

PLC Based Material Separation

Submitted in partial fulfillment of the requirement of
University of Mumbai for the Degree of
Bachelor of Engineering

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2020-21



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CERTIFICATE

This is to certify that the project entitled “**PLC Based Material Separation**” is a Bonafide work of “**Aakash Ramakrishnan**” (Roll No. – **MEB801**) submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of “**Bachelor**” in “**Mechanical Engineering**”.

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Abstract

In manufacturing industries products are manufactured in bulk and there exists a need to separate these items. The separation is based on their dimensions, colours, weight, machine vision (image processing), type of material and so on. It is very difficult to install different setups for different parameters. Also installing different setups is not cost efficient. Thus, there is a need for a single setup that works for separation of multiple parameters. The project contributes to the development of a simple PLC setup which segregates the objects based on user defined attribute. The system includes segregation based on type of material (metal and non-metal) and shape of the object (rectangle and triangle). A proximity sensor detects presence of an object. The proximity sensor is installed so as to intimate the Pi camera. A Pi camera captures images of objects moving on the conveyor belt. The camera is connected to the Raspberry Pi that processes the image and gives out the shape as the output. A python code has been developed which assists in detecting shape of the object. A capacitive sensor has been used for detection of metallic objects. A ladder diagram has been programmed to perform both the operations. The ladder diagram has been developed in Delta ISPSOFT software. An HMI has been created to make the interaction user friendly. The HMI has been developed in Delta DOPSOFT software. A visual representation of the whole operation has been created. Factory IO software has been used to make the presentation. The PLC coordinates with sensors and piston valves in order to achieve the desired functionality and demonstrate the fully automated product sorting system.

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Chapter 1

Introduction

A programmable logic controller (PLC) or programmable controller is an industrial digital computer which has been designed and adapted for the control of manufacturing processes. It includes processes such as assembly lines, or robotic devices, or any activity that requires high reliability, ease of programming and process fault diagnosis. PLCs can range from small modular devices with tens of inputs and outputs (I/O), in a housing integral with the processor, to large rack-mounted modular devices with a count of thousands of I/O, and which are often networked to other PLC and SCADA systems.

They can be designed for many arrangements of digital and analog I/O, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory.

PLCs were first developed in the automobile manufacturing industry to provide flexible and easily programmable controllers to replace hard-wired relay logic systems. Since then, they have been widely adopted as high-reliability automation controllers suitable for harsh environments. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.



Figure 1.1 Programmable logic controller

1.1 Construction

A PLC is an industrial microprocessor-based controller with programmable memory used to store program instructions and various functions. It consists of:

- a processor unit (CPU) which interprets inputs, executes the control program stored in memory and sends output signals,
- a power supply unit which converts AC voltage to DC,
- a memory unit storing data from inputs and program to be executed by the processor,
- an input and output interface, where the controller receives and sends data from/to external devices,
- a communications interface to receive and transmit data on communication networks from/to remote PLCs

1.2 Programming and its Simulations

1.2.1 Programming Devices

PLC programs are typically written in a programming device, which can take the form of a desktop console, special software on a personal computer, or a handheld programming device. Then, the program is downloaded to the PLC directly or over a network. It is stored either in non-volatile flash memory or battery-backed-up RAM. In some programmable controllers, the program is transferred from a personal computer to the PLC through a programming board that writes the program into a removable chip, such as EPROM. Manufacturers develop programming software for their controllers. In addition to being able to program PLCs in multiple languages, they provide common features like hardware diagnostics and maintenance, software debugging, and offline simulation. A program written on a personal computer or uploaded from PLC using programming software can be easily copied and backed up on external storage.

1.2.2 Simulation

PLC simulation is a feature often found in PLC programming software. It allows for testing and debugging early in project's development. Incorrectly programmed PLC can result in lost productivity and dangerous conditions. Testing the project in simulation improves its quality, increases the level of safety associated with equipment and can save costly downtime during installation and commissioning of automated control applications since many scenarios can be tried and tested before the system is activated PLC compared with other control systems.

1.3 HMI (Human Machine Interface)

HMI is short for Human Machine Interface. We use HMIs in industry to control and monitor machines. A very common HMI that you all encounter on a regular basis would be an ATM machine. The screen and pushbuttons allow you to operate the machine to dispense a certain amount of money, or to deposit money.

Let's talk about industrial HMIs now. It would be hard to have a good automated process in industry without an HMI. Many times, an HMI will be in the form of a screen, kind of like a

computer screen, and more times than not, they are touch screen. Operator or maintenance personnel can operate and monitor the machine from the HMI.

They may include information like temperature, pressure, process steps, and material counts. They can also show very precise levels in tanks and exact positioning of machines.

Where machine information used to be viewed on multiple indicators can now be viewed on one screen. The possibilities are only limited to the software and hardware used.



Figure 1.2 HMI

For maintenance personnel, many HMIs can also connect to PLC logic and display it on the screen for troubleshooting purposes. This can save valuable time compared to connecting a computer or laptop every time. Another benefit of having a modern HMI is the fact that plants and other industrial sites can monitor and control multiple machines or other equipment. A small manufacturing facility could even monitor the entire plant on one centrally located HMI. Water and wastewater facilities have utilized this for years by coupling an HMI with a PLC. They are able to monitor remote locations, like water pumps, as well as equipment inside the plant.

First, HMIs use special software so engineers can program them correctly. Different brands of panels use different software accordingly. The software allows the engineer to design what the operator will actually see on the screen, what they can monitor on the screen, what “buttons” can be pushed, and how the operator can manipulate the machine. For example, an HMI may have a large tank displayed on the screen with the level of a liquid displayed (as shown in Figure 1.2). Next to the tank is a pump to lower the liquid level. An HMI can also have the start and stop button displayed and usable on the screen next to the pump.

This display would be able to actually turn the pump on and off. The person doing the HMI programming has to program each indicator and button to a specific input or output address of a PLC.

1.4 Sensors

We live in a World of Sensors. You can find different types of Sensors in our homes, offices, cars etc. working to make our lives easier by turning on the lights by detecting our presence, adjusting the room temperature, detect smoke or fire and many other things. All these and many other automation tasks are possible because of Sensors. Few of the sensors that we will be using is mentioned below.

1.4.1 Proximity Sensors

In PLC automation, they are usually used in detecting the presence or absence of objects made of varying materials. They do so without making contact. Sometimes they are called “proximity switches” because the output is binary, HIGH or LOW—just like a switch.



Figure 1.3 Proximity Sensor

1.4.2 Capacitive Proximity Sensor

The capacitive proximity sensor has the ability to detect both metallic and non-metallic objects. Essentially, two plates of the capacitor are separated by some distance. The distance between the two plates dictates its capacitance, or its ability to store energy for a specific voltage drop. To exploit this characteristic, the capacitive proximity sensor has only one of the plates, and the other plate parallel to it would be the object being sensed. Because objects have different dielectric constants, the object is detected by a change in the capacitance. Take note that a lot of objects have dielectric properties, which makes them eligible for detection in PLC automation using the capacitive proximity sensor.



Figure 1.4 Capacitive Proximity Sensor

1.4.3 Vision Sensors

Images captured by a camera to determine presence, orientation, and accuracy of parts. These sensors differ from image inspection “systems” in that the camera, light, and controller are integrated together, which makes the unit’s installation and operation simple. There are differences between these sensors and other general-purpose sensors. For example, multi-point inspections can be done with a vision single sensor. In addition, thanks to the wide field of view, detection is possible even when the target position is not consistent.

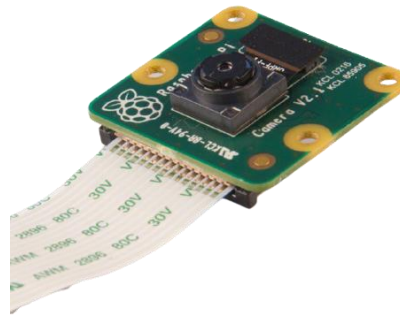


Figure 1.5 Vision Sensor

Chapter 2

Literature Review

A literature review is a survey of scholarly sources on a specific topic. It provides an overview of current knowledge, allowing you to identify relevant theories, methods, and gaps in the existing research. A few literature reviews were conducted for our project work. And based on our studies and keeping in mind our aim and objective we could find a few papers that could be used as a reference to develop our idea.

2.1 Automatic Metal Separation and Packaging using PLC

2.1.1 Introduction

The aim of this project is to design and develop a PLC material separation system for separating metals and non-metals. The components used for this project are programmable logic controller (PLC), proximity sensors, DC Motors and conveyor system.

2.1.2 Working

Initially, when the push button is been pressed the conveyor start to move in a forward direction. In the conveyor, any metal or non-metal product is placed on it. After some distance the object which has been moving in the conveyor will be detected by the metal detector, that is whether the object is metal or not. If the object is metal, then the conveyor 2 will be moving in the reverse direction. Finally, the metal object which moved in the reverse direction will be get into the packing zone by which the packing gets completed.



Figure 2.1 Detecting metals and non-metals

2.1.3 Results and Conclusion

The project gave an overall idea how to automate packing process using PLC automation. The main application of this project is widely used in garbage disposal system. The system meets the demand of high-speed production using the least mechanism requirements. The system also provides high accuracy and precision of incoming metals or any other non-metallic products.

2.1.4 Future Scope

Model can be extended to include other types of sensors and objects of different material (i.e., different chemical properties) to ensure repeatability and model consistency [2]

2.2 Object sorting automated system using Raspberry Pi

2.2.1 Introduction

The aim of the object is to sort objects based on their colour and shape. Three objects of shape (square, triangle and pentagon) is used for separation. Ultrasonic sensor used to detect the presence of object. A USB webcam is used to find the type of object (its shape and colour using OpenCV Python). A robotic arm connected to servo motor is used for separation. Also, the acquired data is stored in SQL.

2.2.2 Working

The project consists of a Raspberry Pi, USB webcam, servo motor driver, robotic arm, ultrasonic sensor and MySQL database. To start with, the ultrasonic sensor detects whether the object is in the vicinity or not. If it senses the object, it gives input to the Raspberry Pi which then sets the webcam ON to capture the image of the object. OpenCV with Python is used to process the image to identify its colour and shape. On knowing the attributes of the object, the Raspberry Pi sends command to the motor driver to drive the motors up to a certain degree based on the object's colour and shape. The servos present in the robotic arm rotate and finally places the object in its respective compartment. Simultaneously as this execution is going on, the Raspberry Pi executes a query for updating the value of the necessary column in the table.

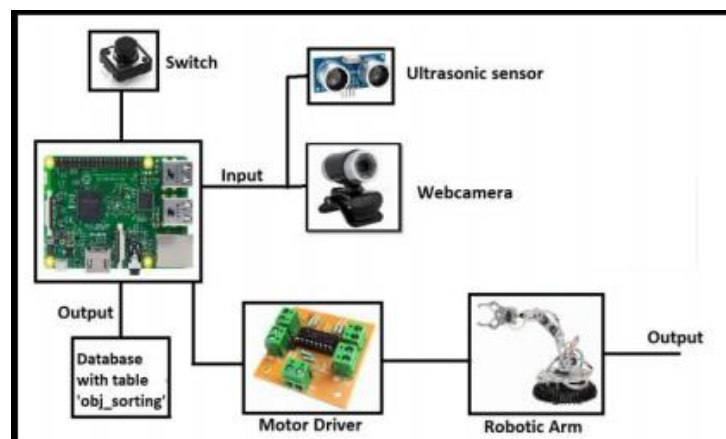


Figure 2.2 Object sorting using Raspberry Pi

2.2.3 Results and Conclusion

After executing the image processing codes, the colour and shape of the object were detected correctly almost every time. However, bad or dim light around the object can lead to wrong detection in case of shape. This issue was overcome by using a flash light and a LDR (Light Dependent Resistor) which were placed near the web camera. The above system can be used at departmental stores to sort objects based on colour, in a chemical industry to sort paints and coating, in bottle manufacturing industry to sort bottles of different shapes and colours, in a toy manufacturing unit to separate different coloured and sized toys.

2.2.4 Future Scope

The object sorting system will be of a great help in the agricultural sector. Fruits can be sorted based upon their ripeness levels. Any decay or disease in fruits or vegetables will be easily identified and the seller/consumer will be notified using a buzzer or an alarm [1].

2.3 Other Literature Surveys

Table 2.1 Literature Review

Sr No.	Name of Journal and Author	Investigation	Scope
1	Science Direct Author Bankole L. Oladapo	Used Proximity sensor, PLC and double acting cylinder to drive the object into the specified compartment, by varying the motor speed the effect of weight of material on conveyor can be reduced.	Model can be extended to include other types of sensors and objects of different material (i.e., different chemical properties) to ensure repeatability and model consistency
2	IJISSE R. Arvind	When button is pressed, material on first conveyor starts moving forward. When it is detected by proximity sensor (metal or nonmetal), if it is metal conveyor starts in reverse direction results in separation to packaging section.	improvement of our work can be done by increasing the efficiency of the conveyor system and by increasing the high range of sensitivity of the sensor.
3	IJRSE K Sashidar	The objects are being sorted according to their respective colour. The main conveyor is supported of two branches to load the distinguished object on to the respective one as separated by the electronic system and detected by the IR sensor.	various other sensors can be used. load cells can be used for measurement and control of weight. a counter can be used to count number of products.

Sr No.	Name of Journal and Author	Investigation	Scope
4	IEEE Li Pielin	The sorting process includes detection, image acquisition, burr detection and sorting. The main objective of this project was to detect the presence of Burr on the surface of the edges. An image processing algorithm is used to detect the burr. If burr is detected then it separated by using a piston by PLC mechanism.	The project is limited to only one type of defect detection that is burr detection. The detection is limited only to two opposite faces of workpiece that is facing the CCD camera. Any defects on other faces cannot be seen
5	IJETSR Rahul Deshmukh	Object is sorted based on metals and non-metals. inductive sensor is used to detect presence of metal object and IR sensor to sense all objects. A pneumatic double acting cylinder is used to crush the material.	The work can be implemented by making use of a robotic arm to pick and place certain materials which can be re-used. Also, limit sensors can be placed at the top of each of the collecting bins to unload them when they are full.
6	IOSR Journal S. V. Rautu, A. P. Shinde	Object Sorting is done on basis of their colour, weight variation and type(metal or non-metal). It mainly focuses on sorting 2different weighing non-metallic objects which are available in 3 different colours using load cell, TCS230 colour sensor, inductive sensor and DC geared motors interfaced with Programmable Logic Controller (PLC).	pH sensors can be installed for food industry application to check the freshness. Replacing DC motors by stepper motors to increase accuracy. Sensors can be replaced by cameras for digital processing. Robotic arm can be used instead of flippers and containers to place the object at desired locations, thus making the process of sorting more effective.
7	Engineering Research and Application Dr R. M. Deshmukh	Scrap material is placed on the conveyor belt. The photoelectric sensor senses the object and the conveyor belt starts moving. Inductive proximity sensor is used for metal detection. Once metal is detected, the conveyor belt stops, robotic arm picks up and drops the metal scrap into bin. And photoelectric sensor restarts the belt.	The project only involves segregation of metals and non-metals. No provision is made for separation of glass, paper, wood and plastic

Sr No.	Name of Journal and Author	Investigation	Scope
8	IRJET Prof. Niyaj Nadat	The system involves multiple storeys building to park cars. Proximity sensor are used to find vacant slots and green LED is used to indicate vacancy. The PLC used in the system for controlling the lifts, which are used for the movement of vehicles in horizontal or vertical directions and it is done by the pneumatic cylinders.	The system won't work during power cut off. So can be overcome by using backup power source or using battery.
9	IRJET- Prof. Yadav N. C.	In this soil moisture sensor are used. The output of the sensor is the input for PLC system. The sensor indicates the moisture level of soil. A threshold value is set. When moisture value is less than threshold, the sensor sends signal to PLC. PLC turns on the motor and valve opens and irrigation starts. When moisture reaches threshold value, sensor signals PLC which in turn closes the valve.	Fire detector, water level sensor, vegetable washer can also be introduced in the PLC system

2.4 Findings

- There exist different material separation techniques which considers only one parameter.
- Attempt to incorporate different parameters in a single system has been put together.
- Plan to develop a ladder diagram and HMI has been made.

Chapter 3

Problem Definition and Project Objective

3.1 Identification of Problem

Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies. Nowadays everyone wants everything to be automatic. Just click a button and the task to be performed should be completed automatically. In manufacturing industries, the products are manufactured in bulk and there are chances that in this mass production system there might be some products that is defective. The speed at which the product goes through the conveyor system, it would be very difficult for any naked eye to detect the defect in the object. So here comes the job of an automation engineer. Before packaging of the final products, industry uses sensors to detect any flaws in the produced finished product. For E.g., if a batch of products produces red coloured objects and by mistake if any blue object enters the production line, then that one blue object needs to be separated from the others. So, the sensors present detects the blue object and actuation is done to separate it from others. If a small-scale industry produces various different types of object at different times, then the industry has to purchase different material separation units which will cost the company a fortune.

3.2 Aim

So, the aim of this project is to develop a simple PLC based material system that will provide the user to choose what type of material separation is required at that particular time. The project consists of two different material separation methods combined in one single unit. This type of system would be very useful for small scale industries that produces various object in one single production line.

3.3 Objectives

The main objective of the project is:

- To segregate objects based on their colour, shape and type of material (Metal or non-metal).
- To reduce the overall cost, efficiency and make the interface user friendly of the material separation unit.

- To use less sensors to detect objects to optimise the overall cost. For E.g., using one single web camera to detect both shape and colour of object instead of using two separate sensors.
- To keep the project as simple as possible so that there shouldn't be any issues at the time of maintenance.

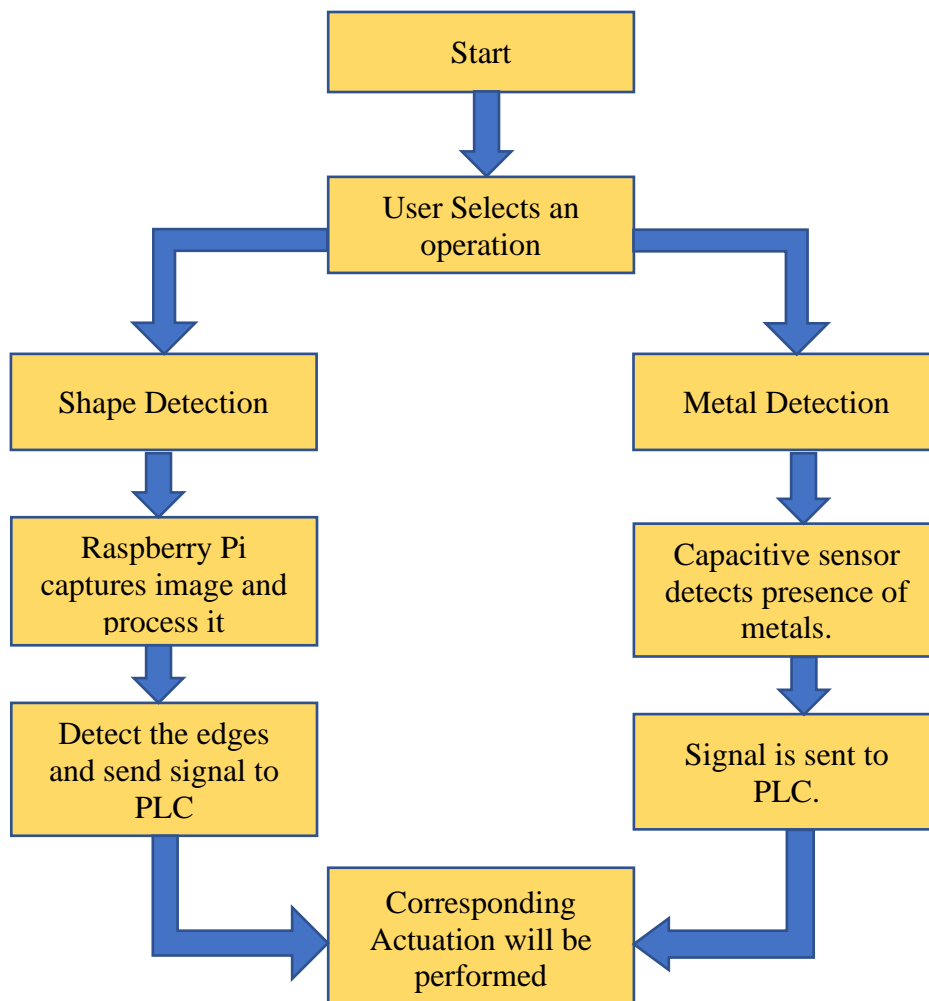
Chapter 4

Methodology

4.1 Our Idea

The main objective of this project is to ask the user what type of material separation is to be done. In small scale industries, for different type of material separation the company has to purchase separate unit for the separation process. So, the aim is to combine two to three different material separation process in one single unit.

4.2 Layout of System



4.3 Process

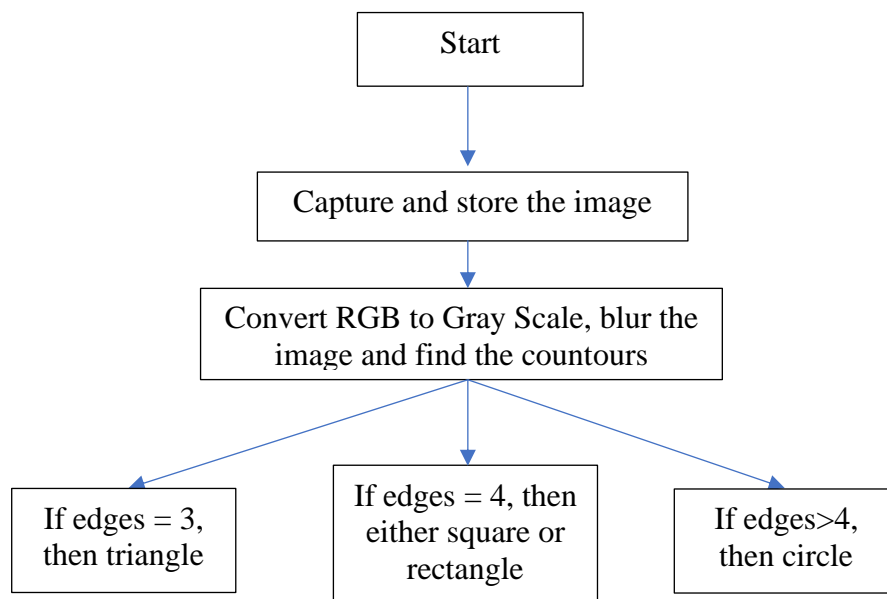
In this project two different material separation (based on shape and metals & non-metals) has been performed. An ultrasonic sensor has been used to sense the presence of the object. The user will select what material separation is to be performed (Shape detection or Metal Detection). The project consists of a raspberry pi, pi camera, capacitive sensor, a PLC, pneumatic cylinders and a conveyor system.

4.3.1 Proximity Sensor

An ultrasonic sensor has been used to detect the presence of an object. When an object passes the ultrasonic sensor, it will send a signal to activate the corresponding process. If user selects shape detection, then the signal will go to raspberry pi activating the pi camera.

4.3.2 Shape Detection

A pi camera has been connected to the Raspberry pi to capture the image of the object. To find the type of shape total number of edges present on the shape was calculated. After comparing the edges, it was decided what type of shape was detected and accordingly separation was done.



To capture the image of the object OpenCV in Python has been used. The code has been generated to capture the image and run the analysis. The following line of code has been used to capture the image of the object.

```
camera = cv2.VideoCapture(0)
```

Once the image is captured it is stored in the computer memory. The captured image will be in RGB form. So first it has been converted to Gray scale and then the image has been blurred which helped to detect the edges more accurately. A separate function called getcountours has been created that has been used to detect the edges in the image.

```
approx = cv2.approxPolyDP(cnt, 0.02*peri, True)
print(len(approx))
objcor = len(approx)
```

The above code gave the exact number of edges the image has. If the value of $objcor = 3$, then the shape is a triangle. If the value of $objcor = 4$, there are two possibilities that it may be a square or a rectangle and that can be differentiated by calculating the aspect ratio. And if the value of $objcor > 4$ then it is considered as a circle.

4.3.3 Detection of metals and non-metals

For detecting metals and nonmetals a capacitive proximity sensor has been used. The sensor will give output high if it is a metal and output low if it is a non-metal.

4.3.4 PLC Ladder Diagram

Once a layout was ready for the material separation process, a PLC ladder diagram was developed to execute the process one by one. For the separation part a pneumatic operated double acting cylinder has been used to segregate the materials. In shape detection 2 shapes (Square and Triangle) has been used. The job of the PLC would be to separate each and every shape in individual container. Same process has been repeated with metals and non-metals.

4.3.5 Building of an HMI

HMI is the most important part in the PLC based material separation project. HMI stands for Human Machine Interface that would be directly connected to the PLC ladder program. The HMI consists of a start and a Stop button and also a kill switch button in case of emergency stopping. Along with these buttons it consists of a few indicators that will turn on when a particular component is turned ON. Also, the type of material separation is a user input that is displayed on the HMI screen. The user will have to choose a single material separation operation. The HMI instructs the PLC the type of operation user wants and run the ladder diagram accordingly.

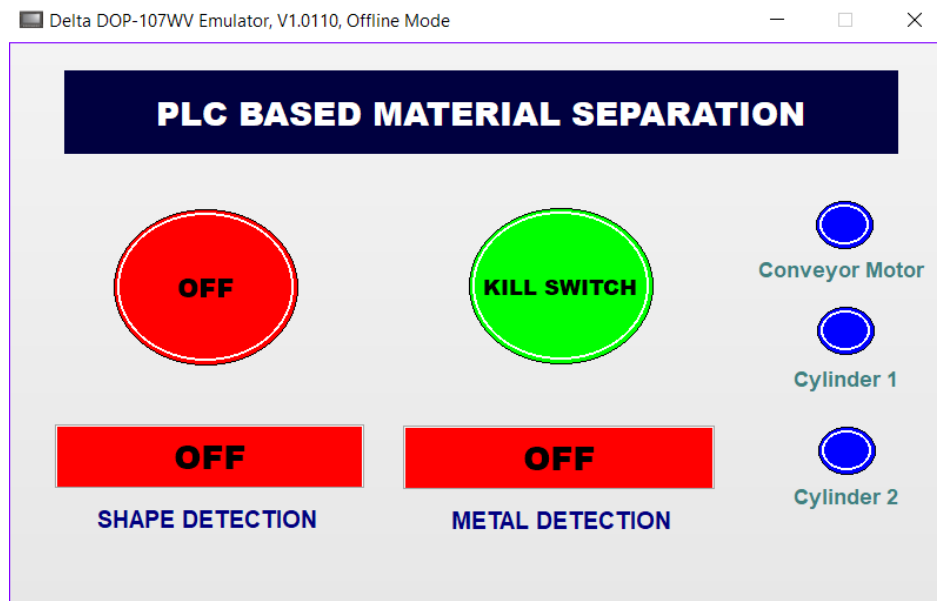


Figure 4.1 Human Machine Interface

Chapter 5

Design of System

5.1 Design of Code

OpenCV in python programming has been used to write the code for shape detection.

5.1.1 Code

The code for shape detection is given below:

```
import cv2
import numpy as np

camera = cv2.VideoCapture(0)
return_value, image = camera.read()
cv2.imwrite('opencv'+str(0)+''.png', image)
del(camera)

def getcountours(img):    #function created to detect the edges
    contours, Hierarchy = cv2.findContours(img, cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_NONE)
    #external retrival method (it retrives extreme external countours)
    for cnt in contours:
        area = cv2.contourArea(cnt)
        print(area)
        cv2.drawContours(imgcountour, cnt, -1, (255, 0, 0), 3)    #detects countours and draw a line around the
edges
        peri = cv2.arcLength(cnt, True)
        print(peri)
        approx = cv2.approxPolyDP(cnt, 0.02*peri, True)    #it gives number of edges it has and true because all
shapes are closed
        print(len(approx))
        objcor = len(approx)
        x, y, w, h = cv2.boundingRect(approx)    #creating box around shape that we detect

        if objcor == 3: objectType = "Triangle"
        elif objcor == 4:
            aspRatio = w/float(h)
            if aspRatio > 0.95 and aspRatio < 1.05: objectType = "Square"
            else:
                objectType = "Rectangle"
        elif objcor > 4: objectType = "Circle"
        else:
            objectType = "None"
```

```

cv2.rectangle(imgcountour, (x, y), (x+w, y+h), (0, 255, 0), 2)    #creating box around shape that we detect
cv2.putText(imgcountour, objectType,
            (x+(w//2)-10, y+(h//2)-10), cv2.FONT_HERSHEY_COMPLEX, 0.7, (0, 0, 0), 2)

path = "opencv0.png"
img = cv2.imread(path)
imgcountour = img.copy()
imgGray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY) #1st to convert image to gray scale and find the
edges
imgBlur = cv2.GaussianBlur(imgGray, (7, 7), 1) #blur the image
imgcanny = cv2.Canny(imgBlur, 50, 50)          #we use canny to detect the edges
getcountours(imgcanny)
imgblank = np.zeros_like(img)

cv2.imshow("Original", img)
cv2.imshow("Detected Shape", imgcountour)

cv2.waitKey(0)

```

5.1.2 Working of our code

The camera has been set with a suitable background to read the image. Then the captured image was stored in the Raspberry pi memory.

To process the shape detection, first the total number of edges present on the shape has been calculated. The total number of edges will help to decide whether the image is a square a rectangle or triangle.

So, the process of edge detection starts by converting the image which is in RGB format to grayscale. Then the image was blurred and canny algorithm was performed to detect the edges.

The canny image was stored in a variable which was then passed to the getcountour function. In this function the perimeter of our object was first calculated and this value has been used in a function called approxpolydp to find the end points of the object. So, by calculating the end points the number of edges were found. The value of edge has been stored in a function named objcor.

Now the edges value can be compared to see what type of shape is detected. If the value of objcor is 3 then the shape is a triangle. If the value of the variable comes out to be 4 it could be either a square or a rectangle and that could be differentiated by calculating the aspect ratio of the edge. And if the edge value comes greater than 4 then it is considered to be a circle.

5.2 PLC Ladder Diagram

The ladder diagram is as follows:

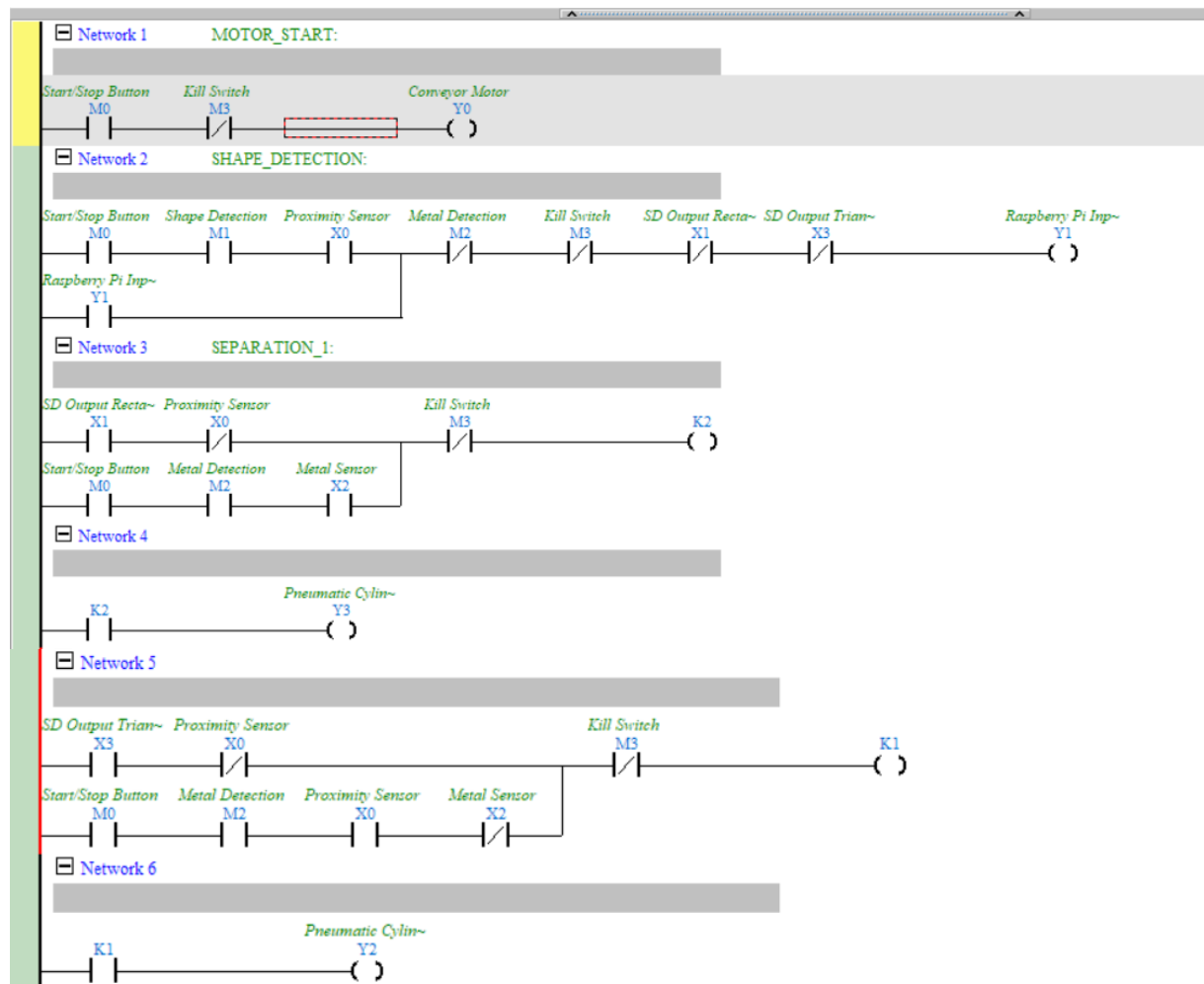


Figure 5.1 Ladder Diagram

PLC Ladder Diagram has been built to perform necessary operations. Delta PLC software has been used to build the PLC Ladder Diagram. ISPsoft is Delta's new generation software development tool for programmable logic controllers. ISPsoft enables user to apply PLC to more complex control systems as well as to small control systems.

A ladder diagram is the symbolic representation of the control logic used for ladder logic programming of a PLC. The Ladder diagram consists of horizontal lines of control logic called rungs. vertical lines at the start and end of Each rungs called as rails.

The structure of a ladder diagram actually looks like a ladder, hence the name ladder diagram. The ladder diagram consists of an input and output section. The input section comprises of memory bits (M0, M1, M2....) and sensor input bits (X0, X1, X2....).

The PLC is linked to the HMI (Human Machine Interface) which acts as an interface between human and machine. So, when the user clicks on the ON button on the HMI, the PLC ladder diagram turns ON which in turn starts the conveyor motor.

If the user wishes to go for Shape detection, then the user will turn ON the shape detection button on the HMI that will turn ON the memory bit M1 on the ladder diagram. When an object is placed on the conveyor belt the proximity sensor detects the object that turns ON the output Y1 (Raspberry Pi input). The raspberry pi will activate the pi camera and take picture of the object. The captured object has been stored in the raspberry pi memory and shape detection has been performed on the object to detect the shape.

If the object is a rectangle, then memory X1 will turn high which in turn actuate the pneumatic cylinder Y3. If the object is a triangle, then memory X3 will turn high which in turn actuate the pneumatic cylinder Y2.

If the user wishes to go for Metal detection, then the user will turn ON the metal detection button on the HMI that will turn ON the memory bit M2. The capacitive sensor has been used to detect metals and non-metals. If the object is a metal memory bit M2 will turn ON which will actuate the pneumatic cylinder Y3. If the object is a non-metal, then memory bit X4 will turn ON which will actuate the pneumatic cylinder Y2.

Chapter 6

Results and Conclusion

6.1 Code Output

The above python programming was successfully executed and the desired output was obtained.

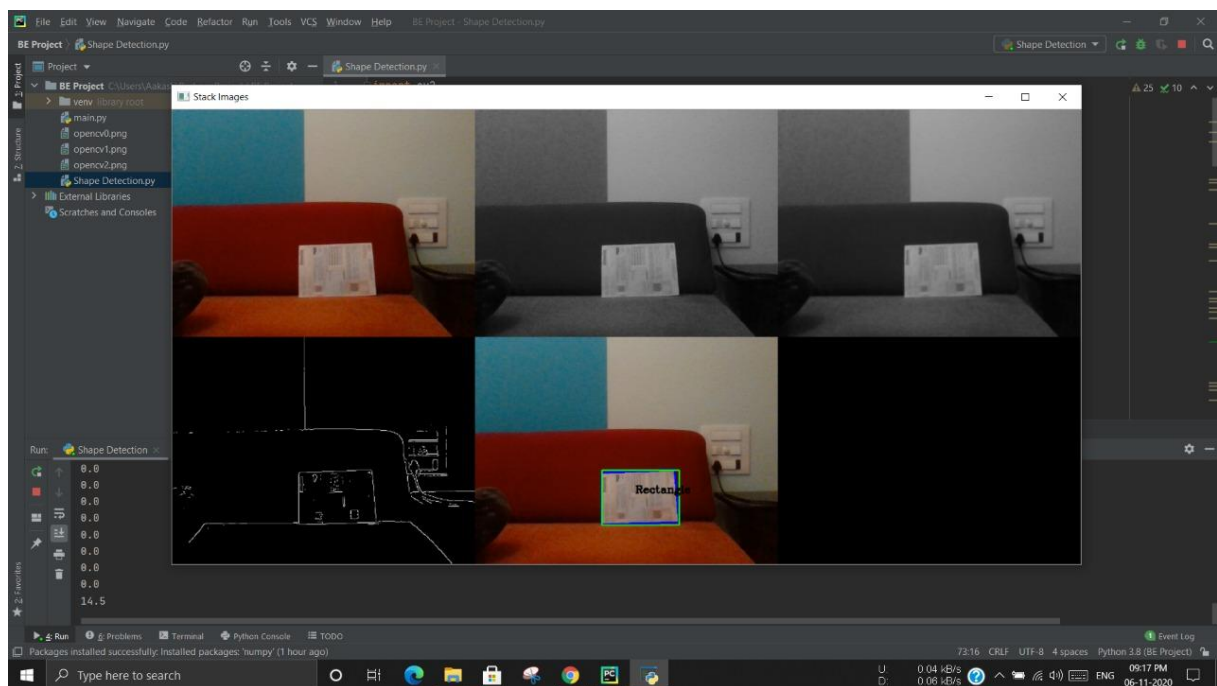


Figure 6.1 Shape Detection Output

As shown in Figure 5.1, a sample piece of paper has been used to detect the shape of the object. The first image is the actual image captured by the Pi camera. Second is the RGB to Gray scale converted image. Then the Gray scale image was converted to blur image for accurate edge detection. The fourth image is how the image will look like when canny algorithm is applied to find the edges. And in the last image, the shape of the object (Rectangle) was detected and displayed on the screen.

6.2 Design Model

6.2.1 Shape Detection

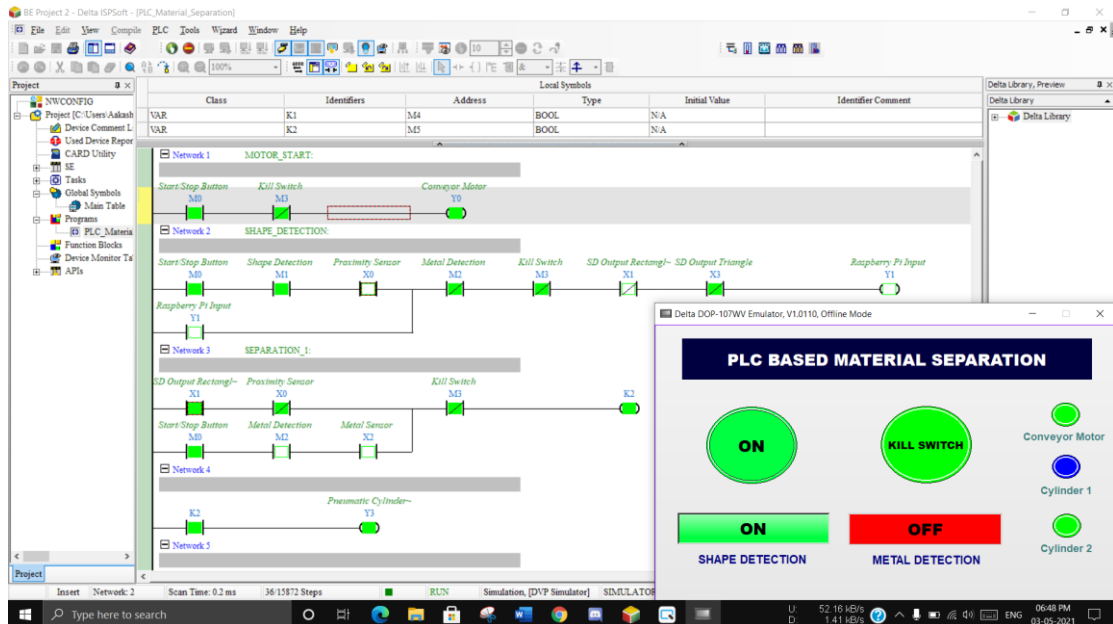


Figure 6.2 Shape Detection

The above shown figure is the PLC ladder diagram simulation for Shape detection. As shown in the figure the user selected for shape detection. When the object was placed on the conveyor motor the object was sensed by the proximity sensor. The input was given to raspberry pi for shape detection. After getting output from raspberry pi the corresponding pneumatic actuation was performed.

6.2.2 Metal Detection

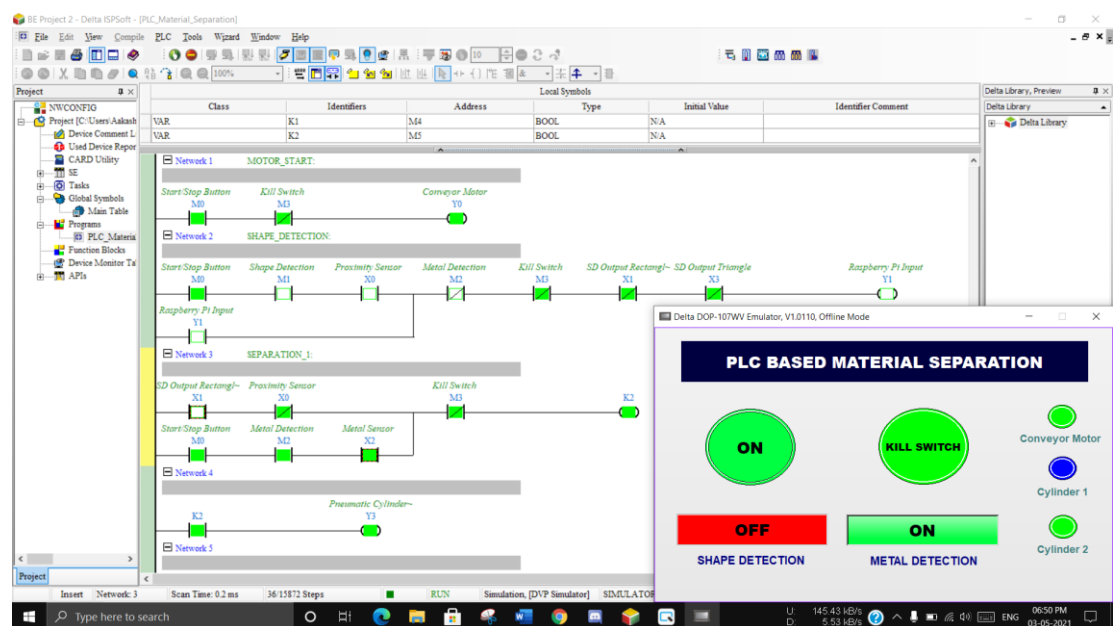


Figure 6.3 Metal Detection

The above shown figure is the PLC ladder diagram simulation for Metal detection. As shown in the figure the user selected for Metal detection. When the object was placed on the conveyor motor the object was sensed by the proximity sensor. The object was then sensed by the capacitive sensor and based on the output corresponding pneumatic actuation was performed.

6.2.3 Model Simulation

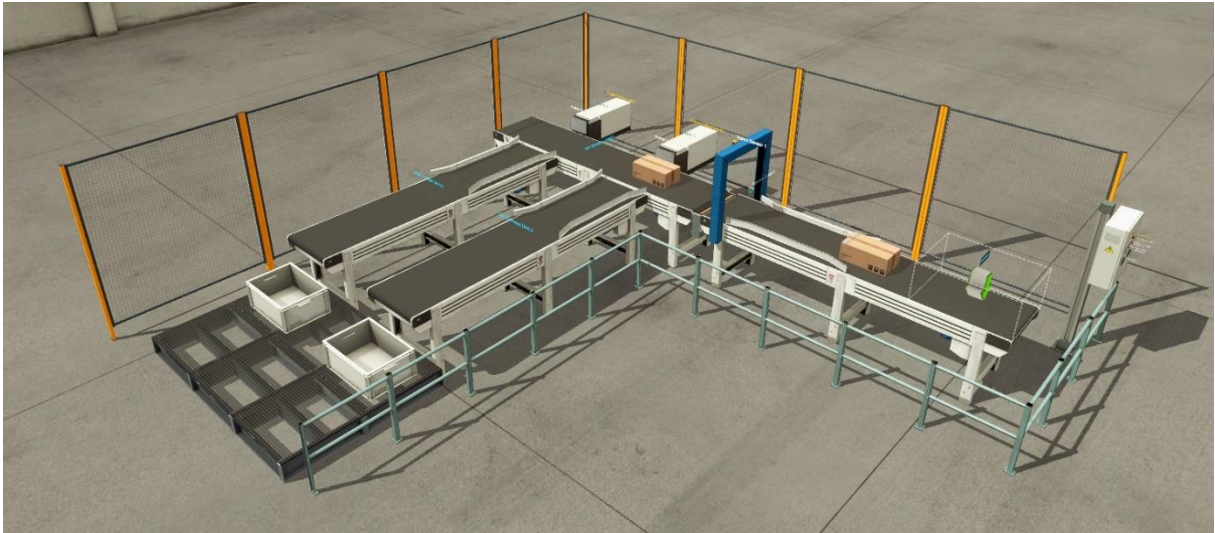


Figure 6.4 Simulation Model

The above figure is the simulation model of PLC Based material separation. It consists of two pneumatic cylinders, three conveyor belts, a raspberry pi module and capacitive sensor placed on the shown blue panel and objects. For the case of metal and non-metal separation, the conveyor parallel to pneumatic cylinder 1 used for metals and the 2nd one for non-metals. For the case of shape separation, the 1st pneumatic cylinder separates square objects and the 2nd one separates triangle objects.

6.3 Future Scope

In the future the idea can be implemented with following features

1. SCADA based smart grid.
2. Power source shutdown notification via SMS.
3. Separation based on other parameters can be included like colour.
4. Load cells can be used for measurement and control of weight.
5. Limit sensors can be placed at the top of each of the collecting bins to unload them when they are full.
6. The programme can be developed to store the data which could be used for future references.

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Acknowledgement

We want to express our appreciation to all those who were instrumental in completing this report. We wish to express our special gratitude to our Principal Dr Sandeep M Joshi, whose constant encouragement and support inspired us to do our best. We would like to thank HOD of the Mechanical Engineering Department, Dr Dhanraj Tambuskar, who provided us the opportunity to write this report. Furthermore, we are grateful to our Dr Dhanraj Tambuskar whose constant encouragement & motivation inspired us to achieve our goal. I am highly obliged in taking the opportunity to sincerely thank all the staff members of Mechanical Engineering Department for their generous attitude and friendly behaviour.