Smart Pill Dispenser
An Arduino-Based Device
To Prevent Drug Overdose

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1. Abstract

According to the CDC, there were 91,799 drug overdose deaths in 2020 in the United States [2]. Since the COVID-19 pandemic, many people have had depression and other mental illnesses that often lead to suicide, and the number of deaths due to drug overdose has increased. There is also a high chance of the elderly accidentally consuming more pills than they are prescribed. So, I designed and created a new pill dispenser that can prevent drug overdoses. The **Smart Pill Dispenser** is an Arduino-based pill dispenser that can prevent drug overdoses. My engineering goals are to have a mechanism that can dispense pills at required intervals, to sense and alert if someone is trying to break in, to control everything easily, and to keep costs low (around $50 maximum). The first goal was addressed with a servo motor mechanism and the second was completed with a vibration sensor. The third goal was achieved by making an app. The cost turned out to be around $25, which is half of my original design goal. The servo motor mechanism had a 90% accuracy and the vibration sensor and app had 100% accuracy. Compared to other options available in the market currently, mine is low-cost and efficient.

2. Introduction

Drug overdose deaths rose from 2019 to 2022 with 107,941 overdoses reported in 2022 alone [1]. Most of these overdoses occur accidentally by the elderly population who may have consumed the wrong amount of pills or by teenagers who act on a quick impulse. Deaths involving synthetic opioids (excluding methadone) continued to increase with 73,838 overdose deaths reported in 2022 [1]. Synthetic opioids, commonly prescribed to treat chronic pain and severe post-surgery, pose a high risk of addiction.

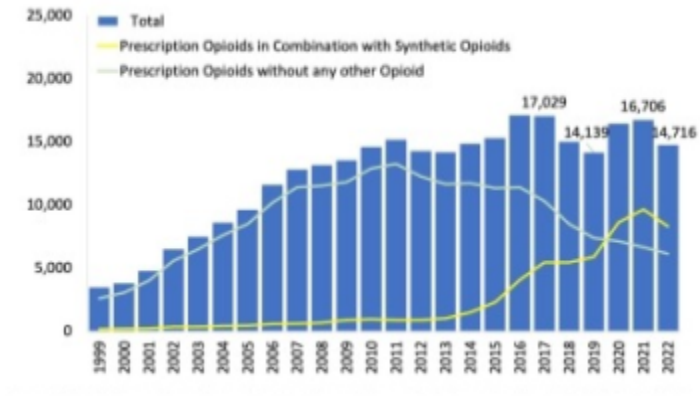


Image 1-National Overdose Deaths Involving Prescription Opiods, 1999 - 2022 (Source: nih.gov)

The problem starts as something small. Patients, especially teenagers, start taking more pain-relief pills than prescribed, underestimating the dangers. This seemingly harmless action leads to a downward spiral into addiction, often leading them to illegal drugs when prescription drugs run out or aren't powerful enough. Preventing these addictions from the root is crucial to preventing these deaths.

Additionally, pain-relief drugs are also used frequently as a coping mechanism. It temporarily numbs the pain but potentially leads to more severe mental health disorders and eventually, even suicide. The impact of these deaths is huge and takes a toll on so many people including families and friends.

To address this worldwide issue, it is imperative to implement preventative measures. A pill dispenser that only releases the prescribed amount of pills to the user can prevent many of the problems that were described above. It can reduce the risks of overdose and addiction, and overall save so many lives around the world.

3. Project Objective

The main goal of my project is to design and develop a smart device that can safely store the pills and dispense them when required and to have a mechanism to alert when somebody is trying to take more pills than required.

4.1. Engineering Goals

There are certain design criteria that I want to address as well while achieving this goal:

Design Goals	Proposed Solutions
The device should dispense the prescribed amount of pills in the correct intervals	To design a mechanism for a lid to open after a specific time period using a servo motor and an Arduino.
The device should alert when tampering is attempted	To use a vibration sensor to alert others if someone is trying to break into the dispenser
The device should be easy to control and use	To design an app that can be used on cell phones.
The design should be low-cost. (< $50)	The cost is reduced by using minimal electronic components. The shell will also be 3D printed using PLA filament to reduce costs.
The device should be reusable	The box can have multiple compartments depending on how many pills are needed. The user can use the same device for their next medication as well.

4.2. Materials Used

- ➢ Ender 3 Pro 3D printer and filament
- ➢ Servo Motor
- ➢ SW-420 Vibration Sensor Module
- ➢ Arduino
- ➢ Batteries (2AA)
- ➢ M/M jumper wires
- ➢ F/M jumper wires
- ➢ Metal hinges
- ➢ HC-05 Bluetooth Module
- ➢ Android phone

- ➢ Breadboard

4.3. Softwares Used

- ➢ MIT App Inventor
- ➢ Arduino IDE
- ➢ TinkerCad

4. Design Methodology

For each step of the design process, I followed an iterative approach. I worked on each independent component and then improved it multiple times until it was as desired.

4.1. Dispenser 3D Designing

I started the project by designing the shell of the dispenser using the 3D design software, TinkerCad. Several iterations were done before finalizing the design. The following are some of my initial designs along with why they were discarded:

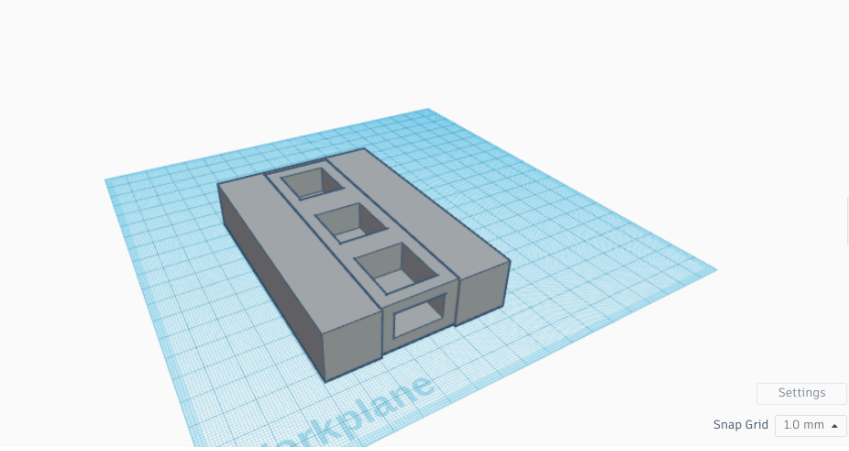


Image 2 - Initial design 1 of pill dispenser shell

This design was discarded due to the lack of space to store the Arduino and the other components.

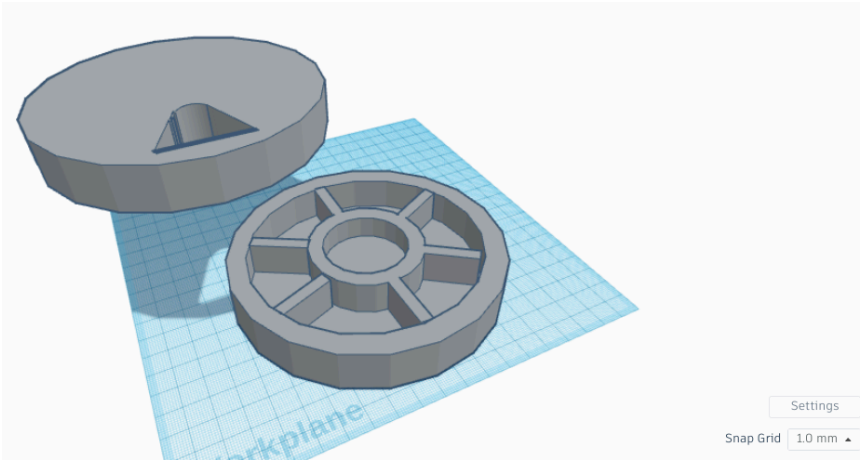


Image 3 - Initial design 2 of pill dispenser shell

This design was discarded due to the lack of space and complexity of the mechanism to rotate the lid.

4.2. Final Design

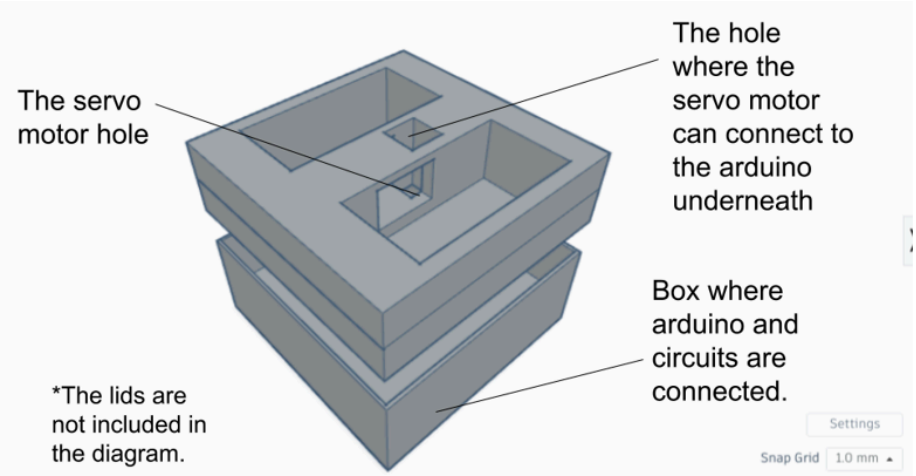


Image 4 - Final design of pill dispenser shell

This is the final 3D design of my smart pill dispenser. It has compartments with tightly closed lids (printed separately) to store the pills. To attach the lids, I originally tried to 3D print hinges, but this was too brittle, so I used metal hinges instead. The Arduino and other electronics are at the bottom layer. Finally, the servo motors are stored in the cutout in the center of the box, and it connects to the Arduino through the hole leading to the bottom layer. This design includes enough space for all of the electronic components and is overall very practical.

4.3. Final Prototype

Image 5 - Photograph of the final prototype

4.4. Design Challenges

Some challenges I faced during the design include:

- ➢ 3-D printing was a new skill I learned for this project, so that was a process that took me some time to get used to. I also had to print the parts multiple times due to the measurements being a few millimeters off in the first print.
- ➢ I attempted to 3-D print hinges. The design turned out to work, but since it needed to be that tiny, the design was too brittle to hold the lid, so I bought some metal hinges to use.
- ➢ The design process was the hardest part. I needed to find a design that would fit all the criteria.

4.5. Implementation of algorithms

After 3D printing the shell, the next step was to set up the electronic components. The shell was specifically designed to fit these components using its measurements.

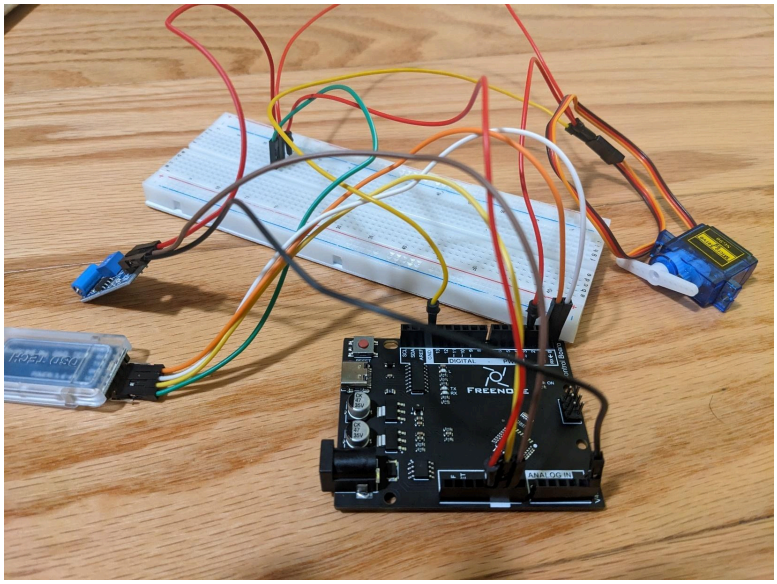
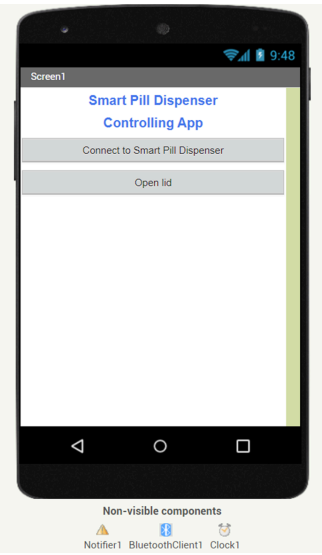


Image 5 - Photograph of the electronic components

I set up the necessary components and wrote the code using Arduino IDE to run the servo motor at specific time intervals and to alert when tampering is attempted. When it is the specified time, the servo motor will spin its attachment which will push open the lid of the pill compartment from the inside. If someone tries to break into the box, then the vibration sensor will detect it and alert people. Both of these components are connected to the Arduino that runs the code.

4.6. App Development



Lastly, I developed an app to go along with the device, which alerts users when the device is being tampered with. I used MIT App Developer to do this and connected an HC-05 Bluetooth module to the Arduino to communicate with the app. This is also located in the bottom layer of the device. The app will send an alert when the vibration sensor picks up any violent movement. In a real-life application, this app will also send an alert to emergency contacts when the vibration sensor detects tampering with the device. This will ensure the safety of the user.

Image 6 - Controlling App

4.7. Device Flowchart

The diagram below shows the basic workings of the device.

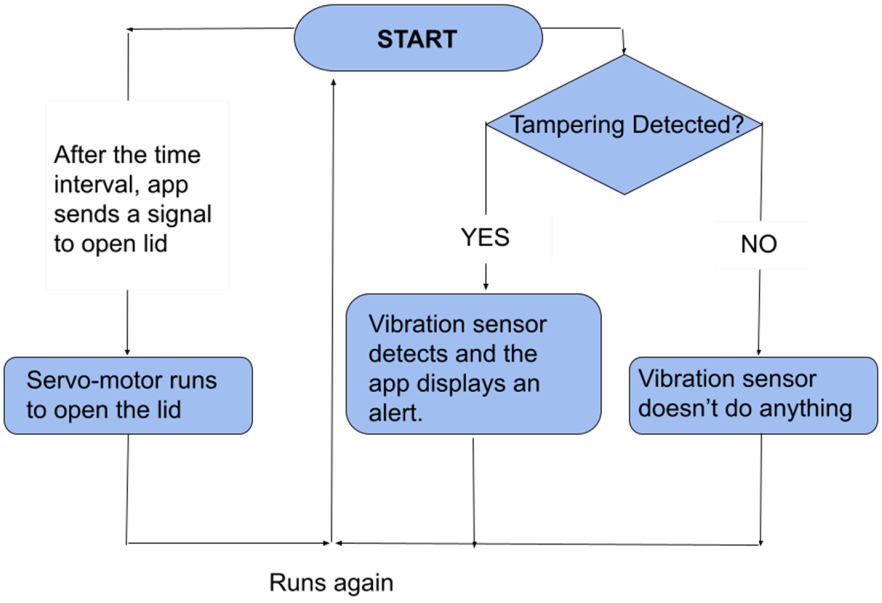


Image 7 - Flow chart showing the basic workings of the device

5. Testing and Test Results

For testing purposes, I tested each component separately. I tested the device's ability to open the lid at a specified time as well as its ability to alert/notify when the mechanism is tampered with using the app.

Trials	The app opens the lid at a specified time period	The app alerts the mechanism when shaken
1	Failure	Success
2	Success	Success
3	Success	Success
4	Success	Success
5	Success	Success
6	Success	Success

7	Success	Success
8	Success	Success
9	Success	Success
10	Success	Success
Accuracy:	**90% Accuracy**	**100% Accuracy**

The servo motor mechanism had a 90% accuracy while the vibration sensor had a 100% accuracy. This surpasses the initial goals and proves that the device works better than expected. The reason the servo motor mechanism failed one trial was that the servo motor was placed inside very loosely. Because of this issue, the attachments weren't strong enough to push the lid open. However, this was easily fixed for the following trials by changing the position.

6. Discussion

Compared to existing methods, my smart pill dispenser is a unique and effective solution to overdosing. Currently, everyone uses those orange pill bottles that have no precautions against overdosing, accidental or intentional. There are other options available in the market, but these are more for organizational purposes. They sort pills into days of the week or month. This may prevent a few accidental overdoses but doesn't protect against intentional overdoses. Since overdoses are a common method of suicide, there needs to be a pill dispenser that protects against them. So, this is why my pill dispenser locks its compartments to only allow users to take their prescribed amount of pills. Additionally, it has a vibration sensor that can detect tampering or harsh movements and alert people using an app. This can help save someone who is trying to break into the device and take more pills than needed. Additionally, the cost of those organizing dispensers is very high. The cost of my device is relatively low, at approximately $25, which is half of my design goal. So overall, the Smart Pill Dispenser can prevent overdoses and save many lives.

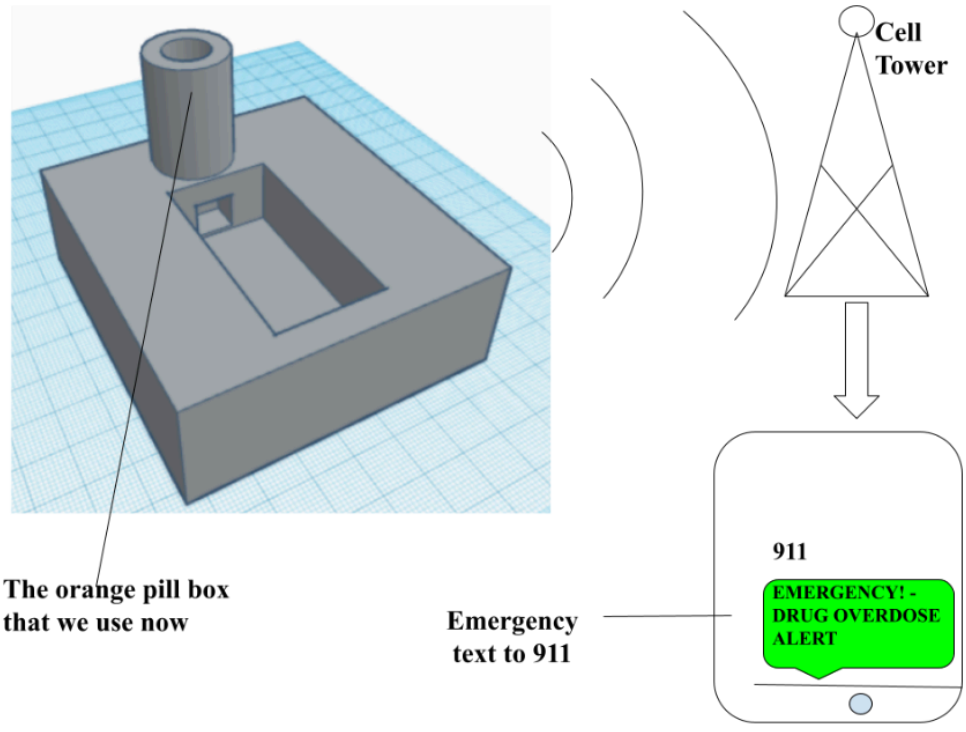
7. Future Improvements

- ➢ To make the device more practical, I plan to make it more compact. This can make it easier to carry around and use.
- ➢ It would assure the safety of the user even more if the device could send texts to emergency contacts when tampering is detected.

8. Conclusion

All of the engineering goals were met, and the device successfully operates. Also, the device is very practical and has a cost of approximately $25. After implementing a few of my improvements, the next step would be to integrate this device into current society. It would save lives around the world of all ages, especially the elderly and teenagers. The number of attempted suicides would decrease along with the number of overdoses. This device also prevents people from going into further depression and drug addiction, thereby improving the overall well-being of our future generations. It helps people seek peace in other activities rather than drugs. Overall, I believe this device could help the overall health of the entire human population.

9. Vision



This is an improved vision of my Smart Pill Dispenser. While the current version is good, I think this new design is more practical in real-life applications. The cylinder represents the spot where we can fit the orange pill bottle that we use now. There will be a servo motor mechanism that attaches below the box, and it will drop the appropriate number of pills down through the hole. This will help make the box more compact as there is no need for more than one compartment and locked lids. However, the main reason as to why this new design is my vision is because this version would be easier to integrate into society. This is because we are still using the orange pill bottles from the pharmacies in the new design. There will just be a device connected to it. Additionally, in the future, instead of just displaying the message on the app, I want it to communicate with a cell tower and send a text message to 911 or any other emergency contact that a drug overdose is occurring. This will help guarantee the safety of the patient even more than my current design.

10. References

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