# TRIBHUWAN UNIVERSITY

# INSTITUTE OF ENGINEERING

## THAPATHALI CAMPUS

**A project on Design, Fabrication and Testing of Vegetable Segregation using Image Processing**

Prepared by


| | |
|---|---|
| Denish Maharjan | 51610 |
| Prabhat Baskota | 51625 |
| Prabin Thapa | 51626 |
| Sunil Lama | 51646 |


SUBMITTED TO:

DEPARTMENT OF INDUSTRIAL ENGINEERING

KATHMANDU, NEPAL

DEC 2022

# COPYRIGHT

**TRIBHUVAN UNIVERSITY**

**INSTITUTE OF ENGINEERING**

THAPATHALI CAMPUS

DEPARTMENT OF INDUSTRIAL ENGINEERING

It is hereby certified that this paper, entitled

**"A Project report on Design, Fabrication and Testing of vegetable segregation using Image Processing"**

prepared by

Denish Maharjan, Sunil Lama, Prabhat Baskota, and Prabin Thapa

is an outcome of the research conducted under

**"Department of Industrial Engineering"**

The facts and ideas presented in this paper are an outcome of the student's hard work and dedication to the project, undertaken as a partial fulfillment for requirements for degree of

**Bachelor in Industrial Engineering.**

The outcome of this project has been highly appreciated.

Internal Supervisor

Er. Sushant Raj Giri

External Evaluator

Inspector, Er. Rajan Panthi

Ministry of Education, Science and Technology

Head of Department

Er. Bishworam Parajuli

## Abstract

Grading agricultural and food products through manually sorting them is a very costly, difficult, and time-consuming stage in the quality control process. In addition, neither the performance of this method can be guaranteed nor is it possible to exert sustainable and uniform control on the food materials involved. Compared with traditional methods, computerized inspection of food products is more cost effective, sustainable, and efficient. Due to high customer demand for safe and high-quality food products and due to the significant theoretical and practical developments in image-processing techniques in the past few decades, a system is introduced for separating potatoes in the sorting line based on the image-processing technique where the pictures taken by a digital camera are pre-processed in the Open CV.

Although there are many industrial machines used, classification of potatoes in terms of quality is generally performed by human experts. Due to economic losses of this rather subjective process, automatic and computerized methods are needed in order to obtain reproducible and objective results in classification. With the aim of remedying this insufficiency in segregation, a new electro-mechanical system, which automatically classifies potatoes while they are on a conveyor belt and groups them with the help of a control mechanism, is proposed. The developed system is composed of two parts: the software part acquires digital images of potatoes, extracts several features using these images, and finally performs the classification using mechanical methods. The hardware part is composed of a conveyor belt, a serial port communication system, servo motor, micro controller, and its control circuits, all employed together for grouping the potatoes mechanically. Our system comes with a complete conveyor belt acting as an element that links the production line with the proposed system. This allows the possibility of embedding the proposed system into the production line of potatoes.



*KEYWORDS: Food safety, image processing, potato, Open CV, conveyor belt, micro controller*

## ACKNOWLEDGEMENTS

Firstly, we would like to thank The Department of Industrial Engineering, Thapathali Engineering Campus for providing us with this marvelous opportunity. Also with immense pleasure we express our gratitude and respect to our Supervisor Er. Sushant Raj Giri for his suggestions on initiation of this project and his valuable time, effort, constructive criticism and guidelines regarding this project. We would also like to thank the teachers from Department of Industrial Engineering for providing their valuable insights and suggestions regarding the project at different phases. We would also like to thank our teachers on the machine section who advised us on the project's design and kindly provided us with the address of parts suppliers. We are grateful to the fabrication store for providing us with tools, equipment and permissions on operating different machines.

And last but not the least; we are grateful to all of our teachers who taught us different engineering topics that we have implemented in the preparation of this project. We are extremely grateful to everyone who helped us prepare this project in every possible way, without the support this project would have not been possible.

# TABLE OF CONTENT

## LIST OF ABBREVIATIONS

CV: Computer Vision

mm: millimeter

DC: Direct Current

ML: Machine Learning

CNN: Convolutional Neural Network

AI: Artificial Intelligence

R-CNN: Region-Based Convolutional Neural Network

SRAM: Static Random Access Memory

EEPROM: Electrically Erasable Programmable Read Only Memory

CLK: Clock Speed

IDE: Integrated Development Environment

USDA: United States Department of Agriculture

ANN: Artificial Neural Networks

## LIST OF FIGURES

# CHAPTER ONE: INTRODUCTION

## 1.1 Background of Study

When it comes to potato grading, growers and packers face a lot of challenges. In most cases, this effort requires many people who are tasked with manually assessing the quality of the produce in order to meet the standards of their customers. Based on this process, grading and sorting is often the limiting factor to increased production. The other challenges of sorting potato grading are:

i. Assessing internal quality.
ii. Infection of good produce.
iii. Efficient handling and grading of different shapes and size.

Here, we have used image processing using computer vision for automatic sorting of potato based on their size.

Computer vision is a technological application that can detect, locate, or track objects. It can be used for the surface defect detection, object detection, automatic harvesting, and crop yield estimation. Precision agriculture is a management system based on information and technology which analyses the spatial and temporal variability within the field and addresses them systematically for optimizing productivity, profitability.

The ongoing system of farming practices in Nepal is deemed insufficient to explore the available resources in its optimum potential. Many cultivable lands in the country are still a virgin, and man indigenous crop varieties have remained unexplored in their wilderness that is rich in biodiversity.

The national economy can be flustered and the environment can also be conserved using precision agriculture. Machine vision technology gives industrial equipment the ability to “see” what it is doing and make rapid decisions based on what it sees. The most common uses of machine vision are visual inspection and defect detection, positioning and measuring parts, and identifying, sorting, and tracking products. Technological advancement is gradually finding its applications in the field of agriculture and food sector, in response to one of the greatest challenges i.e. meeting the need of the growing population demand. (JOUR, 2012)

## 1.2 Problem of Statement

Potatoes are a difficult crop to grade in the postharvest process because of their wide diversity in shape, deformity, and mass. The grading process thus still relies on experienced workers. Manual grading is a tedious, expensive, and time-consuming process, and it is often affected by a shortage of labor during the harvest season. In addition, inconsistent sorting and grading errors often occur during the manual grading process because workers are easily influenced by the surrounding environment.

## 1.3 Objectives

### 1.3.1 General Objective

The general objective of the project is to segregate potatoes using computer vision based on image processing.

### 1.3.2 Specific Objectives

The specific objectives of the project are as follows:

- To design and fabricate a conveyor system along with the proper installation of motors, webcam, and ultrasonic sensors in the system.
- To control the motion of the conveyor belt.
- Use of image processing and deep learning in precision agriculture.
- To efficiently segregate the potatoes.

## 1.4 Significance of Project

This project will demonstrate the effective sorting of potatoes or any other object based on their size(area). The project has potential to scale up in Nepalese vegetable markets & departmental stores. It improves the accuracy of segregation along with the possibilities to use different sizes of produces for various specific purposes thus customer choice for same product increases with varying price options as well. It saves the excess potato that gets peeled off for unusual shapes. Fast Food Stores, Restaurants, households get benefited. Also export of such sorted produces improves market. Since the cost of project is also affordable, even the small-scale industries can implement it.

# CHAPTER TWO: LITERATURE REVIEW

A prototype inspection station based on the United States Department of Agriculture (USDA) inspection standards was developed for potato grading. The station consisted of an imaging chamber, conveyor, camera, sorting unit, and personal computer for image acquisition, analysis, and equipment control. A sample of 9.1kg (201b) of pre-graded potatoes was evaluated in three separate experimental runs to assess the system performance. The system correctly classified 80%, 77%, and 88% of the moving potatoes in the three runs at 3 potatoes/min, and 98%, 97%, and 97%, in three runs of stationary potatoes. Shape Analysis was adversely affected by the potato motion, and this contributed to the misclassification error.

Rios-Cabrera determined potato quality evaluating physical properties using Artificial Neural Networks (ANN's) to find misshapen potatoes. The results showed that FuzzyARTMAP outperformed the other models due to its stability and convergence speed with times as low as 1 ms per pattern which demonstrates its suitability for real-time inspection. Several algorithms to determine potato defects such as greening, scab, cracks were proposed. (Rios-Cavrra, 2018)

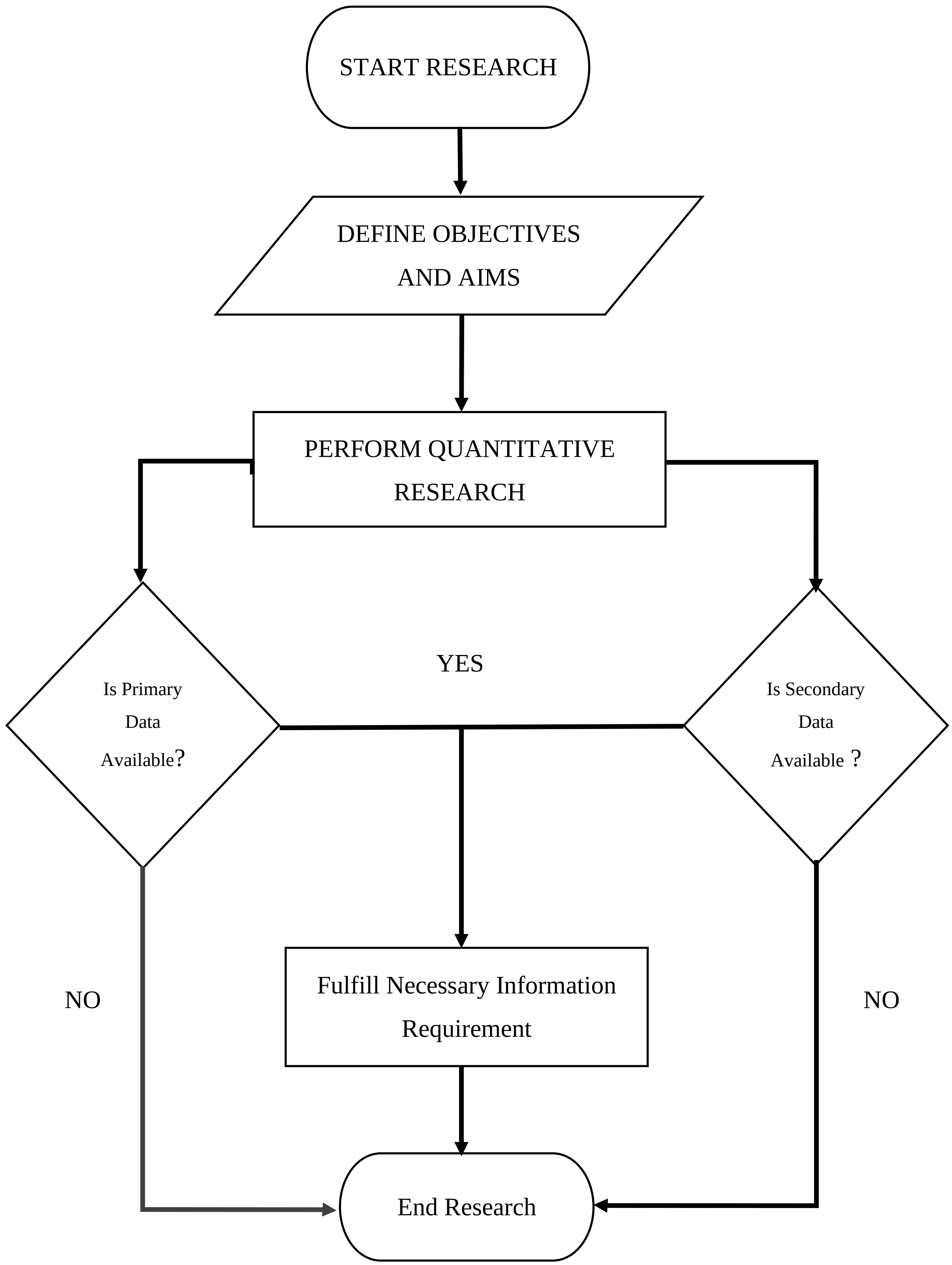
Barnes introduced novel methods for detecting blemishes in potatoes using machine vision. The results show that the method is able to build "minimalist" classifiers that optimize detection performance at low computational cost. In experiments, minimalist blemish detectors were trained for both white and red potato varieties, achieving 89.6% and 89.5% accuracy respectively.

In the journal "Sensors" in 2019. This paper presents a study in which a computer vision system was developed using OpenCV to automatically segregate solid waste materials into different categories. The system was trained on a dataset of images of waste materials, and was able to accurately classify materials into different categories such as plastic, metal, and paper.

The study found that the system was able to achieve an accuracy of over 90% in classifying materials, which is significantly higher than the accuracy of manual inspection methods.

## CHAPTER THREE: RESEARCH METHODOLOGY

### 3.1 Study Design



### 3.1.1 Source of Data and information

For the completion of the project, necessary data were accumulated both through primary and secondary sources. We went through many websites to gather information about the materials, design, technology. Research papers on similar projects that were available online helped to carry idea and develop achievable goals.

#### 3.1.1.1 Primary Sources of Data

Following methods had been adopted to collect the primary data required:

- Information and ideas were taken from Collogues having experience working on similar projects.
- Documentation of different python library

#### 3.1.1.2 Secondary Sources of Data

For secondary data, these were some sources:

- Research Papers
- Journals
- Websites like Kaggle, reddit

## 3.2 Problem Analysis

Traditional methods of sorting based is still prevalent in Nepalese Agricultural and Industrial sectors. It is not seen as an issue until now though automated sorting environment has become prevalent in western agricultural and industrial sectors. Even in the warehouses there are is lack of effective automated systems to segregate objects. Some problems that Nepalese agricultural sector face due to traditional/ manual segregation methods are as follows:

- Expensive method and time consuming.
- Tedious for the workers.

## 3.3 Design Selection

The problem as seen can be addressed by developing an automated object sorting machine using combination of machine learning, machine vision and conveyor system with addition of some other necessary components. As per the pre-requisites of the agricultural product and industrial product that is to be sorted, changes in the program and environment can be provided. For our design, the aim is to segregate the potatoes.

# CHAPTER FOUR: TECHNICAL DESCRIPTION

## 4.1 Overview

### 4.1.1 Open CV

OpenCV (Open Source Computer Vision) is a library of computer vision algorithms and utilities that can be used for many different applications, including image and video processing. In the context of segregating potatoes, OpenCV is used to analyze images or video of potatoes and identify individual potatoes based on their shape, size, and other characteristics. This information could then be used to separate the potatoes into different groups or categories, such as by size or grade.

To use OpenCV for potato segregation, we first capture images or video of the potatoes using a camera or other imaging device. We then use OpenCV's image analysis and processing functions to identify and analyze the individual potatoes in the real time. This involve applying various image filters and algorithms to extract features from the potatoes and use them to classify the potatoes into different groups.

Once the potatoes have been segregated, we use OpenCV to automatically control a sorting / conveyor system to physically separate the potatoes into different bins or containers based on their classification. This would allow for efficient and automated potato segregation, without the need for manual sorting.

### 4.1.2 Deep Learning

Deep learning is a type of machine learning that involves using large neural networks to learn complex patterns and relationships in data. It is a powerful technique that has been applied to many different fields, including computer vision, natural language processing, and speech recognition.

In the context of using OpenCV for potato segregation, deep learning is applied to enhance the accuracy and performance of the image analysis and classification algorithms. By training a deep learning model on a large dataset of labeled potato images, the model can learn to recognize and differentiate between different types of potatoes based on their visual features. This allows for more accurate and reliable potato segregation, potentially reducing the need for manual sorting and increasing the efficiency of the process.

To use deep learning for potato segregation with OpenCV, we first collect a large dataset of labeled potato images, where each image is labeled with the correct size or grade of the potato. We then use this dataset to train a deep learning model, such as a convolutional neural network, to recognize and classify the potatoes in the images. Once the model is trained, we integrate it into your OpenCV-based potato segregation system, allowing the system to automatically classify and segregate the potatoes using the deep learning model's predictions.

### 4.1.3 Open CV to segregate according to area

OpenCV is a computer vision library that allows for the manipulation and analysis of digital images. One of the things that it can do is to segregate objects in an image according to their area. This is typically done using a technique called contour detection, which involves identifying the outlines of objects in an image and then measuring the size of the enclosed area.

To perform contour detection, OpenCV first converts the image into a binary image, where the pixels are either black or white. It then applies an algorithm to identify the outlines of objects in the image. This typically involves applying a series of mathematical operations to the image, such as edge detection and thresholding, to identify the boundaries of objects.

Once the outlines of the objects have been identified, OpenCV can then measure the size of the enclosed area. This is typically done by calculating the number of pixels within the contour and then multiplying by the size of each pixel to find the total area.

Once the areas of the objects have been measured, OpenCV can then segregate the objects according to their size. This is typically done by sorting the objects by their area and then dividing them into groups based on size. For example, objects with a small area might be grouped together, while objects with a large area might be grouped into a separate category.

In summary, OpenCV can segregate objects according to their area by using contour detection to identify the outlines of objects in an image and then measuring the size of the enclosed area. This allows for the automatic grouping of objects based on their size, which can be useful for a variety of applications in computer vision and image analysis. (Library)

### 4.2 Conceptual Framework

We came up with an idea to design and fabricate conveyor belt and integrate it with image processing. The system consists of a software section and a hardware section. The former comprises the computer, the camera, and the micro controller, and the software section uses Open CV to process images. The reason for selecting OpenCV was its high power in analyzing color images and its powerful image-processing functions along with its faster execution. OpenCV being open source platform was a plus point.

The image processing section requires the following:

#### 4.2.1 Data Acquisition

The Image acquisition system first takes pictures in different directions with a digital camera. To provide suitable lighting, the potatoes are placed on a white plate before taking the pictures with the digital camera. Then, the obtained pictures are pre-processed to reduce their noise and improve their contrast. In the proposed method, first the required pictures were taken with a digital camera. Subsequently, the noise elimination and contrast improvement operations were conducted on the images.

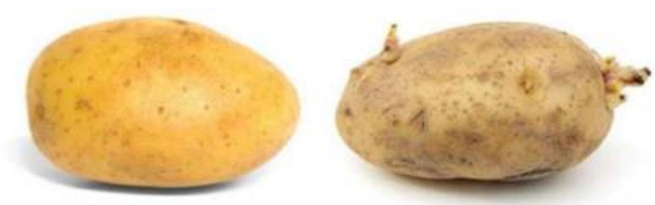


*Figure 1Potato Sample*

#### 4.2.2 Creating Datasets

After collecting the images. Datasets were created using those images. In our system we prepared data set of 43 images in different condition. Sample of the data sets are as follow:

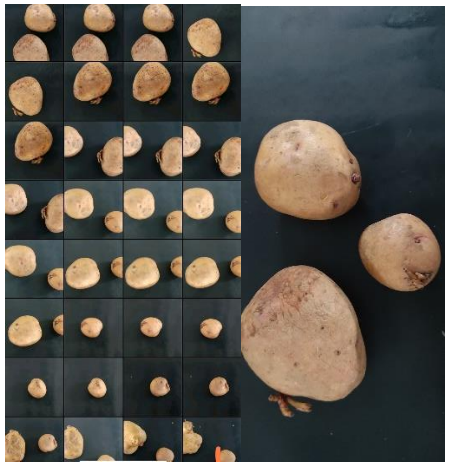


*Figure 2 Potato Dataset*

After creating the dataset we trained our computer to recognizie the image that we sent in real time. We used Mask R-CNN in order to train our compuer. Mask R-CNN is a Convolutional Neural Network (CNN) and state-of-the-art in terms of image segmentation. This variant of a Deep Neural Network detects objects in an image and generates a high-quality segmentation mask for each instance. In order to create mask around our subject(potatoes) we use an open source project called Make Sense. Make Sense.AI  is an open source project which helps to create annotations for our dataset. Each 43 images were loaded in the project and mask were created in each individual images using polygon.

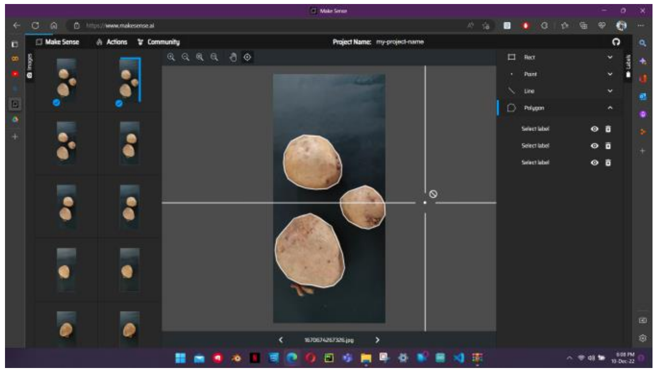



*Figure 3 R-CNN Training*

After creating the annotation, we created a train.h5 model in order to train our system.

### 4.2.3 Potato Classification

Initially, we used a deep learning algorithm, Convolutional Neural Network to classify whether the vegetable object is potato or not. In order to do it, we used the Fruits-360 dataset which consists image data with following properties:

Total number of images: 90483.

Training set size: 67692 images (one fruit or vegetable per image).

Test set size: 22688 images (one fruit or vegetable per image).

Multi-fruits set size: 103 images (more than one fruit (or fruit class) per image)

Number of classes: 131 (fruits and vegetables).

Image size: 100x100 pixels.

*Figure 4 Fruits and Vegetable Dataset*

The following code represented the CNN model:

```
from keras import layers
from keras import models

model = models.Sequential()
model.add(layers.Conv2D(32,(3, 3), activation='relu',
                        input_shape=(128, 128, 3)))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Conv2D(64,(3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Conv2D(128,(3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Conv2D(128,(3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Flatten())
model.add(layers.Dense(512,activation='relu'))
model.add(layers.Dense(2,activation='softmax'))
```

*Figure 5 CNN Train Code*

The model summary for the neuron layers is represented below:

```
model.summary()

Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 126, 126, 32)      896

 max_pooling2d (MaxPooling2D  (None, 63, 63, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 61, 61, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 30, 30, 64)       0
 2D)

 conv2d_2 (Conv2D)           (None, 28, 28, 128)       73856

 max_pooling2d_2 (MaxPooling  (None, 14, 14, 128)      0
 2D)

 conv2d_3 (Conv2D)           (None, 12, 12, 128)       147584

 max_pooling2d_3 (MaxPooling  (None, 6, 6, 128)        0
 2D)

 flatten (Flatten)           (None, 4608)              0

 dense (Dense)               (None, 512)               2359808

 dense_1 (Dense)             (None, 2)                 1026

=================================================================
```

*Figure 6 Model Layers*

### 4.2.4 Model Accuracy

The model achieved an accuracy of 98.95% for the test set, and accuracy for validation 100%, and accuracy for training 97.45%.

```
test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size = (128,128),
    batch_size = 20,
    class_mode = 'categorical')
test_loss, test_accuracy = model.evaluate_generator(test_generator, steps= 50)
print('test_acc :', test_accuracy )
test_acc : 0.9895266278
```

*Figure 7 Accuracy Test*

Thus 98.95 % test accuracy means, 98.95 times, the model is able to identify potatoes correctly from a set of 100 vegetables.

In order to train our model, we needed high computing power and GPU power so we used  google collab in order to train and test our model.

### 4.2.5 Potato Segregation

Open CV is used to track the potato moving over a conveyer belt to generate contour over it. Then, the area of contour is calculated in $mm^2$. The contours then were label under different categories.

Large Potatoes: 75000-80000

Medium Potatoes: 45000-50000

Small Potatoes: 4000-10000

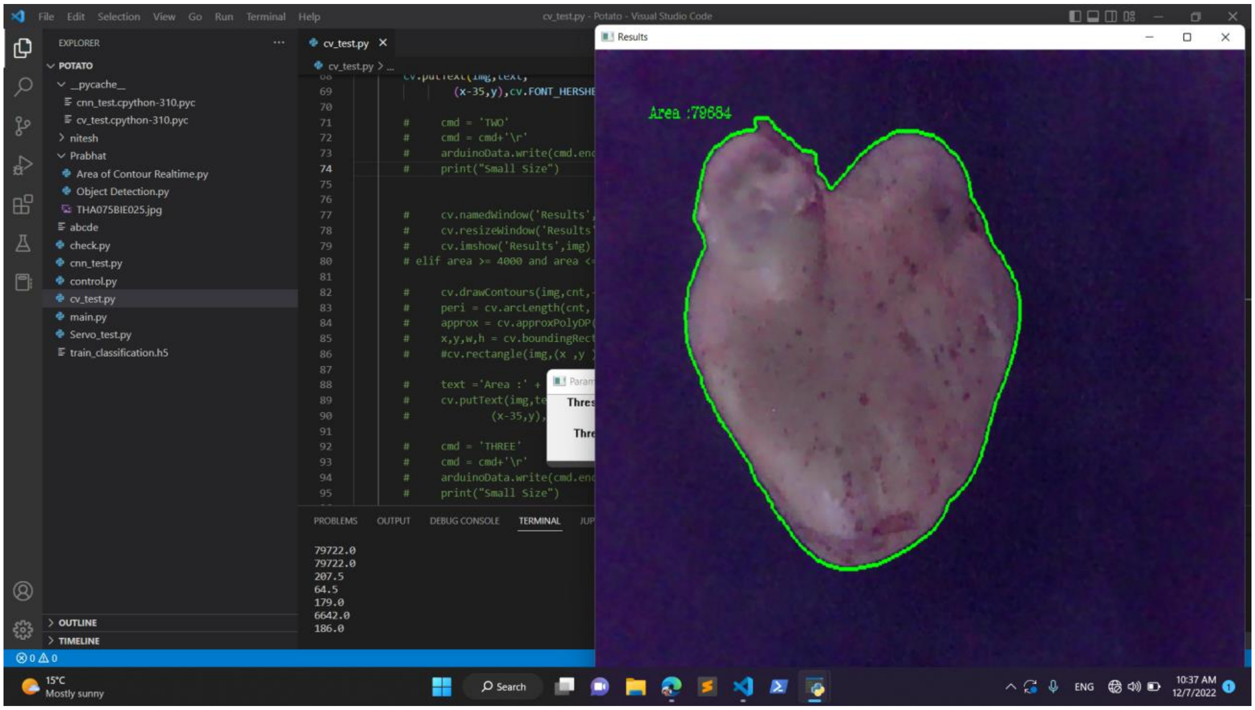



*Figure 8 Contour Generation*

*Note: The area may vary according to the position of the camera, contour detected under different lighting conditions*

### 4.2.5.1 Video Streaming through webcam

```
cap = cv.VideoCapture(1)
while True:
    bool, img = cap.read()
    #img = cv.imread('download.jpeg')
    imgGray = cv.cvtColor(img,cv.COLOR_BGR2GRAY)
    imgBlur = cv.GaussianBlur(imgGray, (7,7),1)
    thres1 = cv.getTrackbarPos('Threshold1','Params')
    thres2 = cv.getTrackbarPos('Threshold2','Params')
    imgCanny = cv.Canny(imgBlur,thres1,thres2)

    kernel = np.ones((5,5))
    imgDil = cv.dilate(imgCanny,kernel,iterations = 1)
    contours,_ =cv.findContours(imgDil,cv.RETR_EXTERNAL,cv.CHAIN_APPROX_NONE)
```

### 4.2.5.2 Generating Contour and Calculating Area

```
for cnt in contours:
    area = cv.contourArea(cnt)
    print(area)
    if area >= 4000 and area <=10000:
        print('Small Potato')

        cv.drawContours(img,cnt,-1,(0,255,0),2)
        peri = cv.arcLength(cnt, True)
        approx = cv.approxPolyDP(cnt,0.02*peri,True)
        x,y,w,h = cv.boundingRect(approx)
        #cv.rectangle(img,(x ,y ),(x+w ,y+h ),(255,0,0),4)

        text ='Area :' + str(int(area))
        cv.putText(img,text,
                (x-35,y),cv.FONT_HERSHEY_COMPLEX,0.4,(0,255,0),1)

        cmd = 'ONE'
        cmd = cmd+'\r'
        arduinoData.write(cmd.encode())
```

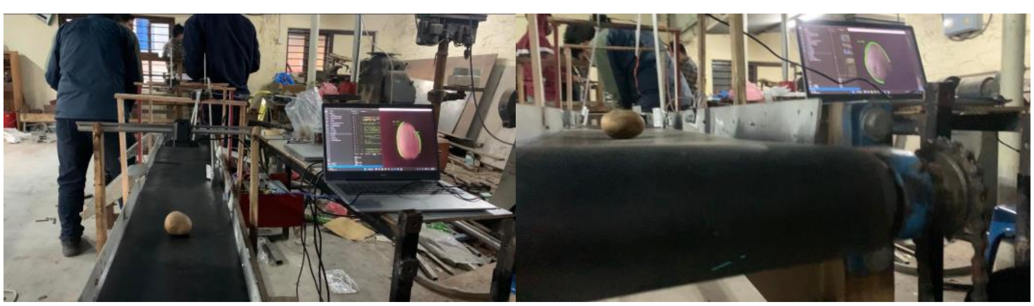


*Figure 9 Working Test*

#### 4.2.5.3 Noise Filtration

In order to generate a perfect contour around the subject (Potato) suitable lighting condition and high-resolution camera is need. Due to unwanted lighting condition certain noises were detected. In order to reduce the noises we adjusted our threshold and params by hit and trial method.

```
def empty(a):
    pass

cv.namedWindow('Params')
cv.resizeWindow('Params',640,90)
cv.createTrackbar('Threshold1','Params',103,255,empty)
cv.createTrackbar('Threshold2','Params',39,255,empty)
```

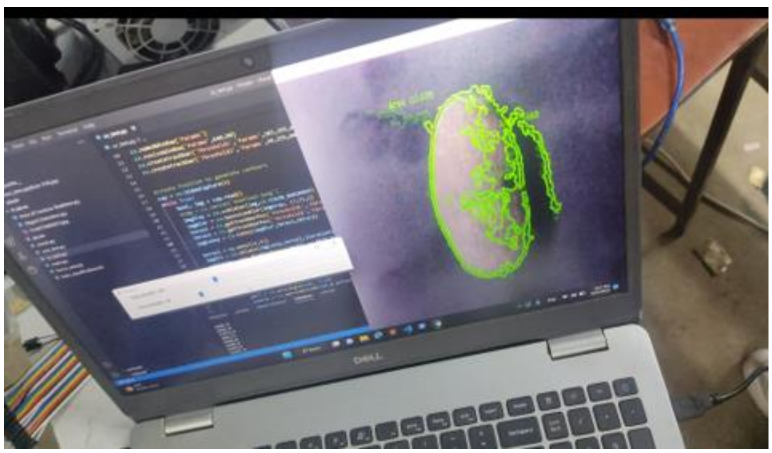


*Figure 10 Noise in Contour*

### 4.2.6 Communicating with hardware

In order to communicate our software to hardware we used Arduino Uno. Since the major part of our project were writing in python programming language, we needed to create a bridge between the two. A simple logic was created in order to achieve it. First, once contours of certain label were identified we encoded a character which were separated by '\r' character and was passed into Arduino using serial port and once the character were read by Arduino certain function were triggered.

```python
import serial
arduinoData = serial.Serial('com3', 9600)


area = 6
while True:
    if area < 5:
        cmd = 'ONE'
        cmd = cmd+'\r'
        arduinoData.write(cmd.encode())
        print("Small Size")

    elif area >=5 & area <10:
        cmd = 'TWO'
        cmd = cmd+'\r'
        arduinoData.write(cmd.encode())
        print("Medium Size")

    else:
        cmd = 'THREE'
        cmd = cmd+'\r'
        arduinoData.write(cmd.encode())
        print("large Size")
```

```cpp
void loop()
 {
  while(Serial.available()==0){

  }
  myCmd=Serial.readStringUntil('\r');
  // Serial.println(myCmd);

  if (myCmd == "ONE"){
  digitalWrite(trigPin1, HIGH);
  delayMicroseconds(1000);
  digitalWrite(trigPin1, LOW);
  duration1 = pulseIn(echoPin1, HIGH);
  distance1 = (duration1/2) / 29.1;
  // Serial.println(distance1);
  delay(1500);
```

### 4.2.7 Mechanically Sorting the potatoes

In order to mechanically sort the potatoes according to the size we used ultrasonic sensor and servo motor. Ultrasonic sensors were used to detect the position of potatoes in the conveyor belt and to trigger the servo motor. Altogether 3 ultrasonic sensors and 3 servo motors were used. Each pair were triggered according to the contour label.

```
void loop()
 {
  while(Serial.available()==0){

  }
  myCmd=Serial.readStringUntil('\r');
  // Serial.println(myCmd);

  if (myCmd == "ONE"){
  digitalWrite(trigPin1, HIGH);
  delayMicroseconds(1000);
  digitalWrite(trigPin1, LOW);
  duration1 = pulseIn(echoPin1, HIGH);
  distance1 = (duration1/2) / 29.1;
  // Serial.println(distance1);
  delay(1500);

   if (distance1<=20 and myCmd=="ONE"){
   for(p=0;p<=100;p=p+2)
   {
     motor1.write(p);
     delay(20);
   }
   for(p=100;p>=0;p=p-2)
   {
     motor1.write(p);
     delay(20);
   }

   }
   }
```

```
if (distance2<=20 and myCmd=="TWO"){
for(q=100;q>=0;q=q-2)
{
  motor2.write(q);
  delay(20);
}
 for(q=0;q<=100;q=q+2)
{
  motor2.write(q);
  delay(20);
}
}
}
```

# CHAPTER FIVE: DESIGN AND FABRICATION

## 5.1 Design Selection

### 5.1.1 Wooden Frame

The support for the flat belt conveyor is a wooden frame/structure. The legs are of 700mm*50mm*50mm. The belt bed is of width 280mm and length 1745mm.

Operations: Cutting, Grinding, Drilling

Tools: Hacksaw, Drill bit-10mm, Grinder, Measuring tape, Hammer, Sand Paper

### 5.1.2 Servo Motor and Camera Holders

On both sides of the frame wooden ply of dimension of 39cm*3cm*1cm are screwed and another wooden ply of 350mm*30mm*10mm on top.

On both sides of the frame wooden ply of dimension of 390mm*30mm*10mm are screwed and a metal plate on top.

Operations: Cutting, Grinding, Drilling

Tools: Hacksaw, Drill bit-10mm, Grinder, Measuring tape, Hammer, Sand Paper

### 5.1.3 Conveyor guide rails

A L-guide rail of 1700mm length is used. Dimension: 55mm*50mm

### 5.1.4 Conveyor roller

The roller comprises a roller body and a driving force receiver connected and disconnected by a sprocket driven by separate rotation driving means. When the driving force receiver is driven, the roller body is driven and rotated by engagement of the driving force receiver and the roller body.

Dimensions: Internal Diameter = 10mm

External Diameter = 40mm

Operations: Turning, Cutting, Welding, Drilling

Tools: Lathe Machine, Welding Machine, Drill-bit 18mm, Abrasive

*Figure 11 Roller*

### 5.1.5 Sprocket and Chain Drive

A sprocket is a simple mechanical wheel with teeth or small notches which are designed to rotate and engage with the links of a chain. Sprocket of tooth no. 16 and internal diameter 25mm is used.

A drive chain is used to transmit power from motor sprocket to the conveyor roller.

### 5.1.6 Pillow Block Bearing

A pillow block bearing, or a bearing housing or plummer block, is a pedestal that is used to prove support for a rotating shaft with compatible bearings.

Pillow block bearing of  2" Shaft, 6-15/32" to 6-31/32" Bolt Hole Spacing is used.

*Figure 12 Bearing and Housing*

### 5.1.7 MG996R Servo Motor

Features:

- Operating Voltage is +5V typically

- Current: 2.5A (6V)
- Stall Torque: 9.4 kg/cm (at 4.8V)
- Maximum Stall Torque: 11 kg/cm (6V)
- Operating speed is 0.17 s/60°
- Gear Type: Metal
- Rotation : 0°-180°
- Weight of motor : 55gm
- Number : 3

*Figure 13 MG996R Servo Motor*

### 5.1.8 Driving Motor

The motor used to drive conveyor roller is Toyota Wiper Motor.

Features:

- Motor Operation Voltage:12V
- Speed: 55 Rpm
- No load current: 2A
- Stall current: 10A
- Stall Torque: 45 kg-cm
- Motor Power: 120W
- Shaft diameter: 10mm
- Shaft dimension: 29mm
- Weight:1280gr
- Number: 1

*Figure 14 Wiper Motor*

### 5.1.9 Arduino UNO

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller.

Features:

- The operating voltage is 5V
- The recommended input voltage will range from 7v to 12V
- The input voltage ranges from 6v to 20V
- Digital input/output pins are 14
- Analog i/p pins are 6
- DC Current for each input/output pin is 40 mA
- DC Current for 3.3V Pin is 50 mA
- Flash Memory is 32 KB
- SRAM is 2 KB
- EEPROM is 1 KB
- CLK Speed is 16 MHz
- Number: 1

*Figure 15 Arduino Uno*

### 5.1.10 Camera

In order to capture image in real time and send it to python we used an external webcam of 1080MP resolution. In order to achieve higher accuracy higher resolution camper can be used.

*Figure 16 Webcam*

### 5.1.11 Belt

As a part to convey material we used synthetic rubber belt. Synthetic conveyor belts are made of fabrics with a coating on the top and/or bottom side. A belt consists of one or more fabric plies to give certain features such as strength, stability and impact resistance.

Properties:

Coefficient of friction, $\mu$=0.3

$\sigma$=2.6N/mm$^2$

*Figure 17 Belt*

### 5.1.12 Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal.


*Figure 18 Ultrasonic Sensor*

### 5.1.13 Other Components

In order make our project complete we used other components like:

Jumper Wire, Bread Board, Power Supply, Adaptor

# CHAPTER SIX: DESIGN AND DIMENSIONS

## 6.1 Frame Work

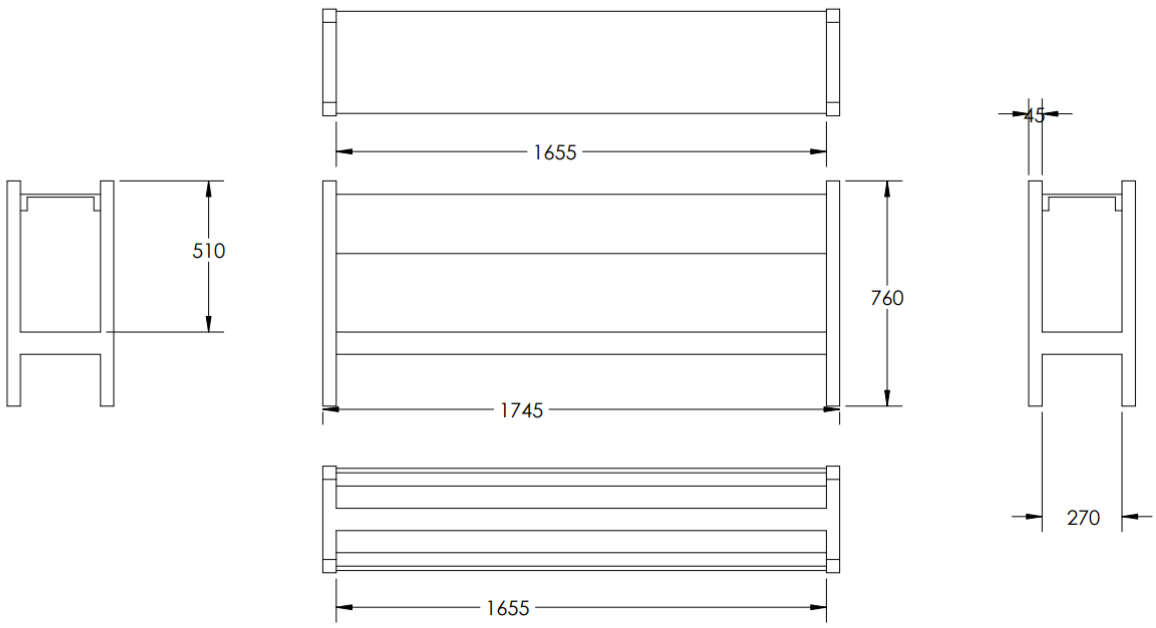



*Figure 19 Table Dimensions*

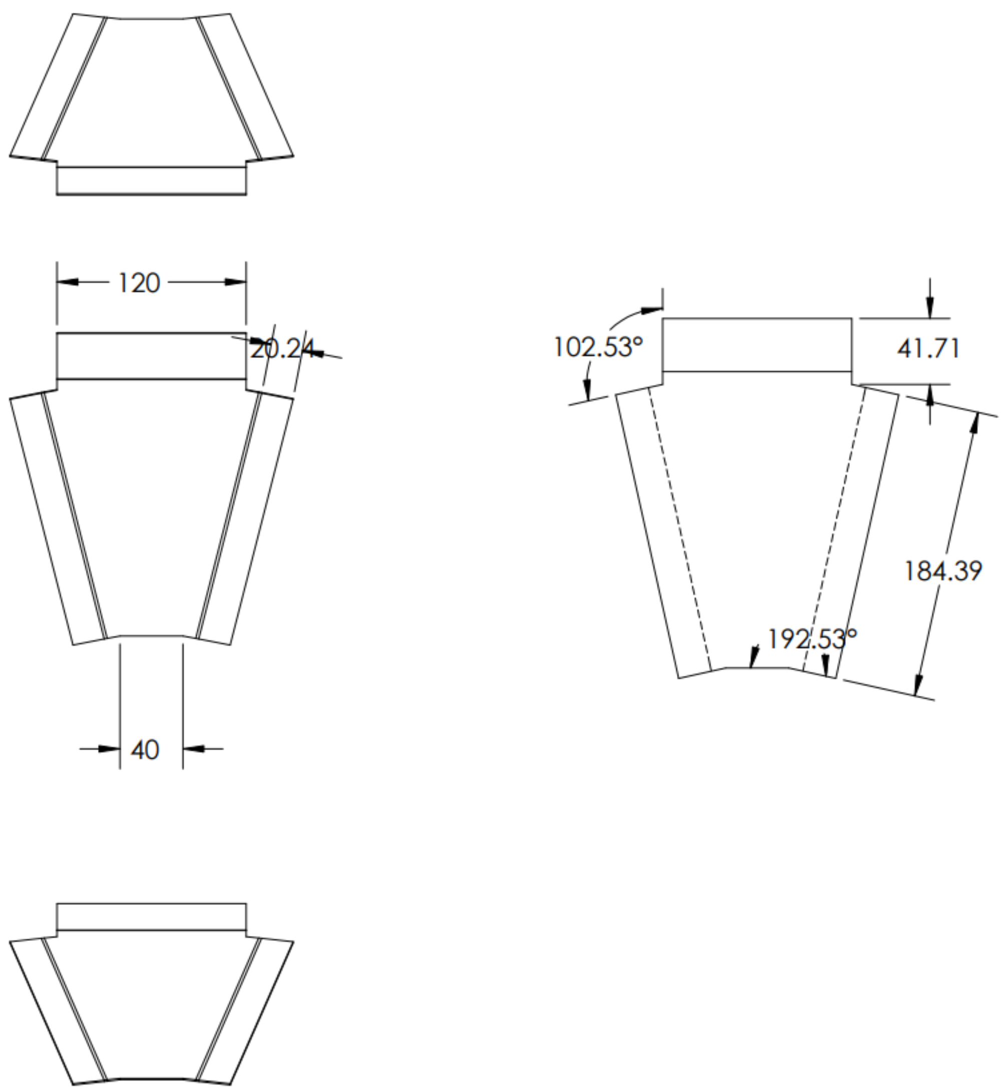



*Figure 20 Passage*

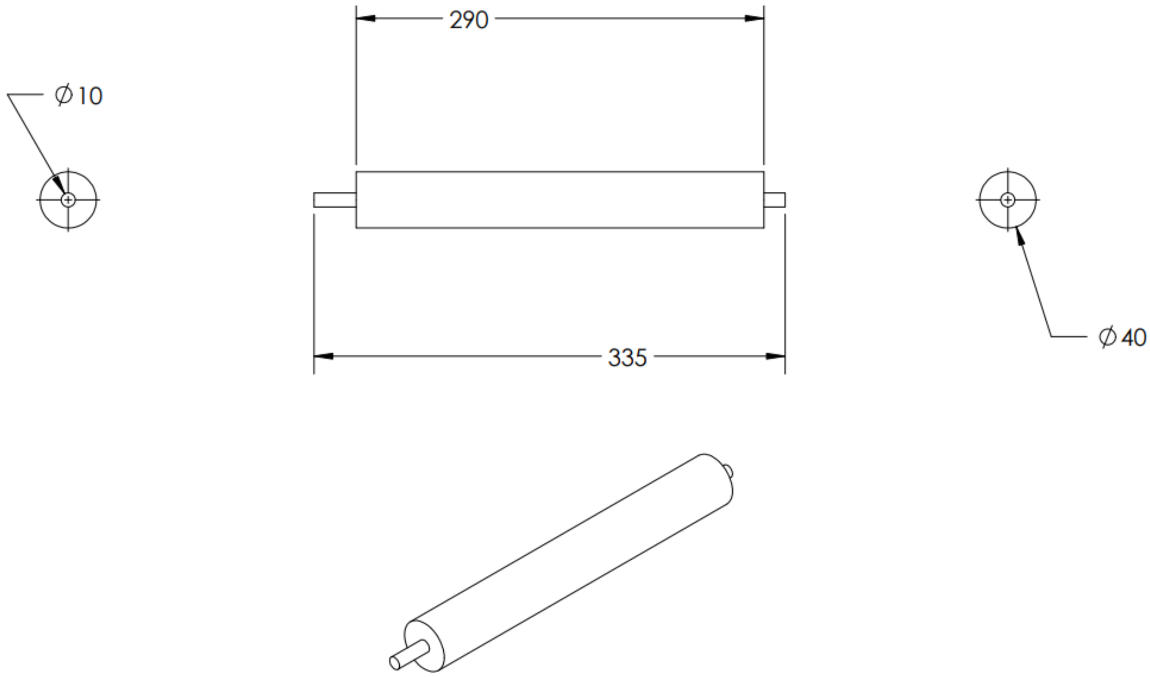



*Figure 21 Roller*

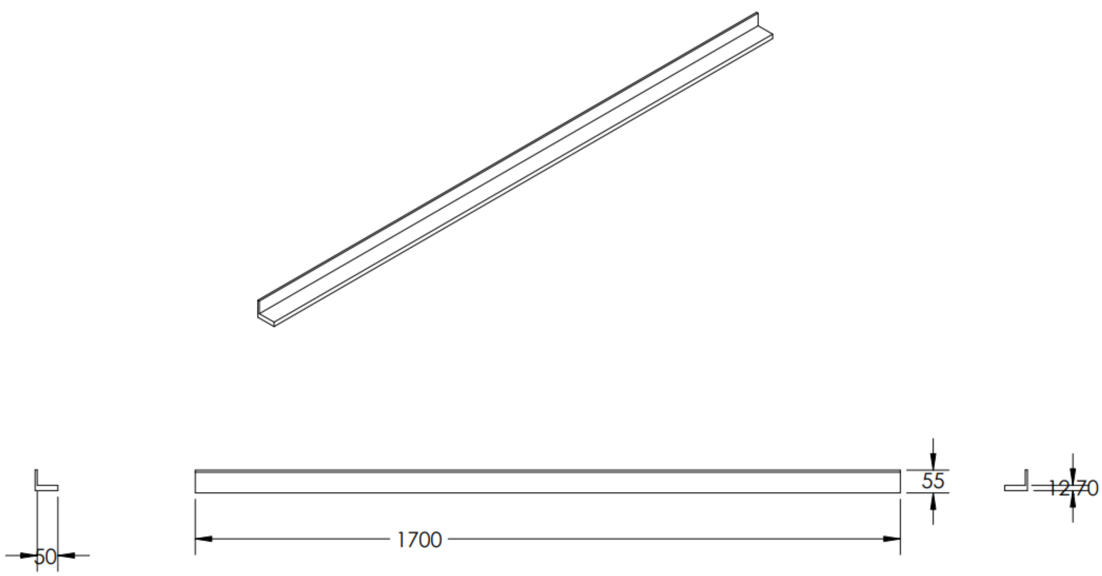



*Figure 22 Guide*

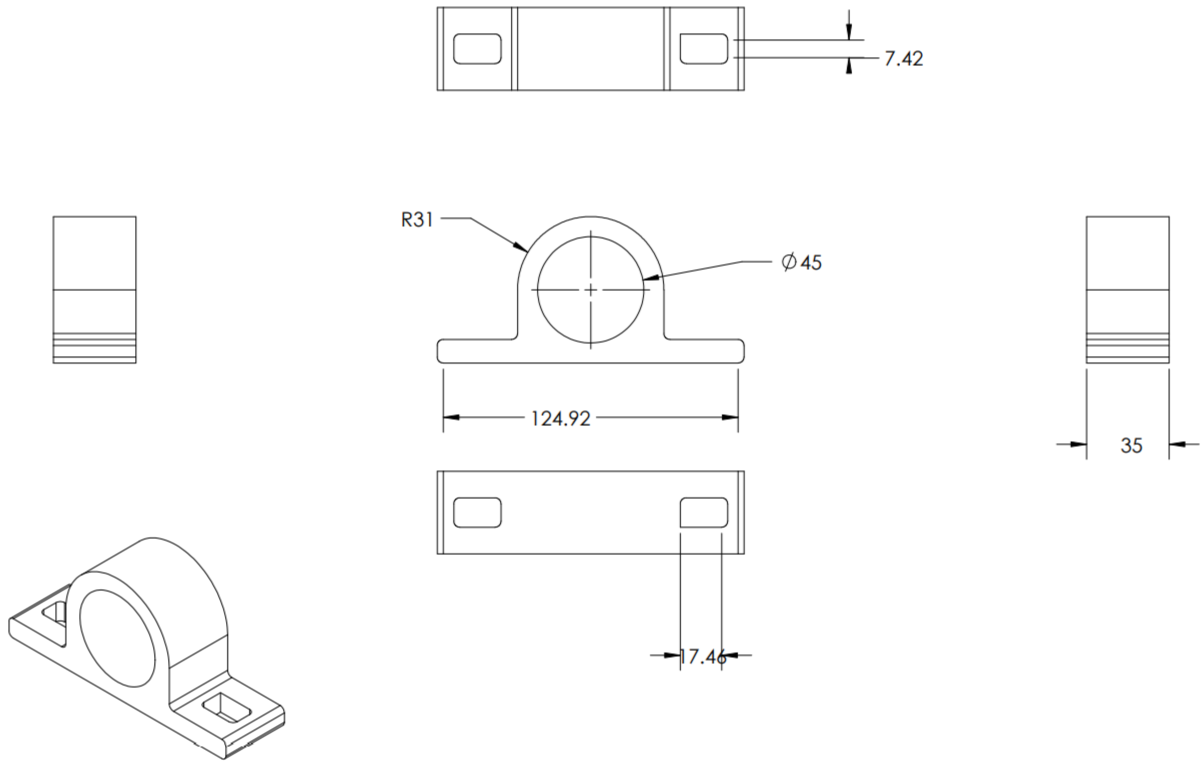



*Figure 23 Bearing Housing*

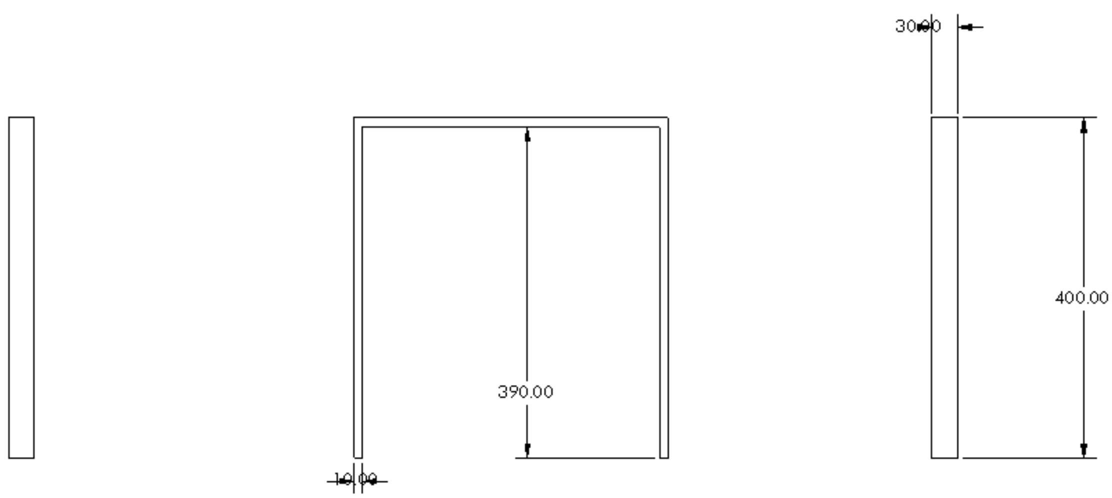



*Figure 24 Holder*

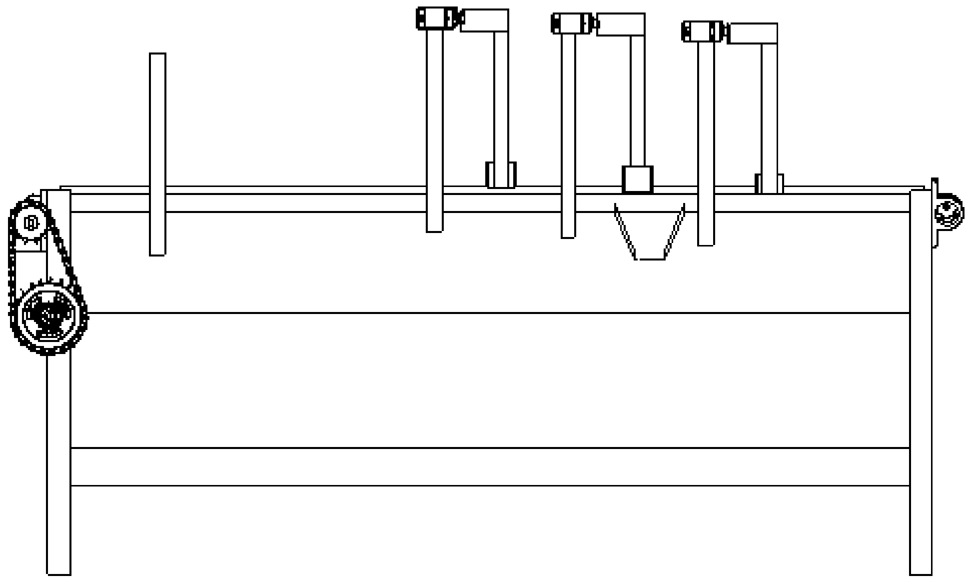


*Figure 25 Final Design*

*Figure 26 Actual System*

## CHAPTER SEVEN: DATA ANALYSIS

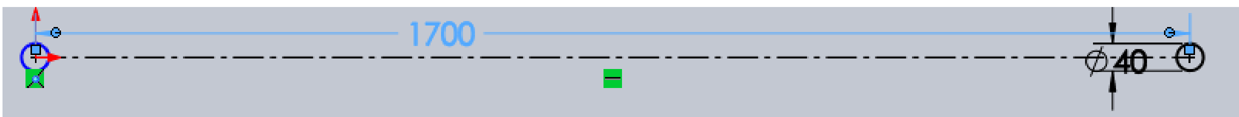
### 6.1 Calculations

### 6.1.1 Length of Belt

R= Radius of Roller

D= Diameter of Roller

C= Distance between the center of two rollers




R = 20mm

D = 40mm

C = 1700mm

Length of belt (L) = $2C+2\pi R$

$= 2*1700+ 2*\pi*20$

= 3525.66 mm

This value is theoretical value in order to avoid slippage and to drive the belt the length should be greater than the theoretical value.

Actual length of the belt = 3535 mm

### 6.1.2 Power of Conveyer Belt

Length of belt (L) = 3535mm

Width of belt (W) = 240mm

Thickness of belt (T) =2.5mm

Volume (V) = L*W*T

= $0.00212m^3$

Density of belt ($\rho$) = 1360 kg/m3

Weight of belt (W) = $\rho$*V

=2.88456kg

Average weight of potato = 280 gram

Number of potatoes = 4

Weight of material on belt (w) = 280*4

= 1120 gram

= 1.12 kg

Linear speed = 0.01 m/s

Coefficient of friction = 0.5

Total Weight = 4.00456 kg

Consider, factor of safety Total Weight = 8kg

Required Belt pull = Total Weight* Coefficient of friction

=4 N

Required Power = Belt pull * Belt Speed

= 40 watt

Wiper motor Specification Power is 120 Watt and speed is 55 rpm which is sufficient to drive our belt system.

**6.1.3 Angle of contact between belt and pulley/ Angle of embrace**

$\sin\alpha = (R1+R2)/C$

$= (20+20)/1700$

$= 0.0235$

$\alpha$= 1.34826 degree

$\theta$=180+2$\alpha$

= 180 +(2*1.34826)

= 182.69652 degree

= 3.1886 rad.

### 6.1.4 Tension between the belts

2.3log(T1/T2) = $\mu\theta$

For rubber, coefficient of friction, $\mu$=0.3

$\sigma$=2.6N/$mm^2$,

T1 = $\sigma$*W*T

= 2.6*240*2.5

= 1560 N

Hence 2.3log(T1/T2) =0.3*3.1886

T2=1030 N

### 6.1.5 Torque Calculation for Flipper

Average weight of potato (w) = 280gm

= 0.28kg

Length from the center (r) = 35cm

= 0.35m

Required torque (T) = w*g*r

= 0.26*10*0.35

= 0.91 N-m

Servo motor torque is 9.4 kg/cm which is sufficient for our flipper.

### 6.2 Cost Estimation

| S.N | Material | Specification/Dimensions(mm) | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 1 | Wood Lumbers | Total length= 5835mm<br>Width =10mm<br>Thickness =10mm | | 2400 | ₹ 5000 |
| 2 | Nuts And Bolts | M10 | 15 | ₹ 20.00 | ₹ 300.00 |
| 3 | Washer | 10 | 30 | ₹ 10.00 | ₹ 300.00 |
| 4 | Bearing and Housing | Internal Diameter=<br>External Diameter= | 4 | | |
| 5 | Servo Motor | MG996R Metal Gear | 3 | ₹ 899.00 | ₹ 2,697.00 |
| 6 | Wiper Motor | 120Watt | 1 | ₹ 10,000.00 | ₹ 10,000.00 |
| 7 | Belt | Total length=<br>Width =<br>Thickness = | | | ₹ -<br>₹ -<br>₹ - |
| 8 | Webcam | 1080P | 1 | ₹ 1,000.00 | ₹ 1,000.00 |
| 9 | Micro Controller | Arduino Uno | 1 | ₹ 1,500.00 | ₹ 1,500.00 |
| 10 | Jumper Wires | Male to Male pair | 1 | ₹ 150.00 | ₹ 150.00 |
| | | Male to Female pair | 1 | ₹ 150.00 | ₹ 150.00 |
| | | Female to Female pair | 1 | ₹ 150.00 | ₹ 150.00 |
| 11 | Bread Board | 400pts | 1 | ₹ 130.00 | ₹ 130.00 |
| 12 | Power Supply | Output: 5V 12V DC | 1 | ₹ 1,000.00 | ₹ 1,000.00 |
| 13 | Sheet Metal | Length=<br>Thickness = | | | ₹ -<br>₹ - |
| 14 | Spray Paint | Black | 2 | ₹ 250.00 | ₹ 500.00 |
| 15 | Wood Paint | | 1 | | |
| | | | | Total Cost | ₹ 22877 |

### 6.3 Economic Analysis

let us assume that the system operates 20hr a day and 30 days a month.

Total power consumed by the System:

Power consumed by Servo motor: 15Watt (2.5 amps at 6 volts)

Power consumed by Wiper motor: 50Watt (4.2amps at 12 volts)

Power Consumed by micro controller: 0.29Watt (42mA at 7 volts)

Total Power Consumed = Power consumed by Servo motor+ Power consumed by Wiper motor+ Power Consumed by micro controller

= (15 + 50 + 0.29) Watt

= 65.29 Watt

Total Operating Time: 20hr

Total Power Consumed/day = Total power Consumed*Total Operating Time

= 65.29 Watt * 20 hr

= 1305.8 Whr

= 1.3058 kwh

Unit Cost of Electricity: Rs. 9.370 (For Business Purpose)

Total Operating Cost/month = Total Power Consumed/month* Unit Cost of Electricity

= 1.3058 * 30 * 9.3750

= Rs. 367. 25625

= Rs 368

Let the Annual maintenance cost = Rs. 10,000

Service life of the system = 10 years

Our system is capable to replace equivalent to 4 labor resources in an Industry.

According to Nepalese government the minimum wage for a worker is Rs 15000

### 6.3.2 Saving in terms of labor replacement

The use of an OpenCV-based system could also potentially save time and labor costs in the long run. Because the system can automatically classify and segregate the potatoes, it would not require manual labor to sort the potatoes. This could potentially reduce the time and labor needed for the segregation process, resulting in cost savings.

In addition, an OpenCV-based system may also be more efficient and accurate than manual labor. Because the system can automatically identify and classify the potatoes based on their visual features, it is less likely to make mistakes or overlook potatoes. This could potentially increase the overall productivity of the potato segregation process, leading to additional cost savings.

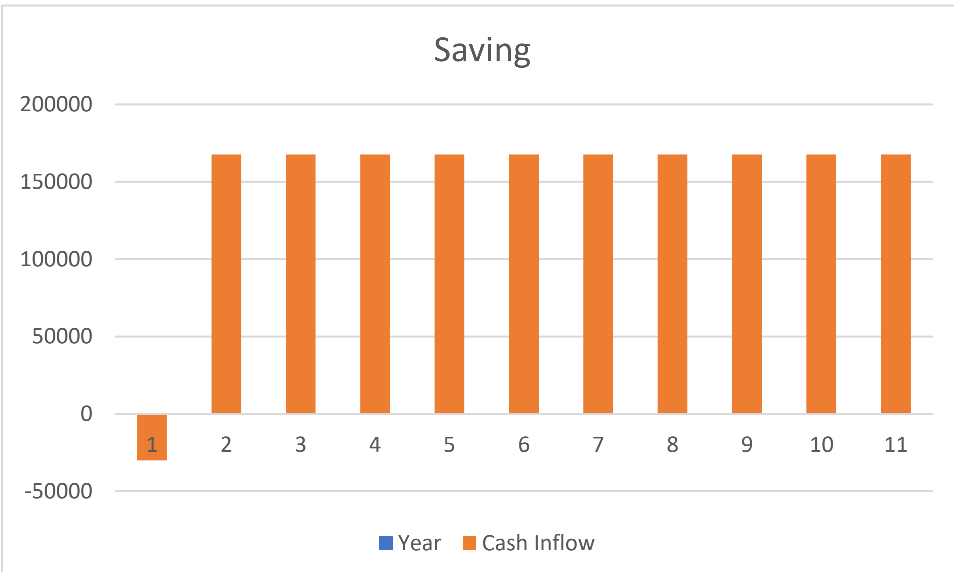



*Figure 27 Saving*

## CHAPTER EIGHT: RESULT AND DISCUSSION

### 7.1 Result Analysis

The sorting machine has been tested successfully with three different labels of potatoes.

The response time taken from recognition of materials till sortation has been recorded and displayed in the chart.

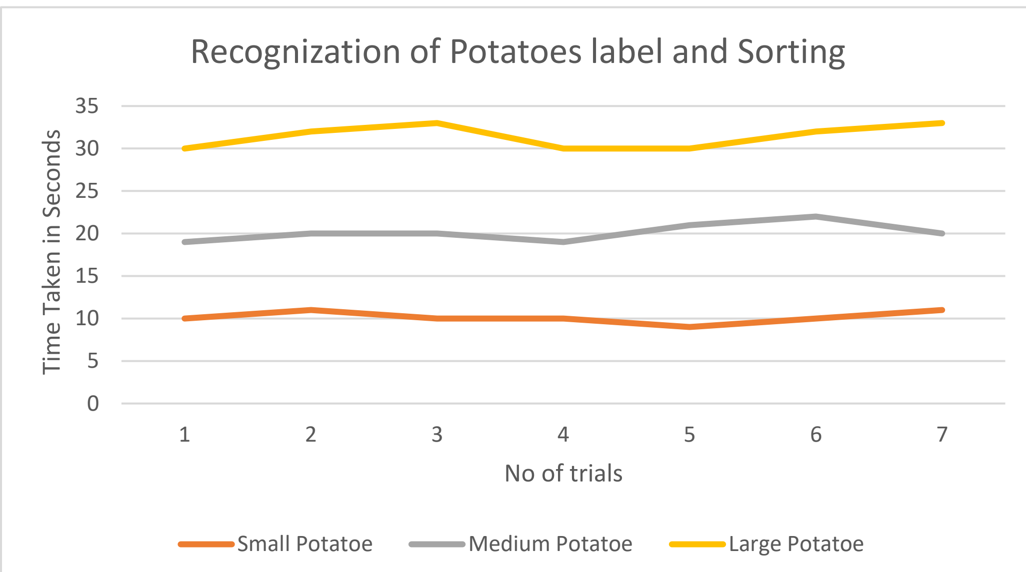



*Figure 28 Test Graph*

### 7.2 Discussion

### 7.2.1 Scope of Image Processing in Agriculture

In agriculture, OpenCV can be used for tasks such as monitoring crop health and growth, detecting pests and diseases, and automating irrigation systems. It can also be used for more specialized tasks such as identifying plant species and predicting yield. Additionally, OpenCV can be used to analyze data from drones and other aerial imaging systems to provide detailed, real-time information about crops. Overall, the potential applications of OpenCV in agriculture are vast and can help improve efficiency, productivity, and sustainability in the industry.

### 7.2.2 Scope of Image Processing in Industry

In industry, OpenCV can be used for tasks such as quality control, object recognition and tracking, and autonomous robots and systems.

For example, in manufacturing, OpenCV can be used to automatically inspect products for defects, such as cracks or scratches on the surface. It can also be used to track and control the movements of robots and other automated systems, ensuring that they operate efficiently and safely. Additionally, OpenCV can be used to analyze data from various sensors, such as temperature and pressure sensors, providing valuable insights and enabling data-driven decision making in industry.

In the transportation industry, OpenCV can be used for tasks such as traffic management and surveillance, as well as autonomous vehicles. For example, it can be used to monitor traffic flow and identify congestion or accidents, enabling traffic authorities to take appropriate action. It can also be used in self-driving cars to recognize and track objects in the environment, such as other vehicles and pedestrians, helping the car make safe and efficient driving decisions.

Overall, the potential applications of OpenCV in industry are numerous and can help improve efficiency, productivity, and safety in various industries. By automating tasks and providing valuable insights from data, OpenCV can help industries operate more efficiently and effectively.

## CHAPTER NINE: CONCLUSION

In conclusion, the project is a successful implementation of computer vision and machine learning technology. The system is able to accurately recognize and classify different materials based on their visual characteristics. This is achieved through the use of machine learning algorithms, which are trained on a large dataset of images to learn the features that distinguish each material.

Once the system is trained, it can be used to automatically sort materials by analyzing images of the materials and assigning them to the appropriate category. This can save time and labor compared to manual sorting, and also improve the accuracy and consistency of the sorting process.

Additionally, the use of OpenCV allows for real-time analysis and processing of images, enabling the system to sort materials quickly and efficiently.

The project also demonstrates the flexibility and adaptability of OpenCV, as it can be applied to a wide range of materials and sorting tasks. By fine-tuning the machine learning algorithms and adjusting the system parameters, the project can be customized to sort different types of materials or handle more complex sorting scenarios.

Overall, the project demonstrates the potential of OpenCV to automate tasks and improve efficiency in various industries. Its ability to accurately recognize and classify objects based on their visual characteristics makes it a valuable tool for a wide range of applications.

# CHAPTER TEN: REFERENCE


JOUR. (2012). *Potato Sorting Based on Size and Color in Machine Vision System.* City: NewYork.

Library, P. (n.d.). Open CV documentation. (p. 100). Python.

Rios-Cavrra. (2018). ANN- Artificial Neural Network. (p. 20). New York.