Image Processing Based Glass Jam Cap Inspection System

B.E. SENIOR DESIGN PREOJECT REPORT
Electronics

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ABSTRACT

Pakistan is a heavy flavored food preservatives producer country and is known for its product worldwide. Pakistan is in the process of growing industrial automation and still behind in this field from developed countries. There are many good JAM companies in Pakistan and every JAM is better and tastier than other. When we visit industry we seen that Jam filled in the bottles and then encapsulated by another machines. Some are properly encapsulated and some are not those which are not perfectly encapsulated. A person near the machine picks those bottles and then reprocess again. So our main task is to automate this work and replace a human labor by machine which is more reliable, very less cost, etc. The purpose of the project is to sort and grade the Jams whether they are tightly packed. The mechanical system consists of conveyor belt. The inspection is basically done through image processing and sorted through an actuator. A4 Tech cameras are used to capture the frames of the JAM caps and Opencv is used to process the image frame and take decision rather the JAM cap is tight or not. The frame is captured and then converted from RGB (Red, Green, Blue) to HSV (Hue, Saturation, Value) color space and then by the help of fixed threshold, the frame is then masked and as a result only green masked area is left and all other are set zero. As a result we get a masked image of that frame. If the masked area is green then the JAM is properly capped and is further processed

KEYWORDS

JAM cap inspection

Automatic Sorting of Jams

Image Processing

Jams Grading

Color Sorting

Machine Vision

Opencv

Python

Visual Studio

Raspberry Pi

Conveyor

Actuator

LIST OF ABBREVIATIONS

S/No	Abbreviation	Full Form
1	ADC	Analog to Digital Converter
2	HSL	Hue Saturation Lightness
3	HSV	Hue Saturation Value
4	RBG	Red Blue Green
5	IR	Infrared
6	LR	Linear
7	PC	Personal Computer

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1. INTRODUCTION

1.1 Bachground

Pakistan is the biggest Jam producer in the Asia and to maintain this credibility automation must be employed in its industrial processes. This will not only lower the quality inspection cost but also will be a hygienic product to its customer.

Our main task is to automate this work and replace a human labor by machine which is more reliable, very less cost, etc. The purpose of the project is to sort and grade the Jams whether they are tightly packed. The mechanical system consists of conveyor belt. The inspection is basically done through image processing and sorted through an actuator. A4 Tech cameras are used to capture the frames of the JAM caps and Opencv is used to process the image frame and take decision rather the JAM cap is tight or not. The frame is captured and then converted from RGB (Red, Green, Blue) to HSV (Hue, Saturation, Value) color space and then by the help of fixed threshold, the frame is then masked and as a result only green masked area is left and all other are set zero. As a result we get a masked image of that frame. If the masked area is green then the JAM is properly capped and is further processed.

1.2 Motivation

As the world is going very fast and new technologies are replacing the old ones day by day so we also need to technologies our world with the available sources. Pakistan is not technologically that much advanced in industrial quality inspection process. Therefore we decided to take initiative by employing vision system in the field of food industry and setting an example as a Pakistani to the world.

Benefits of Project:

- Use of automation in the Pakistan Food industry.
- Applying Image Processing in quality food inspection.
- Applying our complete electronics knowledge.
- Lower the cost of industry on inspection processes.

Objectives:

- To initiate the automation in Pakistan so that the product inspection could easy.
- To design a Jam sorting machine that sorts Jam on the basis of their acceptance.
- To design a low-cost hardware design of Jam sorting machine.
- To use Opencv using Python and C++.
- Using python on Raspberry pi2 and C++ on visual studio.

2. BACKGROUND AND LITIRATURE REVIEW

2.1 Introduction

Pakistan is the largest food preservatives producing country and its economy heavily depends on the exports of these products. These products must meet the international demands for its acceptance worldwide. These products must be hygienic and of utmost quality. Exports depend on your speed of production. Moreover speed production must not affect the quality of products. Therefore Pakistan food industry must adopt automation to yield profits in the international market.

Basically our project idea is more of an invention because cap inspection through image process is highly expensive project in actual industry. We have gathered information regarding these industrial inspections and put use of our electronics knowledge to implement on Jams caps with economical resources.

2.2 Industrial PLC inspection Machines

In food industries no compromise is made on product packaging and inspections. Importance is given to the quality of the product so that it remains healthy product for its customers. That's why industries use highly expensive PLCs that inspect bottles/Jars caps and packaging. These PLCs are highly accurate and precise.

Figure 1 : Industrial PLC

These PLCs uses highly precise cameras and yield perfect result. Moreover they have fast inspection speed.

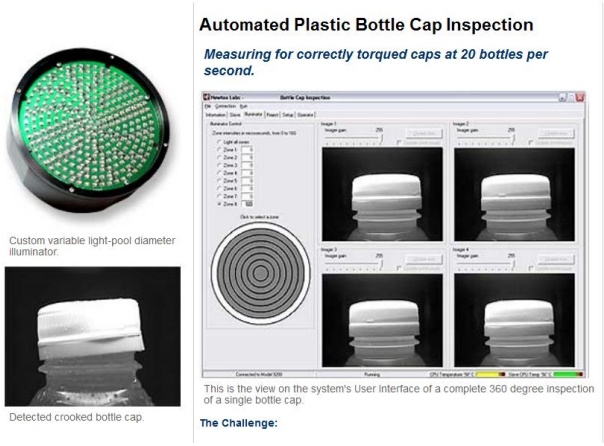


Figure 2 : Results of PLC

2.3 Vision Inspection Solutions:

In some industries vision systems for bottle caps inspection and packaging are installed. They have highly accurate cameras that work on the principle of image processing automation. These systems are smaller than PLCs but efficient.

Figure 3 VIS

These systems have software that is quiet expensive but produce promising results and is perfect for food industry.

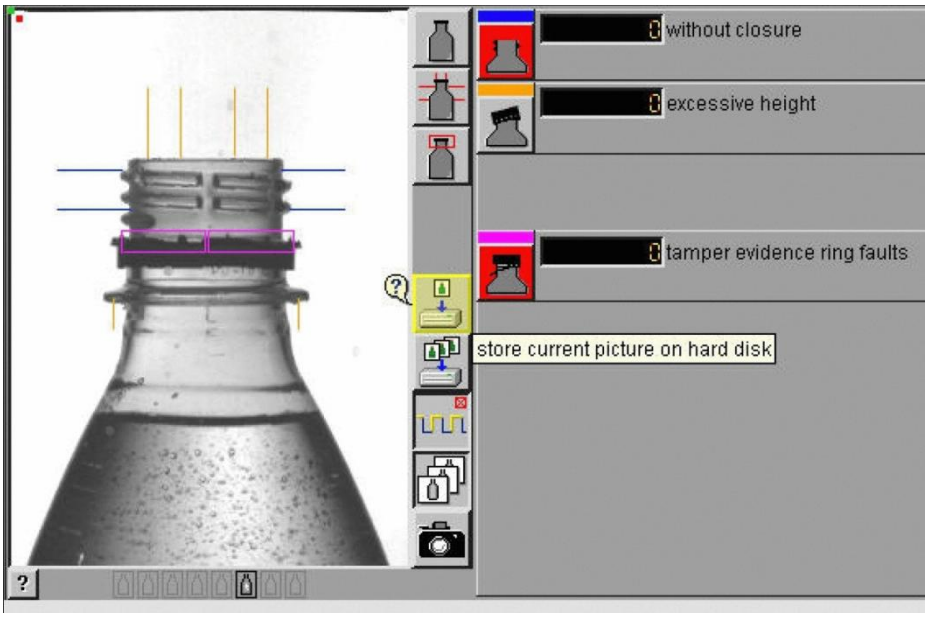


Figure 4 Camera Results

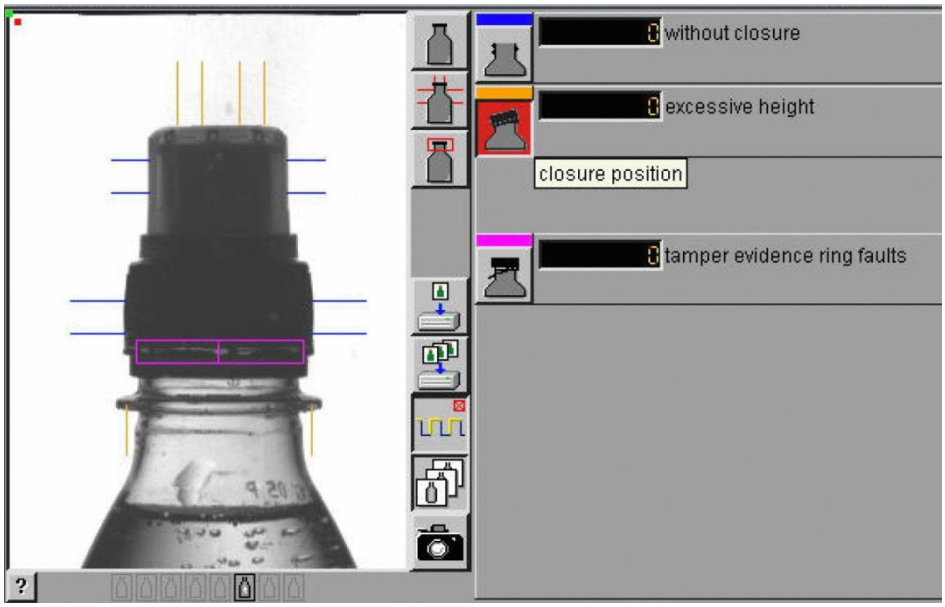


Figure 5 Camera Results

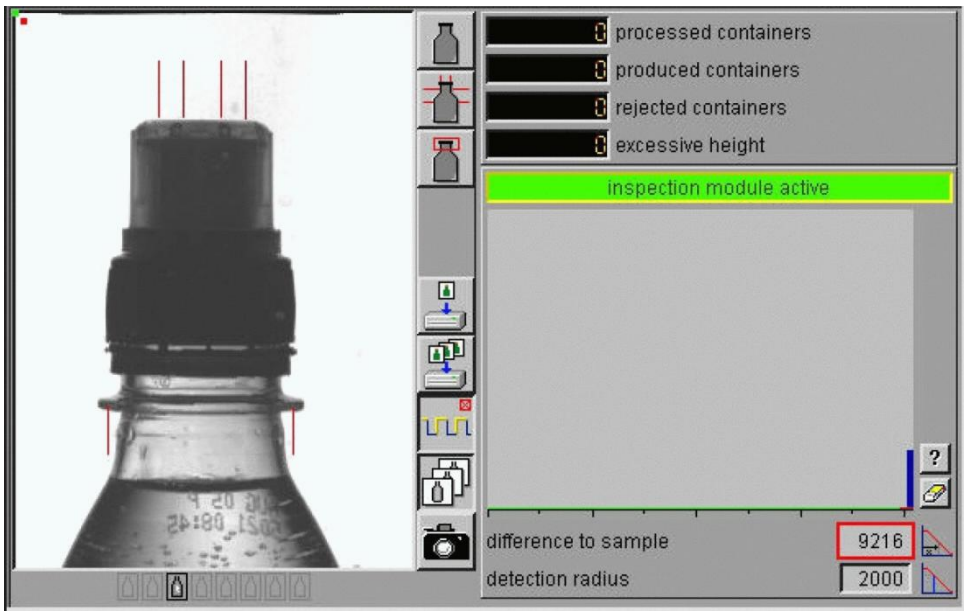


Figure 6 Camera Results

2.4 Inspection CAM

We also researched on some economical resources of industrial cap inspection modes. The most economical we found was Inspection CAM that was quiet sound and efficient. This type of machines is used in some of Pakistan Jam producing companies.

Figure 7 CAM

2.5 Cap inspection System

Rely on Enercon's new cap inspection system to prevent unsealed products from leaving your facility and ensure your containers are properly sealed to prevent leaks, preserve freshness and provide tamper evidence.

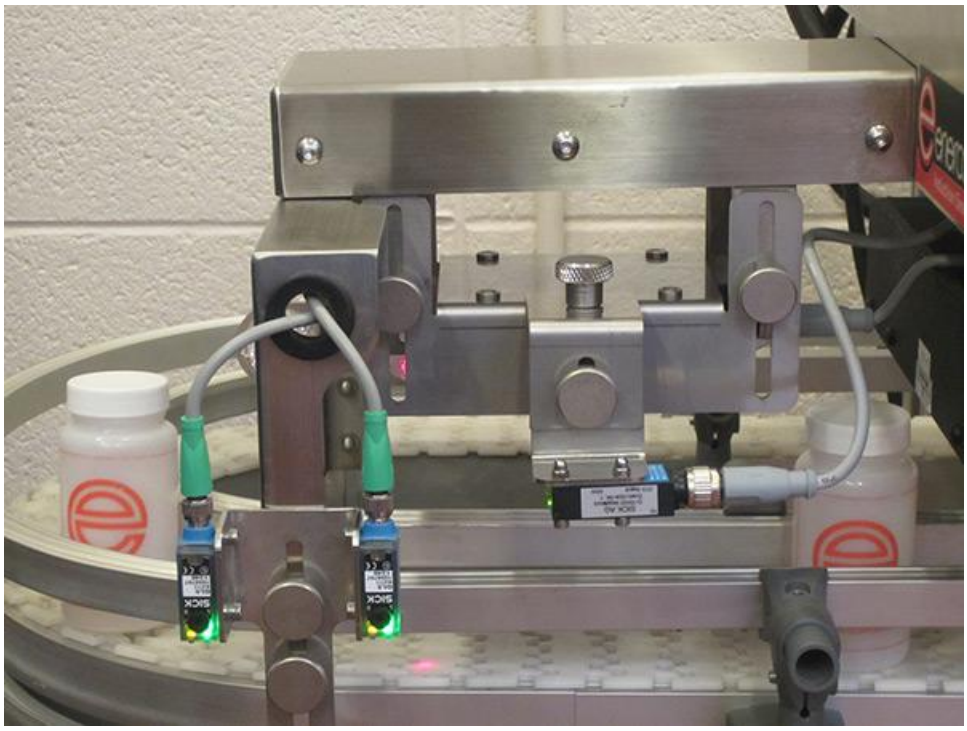


Figure 8 Cap Inspection System

Easy set up and Operation

- Mechanical Integration - the sensor arms are integrally mounted with the sealer
- Integrated touch screen control of inspection & rejection modules
- Interchangeable Sensors
- Easy Tool-less Adjustments

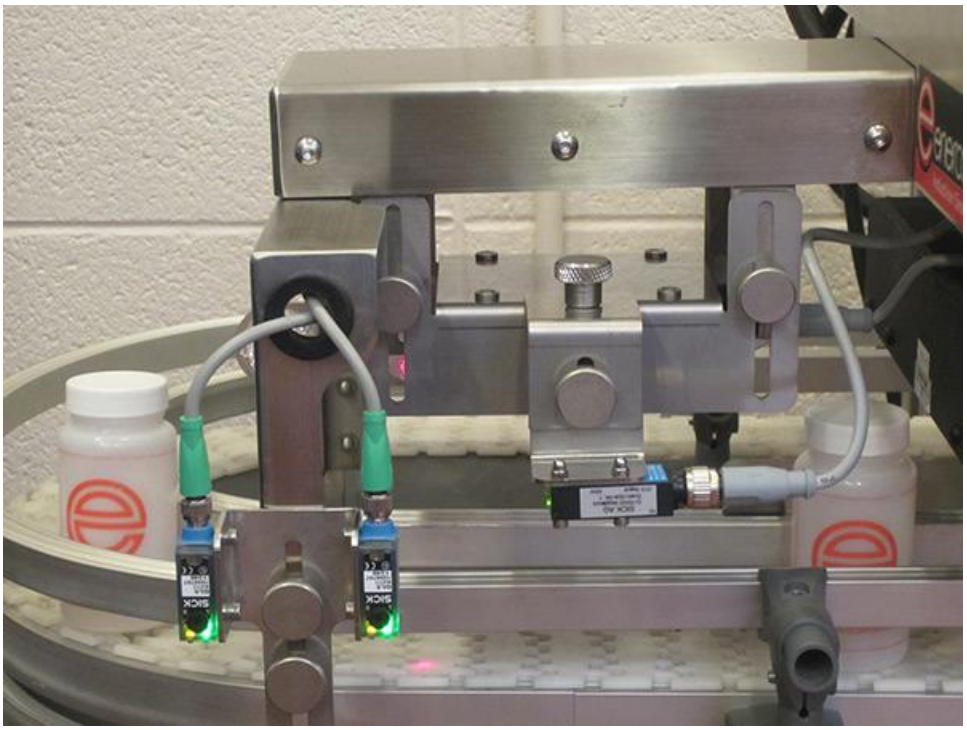


Figure 9 Cap Inspection System

Available Features

- **Missing Foil Detector**
  If a container is missing its cap or liner it will be detected by the missing foil detector. This circuit also provides a signal for triggering a reject device. It includes bottle counter and missing foil counter.
- **Stalled Bottle Detector**
  Sometimes also referred to as motion detection system, it detects when a bottle fails to exit the sealing head within a preset time. When this occurs, the sealer is automatically turned off and a "stalled bottle fault" is displayed on the screen of the system.
- **Cocked Cap Detector**
  It senses a cap that is not properly seated. It prevents containers from colliding with the induction sealing head and creating a down bottle situation. Also identifies cocked caps which may not be providing the required torque for successful induction sealing. The circuit provides a signal for triggering a reject device. It includes bottle counter and cocked cap counter.
- **LED Bottle Centering Guide**
  Provides precise centering point to align containers on the conveyor at the in feed and discharge of the station. Sensors used in this guide may also be used as backup for other

sensors used in the system. Included at discharge with stalled bottle detection and at both infeed and discharge with missing foil and cocked cap detection.

2.6 Image Processing

Image Processing means to change the nature of an image for the desired task we want to complete. The task can be the improvement or betterment of the image to view or to process the image making it upright for desired machine vision automation. Image Processing technique of images have an image or picture as the input of the process and the processed or improved image is taken as the output of that process. Image processing can be analog or digital. In our case, we are more concerned with digital image processing. We are using digital image processing to sort the tomatoes on the basis of their color.

2.7 Color

Color is one of the most essential components of fruits and vegetables. The quality of many fruits and vegetables can be judged by the visual color identification by which we can easily categorize those fruits or vegetables. Color is basically a light ray reflecting a material. For instance, white light hits a tomato and reflects back. All the colors are absorbed except red. It reflects the red color. As a result we see a red tomato. All colors have different wavelengths. The wavelength of red is greater among all. Human eye can distinguish the rays or colors having a wavelength between 390nm to 700nm.

2.8 Color Spaces

Color Spaces are the definite arrangement of colors. There are different color spaces available for different systems to perform different tasks. The most widely used and commonly known color space is RGB.

Figure 10 Color spaces

There are also different color spaces like HSV, HSL (Hue, Saturation, Lightness) etc. Some of the color spaces are defined below:

RGB:

RGB means Red, Green, Blue. It is a color space having the red, green and blue components. RGB color space is used in CRT (Cathode Ray Tube) Monitor. As it has a red, green and blue color; so this color space can show up these colors and the colors made by the combination of these colors or two or more of these colors. For example, yellow is the combination of Red and Green so we can show up yellow by combining Red and Green keeping the value of Blue zero.

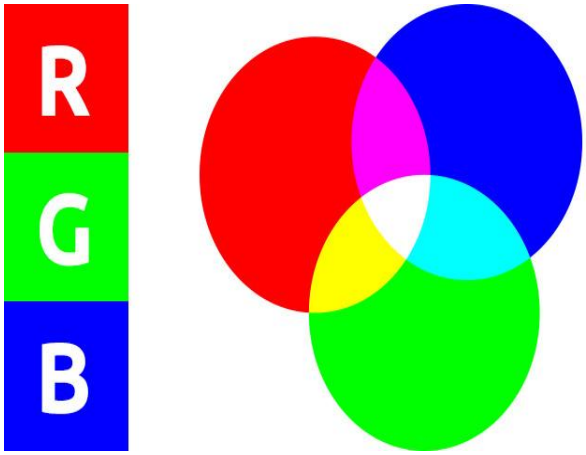


Figure 11 [https://blog.fotolia.com/us/files/2015/03/1-rgb.jpg]

HSV:

HSV means Hue, Saturation, Value. HSV is basically the cylindrical color space. Hue defines the color. It is angular as it is the circulation around the vertical axis. The angle of Hue defines the color. Highest saturation is the diameter of the cylinder and value defines the depth of the cylinder.

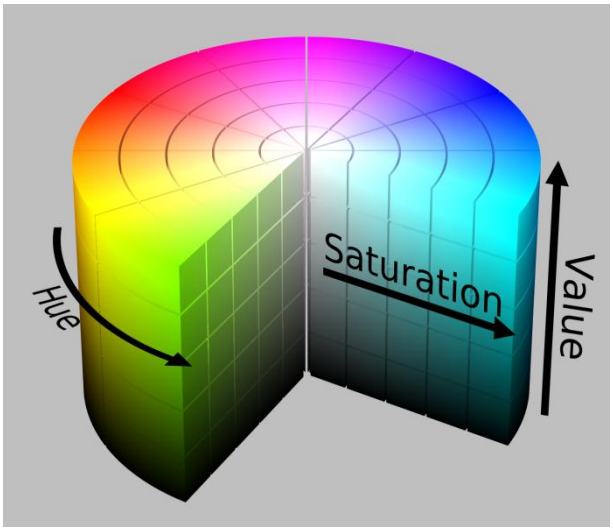


Figure 12 [https://upload.wikimedia.org/wikipedia/commons/0/0d/HSV_color_solid_cylinder_alpha_lowgamma.png]

HSL:

HSL means Hue, Saturation, Lightness. It is also a cylindrical color space. Hue defines the color. It is angular as it is the circulation around the vertical axis. The angle of Hue defines the color. Highest saturation is the diameter of the cylinder and lightness defines the depth of the cylinder.

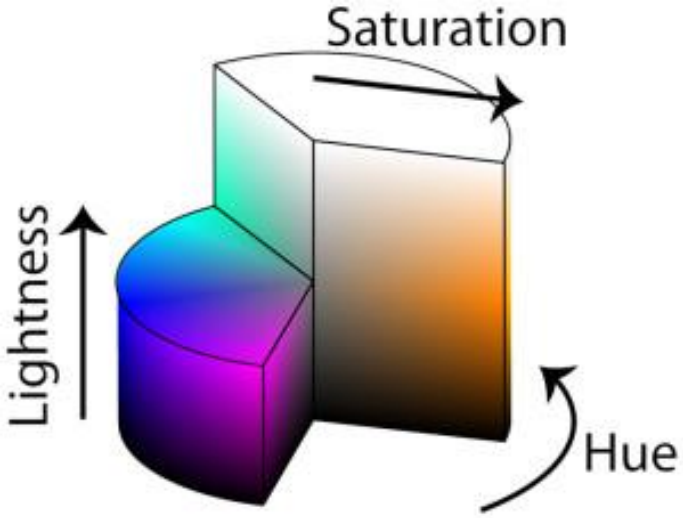


Figure 13 [https://cdn4.nixsensor.com/wp-content/uploads/2015/05/hsl-cylinder-300x228.jpg]

CMY:

CMY (Cyan, Magenta, Yellow) color space is like RGB color space. It is also a Cartesian color space defined as a cube containing the cyan, magenta and yellow colors as primary and red, green, blue are formed by their combination. It is more or less the same as RGB color space. The only difference is the point of view or origin of the color space. RGB has black color as its origin while CMY has white color as its origin. This is the reason that CMY is a subtractive color space.

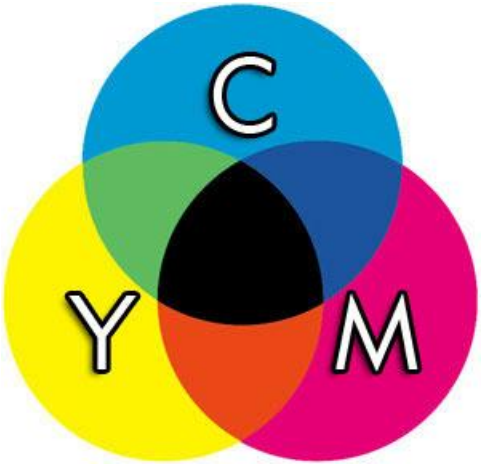


Figure 14 [http://www.designwebidentity.com/wp-content/uploads/2012/11/CMY.jpg]

2.9 Vision System

Industrial vision camera for this project is quiet expensive but have fast speed. We faced many problem regarding speed of caption in our project. Our selection of camera for cap inspection depends on:

- Pixels
- Frame Rate
- Color Recognition
- Anti Glaring

Pixels:

A megapixel (MP) is a million **pixels**; the term is used not only for the number of **pixels** in an image, but also to express the number of image sensor elements of digital **cameras** or the number of display elements of digital displays.

Frame Rate:

Frame rate, also known as **frame** frequency, is the frequency (rate) at which an imaging device displays consecutive images called **frames**. The term applies equally to film and video cameras, computer graphics, and motion capture systems. **Frame** rate is usually expressed in **frames per second** (**FPS**).

Color Recognition:

Reads an image from a camera and looks for a blob of a particular color.

Anti Glaring:

An **antireflective** or **anti-reflection** (**AR**) **coating** is a type of optical coating applied to the surface of lenses and other optical elements to reduce reflection.

3. Image Processing Based Glass Jam Cap Inspection System

3.1 Introduction

Machine vision system is generally referred to the system which extracts desired features from digital images. Captured input images are the main objective of this system.

Application of the vision system in industries in order to automate manufacturing process is considered as Automated visual inspection (AVI) when attempts are made to inspect, control products and recognize the defects by using only images of the products. In fact, human as inspectors are slower and their efficiency is affected by their state of illness, exhaustion or other human shortcomings. In some applications they need sometimes special environments which are dangerous and not conductive for human operation

On the other hand, especially in the manufacturing environment, it is necessary to improve quality control and productivity.

Inspection is carried out by machine vision system via image processing technique is application in beverage and food industries, milk industries, medicine industries and other chemical product industries. In this area, accurate filling, inspection of cap closure, sorting, recycling bottle is done and defected products are distinguished automatically.

Industrial Inspection cannot handle all the tasks in every aspect of application. So each and every aspect of inspection is given particular treatment according to the requirement.

In his project we have shown different principles of Jam caps inspection by presenting different methods and techniques for automation of Jars and the most recent algorithms are stated.

Our system uses algorithms that inspect the presence of Jam cap and whether it is tightly capped. Softwares like LAB view, Opencv, Matlab, MV impact will provide various digital image processing techniques used for obtaining required information from an acquired image. We have used Opencv in our project as sole software. Based on the extracted image the processor will take decision i.e. acceptable or not acceptable. Hence the NOT acceptable will be removed from the production line.

3.2 Jam Cap Inspection System

Our system consists of the following parts:

1. Hardware
2. Operational Board
3. Software
4. Sensor
5. Vision Device
6. Actuator

Hardware

We have designed a conveyor belts that is the main hardware of our project. We have given a prototype look of a production line where inspection takes place. It weighs about 17kg and is black in color.

Figure 15 Conveyor Belt

Its main features are:

- Motor
- Chain
- Belt
- Sorter

Operational Board

We have used Raspberry Pi2 as our sole operational board. It is a small sized single board computer. For the purpose of python we have selected this board.

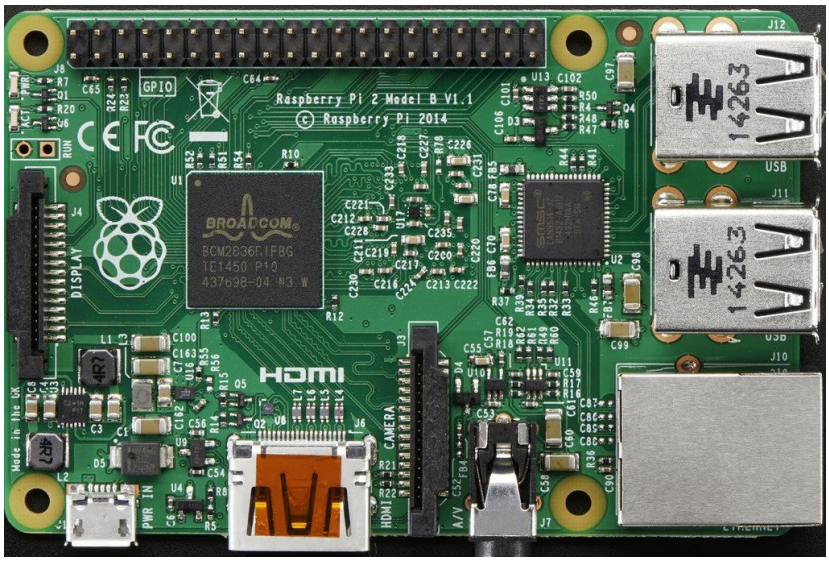


Figure 16 [https://cdn-shop.adafruit.com/1200x900/2358-03.jpg]

Its main Features are:

- Broadcom BCM2837 Arm7 Quad Core Processor powered Single Board Computer running at 900MHz.
- 1GB RAM.
- 40pin extended GPIO.
- 4 x USB 2 ports.
- 4 pole Stereo output and Composite video port.
- Full size HDMI.
- CSI camera port for connecting the Raspberry Pi camera.

Software:

Opencv is our sole software in this project which is a suitable for engineering student projects. Its use is free of cost. It has about thousand of libraries and has about 300 algorithms.

Figure 17 [http://docs.opencv.org/3.0-beta/index.html]

We have used opencv using the following programming setups:

- Python
- Visual Studio C++

Figure 18 [https://realpython.com/learn/python-first-steps/images/pythonlogo.jpg]

Figure 19 [google.com/vs]

Sensor

We have used IR sensors on the conveyor so that Jam bottle stops at the designated inspection points.

An **infrared sensor** is an electronic device that emits in order to sense some aspects of the surroundings. An **IR sensor** can measure the heat of an object as well as detects the motion. These types of **sensors** measures only **infrared** radiation, rather than emitting it that is called as a passive **IR sensor**.

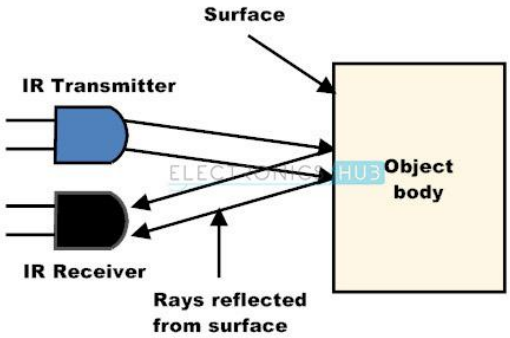


Figure 20 [http://www.electronicshub.org/wp-content/uploads/2015/01/4.-Working-principle-of-IR-sensor.jpg]

Vision Device

In our project we have used A4 Tech cameras. These cameras are very common in the market and are best at image processing.

Figure 21
[https://www.google.com/imgres?imgurl=http%3A%2F%2Fa4tech.com%2Fimages%2Fproducts%2FAccessary%2FPK-920H]

Figure 22[https://www.google.com/imgres?imgurl=http%3A%2F%2Fwww.a4tech.com%2Fimages%2Fproducts%2FAccessary%2FPK-333E-3b.gif&imgrewww.a4tech.com]

Actuator

We have two actuators in our project that play a particular role on the conveyor belt.

- **Linear actuator** is used to remove rejected Jam jars from the conveyor belt.

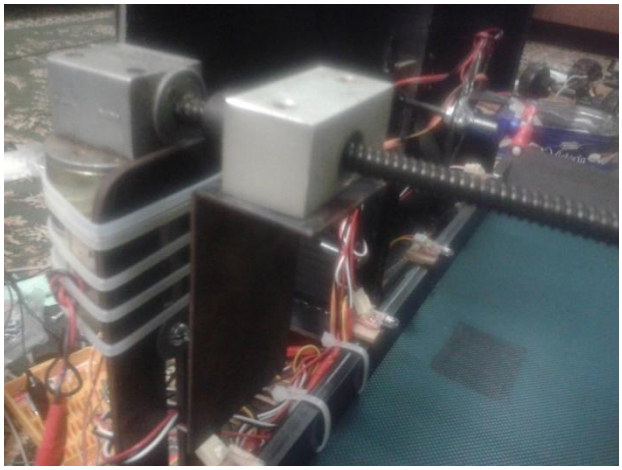


Figure 23 Linear actuator

- **Servo Actuator** that serves purpose of detecting presence of pressured Jam Jar.

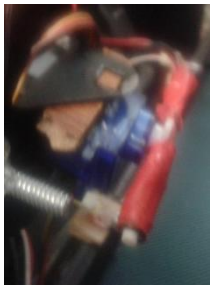
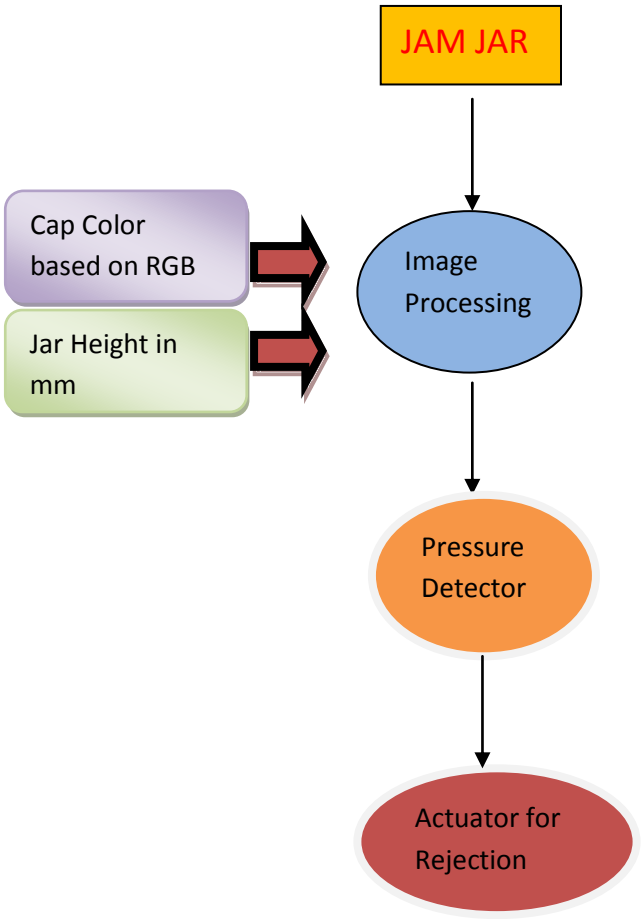


Figure 24 Servo

3.3 Working of System

Block Diagram



3.4 Image Processing Algorithms

Basically we have done programming based on color detection and size detection.

- **Color Algorithm Result**

Figure 25 Color

- **Size Algorithm Result**

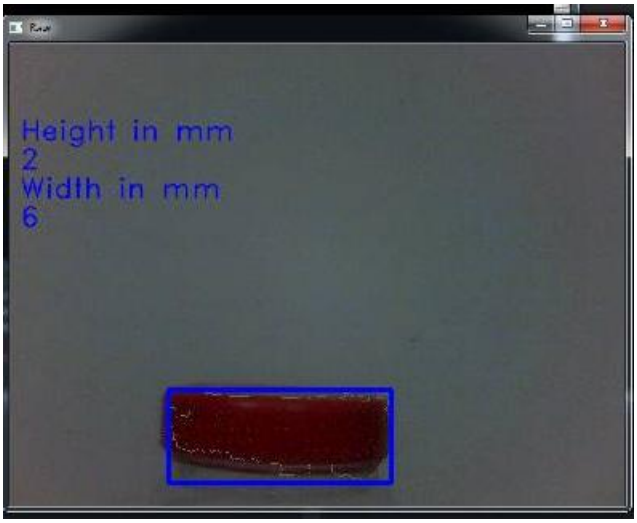


Figure 26 Size

3.5 Circuit Design

The following is the circuit diagram of our system.

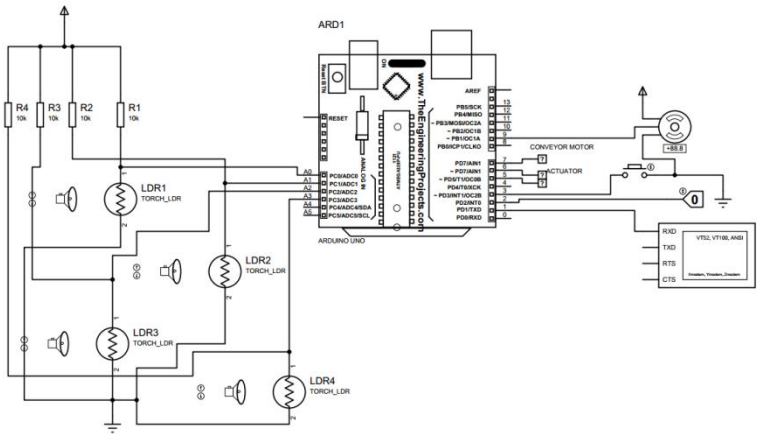


Figure 27 Circuit

3.6 Additional Automation Features

In addition to our image processing inspection system, we have also added a 5 DOF Robotic Arm and IR sensor base stock counter.

5 DOF Robotic Arm

It is a prototype Robotic arm that is able to grip and lift an object of 6 kg in entire reach of the arm. It is very common application of automation these days and could revolutionize Pakistan industry.

- 180 degree movement
- Servo controlled

Its purpose is to pick the accepted Jar and put it in a box after being processing through our main system.

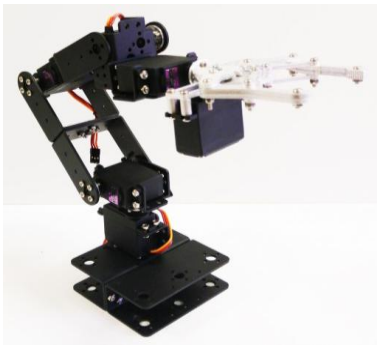


Figure 28 Robotic Arm

IR Sensor Stock Counter

It is very basic IR sensor based circuit that is supported by four sensors and could be useful in production line for counting products. This counter can be further enhanced by the use of IOTs

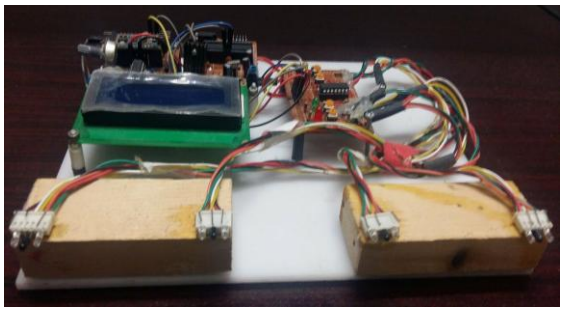


Figure 29 Stock Counter

3.7 Problems Faced during Hardware Design

We designed the conveyor belt ourselves and faced many in the actual implementation of design. Problems we faced were:

- **Motor torque**
  First we selected a motor of torque that was not up to mark and needed to be changed.

- **Conveyor bearing flexibility**
  At first conveyor was not flexible enough and too much resistance was present. Then we went to a car shop were they built and repair bearing. They sorted out the problem and advised us to make some additions to the bearing designed.

- **Chain breakage**

Chain breakage was the most often problem we faced while running but with the help of a mechanical engineer we sorted out the problem and added a motor bike chain.

- **Belt material**
  Belt material always needed a change after so much testing run until we came upon a rubber type frictionless material that solved our problems.

3.8 Problem faced during Software Program

Python- Raspberry Pi Program

Installing opencv in Raspberry pi was a very difficult task but after doing research on the internet it went quiet well. Then when the color recognition program was written and compiled successfully, it barred my program running with the Gpio pin execution program. It required my program root user permission. This error cost me a week but then after doing updates to my Raspbian OS, problem was solved.

Visual Studio C++ PC Program

The main problem we faced was the addition of (.h) library files and version compatibility. Calibration of camera was the most difficult task in visual studio program and forced me to make a complete box for image processing where no environment reflection present.

3.9 Algorithm

Step 1: Get the input video object.

Step 3: Set the green bounding box property.

Step 4: Set the texts.

Step 5: Play the video.

Step 6: Get a single frame.

Step 7: Mirror the image.

Step 8: Subtract the gray scale image from RGB image.

Step 9: Apply Erosion Filter to remove the noise.

Step 10: Get the resultant Binary image.

Step 11: Calculate x y coordinates using moment function

Step 12: Obtain the area

Step 13: Taking the appropriate decision.

Step 14: Sending command to the GPIO pins.

4. Experiments and Results

Color Recognition

We first used a simple plastic bottle that has a red cap. Our target color was red so we converted RGB colors image to the set HSV image and got its threshold.

Figure 30 Red

The resultant threshold image lack perfection and had a lot of noise, so we applied some filtering. We then used erosion and dilation morphological transformation, which successfully removed the noise.

Then we made changes to our prime python program and now applied it to original jam bottle which gave us very excellent results.

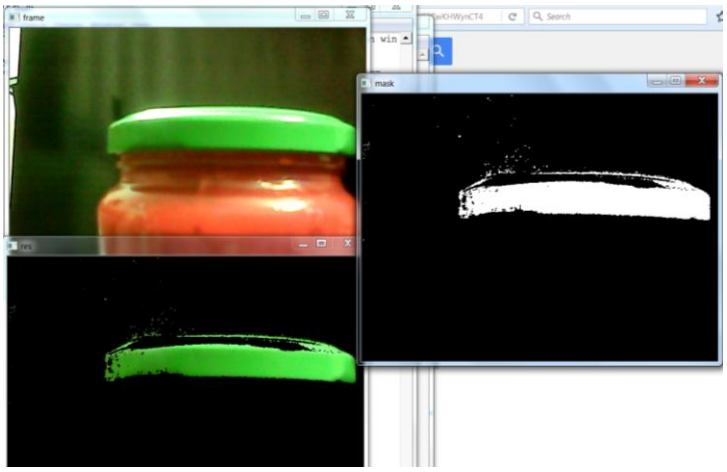


Figure 31 Jam bottle

Size Recognition

To make our system stronger our aim was to detect the size of our Jam bottle to know whether they are tight enough. We used code book method for background calibration. The background subtraction method was used which detect any object that differs from the background.

Then we draw contours around the detected object and form a rectangle which provide x and y pixels points. These points (x,y) are converted into height and width in mm. The results are good but are affected by reflection.

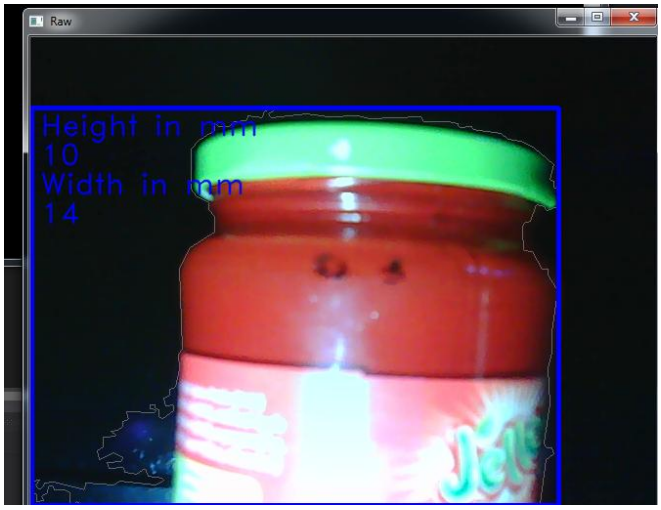


Figure 32 Size detection

5.Conclusion and Future work

We successfully completed our project based on image processing. The conveyor worked very well for our project. Our system sorted the acceptable and defaulted Jams. Inspection system proved very economical for us and it set a very good example for the industrial automation and vision system.

Our algorithm that contributes to the size of the Jam bottle works up to 60% accuracy and more work could be done in that area.

6. References

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