

# **Pillsafe Smart Cap and App**

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# 1.Introduction

## 1.1 Objective

Many people are struggling with drug abuse in the world. This problem has aroused great concern of the government. According to the National Center for Drug Abuse Statistics (NCDAS), 700,000 drug overdose deaths have happened in the US since 2000. \$34.6bn has been used for the Federal budget for drug control in 2020. (Deaths, Crisis, Deaths and Crisis, 2020) More often, the overuse occurs in daily life, because doctors and guardians are hard to supervise patients to use the correct number of pills. Although there are several commercial items related to drug use on the market now, they all have some defects. For example, most of the existing smart pill boxes are not for drug abusers. Thus, we believe designing and building a device for preventing drug abuse is meaningful and useful.

Inspired by the Health Maker Lab project 5, we are going to design a smart cap for pill bottles. The smart cap has the following functions. Firstly, it has a dispenser system which can count exactly the number of specific pills needed for the patient each time to avoid overuse using a photoelectric sensor. Secondly, it has a security system to avoid any tampering with the cap or the bottle. Last but not the least, it has a notification system which involves three parts. One is an LCD to display the number of pills. Another is an LED which serves as an alarm to notify the user when he cannot take anymore. The last part is to notify the doctor or the guardian when the patient uses the drug and if the user has any misuse performances through our supporting apps.

## 1.2 Background

The reality is that drug dealing can happen anywhere by anyone because prescription drugs are so easily accessible and their abuse is on the right according to the Center for Behavioral Health statistics and quality an estimated 18 million people 6% of whom are 12 and older have been reported to misuse prescription medications at least twice within the past year. A 2017 National survey on drug use and health estimates that 2 million Americans have misused prescription

painkillers for the first time in the past year belching in an increase in addiction and at worst death by overdose.(Mizan, 2020) There are not many products in the industry that can prevent people from drug abusing and this is why we are going to produce a device like this. We need a device that can prevent people from drug abusing and PillSafe Smart Cap could accomplish that.

### 1.3 Physical Design

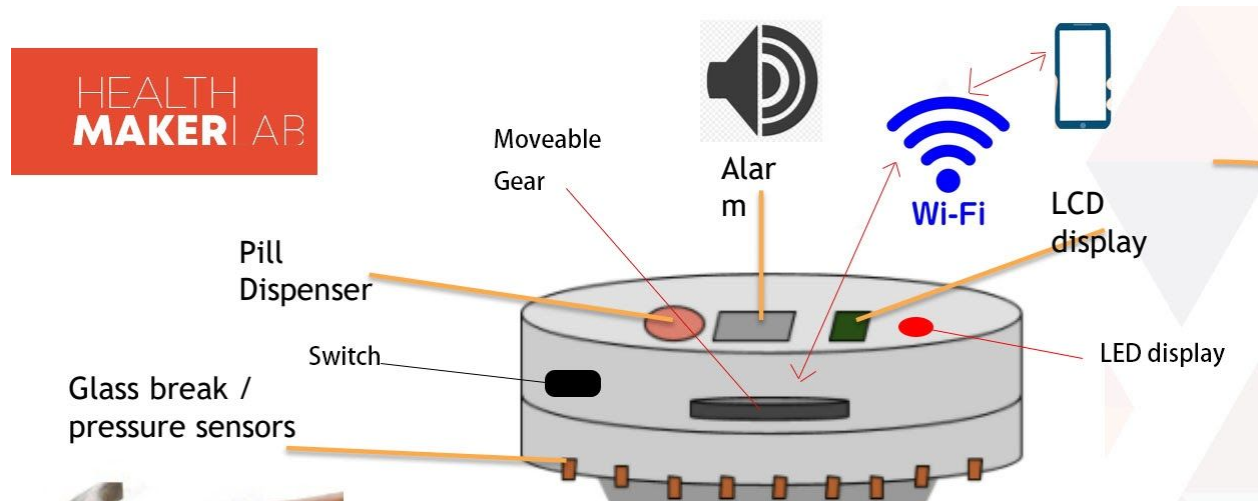


Fig 1: Physical design

- 1) All functions are contained in Fig 1.
- 2) The pill leak mouth (dispenser), the speaker, LCD and LED display are on the top surface of the cap. The moveable gear to control the dispenser is on the side of the cap. The switch will be on the side of the cap.
- 3) The photoelectric sensor, control unit ,and wifi module are inside the cap.
- 4) The pressure/ glass break sensor is on the bottom of the cap which can be attached to any pill bottles.
- 5) The entire cap can be twisted onto bottles safely before the switch is turned on.

## 1.4 High-level requirements list

- 1) The PillSafe cap can identify the number of pills being dispensed and displays the number on the LCD with a 100% accuracy.
- 2) The PillSafe cap can detect violations at a 90% rate and create alarms on the cap at the same time when violations happen. Notifications on users' software app will appear in 3s, with at most 5s lagging.
- 3) Patients/doctors/guardians are able to use the app to set the number of pills that can be dispensed safely.

## 2.Design and Requirements

### 2.1 Block Diagram

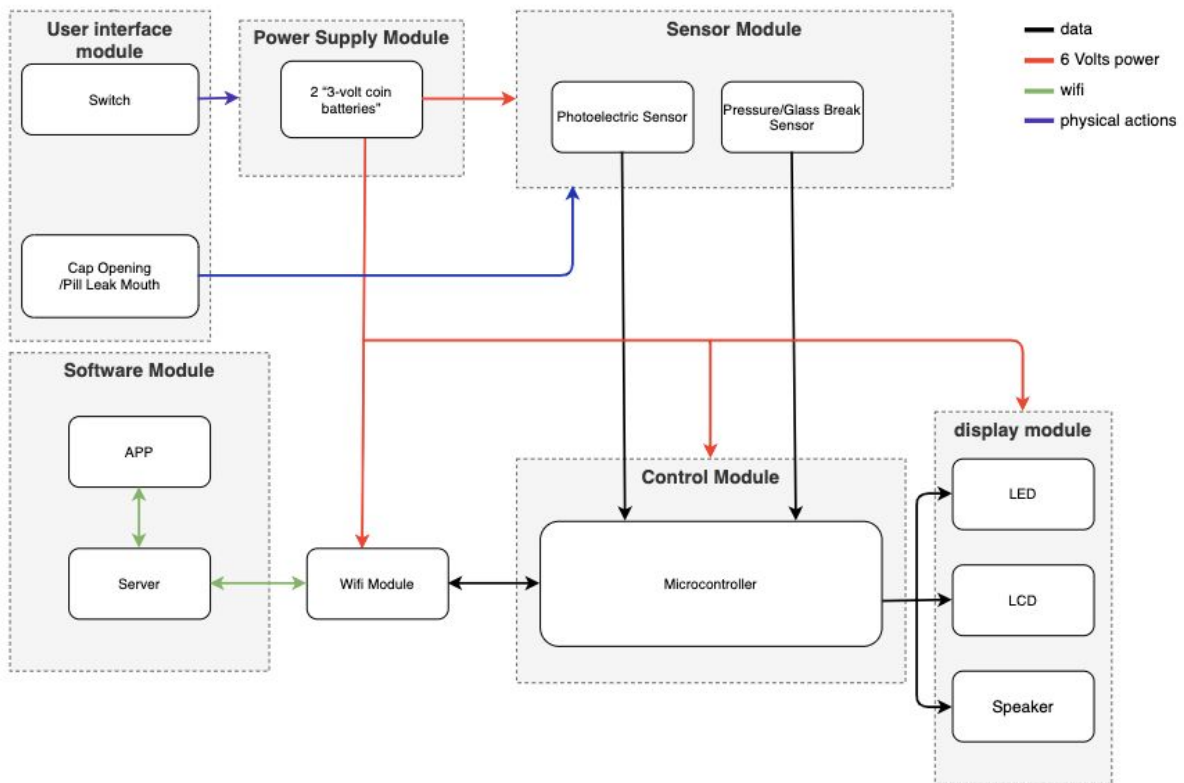


Fig 2: Block diagram

## 2.2 Functional Overview & Block Requirements

### 1) Power Supply

- a) Description: The power supply module contains the battery to supply power for the control unit, display module and sensor module in the smart cap. It supplies 6 volts DC voltage.
- b) Requirement: It should be 2 3 Volts coin battery.

### 2) User interface module

#### a) Switch

- i) Description: The physical switch to control the power supply unit.
- ii) Requirement: The switch should be the only way to open/close the power supply. Turn on/off the switch will be reported as an action to the doctor/guardiance. The switch should be on always unless there is a risk in power leakage or other safety concerns.

#### b) Cap Opening/ Pill Leak Mouth

- i) Description: The user interface module contains the safe opening on the cap. A moveable gear that can control the size of the leak mouth and a cushion with cuts on it set under the leak mouth.
- ii) Requirement: The user should be able to open the cap freely as they want. The leak mouth should fit at least 5 common pill sizes on the market. The cushion should prevent pills from falling out at once.

### 3) Sensor Module

#### a) The Photoelectric Sensor

- i) Description: The photoelectric sensor is used to count the pills dispensed by the user. It is a through-beam photoelectric sensor with a collector and a receiver.
- ii) Requirement: It should be able to count the number of pills correctly. It should also have the function of distinguishing colors and shapes of different pills.

- b) The Pressure/ Glass Break Sensor
  - i) Description: The pressure/ glass break sensor is used to prevent users from physically destroying the pill bottle.
  - ii) Requirement: The pressure sensor should only send an alarm when the force is enough to destroy the bottle. It should not send an alarm when users are dispensing pills. The glass break sensor should be sensitive only to glass-break noise, not environment noises.
- 4) Control Module
  - a) Description: This module contains the microcontroller. The microcontroller gets data inputs from the sensor module and the software module. It outputs data to the display module and the wifi module.
  - b) Requirement: It should be able to transfer the data from the photoelectric sensor to numbers and send it to the display module. It should also transfer data between the control unit and the software unit. The microcontroller should have little power consumption, so TI MSP 430 is preferred.
- 5) Display Module
  - a) LED lights
    - i) Description: LED lights are used to notify the user the situation of dispensing. LED should have three modes: red, yellow and green.
    - ii) Requirement: Green will light up when users start dispensing pills. Yellow will light up when the allowance number of pills is approaching. Red will light up when the met or beyond the exact number of allowance.
  - b) LCD screen
    - i) Description: LCD screen is used to display the number of allowance of pills. The number is setted by the software. Together with the LED, it provides graphical and digital information to the user.
    - ii) Requirement: The size should be 2cm long, 1 cm wide and 0.5cm thick. It should display digital numbers clearly.
  - c) Speaker

- i) Description: The speaker is used to creating buzzing sounds to notify the user that they are violating rules. This is used as a supplementary to the software notification of violations.
- ii) Requirement: A button size speaker. It will buzz when the number of pills dispensed is above the allowance.

#### 6) Software Module

- a) Description: The application will have an interface with the display module and the control unit. It will set the allowance of pills and display on the LCD screen; it will use the data from the microcontroller to detect violation.
- b) Requirement: Guardians/Doctors can reset the allowance number remotely . The application must be able to update the number of pills allowed taken by the patient displayed on our Cap within 3 seconds and it must be able to send the alarm to the doctor/provider when the patient is misusing the drugs within 3 seconds.

#### 7) WiFi Module

- a) Description: The microcontroller in the PillSafe Cap uses WiFi protocol to transfer the data between the control unit and the software module.
- b) Requirement: It must be able to allow the data from the microcontroller to be sent via UART and be able to be accessed on a WiFi network.

## 2.3 Risk Analysis

#### 1) Challenging Part

- a) The pill dispenser is a challenging part, which may put risk on successful completion of the project. Currently, we plan to use photoelectric sensors to accomplish the functions of counting and distinguishing pills. Without talking with the machine shop and doing further research, we cannot guarantee to be able to implement the above two functions using only one sensor. To increase precision of counting, we have designed a special structure for the dispenser to limit the amount of pills that has been poured out.

- b) The pressure sensor is another challenging part. Due to the sensitivity of the sensor, and the difficulty to distinguish between reasonable actions to dispense pills, such as shaking bottles, and unreasonable actions to open the pill bottle, such as twisting the cap. We should develop a thoughtful pressure analysis to prevent errors on the notification.
- 2) Contingency Plan
- a) If this course goes all online, we will add more complex functionalities in the software part. We would add more data analysis functions and personal design to our App. People can react differently to the same drug based on their various absorptions to the medicine and their age variance. Based on the patient's age and his/her history of taking medicine, our app will be able to provide scientific data analysis and suggestions on his/her future drug using.

### 3.Ethics and Safety

Some ethical issues need to be considered for our project. Since our app is able to get first hand information about users' drug habits, we are responsible to protect our users' privacy. Also, our project is designed for public health. These are implement of #1 of IEEE code of Ethics: "to hold paramount the safety, health, ..." (IEEE Code of Ethics, 2020) So it should be the hospital's responsibility to secure the user information and data.

Since there are privacy concerns, we should focus on implementing the security for the software module. Unfortunately, on the internet, it is definitely possible that the network will be used in some unlawful way, such as helping the drug abusers to change the allowance of number of pills without being discovered by the doctor/provider.

Despite the facts talking above, we should also consider the user's individual/personal rights. Since this application will give the absolute control to the doctor/provider side, there might exists discrimination, financial or sexual orientations which violating #8 of IEEE code of Ethics(IEEE



Code of Ethics, 2020). Even though we are not able to control the behavior on the administrator side, we can give users/patients the right to stop the program under emergency situations.

Beside the ethical issues, Our device is generally safe to implement. However, there are some points that we need to take care of. We need to pay attention to the voltage we apply to the battery, if an overcharge happened, the battery could explode and cause danger. Since we do not give patients the right to turn off the switch unreasonably, the circuits are being powered consistently. So the entire application must work under little power supply. Also, the cap contains mechanical parts for the user interface module. We should make sure that they are safe and not harmful to physical bodies.

## References

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