Low Cost Foolproof Medicine Dispensing System

T. Alexander, E. Brass, E. Diaz, R. Freas, R. Reyes, M. Moges
Department of Engineering Technology
University of Houston
talexander4@uh.edu, esbrass@uh.edu, ejdiaz2@uh.edu, rbfreas@uh.edu, rjreyes2@uh.edu, mmoges@uh.edu

Sai M. Chittajallu, H. Nandagopal
Department of Electrical and Computer Engineering
University of Houston
schittajallu@uh.edu, hnandagopal@uh.edu

Abstract

To get the best results from any form of treatment, it is essential to stay on schedule with the medicine. Unfortunately, many people have difficulty in remembering when to consume their medication, owing to multiple medications with complex time schedules, or simply because they are forgotten in the busy hours of a typical day. Also, there are known cases of misuse and abuse of medications, often resulting in hospitalization and sometimes proving to be fatal to the patient. To circumvent these simple (but important) issues, an automated pill dispensing system, for the use of patients who need close proficient supervision, is presented in this paper. Although implemented before, the devices available today in the market are absurdly expensive. This system has been designed with better technology at only a fraction of the cost of these devices. The proposed device is equipped for supplying medication according to a schedule, along with a security system to prevent abuse of these medicines. The schedule of medication is keyed in by the caretaker into a Google Calendar API developed for the system. The dispenser sounds an alarm when it's time for a dosage and identifies the person in need of medication using facial recognition. Finally, it dispenses the right medicine in right amounts according to the time of the day. A complete list of medicines dispensed will be notified on a regular basis to the caretaker, to ensure safety and reduce risk.

Introduction

This paper demonstrates the design and building of a fully-functional automated pill dispensing instrument to be used as an aiding tool in conjunction with a caretaker in order to ease the process of scheduling medication for patient to consume [1][2]. The aim is to automate the entire process by remotely managing the dispenser, only requiring the user to refill the silos based on their prescriptions [3]. The current target audience is senior citizens, as they are most likely not to adhere to their medication schedule. It can also be employed for other individuals who are physically week, like cancer patients, handicapped people and Alzheimer's patients. The patients in this category have difficulty remembering when to consume their medication.

The designed pill dispensing system can assist groups of people with 3 or more regular prescriptions a month. Although many alternative instruments are available in the market, solutions provided by the current technology would require tedious preparation, thereby making it not suitable for those with memory problems, or physical disadvantages. Some of the existing pill dispensers require patients or their caretakers to manually prepare every dosage of each prescription in daily containers for each week. Another device has an audible alarm, but requires no authentication when dispensing the medication, which makes for a very insecure system [4]. The available options are also exhaustively expensive with little functionality. In order to overcome these disadvantages, our system needs to provide more features than the market standard, yet designed at a lower price.

Background Information

According to a study, done by the American Society of Health System Pharmacists, about a third of older adults take more than 8 prescribed pills every day [5]. As people grow older, at about ages of 65 and older, it becomes increasingly difficult for them to manage their medication especially on days where their schedule might be full. When people forget to take their medication, they might try to catch up on the following dose; taking double the prescribed amount, as a way of compensating. Taking more medicine than prescribed will most likely cause side effects and thus can be harmful. A survey done by the British Pharmacological Society found that more than 80% of the elderly that go to the hospital are treated for medicine reactions due to dosage issues [6]. Our solution to this problem is the creation of an automated pill dispenser, which can be scheduled solely by the patient, patient's doctor's office, a nurse/pharmacist, or a caretaker. The solution was chosen by the team, as an inexpensive and effective way to regulate a controlled substance. We felt it would be safe and secure enough to entrust Google's systems with items such as a prescription schedule. The program that would control the automation would access Google application programming interface (API) libraries through an encrypted API key code, which would decrypted by Google's API.

Through our research we have discovered that we need to create a device to help with the safety and dosage of medication and to additionally help monitor and prevent potential stroke victims. Facial paralysis occurs when a person is no longer able to move some, or all of the muscles on one side of their face. This is a clear indication that the person is about to have a stroke. One of the most common symptoms of a stroke is the face drooping on one side. Some issues can arise from medication not being properly secured. Several advertisements have been run on television related to children having access to their parent's medicine cabinets. The pill dispenser, having an electro—magnetic lock [7], in our marketable prototype schematics, prevents circumstances like children over-dosing on un-prescribed medicine if they were to every stumble onto pill bottles.

A secondary feature that has been implemented is recognizing whether the user is beginning to suffer from a stroke. Strokes cause changes to the face of the affected person over a period of time. Through the use of facial recognition, a percent error threshold can be established, allowing the system to warn the doctor or caretaker that the threshold has not been met, and that the patient's image is changing. If the threshold is not met over time, it could be a good indicator that the user is potentially experiencing a stroke, thus giving the patient an early warning and informing them the need to seek urgent medical care.

Project Description

The automated pill dispenser will require only a few things for the user to poses in order to use the device. A Google account is essential in order to access Google Calendar, send email notifications, and set up their schedule for their medication. The best method is having a caretaker or provider to help with this in order to perfect the schedule. The automated pill dispenser is required to be plugged into a standard wall outlet. This device should be readily accessible at any time that the medications are to be dispensed, to make sure to plug in the device into a central location with reliable internet. Once the device is plugged in and the calendar is set up, the device can start up the process of stress-free medication dispensing. The overall block diagram for the project is shown in figure 1.

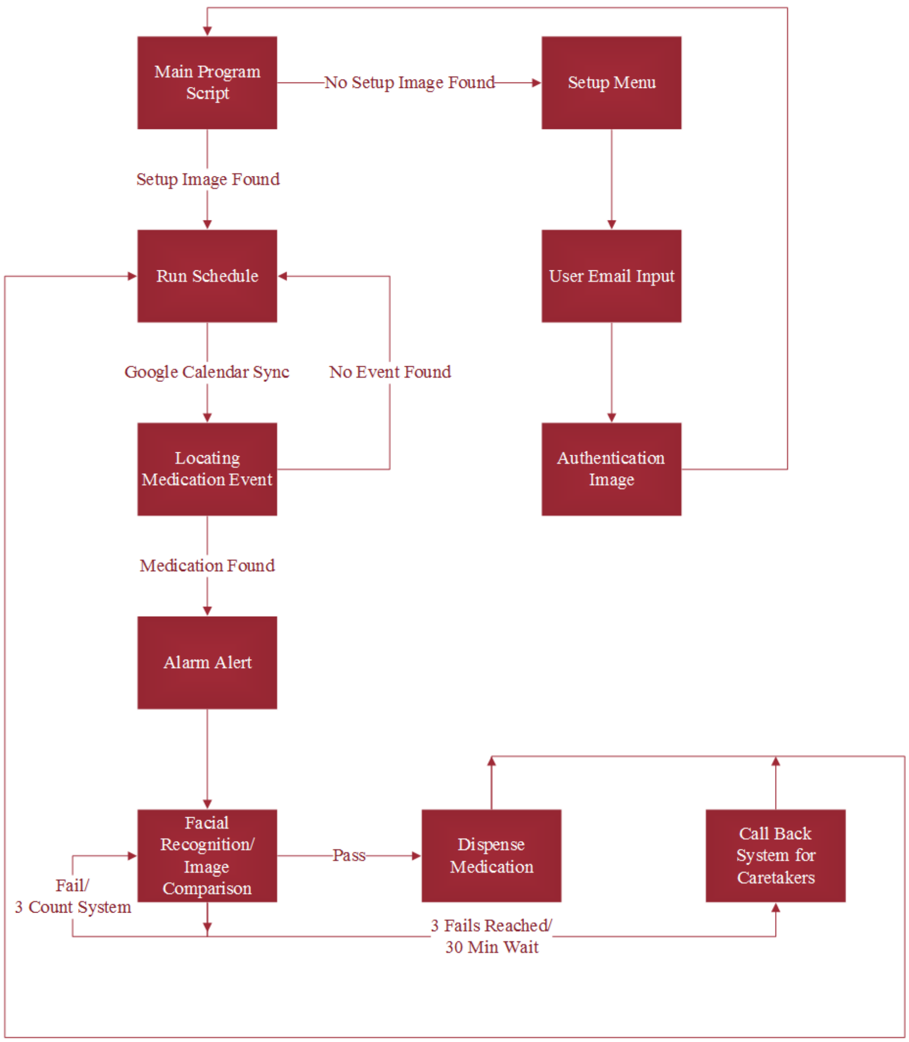

Figure 1. Flow chart describing the process of autonomous pill dispensing

Hardware description

The processing backbone for the project is the DE2i-150 Development and Education Board. The board is composed of 2 main sections, the Intel Atom N2600 and the Altera Cyclone IV GX FPGA. The Intel Atom portion is x86 computer motherboard so it is able to run common operating systems like Windows and Linux [8]. The Altera portion is a modular programmable circuit that is able to be configured by the programmer in any way possible. The drawback to using such a FPGA is that we would be required to reload all of the packages to the circuit every time the device is restarted. The design will make use of the Intel Atom portion of the embedded board. The exterior of the prototype has been designed to be completely transparent for easier viewing. Our design would be either cylindrical or cube in shape. As of now we currently do not have a touchscreen working with our system, a necessity for the design to be more user friendly. The design includes a backup battery system, since this automated pill dispenser depends solely on use of the internet.

Pololu Micro Maestro 6-Channel USB Servo Controller:

To provide access to the dispensing motors, a USB to GPIO control module is employed. Pololu Micro Maestro 6-Channel USB Servo Controller is the module used. The controller is specifically designed for servo motors, which are the type of motors we need if we want to rotate them 180 degrees to use one motor for 2 dispensers. USB controller was used instead of the GPIO ports found on the FPGA portion of the board because every time the board is turned off [9].

Gear design:

All of the gears will be of the same shape with the only varying factor being the size of the gear itself and the pill pocket. The size of the gear will depend on the size of the pill it will dispense. The design of the pocket allows for the pill to only be dispensed when the gear is rotated in the proper direction. This is needed as two gears will be setup per motor. One direction will drop the medication of one gear and the other direction will drop the other medication. When the dispenser not in use, it is spun in the opposite direction. The pill cannot be dropped since the pocket had to be built to keep this from happening. Figures 2 and 3 provide the design for the gear system.

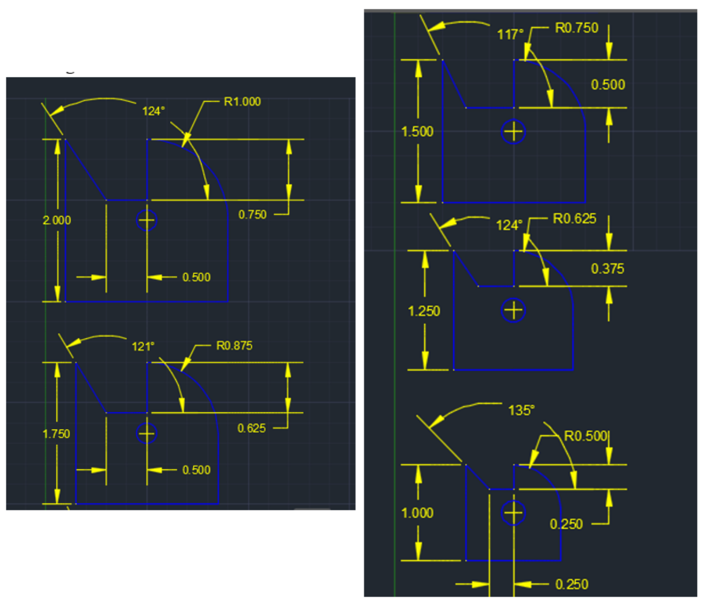

Figure 2. Gearbox Design

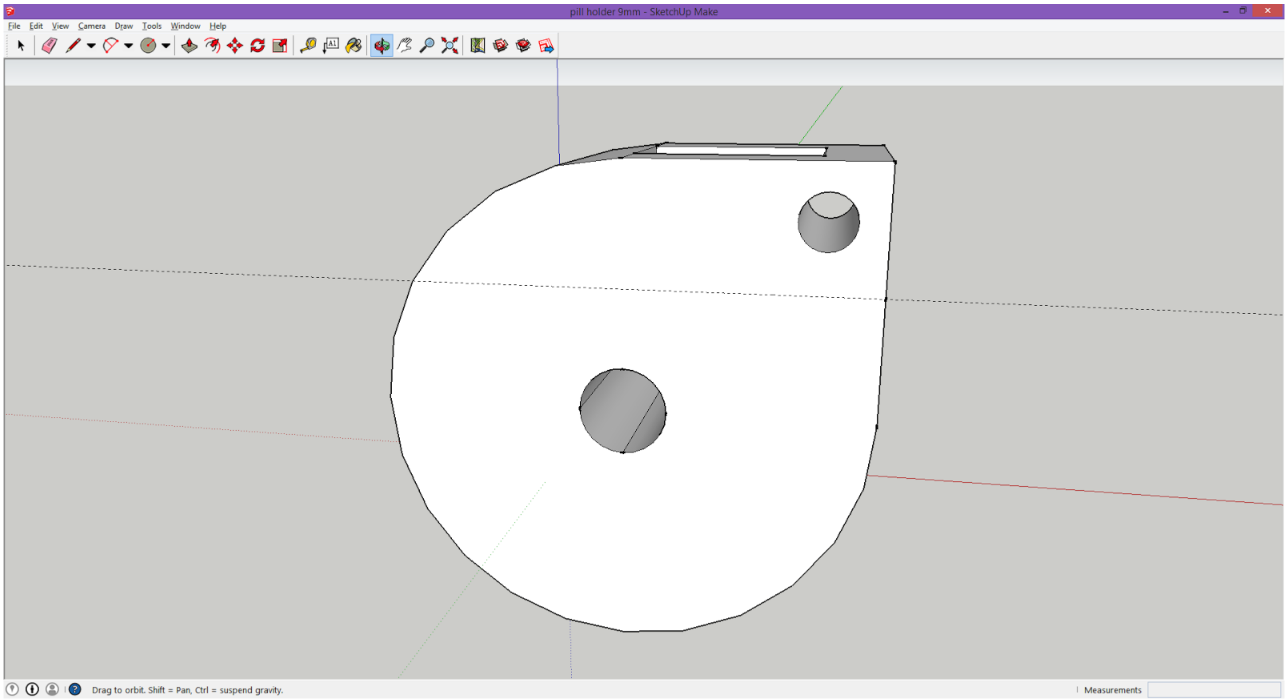

Figure 3. 3D MODELLING OF THE Gearbox Design

Dispensers:

The design for each pill holder or silos will be in a funnel shape and will be able to hold around 360 pills each. Each silo will be designed according to different pill sizes and shapes. 6 different clear vinyl tubing's that range from sizes, ¼ inch, 3/8 inch, ½ inch, 5/8 inch, and ¾ inch were attached to the silo's in order to ensure proper dispensing of the pills. The figure 4 shows how the dispensing system works.

When that pill is accessed by the device, the gear will move in a certain direction to dispense the one pill that has been resting in the gear. These 6 gears will be attached to 3 different motors. We will have 2 different gears attached to one motor that will be using PWM to dispense the medication [10]. The motor will be housed between 2 gears. The gears will be cut in two different ways, so if the motor turns to the right then the medication on the left will dispense and if the motor turns to the left than the medication on the right of the motor will dispense. The medications that are dispensed by the gears will fall into a large funnel that will be attached to the bottom of the gears. This funnel will be created by using PVC Pipes that will create a slide for the pills. This slide will fall out of a single opening into a collecting cup.

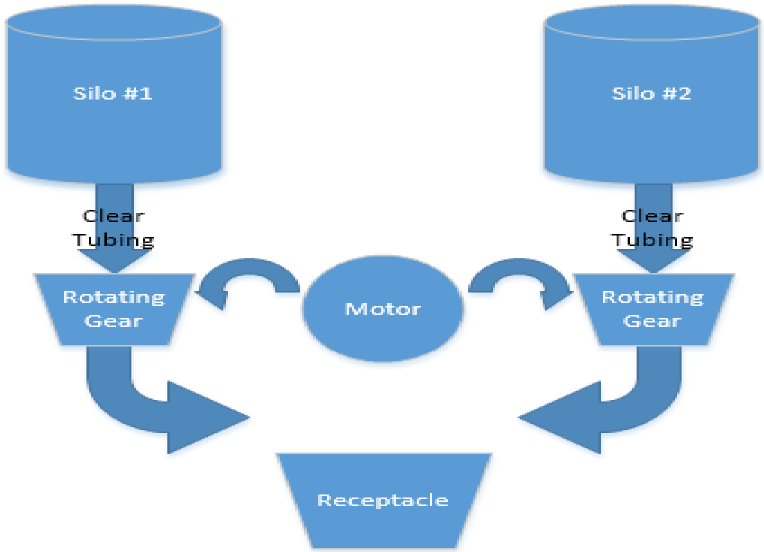

Figure 4. Dispensing system block diagram

Software description

The program used will begin by comparing the image captured with the stock image of the user available in the software. If an image is not found then the program will proceed to ask for an email address of the caretaker for callback purposes and then take an image of the user. After the image is verified, the system will proceed to access Google Calendar looking for scheduled medication events. As long as an event is not found, the program will keep looping and checking for an event periodically. When an event is found, an alarm will notify the user about next dosage. The user's image will again be captured but this time as an authentication measure. If the variation threshold is met, then the medication will be dispensed. If the threshold is not met, the user will have three opportunities before the callback system is activated. A wait time of 30 minutes with no medications being taken will also set off the callback system. The program will continue run after the medication has been taken or the callback system has been engaged. The purpose of the callback system is to keep the caretaker up-to-date. This allows for more accurate monitoring of proper dosages being taken or if they have been consistently missing their medications.

Scripting tools and libraries:

Python:

The majority of the scripting for the project was done using the Python programming language because it allows for easy integration with Linux and OpenCV.

OpenCV:

OpenCV is a free software program that is aimed at providing real-time image processing, and is used here to take the stock and current images of the user and to aid in the development of the facial recognition code.

Google API Calendar:

Google provides application programming interfaces, or APIs, for many of its services. APIs allow for integration of the host services into third party applications. Access to these host services is provided after providing the appropriate credentials. The newest version of the Google API, Version 3, provides greater security as no emails or passwords are stored onto the computer in plain text. All credentials are authenticated using encrypted API keys that only access the appropriate account. The manner by which the Google Calendar APIs and the python code are integrated is through the script containing the header files needed to access Google, a .json file with the credentials to access the appropriate account, the API keys for the calendar, and the correct functions. Once the credentials have been established the programs pings Google every so often to look for calendar events. The system keeps pinging in a loop until an event with the matching name occurs. The figure below shows a screenshot of the Google Calendar spreadsheet.

Photo Comparison Technique:

The comparison of the two images will be done by taking both pictures and comparing all the pixels in both the images using the Structural Similarity Index formula [11]. The formula returns a value after the comparison ranging from 1 to -1, with 1 being the most precise. The formula can be seen below:

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

This formula is included in a Python library called *scikit-image*, so the program will be able to calculate the values automatically without any manual input. Other libraries required are *matplotlib* to provide the X and Y coordinates needed for the equation, *Numpy* to the calculate portion and *OpenCV* for the imaging process.

The idea is to make the imaging comparison more accurate by extracting the face of the user on the image and then use that for comparison. This provides for a more realistic facial recognition algorithm, as the surroundings are not taken into account.

Conclusion

The inspiration for designing and creating the automated pill dispenser is to provide a safe and efficiency way for people who are either having trouble keeping up with their prescriptions. The current solutions available for this issue are both tedious and very time consuming and is absurdly expensive. The use of Google API Calendar allows for an efficient way to manage the schedule. The image recognition software provides better security and avoid the risk of using the medicines for unlawful purposes. The physical design is constructed with accurate measurement as the main objective. It is possible to allow doctors and other hospital personnel related to the patient's treatment to update the Google API Calendar remotely. This will further reduce the risk of complexity in the future developments. The e-pill MedSmart PLUS Monitored Automatic Pill Dispenser currently available in the market costs about $790. But the system designed in this paper costs about $588. The main component is the Intel Atom board which costs about $555. If it is purchased in a large quantity, this will reduce the cost. Moreover then system available in the market has a few disadvantages. It is limited to dispensing only 6 times per day and it provides only two medication trays. Our system is not limited in these areas. The security system incorporated also checks if the caretaker collecting the medicine is registered in the system and provides only the medication that is authorized to the caretaker. This can help in reducing the misuse of the medication by the caretaker as well.

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