GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

AUTOMATED MEDICINE DISPENSER WITH PRESCRIPTION CHARACTER RECOGNITION

PROJECT REPORT

Supervised by

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INTAKE 34

2020

DECLARATION OF AUTHORSHIP

We, DNB Arambepola, SAIR Satharasinghe and MRS Madhawa declare that this thesis titled “Automated Medicine Dispenser with Prescription Character Recognition” and the content presented in it, is our own. We conform that,

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- Where we have consulted the published work of others, which has been always clearly attributed.
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- We have acknowledged all main sources of help.

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Date: ……………………….

DECLARATION BY SUPERVISOR

I certify that the above statement made by the authors is true and that this thesis is suitable for submission to the university for the purpose of evaluation.

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ABSTRACT

Our project is based on automating the drug dispensing mechanism along with the process of printed drug prescription recognition. Due to the fact that many errors occur during the reading of the prescription and dispensing of the pills. These errors can be reduced by automating the process of reading the prescription and dispensing of the pills. The main aim of our project is to design a system that can read the printed prescriptions along with a fast and accurate dispensing method. In order to fulfil our aim, we created a enclosure with a webcam with a proper light source to take the image of the prescription and this image is used for OCR. The OCR is done using Tesseract OCR. The recognized text is then verified by the pharmacist and the relevant pills needed are dispensed according to the number of pills needed. The dispensing mechanism is valid for round pills as well as capsule pills. This mechanism requires an adjustable system to be used for pill isolation and requires a small adjustment. After the pills of each dispenser is dispensed, the indications are given to take out the pills dispensed.

The main design has all the components designed using Acrylic and the rest of the design components are 3D printed.

Key Words: Tesseract OCR, Dispensing Mechanism, Easily Adjustable System.

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ABBREVIATIONS

APD	-	Automated Pill Dispenser
3D	-	3 Dimensional
MCU	-	Microcontroller
I/O	-	Input/ Output
GUI	-	Graphical User Interface
IR	-	Infra Red

CHAPTER 1 INTRODUCTION

BACKGROUND

The field of health services is not as error free as expected by the patients. During the stages of prescribing, transcribing, supplying and dispensing, preparing and monitoring it is clear that the errors are common at every stage mentioned above. "Not all the errors that lead to injury and death, but a number of preventable injuries do occur" (Stencel 2006). There is also the fact that the errors occur to the patient is not informed unless there is an injury or death occur to the patient and a court order is needed to commence a full investigation and this could result in penalties to the people in the health services. In addition, the written paper prescriptions bring higher error rates due to confusion with similar drug names. The other errors that comes with dispensing of the drugs is incorrect labeling of the pill container, incorrectly packing the drugs, or improper storage of the drugs. "Errors occur at a rate of 4 per day in a pharmacy filling 250 prescriptions daily, which amounts to an estimated 51.5 million errors out of 3 billion prescriptions filled annually nationwide" (Nair 2010). During a busy day in the pharmacy, the proper organization which once was at the start of the day might fail to be present at the middle of the day, since there is no time for the pharmacist to work with one drug label it and place it in the proper place it was, because it will result in unnecessary movement to the employees of the pharmacy which is considered as a waste for the pharmacy. The area in focus here is properly reading the printed paper prescriptions and identifying the dosages and the number of tablets needed. Automating these features are main important tasks the pharmacist could do to ensure an error reduction using patient counseling, "Approximately 83% of errors are discovered during counseling and are corrected before the patient leaves the pharmacy" (Nair 2010). Since the last point of contact between the medical services and the patient is the pharmacist proper optimization of this area of medical services would help reduce the errors occurred.

The original electronic portable digital tablet counting technology was invented in the early seventies of the last century. These early electronic counters were designed to help pharmacies replace the common (but often inaccurate) practice of counting medications by hand. A simple to operate machine had been developed to accurately and quickly count prescription medications. The substantial investment in new technology was a major consideration for many pharmacies. Eventually the pharmacy community adopted the use of a counting machine as a superior method to hand-counting medications. These devices became known as tablet counter, capsule counter, pill counter, or drug counter. These counters aided the pharmacy industry with time-consuming manual counting of drug prescriptions. A counting machine was found to consistently count medications accurately and quickly. A system of pharmacy automation was quickly adopted, and innovations emerged every decade to meet the needs of the pharmacy industry to deliver medications quickly, safely, and economically. Modern pharmacies have many new options to improve their workflow. This requires them not only to use the new technology, but to work out how to choose intelligently from the many options available. These industrial units were designed to be fast and simple to operate, yet remain small. At the turn of the technical advances saw the design of a new breed of counters with a verification system. With an onboard computer, displaying photo images of medications to assist the pharmacist or pharmacy technician to verify that the correct medication was being dispensed. In addition, a database for storing all prescriptions that were counted on the device. Today's pharmacy industry recognizes the need for heightened vigilance against medication errors across the entire spectrum. Prescription dispensing safety and accuracy in the pharmacy are an essential part of ensuring the right patient gets the right medication at the right dosage. A trend in pharmacy is to place a greater reliance on technology and pharmacy automation to minimize the chance of human error and speed up the process of dispensing.

PROBLEM STATEMENT

Can intelligent automated system be used for error reduction and quick dispensing of drugs in a pharmaceutical industry?

OBJECTIVES

- Design and develop the automated pill counting machine and character recognition.
- Fabrication of the automated pill counting machine and character recognition.
- Testing of the automated pill counting machine and character recognition.

SCOPE

The model will be trained for the prescriptions written in Sri Lanka. The errors occurred when reading the prescription, the errors occur when counting the pills and the proper storage of the drugs are identified and rectified. The prescriptions are read only for a selected number of standard abbreviations and only for a selected set of drugs with a selected prescription form format since the training data needed for a small number of drugs is also a very large amount. The data is also collected from a relatively small sample size relative to the number of doctors in Sri Lanka. This is due to the time constrains of the project. The rack is not designed for full scale, due to budget constraints.

Optical Character Recognition (OCR) is implemented for printed prescriptions. The errors occurred when reading the prescription, the errors occur when counting the pills and the proper storage of the drugs are identified and rectified. When the OCR is used to identify several types of fonts of prescriptions.

PROJECT OUTCOMES

The primary objective is to build a proper working prototype of the drug dispensing system consisting of the recognition, storing and counting mechanism for the drugs in the rack. In addition, this could benefit the pharmacist from unnecessary workload and improve the profits of the pharmacy. This project could reduce the errors occurred by the pharmacist while dispensing and help reduce the errors occurred from the other sectors of medical services.

CHAPTER 2 LITERATURE REVIEW

Illegible handwriting of the medical professionals.

When the legibility of the handwriting of the doctors are poor, the prescription errors occur. An experiment was conducted where, doctor's handwriting was compared with that of administrative staff and other healthcare professionals. The findings stated the fact that that doctors, when they were requested to write as neat as possible, produced handwriting that is worse than that of other professions. Therefore, this research can support the fact for the common notion that the legibility of doctors' handwriting is usually poor (Lyons et al, 1998). The other common notion is that the doctors scribbled because they wanted to keep the records private, the research of Skol and Hettige suggested why this notion is also not applicable to the modern day. In the past centuries, doctors scribbled notes for the sole purpose of keeping personal records of their patients' medical history. Only the doctors can understand those notes. But today, doctors do not work alone anymore; they are now accompanied by dozens of professionals, forming a multidisciplinary health care team (Sokol and Hettige, 2006). In an article by Emirates 24/7 has stated as follows "The Institute of Medicine (IOM) reported that the sloppy handwriting of physicians is responsible for 7,000 deaths each year." (Majorie van Leijen, 2012). The pharmacists have stated follows about the handwriting of medical professionals "Experience is a must. It takes about 3-4 year. Trainees have a difficult time. We advise them always to ask the doctor." (Majorie van Leijen, 2012). In addition it is also stated that the sloppiness of the handwriting of doctors happen mainly due to the rush of the doctors.In the research of Adlay (2013), it is mentioned that doctors' sloppy handwriting kills more than 7,000 people annually (Alday and Pagayon, 2013). In the Saudi Pharmaceutical Journal, an assessment of the legibility of the handwritten Prescriptions and the e prescriptions were done and the results were published as follows, 398 prescriptions (199 handwritten and 199 e-prescriptions) were assessed. About 71 (35.7%) of handwritten and 5 (2.5%) of electronic prescription errors were identified. A significant statistical difference ($P<0.001$) were observed between hand written and e-prescription in omitted dose and omitted route of administration category of error distribution (Albarrak et al., 2014). It was concluded in the assessment that the e prescription showed significant decline in errors.

OCR system

There are several types of OCR engines we can use both paid and non-paid. They are Calamari, OCRopus and Tesseract for open source and Abbyy Cloud, Google Cloud Vision, and Microsoft Azure Computer Vision for paid versions. The details on comparison with the paid versions was not followed.

Calamari is built on TensorFlow, this gives Calamari the space to take advantage of TensorFlow's neural network capacity. It is relatively straightforward to use but has some tricky items to consider. Because Calamari only does text recognition, you must use another engine (recommend OCRopus) to increase contrast, de-skew, and segment the images you want to read. OCRopus requires Python 2 and Calamari is written in Python 3. Calamari is free and open-source software. (source.opennews.org, n.d.)

OCRopus needs higher resolution images. There will be many errors if resolution is below 300dpi (source.opennews.org, n.d.). There are less instructions on OCRopus and this OCRopus uses some specialized instructions. (source.opennews.org, n.d.).

Kraken, a turnkey OCR system derived from OCRopus. Kraken does output geometry in hOCR or ALTO format. Analyzed Layout and Text Object is an XML schema for text and layout information. Kraken is just OCRopus bundled nicely, so the actual results will be like OCRopus results (source.opennews.org, n.d.). Kraken is a free software.

Tesseract is a free and open-source command line OCR engine that was developed at Hewlett-Packard in the mid-80s and has been maintained by Google since 2006. It is well documented. Tesseract is written in C/C++. Their installation instructions are reasonably comprehensive. Tesseract can give the results in plain text, hOCR or in a PDF, with text overlaid on the original image. Tesseract is free and open-source software (source.opennews.org, n.d.).

In a AI and machine learning blog which has created a comprehensive guide for OCR with tesseract, OpenCV and python has introduced about Tesseract, before describing about the OCR abilities it as explained that that "conventional OCR systems have never overcome their inability to read more than a handful of type fonts and page formats" (AI & Machine Learning Blog, 2020). The solution to this problem and the problem of the inability to read the proportionally spaced typewriter fonts and laser printer fonts but the next generation OCR engines which use deep learning and the large number of datasets that are available and are synthetic, these problems can be addressed. The main challenge that still exists is explained as follows "Optical Character Recognition remains a challenging problem when text occurs in unconstrained environments, like natural scenes, due to geometrical distortions, complex backgrounds, and diverse fonts" (AI & Machine Learning Blog, 2020). When discussing about Tesseract Engine this began as a Ph.D. research project in HP labs in a time between 1984 to 1994. In 2005 HP released Tesseract as an open-source software. Since 2006 it is developed by Google (AI &

Machine Learning Blog, 2020). Tesseract is a LSTM (Long Short-Term Memory) that has been designed using C++.

Legacy Tesseract 3.x is having a multistage process where the stages are Word finding, Line finding and Character classification. Word finding was done by organizing text lines into blobs, and the lines and regions are analyzed for fixed pitch or proportional text. Text lines are broken into words differently according to the kind of character spacing. Recognition then proceeds as a two-pass process. In the first pass, an attempt is made to recognize each word in turn. Each word that is satisfactory is passed to an adaptive classifier as training data. The adaptive classifier then gets a chance to recognize text lower more accurately down the page (AI & Machine Learning Blog, 2020).

The LSTM model is the process of the processing the input image in boxes line by line feeding into the LSTM model and giving the output. This is shown in Figure 1.

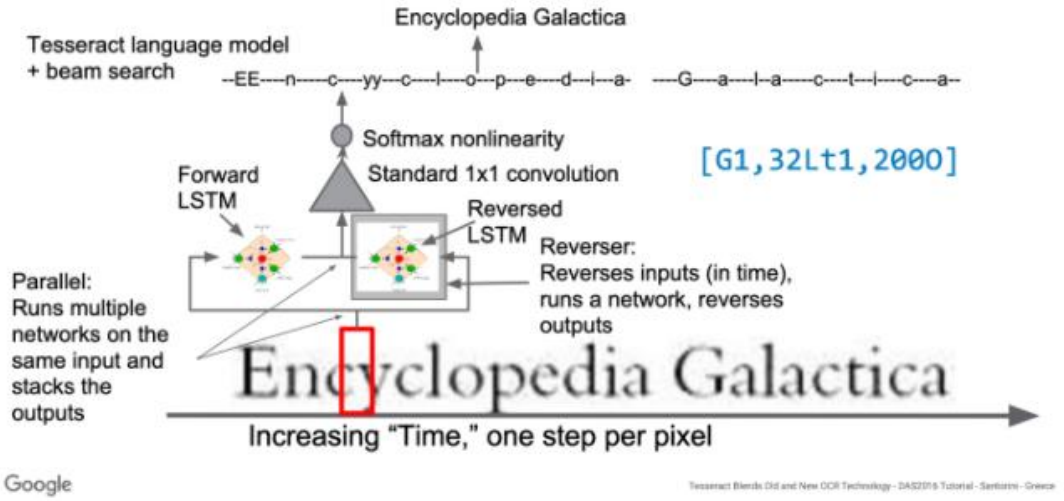

Encyclopedia Galactica
Tesseract language model
+ beam search
--EE----n-----c----yy---c----l----o---p---e----d---i---a-   ----G----a----l--a-----c----t---i----c----a--
Softmax nonlinearity
Standard 1x1 convolution
[G1,32Lt1,200O]
Forward
LSTM
Reversed
LSTM
Reverser:
Reverses inputs (in time), runs a network, reverses outputs
Parallel:
Runs multiple networks on the same input and stacks the outputs
Encyclopedia Galactica
Increasing "Time," one step per pixel
Google
Tesseract Blends Old and New OCR Technology - DAS2016 Tutorial - Santorini - Greece

Figure 2-1 - LSTM model working visualization.

This LSTM model does not work well with handwritten texts and weird fonts (AI & Machine Learning Blog, 2020). These to are two engines that are in tesseract they are the legacy engine and the and the LSTM engine and they are working in four modes. The four modes of operation chosen using the --oem option.

0 Legacy engine only.

1 Neural nets LSTM engine only.

2 Legacy + LSTM engines.

3 Default based on what is available.

Preprocessing for Tesseract.

To avoid all the ways your tesseract output accuracy can drop, you need to make sure the image is appropriately pre-processed. This includes rescaling, binarization, noise removal, deskewing (AI & Machine Learning Blog, 2020). There are several other features of tesseract, but they are not referred because they are not much needed in the application.

Misha Malkovich has stated in the “The battle of OCR Engines” about the relevance of OCR for extracting information or finding out the validity of the prescription of a prescription against a database OCR can be used. In this article Tesseract OCR is compared with the Google Cloud’s Vision API. In here the author has tested three modes in tesseract to understand which extracts more accurate results. They are,

Single Block: the system assumes that there is a single block of text on the image.

Sparse Text: the system tries to extract as much text as possible, disregarding its location and order.

Single Column: the system assumes that there’s a single column of lines of texts.

Google Vision, on the other hand, does not provide as much control over its configuration as Tesseract (fuzzylabs.ai, n.d.). In here the two modes are very effective in general and the effectiveness of the two OCR are compared after preprocessing. The main preprocessing that can be done such as de-noising, lighting adjustment, sharpening and thresholding. The mainly used preprocessing is Thresholding where an operation that turns an image into a binary one by setting the pixels to black if their intensity values are above a certain threshold, and to white otherwise. The main method of thresholding is using Otsu method. This method chooses the best threshold, based on the distribution of pixel intensities. The results of the process are shown.

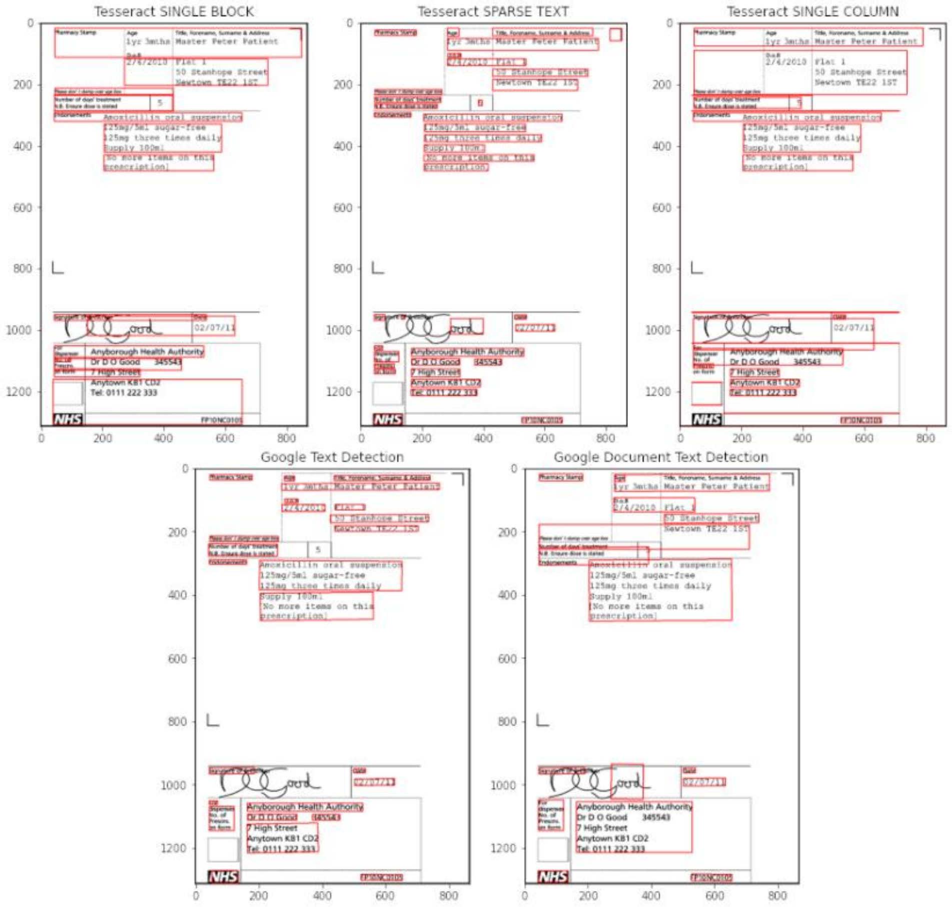


Figure 2-2 - Results of the text detection

Tesseract's results have not changed much (since it was not affected by the background anyway). However, Google's results have improved: no more unwanted elements are recognized. Tesseract's Sparse Text mode still stands superior to the other two, detecting the layout correctly, and recognizing most of the text without mistakes. There are some occasional extra characters inserted: for example, "i 50 Stanhope Street", where 'i' is not a real character, but part of the box to the left of the text. Google Document Text Detection model does not seem to perform well on this one, combining texts into a single paragraph when they clearly do not belong together. The possible reason here is that the text is not dense enough for that model. Google Vision sometimes fails to recognize short strings or lone characters standing on their own (Google Text Detection model failed to detect that single '5' in the middle of the page). But overall, when the text was detected, it was indeed recognized correctly (fuzzylabs.ai, n.d.).

When using OCR which is like humans in the sense the ability of understanding the text varies from person according to many factors. The capability and performance of OCR directly varies on Quality of input document. Tesseract text recognition engine is mainly used because of the flexibility and widespread applications. Tesseract is used in handling traditional black and white images and as well as white on black texts. Tesseract performs activity to recognize words. This recognition activity is mainly consisting of two passes. The first pass tries to recognize the words. Then satisfactory word is passed to Adaptive Classifier as training data, which recognizes the text more accurately. Preprocessing is an important stage of an image because the majority of OCR application uses gray scale images. The images may have watermarks or non-uniform background that make recognition with errors. There are several standard steps we take. The initial step is to adjust the contrast or to eliminate the noise from the image called as the image enhancement technique. The next step is to do thresholding for removing the noise. (Converso and Hocek, 1990)

A mobile prescription recognition system is developed so that it can read the prescriptions easily this mobile app uses tesseract OCR as the OCR engine. In here the handwritten prescriptions are read and they are converted to editable text. In here the tesseract is trained for lower case training scripts. They have conducted several tests on several different medicine names and have concluded that handwritten medical prescriptions can be converted to text the main drawback of this system is that it cannot recognize the cursive letters and it is developed as a (Adlay, 2013).

In a research of automated drug detection and location identification for visually impaired using image processing and voice commands is a project which highlight the text from object and extract the text from that object (Drug box) in real-time video frames in purpose of giving voice assistance to a person. For the text extraction the researchers have considered several OCR engines such as Apose OCR, Tesseract and Afroge and the best result is taken through tesseract. According to accuracy and performance, the avg. total charter error is 11.0 and the word precision error is 25.4 which is a good rate of accuracy. These results are given below.

OCR Engine	Test Language	Text extraction		Total Character Errors	Word Precision Errors
		Plain Text	RGB Colored Text		
Google Tesseract	English	Yes	Yes	11.0	25.4
Aspose OCR	English	Yes	No	20.9	37.2

Figure 2-2- Comparison between Google Tesseract OCR and Aspose OCR engines

The project of recognizing drugs on medical prescriptions are recognized through an Optical Drug Recognition (ODR) system. This is a smartphone app, this ODR would make it possible for physicians to instantly analyze all drug interactions in a printed medical prescription. They have developed their own OCR system. The training data is generated by them with and used the French public drugs database as reference vocabulary. For the model at the core of the pipeline stands the OCR. It is composed of a convolutional neural network (CNN), followed by a bi-directional Long Short-Term Memory (LSTMs) network and a Connectionist Temporal Classification (CTC). The results are compared with the google vision API and the Figures below show the precision and recall distributions after the evaluation from both Google (orange bars) and Synapse (blue bars) pipelines. We see that, on this specific medical prescription analysis task, both pipelines provide comparably good performances.

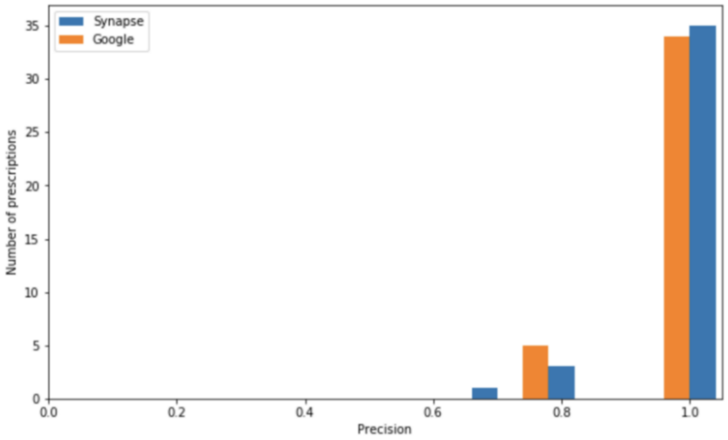
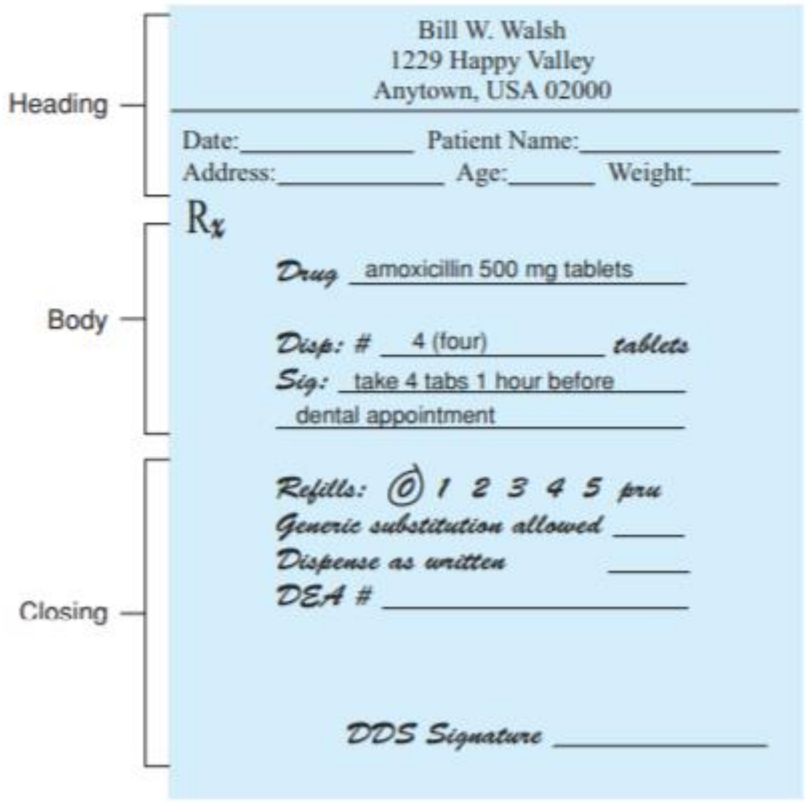


Figure 2-4 - Precision distribution among the set of prescriptions

In the research of Adlay (2013) for developing a mobile application for medical prescriptions they have implemented Tesseract OCR as their OCR. The author has further recommended to Binarize the image when it is being applied to the OCR (Alday and Pagayon, 2013) . The accuracy results of tesseract in 2014 for English is 0.47% character error rate and 6.4% word error rate (Ohlsson, 2016).

Parts of a prescription


Heading
Body
Closing

Bill W. Walsh
1229 Happy Valley
Anytown, USA 02000

Date:__________ Patient Name:__________
Address:__________ Age:______ Weight:______

Rx

Drug amoxicillin 500 mg tablets

Disp: # 4 (four) tablets
Sig: take 4 tabs 1 hour before dental appointment

Refills: [✓ 0] 1 2 3 4 5 prn
Generic substitution allowed ______
Dispense as written ______
DEA # __________________

DDS Signature ______________

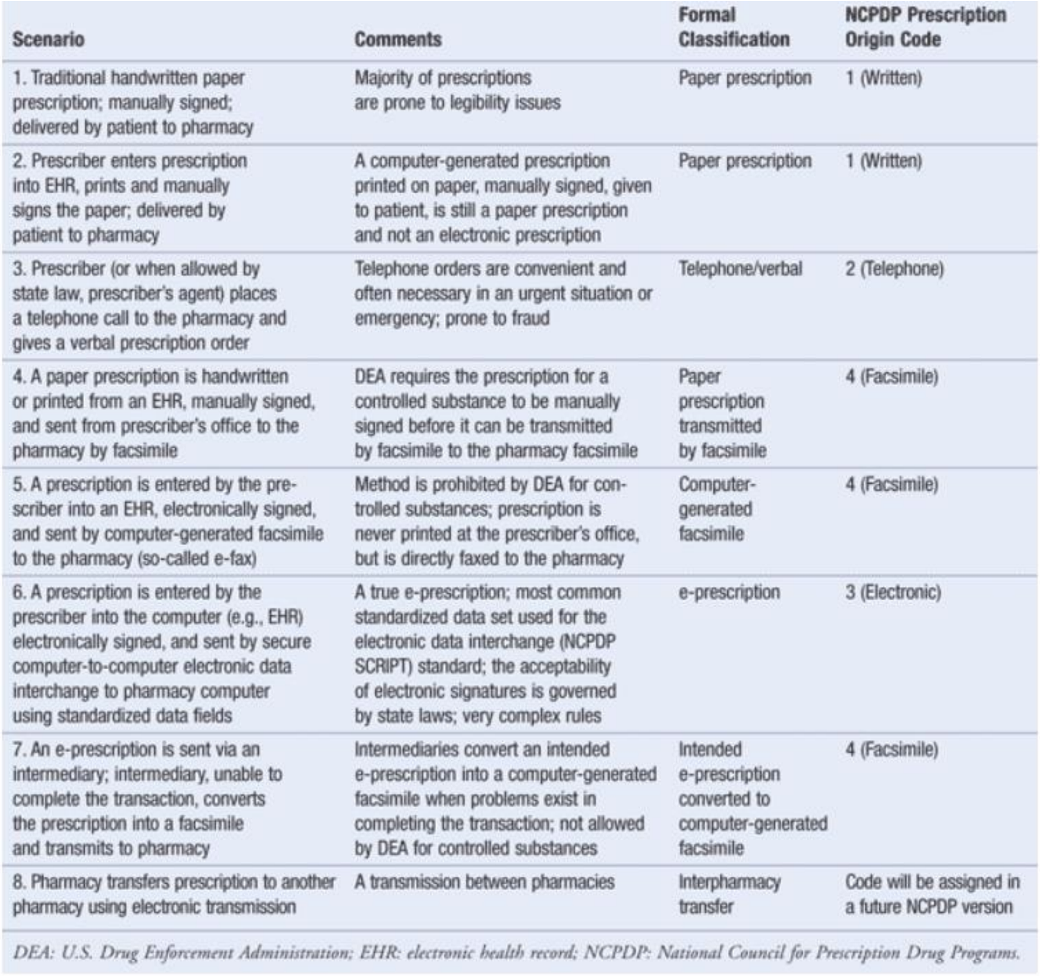
Figure 2-5 - Parts of a Prescription

The heading is used to find out about the prescriber (name, phone number, and address), the date of the prescription, and lists the patient information (name, age and weight [for children], and address). For children, the age and weight should be noted so the pharmacist can monitor the dose prescribed, as a double check to reduce possible errors in prescribing (Terms and Acronyms, 2008).

The body gives the directions to the pharmacist the specific drug, dose or concentration, and amount to be dispensed. It also provides directions to the patient (transcribed by the pharmacist to the packaged drug) that state precisely how the patient is to self-administer the drug (Terms and Acronyms, 2008).

The closing is keeping space for the signature of the prescriber, the prescriber’s U.S. DEA number (if applicable), instructions to the pharmacist about product selection (Terms and Acronyms, 2008)

There are different types of prescribing methods they are as follows



Scenario	Comments	Formal Classification	NCPDP Prescription Origin Code
1. Traditional handwritten paper prescription; manually signed; delivered by patient to pharmacy	Majority of prescriptions are prone to legibility issues	Paper prescription	1 (Written)
2. Prescriber enters prescription into EHR, prints and manually signs the paper; delivered by patient to pharmacy	A computer-generated prescription printed on paper, manually signed, given to patient, is still a paper prescription and not an electronic prescription	Paper prescription	1 (Written)
3. Prescriber (or when allowed by state law, prescriber's agent) places a telephone call to the pharmacy and gives a verbal prescription order	Telephone orders are convenient and often necessary in an urgent situation or emergency; prone to fraud	Telephone/verbal	2 (Telephone)
4. A paper prescription is handwritten or printed from an EHR, manually signed, and sent from prescriber's office to the pharmacy by facsimile	DEA requires the prescription for a controlled substance to be manually signed before it can be transmitted by facsimile to the pharmacy facsimile	Paper prescription transmitted by facsimile	4 (Facsimile)
5. A prescription is entered by the prescriber into an EHR, electronically signed, and sent by computer-generated facsimile to the pharmacy (so-called e-fax)	Method is prohibited by DEA for controlled substances; prescription is never printed at the prescriber's office, but is directly faxed to the pharmacy	Computer-generated facsimile	4 (Facsimile)
6. A prescription is entered by the prescriber into the computer (e.g., EHR) electronically signed, and sent by secure computer-to-computer electronic data interchange to pharmacy computer using standardized data fields	A true e-prescription; most common standardized data set used for the electronic data interchange (NCPDP SCRIPT) standard; the acceptability of electronic signatures is governed by state laws; very complex rules	e-prescription	3 (Electronic)
7. An e-prescription is sent via an intermediary; intermediary, unable to complete the transaction, converts the prescription into a facsimile and transmits to pharmacy	Intermediaries convert an intended e-prescription into a computer-generated facsimile when problems exist in completing the transaction; not allowed by DEA for controlled substances	Intended e-prescription converted to computer-generated facsimile	4 (Facsimile)
8. Pharmacy transfers prescription to another pharmacy using electronic transmission	A transmission between pharmacies	Interpharmacy transfer	Code will be assigned in a future NCPDP version

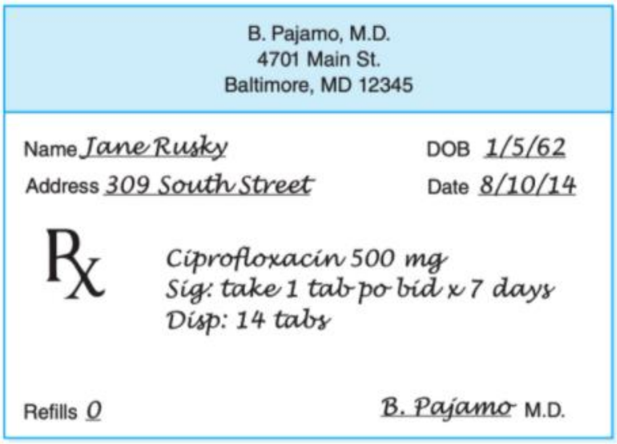
DEA: U.S. Drug Enforcement Administration; EHR: electronic health record; NCPDP: National Council for Prescription Drug Programs.

Figure 3-6 -Types of ambulatory prescriptions is today’s marketplace.

The manual preparation of the prescription of the prescription such as in the first scenario is the step where errors can be introduced. The prescriber must check for appropriateness of the dose, allergies and adverse reactions, drug interactions, formulary compliance, and clinical appropriateness regarding the patient's condition. Then the prescription must be written in such a manner as to be legible. For example, look-alike drug names can cause potential problems. Poor handwriting skills may lead to clinical errors. (Illinois, n.d.)

The second scenario introduces a technical solution to address some of the issues raised in the first. In the second scenario, the preparation of the prescription is carried out on a computer, typically in an electronic health record (EHR), and then printed on paper. The biggest advantage here is that the printed paper does not cause issues created by poor penmanship. Another potential advantage is that the software package of the EHR can perform several edits to reduce the occurrence of clinical errors. The software can check the prescription against a list of known allergies and against a list of the patient's other medications. This functionality is known as computer decision support. Decision support can be very robust and might incorporate several edits, including drug-laboratory interactions, drug-age interactions, drug-allergy interactions, drug-drug interactions, drug-disease interactions, drug-formulary compliance, etc. Once the prescription is printed on paper and manually signed, it is still considered a written paper prescription. (Illinois, n.d.)

This prescription is an example of the above-mentioned prescription.



B. Pajamo, M.D.
4701 Main St.
Baltimore, MD 12345

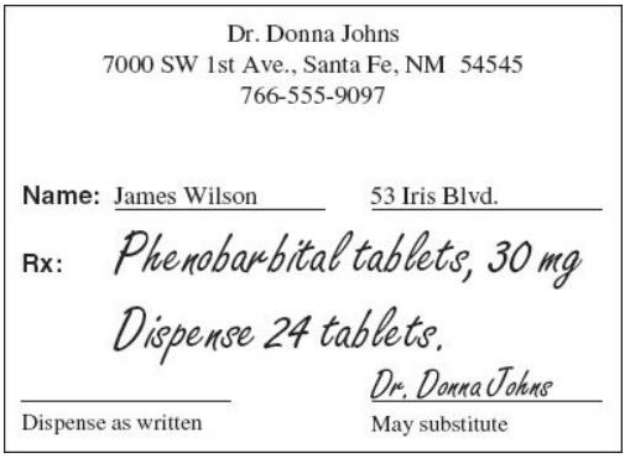
Name *Jane Rusky* DOB *1/5/62*
Address *309 South Street* Date *8/10/14*

℞ *Ciprofloxacin 500 mg*
Sig: take 1 tab po bid x 7 days
Disp: 14 tabs

Refills *0* *B. Pajamo* M.D.

Figure 2-7- Sample prescriptions

In addition (Themes, 2016) also confirms the following prescriptions should contain the following features. The image of the prescription is mentioned below.



Dr. Donna Johns
7000 SW 1st Ave., Santa Fe, NM 54545
766-555-9097

Name: James Wilson 53 Iris Blvd.

Rx: *Phenobarbital tablets, 30 mg*
Dispense 24 tablets.

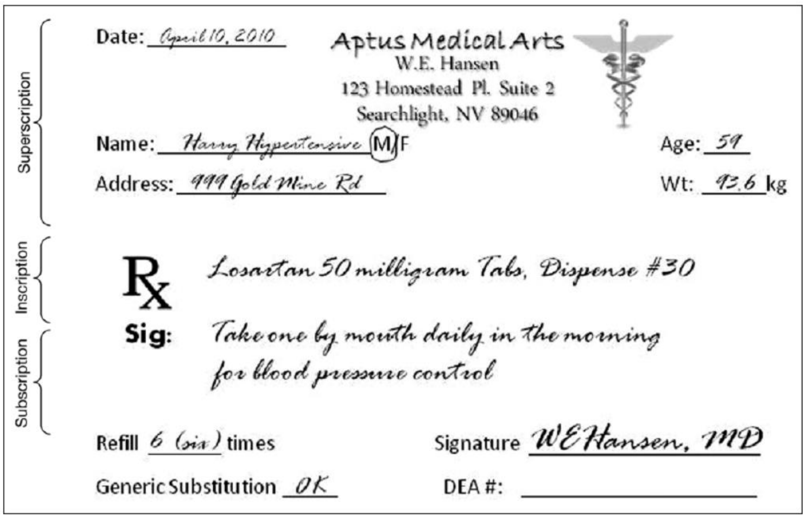
Dr. Donna Johns

Dispense as written May substitute

Figure 2-8 – Example of a prescription

The ISO standard created for the printed prescription mentions the following. This section contains information on the therapeutic use of the prescribed product. The prescription shall contain all information that is needed to use the prescribed product as agreed between the patient and the prescriber. This contains data on the route of administration, strength, the dose regimen quantity, directions of use. This information is also needed by the dispenser in order to dispense the correct amount of the prescribed product e.g, number of tablets (International Organization for Standardization, 2014).

In countries of south Asia such as India is also adhering to the standards that are supplied by ISO (International Standards Organization) and the medical council of India also has provided a format for the prescription (Kalra BS, 2016).


Superscription
Inscription
Subscription

Date: April 10, 2010

Aptus Medical Arts
W.E. Hansen
123 Homestead Pl. Suite 2
Searchlight, NV 89046

Name: Harry Hypertensive [✓ M] F Age: 59

Address: 999 Gold Mine Rd Wt: 93.6 kg

℞ Losartan 50 milligram Tabs, Dispense #30

Sig: Take one by mouth daily in the morning for blood pressure control

Refill 6 (six) times Signature WE Hansen, MD

Generic Substitution OK DEA #: ____________

Figure 2-9 - Description of the parts of prescription. Adopted from Goodman and Gilman's, The Pharmacological Basis of Therapeutics, 12th ed. McGraw Hill Publication

Therefore, we can determine that the prescriptions that are printed should follow the following procedure.

When considering about the fonts used in the medical prescriptions the ISMP (Institute of Safe Medical Practices) suggests the following as the basic approach in the process of preventing errors. In here it mentions the following.

Label formats should include larger fonts, lists, headers, whitespace, simple language, and logical organization to improve readability and comprehension. (forms.ismp.org, n.d.)

- Minimum font size for patient name, generic drug name, and patient-specific dose should be 12 point or equivalent.2 (A 1994 study of adults and seniors found more self-administration medication errors with 9 vs. 12 or 14-point font and Courier vs. Helvetica fonts.) (forms.ismp.org, n.d.)

- Use standardized font styles such as: Arial, Verdana, or their equivalent for all text and numbers. To improve typography, use larger, sans serif font. Do not use italic, oblique, narrow, or condensed type fonts. (forms.ismp.org, n.d.)

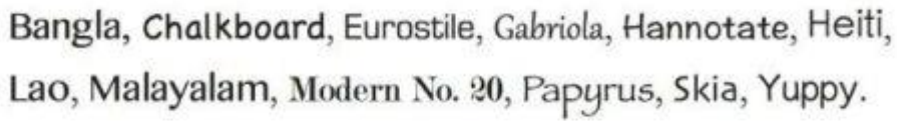
- When applicable, use numeric vs. alphabetic characters when describing drug doses, concentrations, or frequencies. (forms.ismp.org, n.d.)

- Allow for horizontal text only. (forms.ismp.org, n.d.)

- Use thicker, denser lined letters where appropriate as they are easier to read. (forms.ismp.org, n.d.)

Prescription fonts

Show below are some prescriptions that are said to look less authoritative according to (Anon, 2014)

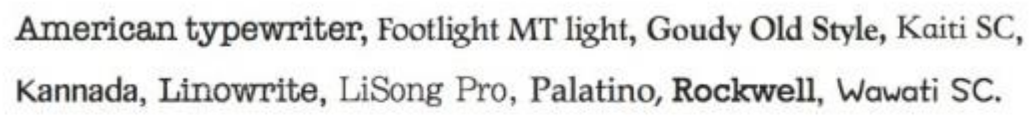


Bangla, Chalkboard, Eurostile, Gabriola, Hannotate, Heiti,

Lao, Malayalam, Modern No. 20, Papyrus, Skia, Yuppy.

Figure 2-10 - less authoritative font styles

Same thing goes for fonts that are complicated. Even fonts that seem to look professional may have too much going on or have letters that are spaced too closely together. Here are some examples of fonts that give a crowded, less-than-legible look to your text.

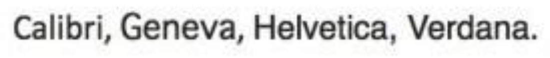


American typewriter, Footlight MT light, Goudy Old Style, Kaiti SC,

Kannada, Linowrite, LiSong Pro, Palatino, Rockwell, Wawati SC.

Figure 2 - 11 -Less legible fonts

Some good fonts for medical presentations include:



Calibri, Geneva, Helvetica, Verdana.

Figure 2 -12 - Recommended prescriptions

Bad fonts outnumber good ones by, oh, 100 to 1. If you really must use a serif font, Calisto works well. Garamond does not. (Anon, 2014).

The American foundation for the blind has stated to best meet the needs of persons with vision loss the general recommendation for prescription.

- Use sans serif, standard font (not narrow or condensed), such as Arial, Verdana, or APHontTM. APHontTM was developed specifically for low vision readers and embodies characteristics that have been shown to enhance reading speed, comprehension, and comfort for large print users.

- Use upper and lower case, not all caps.

  The print authority has stated few best fonts for medical printed materials they are, Verdana, Lora, Source Sans Pro, Proxima Nova, Times New Roman, Rockwell, Avenir, Comfortaa, Quicksand, News Cycle (Authority, 2019).

PyFirmata

Firmata is a protocol for communicating between an Arduino (as well as other microcontrollers) and the host computer, providing direct access to the IO pins (nodered.org, n.d.). This is done using serial communication. This is an easy method to control the Arduino using the computer. In addition, this library can be used in python.

Record maintaining methods of pharmacies in Sri Lanka.

The guidelines submitted by National Medicine Regulatory Authority (NMRA) of Sri Lanka has mentioned in the equipment required section, a computerized system (NMRA, 2017). In addition, a method of keeping records is needed, computerized or manual. If manual method is used separate cabinets for keeping the records should be present. In addition NMRA in 2019 has again specified in the guideline for good pharmacy practice of using computerized system for record keeping and inventory maintenance(NMRA,2019). Therefore, Sri Lankan NMRA promotes the use of computerized systems.

Pill Storage

Achieving the task of storing medicines minimizing the deteriorations and contaminations for dispensing the required number of pills is the most challenging task of the dispenser.

Storage Conditions for Pharmaceuticals

Drug storage is the most important concern to a pharmacist. To ensure the quality of medicine methods were developed and implemented to prevent contamination and deterioration. The stability of the product is ensured within the specified limit, throughout storage and use (Bajaj, Singla and Sakhuja, 2012). During storage of the pharmaceutical products is one of the fundamental concerns inpatient care (Kiron, Shirwaikar and Saritha, 2011). High temperature and humidity are the main factors that affect the degradation of medicine. Monitoring for the correct temperature is important. Time and production process characteristics also affect the quality of medicine.

Many studies had emphasized the importance of storage conditions of pharmaceuticals inside the storage. Those conditions affect on effectiveness and safety of pharmaceuticals. So pharmaceuticals require controlled conditions to ensure their quality. Proper temperature, humidity, light, ventilation, & conditions of sanitation must be maintained inside drug storages.

Medicines must be stored under the manufacturer’s recommendations and terms of product authorizations. Protection from extreme temperatures, moisture, contamination, sunlight and UV rays should be considered.

Pharmaceuticals should be packed in a well-closed container to prevent contamination from extraneous solids, liquids or vapours and loss of product. Following storage factors are the proper storage conditions (Shafaat, 2013),

1. Sanitation
2. Temperature
3. Light
4. Moisture
5. Ventilation
6. Segregation

Through distribution process good storage practice is applicable.

Storage condition on Label

Storage condition of pharmaceuticals should be described with the label, which is based on stability testing. Medicines should be stored as mentioned in the label. The label should specify special conditions required. Excursions of labelled conditions must be investigated and disposition. Stability testing can examine environmental factors, which affect on the quality of medicine and determine shelf life & proper storage conditions and suggest labelling instructions(Tangri and Bisht, 2012).

Storage on the label (For Tablets):

Store in a cool, protected from light and moisture.

Store in a cool and dark place, protected from light and moisture.

Keep in a dry dark place.

Store in cool dry and dark place.

Storage on the label (For Capsules):

Store in a cool and dry place, protected from light.

Guidelines for Storage Area

1. Should be insufficient capacity to various categories products, products to released, returned, reject and recall
2. Should ensure good storage conditions (Ensure conditions in the label)
3. Should be stored off the floor and space to cleaning and inspection
4. A written sanitation programme should be available
5. Should prevent contamination & mix-ups
6. Narcotic drugs should be stored under national laws and regulations
7. Radioactive materials, psychotropic, cytotoxic, dangerous drugs should be stored under additional safety and security measures

From the above procedures, necessary procedures should be followed depending on the drug and process, which are considered for the storage and transportation of pharmaceuticals(World Health Organization, 2003).

Storage designs

There are several machines designed to automate this process to pharmacists and healthcare workers. Techniques and methods used in those automated systems had to be cheap to manufacture, and affordable which should be a simplistic design. The solution to this was to use CAD software and 3D printing for most of the structure as it resulted in a low manufacturing cost, and strong, light structure.

In selecting a suitable mechanism for pill feeding mechanism from pill storage to pill counter similar methods of user pour pills to slide for counting were found. Each design was analyzed to determine which worked best with specific pill variables. These variables include shape, size, and type. Testing of these designs will be useful for later design stages of which option is the most suitable for all pill types(Boudrias et al., n.d.).

Controller

Apart from pill counters, automated pill dispensing systems are focused on the limited amount of pill dispensing units. So mostly microcontrollers were used to function the circuit and controlling process. ATmega and PIC controllers are used as MCUs. ATmega328P, ATMega2560 is mostly used with 5V power level. Also, the Arduino Mega2560 development board is used for most designs considering the number of pins and ease of programming (Chariah and College, 2016).

The Arduino Mega2560 development board has 54 digital I/O pins. From 54 Pins,15 pins can also be used as PWM outputs, 16 pins as analog inputs, 4 pins as hardware serial ports (UARTs). Also has a 16MHz crystal oscillator, a power jack, a USB connection, an ICSP header and a reset button.

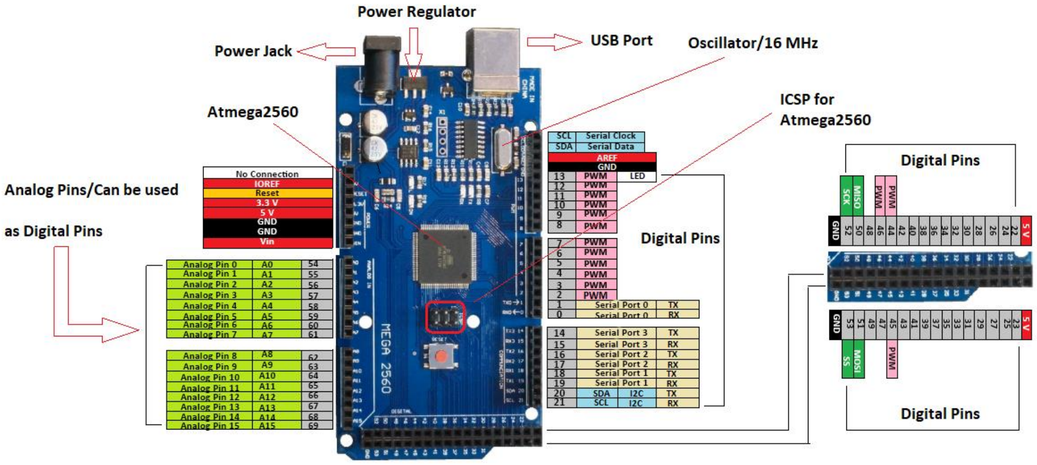


Figure 2-10 – Arduino Mega2560 pin I/O

Power Supply

Most designers and developers had used a step-down converter for 5v DC supply for most components and microcontrollers. Several designs were used the voltage regulators to buck the 12 VDC input to a 5V DC output because the constant direct current is critical to supplying the digital components the needed power.

Sensors

In previous researches and designs with above-mentioned controllers, 2 main types of the sensor had used with the pills. Counting the number of pills is identified as the most used application.

1. IR Break Beam Sensor
   IR LED is a special purpose LED that transmits infrared rays. IR detector reacts to the IR radiation. The two main types of detectors are thermal and photonic (photodetectors). Used for pill counting process considering the detection when a single pill has been dispensed (Win, Maung and Tun, 2014).

2. Laser
   The accuracy and efficiency of using a laser for pill counting process were tested in previous research. The laser and photoresistor arrangement were tested to find the threshold for which a pill would break the laser beam and it can be incremented (Boudrias et al., n.d.).

Actuators

As dispensers are compact and small in size motors are used as actuators, which are working by converting electrical energy into mechanical energy. There are three main types of motors were used,

1. Stepper Motors

Compact stepper motors were used to precisely turn the pill flow from pill dispenser. So that the correct dosage of medication is dispensed(Mukund, 2012). Also capable of accepting incoming commands from the software through the microcontroller.

2. Servo Motors

The continuous servos do not have a limited turn radius, and the input signal adjusts the speed which is important for the design to ensure one pill falls at a time(Chariah and College, 2016). Servo motors will be powered by their voltage regulator out of the power supply. And also can be powered through a motor controller. Those type of has a pin for the controller signal from the microcontroller.

3. DC Motors

DC motor is an internally commutated electric motor, which is designed to run from a direct current power source. A brushed DC motor is rotated the circular plate which is carried the required number of tablets(Win, Maung and Tun, 2014). In the counting process, low-speed motors were used mostly with the 12v Supply.

The motor controller is used to regulate the motion of motors. Uses to energize the motor from start to stop. Motor current requirement is fulfilled by the motor controller. Supplied power to the motor is controlled by the signal from the microcontroller.

Alerting Components

An indication from LED light/bulb or speaker/buzzer is used to alert the user when to take the medicine from the dispenser. Lights are used with flash and speaker to emit a sound for alerting the user. Most designs had used the microcontroller to command the indicator bulb or speaker. Also, SMS alerts with GSM module are used to alert the user in several designs.

Pill Counter Design

The material design of the tablet counting machine is built in four stages. At first, the frame of the machine is designed by a plastic plate. The plastic plates are cut according to the desired requirements and each part is fixed in the shape of the machine.

in the second step, the brushed DC motor is built in the middle of the frame and rotates the support plate. The tablets on the plate are moved as desired by inserting the shape of the arched plastic piece on top of the rotating plate.

in the third step, the place of the tablets on the turntable is shaken by the vibration motor and emerges into the base of the installation.

In the last step, the movement of the desired tablet falls on the key path of the frame and in this way is detected by the infrared sensor. The IR sensor captures the passage of the tablet(Win et al., 2014). for the desired design as the first stage, the fundamental frame designed by solid works and the material cut according to the requirements. Acrylic material was used to make the body of the design. Desired design was used the DC gear motor for the brushed DC motor and also it was mounted in the middle of the bottom plate. the system needs to stop the r rotating table was used on behalf of the vibrating system. When the table rotates, the tables were moved into desired point. IR sensor also used to count the tablets.

The pills as a whole are stored in the bottle. Therefore, from the multitude of pills in the bottle, it is essential to separate a pill. The servo motor mounted at the bottom of each division of the receptacle does the job. Every receptacle division is angled upward from the upper mouth, such that the end of the dispensing pill is located on top of the end of the input. The pills that are fed through the pipe pass upward toward gravity in this manner. To centralize the tablet, this oblique bottom wall allows. The pill dispensing system is operated rotationally by the main controller by the servo motor.

On the periphery of the oval disk that is connected to the servomotor, the carousel at the bottom has two small grooves that are 180 ° apart. This groove on the disk allows the pill to be marked. The slot takes only one pellet as the servo motor is told to turn, and spins along with the carousel. A tiny opening, a little below the carousel, is put at the bottom of the partition. The pill is lowered into the feed chute when the slot and hole fit, which eventually leads to the packaging section. To lower running time and increase performance, the number of slots can be expanded.

Positioned next to the servo motor, the infrared slot sensor ensures that one tablet fall with every half rotation of the carousel disk. The sensor signal is used to trigger the packaging system, control the pill's flow, and also to manage the inventory of medications. Dust accumulates over a prolonged period of work on the sensor. Therefore, stock care and cleaning are required to maintain a correct tablet count and an economically relevant factor is the usable life of the equipment (Brolin et al., 2018). The desired model pill container was done by using serve motor at the bottom of the pill container. The serve motor was opened in every harmonic time period.

A method in which the user pours pills into a sprout, where they are counted before they are put in a bottle. The remainder of the pills in the funnel will be guided to a separate bud and scattered onto a tray until the count exceeds the target level. To complete another prescription with the same drug, extra pills in the tray should be inserted back in the initial bottle or funnel. This recommended design will be designed to provide speed and accuracy. The laser matrix to count the pills as they slip through the shot is the module that this project is making. In this effort, in order to determine the action of a range of pills, multiple prototypes were created and evaluated. To determine which one performed best with specific pill variables, each design was analyzed. Shape, size, and type include these variables. For the later phases of the design, the testing of these designs will be useful, the option of which is most appropriate for all types of pills.

Maker bot 3D printing has manufactured the funnel and sprout structure using Maker bot PLA plastic to construct the funnel, sprouts, and housing that will hold the system together. Multiple connecting pieces consisted of the design. The shoot was completed as one piece, then linked to the funnel. A hole for a small printed PLA plastic hatch that will rotate on a hinge is formed by a part of the bottom section of the bud. A digital counting screen as well as a touch panel for the pharmacist to select the number of counts needed to fill the prescription will be included in the housing. A laser grid that was installed based on the results of the counting tests was housed in the funnel system.

A solenoid will hold the hatch, which rotates around a hinge. When the count reaches the specified quantity, the solenoid will retract by pulling back and allowing the door to open, leading to a hole in the main bud for excess pills to fall into the separate bud leading to a tray. The solenoid expands to push the hatch into place after the stroke is over, so that the main shot is complete and ready for another run.

With lasers with their corresponding photo resistors, the counting system was constructed. Through sliding pills through the socket through various laser matrices, a 650nm laser module was tested to see which arrangement has the highest precision and efficiency. With the photoresist flush against the direct reverse side of the session, the laser was flush with the interior of the session. To find the threshold by which a chip would break the laser beam to indicate that the count should be increased, the laser layout and photoresist were tested (Boudrias et al., n.d.).

There is a wide range of assistive equipment for non-professional patients to prescribe medications. Much of them are manual and have pill trays labeled several compartments. Tray pill It has multiple compartments of drugs that can be filled. Each compartment is capable of containing various sizes and drug combinations. The drug should be taken by the user each time. The dosages for up to 28 days every day. It does not have a warning to show when to take the drug. The booster for Pill-Mate-Medicine is a system that uses both sound triggers to remind the customer. At a fixed time, remember to take medicine or attend those activities (Mukund, 2012). For the desired design was used the above compartment for collected pill, but requirement was collect the same type of pills in single unit, so the design was developed according to the requirement. According to the above design the sound triggers remind to the customer at the end of the process. The desired design was used the LED indicator for remind the counting process end.

As the storing mechanism, a vacuum-operated mechanism was used by some inventors. It's a vacuum-operated system for individually dispensing items of oral solid medicine from bulk storage to a user, where the medicine is dispensed under computer control, and the quantity and type of medicine are selected in advance by the user. The invention includes medicine dispensing equipment and the computer that provides a user interface. (Rogers et al. 1995).

The counting system will consist of a laser sensor located in the bottom of rotating table. The purpose of the counting system is to detect dosage whether a pill has been dispensed. Once the tablet falling from the rotation table, the tablet will enter through a sensor. this motion will be detected by the lase sensor. The information gathered from the lase sensor will be stored in a latch and this information to count how many tablets have been dispensed. The main challenge of the counting and transporting mechanism is to isolate a single tablet from the store and dispense that tablet into another location. Dispensing mechanism will receive a single-bit digital signal from the device that will inform it when the serve motor needs to run. It will transmit a signal to the device informing it when a tablet is being falling from the store.

CHAPTER 3 METHODOLOGY

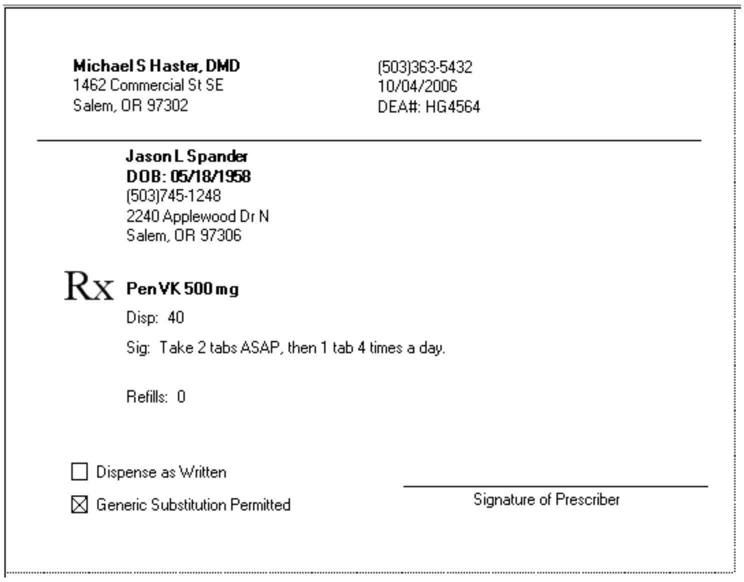
Since the task to be done first is finding a method to read the pictures and recognize the characters. Then develop the code for the text recognition. The next phase is to observe the input images and do the relevant. Then the identified data is verified with the pharmacist before dispensing.

Identifying the features of the prescription.

For the identification of the drugs and the number of pills required it was required to find the proper format of the prescriptions and the fonts used in the printed prescriptions. After the search through the literature on the best fonts that are being used on prescriptions are Verdana, Lora, Source Sans Pro, Proxima Nova, Times New Roman, Rockwell, Avenir, Comfortaa, Quicksand, News Cycle (Authority, 2019).

For the testing of the system few fonts were selected, they are Calibri, Verdana, Times New Roman, Source Sans Pro.

The prescription formats were observed and the literature relevant to printed prescriptions were observed. when these factors are observed. In printed prescriptions the name of the medicine and the dosage of that medicine is mentioned. Next the number of pills as a value to be dispensed is mentioned next. Then the relevant information regarding the usage of the pills are then stated after, this format was always followed in all the printed and the e- prescriptions. The ISO standard for e – prescription has also stated that these information regarding the drug should be mentioned. The general format used in the prescription for this project is shown below.



Michael S Haster, DMD
1462 Commercial St SE
Salem, OR 97302

(503)363-5432
10/04/2006
DEA#: HG4564

Jason L Spander
DOB: 05/18/1958
(503)745-1248
2240 Applewood Dr N
Salem, OR 97306

Rx **Pen VK 500 mg**

Disp: 40

Sig: Take 2 tabs ASAP, then 1 tab 4 times a day.

Refills: 0

□ Dispense as Written

☒ Generic Substitution Permitted

Signature of Prescriber

Figure 3 - 1 - The prescription format used for the project

It was observed that the number of tablets is mentioned after the keyword “Disp:”, “Supply:” or “Disp”. These features were noted down as distinct features of the prescription.

Selecting the OCR for the project.

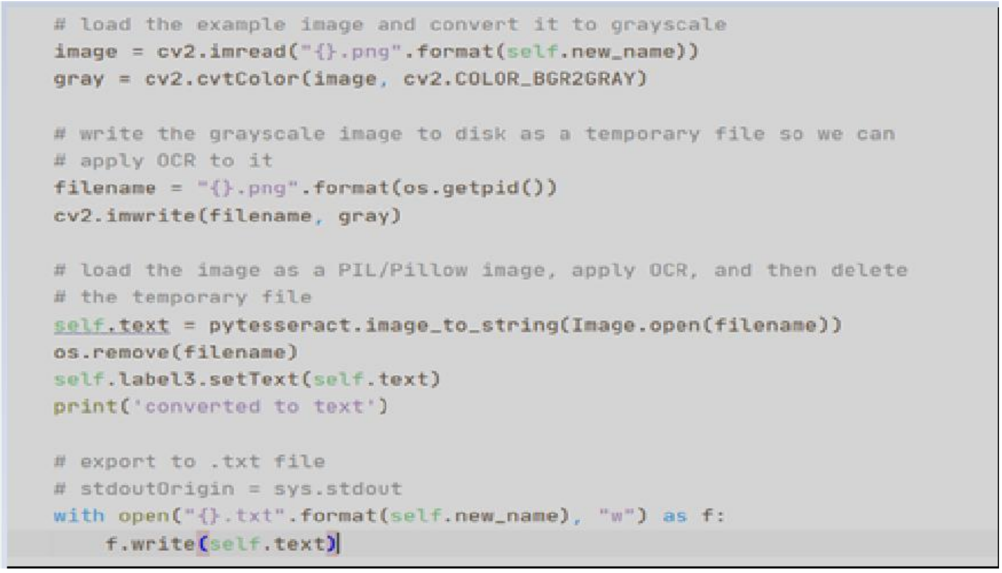
The main reason for selecting a turnkey OCR is due to the facts mentioned below,

- Many fonts are available in when considering fonts for the prescriptions.
- Due to the lack of training data and the computation time of developing an Artificial Neural Network.
- In the previous literature for the OCR used in several medication identification projects, a turnkey OCR was used (Alday and Pagayon, 2013)(Roy and Alam, 2017).

After deciding on using a turnkey OCR there are many available on the market. Several OCR were identified and compared for the application using the previous literature and presence of documentation for the implementation of the OCR. Therefore, considering these factors it was decided to use Tesseract as the OCR.

Implementing the OCR

The OCR is to be implemented in a computer since the computers do not compromise the speed of the system in comparison to the Raspberry PI. In addition due to the promotion of computerized systems, this pre implemented systems can be updated by this method instead of adding a higher hardware cost. When implementing the OCR, the there are several stages in implementing the OCR. First is preprocessing, Text recognition, and data manipulation. The main preprocessing will be done during the testing phase to get the best results from the OCR. This is done during the testing phase because the image taken by the camera and the setup is tested and the accuracy is improved by preprocessing the image by changing the threshold values. Initially only the BGR image is Converted to gray image as the preprocessing and any other types of preprocessing is not done.



```
# load the example image and convert it to grayscale
image = cv2.imread("{}.png".format(self.new_name))
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

# write the grayscale image to disk as a temporary file so we can
# apply OCR to it
filename = "{}.png".format(os.getpid())
cv2.imwrite(filename, gray)

# load the image as a PIL/Pillow image, apply OCR, and then delete
# the temporary file
self.text = pytesseract.image_to_string(Image.open(filename))
os.remove(filename)
self.label3.setText(self.text)
print('converted to text')

# export to .txt file
# stdoutOrigin = sys.stdout
with open("{}.txt".format(self.new_name), "w") as f:
    f.write(self.text)
```

Figure 3 - 2 - OCR and image preprocessing code

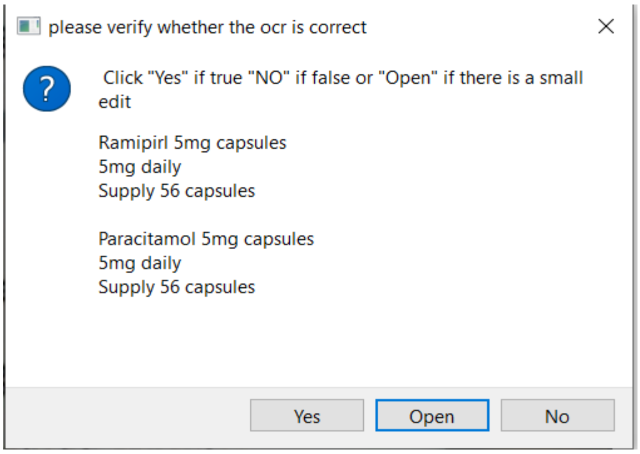
First the image is converted to gray image and this image is stored in the memory temporarily for it to be fed to tesseract to convert the image to string. Then after the image is converted to text then the temporary file is then removed. This text is then exported to a .txt file with the name of the patient as the name of the file.

The libraries used in this process is open cv is used to import the image and do the preprocessing and os library is used to save the image and remove it.

Verifying the recognized text

The text which is recognized by the OCR has to be verified before it is further sent to processing this verification is done manually. The verification process occurs as follows after the image is converted to text, it is displayed, and a popup window appears. Asking the pharmacist to verify whether the text is converted to the correctly or not. In addition, another option is present called the “Open” stage.

If the drug, dose or the number of pills is displayed as it is on the prescription then the pharmacist presses “Yes” in the pop-up window. If any of the above items are displayed wrong the pharmacist has two options. The first option id the “No” option where the camera again turns on and the image is taken again, and that image is sent to the tesseract system to be converted to text. This process where you take the picture of the prescription can be done three times. If every time the conversion of image to text is unsatisfactory then, after the third time the .txt file which the data converted is stored is opened and the pharmacist has to the relevant edits to that file, then save the file. The saved file is then sent to the next stage of processing. The other option which is available to the pharmacist is when the image is almost fully recognized and the pharmacist desires to not retake the picture but to edit the recognized text since the error is very minute then "Open" option is present. In the "Open" option the .txt file which the data converted is stored is opened and the pharmacist does the relevant edits to that file, then save the file. This saved file will then be used for further processing. The image of the pop-up window is shown below.



please verify whether the ocr is correct

Click "Yes" if true "NO" if false or "Open" if there is a small edit

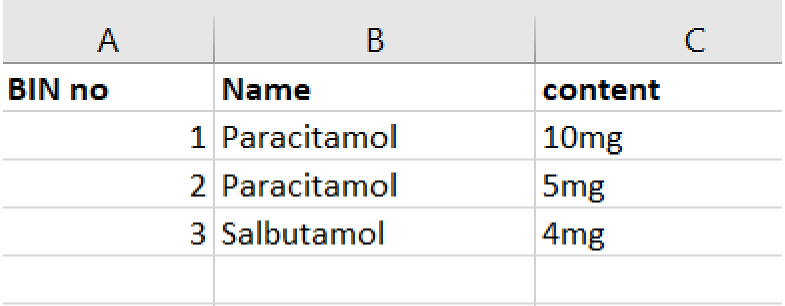
Ramipirl 5mg capsules
5mg daily
Supply 56 capsules

Paracitamol 5mg capsules
5mg daily
Supply 56 capsules

Figure 3 - 3 - Verification pop-up window

Manipulating the recognized text

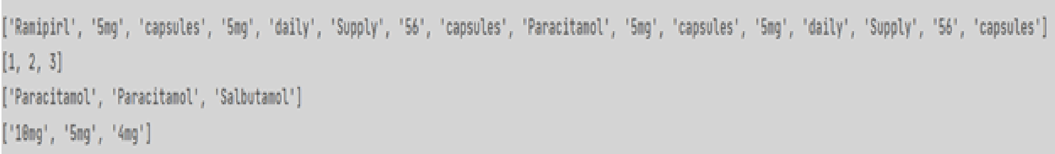
After the recognized test is identified and verified then the identification of the pills available, the dispensers which the pills are available, and the number of pills needed. The pills that are in each dispenser is recorded in an excel file. That file contains the dispenser number, name of the drug, and the dosage of each drug. The data that is entered in the Excel sheet are shown below.



A	B	C
BIN no	Name	content
1	Paracitamol	10mg
2	Paracitamol	5mg
3	Salbutamol	4mg

Figure 3 - 4 - Available drug list in the dispensers

For the data manipulation first, recognized text is first imported to a list. The items on the excel file is also imported column by column. Where each column is exported to a list.



```
['Ramipirl', '5mg', 'capsules', '5mg', 'daily', 'Supply', '56', 'capsules', 'Paracitamol', '5mg', 'capsules', '5mg', 'daily', 'Supply', '56', 'capsules']
[1, 2, 3]
['Paracitamol', 'Paracitamol', 'Salbutamol']
['10mg', '5mg', '4mg']
```

Figure 3 - 5 - Text exported as a list.

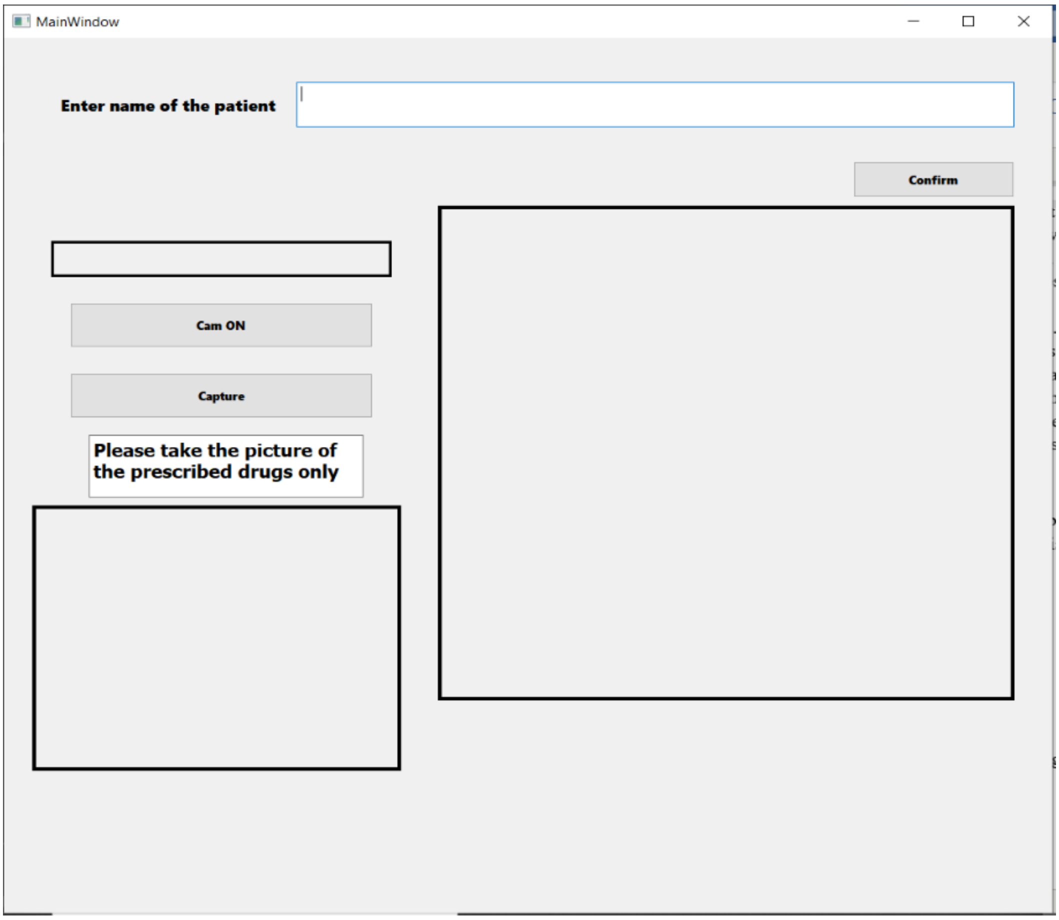
When identifying the pills that are present in the dispenser. First the list containing the converted text, and the list containing the name of the pills is searched for similarity. If the name of the drug and the name in the converted list is the same, then the next string is in the converted list is read. The next string according to the observations and the standards mentioned in the literature review always contain the dose of the pills. This string is then compared with the dose of the same pill contained in the excel sheet. If the doses match, the name of the pill the dose and the bin number will be exported to another list. To find out the number of capsules needed from the medicine, which was identified, again the list of the converted text is searched. This search is done from the point where the name of the drug was identified and forward the list. When searching the list, the keywords “Disp:”, “Disp” or “Supply” is searched. The reason for searching for the keywords is mainly because the number of pills that are needed are displayed after these keywords. This is observed in all the printed prescriptions that were take into the consideration. After identifying these keywords, the next character is the number of pills that are to be dispensed in the drug. If the drug doses are not similar, then the search continues. The libraries used are os and pandas.

Developing the GUI

The product that is being developed is a system that is being used by pharmacists, therefore this system need to have a user interface. The user interface should consist of the following features.

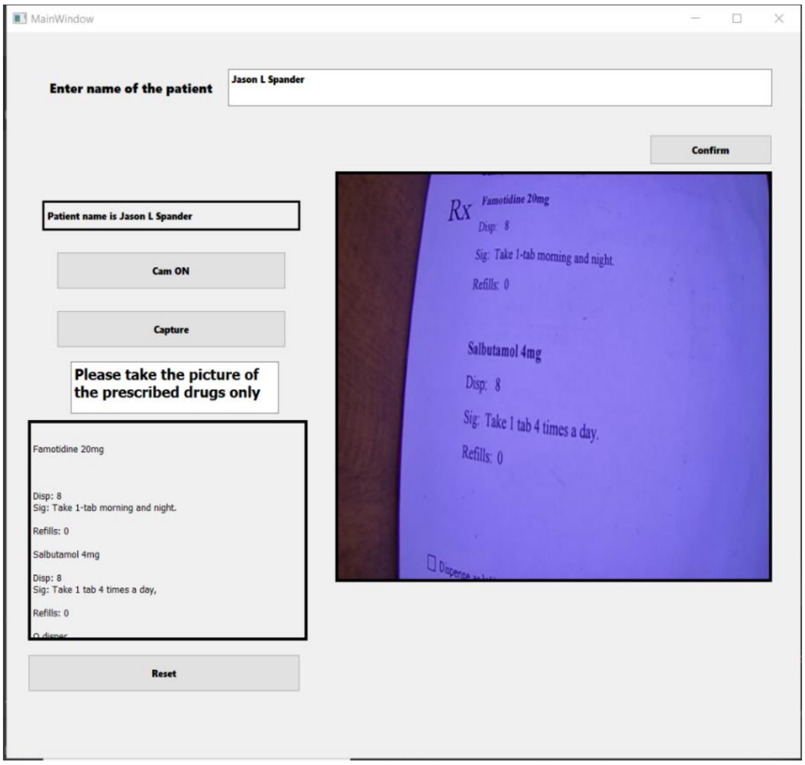
1. Slot to enter the name.
2. Button to confirm the name.
3. Button to turn on the web camera.
4. Button to capture the image.
5. A label to display the video feed.
6. Button to capture the image.
7. An area to display the recognized text.

This GUI is created using Qt designer. The library used in assigning functions to the buttons are PyQt5. The GUI and the working interface of the GUI is shown below.



Please take the picture of the prescribed drugs only

Figure 3 - 6 - The designed GUI



Enter name of the patient: Jason L Spander

Patient name is Jason L Spander

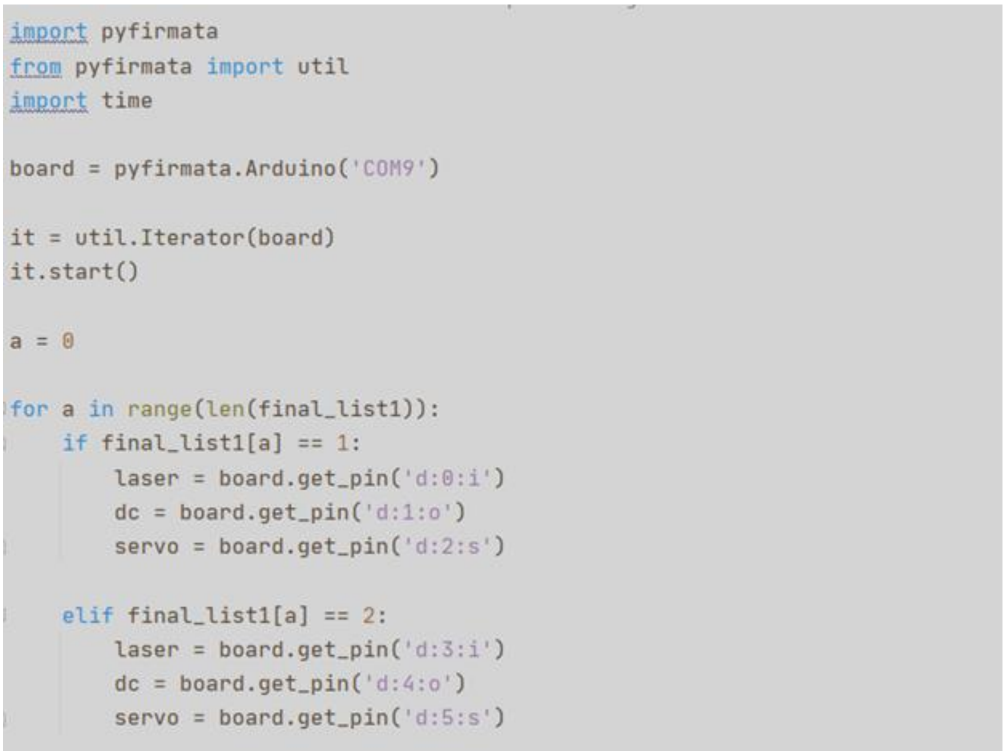
Please take the picture of the prescribed drugs only

```
Famotidine 20mg


Disp: 8
Sig: Take 1-tab morning and night.

Refills: 0

Salbutamol 4mg

Disp: 8
Sig: Take 1 tab 4 times a day,

Refills: 0

O disper
```

Figure 3-7 - The implemented GUI

Developing the Arduino control

For the Arduino control through serial communication from the control pc. The library used in programming this is pyfirmata. In addition to time library is also needed in controlling the Arduino. This library is not well documented but due to the simplicity of the library and due to the fact that all of the processing part is done in the pc this library is easier to be used as a means of controlling the motors, the other outputs and the inputs.

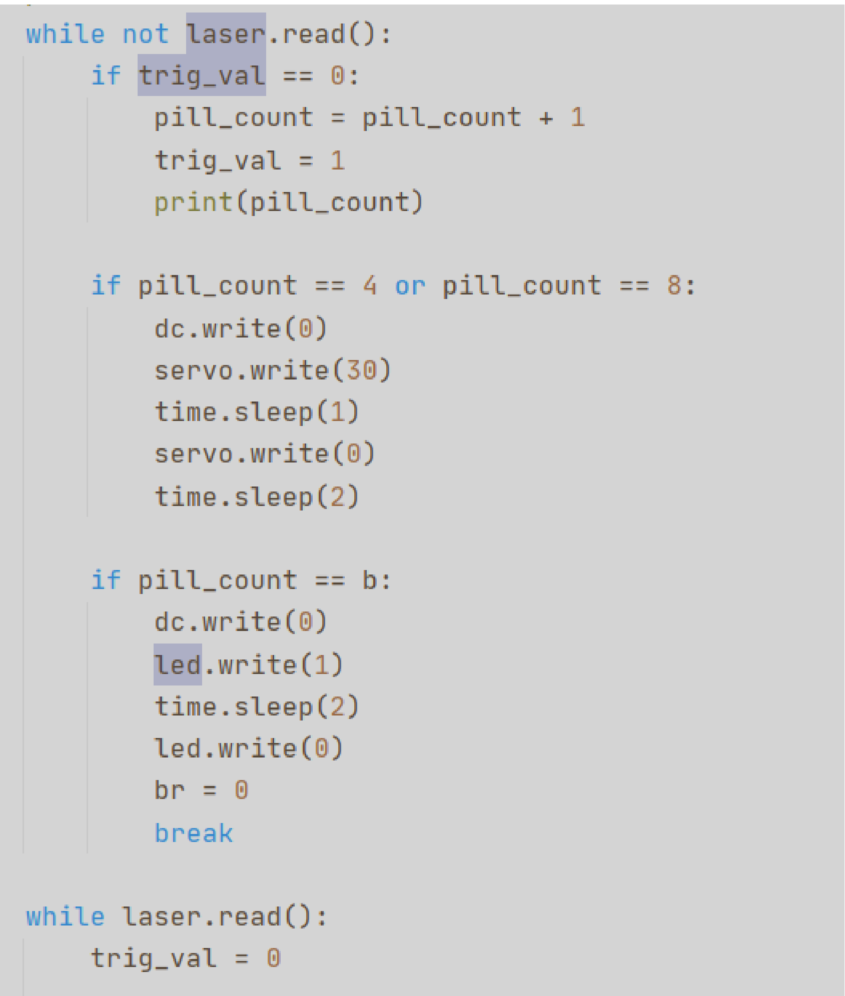


```
import pyfirmata
from pyfirmata import util
import time

board = pyfirmata.Arduino('COM9')

it = util.Iterator(board)
it.start()

a = 0

for a in range(len(final_list1)):
    if final_list1[a] == 1:
        laser = board.get_pin('d:0:i')
        dc = board.get_pin('d:1:o')
        servo = board.get_pin('d:2:s')

    elif final_list1[a] == 2:
        laser = board.get_pin('d:3:i')
        dc = board.get_pin('d:4:o')
        servo = board.get_pin('d:5:s')
```

Figure 3 - 8 - pyfirmata sample code

In here the previous identified pill containing bins which were imported to a list read and the relevant pins numbers for each bin are assigned.

The process that occurs in this part is the number in the list is read in a loop. First one value is read, and the relevant values are imported to the variables. Then another list containing the number of pills in each bin is read. This list contains the number of pills needed in the correct order of the respective bins. The process of the dispensing starts. First the pills in the storage container are released using the servo motor to the pill counter. The geared dc motor is rotated for the pill singulation process. The pill counting is done by considering the negative edge triggering in the laser sensor. For negative edge triggering it is not possible in the pyfirmata library. Therefore, a software solution was applied instead of negative edge triggering.



```
while not laser.read():
    if trig_val == 0:
        pill_count = pill_count + 1
        trig_val = 1
        print(pill_count)

    if pill_count == 4 or pill_count == 8:
        dc.write(0)
        servo.write(30)
        time.sleep(1)
        servo.write(0)
        time.sleep(2)

    if pill_count == b:
        dc.write(0)
        led.write(1)
        time.sleep(2)
        led.write(0)
        br = 0
        break

while laser.read():
    trig_val = 0
```

Figure 3 - 9 - Negative edge triggering software implementation

In here negative edge triggering occurs such that when the laser detects the pill, the laser.read() becomes 0. When the laser.read() becomes 0 from value 1. The trig_val change is recorded and this change is used to count the pill. The use of trig_val variable is used to get the edge triggering as the software implementation. The main aim of trig_val is to know that the when the value becomes 0 the count should happen only if in the past the laser. read() has been 1. This is done because if not the pill_count will keep adding several times when only one pill is bing contacted with the laser.

The webcam.

For the OCR, the image of the prescription should be taken. The image of the prescription should be taken. To take the image of the prescription is taken through a webcam. The webcam that was available locally during the time of buying was considered. The web cam that was bought was a B1 – 1080P webcam with 3.6mm focus.

Mount and the enclosure for the webcam.

The enclosure needed for the web cam was manufactured using wood. The front of the enclosure is made so that it can slide up and down. This is done so that the prescription can be inserted by lifting the sliding door. The main purpose of the enclosure is to stop the outside light from affecting the picture. The enclosure of the prescription capture is shown below.

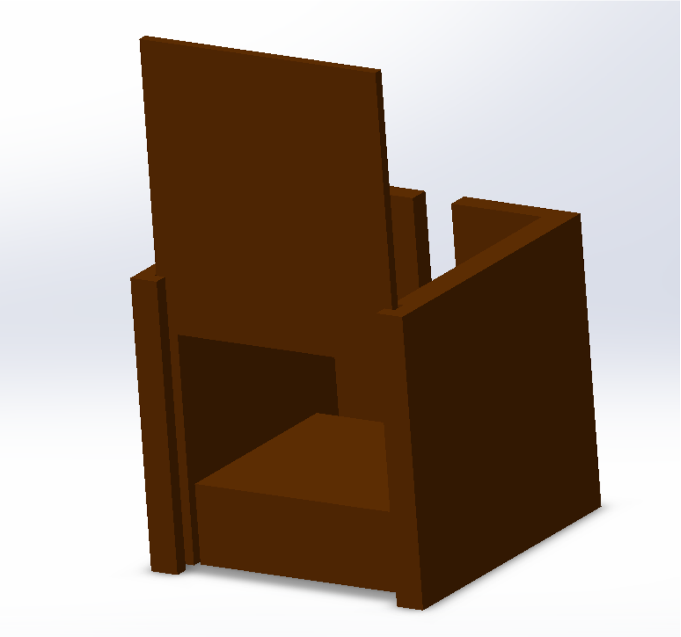


Figure 3 - 10 - Enclosure of the prescription capture unit

The cam holder is made of box bar and was manufactured by the materials available at the workshop. The webcam holder was designed such its vertical position can be changed. A led light strip was attached to the upper rectangle. This is done to give light to the prescription.

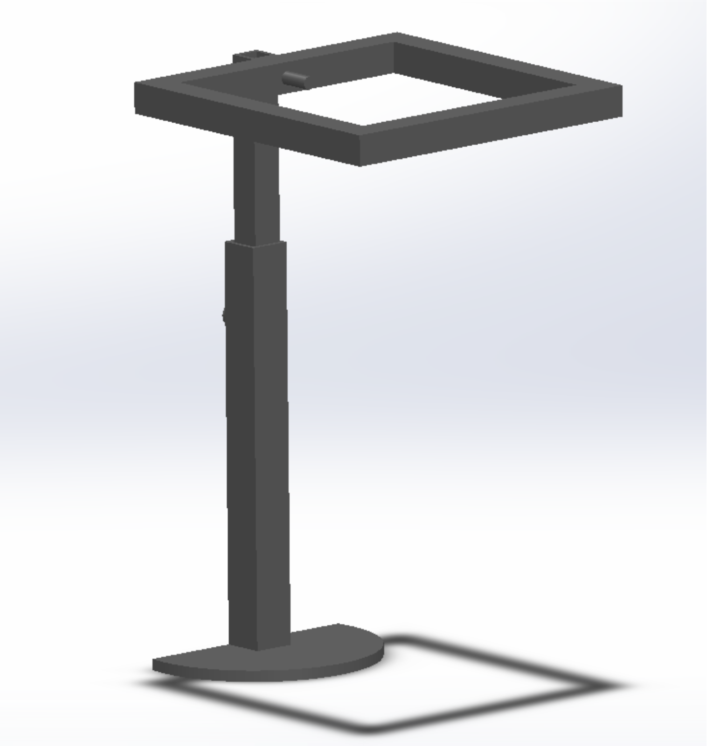


Figure 3 - 11 - web cam holder

Testing the OCR

The OCR is tested in several ways to identify its accuracy and several features, first the accuracy of the OCR is tested using high quality images. Mainly these images are screen shots of the document of the prescription. In here these prescriptions are of several font types and they have several font sizes. The font types used in the testing are Calibri, Source Sans PRO, Times New Roman, Verdana. The next type of testing is testing the OCR with the images from the webcam. These webcam images are preprocessed, and the results are taken. In here the two main preprocessing methods are are done and the accuracies of the results are compared. First the webcam image is taken, and the gray scale image is taken and fed to the OCR. For the next image, a binarized image is fed to the OCR. When talking about the binarized image the binarization used in here is Otsu binarization where the threshold values are created by automatically thresholding by analyzing the image. The accuracies of these results are taken and compared.

The Design

As described in the introduction, the process of Pill dispenser is done as shown below. The developed automated design can be observed thoroughly using the below flow chart.

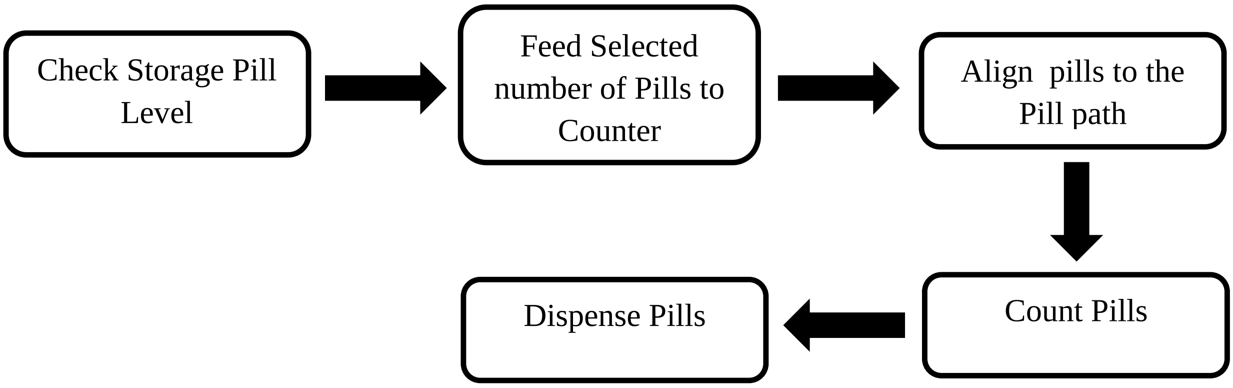

Check Storage Pill Level
Feed Selected number of Pills to Counter
Align pills to the Pill path
Count Pills
Dispense Pills

Figure 3 - 12 – Process Flow Chart

As above shown processes, the main processes can be identified as feed pills to the counter, align pills to pill path, count & dispense. For the shown processes, we have designed several solution models,

	Solution A	Solution B	Solution C	Solution D
Storing Pills	Plastic Box	Plastic Tube	Wooden Box	Special Container
Non-Pill Condition Notification	Buzzer	-	Speaker Module	LED ON
Pill dispensing	Sliding Mechanism	Mechanical Method (Gears)	Pneumatic	Servo Motor
Prevention from rust	Use coating	Use glass casing	-	Use plastic materials
Display Messages	LCD Module	-	LED Monitor	GUI & LED
Notification	Buzzer	Music System	Human Voice	LED Blink
Power Source	Battery	Solar	-	Charging

Table 3-1 – Morphological Chart

	Solution A	Solution B	Solution C	Solution D
Cost	4	6	2	7
Power Consumption	7	7	1	7
Safety	5	4	3	7
Dust Proof	4	4	2	6
Accuracy	3	3	7	7
Compactness	4	5	1	6
Feasibility	5	4	2	7
Efficiency	4	5	7	7
Complexity	6	5	2	5
Total	42	43	27	59

Table 3-2 – Evaluation Matrix

Out of the above-shown solution models we have selected the best model for our design as Design D (Solution D). For achieving the process of dispensing medicine with prescription recognition, we have fabricated our prototype.

Pill Container

Considering deterioration conditions, pill storage is designed to air/ moisture-proof & minimum light conditions. Also considered the average medicine storage temperature inside a pharmacy, which is 25-27°C. Pill container and the pill drawer are designed considering these factors and conditions.

Pill Container Mechanism

In designing the storage and dispensing unit, the thickness of the parts was selected suitably. Flap controls the number of pills from the pill container to the pill counter. The Support plate is used with the flap to obtain the weight of pills in the container. So, flap only controls the pill following path. To adjust the size of the path of pills flap uses with the servo motor. Using this mechanism flap can control the number of pills with a quick response.

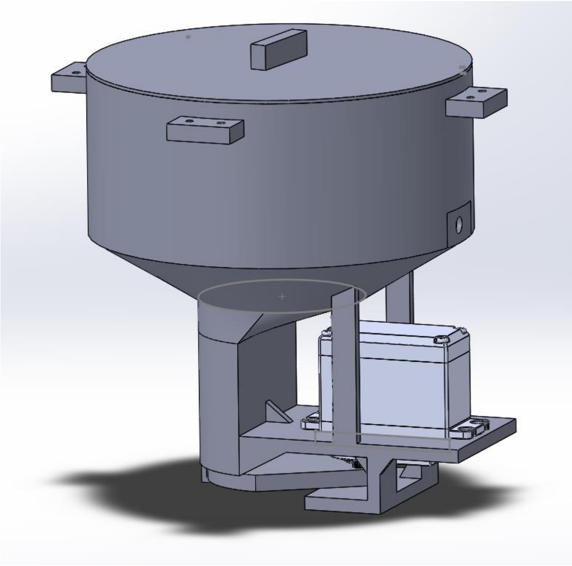


Figure 3 - 13 – Pill Container Design

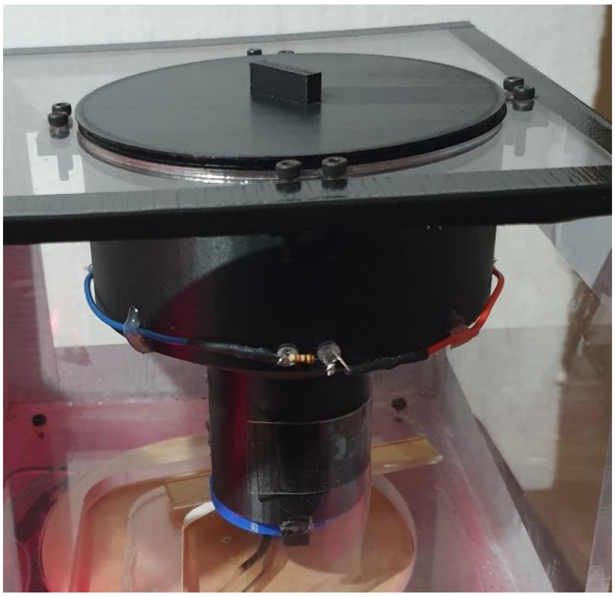


Figure 3 - 14 – Fabricated Pill Container

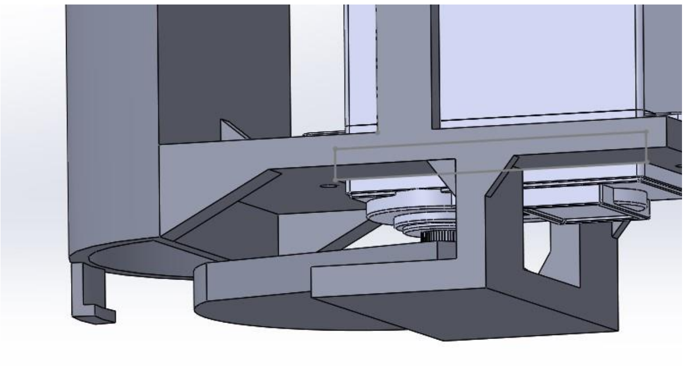


Figure 3 - 15 –Pill Container Mechanism

Calculating numbers of pills of the container

Using Paracetamol, we found out 1000 pills can be stored in a volume of 684.25cm^3.

Volume of Container = 597435.59 mm^3

$$\text{Number of pills on storage} = \frac{1000}{684.25 \times 10^{-6}} \times 597435.59 \times 10^{-9}$$

$$= 873.124$$

In average 873 pills can be stored in the storage.

Drawer for Pills

Purpose of the Drawer is to collect the counted pills until the pharmacist collects them. So, the drawer is designed to store pills for a short time. So the contamination from the air & moisture is minimum. Pill drawer can be taken out through the front plate of the pill dispenser using the handle of the drawer.

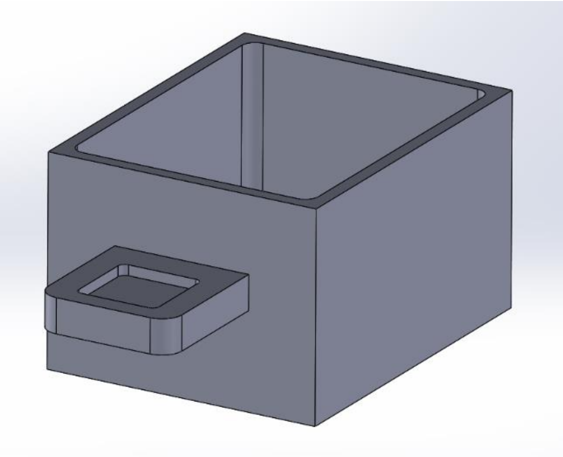


Figure 3 - 16 – Pill Drawer

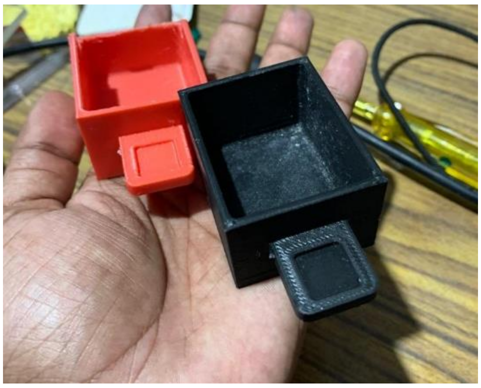


Figure 3 - 17 – Fabricated Pill Drawers

Calculating numbers of pills for one counting time

Volume of the bottom drawer = 48368×10^{-9}

Numbers of pills for one counting time = $\frac{1000}{684.25 \times 10^{-6}} \times 48368 \times 10^{-9}$

= 70.687

In average 70 pills can be get-out from the Pill counter for one counting time.

Requirement of the Design

A very long and complicated process is the dispensing of prescription drugs. Depending on the type and quantity of tablets and medications prescribed, the pharmacist must perform many tasks that can take long periods of time. The tasks of a pharmacist are not limited to counting and dispensing pills according to a prescription pad. Each pharmacist must check the prescription quantity, count and count, the number of pills and clearly explain how to take the prescribed medicine to the patient. The verification method involves authenticating the prescribing physician and double checking the prescribed dose using calculations. Then depending on the patient's records, the dose of the drug should be tested if it is too high or too low. The counted pills should be given correctly to the system according to the prescription outcome.

Body

All the body parts were designed using acrylic material. There were nine major parts including to complete the full design. They were front plate, back plate, left plate, right plate, bottom plate, top plate, top-top plate, rotating table and upper plate. Each parts had 6mm thickness. Length of the body was 192mm, width was 192mm and height of the unit was 236mm.area of the back plate side was 192mm x 236mm. so 22units can be mounted in 1m x 1m area. It means 22tableats can be provided from 1m x 1m area. Considering the body, some of the body parts were combined using stainless steel Alan keys. Stainless steel had non corrosion characteristic. It was more considerable factor for the medicines.

Material Selection

This lightweight thermoplastic has thermal insulation properties and is an effective replacement for glass. It is known for its sleek gloss finish, available in clear or almost any color and in clear, translucent and opaque options. For extended outdoor use, most colors can be designed to provide longevity.

Without losing its clarity, gloss or dimensional shape, acrylic withstands years of exposure to components and even corrosive atmospheres. From exposure to fluorescent light, it will not darken or deteriorate either.

Acrylic has strong chemical resistance and effect. For short periods of time, it can withstand great strain and is one of the most scratch resistant thermoplastics.

- Acrylic material characteristic
- Lightweight
- Better impact resistance
- Non-corrosive

- UV resistance
- Good impact resistance
- Outstanding thermal insulator
- Easy to heat form
- Excellent clarity

Pill isolation mechanism

When the tablets were falling down to the rotation table, the tablets were moved into the tablet isolating part. Tablet isolating part was the small thickness plate. Main purpose of the isolating plate was the prevention of the two tablets moving into pill singulation process simultaneously. when the two tablets entered simultaneously, error can be occurred. So the isolation process was more important. The isolation part can be adjusted, it was mounted to the top top plate from the Alan, it can be rotate around the Alan and it's position was depend on the pill container and adjustable hand. There was a 6mm gap between rotation table and isolation part. Panadol tablet was the largest thickness tablet.it had 5mm thickness.so only one tablet can go through the space (one tablet < 6mm). two tablets cannot go through the space (6mm < two tablets). And also the minimum thickness tablet was Piriton. It had 3.5mm thickness. So only one tablet can go through the space (one tablet < Piriton 6mm). two tablets cannot go through the space (6mm < two tablets).

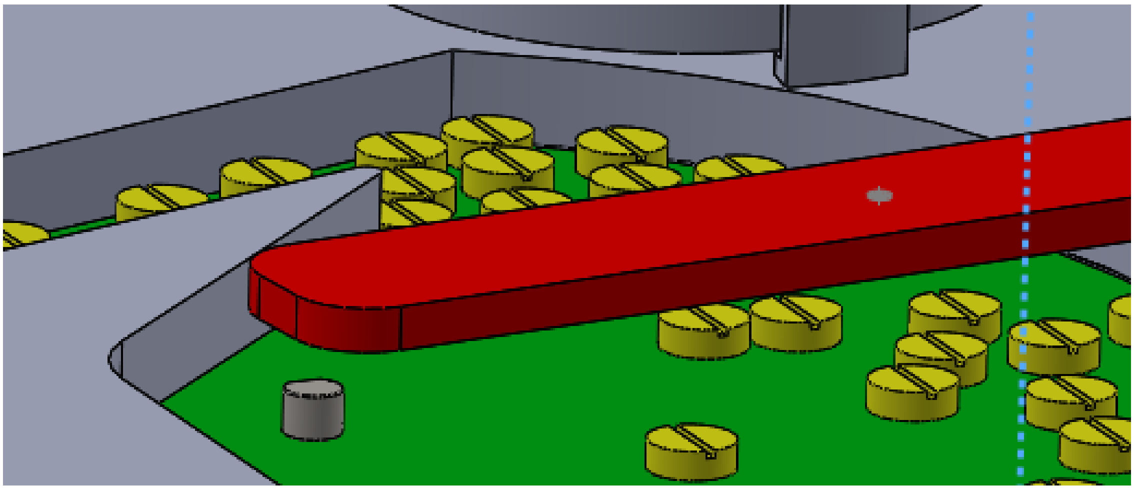


Figure 3-18 - Pill isolation mechanism

Pill singulation mechanism

Another main important thing was pill singulation mechanism. it should be high accurate and high precision. Because counted pill quantity was Depends on the accuracy of the pill singulation mechanism. Difference between two pills was depends on the speed and friction of the rotating table. When the speed of rotation table was high, the Difference of two tablets were increased. And also friction between rotation table and tablets were low, the Difference of two tablets were decreased. The rotation table was mounted to the DC motor. DC motor was mounted in the middle of the bottom plate. Motor guide was used to mount the motor. Prevent the play of rotating table, stabilization plates were mounted under the rotating table.it was balanced the rotating table when rotate.

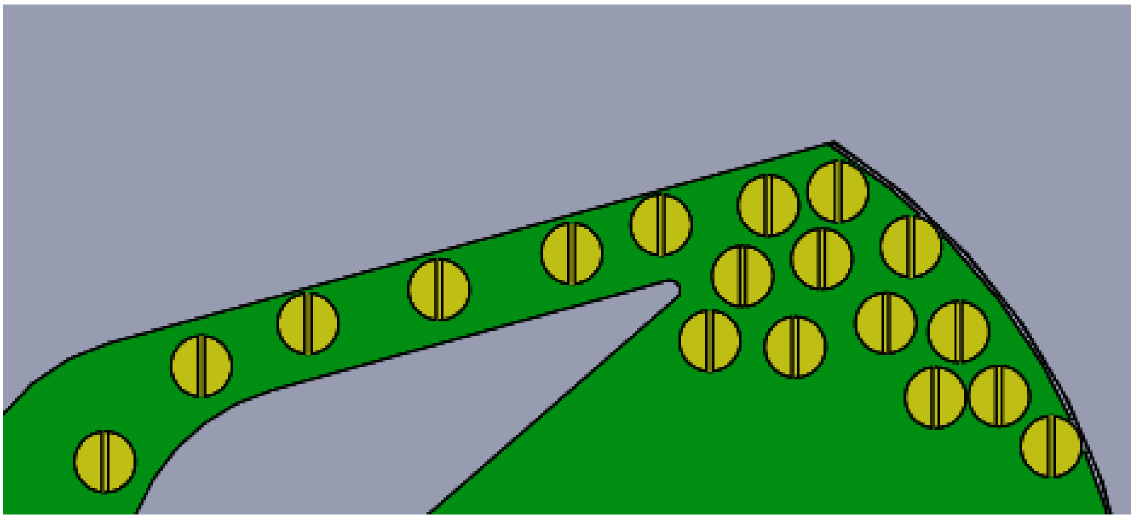


Figure 3 - 19 - Pill Singulation Mechanism

Adjustable hand

Adjustable hand was the adjusted according to the pill sizes and its shape. Considering the size and shape of the tablet it can be adjusted moving the hand as the direction of forward and backward. Clearance of the two tablets depends on the speed of the rotating table and friction between tablets and surface. Adjustable hand also made using acrylic material.

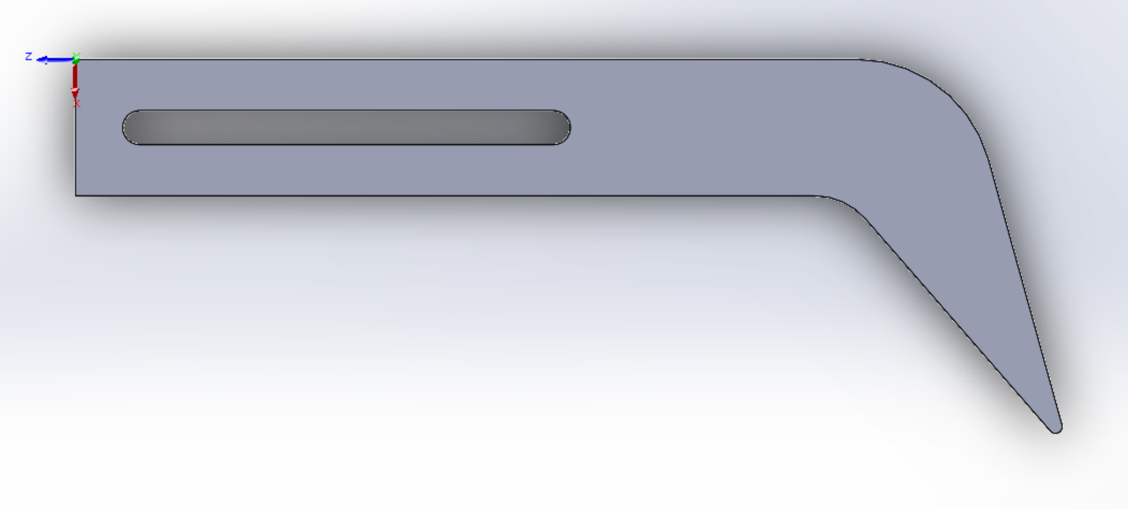


Figure 3 - 20 - Adjustable hand

Counting mechanism

Main purpose of the product was Provide the tablets according to the given data. So the machine should count the tablets according to the prescriptions and dispense it. Due to that reason the counting mechanism attached to the system. Laser sensor method and IR sensor method can be attached to the system. But the laser system was very accuracy than IR sensor because the IR sensor cannot read the short length data. It can only read the data above 2cm. so the laser sensor method was most suitable method for the counting mechanism. The laser sensor counting unit was Consist of two main Unit. One was the laser sensor other one was the laser detector. Two units were mounted under the top plate. The laser detector was read the output data of the laser sensor. The laser sensor was always Provide the laser waves to the detectors. When the tablets was go through the laser waves, the detector was identified and counted it. The sensor and detector was placed between the drawer and the top plate. So the counted pills Was fall into the drawer. At the end of the process the drawer pills should return into the medicinal cases.

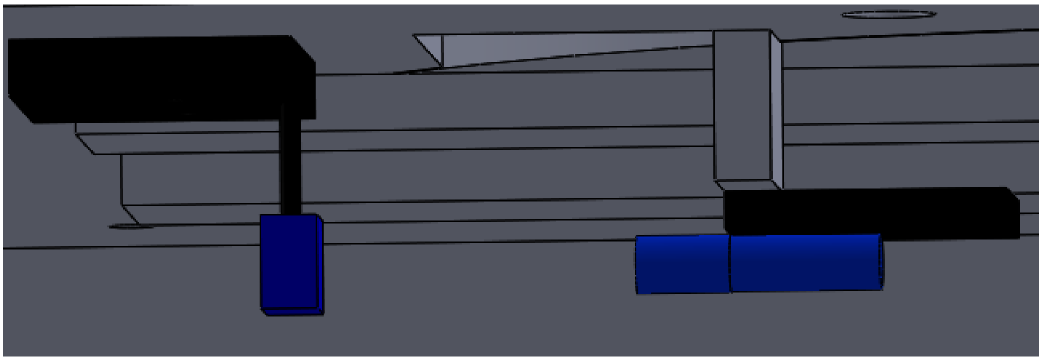


Figure 3 - 20 - Counting Mechanism

Single unit

This is the single unit used for one types of tablet. All the designing parts were combined together and whole unit were sealed. It means dust and humidity control. And also it was water proof, all the joints were sealed using silicon. Total weight of the single unit was 2.8kg.

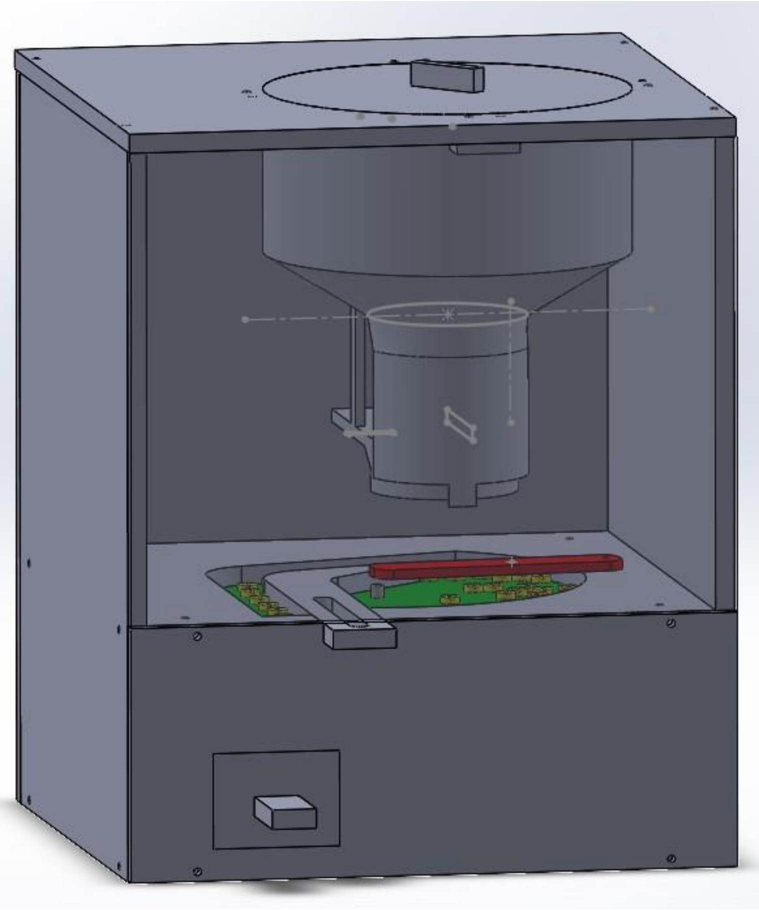


Figure 3-21 – Single Unit

Final Design

This is the final design of the project. all the single units were combined together. Number of units depends on the how many types of pills on the pharmacy. Single units can arrange as raw and columns according to the requirements.

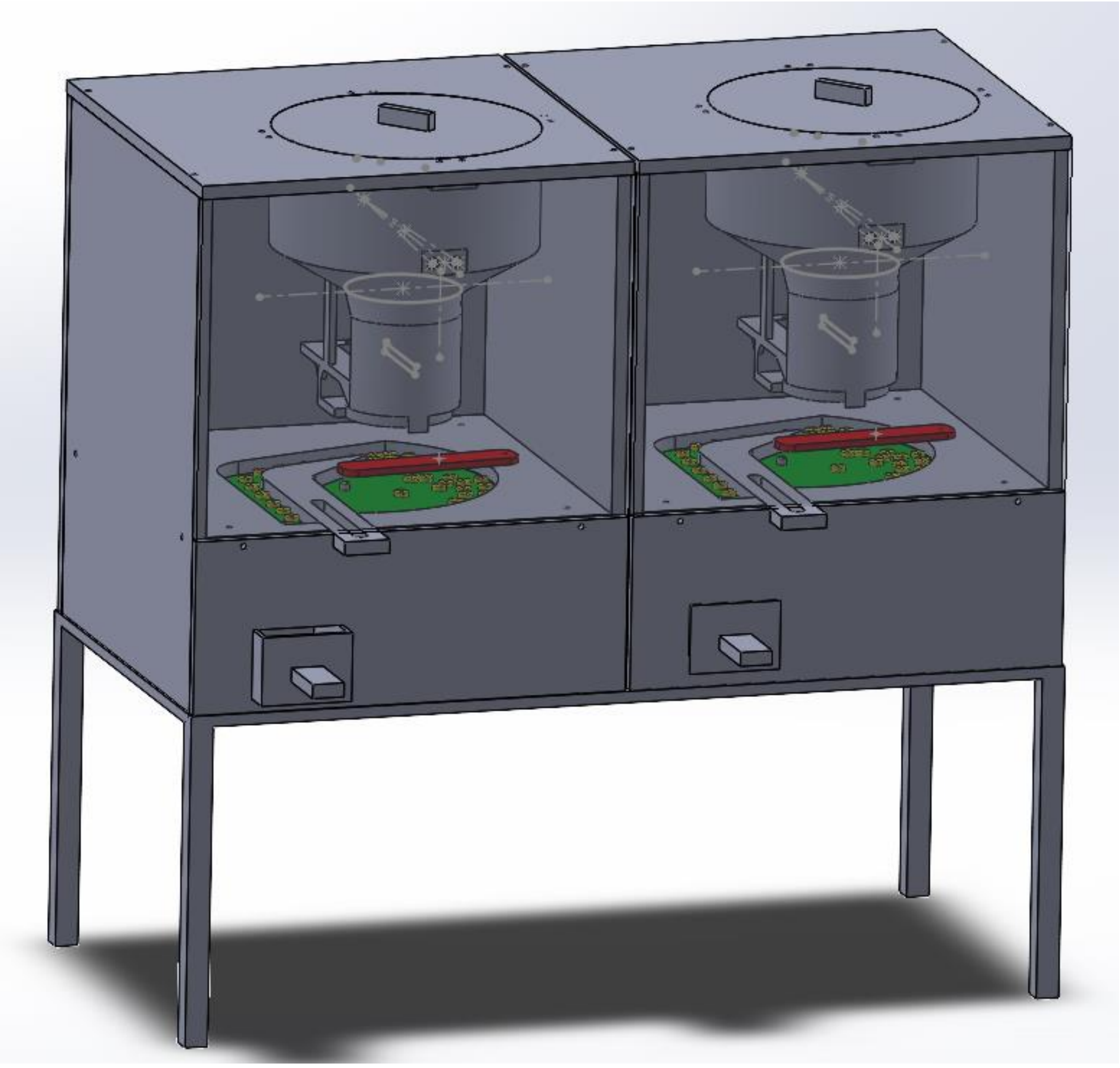


Figure 3-22 – Final Design

Motor Selection

Motor for Pill Counter Unit

For several motor calculations, the data taken from the SolidWorks model of the design is used.

Rotating disk data,

$D = 129mm$

$I = 97873.15\ gmm^2$

$m = 46.98 \times 10^{-3}\ kg$

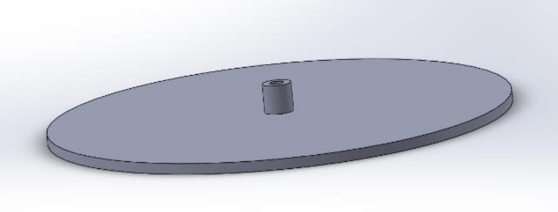


Figure 3 - 23 – Rotating Disk

Required pill count is 180 pills per minutes. Considering maximum pill diameter as 17mm (Standard dimension) and spaces among pills, choose to achieve the maximum angular velocity as 240rpm during 1s of time.

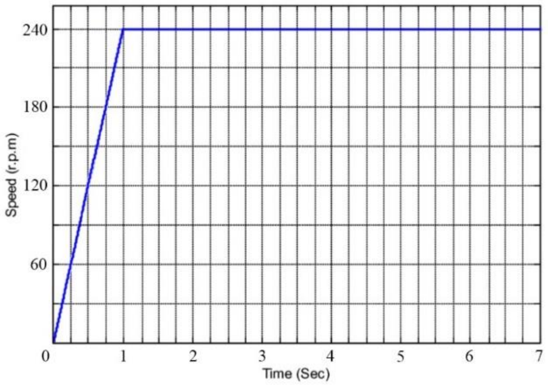


Table 3 - 3 – Motor RPM with Time

Also considered,

$\omega_1 = 0$

$\omega_2 = \frac{2\pi}{60} \times 240 = 8\pi$

$t_1 = 0$

$t_2 = 1s$

$$\alpha = \frac{\triangle\omega}{\triangle t}$$

$$= \frac{\omega 2-\omega 1}{t2-t1}$$

$$= \frac{8\pi}{1}$$

$$= 25.1327 \text{ rads}^{-2}$$

$$T = I\alpha$$

$$= (97873.15 \times 10^{-3} \times 10^{-6}\ ) \times 25.1327$$

$$= 2459816.517 \times 10^{-9} \text{ kgm}^{2}\text{rads}^{-2}$$

$$P = I\omega^{2}$$

$$= (97873.15 \times 10^{-3} \times 10^{-6}) \times (8\pi)^{2}$$

$$= 61822033.407 \times 10^{-9}$$

$$= 0.0618 \text{ W}$$

The requirement is 240rpm, 0.0618W motor. As we need low power and low torque motor DC powered motor is used. Considering our application conditions DC powered DC Gear motor is used in the required angular velocity range. L298 DC Motor controller is used with the motor for adjusting speeds with PWM. One motor for one type of dispensing unit, which means one type of pills is used.

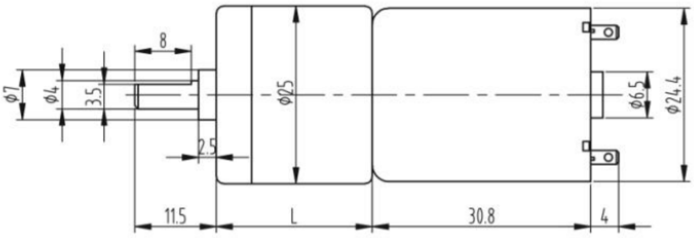


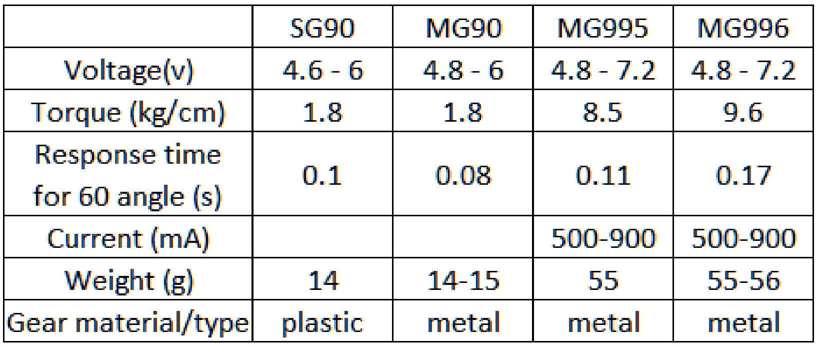
Figure 3-24 – JGA25-370 Geared Motor dimension

Figure 3-25 – JGA25-370 Geared Motor

Motor for Pill Container Unit

The flap is used to get pills from the pill container to the pill counter machine. So, the flap should able to obtain the weight of pills in the container. As a safety condition, we use a support plate under the flap to bear this weight. So, flap only controls the pill following path. To control the flap a motor is selected.

As considering the quick response, high efficiency, closed-loop control servo motor could be used. Below table shows servo motor models that used for small applications, which can be used with microcontrollers.



	SG90	MG90	MG995	MG996
Voltage(v)	4.6 - 6	4.8 - 6	4.8 - 7.2	4.8 - 7.2
Torque (kg/cm)	1.8	1.8	8.5	9.6
Response time for 60 angle (s)	0.1	0.08	0.11	0.17
Current (mA)			500-900	500-900
Weight (g)	14	14-15	55	55-56
Gear material/type	plastic	metal	metal	metal

Table 3 - 4 – Servo Motor types

Considering the quick response time and take care of the weight of medicine with a supporting plate requires a durable, high-efficiency motor. MG995 servo was selected to the design.

Figure 3 - 26 – MG995 servo motor

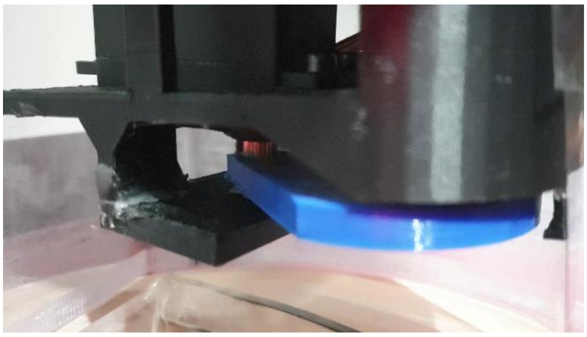


Figure 3 - 27 – Servo motor & the Flap

Sensor Selection

According to our design, sensors were used for continuing different tasks of the process. One task is to identifying pill level of the storage. Pill level of the Storage should be identified to start the process.

Sensor for storage pill level

For identifying the pill storage level TSSP 4038 IR Receiver can be used with 2 Radial T1 3/4 SFH IR Emitters. Sensors are positioned to the bottom of the pill container. Accuracy, precision and low energy usage are the factors for choosing the IR sensors. Identifying pill level is important to get the correct number of pills from the dispenser. If the pill level is lower than the required level, it would be indicated by a bulb. Storage should be refilled when the indicator bulb is turned ON.

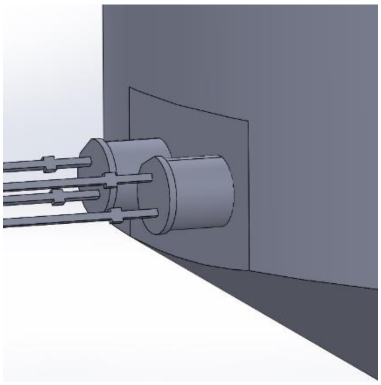


Figure 3 - 28 – IR Emitters

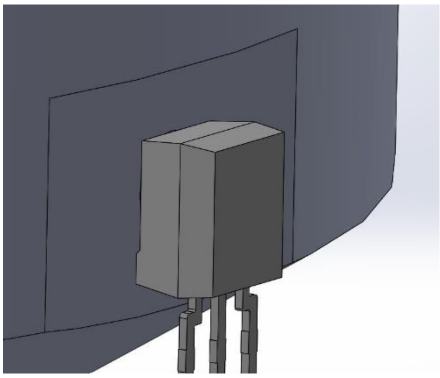


Figure 3 - 29 – IR Receiver

Sensor for Pill Counting

KY008 Laser Transmitter

For counting pills, after the pill singulation unit, KY 008 Laser receiver is used with the laser emitter. Using a low energy laser beam is the reason for choosing the sensor receiver & the emitter.

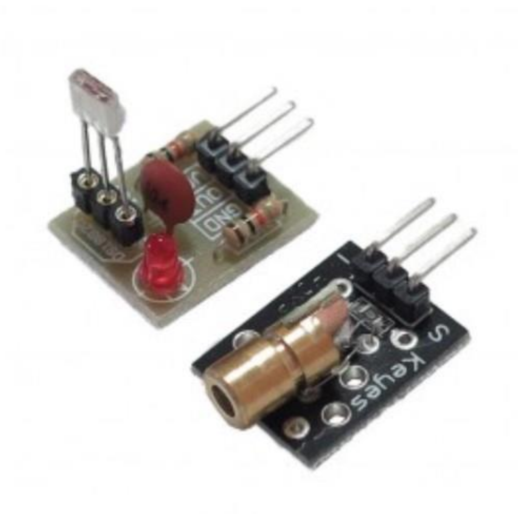


Figure 3 - 28 – KY008 Laser Receiver & Emitter

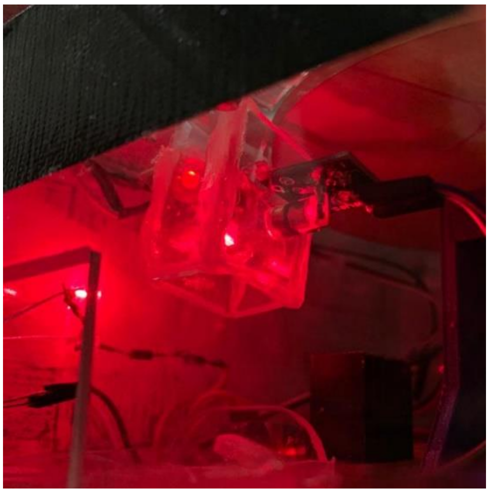


Figure 3 - 29 – Laser Receiver & Emitter

Power Electronics

Power Supply & Buck Converter

The voltage from 230v AC to 12v DC is converted by RS-25-12 Step Downconverter. DC Motor Controller drives are directly connected to the output of the converter. Other servo motors, sensors and indicators are powered by LM2596 Buck converter which is connected to the output of RS-25-12 converter.

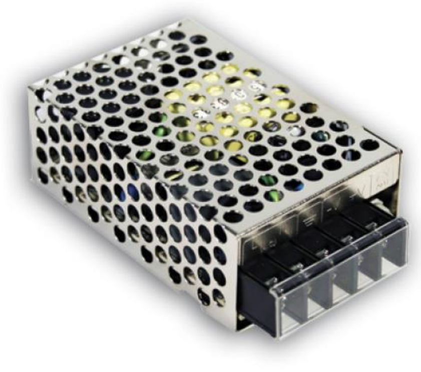


Figure 3 – 30 – RS-25-12 Power Supply

Figure 3 - 31 – LM2596 Buck Converter

Circuit Design

For the prototype Pill dispenser unit is controlled by Arduino Mega 2560 for the prototype, which is based on the ATmega2560. It was chosen considering the number of pins and considering the connections to the computer. The circuit diagram is designed for two pill dispensers, which fabricated to demonstrate the prototype.

Outputs from the RS-25-12 power supply directly connected to the motor controllers for controlling the DC motors(12v). Also, the outputs from the RS-25-12 power supply is connected to two LM2596 Buck converters(Step down). One LM2596 5v output uses to power the Servo motors, KY 008 Laser receiver & the emitter. And other LM2596 3.7v output uses to power TSSP 4038 IR Receiver & 2 Radial T1 3/4 SFH IR Emitters. Data cable and power cable (connected through a barrel connecter to the pill dispenser) should be connected to the unit.

IR Sensor circuit works independently from the MCU. If the pill level is lower than the required level, top LED will be turned ON. Also, one pill dispensing unit is controlled at a time. LED indicators will display the ON/OFF condition of the units. Also, the processed pill dispenser unit will be indicated.

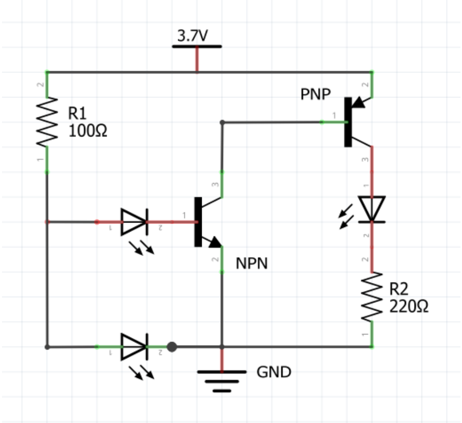


Figure 3 - 32 – Infrared Sensor Circuit

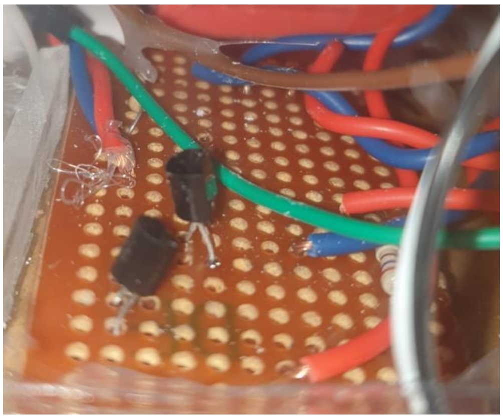


Figure 3 - 33 – Designed Circuit

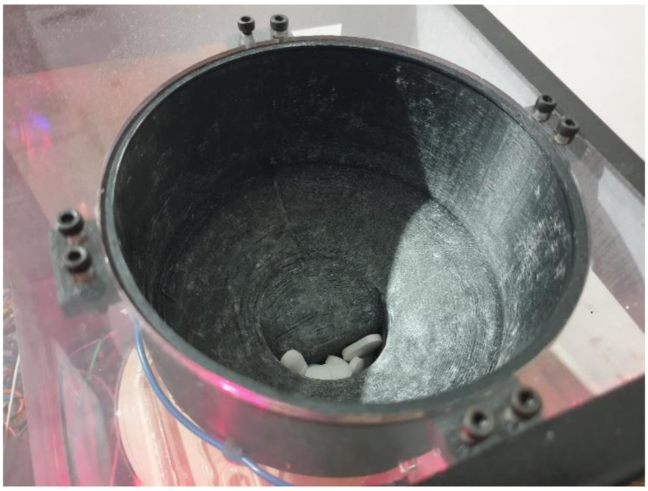


Figure 3 - 34 – Pill Container & IR Sensors

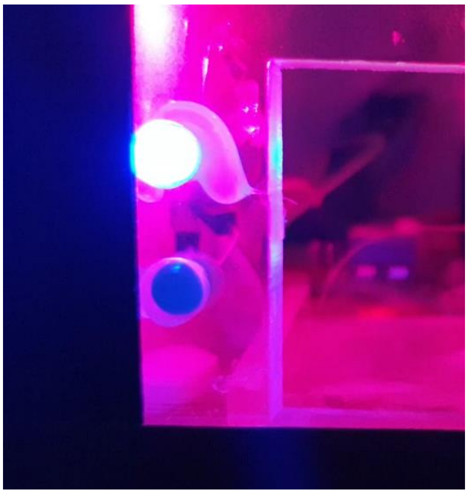


Figure 3 - 35 – Indicator LEDs

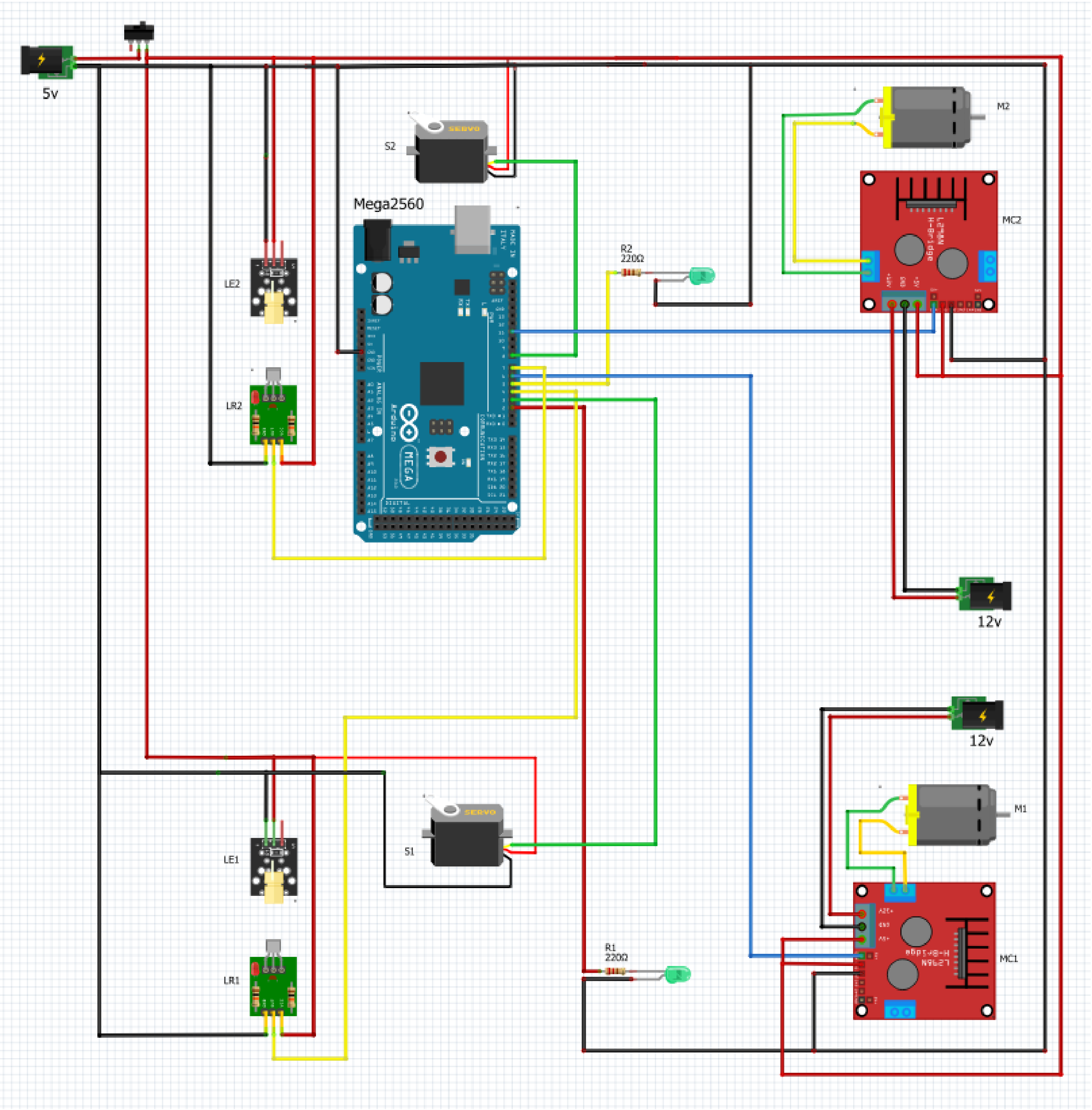


Figure 3 - 36 – Wiring Diagram

CHAPTER 4 Results and Discussion.

Performance of the OCR.

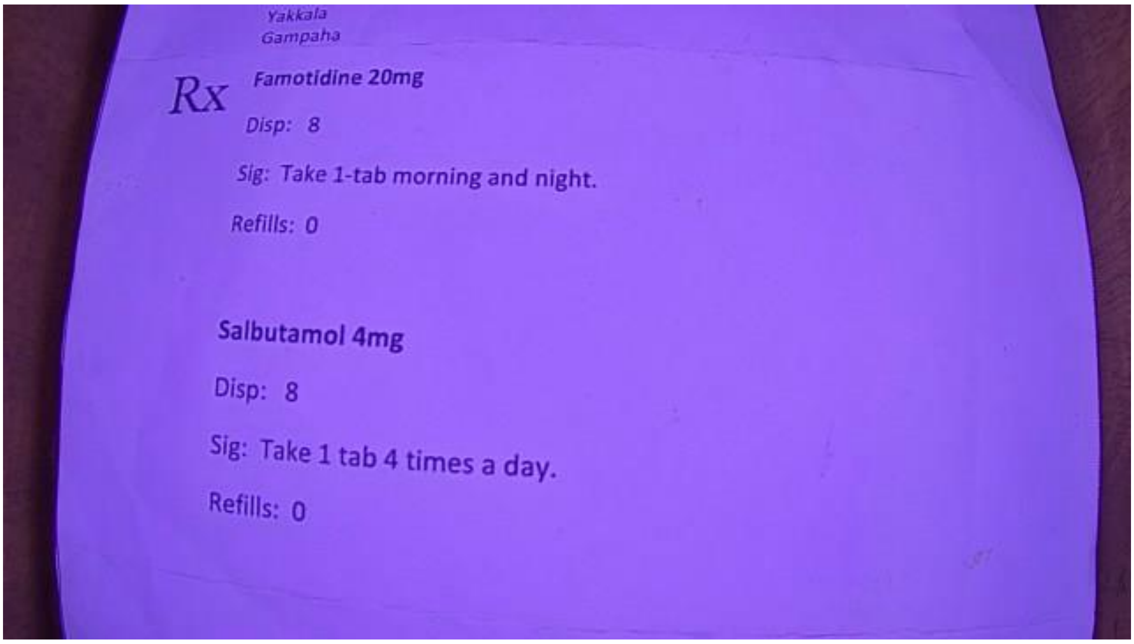
The OCR is tested as mentioned in the testing of the OCR and the results are as follows. In the high-quality image input the results are as follows, for Calibri font the accuracy is 95.89%, for Source Sans Pro the accuracy is 97.56%, for Times New Roman the accuracy of the system is 97.81% and for Verdana the accuracy is 95.89%. from these data we can conclude that the overall average accuracy of the system is 96.78%.

The readings of the OCR from the webcam for grey images gave an accuracy of 80% and the binary image gave an accuracy of 77.5%.

During several testing there was a main error that occurred which did not occur repetitively, and this could cause the wrong recognition of the number of pills. The recognition of the pills sometimes reads “Disp:” as “Disp;” in here the colon is recognized as a semi colon. These errors are not easy to be recognized by the pharmacist, Since these errors occurs rarely, the pharmacist ca easily miss these features. As a solution to this problem in the sorting of the number of pills, instead of searching the correct key words we also started searching the possible wrong keyword that could be wrongly identified and be missed by the pharmacist. This is done to even reduce the dispensing errors.

The webcam

The properties of a web cam for using to read images at proximity is not a good use of the web camera. But due to the expensive nature of the cameras in the market and the budget, this camera is the most cost-effective camera that was available. But the main problem was the image gives a convex image. A convex image has its center of the image magnifying and reducing its magnification as it goes further. In addition to this the web cam gave a low-quality image with only 72 dpi and the general recommended image for an image that should be input to the OCR id about 300 dpi.



Yakkala
Gampaha

Rx Famotidine 20mg

Disp: 8

Sig: Take 1-tab morning and night.

Refills: 0

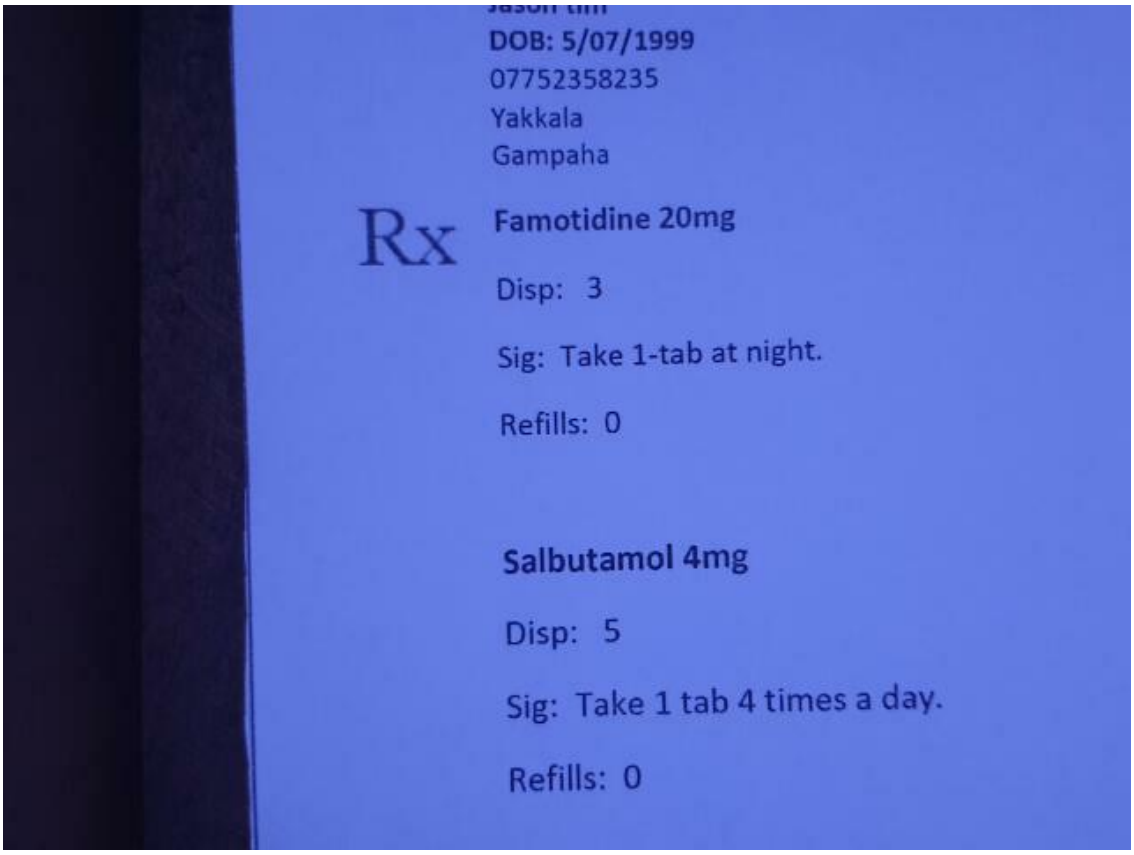
Salbutamol 4mg

Disp: 8

Sig: Take 1 tab 4 times a day.

Refills: 0

Figure 4 - 1 - Webcamera image with convex effect



DOB: 5/07/1999
07752358235
Yakkala
Gampaha

Rx Famotidine 20mg

Disp: 3

Sig: Take 1-tab at night.

Refills: 0

Salbutamol 4mg

Disp: 5

Sig: Take 1 tab 4 times a day.

Refills: 0

Figure 4 - 2 - Image without the convex effect taken from a high quality camera

The camera holder and the enclosure.

The enclosure is a small enclosure. This enclosure only has the capability of getting prescriptions of paper size A5 and lesser paper sizes. The A4 paper should be inserted to a larger system which has a better camera for the capability of capturing better image. For a small image also, the convex effects affect the quality of OCR therefore higher paper sizes cannot be used.

The GUI of the system

The main properties of the GUI is the simplicity of the system. The main simple aspects of the system id the simplicity. The GUI is equipped with many notification in the form of pop up windows to help the user to navigate through the software and provide the best service for the customer and in reducing the time consumption of the pharmacist per patient.

Design

At the end of the all processes the unit was tested. Initially when the tablets falling from the store, the tablets were go away from the rotating table. Due to that issue the counted tablet quantity can be error. Another issue was tablets were spread every places. As a solution, the transparent cover was added around the storage and fixed that problem. due to this cover the tablets were fall down again to the rotating table. Another problem was tablets were stack around the middle of the rotating table that issue was fixed the curving plate attached to the adjustable hand. Due to that problem, the small amount of tablets blocked in the middle of the rotating table at every time. So lots of tablets stay at the rotating table at every time it is not a big issue but the aim of the project was every tablets were put in into the drawer and every tablets were counted. Due to this curving plate the tablets were moved away from the middle of rotating table and adjustable hand. Result of the that every tablets were counted. Another issue was smooth less of the 3D printing parts, due to that reason the tablets were block at the bottom of the pill container. Due to that reason the tablets could not fall down to the rotating table when the servo motor was opened. This was a big issue because the no pills were counted. So the solution was increase the smoothness of inside of the pill container. So the sand papers were used to increase the smoothness. Finally this problem was fixed. Another problem was the hole making process of thickness side of the body plates. All the holes were used to combine the body plates together. Due to the chemical structure of the acrylic plates, this process was hard to done. As the solution of that problem, silicone gum and super glue were used to combine the body plates. But other side holes were made using drilling machines and threads were made using hand tapping tool. Another problem was the laser sensor mounting procedure, the laser waves were focus on the small place to the transmitter due to that reason the tablets should go across the laser waves at the proper angle. But the speed of the rotating table and the size of the counting hole, this process was not work properly. Due to that reason the laser sensor mount angel were increased the solution of the problem. And the purpose the tablets were go through the laser sensor at the every position, at the every speed at the every time. This issue was done increase the angle of the sensor mount.

Electrical Components and circuits

To overcome the issue of heating of electric components including motor drivers and other modules for using pill dispenser over about 12hrs, external controller box should be used in future designs. Compacted electrical components provide lesser airflow into the pill dispenser unit.

For the efficiency of IR sensors black colour material or black colour coating is better to use inside the pill container. In the prototype, one of a dispensing unit was 3D printed in red colour PLA material, while the other pill dispenser was printed in black colour PLA material. For the response of the IR detector with storage pill level is more efficient for black colour pill dispenser than the red colour pill dispenser.

Although the prototype uses Arduino mega 2560 development board for control the automated pill dispenser, using development board like portenta should be beneficial for reading signals from sensors. Industrial grade controller (PLC) is more suitable for implementing the design for a significant number of automated pill dispensers. A lot of pins including analog pins are required from the controller to implement the system for a drug store. Also, the responses from sensors are more efficient with an industrial level controller.

CHAPTER 5 Conclusion and recommendations.

The main idea of this project was to develop a system of automatic dispensing of the required medicine by reading the prescription. In this project the printed prescription is read and the items in the prescription are identified along with the number of pills. The number of pills and the name of the pills in the picture are identified using string search. Then using this information, the dispensers connected to the Arduino is controlled using the main processing computer. The dispenser contains a pill storage module and a mechanism to singulate one pill for it to be fed into the counter. The pills when they are being dispensed, firstly they will be released from the storage of the pill container to the rotating disk which will singulate one pill from a lot of pills that fall onto the disk. One by one each pill will be fed to the counter to be counted. After the required number of pills are obtained, the rotating disk stops, and a LED indicates that the pills are dispensed correctly.

Implementing this mechanism for pharmacies instead of other higher end solutions which gives the same result is not recommended since this method is much more cost effective than the other designs. This method also makes the mixing of several drugs impossible as each drug is contained in a separated container. The pharmacist assists and the prescription verification further improves the reliability of the system toward the reduction of errors occurred.

This solution provides extra time for the pharmacist to do counseling with the patient so that many other dispensing errors will be identified and reduced. In addition, the future recommendations of making the system intelligent enough to recognize the validity of the prescriptions and in addition, the implementation of industrial grade controllers, camera and sensors will increase the reliability of the machine to a further extent.

By considering the accuracy and the accuracy of the system in counting the pills along with the design features, it is possible to conclude that the project is a success. We believe that this project when implemented in the industrial scale will largely impact our society and help in the process of improving the health of the patients quickly in an error free manner.

Future Work

According to our time plan of the project, we have completed our prototyping and testing level. The following will be our future targets to achieve.

- Fabricate our final machine as done in our prototype
- Include more safety features to dispense accurate number of pills
- Increase the amount of pill dispensing units
- Develop our GUI

Future work of the design

- Develop the inside Smoothness of the pill Store.
- Develop the Smoothness of the laser cutting parts
- Prevent the play of the rotating table
- Increase the Accuracy of counting mechanism

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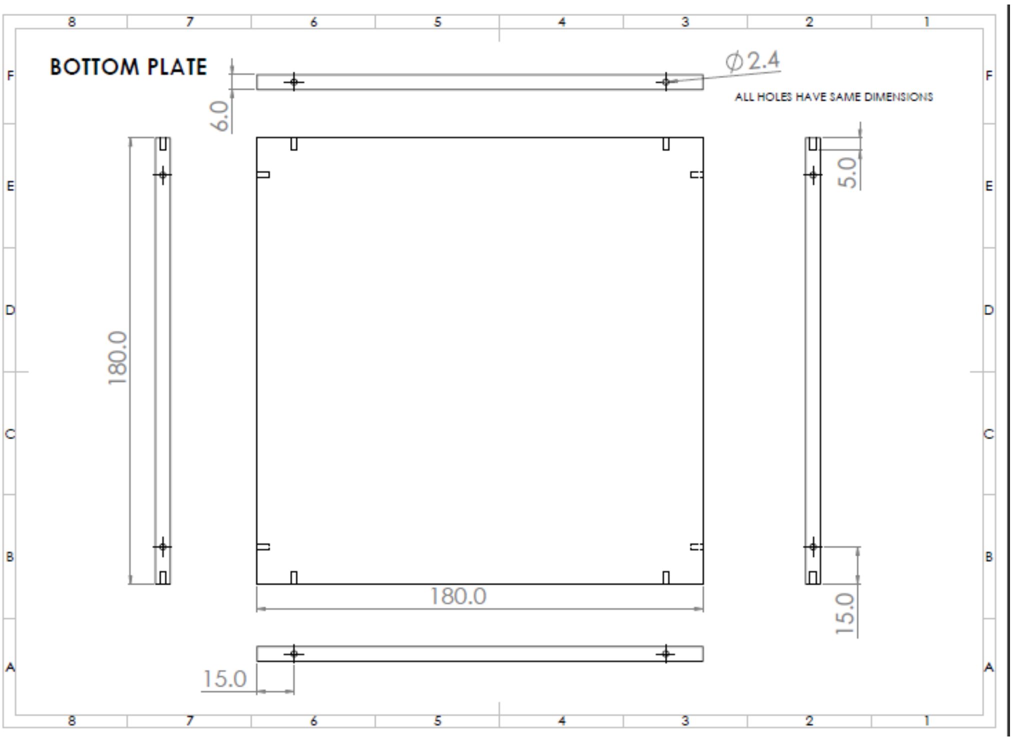
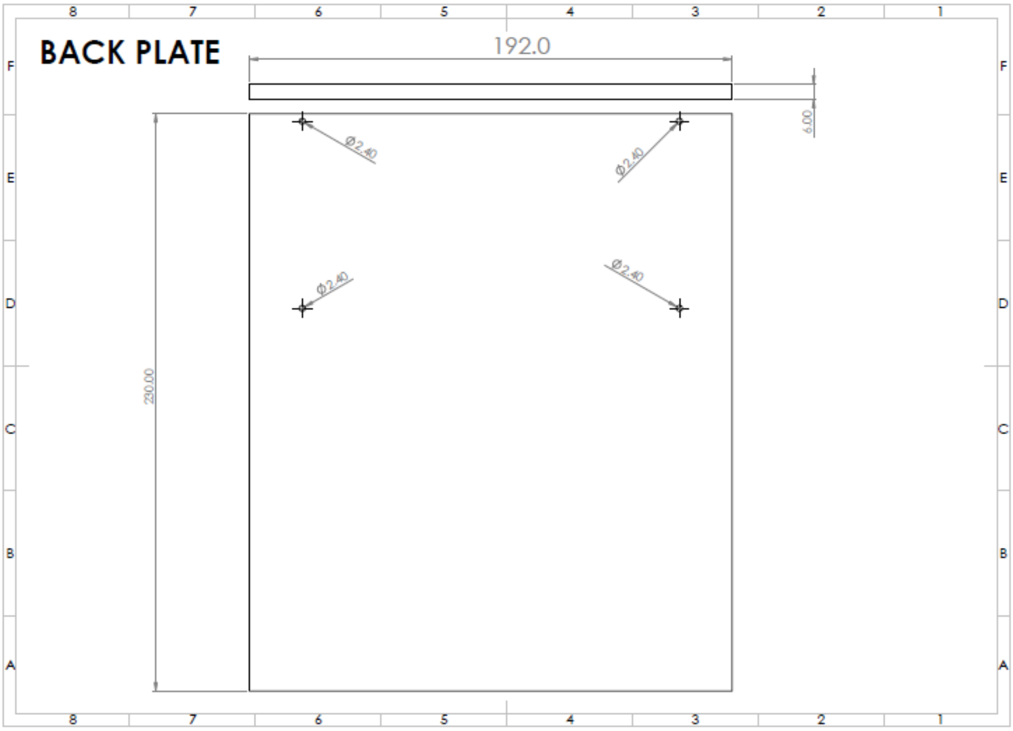
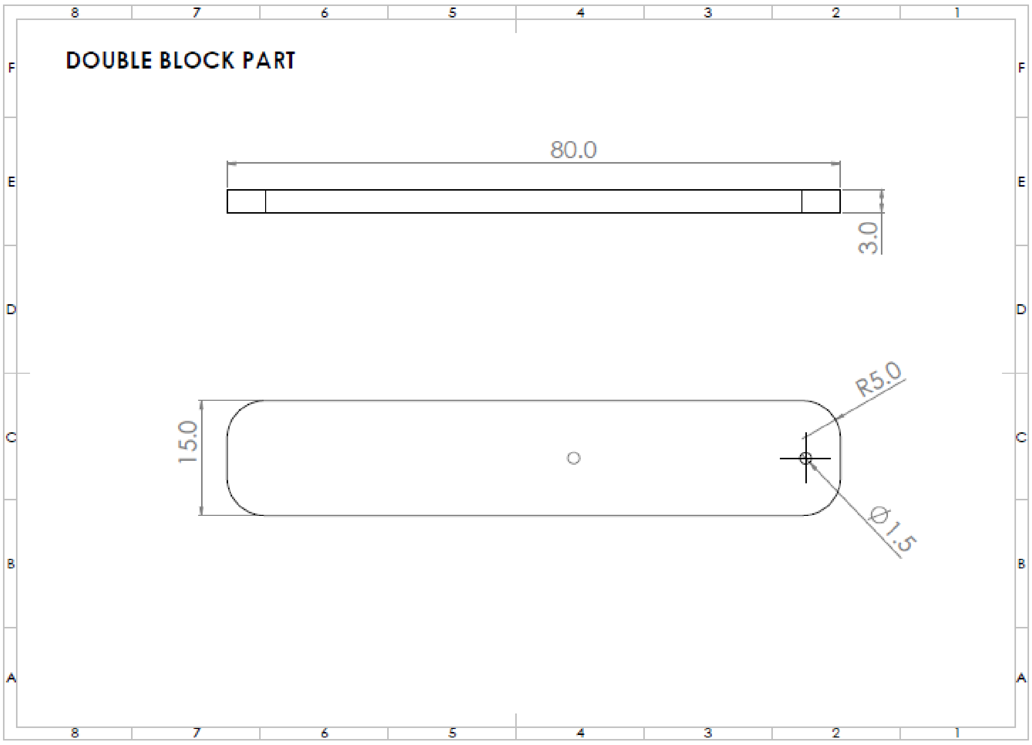
Annexes

Detailed Drawings

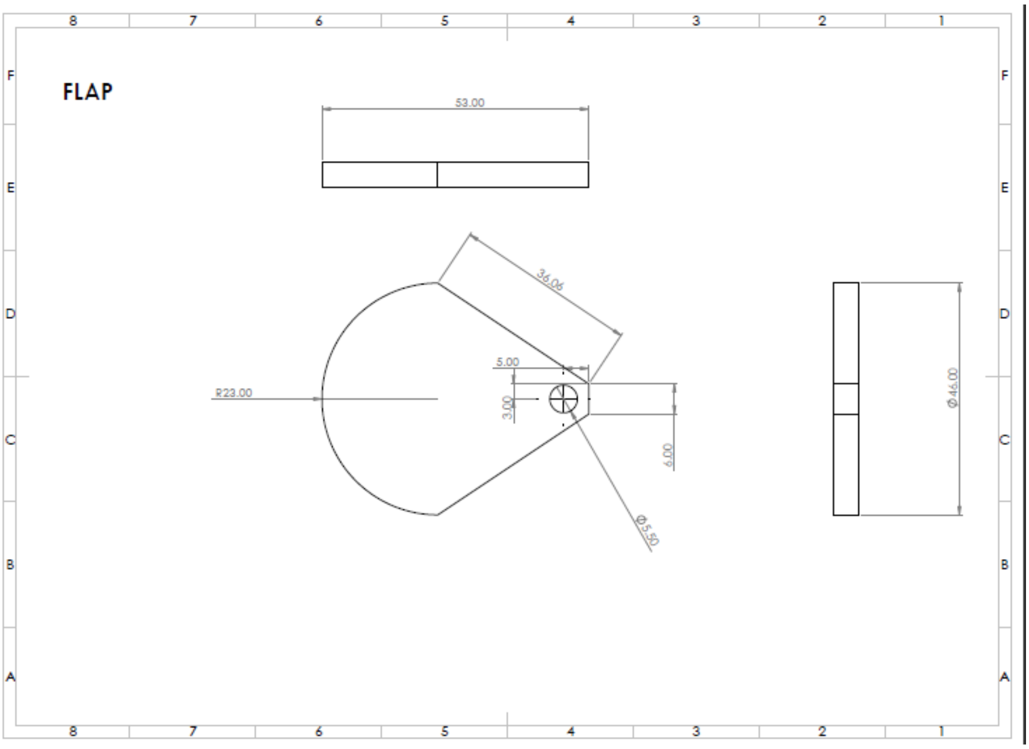


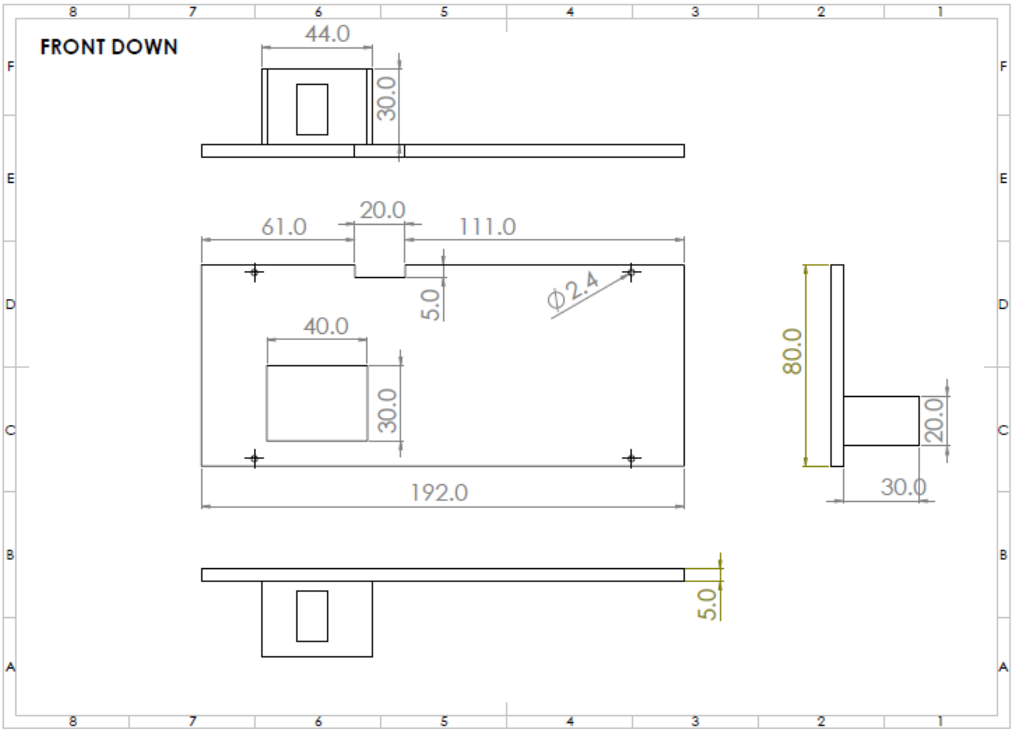


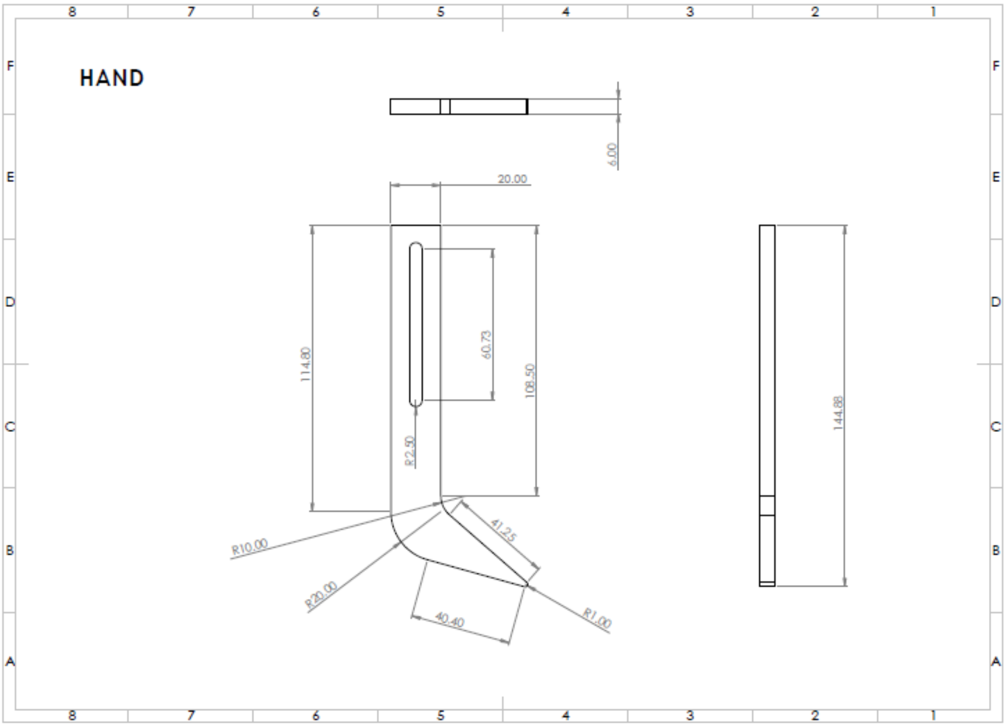
DOUBLE BLOCK PART

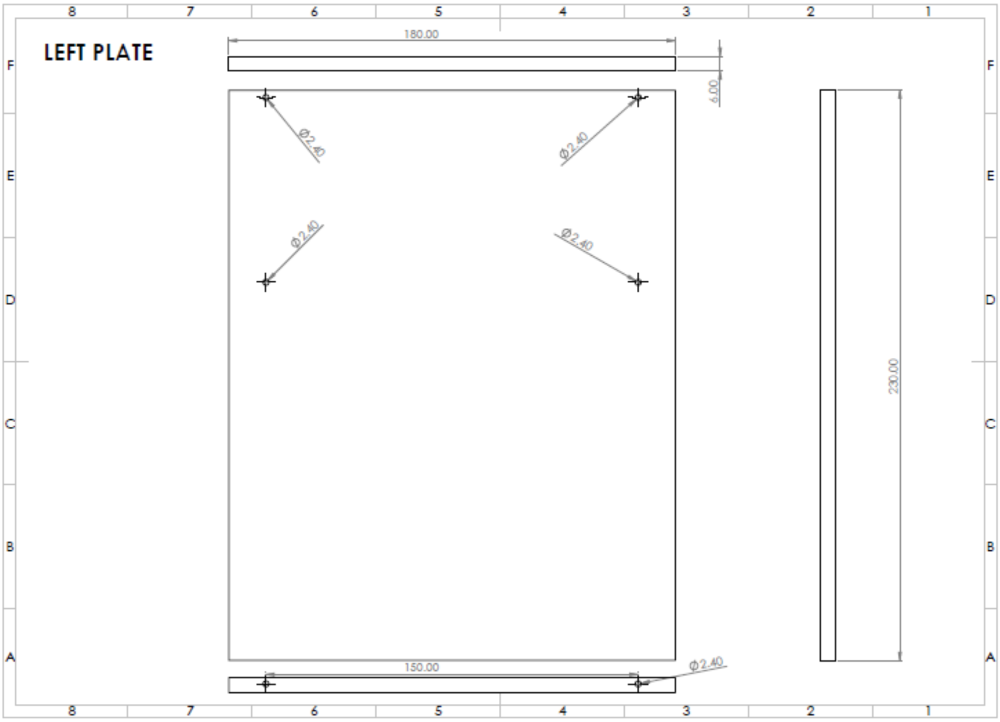


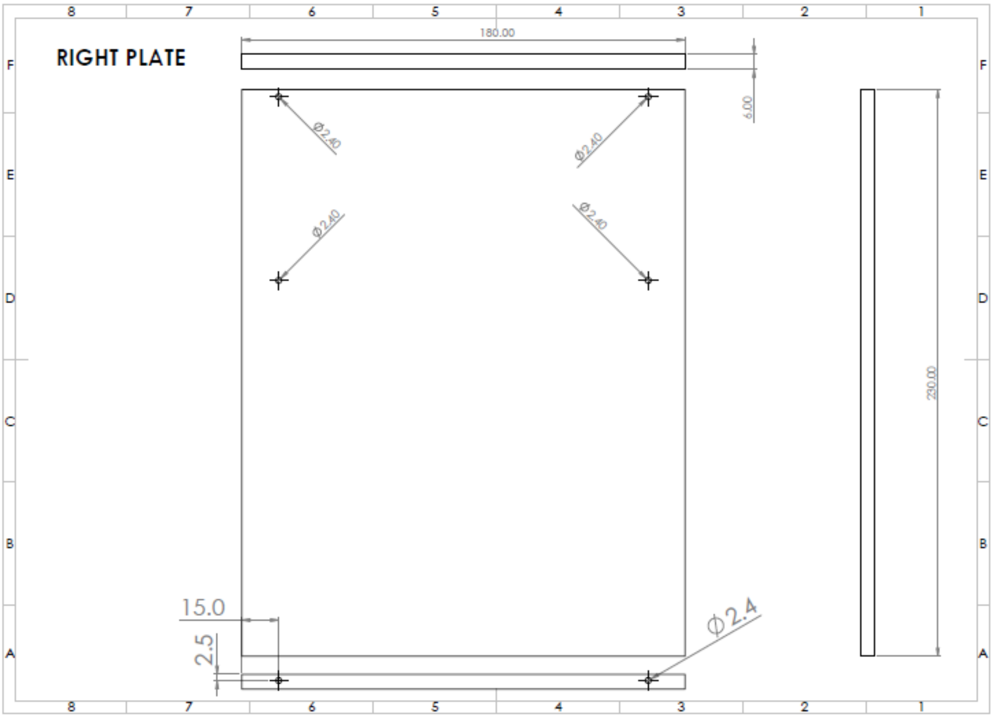
FLAP

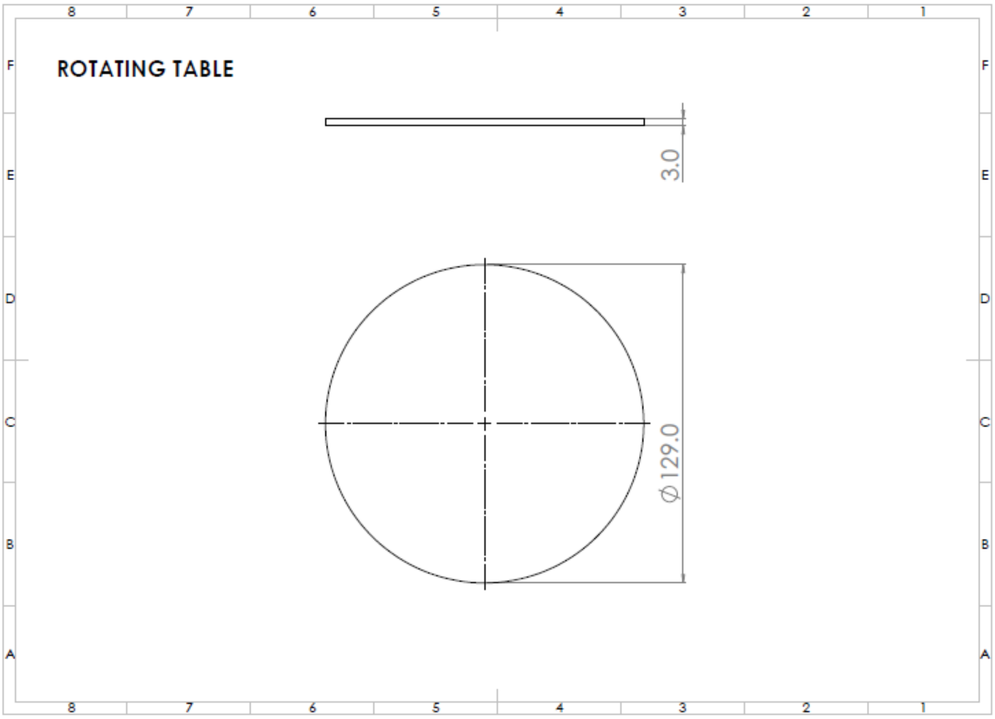


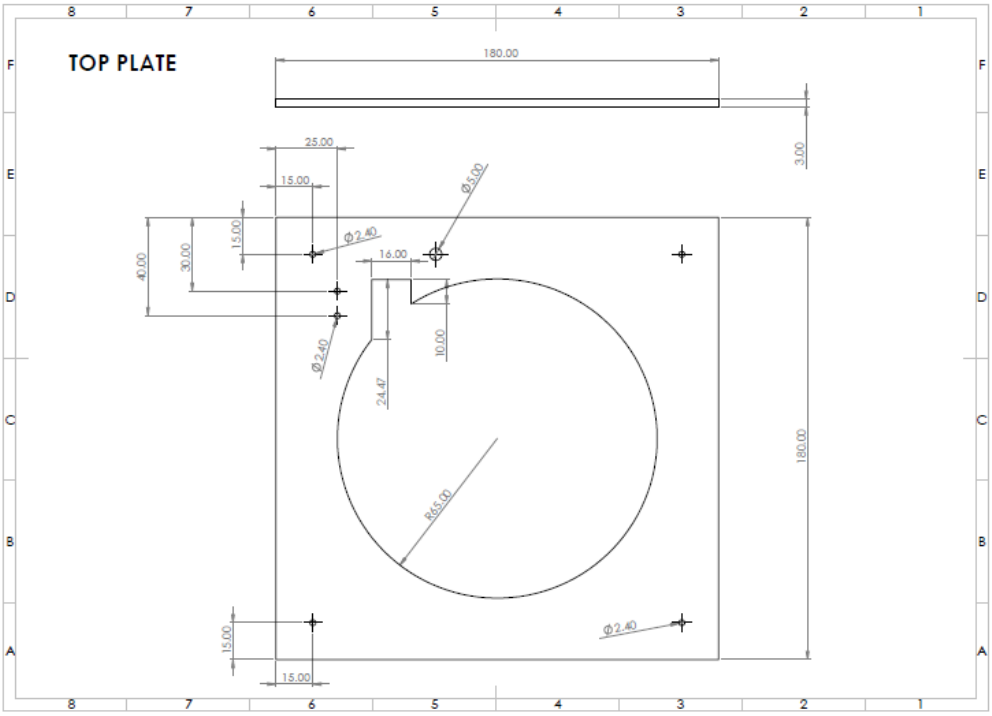

FRONT DOWN
44.0
30.0
61.0
20.0
111.0
5.0
⌀2.4
40.0
30.0
192.0
80.0
20.0
30.0
5.0
8
7
6
5
4
3
2
1
F
E
D
C
B
A


HAND
6.00
20.00
114.80
60.73
108.50
R2.50
144.88
R10.00
41.25
R20.00
40.40
R1.00
8
7
6
5
4
3
2
1
F
E
D
C
B
A

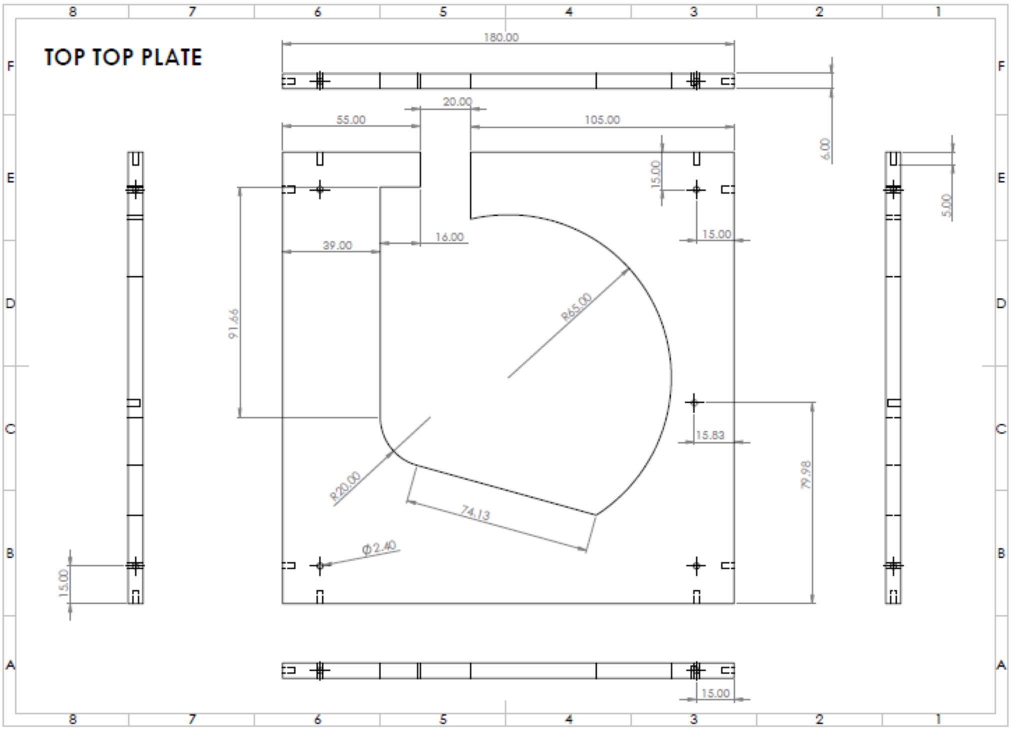

LEFT PLATE
180.00
6.00
Ø2.40
Ø2.40
Ø2.40
Ø2.40
230.00
150.00
Ø2.40


RIGHT PLATE
180.00
6.00
Ø2.40
Ø2.40
Ø2.40
Ø2.40
230.00
15.0
2.5
Ø2.4

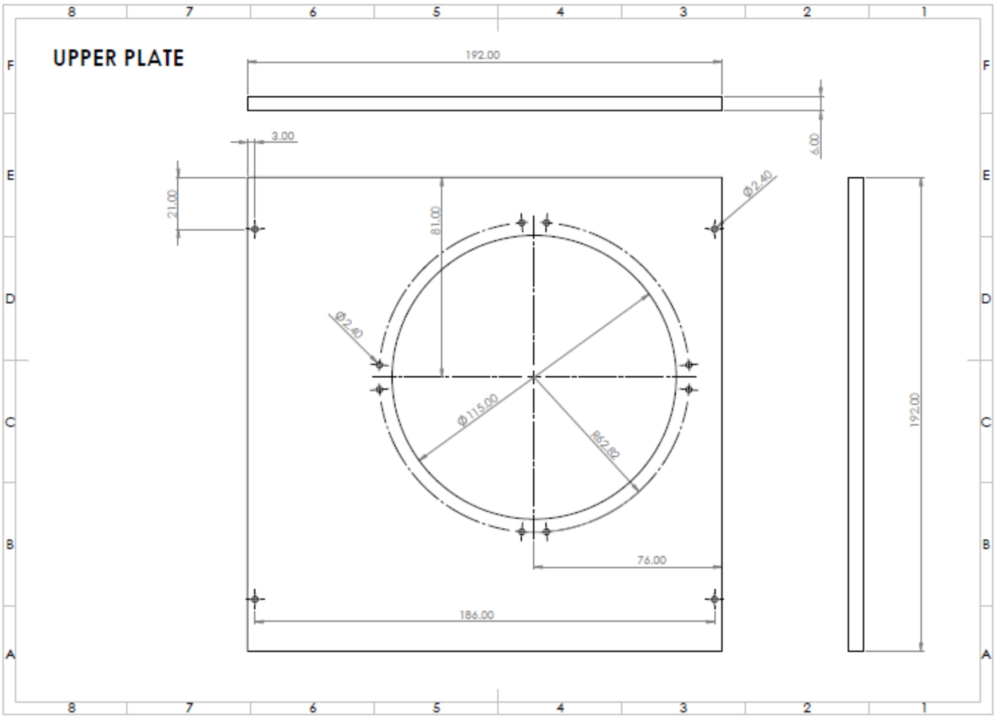

ROTATING TABLE
3.0
Ø129.0

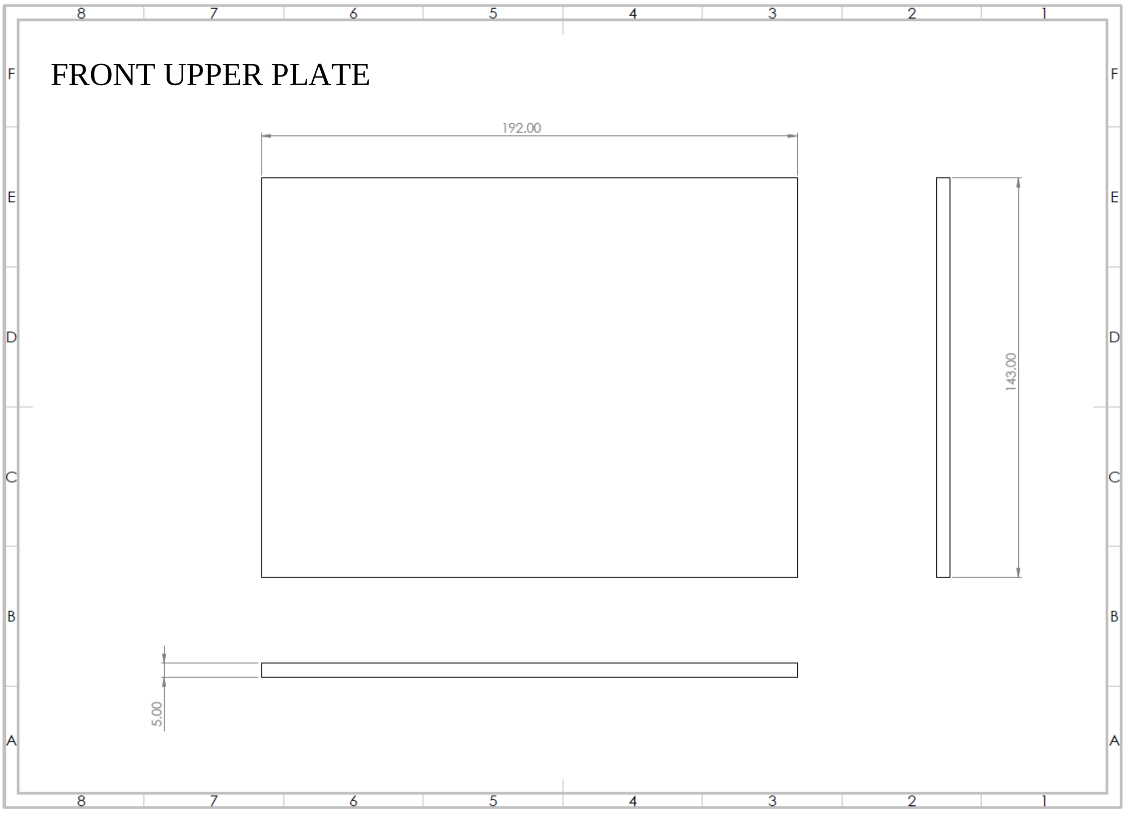

TOP PLATE
180.00
3.00
25.00
15.00
Ø5.00
15.00
Ø2.40
16.00
40.00
30.00
Ø2.40
10.00
24.47
R65.00
180.00
15.00
Ø2.40
15.00

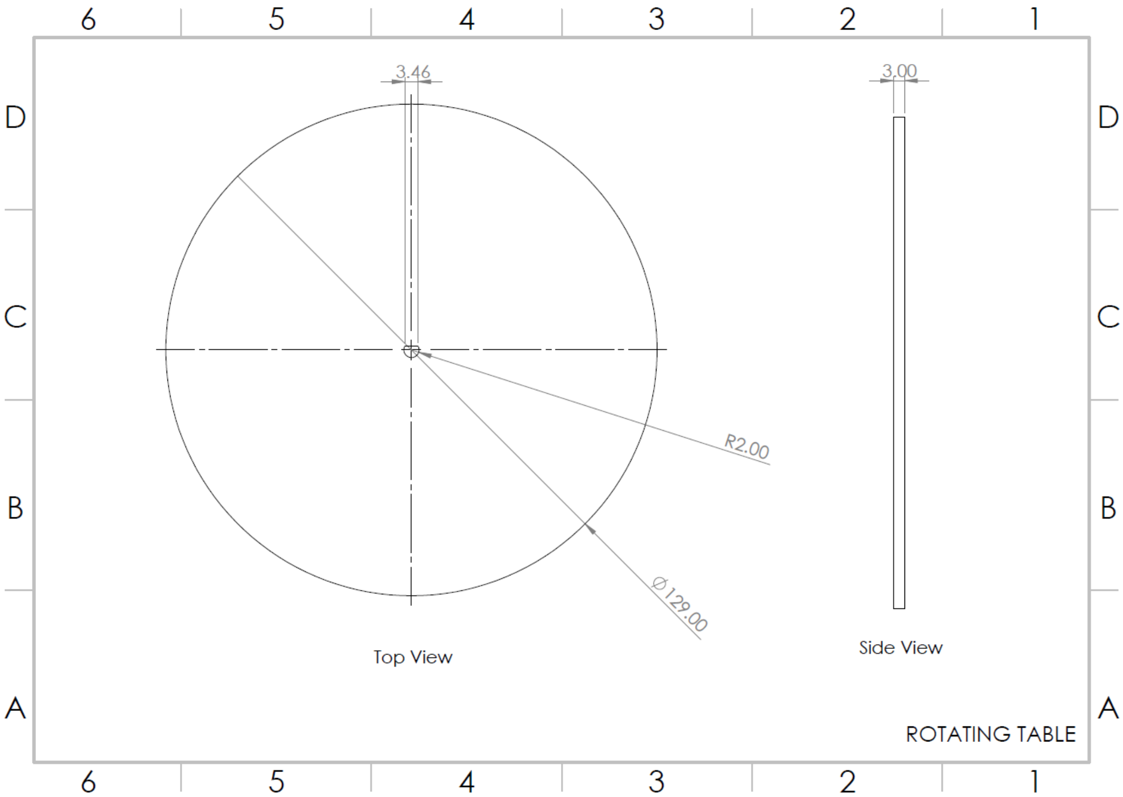
TOP TOP PLATE



UPPER PLATE




FRONT UPPER PLATE
192.00
143.00
5.00
8
7
6
5
4
3
2
1
F
E
D
C
B
A


3.46
3.00
R2.00
Ø129.00
Top View
Side View
ROTATING TABLE
6
5
4
3
2
1
D
C
B
A

Source code

```
import cv2

import sys

from PyQt5 import QtCore

from PyQt5.QtCore import pyqtSlot

from PyQt5.QtWidgets import QApplication, QMainWindow, QMessageBox

from PyQt5.QtGui import QImage, QPixmap

from PyQt5.uic import loadUi

import os

from PIL import Image

import pytesseract

import pandas as pd




class dispensercode(QMainWindow):

    def __init__(self):

        self.name = 'delila'

        super(dispensercode, self).__init__()


        loadUi('gui1.ui', self)

        self.logic = 0

        self.capdone = 0

        self.count = 1

        self.x = 'm'

        self.ver = bool
    self.Confirm.clicked.connect(self.confirmed)

    self.Camon.clicked.connect(self.Camturn)

    self.Capture.clicked.connect(self.captureClicked)

    self.reset.clicked.connect(self.Reset)


@pyqtSlot()

def confirmed(self):

    name = self.NameInput.toPlainText()

    self.new_name = name

    self.label2.setText('Patient name is ' + name)

    return self.new_name


def Reset(self):

    self.label1.clear()

    self.label2.clear()

    self.label3.clear()

    self.capdone = 0

    self.count = 1

    cap = cv2.VideoCapture(1)

    cap.release()

    self.NameInput.clear()


def Camturn(self):

    cap = cv2.VideoCapture(1)


    while cap.isOpened():
            ret, frame = cap.read()

            if ret:  # ret is if cam is working

                print('here')

                self.displayimage(frame, 1)  # frame is the image

                cv2.waitKey()


                if self.logic == 2:

                    cv2.imwrite('%s.png' % self.new_name, frame)  # %s will be substituted by %(self.value)

                    self.logic = 0

                    self.capdone = 1

                    print('cap done is ', self.capdone)

                    cap.release()

                    cv2.destroyAllWindows()


                    if self.capdone == 1:

                        self.loadClicked()

                        self.ocr()

                        self.capdone = 0


# -------------------create verification pop up window----------------------------------#

                        msg = QMessageBox()

                        msg.setWindowTitle('please verify whether the ocr is correct')

                        msg.setText(' Click "Yes" if true "NO" if false or "Open" if there is a small edit')

                        msg.setIcon(QMessageBox.Question)
                        msg.setStandardButtons(QMessageBox.Yes | QMessageBox.No | QMessageBox.Open)

                        msg.setInformativeText(self.text)

                        msg.buttonClicked.connect(self.popup_button)

                        x = msg.exec_()


                        print('this is before if is running')

                        print(self.ver)

                        while not self.ver:

                            print('this while is running')

                            if self.count <= 3:

                                self.count = self.count + 1

                                cap = cv2.VideoCapture(1)


                                while (cap.isOpened()):


                                    ret, frame1 = cap.read()

                                    if ret == True:  # ret is if cam is working

                                        self.label1.clear()

                                        print('here')

                                        self.displayimage(frame1, 1)  # frame is the image

                                        cv2.waitKey()




                                        if (self.logic == 2):
```

```
                cv2.imwrite('%s.png' % self.new_name, frame1)
                # %s will be substituted by %(self.value)
                self.logic = 0
                self.capdone = 1
                print('cap done is ', self.capdone)
                # self.textBrowser1.setText('image saved pres cap for another image')
                cap.release()
                cv2.destroyAllWindows()

                if (self.capdone == 1):
                    self.loadClicked()
                    self.ocr()
                    self.capdone = 0
# -------------------create verification pop up window----------------------------------#
                    msg = QMessageBox()
                    msg.setWindowTitle('Please verify whether the ocr is correct')
                    msg.setText(' Click "Yes" if true "NO" if false or "Open" if there is a small edit')
                    msg.setIcon(QMessageBox.Question)
                    msg.setStandardButtons(QMessageBox.Yes | QMessageBox.No | QMessageBox.Open)
                    msg.setInformativeText(self.text)
                    msg.buttonClicked.connect(self.popup_button)
                    x = msg.exec_()
                    else:

                        os.startfile('{}.txt'.format(self.new_name))

                        # -------------------create done pop up window---------------------------
--------#
                        msg1 = QMessageBox()
                        msg1.setWindowTitle('notify when done')
                        msg1.setText(' Click "Yes" if done')
                        msg1.setIcon(QMessageBox.Question)
                        msg1.setStandardButtons(QMessageBox.Yes)
                        msg1.setInformativeText('Is the work done')
                        msg1.buttonClicked.connect(self.popup_button1)
                        x = msg1.exec_()
                        break

                self.readlist()

                msg1 = QMessageBox()
                msg1.setWindowTitle("Please collect the pills")
                msg1.setText('final_list2')
                msg1.setIcon(QMessageBox.Question)
                msg1.setStandardButtons(QMessageBox.Yes)
                msg1.setInformativeText('Are the pills connected')
                msg1.buttonClicked.connect(self.popup_button3)
                x = msg1.exec_()
```

```
                    self.logic = 1
                else:
                    print('return not found')



    def captureClicked(self):
        self.logic = 2


    def displayimage(self, img, window=1):
        qformat = QImage.Format_Indexed8


        if len(img.shape) == 3:
            if (img.shape[2]) == 4:
                qformat = QImage.Format_RGBA8888


            else:
                qformat = QImage.Format_RGB888
        img = QImage(img, img.shape[1], img.shape[0], qformat)  # Qimage is used to load the image
        img = img.rgbSwapped()
        self.label1.setPixmap(QPixmap.fromImage(img))  # QPixmap is used to show the image
        self.label1.setScaledContents(True)  # scale the image according th the frame
        self.label1.setAlignment(QtCore.Qt.AlignHCenter | QtCore.Qt.AlignVCenter)


    def loadClicked(self):
        img1 = cv2.imread("{}.png".format(self.new_name))
        self.displayimagef(img1, 1)
        cv2.destroyAllWindows()

    def displayimagef(self, img1, window=1):
        qformat = QImage.Format_Indexed8

        if len(img1.shape) == 3:
            if (img1.shape[2]) == 4:
                qformat = QImage.Format_RGBA8888

            else:
                qformat = QImage.Format_RGB888
        img1 = QImage(img1, img1.shape[1], img1.shape[0], qformat)  # Qimage is used to load the image
        img1 = img1.rgbSwapped()
        self.label1.setPixmap(QPixmap.fromImage(img1))  # QPixmap is used to show the image
        self.label1.setScaledContents(True)  # scale the image according th the frame
        self.label1.setAlignment(QtCore.Qt.AlignHCenter | QtCore.Qt.AlignVCenter)

    def ocr(self):
        config = ('-l eng --oem 1 --psm 3')
        # load the example image and convert it to grayscale
        image = cv2.imread("{}.png".format(self.new_name))
        gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
        # write the grayscale image to disk as a temporary file so we can

        # apply OCR to it

        filename = "{}.png".format(os.getpid())

        cv2.imwrite(filename, gray)


        # load the image as a PIL/Pillow image, apply OCR, and then delete

        # the temporary file

        self.text = pytesseract.image_to_string(Image.open(filename), config=config)

        os.remove(filename)

        self.label3.setText(self.text)

        print('converted to text')


        # export to .txt file

        # stdoutOrigin = sys.stdout

        with open("{}.txt".format(self.new_name), "w") as f:

            f.write(self.text)


    def popup_button(self, i):

        print(i.text())


        if i.text() == '&Yes':

            self.ver = True

            print(self.ver)

            return self.ver


        elif i.text() == '&No':
            self.ver = False
            print(self.ver)
            return self.ver

        else:
            os.startfile('{}.txt'.format(self.new_name))
            # -------------------create done pop up window----------------------------------#
            msg1 = QMessageBox()
            msg1.setWindowTitle('notify when done')
            msg1.setText(' Click "Yes" if done')
            msg1.setIcon(QMessageBox.Question)
            msg1.setStandardButtons(QMessageBox.Yes)
            msg1.setInformativeText('Is the work done')
            msg1.buttonClicked.connect(self.popup_button2)
            x = msg1.exec_()



    def popup_button1(self, j):
        if j.text() == '&Yes':
            print('yes')

        else:
            print('no')

    def popup_button2(self, j):
        if j.text() == '&Yes':
            self.ver = True
            print('yes')
            return self.ver

        else:
            print('no')

    def readlist(self):
        with open("{}.txt".format(self.new_name)) as f1:
            os.startfile('{}.txt'.format(self.new_name))
            flat_list = [word for line in f1 for word in line.split()]
            print(flat_list)

        # ---------read the csv file of pills-------------------------------------------#
        df = pd.read_excel('items.xlsx', sheet_name=0)  # can also index sheet by name or fetch all sheets
        bin_no = df['BIN no'].tolist()
        Name = df['Name'].tolist()
        content = df['content'].tolist()

        print(bin_no)
        print(Name)
        print(content)

        # iterating through the list
        final_list = []
```

```
final_list1 = []
final_list2 = []
i = 0
for i in range(len(flat_list)):
    print('i', i)
    for j in range(len(Name)):
        print('j', j)
        if Name[j] == flat_list[i]:
            print('found one')
            if content[j] == flat_list[i + 1]:
                print('content correct')
                final_list.append(bin_no[j])
                final_list1.append(bin_no[j])
                final_list.append(Name[j])
                final_list.append(content[j])
                print('list1 appended')
                x = i+1
                for k in range(x, len(flat_list)):
                    if ('Disp:' or 'Disp' == flat_list[k]):
                        print('flat_list',flat_list[k + 2])
                        final_list.append(flat_list[k + 2])
                        final_list2.append(flat_list[k + 2])
                        break

                    else:
                        continue
            else:
                continue
        else:
            continue
print('final list is ', final_list)
print('final list1 is bin is  ', final_list1)
print('final list2 is no of pills is ', final_list2)

import pyfirmata
from pyfirmata import util
import time

board = pyfirmata.Arduino('COM9')



a = 0
for a in range(len(final_list1)):

    it = util.Iterator(board)
    it.start()

    if final_list1[a] == 1:
        laser = board.get_pin('d:4:i')
        dc = board.get_pin('d:6:p')
        servo = board.get_pin('d:3:s')
        led = board.get_pin('d:2:o')

    elif final_list1[a] == 2:
        #laser = board.get_pin('d:4:i')
        #dc = board.get_pin('d:6:p')
        #servo = board.get_pin('d:3:s')
        #led = board.get_pin('d:2:o')
        pass



    else:
        laser = board.get_pin('d:7:i')
        dc = board.get_pin('d:11:p')
        servo = board.get_pin('d:8:s')
        led = board.get_pin('d:5:o')



    b = int(final_list2[a])
    print(b)

    br = 1
    print(b)
    pill_count = 0

    servo.write(50)
```

```
time.sleep(1)
servo.write(0)
time.sleep(2)

print('abd')
while True:
    dc.write(0.8)
    print('motor')
    while not laser.read():
        if trig_val == 0:
            pill_count = pill_count + 1
            trig_val = 1
            print(pill_count)

        if pill_count == 4 or pill_count == 8:
            dc.write(0)
            servo.write(30)
            time.sleep(1)
            servo.write(0)
            time.sleep(2)

        if pill_count == b:
            dc.write(0)
            led.write(1)
            time.sleep(2)
            led.write(0)
```

```
                        br = 0
                        break

                while laser.read():
                    trig_val = 0

                    if pill_count == b:
                        break

                if br == 0:
                    br = 1
                    break

app =QApplication(sys.argv)
window = dispensercode()
window.show()
try:
    sys.exit(app.exec_())
except:
    print('exiting')
```