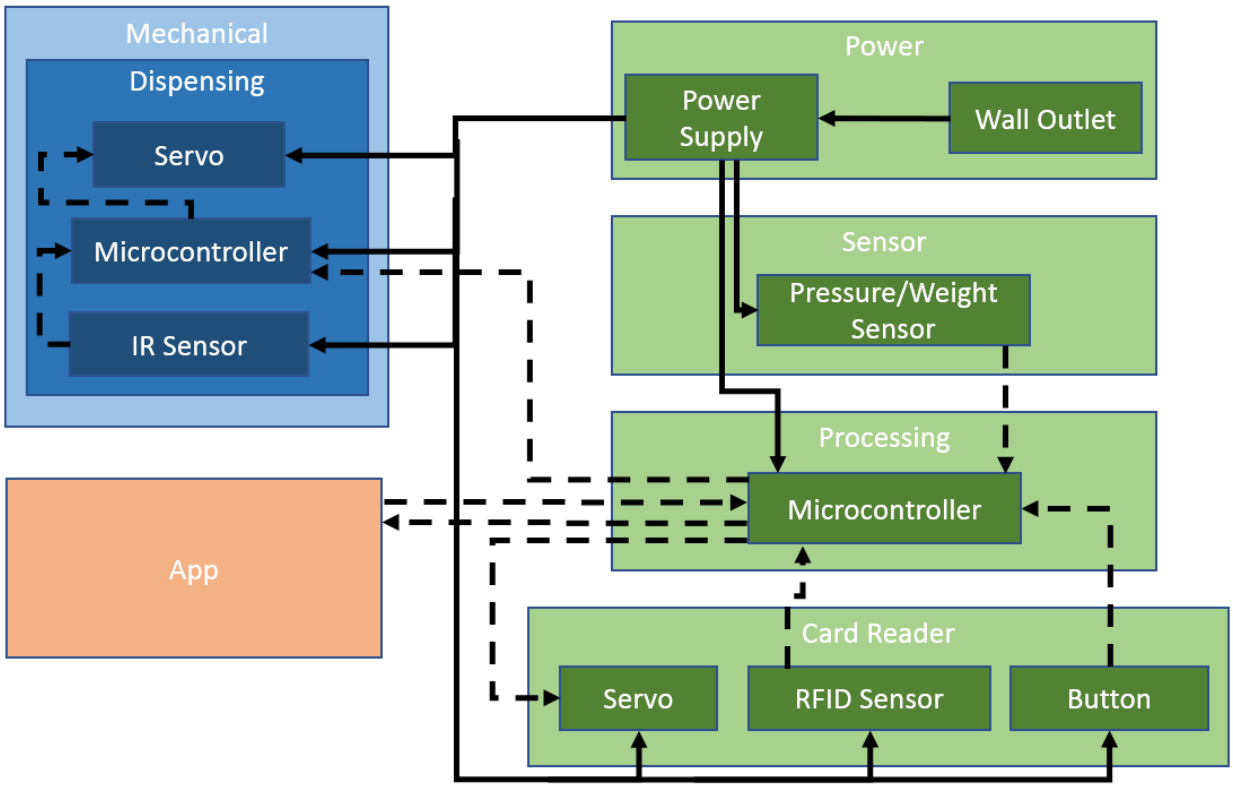

Physical Design:

The physical design is shown below - as we start from the top left, we see the pill reservoir - able to hold approximately the size of a pill bottle, has built in slants to direct pills to the bottom wheel, and contains the wheel/servo/sensor system below it, to ensure one pill is dropped at a time, and that no pills are stuck/rendered useless within the reservoir.

To the top right is the wheel system. The wheel has slots along its perimeter to hold one pill each. For the purposes of this project, we will keep the size of the pills uniform - .25" diameter, and .1875" thick. The wheel will have an incline sitting on top of it, to ensure the pills are oriented correctly, and will ensure more than one pill is not in a single slot. Below the wheel are two things - a sheet covering all holes except 1, and the one that is open contains the IR Sensor, to confirm when a pill has been dropped.

Lastly is the overall system. The reservoirs will sit in the top, the funnel below, and the cup below it. On the bottom right is the card reader/slot.

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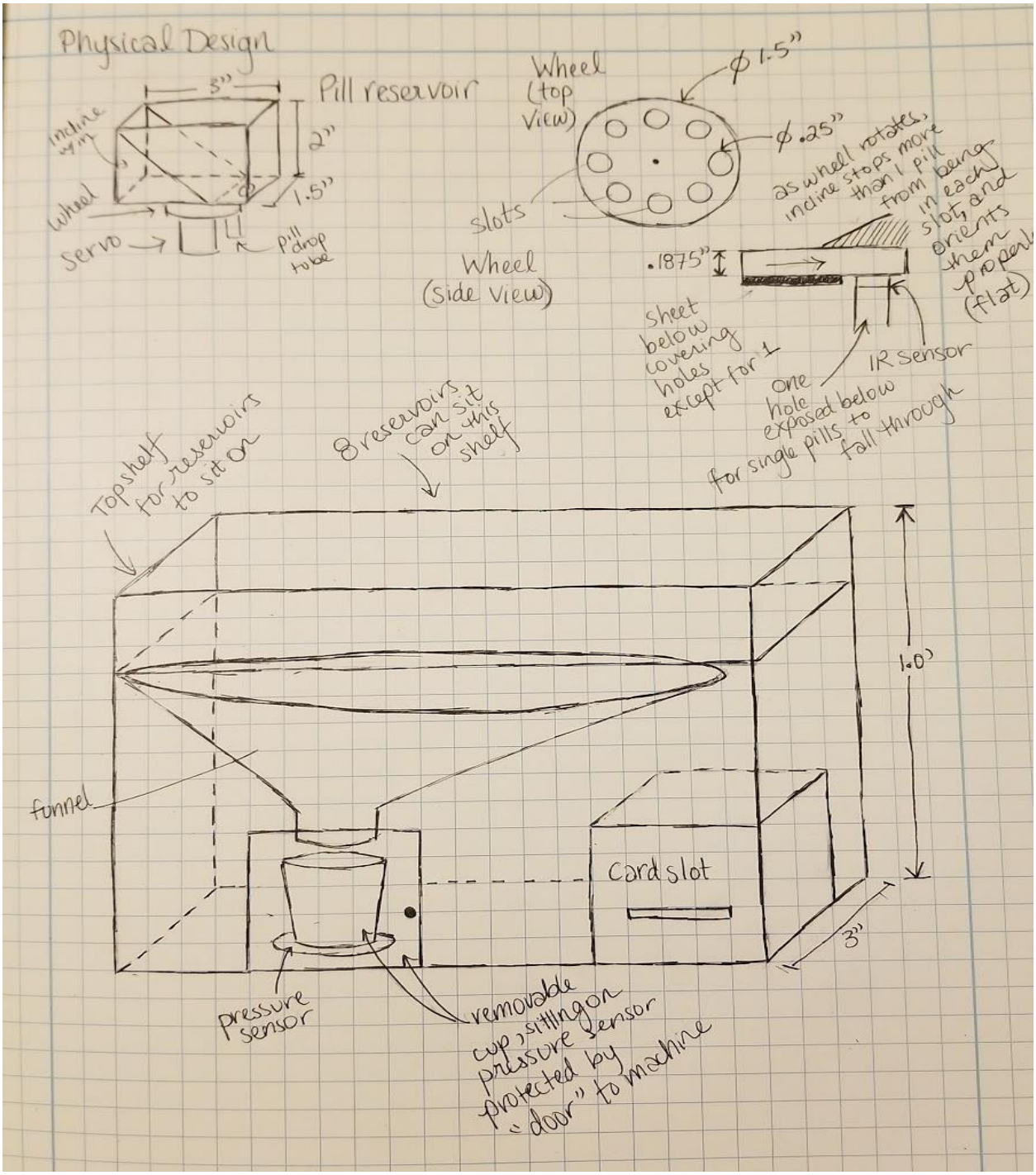

Functional Overview:

2.1 Power Supply Unit:

We would like to power the device using a wall outlet, thus our power supply unit must contain an AC to DC converter.

2.1.2 2 x 110v to 5v 5A Converter

The converters 2x 110V to 5V 5A converters

We need two to ensure that both the micro controllers and the servos can get enough power.

Requirements: The converter must be able to output of 6V ± 1.5V and 5A ± 1A

2.2 Control Unit

The control unit consists of a microcontroller which communicates with the microcontroller in the dispensing unit, the card reader, the pressure sensor and the app.

2.2.1 Microcontroller

The microcontroller receives information about the user's pill schedule via the app and will store that information in flash memory. The controller communicates with the Card Reader to recognize the user's card. The information about that user is then sent to the appropriate dispensing unit. After the dispensing unit returns that the medication has been dispensed. The controller must monitor the pressure sensor to ensure that the medication has been removed and the cup returned before telling the card reader that the user's card can be returned. If the user does not collect their dosage within an hour of the scheduled time, an alert will be sent to the app.

Requirement 1: The microcontroller must be able to communicate with another micro controller either through I2C or SP1

Requirement 2: The microcontroller must be able to read the outputs from the pressure sensor.

Requirement 3: The microcontroller must be able to communicate with a computer that is running our app either through Bluetooth or Wi-Fi.

Requirement 4: The microcontroller must be able to control the servos in the card reader

Requirement 5: The microcontroller must be able either store information on itself, or store information onto a SD card

2.3 Sensors

2.3.1 Pressure sensor

A pressure sensor is required to ensure that user takes out their medication and returns the cup to the device.

Requirements: The pressure sensory must be sensitive enough to verify that the returned cup is empty i.e. must be sensitive to a degree under the weight of a single pill.

2.4 Card Reader

The card reader should detect when a user has inserted their card, fully pull the card into the device and recognize the user based on the card.

2.4.1 2x Servos:

The servos pull the card into the device when prompted by the processing unit.

Requirement 1: The servo must be able to be fitted with rubber wheels for traction against the card.

Requirement 2: The servo be able to continuously rotate so the card can be fully pulled into the device (can also have a large circumference for the rubberized wheel.)

2.4.2 RFID Card scanner:

The scanner recognizes the user with their card

Requirements: The scanner cannot make any mistakes when identifying different users

2.4.3 Button:

The button should be able to sense when the user has provided a card to the card reader.

Requirements: The button should be able to be activated when the card is provided but not impede the card from being inserted into the device completely.

2.5 Dispenser

The dispenser houses several medications and must be able to receive instructions from the control unit and dispense the appropriate medication in the correct dosage

2.5.1 5x Servos

Each of the servos are used to spin a piece that is designed for the specific medication. The piece has a divet in which only one pill fits in, the piece then rotates under a panel to ensure that only one pill is selected. The pill then drops down into the cup

Requirements: Each servo draws under .7A ± 10%

2.5.2 IR sensor

The sensor is used to detect when a pill is dropped down to the cup

Requirements: The sensor must be sensitive enough to determine when a pill passes by

2.5.3 Microcontroller

The controller must be able to communicate with the controller in the control unit and interpret the instructions to determine which medication needs to be dispensed. The controller then causes the corresponding servo to spin until a pill is dropped.

Requirement 1: The microcontroller must be able to communicate with another micro controller either through I2C or SP1

Requirement 2: The microcontroller must be able to read the output from the IR sensor.

Requirement 3: The microcontroller must be able to control the appropriate servo when needed

Requirement 4: The microcontroller must have a latency shorter than half the time it takes for the servo to complete one rotation. This is to ensure that the controller can stop the servo when a pill is detected by the IR sensor

2.6 App

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The app will primarily be used by the caretaker to adjust the medications or dosage for each patient. The app should also be able to check some of the history for previously dispensed medication and to see if a certain patient has gotten their medication yet

Requirements: The app must allow for changes to doses and medications

Risk Analysis:

Our entire design rests on the idea that we can successfully dispense a single pill when it is requested by the control unit. For this reason, we will hinge mostly on the dispensing subsystem and will have to devise a way to separate the pills effectively. Our current design relies on the pills falling into an opening in a disc that is being spun by a servo.

We can modify the sizes of the opening by changing the depth of the disc and width of the hole. The main factor in determining the success of this module is getting the pills to fall uniformly every time. If we do get a problem where the pills are stuck and will not fall into the opening, we could also add a wire, attached to the servo, that stirs the pills in the bottle. The hole must be deep enough and wide enough that an entire pill can fit in it but not so deep or wide that multiple pills could fit in that slot.

In addition, to make sure that a pill is dispensed every time, we will install an IR sensor to detect when something passes it. When one pill passes the sensor, it will register with the microcontroller and stop spinning the servo. It is critical that this sensor picks up the pill because if it does not then it will continue to dispense pills until the bottle is empty.

Ethics and Safety

In dealing with devices that cross into the healthcare domain, there are many things to be conscious about including information privacy, malicious use of the system, and medical regulations.

Since we deal with sensitive information such as an individual's medications and medication schedule, we must worry about potentially leaking this information, intentionally or unintentionally. This makes us susceptible to possible breaches of ACM codes 1.6 and 1.7 (1) which require respecting privacy and honoring confidentiality. We need to make sure that we are securing the user's data correctly and making sure that we do not access information needlessly.

The best solution to dealing with this information is to encrypt it within the app subsystem and only store critical information on the actual device. Information on the device will be restricted to the timings and the dispensers while the app can have information such as the patient's name, which medications are set to dispense, and when they are set. Since that information is sensitive and private only to the caretaker and the individual, we will set a login

for accessing the information on the app. Only after a successful login will the caretaker or individual be able to access scheduling, medicine, and settings for the device. Hosting all the information on the app will ensure that developers cannot see the private information and the login protects against a malicious user attempting to access that private information.

When working with medicine and peoples' medicine schedule, we do have to take into account the users' health. The IEEE code of ethics also takes this into account with rule number 9 (2). In terms of our project, we must ensure that pills are dispensed correctly every single time without any missed doses or double doses. We plan to guarantee this by placing a sensor to check when each pill is dispensed and will keep spinning the servo until that pill is dispensed. On the other hand, we will create a compartment in the disc that the servo spins that will hold exactly 1 pill. With both the mechanical and sensor design we can ensure that the correct number of pills is dispensed every time.

Due to the many regulations related to group homes and nursing homes, this device will most likely be targeted at individuals, their families, and caregivers. Because families and individuals aren't governed by any one group, there isn't a specific list of qualifications to pass for medicine dispensing devices. Primarily we will have to show these groups that the device is consistent, dependable, and easy to use. This will be considered during the entire design process and tested through interviews with people that may be using our device.

There are several other safety concerns that we will have to address. The first would be that of a malicious user attempting to access the individual's medication. While this would already be a problem for someone using the device, we can possibly make it even more secure by locking up the medication and only dispensing it when the user presents their card. In addition, we could also prevent a case where the user forgets to take their medication on time. To combat that, we are going to have alerts sent to the caregiver when the individual has missed a dosage at a certain time. This can help the caregiver keep track of how often the user is missing doses and if more intervention might be necessary.

Bibliography:

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