Automated Pill Dispenser

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Abstract

In this project, we are building a machine to sort and dispense a user's pills for them using an Arduino microcontroller. The user will pour each pill box separately into the machine's individual funnel compartments, then use the buttons and LCD screen to designate how many pills per day the user will need for each pill, and set the time of day that they would like to take their pills. Each funnel compartment is attached to a 180 degree servo motor that is used to dispense the pills in the funnel at the time set, and an alarm goes off once the pills are dispensed to alert the user that it is time to take their pills. The benefit of this machine is to save time for the user, and to easily and conveniently remind the user to take their pills each day. It can take up to an hour for someone with a lot of different prescriptions to sort out all of their pills that they need to take for the week, and even after sorting them out, the person still needs to remember to take them at the correct time. With our machine, the pills all get dispensed at the time needed, and the users will hear an alarm to know when it is time to take their medication. Along with being used at home, this device could also be used in places like hospitals and nursing homes where workers are responsible for giving others their pills.

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1. Introduction

The automated pill dispenser we created is used to help ease the lives of people who need to take a lot of medication. The motivation behind our project is to save users time and energy when they are sorting their pills, and help remind them to take their pills and alert them when it is time for a prescription refill. When my mother used to help my grandmother sort her weekly pills, it took her over an hour each week to get all of her prescriptions sorted into the weekly prescription containers. Even after the pills are sorted into their compartment, there is no guarantee that the person will remember to take their pills when they need to. Seeing how much time and effort went into this process, I realized that there has to be something that could be done to automate the process.

We believed that we should utilize our senior design project to create something that would benefit the lives of many. Since there are so many people who take lots of vitamins and pills daily, the pill dispenser seemed to be a product that could reach the level of impact that was desired. Our main objective was increased efficiency. We've seen other sorting devices and found them to be interesting and since our whole team is composed of electrical and computer engineering students, sorting and sorting efficiency is something that we have had quite some experience with. As previously stated, our project was made to save users time and energy, but it also adds a better sense of organization when it is compared to the traditional 7 compartment pill dispenser made for 1 week because we felt like 1 week was not long enough. To gain maximum efficiency, the plan was to reduce the amount of effort for the user as much as possible so they almost never have to do anything other than pick up the pills from a tray.

2. Methods / Results / Approach

2.1. *Methods*

2.1.a. System design and implementation challenges

The system design for our Automated Pill Dispenser has changed throughout the semester as we have continued to come up with better ideas that would make things easier for both the users and the developers. Originally, we were going to only have one funnel for our machine, and the user would have to dump prescriptions in one at a time, then have a slide like device under the funnel that would guide the pills to different compartments corresponding to different days of the week, and from there they would sit until it was time for that compartment to get dispensed. We quickly realized that this implementation could be confusing for the user, and there would need to be a lot of different compartments if we wanted to split up the weekly pills into AM and PM pills as well.

After our first Capstone presentation, we came up the idea to use five different funnels, and have the pills just get held in the chambers until it is time for the user to take the pills. Since our machine has only five funnels, that limits the amount of different prescriptions the user can have to five. This was just a proof of concept idea, where having ten funnels for up to ten different prescriptions would have been more ideal, but we could not afford to have ten funnels with our current budget, so we chose five. There is one button associated with each funnel, which is used to set the number of pills needed each time the user takes their medication. There is an hour and minute button next to the LCD screen to set what times the user needs to take their medicine, and an “Okay” button to confirm that the data inputted was accurate and stored

correctly.

The best way to explain the flow of the Automated Pill Dispenser is by using an example. Say there is a user named Bob, who has five prescriptions to take: Pill A, Pill B, Pill C, Pill D, and Pill E. He needs to take his medicine every day at 5 PM, and when he takes them, he needs 1 pill of Pill A and Pill B, 2 pills each of Pill C and Pill D, and 1 pill of Pill E. He goes up to the machine, dumps Pill A into the Funnel 1, and clicks Funnel 1's button once to select that he needs one pill from Funnel 1, then clicks the save button next to the LCD screen. He follows these same steps for the following pills and funnel, with the only difference being that he incremented Pill C and Pill D to dispense two pills at the time needed. Once the pills are all in the funnels, he can use the hour and minute hand to set what time he would like to take his pills, and click the save button to save the dispense time. Once that time set occurs, Funnel 1, Funnel 2, and Funnel 5 all dispense one pill, and Funnel 3 and Funnel 4 both dispense 2 pills, and an alarm rings to alert the user that they need to take their medication.

We thought of a few potential challenges that we may face, so our design tried to prevent these challenges from arising as best as we could. We believed that it is possible for pills to get stuck in the dispenser when they are being dispensed. Many pills have jagged edges instead of rounded and due to the small holes that the pills fall through, we thought that it would make sense for it to be possible for pills to get stuck on their way out. Although we did not add a way to prevent this, we did come up with one for future development. We could have a motion sensor placed within the exit tube to let the system know that a pill was dispensed. If the sensor is not activated when it should have been, then the motor would then rotate again to attempt to

dispense another pill to compensate for the possibility of it getting stuck. Otherwise, if the sensor is activated, the system will know that the pill was dispensed and the motor will not try to dispense it again.

If we were to have more time or to continue further in our design, we would implement a peripheral app that works with the device. Our ideas for the app included functions that would make the automated pill dispenser even more efficient and make it easier to know more about what's going on inside the product. The app would send notifications to the user when it is time to take their pills in case the user does not hear the alarm. It would also show you how many pills are left in each funnel. We thought it would be nice to include a library of common medications so that the app could be used to select what pills are in each funnel, and display information about what they are used for in case the user or someone else needs to know.

2.1.b. Time constraints and their impact on design

Time constraints limited the design of our project because we weren't able to accomplish everything we would have liked in order to make the most useful pill dispenser that we possibly could. We had to wait over a month in order to get our 3D printed parts, which is an essential part of the project and really delayed the development process. We started some of the programming and building the circuit prior, but needed to wait for the funnels to start actually implementing and testing everything, which didn't arrive until late March. Although we started late, the Automated Pill Dispenser is completed, however there were some additional features we would have liked to incorporate into our project that would have benefitted the user even more. We are planning on developing an app and web page for our dispenser, which keeps track of how

many pills the user has remaining in each of the funnels, when it is time for the user to take their pills, and when they need to call the pharmacy for a refill on a prescription. We would have also liked to add the motion sensor incase a pill gets stuck, so that way it would attempt to dispense the pill again. Regardless that the deadline for the semester is up, we plan to continue improving our design throughout the summer and finishing the app and web page.

2.1.c. Required knowledge base for the project

This project requires knowledge in both hardware and software, The logic for the Arduino is written in C/C++, but with the tutorials provided, if you have any programming experience (Java, Python, etc.), then you should be able to pick it up relatively easy and figure out what you need to do to implement the Arduino how you like. Along with the programming, you need to have knowledge in building electrical circuits as well. Like the programming aspect of Arduino, the hardware aspect is made to be fairly simple as well. You wire the hardware onto the breadboard as you would a normal circuit (LED lights, buttons, resistors, etc.), and they each need their own digital pin on the Arduino board which is specified in the code, and when different pins go high, or are turned on, then it reacts in different ways depending on how you program the logic. Lastly, we needed someone who is skilled in building boxes out of plexiglass, because we had to specially design our case to fit our needs. One of our parent's friends works with plexiglass for a living, so he helped us design and build the box for our project.

2.1.d. Required hardware and software tools and accessibility

For our project, we used a combination of hardware and software to create our Automated Pill Dispenser. The hardware we are using includes an Arduino Mega board, breadboard, momentary push buttons, servo motors, an LCD screen, a Real Time Clock for

Arduino, a wifi shield, wires, and plexiglass. The software that we used was the Arduino IDE to program the logic for the Arduino, along with SolidWorks to create the 3D model for the funnels and wheels for the dispenser. One of the struggles we faced was finding a way to get our 3D models printed. We went to Makerspace on Livingston campus, but they were having technical difficulties with their printer for over a month. Since we were unable to print it at makerspace, we uploaded our 3D models onto a website called Shapeways, and within a week we had received our 3D parts in the mail. We needed a laser cutter and drill to complete the plexiglass case, and a soldering kit to solder wires to certain hardware components like the buttons and LCD screen.

2.2. *Use of Standards*

For the Arduino IDE, we needed to have a Java Development Kit (JDK) of 7 or higher. We used the Arduino IDE, which is a Java based program and we wrote our code in C++ for the logic of the Arduino. Arduino is an open-source hardware and software, which is licensed under the GNU Lesser General Public License (LGPL) and the GNU General Public License (GPL). The arduino board utilizes serial communications interfaces like the Universal Serial Bus. We also followed Agile software development principles, performing fast iterative sprints to get results quickly and increment until we had a final product. We needed to use a Real Time Clock to keep track of time, so we used the RTC Library for Arduino. The RTC uses a crystal oscillator with a frequency of 32.768 kHz. We also needed to use the Servo Library because we used 5 servo motors to make the pills fall through the funnels. They are standard servos that rotate anywhere between 0 and 180 degrees. The final library that we used to code our project was the

LiquidCrystal Library, This library was for the LCD screen, and it is how we got the screen to display the information to the user. The library works in an 8-bit mode, which means that it uses 8 data lines in addition to the rs, enable, and the rw control lines. The information that we displayed with this is the time and date, temperature, and how many pills the user needs from each funnel.

2.3. *Experiment / Product Results*

Throughout our time working on our design, we used Advil liquid gel pills and Spring Valley B12 tablets for testing purposes. We started with 1 funnel, 1 motor, and 1 pill, with no buttons or LCD screen to get started. It took quite some time to get the code to run in the way that we wanted it to but we realized that it was because of the motor we were using. We were trying to use a continuous rotation motor, but it was difficult to get that type of motor to stop at the correct angle, so we had to switch to standard 180 degree servo motors. Once we received the appropriate motor, the code was much easier to work with. As time went on we progressively built on top of the initial design. We then increased the number of pills to be dispensed at a time, and added the button to try to make our product dispense with every press. Following the addition of the button, we moved on to programming the LCD screen so we could add the next funnel and motor and know which one we are controlling. Through trial and error and slowly progressing one step at a time, we made our way to building our entire system.

Once we had the code working and the circuit set up, we began designing the plexiglass case that we were going to use for it. We measured each piece of hardware to map out exactly what size box we thought we needed, and got help by someone who works with plexiglass to

make our design come to life. We then used a laser cutter to cut the holes that we needed into sheet of plexi to put all of our components in. Once all of the components were in, we had to rewire the entire circuit to make the wires look neater and more organized. After several attempts of figuring out where the canoe needs to go that causes the pills to fall down and into the container, we finally got it so that each pill falls into the container and doesn't get stuck on the canoe.

The Automated Pill Dispenser seems to work very well, however the only problem is that it is not optimal for every type of pill. If the user has very tiny pills that they need to take, the dispenser will probably dispense more than one at a time, and if the pill is quite large, it can get stuck in the funnel. For most standard sized pills, our product works. In the future, we need to design our funnels to be able to handle any size pill.

3. Cost and Sustainability Analysis

3.1 Cost per one unit:

Item	*Unit Cost*	*Quantity*	*Total Cost*
3D Printed Funnels	$30.96	5	$154.84
Arduino Mega	$37.59	1	$37.59
Buttons	$0.42	5	$2.12
Servo Motors	$2.60	5	$12.99
LCD Screen	$5.63	1	$5.63
Real Time Clock for Arduino	$5.59	1	$5.59
Breadboard	$6.70	1	$6.70
Wires	$8.98	1	$8.98
Plexiglass	$20.00	1	$20.00
Total Cost for 1 Unit:			**$254.44**

3.2. Cost for mass production (10,000 units).

Mass Production: 10,000 Units

Item	*Unit Cost*	*Quantity*	*Total Cost*
3D Printed Funnels	$3,000 base charge for 3D Printer + $1.50/unit (PLA)	50,000	$78,000
Arduino Mega	$10	10,000	$100,000
Buttons	$0.16	50,000	$8,000
Servo Motors	$0.24	50,000	$12,000
LCD Screen	$2.05	10,000	$20,500
Real Time Clock for Arduino	$1.88	10,000	18,899
Breadboard	$0.75	10,000	$7,500
Wires	$3.25	100 spools	$325
Plexiglass	$12	10,000	$120,000
Total Cost for 10,000 Units: $365,224		**Cost per Unit: $36.52**	

3.3. Cost savings

In order to save more money, we could resin cast the funnels rather than 3D printing them when doing mass production since resin casting would be much more cost efficient. The plexiglass is the most expensive aspect of the pill dispenser, so if we were able to either use less plexiglass, or change materials to something cheaper like wood, then this product would cost us less per unit to make, which would give us bigger margins if we were to ever sell our product.

3.4. Social impact of the product

i. *How can the developed product impact people's lives?*

The automated pill dispenser will benefit people's lives because they will have an easier time keeping track of their pills, when to take them, and which they need to take. Some people are used to spending over an hour each week sorting their pills into their weekly pill sorters, and when they switch over to our automated dispenser, it will turn that hour process into a 5 minute task. Not only does it shorten the amount of time the user needs to put into sorting their pills each week, but it is also more effective at alerting the user to take their pills, as it rings an alarm when the pills are dispensed. In the future, when we finish developing our app for the Automated Pill Dispenser, it will send a notification to the users phone alerting them that it is time to take their pills.

ii. *What community or personal needs does it address?*

As stated, this automated pill dispenser would most likely be used for people who have to take an abundance of pill on a regular daily basis or people who have trouble keeping up with or

counting them. On average, that focuses on primarily on but is not limited to the elderly.

iii. *Is the product going to change consumption patterns?*

The product that we designed will not change the consumption patterns for anyone beside helping people keep a steady schedule. The efficiency of our design allows the user to save time, thus they will no longer have to go through the manual sorting process. Therefore, the only change in the pattern is the fact that the user can more accurately take their pills at the desired time everyday.

iv. *Is the product automating a task currently performed manually and therefore might impact employment?*

The main purpose of our project is to convert a manual, time consuming task into an automated one. This is actually beneficial when it comes to how this impacts employment. Since we believe that our device could be used in places like nursing homes and hospitals, our device wouldn't be replacing the jobs of people who have the task of sorting and distributing pills. Instead, it would just make their jobs easier. For the users who would be in their homes, unless there is someone like a nurse who had the job of sorting pills, it still would not affect employment other than making the person's job easier because that nurse could be the one that controls the machine.

v. *Does the product create new jobs or fields?*

Our product does not create new jobs or fields, however it benefits already existing jobs like nurses or caregivers.

vi. *Safety aspects and health concerns*

One safety concern that we came across was the possibility of someone setting the amount of pills to dispense too high. This is also a safety concern with the traditional method without our product because anyone can overdose on their medication if they take too many pills. Since we did not implement a method to know what is an acceptable dosage of a given medication or a method to input the mass of each pill, we did not get to the point where we were able to implement a safety function for overdosing. The only restriction the product currently has is that it cannot dispense more than 9 pills from a funnel at one time.

4. Conclusions / Summary

In conclusion, the Automated Pill Dispenser's functions worked to the extent that we had hoped. Our design can successfully dispense a desired number of 5 different types of pills at a specified time of the day. Getting a product like ours into the real world market could benefit millions through its ability to save users the time and struggle of sorting through an abundance of pills one by one. The lightweight, compact design is perfect for travel or a bedside nightstand and surpasses the 7 container pill sorter by far. In other words, we achieved our goal of a product that is focused on increased efficiency.

Although our design works for most standard sized pills, if a pill is either too large or too small, the machine may not handle dispensing it properly. In the future, we would like to come up with a new design for our funnel that will be able to handle any size pill that the user has. If the feed wheel that holds the pills in the funnel is able to be dynamically adjusted in size, then

this may help us with what we would like to accomplish. We would also like to add a sensor on the bottom of the funnels to check if a pill was actually dispensed or if it got stuck in the funnel. If it detects that no pill dropped from the funnel, it can try to dispense it again. The last addition we would like to make in the future is a website or app to go along with our design, The website or app will alert the user when they need to take their pills, how many pills are left in the dispenser, and when it is time for a refill for the prescription from the pharmacy. We plan on continuing to work on our design for the Automated Pill Dispenser over the summer, and hopefully one day actually get our product on shelves for retail.

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