PhotoMed

The Pill Identifying App

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Abstract

A pill is a small, roundish or capsule-shaped, mass of medicine. Pills are used for many reasons today, from treating the common cold to curing Lyme disease. Each pill has unique characteristics which distinguish from its constituents: shape, color, and engraving are three of many. The goal of my project was to create a mobile application that allows the user to identify pills which they may have forgotten the names of. My app runs a slightly modified version of Google's MobileNet image classifier which I trained on my own data and created a user-friendly interface for. The Inception classifier uses my data in order to create a predictive model, which it then cross-references with what the camera sees. Based on the graph of the predictive model, the classifier makes an extremely educated "guess" as to what the pill is.

Introduction

The FDA estimates that "1.3 million people are injured by medication errors annually in the U.S." These medication errors refer to the phenomenon of people, usually elderly ones, not being able to recall which pill is which, or what capsule provides what vitamins. In 2012 alone, 414 people in the United States died from said medical errors. These "simple" errors are so harmful to the population, yet there is no simple solution to them. The fact of the matter is, the vast majority of the population injured by medication errors are ages 50 and older. This led me to believe that whatever solution I was planning had to be extremely simple.

August 19, 2019. I was sitting at the dinner table, Dominoes cheese pizza in one hand, cellphone in the other. I had just completed Project-Euler's, a repository comprised of computer science and mathematics problems, problem #100. I was on top of the world, the next Alan Turing. As I was about to take a bit out of that juicy, cheesy crust, I heard a shrill screech: "Avi, where the hell are those goddamn Amlodipine?" As I opened my mouth to respond, my grandmother, anticipating my smart-alecky retort, yelled "Just shut up and get your ass over here right now! I have 15 pills and I have no idea which one is that darn Amlodipine." At that moment, my parents walked in, and they found the entire affair quite amusing. "You know," my mother said, "I feel like designing an app to help people identify their pills would be a really good idea. The intersection of medicine and technology is booming, and I think that this could really help some people out." "Yeah, I guess" I said. "Damn," I thought, "she was right. That was a killer idea." After the pill had been identified, I got to work. Not on the app, but on that beautiful 12-inch Dominoes pie. Of course, later that night, "Photo Med" was born, but not the cutting-edge image recognizing application you will all be familiar with. The first iteration of PhotoMed was simply a loop iterating through a dictionary, comparing the different properties of

the pills. Then it hit me, if I wished to create an app that helps people and simplifies their lives, I can't just have them putting in the information, I can make it even easier on them. So, I decided to tread the path of machine learning, and I turned PhotoMed around, like the Beast in *Beauty and The Beast* transforming into a prince, PhotoMed had now become a prince, and had left behind that clunky, inefficient past of its.

General Breakdown of Image Classifier Algorithm

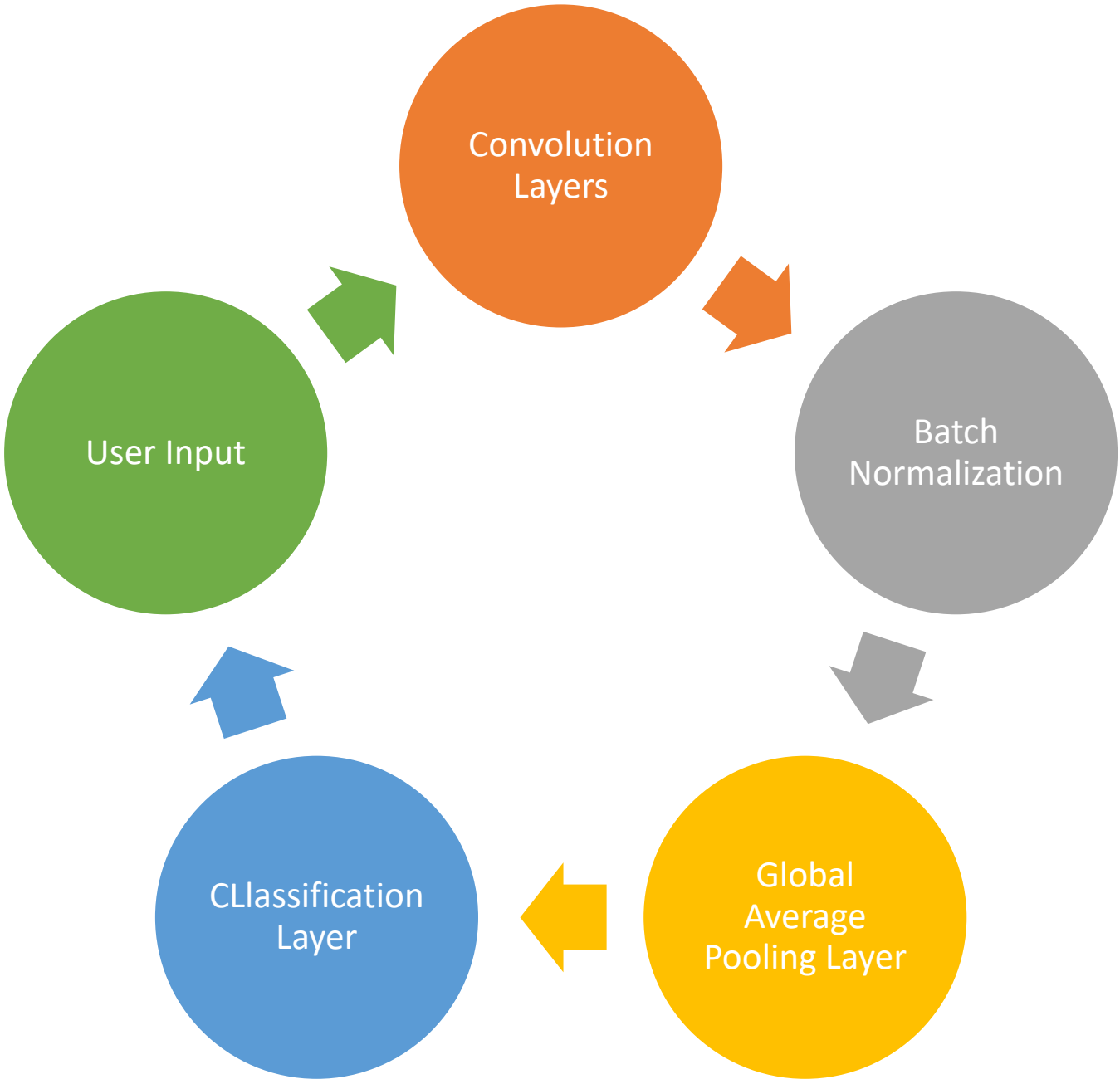
1. The program initially finds the directory in which the folders of pill-images are stored.
2. It then creates a graph based on those images.
3. The graph is passed on to the classifier, which then trains a predictive model based on the data from the graph.
4. Then, the user opens the app, and points their camera at the pill.
5. The algorithm then displays labels for the pill, updated in real time, by predicting which label the pill would fall under based on the images it has been trained on.

The Algorithm Used to Identify Images

The algorithm/model which I use to classify the images of pills that the camera sees is Google's MobileNet model. The algorithm first accesses the folder in which all of the folders of images of pills are. It then created a graph based on these folders, where each image of a pill corresponds to its label (the name of the folder which it is in). The graph is created by using a Machine Learning library known as "TensorFlow." What TensorFlow allows people to do is to create and produce graphs which dictate the manner in which data moves throughout the structure, and which data is related to which labels. Each node of the graph is represented as a vector, which is then interpreted by the computer as an image/data. TensorFlow allows the users to utilize the immense power of machine learning without having to create and write their own algorithms from scratch. The MobileNet model first uses two layers: a depth wise convolution layer which filters out the input and passes on usable data, which is followed by a convolution layer which simply merges these filtered values in order to create new features/nodes. These two layers come together to form what is known as a "depth wise separable convolution block." What the convolutional layers actually do, is they take the input as a vector, they then perform a series of dot products along with other transformations until the original inputs reach a suitable output.

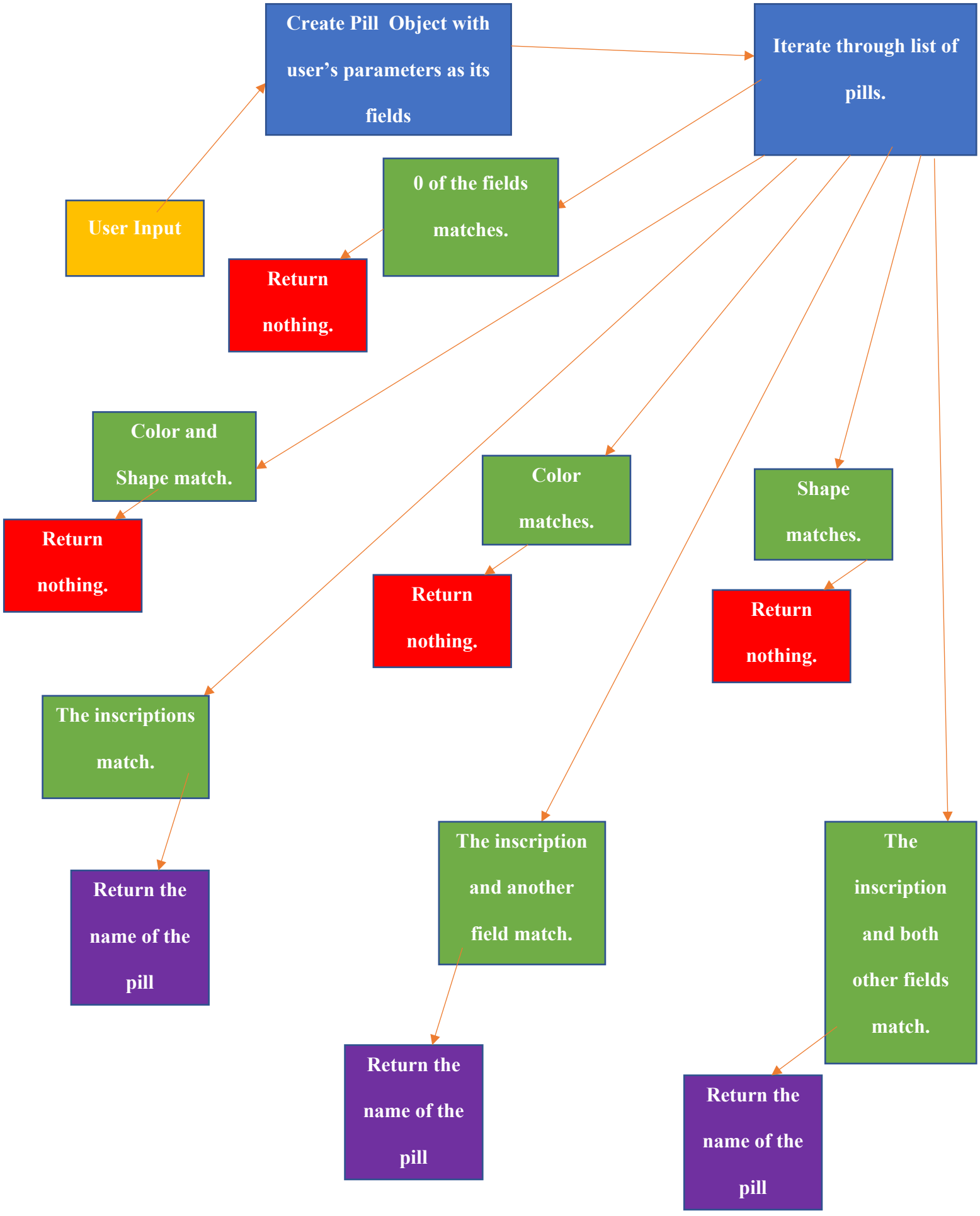
After the convolution layers, batch normalization is then applied. Batch normalization is the process of normalizing the inputs of the graph in order to limit the amount of covariate shift, the process of the algorithm slowing down due to each layer adapting itself to a new distribution of data during each sequence of training. Layers are normalized by calculating the mean and variance of the layer's input, and then using these values to shift and scale the layers such that their inputs become normalized. I did not implement a batch normalization algorithm myself, as TensorFlow comes pre-installed with it.

At the very end of the MobileNet model, there are two layers: a global average pooling layer and a classification layer. These layers simply allow the actual images to be classified into a group. In addition to all of the layers which MobileNet is comprised of, there are hyperparameters which allow you to modify certain architecture settings. One of these parameters, the depth multiplier, allows the user to alter the number of depth channels in a certain layer. The smaller the number of channels in any given layer, the faster the model is, but the less accurate the actual classification becomes. Since the classification of the pill is constantly updating in real time, the sequence of layers described above is being iterated through in a constant loop. Lastly, after all of these computations are finished, my GUI (Graphical User Interface) simply displays whatever group the model sorted the pill into. Below I have included a flowchart of the algorithm, however, I cannot include code for the app itself, as that would take up about 50 pages.


Convolution Layers
Batch Normalization
Global Average Pooling Layer
CLlassification Layer
User Input

Dead End

One “dead-end” which I encountered was actually my first attempt to resolve the pill-identification crisis. I decided to write a java script which would prompt the user for different defining characteristics of their pill. For example: “What is the color of your pill?” or “what shape is your pill?”. I had created a “Pill” Object which had the fields: color, shape, and inscription. I would then enter these values for each pill, and then append them to the pill-list which I had created. After I got the user’s input, I created I Pill Object based on their parameters, and then iterated through the list until I found a match. This worked; however, it was the completely wrong way to go about solving this problem. As the creator of a product, you want the user to have to put in the least possibly effort for great results. And I thought that by asking the user for all of these attributes, I was doing something extremely slowly that a camera could do much faster. That is how the iterative loop was abandoned in favor of the TensorFlow MobileNet algorithm. The flow-chart for this dead-end can be seen below, and the code is in the appendix.


Create Pill Object with user's parameters as its fields
Iterate through list of pills.
User Input
0 of the fields matches.
Return nothing.
Color and Shape match.
Return nothing.
Color matches.
Return nothing.
Shape matches.
Return nothing.
The inscriptions match.
Return the name of the pill
The inscription and another field match.
Return the name of the pill
The inscription and both other fields match.
Return the name of the pill

Conclusion

The purpose of this experiment/app was to discover a solution to a problem plaguing the people of the United States of America. Initially, I intended to and partially did create an app which simply asked the user for characteristics which describes their pill, and I then cross-referenced these inputs with a list of pills. I deemed this solution to be both inefficient and cumbersome to the user, thus I turned to a more practical idea: machine learning. This new method was much faster, and it minimized the amount of actual work that the user had to do. Throughout this entire process, I learned that failure is not bad. Failure shows us what we did wrong, how we did it wrong, and what we can improve next time. Failure and our shortcomings allow us to improve as a society. I also learned in order to effectively solve a problem; one must look at it with a different lens. That could be another person, or it could even mean just trying another idea. The more possible solutions you can get, the better final solution you can create. In the future, I could possibly expand on the app so that it identified liquid drugs, or possibly plant-based medicine. We as a society understand so little about machine learning that the possibilities are truly infinite, and that is a little terrifying. But as long as people continue to use it for good, it can become a part of our society, like the car, or even McDonalds. This app, of course given more time to short it up a bit and expand its capabilities, could truly eliminate the problem of misidentified drugs, and cure the world of a pestilence which has been infesting the world since the dawn of modern medicine.

Bibliography

Commonly Abused Prescription and OTC Drugs. (n.d.). Retrieved from WebMD database.

Medication Errors More Than Double. (n.d.). Retrieved August 17, 2019, from AARP website: http://www.aarp.org/health/drugs-supplements/info-2017/medication-errors-rise-fd.html

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Appendix

Previous Pill Identifier Code

```
public class Pill {
//Attributes of the pills
String shape;
String color;
String side1;
String side2;
String name;
//I need to override the toString method to be able to print out pills
@Override
public String toString() {
                                                                    return name;
}

}
```

```
import java.util.*;
public class Real_Pills extends Pill {
//The pills that I created are here
//Pill_Count = 24 pills
static Pill phenobarbital = new Pill();
static Pill mebaral = new Pill();
static Pill seconal1 = new Pill();
static Pill seconal2 = new Pill();
static Pill nembutal = new Pill();
static Pill valium1 = new Pill();
static Pill valium2 = new Pill();
static Pill oxycontin1 = new Pill();
static Pill oxycontin2 = new Pill();
static Pill oxycontin3 = new Pill();
static Pill oxycontin4 = new Pill();
static Pill oxycontin5 = new Pill();
static Pill xanax1 = new Pill();
static Pill xanax2 = new Pill();
static Pill xanax3 = new Pill();
static Pill xanax4 = new Pill();
static Pill ambien1 = new Pill();
static Pill ambien2 = new Pill();
static Pill sonata = new Pill();
static Pill lunesta1 = new Pill();
static Pill lunesta2 = new Pill();
```

```
static Pill adderall1 = new Pill();
static Pill adderall2 = new Pill();
static Pill adderall3 = new Pill();
static Pill adderall4 = new Pill();
static Pill adderall5 = new Pill();
//Where the pills will be stored
static ArrayList<Pill> pill_list = new ArrayList<>();
//How I will get user input
static Scanner sc = new Scanner(System.in);
//Where I will store user input
static boolean isPill = false;
//Helps form my else statement if the user pill is not in my list
static Pill userPill = new Pill();
public static void main(String[] args) {
//*************************************************************************
                                                    phenobarbital.color = "white";
                                                    phenobarbital.shape = "circle";
                                                    phenobarbital.side1 = "ww 458";
                                                    phenobarbital.name =
"phenobarbital";
                                                    pill_list.add(phenobarbital);
//*************************************************************************
                                                    mebaral.color = "white";
                                                    mebaral.side1 = "m 31";
                                                    mebaral.shape = "circle";
                                                    mebaral.name = "mebaral";
                                                    pill_list.add(mebaral);
//*************************************************************************
                                                    seconal1.color = "red";
                                                    seconal1.side1 = "rx679";
                                                    seconal1.shape = "capsule";
                                                    seconal1.name = "seconal";
                                                    pill_list.add(seconal1);
//*************************************************************************
                                                    seconal2.color = "orange";
                                                    seconal2.side1 = "lilly f40";
                                                    seconal2.shape = "capsule";
                                                    seconal2.name = "seconal";
                                                    pill_list.add(seconal2);
//*************************************************************************
                                                    nembutal.color = "yellow";
                                                    nembutal.side1 = "ch";
                                                    nembutal.shape = "capsule";
                                                    nembutal.name = "nembutal";
                                                    pill_list.add(nembutal);
//*************************************************************************
                                                    valium1.color = "yellow";
                                                    valium1.side1 = "valium";
                                                    valium1.side2 = "roche roche";
                                                    valium1.shape = "circle";
                                                    valium1.name = "valium";
                                                    pill_list.add(valium1);
//*************************************************************************
```

```
                                                    valium2.color = "blue";
                                                    valium2.side1 = "valium";
                                                    valium2.side2 = "roche roche";
                                                    valium2.shape = "circle";
                                                    valium2.name = "valium";
                                                    pill_list.add(valium2);
//*************************************************************************
                                                    oxycontin1.color = "white";
                                                    oxycontin1.side1 = "10";
                                                    oxycontin1.side2 = "oc";
                                                    oxycontin1.shape = "circle";
                                                    oxycontin1.name = "oxycontin";
                                                    pill_list.add(oxycontin1);
//*************************************************************************
                                                    oxycontin2.color = "pink";
                                                    oxycontin2.side1 = "20";
                                                    oxycontin2.side2 = "oc";
                                                    oxycontin2.shape = "circle";
                                                    oxycontin2.name = "oxycontin";
                                                    pill_list.add(oxycontin2);
//*************************************************************************
                                                    oxycontin3.color = "yellow";
                                                    oxycontin3.side1 = "40";
                                                    oxycontin3.side2 = "oc";
                                                    oxycontin3.shape = "circle";
                                                    oxycontin2.name = "oxycontin";
                                                    pill_list.add(oxycontin3);
//*************************************************************************
                                                    oxycontin4.color = "green";
                                                    oxycontin4.side1 = "80";
                                                    oxycontin4.side2 = "oc";
                                                    oxycontin4.shape = "circle";
                                                    oxycontin4.name = "oxycontin";
                                                    pill_list.add(oxycontin4);
//*************************************************************************
                                                    oxycontin5.color = "blue";
                                                    oxycontin5.side1 = "160";
                                                    oxycontin5.side2 = "oc";
                                                    oxycontin5.shape = "oval";
                                                    oxycontin5.name = "oxycontin";
                                                    pill_list.add(oxycontin5);
//*************************************************************************
                                                    xanax1.color = "blue";
                                                    xanax1.side1 = "xanax 1.0";
                                                    xanax1.shape = "oval";
                                                    xanax1.name = "xanax";
                                                    pill_list.add(xanax1);
//*************************************************************************
                                                    xanax2.color = "white";
                                                    xanax2.side1 = "xanax 0.25";
                                                    xanax2.shape = "oval";
                                                    xanax2.name = "xanax";
                                                    pill_list.add(xanax2);
```

```
//*****************************************************************************
                                                    xanax3.color = "orange";
                                                    xanax3.side1 = "xanax 0.5";
                                                    xanax3.shape = "oval";
                                                    xanax3.name = "xanax";
                                                    pill_list.add(xanax3);
//*****************************************************************************
                                                    xanax4.color = "white";
                                                    xanax4.side1 = "x ana x";
                                                    xanax4.side2 = "2";
                                                    xanax4.shape = "rectangle";
                                                    xanax4.name = "xanax";
                                                    pill_list.add(xanax4);
//*****************************************************************************
                                                    ambien1.color = "red";
                                                    ambien1.side1 = "amb 5";
                                                    ambien1.side2 = "5401";
                                                    ambien1.shape = "oval";
                                                    ambien1.name = "ambien";
                                                    pill_list.add(ambien1);
//*****************************************************************************
                                                    ambien2.color = "white";
                                                    ambien2.side1 = "amb 10";
                                                    ambien2.side2 = "5421";
                                                    ambien2.shape = "oval";
                                                    ambien2.name = "ambien";
                                                    pill_list.add(ambien2);
//*****************************************************************************
                                                    sonata.color = "turquoise";
                                                    sonata.side1 = "10mg";
                                                    sonata.side2 = "sonata";
                                                    sonata.shape = "capsule";
                                                    sonata.name = "sonata";
                                                    pill_list.add(sonata);
//*****************************************************************************
                                                    lunesta1.color = "blue";
                                                    lunesta1.side1 = "s193";
                                                    lunesta1.shape = "circle";
                                                    lunesta1.name = "lunesta";
                                                    pill_list.add(lunesta1);
//*****************************************************************************
                                                    lunesta2.color = "blue";
                                                    lunesta2.side1 = "s190";
                                                    lunesta2.shape = "circle";
                                                    lunesta2.name = "lunesta";
                                                    pill_list.add(lunesta2);
//*****************************************************************************
                                                    adderall1.color = "blue";
                                                    adderall1.shape = "circle";
                                                    adderall1.side1 = "1 0";
                                                    adderall1.side2 = "ad";
                                                    adderall1.name = "adderall";
                                                    pill_list.add(adderall1);
```

```
//*********************************************************************************
                                                        adderall2.color = "orange";
                                                        adderall2.side1 = "dp";
                                                        adderall2.side2 = "1 5";
                                                        adderall2.shape = "oval";
                                                        adderall2.name = "adderall";
                                                        pill_list.add(adderall2);
//*********************************************************************************
                                                        adderall3.color = "orange";
                                                        adderall3.side1 = "3 0";
                                                        adderall3.side2 = "ad";
                                                        adderall3.shape = "circle";
                                                        adderall3.name = "adderall";
                                                        pill_list.add(adderall3);
//*********************************************************************************
                                                        adderall4.color = "blue";
                                                        adderall4.side1 = "adderall xr";
                                                        adderall4.side2 = "10mg";
                                                        adderall4.shape = "capsule";
                                                        adderall4.name = "adderall";
                                                        pill_list.add(adderall4);
//*********************************************************************************
                                                        adderall5.color = "orange";
                                                        adderall5.side1 = "a d";
                                                        adderall5.side2 = "15";
                                                        adderall5.shape = "oval";
                                                        adderall5.name = "adderall";
                                                        pill_list.add(adderall5);
//*********************************************************************************
                                                        //I ask the user the shape of their pill
                                                        System.out.println("What is the shape
of your pill(circle, oval, rectangle, capsule): ");
                                                        //I collect the pill shape
                                                        String userShape =
sc.nextLine().trim().toLowerCase();
                                                        //I store the pill shape and remove
excess whitespace and transform it to lower case
                                                        userPill.shape = userShape;
                                                        //I ask the user the color of their pill
                                                        System.out.println("What color is your
pill: ");
                                                        //I collect the pill color
                                                        String userColor =
sc.nextLine().trim().toLowerCase();
                                                        //I store the pill color and remove excess
whitespace and transform it to lower case
                                                        userPill.color = userColor;
                                                        //I ask the user what is on the first side
of their pill
                                                        System.out.println("What does it say
on one side of your pill (If symbols are not adjacent, put a space between them): ");
                                                        //I collect the pill side1
```

```
                                                    String userSide1 =
sc.nextLine().trim().toLowerCase();
                                                    //I store the pill side1 and remove excess
whitespace and transform it to lower case
                                                    userPill.side1 = userSide1;
                                                    //I ask the user what is on the second
side of their pill
                                                    System.out.println("What does it say
on the other side of your pill: If symbols are not adjacent, put a space between them): ");
                                                    //I collect the pill side2
                                                    String userSide2 =
sc.nextLine().trim().toLowerCase();
                                                    //I store the pill side1 and remove excess
whitespace and transform it to lower case
                                                    userPill.side2 = userSide2;
                                                    //I close my scanner
                                                    sc.close();
                                                    /*This loop will iterate through the list
of pills and check if the imprint of the user pill equals any
                                                      of the imprints of the real pills */
                                                    for(int i = 0; i < pill_list.size(); i++) {

                        //Checks if the imprints, shape, and color are equal

                        if(((userPill.side1.equals(pill_list.get(i).side1) ||

            userPill.side1.equals(pill_list.get(i).side2) ||

            userPill.side2.equals(pill_list.get(i).side1) ||

            userPill.side2.equals(pill_list.get(i).side2)) &&

                                                userPill.color.equals(pill_list.get(i).color) &&

                                                userPill.shape.equals(pill_list.get(i).shape)) ||

                                            ((userPill.side1.equals(pill_list.get(i).side1) ||

            userPill.side1.equals(pill_list.get(i).side2) || userPill.side2.equals(pill_list.get(i).side1) ||

            userPill.side2.equals(pill_list.get(i).side2)) &&

                                                userPill.color.equals(pill_list.get(i).color)) ||

                                            ((userPill.side1.equals(pill_list.get(i).side1) ||

            userPill.side1.equals(pill_list.get(i).side2) ||
```

```
        userPill.side2.equals(pill_list.get(i).side1) ||

        userPill.side2.equals(pill_list.get(i).side2)) &&

                                                    userPill.shape.equals(pill_list.get(i).shape)) ||

                                                (userPill.side1.equals(pill_list.get(i).side1) ||

                                                    userPill.side1.equals(pill_list.get(i).side2) ||

                                                    userPill.side2.equals(pill_list.get(i).side1) ||

                                                    userPill.side2.equals(pill_list.get(i).side2))) {

                                                                        //Prints the pill
to the console

        System.out.println(pill_list.get(i).toString());

                                                                        //Once I find
the right pill I need to exit the loop

                                                                        break;

                        }
                                                        }
}
}
```