Team 08 Design Document

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Roulette Design

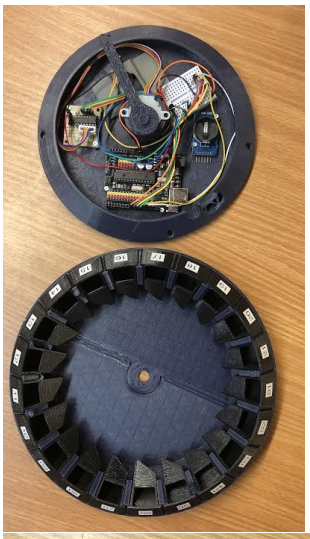

Figure 1: Bird's eye view of the Roulette design. The top half of the image is the lid of the device. Included within the lid are an arduino UNO, a stepper motor, its driver, and a "pushing" rod. The bottom half of the image is the container of the device. The device includes 21 slidable compartments, labeled 01 - 21, 01 standing for Monday morning, and 21 standing for Sunday evening. 02 would therefore equate to Monday afternoon, and so on for one full week. The compartments are capable of holding 14 pills.

Figure 2: Bird's eye view of the Roulette design with both pieces connected. The wire inserted into the device from the right side provides power to the arduino and stepper motor. The LED positioned at the center of the device functions as a reminder system, blinking when the time is right to take medication. The yellow button at the lower left end side of the device will stop the LED from blinking once the user takes the medication.

Introduction

Elderly people often have difficulties with many daily tasks due to a natural decline in physical and mental ability. With modern advances in medicine technology, humans have been able to create medications that have the potential to aid people with these conditions. These medications can change and improve lives by mitigating the effects of an individual's disease or condition. Prescription drugs are an essential part of many peoples' lives, with 89% of Americans over the age of 65 taking daily medication (Kirzinger et. al., 2019). However, due to the declining mental state of many people reliant on these medications, the issue of medication adherence is a large problem. Medication adherence is the act of taking prescribed medicine at the correct times and in the correct amounts (Henderson, 2019). As humans age, their physical and mental capacity slowly decline. This is a natural phenomenon with humankind, however the elderly can also be more susceptible to other detrimental diseases (National Institute on Aging, 2018). Mental decline due to aging can result in poor memory and forgetfulness, which can impact medication adherence. A study conducted in 2019 investigated the causes of lack of medication adherence and confirmed that around 70% of medication nonadherence occurred because of the individual's forgetfulness or procrastination. In addition, approximately 125,000 deaths per year in the United States are due to medication nonadherence (Benjamin, 2012). On the surface, forgetfulness is a simple issue which, for example, could happen due to lack of interest or understanding of why the medication is necessary. If individuals were able to remember to take their medication properly, there could potentially be a significant decrease in incidents due to medication nonadherence.

These problems are extremely relevant to the client as she is over the age of 65 and suffers from loss of memory. These conditions include dementia and cerebrovascular disease. These ailments exacerbate her other diagnosed afflictions that do not affect memory. Many medications have been prescribed–a total of 11–but may not have the desired effect as they are not taken daily. The frustration of the predicament grows as the number of different pills and times at which pills are taken increases. Although the second client of this project, who is also the caretaker of the main client, helps with this process, she is not able to assist every day. Many solutions have been tried such as standard weekly pill

boxes but they are largely unhelpful as it is not uncommon for the client to mistake the day of the week and to take the wrong type or amount of pills. The current method is a customized set-up of pills and small cups in weekly rows. This allows her to see what pills should be taken and not have to take them directly from the pill bottle. Unfortunately, this solution does not stop pills from being mixed up, being taken at improper times, or being left untaken entirely. They are only consistently taken properly when the client is specifically directed to the number, type, and time by the caretaker or another family member. Therefore, the goal of this project is to create a device that informs the client of each of these specifications without the help of another person every day.

Problem Statement

Elderly people with health issues often have numerous daily prescribed medications, and as age increases, it becomes more difficult to remember the amount and type of medication to take.

Objective

The project objective was to create a device that assists users in remembering to take the correct prescribed medication at the correct time of the day.

Target Audience

The device is targeted toward the elderly population who take medication frequently. However, the device is not limited to this audience, as anyone can use the device to aid them in reminding them to take medication on a regular basis.

Market Research

There are already several designs patented to aid with helping one take their medications. However, no patent satisfies all of the client's requirements. In addition to patents, several on-the-market appliances are used to help keep track of their medications.

One competitor is the MedQ Daily Pill Box Reminder. The MedQ Daily Pill Box Reminder is expensive, but it satisfies most of the requirements of this project, as a sound and visual reminding system are integrated into the pillbox. However, as mentioned prior, it is expensive, but also small, since it does not permit a user to fit medication three times a day per week.

A second competitor is a pillbox. A pillbox is cheap, but it does not satisfy any level 1 requirements, other than being sufficiently large to hold a week's worth of pills.

A third competitor is the TimerCap, which is also cheap. However, the TimerCap also does not satisfy any level 1 requirements except for being easily accessible for a user to utilize.

Preliminary Designs

There were three preliminary designs considered in the approach to meet a product satisfactory to the client's needs. The first one, a retrofittable device that attaches to a pillbox, was considered. Figure 3 below shows the design self-serve. The second design, the calendar, would automatically dispense the pills, as shown below in Figure 4. The third design, a smaller, portable "bottle," was created.

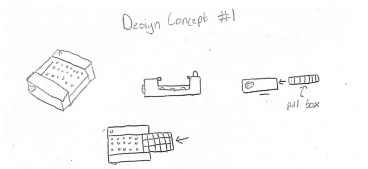

Figure 3: a drawing of the Self-serve design.

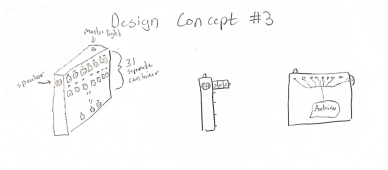

Figure 4: a drawing of the calendar.

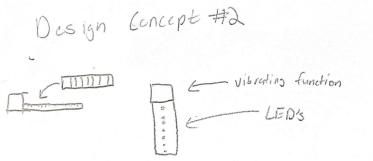

Figure 5: a drawing of the portable "bottle."

Matrix

Table 1 below shows how the roulette design was decided to be further developed

#	Level	Requirement Type	Requirement Statement	Design 1 Pill-Box Attachable	Design 2 21 Servo Motors	Design 3 3 Stepper Motors	**Design 4 Roulette Wheel**
1	1	Functional	The device will have a visible light function that serves to remind the client to take the prescribed pills	Yes	No	No	Yes
2	1	Functional	The device will stop the alert (visual) to take pills once the pills have been	No	N/A	N/A	Yes

			taken.				
3	1	Functional	After a specified time, if pills have not been taken, the device will stop the alert (visual)	Yes	N/A	N/A	Yes
4	1	Functional	The device will allow for a reminder to take medicine at least three times a day	Yes	Yes	Yes	Yes
5	1	Documentation	The Device will come with a Manual and Instructions	Yes	Yes	Yes	Yes
6	1	Ease of use	The pills will be easily accessible for an elderly person	Maybe	Yes	Maybe	Yes
7	1	Functional	The device will hold one week's worth of pills	Yes	Yes	Yes	Yes
8	2	Functional	The pills will be inaccessible to the client until specified times (It will lock)	No	No	Yes	Yes
9	2	Functional	The device will have an optional/adjustable sound function to aid in reminding the client to take their pills	No	No	No	No
10	2	Functional	The device will have a power source supplied by an electrical outlet	Yes	Yes	Yes	Yes

11	2	Cost	The cost of the materials of the device will cost no more than $80	Yes	No	Yes	Yes
12	3	Functional	The device will have a user interface for the caretaker to specify the days and times when the device will remind the client to take their pills	No	No	No	No
13	3	Functional	The device will be supplied with a personalized pill box that allows for the caretaker to fill it up with pills quickly and move it back into place for the clients use	No	No	No	No
14	3	Functional	The device will notify caretaker if pills are not taken at the correct time	No	No	No	No
15	3	Physical	The device will not be larger than 2ft x 2ft x 2ft and will be aesthetically pleasing	Yes	Yes	Yes	Yes

Table 1: A matrix of the requirements each device satisfies.

Table 2 helps decide what design we needed to choose for our final design.

#	Criteria Weight	Requirement Type	Requirement Statement	Design 1 Pill-Box Attachable	Design 2 Vertical Drop	Design 3 Sliding Floor	Design 4 Roulette Wheel
1	9	Functional	The device will have a visible light function that serves to remind the client to take the prescribed pills	9	0	0	9
2	7	Functional	The device will stop the alert (visual) to take pills once the pills have been taken.	7	0	5	7
3	8	Functional	After a specified time, if pills have not been taken, the device will stop the alert (visual)	6	0	0	8
4	10	Functional	The device will allow for a reminder to take medicine at least three times a day	0	10	10	10
5	9	Documentation	The Device will come with a Manual and Instructions	6	6	6	9
6	9	Ease of use	The pills will be easily accessible for an elderly person	4	7	4	7
7	10	Functional	The device will hold one week's worth of pills	10	10	10	10
			Total out of 62:	**42**	**33**	**35**	**54**

Table 2: A decision matrix on a weighted scale

Building and Testing

1. The first step to build this model was to design the parts needed in Solidworks. This consisted of designing the base holder, the top lid with mounts for all components, and the individual compartments for holding pills.

2. Once the files were finished and proper fit between parts was achieved in a Solidwokrs assembly, the CAD files were exported as .stl files.
3. Prints were set up in Ultimaker Cura, and parts were printed on an Ultimaker 3 using PLA material extruded through a 0.8mm nozzle.
4. All parts were printed: two halves of the base piece, the top piece, 21 compartments, and the pushrod.
5. The parts were assembled as shown in the CAD assembly, and all necessary Arduino components and circuitry were assembled.
6. For the Arduino, the UNO board, stepper motor, stepper driver, breadboard, LED bulb, and button were included in the circuit.
7. This circuit was then mounted to the top piece of the model utilizing the previously designed mounting points, and the top was assembled to the rest of the model.
8. The arduino was then coded in Arduino software to implement the necessary loops and commands for the stepper, LED, and button. Code used can be found in the Appendix of this document.
9. When the final code was uploaded to the arduino, the power source was connected through means of a wall-mounted power adapter threaded through predesigned holes in the model.
10. Once the code was uploaded and the model was connected to its power source, testing was carried out to determine the feasibility and functionality of the model. Three tests carried out are described below.

The Simplicity of Taking Medication

23 May 2022

Purpose

The purpose of this test was to determine the difficulty of obtaining medication from each device by measuring the time elapsed for each participant to take medication.

Independent Variable

The independent variable of this test was the device being tested. Two devices were tested: the standard pillbox, and our roulette wheel prototype.

Dependent Variable

The dependent variable of this test was the amount of time it took a user to obtain the medication from a single compartment.

Control Variables

1. Amount of pills to be taken from their respective compartment
2. Amount of compartments the participant must open: 1

Materials

- Colored tic tacs
- Pillbox
- Roulette prototype
- Stopwatch
- Participant

Hypothesis

The hypothesis of this test is that the roulette design will decrease the amount of time it takes a user to obtain the contained medications.

Methodology

1. Each device was filled with the same amount of tic tacs in 1 compartment: 3. Figures 6 and 7 demonstrate how to set up this test using both devices.

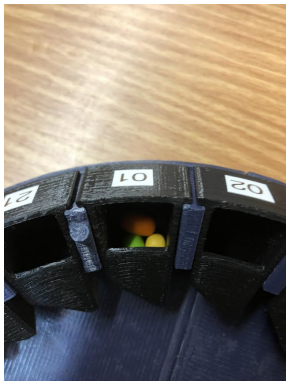

Figure 6: The pillbox with 1 compartment filled with 3 different colored tic tacs.

Figure 7: The roulette design filled with 3 different colored tic tacs.

2. A participant would try to take the pills out naturally.
3. The time from touching the device to closing the device after the medication has been removed was documented.

Results

Table 2 below shows the data acquired from 4 participants on the time it took each person to take the medication out of the device, in seconds.

	Device	
	Roulette = R	
	Pillbox = P	
Participant		**Time to take medication (s)**
1	R	4.11
1	P	8.67
2	R	3.44
2	P	12.08
3	R	3.21
3	P	6.83
4	R	3.43
4	P	11.47

Table 2: a table of the time it took 4 participants to take 3 pills from each device.

Analysis:

The average time to take medication for the roulette design is 3.55 seconds. The average time to take medication from the pillbox design is 9.76 seconds. The data shows the roulette design, on average, decreases the amount of time it takes a user to take medication out of the device and close the device. From the data, it can be inferred that an automation system to dispense pills reduces the time it takes a

user to obtain the medication. Therefore, it can be concluded that future devices should include automated dispensing to make taking medication a more convenient process.

Conclusion:

The time to take mediation from the roulette design was significantly less than the time it took to take medication from the pill box design. The time difference was mostly made up in opening the pillbox design and finding the correct box. There are no decisions being made when taking pills from the roulette design which makes it much simpler, easier, and faster to take pills. In relation to our project, this shows that our novel design functions better in quickly gaining access to the pills. Despite this, there is still room to simplify finding the correct pills in our design.

Future Extensions:

To further increase the simplicity of finding and taking pills, an LED may be added corresponding to each separate box in our design. This would grab the attention and clear up any discrepancy if the arm fails to push the box out to the desired distance and height.

The Simplicity of Refilling Medication

23 May 2022

Purpose

The purpose of this test was to determine the ease with which the user could refill each device.

Independent Variable

The independent variable of this test was the device being tested. Two devices, the standard pillbox, and our prototype, the roulette wheel, were tested

Dependent Variable

The dependent variable of this test was the amount of time it took the participant to fill up each compartment of the device with the correct medication.

Control Variables

1. Amount of tic tacs to fill up each compartment with
2. Amount of compartments each participant fills up

3. Starting and stopping the stopwatch

Materials

- Colored tic tacs
- Pillbox
- Roulette design
- Stopwatch
- Participant

Hypothesis

The hypothesis of this test was that the roulette design would decrease the amount of time it took a participant to fill up all 21 compartments.

Methodology

1. Colored tic tacs separated into 3 large containers, by color. Figure 8 demonstrates how to separate the tic tacs into 3 large containers.

Figure 8: Tic tacs separated by color onto 3 different plates.

2. Participants would put 1 of each colored tic tac into all 21 compartments in a natural motion
3. The time from when the participant initially comes into contact with a tic tac to when the final compartment was closed was documented.

Results

Table 3 below shows the data acquired from 4 participants and the time it took to refill all 21 compartments of each device.

	Device	
	Roulette = R	
	Pillbox = P	
Participant		**Time to restock (s)**
1	R	125.56
1	P	138.44
2	R	138.85
2	P	147.59
3	R	85.96
3	P	122.75
4	R	77.00
4	P	109.26

Table 3: a table of the time it took participants to refill 21 compartments with 3 pills each.

Analysis:

The average time to take medication from the roulette design is 106.84 seconds. The average time to take medication from the pillbox design is 129.51 seconds. From the data, the roulette design had an impact on reducing the amount of time it took a participant to fill up an entire medication storage device when compared to a pillbox. The time discrepancy may be explained by the fact that the pillbox includes lids for every compartment while the roulette design includes one lockable main lid so compartments may be left open. Therefore, time was saved as the roulette design does not require the user to open every lid to every compartment.

Conclusion

Most medication storage systems require human function in order to be refilled. The time it takes the caretaker to refill these devices causes an excess of wasted time. However, manual refilling may be optimized. For example, the data showed that reducing the number of compartments for the whole device may help lower the total time to fill up one device.

Future Extensions:

Locking mechanism but make the lid easier to take off.

More open compartments to enable an easier dropping process.

Memory Assistance

24 May 2022

Purpose

The purpose of this test was to determine the effectiveness of each device in aiding a user to remember the correct times to take medications.

Independent Variable

The independent variable of this test was the device being tested. Two devices, the standard pillbox, and our prototype, the roulette wheel, were tested

Dependent Variable

The dependent variable of this test was whether the participant did or did not believe an effective reminding system was implemented.

Control Variables

1. Video or image shown to participants
2. Questionnaire given to each participant.

Materials

- Pictures of pillbox and roulette design
- Participants
- Questionnaire
    - Would this device be capable or not capable of reminding you to take pills within ___ minutes?

Hypothesis

The hypothesis of this test was that participants would answer that the roulette design would help them more frequently take their medications at the correct time.

Methodology

1. Participants were told what the devices being tested were.
2. The participant would answer either yes or no to the question “would this device be capable or not capable of reminding you to take pills within 60 minutes?”
3. The yes or no answer was documented

Results

Out of 10 participants asked, all 10 participants believed the roulette design would remind them to take pills within 60 minutes and 0 participants believed the pillbox would remind them to take pills within 60 minutes.

Analysis

From the data obtained, the roulette design would better remind a user to take their medication when compared with a pillbox as more participants found the roulette design to be more capable of reminding them to take medication at the correct time.

Conclusion

Users who struggle with remembering to take their medication would benefit from this design from the data acquired. It is concluded from the data that some sort of visual alert would be helpful to help a user take the medication within an allotted time.

Future Extensions

One future extension of this test is the possibility of acquiring data where a participant is in a controlled environment and the number of times each device being tested reminds the user when to take pills is documented. This ensures more precise data on whether or not the roulette design includes a better reminding aspect when compared to a pillbox. In addition, implementing and testing some sort of audio alert could be beneficial to aid in the reminding system of medication storage devices.

References

Benjamin R. M. (2012). Medication adherence: helping patients take their medicines as directed. *Public health reports (Washington, D.C. : 1974)*, *127*(1), 2–3. https://doi.org/10.1177/003335491212700102

Henderson, R., & President, V. (2019, September 19). Study: Proactive efforts improve adherence. Study: Proactive Efforts Improve Adherence. Retrieved March 20, 2022, from https://www.express-scripts.com/corporate/articles/study-proactive-efforts-improve-adherence

Kirzinger, A., Neuman, T., Cubanski, J., & Brodie, M. (2019, August 9). Data Note: Prescription Drugs and Older Adults. Health Reform. Retrieved March 20, 2022, from https://www.kff.org/health-reform/issue-brief/data-note-prescription-drugs-and-older-adults/

U.S. Department of Health and Human Services. (2018, January 24). *Do memory problems always mean alzheimer's disease?* National Institute on Aging. Retrieved March 20, 2022, from https://www.nia.nih.gov/health/do-memory-problems-always-mean-alzheimers-disease

Appendix

Link to .stl files used to print the model:
https://drive.google.com/drive/folders/1-D-nDRFW83VgCoLB_NZ4PH_tdkRX1r55?usp=sharing

Arduino Code

```
// Include the Arduino Stepper.h library:
#include <Stepper.h>

// Define number of  per rotation:
const int stepsPerRev = 2048;

// Create stepper object called 'myStepper', note the pin order:
Stepper mySteps = Stepper(stepsPerRev, 8, 10, 9, 11);

// start off with the flashState "on"
boolean flashState = true;
int ledState = HIGH;

#define LED_PIN     13                  // the number of the LED pin
#define STOP_BUTTON  12                 // the number of the button pin

// time events (48second day, 1hr = 500ms)
const long take = 5000;                 // time during which pills are available
const long holdAM = 8000;
const long holdNOON = (8000 + take + holdAM);
const long holdPM = (8000 + take + holdNOON);
const long holdNIGHT = (8000 + take + holdPM);
const long blinks = 400;                // interval for led blinks
unsigned long prevMillis = 0;           // previous time for led blinking
unsigned long timing = 0;               // rewrite time to use events better

void setup() {
  pinMode(LED_PIN, OUTPUT);             // set led pin as output
  pinMode(STOP_BUTTON, INPUT);          // set button pin as input

  mySteps.setSpeed(7);                  // Set the speed to 5 rpm:
```

```
}

void loop() {
  unsigned long currentTime = millis();          // time since program started in ms

// first time "8am"
  if (currentTime == holdAM) {
    flashState = true;
    mySteps.step(-78);
  }

  if (currentTime >= holdAM && currentTime <= (holdAM + take)) {
    // blink led when time reaches interval
    if (currentTime - prevMillis >= blinks) {
      prevMillis = currentTime;                  // rewrite prevMillis for next blink

      if (ledState == LOW)
        ledState = HIGH;
      else
        ledState = LOW;

      // only flash LED is the flashState is true
      if (flashState == true)
        digitalWrite(LED_PIN, ledState);
    }

    // check the stop button
    if (digitalRead(STOP_BUTTON) == HIGH) {
      digitalWrite(LED_PIN, LOW);
      flashState = false;
    }
  }

  if (currentTime == (holdAM + take)) {
    mySteps.step(-19.6);
```

```
    digitalWrite(LED_PIN, LOW);
  }

// second time "12pm"
  if (currentTime == holdNOON) {
    flashState = true;
    mySteps.step(-78);
  }
  if (currentTime >= holdNOON && currentTime <= (holdNOON + take)) {
    // blink led when time reaches interval
    if (currentTime - prevMillis >= blinks) {
      prevMillis = currentTime;                    // rewrite prevMillis for next blink

      if (ledState == LOW)
        ledState = HIGH;
      else
        ledState = LOW;

      // only flash LED is the flashState is true
      if (flashState == true)
        digitalWrite(LED_PIN, ledState);
    }

    // check the stop button
    if (digitalRead(STOP_BUTTON) == HIGH) {
      digitalWrite(LED_PIN, LOW);
      flashState = false;
    }
  }

  if (currentTime == (holdNOON + take)) {
    mySteps.step(-19.6);
    digitalWrite(LED_PIN, LOW);
  }
```

```
// third time "5pm"
  if (currentTime == holdPM) {
    flashState = true;
    mySteps.step(-78);
  }
  if (currentTime >= holdPM && currentTime <= (holdPM + take)) {
    // blink led when time reaches interval
    if (currentTime - prevMillis >= blinks) {
      prevMillis = currentTime;                  // rewrite prevMillis for next blink



      if (ledState == LOW)
        ledState = HIGH;
      else
        ledState = LOW;

      // only flash LED is the flashState is true
      if (flashState == true)
        digitalWrite(LED_PIN, ledState);
    }

    // check the stop button
    if (digitalRead(STOP_BUTTON) == HIGH) {
      digitalWrite(LED_PIN, LOW);
      flashState = false;
    }
  }

  if (currentTime == (holdPM + take)) {
    mySteps.step(-19.6);
    digitalWrite(LED_PIN, LOW);
  }
}
```