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FINAL YEAR PROJECT

INVESTIGATION OF MINI FOOD PROCESSING AUTOMATION

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" I hereby declare that I have read through this report entitle **"Investigation of mini food processing automation**" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature : ....

Supervisor's Name : ....

Date : ....

INVESTIGATION OF MINI FOOD PROCESSING AUTOMATION

SATYA NARAYANA A/L GOBAL

A report submitted in partial fulfillment of the requirements for the degree

Of Bachelor of Mechatronics Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

“I declare that this report entitle” **Investigation of mini food processing automation**“ is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree”

Signature : ....

Name : ....

Date : ....

DEDICATION

I would like to thank GOD who always blessed me with courage and perseverance to pursue my final year project without any problems. I would also like to thank my supervisor Dr. Ahmad Zaki Bin Haji Shukor, my family and my friends who supported me throughout this this research.

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Abstract

Food manufacturing industry is gaining its important in terms of monitoring quality and quantity mainly. After processing certain types of food they are graded in terms of quality for further processes. As the food processing industry grows it demands more on automation or robotics to ease human effort. In this project it is not only attempt to improve the production of tart shell it also to enhance the image processing technique by detecting color during the baking process through threshold after the conversion of Red, Green and Blue medium to Hue, Saturation, Value medium. The concept of pneumatic press was use to replace human from manually pressing the dough for the tart production analysis. This ensures the consistency of the shape of the tart for the analysis on the upcoming experiment. During the pressing process it requires the conveyor to be stationary with the mold platform so that pressing process can run without any flaws. This is done via placing two ultrasonic sensors to detect the mold platform with appropriate distance in order to stop under the pneumatic cylinder for the pressing process. To run the whole program spontaneously a Raspberry Pi 2 is used to connect all the instruments such as power window motor, pneumatic cylinder and the ultrasonic sensors. Raspberry Pi 2 operates the system when it is programmed with the python programming. Through this it can ease and improve the production of the tart shell instead if using the PLC which can be complicated in terms of connections and understanding. This may also save plenty of time in producing tart shell from human efforts such as the manual pressing of the dough. The perfect shape of a tart is identified by calculating the success rate of a perfect press and imperfect press to determine the number of circle formed in a tart after the pressing process.

Abstrak

Pembuatan makanan adalah salah satu industry yang penting dari segi pemantauan kualiti dan kuantiti. Selepas memproses makanan, ia dinilai dari segi kualiti untuk proses selanjutnya. Industri proses makanan semakin berkembang dan ia memerlukan lebih banyak mesin serta robotik untuk memudahkan kerja manusia. Oleh itu, teknologi automasi diamalkan untuk meningkatkan pengeluaran makanan dengan teknologi yang canggih. Tujuan kajian ini adalah untuk meningkatkan pengeluaran shell tart dan juga untuk meningkatkan teknik pemprosesan imej dengan mengesan warna semasa proses melalui penukaran warna dari medium RGB iaitu merah, hijau, biru ke medium HSV (hue, saturation dan value). Pneumatik, digunakan untuk menggantikan manusia daripada tekanan secara manual untuk analisis pengeluaran tart. Ini dapat memastikan konsistensi bentuk tart bagi analisis pada percubaan yang akan datang. Proses ini berjalan apabila penghantar bergerak dengan platform acuan supaya proses mendesak dapat berjalan secara spontan. Ini dilaksanakan melalui mengadakan dua sensor kedekatan untuk mengesan platform acuan dengan jarak yang sesuai untuk berhenti di bawah silinder pneumatik untuk proses tekanan. Untuk menjalankan keseluruhan program secara spontan Raspberry Pi 2 digunakan untuk menyambung semua instrumen seperti motor, silinder pneumatik dan sensor Ultrasonik. Raspberry Pi 2 fungsi apabila pengaturcaraan python diprogramkan ke dalam Raspberry Pi. Melalui ini ia dapat memudahkan dan meningkatkan pengeluaran shell tart dari menggunakan PLC yang rumit dan ini juga dapat menjimatkan banyak masa dalam menghasilkan shell tart serta bahagian menekan yang dilakukan melalui secara manual oleh manusia. Bentuk tart yang sempurna dapat melalui mengira kadar berjaya tekanan sempurna dan tekanan tidak sempurna untuk mengenalpasti nombor bulat yang berada di dalam sebuah tart selepas proses tekanan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Automation and Robotics have changed manufacturing in almost every industrial sector throughout country and globally. Through this they have increased efficiency in bringing product consistency for the consumers. This is crucial in food manufacturing industry since the demand and the scope of the industry getting bigger. As the demand increases for the domestic environment, satisfaction in terms of food manufacturing in a factory is essential. For example, food and beverages, bakeries and many more are required by the consumers which increase the demand. Products that are high volume, long life and fixed automation can use either robots or combinations of simpler electromechanical devices. Through this, particular process can be done with ease such as food packaging, preparation of the ingredients, food monitoring and so on. If the products are regular in shape and organized, simple solutions will often serve. However, the solution of the robotics will be complicated if the product localization is poor with irregular shape. Without any doubt, that automation and robotics industry has an important role to play by providing improved technology machineries that has influence throughout the global for the food manufacturing industry. It ensures the region continue and meet the demands by providing high-quality and affordable food products for the consumers [1].

This section is organized in six parts where motivation for this project continues after this introduction part. The third part emphasizes on the problem statement specifically on this project while the fourth part presents the objective of this project to overcome the problem given. The fifth part introduces scope where the last section covers the overall view of the project.

1.2 Motivation

In this rising modern technology world, food industries demand are rising equally in making preserved foods and also quality monitoring to ease human effort in processing food products. Automation technology has impact on food processing in terms of high quantities, increased efficiencies and better quality products. Combination of modern technology, robotics, and pneumatic systems has shown dramatic improvement in food processing quality and quantity. However, with advanced automated industries, many highly efficient methods are implemented in food automation system such as food storing and inspection process [2].

Producing tart shell manually requires a lot of time, human effort and energy especially for subsidiary production. As mentioned, it will also increase the labor cost in the process of making the tart shell. One at a time the dough‟s are required to be pressed into its mold form manually by the operator. The shape of the mold should be unvarying in curve and must be managed by a capable person in order to sustain the identical shape and the thickness of the tart shell. Having said that, with the advanced robotic and machines in the production lines a new benchmark for quality improvement and fast production can be achieved. This is due to the manual application of food managing which has greater rate of error and might as well expose to contamination [3].

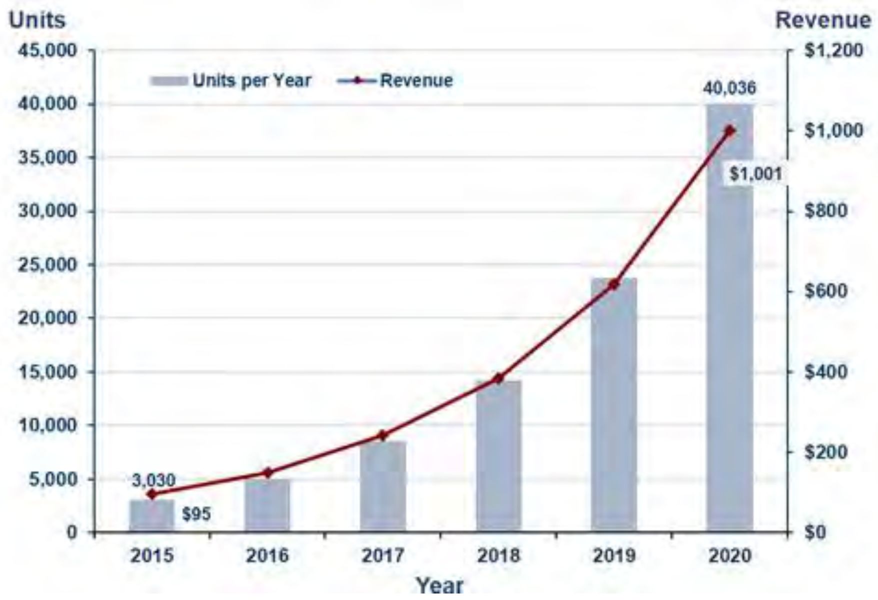


Fig 1.1: The expected robot sales by 2020 [5].

The figure 1.1 shows expected robotic sales by 2020, which is from the year of 2015. The graph is anticipated to be rose from the year of 2015 until 2020. In a recent survey, ABI estimation for the combined robots in the market will be more than 1 billion in upcoming 2020. The survey shows the market share for Asia Pacific (APAC) region that will increase from 19 percent to 57 percent, from the year of 2015 until 2020 [4]. This indicates the robot sales will be at peak in the coming year since the global is now advancing in both technologies and robotics. In a collaborative manner millions of industrial robots are being produced every single day.

Based on the descriptions above, robots can be enabled to do physical task over and over again where it will be hard for human to perform. Robots are combination of high tech parts which are integrated to perform a particular task capably in most of the repetitive working environments such that humans frequently will get exhausted. .

1.2 Problem statement

Actions like pressing with pneumatic system are more consistent rather than manually press to spike up overall yield and reduce waste when it comes to use automation system in the food production. A rough calculation indicates that manufacturers enjoy roughly 3 percent yield improvement with the help of robots in situations like exact pressing and manual pressing [3]. When it comes to using pneumatic system the basic factor should be considered to design an automation food production system is identifying the suitable pressure to press the dough. Immoderate or inadequate pressure of the pneumatic system can influence the shape or the thickness of the tart shell. Apart from that, the platform which holds the mold also have to be sturdy and firm to acclimate the pressure from the pneumatic system while it is being pressed.

Having said that, a tart shell with the size about 450mm in diameter, it requires some skills to maintain its shape when it‟s done repetitively. By using the pneumatic system, it will improve the speed and the timing for pressing the tart shell into its mold [6]. Besides that the accuracy of the tart‟s shape can be influenced by the amount of dough that has been used. To have and maintain the correct amount it is essential to measure the mold‟s weight before it‟s filled in.

Other than that, to identify the appropriate shape and colors in certain conditions is essential for conducting this experiment. Identifying shapes in terms of maturity, shape defect, extra features and many more are considered in this aspect as well. Maturity indicates through color changing perspective, while shape defect is identified through feature extraction method. Problems that arise in machine vision are prone to physical or technical difficulties. There are certain variables considered in machine vision.

First and foremost, for image acquisition process resolution and the distance of the camera from the object of interest plays an important role, where the resolution and distance are connected indirectly. The higher the resolution of a camera, the larger the distance can be from the object of interest and vice versa. For a good quality picture a high resolution camera is required, hence to improve image quality through a short distance. In certain image acquisition process lighting plays an important role to display the picture brighter so it can be viewed clearly for further steps. Fixing lighting in a closed chamber can result the image to be very bright and vice versa with a dim light. Adjusting light intensity according to the camera‟s distance and its resolution quality, it brings out good quality image as a result. In certain cases, position of the camera plays an important part as well to determine the appropriate angle of the image. In order to get an angular view of the image the camera should be tilted and adjusted to capture the image as per the requirement of the image needed. In some cases the camera will be placed uniformly towards the object to obtain direct image, where the angular motion doesn‟t require.

Throughout this research, improving the design of the conveyor system can escalate the tart process production. By doing so, it is provided with organization process to identify the exact shape via image processing technique.

1.4 Objectives:

1. To improve the automation system and the tart shell production.
2. To enhance image processing technique to reject or accept the accurate shape using edge detection and color detection.
3. To analyze the relationship between weight, shape, distance of the camera and its resolutions by using machine vision technique.

1.5 Scope

- The conveyor and pneumatic was operated using Raspberry Pi2 to improve the automation.
- OpenCV-Python will be utilized to integrate the image processing and all the operations in the Raspberry Pi in order to recognize the shape of the tart.
- With the size of 24mm of the dough and 44mm of the symmetry mold is utilized in this experiment.
- Additionally OpenCV-python used to detect the accurate shape and the color of the tart.
- The shape and the aspect of the tart shells are observed by the webcam after being pressed.
- The dough is weighed with electronic scale and placed manually for image processing and it will be taken back manually after the process to be placed on a tray, if accepted.
- The expected tart shell production by this automation machine is 50-100 pieces per hour.

CHAPTER 2

LITREATURE REVIEW

2.1 Image processing method

Image processing is a method that converts captured image into digital form by performing some mathematical operations. Each image has useful information that needs to be extract, enhanced or both at the same time. That is why it has to undergo such process to give clear information about it.

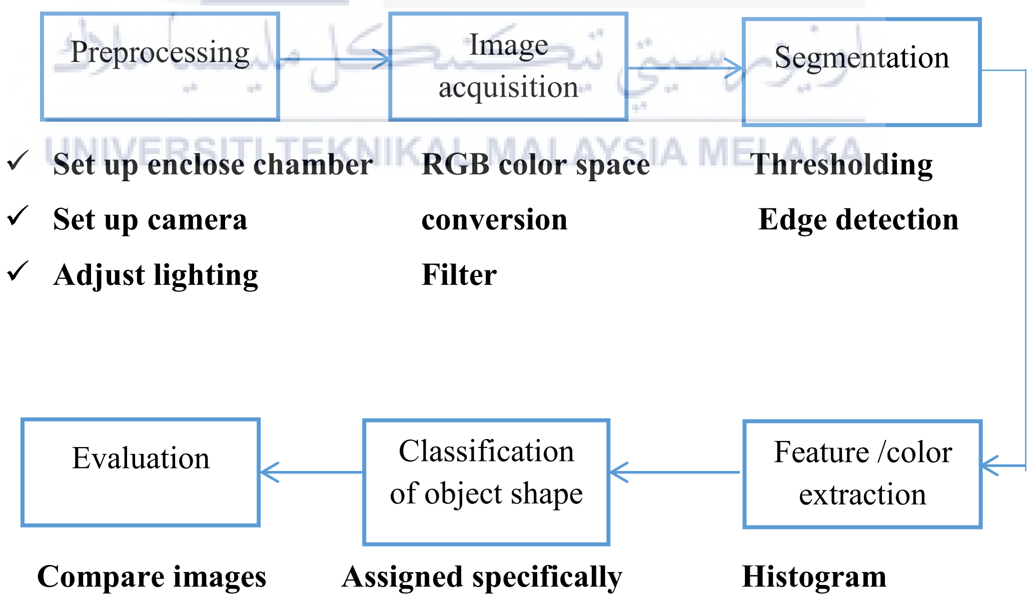


Figure 2.1 General flow of the image processing method.

2.2 Related works

2.2.1 Freshness classification using color analysis

According to journal [5], their research involves any radiation techniques such as gamma radiation, X-ray, and infrared to determine the level of reduction in terms of physical of the beef quality. Main difference of the techniques is the radiation wavelength exposure which is to determine the level of beef freshness by image processing technique. Beef irradiated image will be scaled into 0.2 of its original image

Figure 3.1: irradiated beef image scaled into 0.2 [5].

Pre-processing method is to prepare a beef irradiated image before acquiring its feature of interest. Through this process, the noise of the image will be at lowest with an optimal condition. Then, the image is formatted in jpeg in the form of digital data 8 bits for each base color RGB (Red, Green, Blue) will be converted into the HSV color space (Hue, Saturation, Value) to see the difference of its brightness.

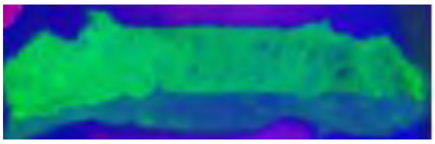


Figure 3.2: Convert RGB to HSV color space [5].

The next step in the journal is to threshold the value of each layer so that they can obtain the beef‶s position to distinguish the beef from the background itself. Then matrix multiplying is done from HSV image and the image resulted from the thresholding process.

Figure 3.3: Thresholding to separate the beef from the background [5].

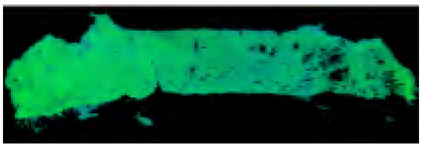


Figure 3.4: Matrix multiplying [5].

Feature extraction defines as a feature-taking process that describes the characteristic of the image. Feature of interest which resulted from feature extraction process is used to compare between one character to another. Feature extraction method which has been used in this research is GHM Multi-wavelet Transformation.

Figure 3.5: Image segmentation of the feature [5].

2.2.2 Effective Maturity using image processing

According to journal [6], the author has done maturity grading or classifying the ripeness of a fruit, based on its color or texture, through a very important process which most of the agriculturists are exposed to. Basically authors have performed feature extraction process using the a* component of the L*a*b* color space, since it is proven to be the best component for tomato maturity estimation [4.0]. By using the previous binary image as a mask, the boundaries of the tomato were acquired and filled and the mean values of all a* in the area of the tomato were calculated as well. Through these values the maturity of the tomato were anticipated, as illustrated in Table below;

Mean value of a*	% of Full Maturity
$a^* < -5.8$	10 - 20
$-5.8 \leq a^* \leq 2.1$	30 - 40
$2.1 \leq a^* \leq 9.2$	50 - 60
$9.2 \leq a^* \leq 21.5$	70 – 80
$21.5 \leq a^*$	Full maturity

Figure 4.1: Maturity Table [6].

One of the most important steps before the extraction of area of interest of the tomato from the background is to convert the image obtained to a suitable color space model. This step is performed to ensure the correct segmentation of the image that gives a successful result. Not to mention to reduce the total amount of processing time required for the process. Each pixel in the RGB image obtained from the camera is 24 bits in size wherein the first 8 bits represent Red and the second 8 bits represent Blue and last but not least 8 bit for Green.

In order to perform segmentation, authors has justified by doing histogram analysis over 100 images of tomatoes acquired from the internet and also captured using computer camera under various lighting conditions. This is to indicate Cr component of a pure red tomato that lies within the range of 135 to 180.

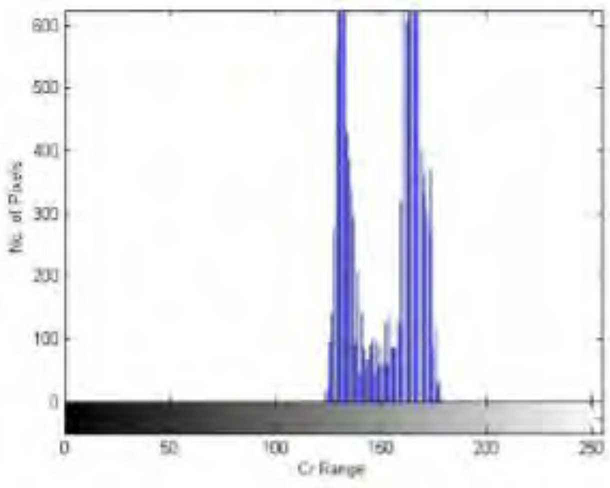


Figure 4.2: Cr color model of a tomato image [6].

The resultant image obtained will be subjected to some noise which can be eliminated by using morphological operations, the most popular being erosion. Erosion was performed on the image using a structuring element of 7x7. In order to compensate the shrinking of the tomato due to erosion, dilation was performed on the resultant eroded image. This was performed using a basic 3x3 structuring element. Once the dilation is performed on the image, the tomatoes marked in white while the background remains black.

Based on experiments on various tomatoes of differing ripeness, the authors implemented a 1:1 correlation to observe the maturity between the tomato and the average total number of white pixels representing the tomato in the dilated image.

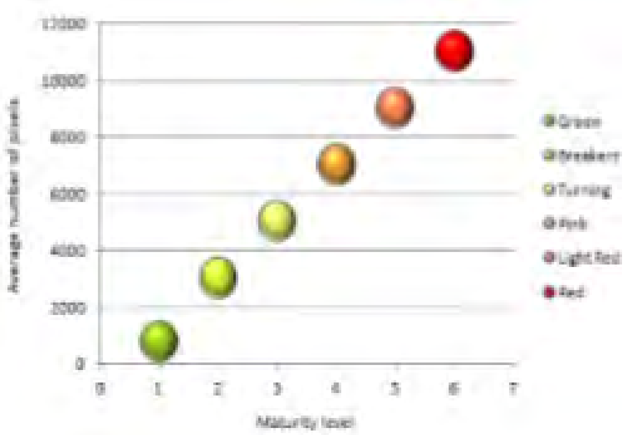


Figure 4.3: Grading of tomatoes on various maturity levels [6].

Figure 4.4: Green, Turning and Red tomatoes are observed by the camera [6].

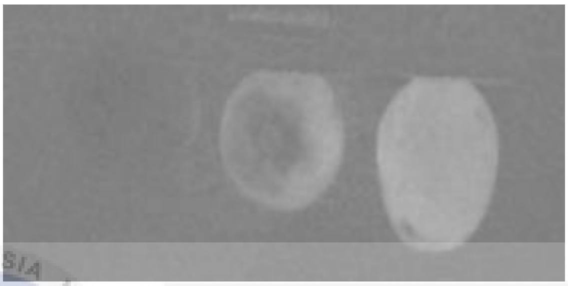


Figure 4.5: The converted Chroma (Cr) image from the RGB image [6].

Figure 4.6: Segmented image [6].

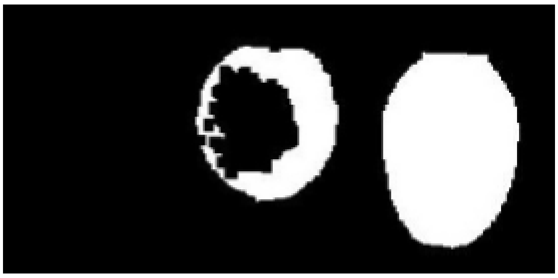


Figure 4.7: Image obtained after erosion process [6].

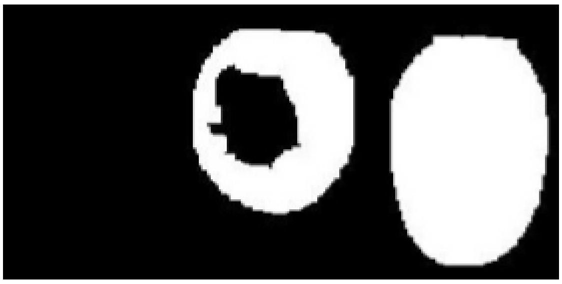


Figure 4.8: Final image after dilation process [6].

2.2.3 Quality Analysis Using Image Processing Technique

Referring to journal [7], the writer have justified that quality control in food is very important and in food industry as well because based on quality parameters food products will be classified into different grades. The journal shows grading and evaluation of rice grains on the basis of grain size and shape using image processing techniques. Specifically edge detection algorithm is used to find the region of boundaries of each grain.

Image is captured using a color camera in three dimensional color space which is RGB color space. It is then converted into grey image using color extractor. Also filter is applied to remove the noise from the image and threshold to segment the rice grain from the background.

Figure 5.1: Grey image [7].

Then by using edge detection, region of boundaries of rice grains identified as shown. Writer has used sobel operator as the edge detector for edge detection of the rice grains.

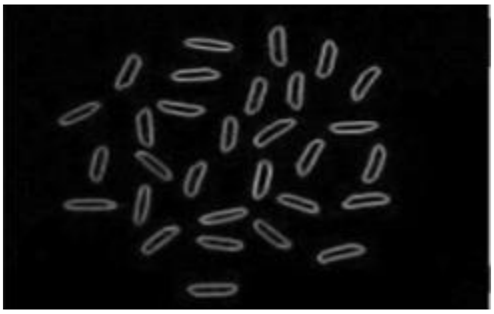


Figure 5.2: Edge detection on the rice grains [7].

Object is then classified via measuring the value of length and breadth of each rice grain. Through this we can calculate the length-breadth ratio.

Ratio L/B= (Average length of rice/Average breadth of rice) x100

Figure 5.3: Number of rice grains [7].

2.2.4 Maturation Assessment Using Computer Vision Techniques

According to journal [8], the research is all about to evaluate the maturation of the pineapple automatically in post-harvest using computer vision techniques. The evaluation is done by implementing a digital color-image processing that is based on the stages of preprocessing, segmentation, feature extraction and statistical classification.

Primarily transformation of the RGB color space to the HSV color space took place, where the H and S channels generated histogram, and finally, used median filter: a moving average filter. The HSV color space represents hue, saturation and value. Hue represents the value of the kind of color. The saturation refers to the wavelengths added to the color frequency determining the amount of white contained in a color. The value corresponds to the particular appreciation of darkness and lightness.

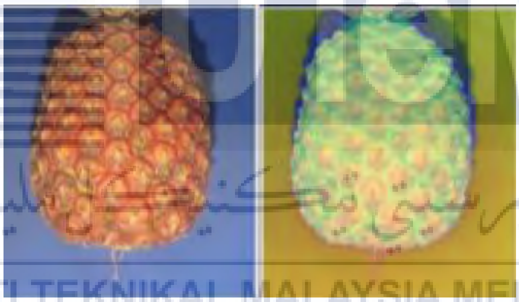


Figure 6.1: Pineapple in RGB and HSV color space [8].

The method for segmentation is done by thresholding which uses the information from the histogram of H and S planes. This step is achieved by a continuous tagging of the image pixel by its pixel until it has certain value. This method carries out the selection for the final quality result of the segmentation which uses Otsu"s method. When threshold reaches its optimum level the binary image is created where the area of interest is extracted from the original image. There are three classes to assign and classify the extracted image into a specific class which is green pineapple, half ripe pineapple and ripe pineapple. It corresponds to the three stages to determine the maturation of the pineapple. The statistical parameters that define them (mean, variance, correlation between classes) is unknown and so does the number of classes. That is why the non-supervised classification method by clustering is used.

Figure 6.2: Original Image, Binary Image, Segmented image [8].

2.2.5 Shape Recognition in Machine Vision Application

According to journal [9], the writers have proposed shape recognition method where the circle, square and triangle will be recognizable by the algorithm. So throughout this research, the shape recognition is done by the algorithm where it is aided by other features like threshold that uses Otsu‟s method to obtain binary image, and filtering to remove noise, sobel operator to detect the edge and also compactness of the region.

Firstly, HSL color space is chosen and only one channel, L will be processed and there will be no usage of three dimensional color models that is RGB. The advantage of using one color channel is to reduce the processing time and complexity. The figure below shows the conversion of the RGB color space to L channel in HSL color space.

$$L = \frac{max(R,G,B) + \min(R,G,B)}{2}$$

Figure 7.1: RGB color space to L channel in HSL color space [9].

Otsu‟s threshold selects a threshold automatically from a gray level histogram that must be adequate threshold of gray level to extract the object of interest from their background.

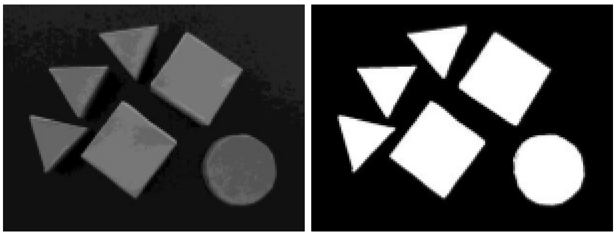


Figure 7.2: Otsu‟s Threshold [9]

Median filtering widely used to reduce "salt and pepper‟ noise and to preserve edges as well. In this method, the size for median filter operator is set to 10x10 matrices. This process ensures that all the corresponding edges are connected properly so that the perimeter can be computed correctly for each object.

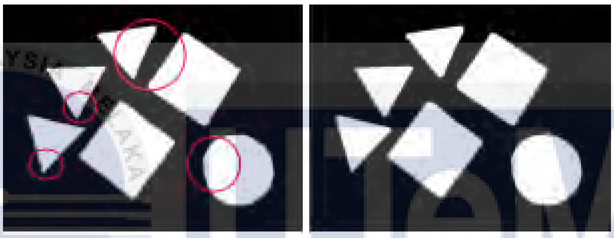


Figure 7.3: 10x10 Median Filtering [9].

For edge detection algorithm, Sobel operator was used as an operator. Sobel mask was used to detect the shapes edges where each shape is required to compute the perimeter. The perimeter is determined by counting the total white pixels in the edge of a shape of the image.

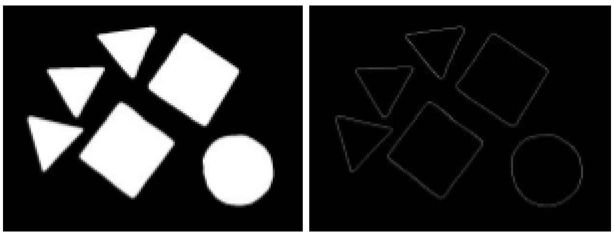


Figure 7.4: Edge detection using Sobel operator [9].

Shape recognition method recognizes the shapes of an object by computing the compactness equation.

$$c = \frac{p^2}{A}$$

C= compactness

P= Perimeter

A= Area

Figure 7.5: Object Template and Detection Output [9].

2.2.6 K-mean Clustering for Segmentation of Irregular Shape Fruit

According to the journal [10], the writers had done their research to propose an image segmentation method is designed based on k-means adaptive clustering. They are applied for grading or inspecting quality of food and fruit products in various shapes particularly which are non-circular (like banana, mango, and pineapple) and captured in various illuminations.

One of the most used threshold method in segmentation process is Otsu's thresholding, that repeats all possible threshold values and calculates a spread for the pixel levels on both sides of the threshold value. Color based K-means cluster identifies fruits defect using segmentation. This method is more suitable for images containing blur boundaries around them.

Figure 8.1: Original fruit image [10].

Usually fruit images are captured in RGB color space values to 400x400 pixels which is to keep the even intensity of all pixel values. This will prevent time consumption and converts the images to grey scale. Segmentation of various shapes of fruit images has separated into two parts that is unwanted background and segmented image of exact fruit. This significant step is performed by GsKm technique that has great accuracy in segmenting images.

Figure 8.2: Segmented images of fruits [10].

Figure 8.3: Final output [10].

2.2.7 Edge Detector with Adjusted Thresholding

According to the journal [11], the paper proposes a method which combines both median filter and simple standard deviation to complete edge detection for image processing technique. A de-noising process has been applied on the grey scale image using median filter to identify the pixels that could be contaminated in the first place. After that, each 2x2 windows size can be computed with statistical standard deviation.

The fundamental method for edge detection is local operator edge detection method, where the pixels in a region must be compared with the neighbor pixels in order to detect the edge by their differences. Standard Deviation is a measure of how spreads the numbers are and also the dispersion of a set of data from its mean. Window with size of 2x2 used to detect the candidate point as edges.

Median filter is widely used as an impulse noise removal method due to its de-noising ability and computational efficiency. The proposed edge detector gives better results than Sobel and Canny edge detectors when applying in 10% of Salt and Peppers noise image. The proposed edge detector was based on 2x2 window pixels. The standard deviation within the 2x2 window was calculated before removing the noise.

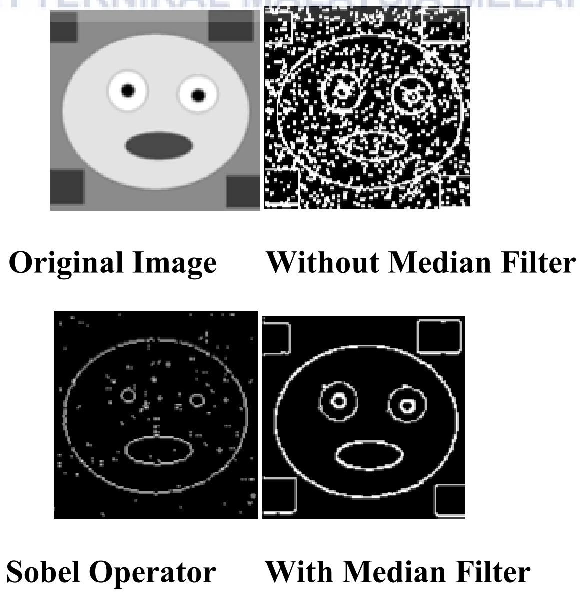


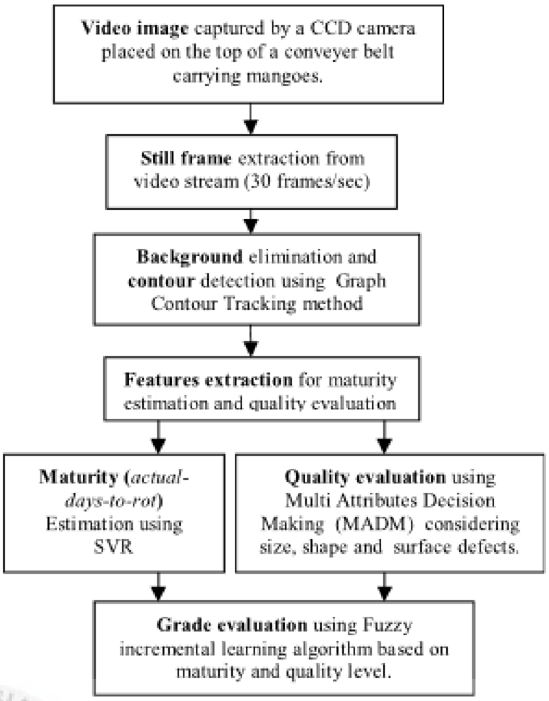
Figure 9.1: Image with filter process [11].

2.2.8 Machine Vision Technique based on Maturity and Quality

According to journal [12], the paper emphasizes that in today agricultural and food industry, proper grading of fruits is very essential. In this paper, a structure for the grading of mango according to their maturity level in terms of actual-days-to-rot and quality attributes, such as size, shape, and surface defect has been proposed. The proposed method needs machine vision-based techniques for grading the mangoes in four different categories. For the experimental works five different varieties of mangoes were collected in local areas.

After acquiring the image, several preprocessing issues were considered, such as frame extraction, filtering, edge detection, background elimination, alignment of mango image performed before the extraction of features using different image processing method. The mango fruit grading process in this proposed method is divided into two sets, one is maturity estimation in terms of actual-days-to-rot and the second one is to determine the quality of the mango. In this proposed work two layer classification was done, first is SVR and MADM and the second layer fuzzy incremental technique. Prediction of maturity level in terms of actual-days-to-rot using SVR and evaluation of quality using MADM is done separately and fuzzy incremental learning algorithm has been applied to classify the mango into four different grades. Support Vector Regression (SVR) is used to determine the number of actual days for the harvested mangoes that can be sent and MADM system estimates quality of mango in terms of characteristics such as shape, size and surface defects. Having said that fuzzy incremental learning algorithm will be applied to combine the decisions of SVR and MADM on maturity and quality respectively, for the final gradation of mangoes into four different categories which is poor, medium, good and very good.

The mango size gradation is applied by using threshold which is according to the length of mango major axis and minor axis. Numbers of defective pixels were calculated and distinguished to validate the gradation effect to obtain and analyze the amount of surface defect while the shape analysis is based on the Fourier Descriptor for each shape category present.



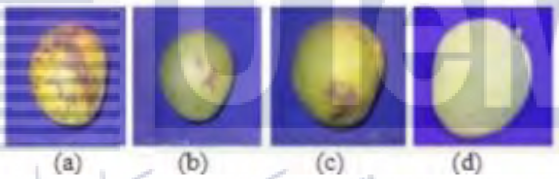


Figure 10.1: Fruits with different grading [12].

A) poor B) medium C) good D) very good

2.2.9 Precision Size Measurement for Irregular Objects

According to journal [13], Precision size measurements are widely used in the industrial production and in the food industries as well. However, the challenge lies to measure irregular objects such as cookies, candy and etc. In this paper, a high-precision measurement device has been propose for measuring irregular objects based on machine vision technique.

In this project, preprocessing includes the acquisition of area of interest which is the background image and extracting feature line from the side of the background image, background deduction, binarization and the contour extraction of the candy. For two different shapes of candy, a novel processing algorithms is proposed which is RVC (Rotary vernier caliper) method that uses both size candy. The distinction of a candy is weighed by the weighing device. Having said that, RVC is used for a rapid measurement of the length and the width for the irregular shape, hence a pair of parallel lines can be used along the edge point and rotate 360 degrees to get the maximum and minimum distances of the candy edge. For the background subtraction, the value of T for the binarization was set to 80. Three images resulted of background subtraction and the result of the binarization of the contour extraction.

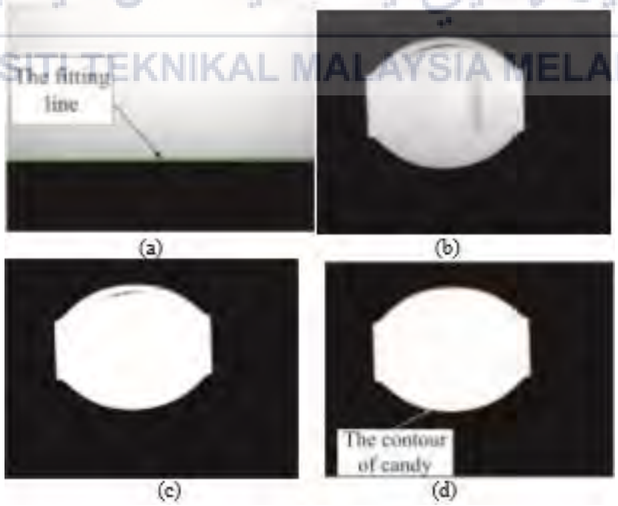


Figure 11.1: Feature extraction of area of interest [13].

A) fitting line

B) background subtraction

C) binarization

D) contour extraction

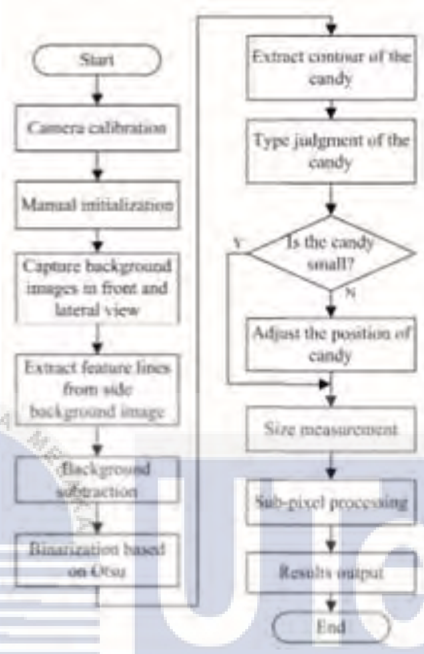


Figure 11.2: System flowchart [13].

2.2.10 Food Selection Using X-ray Images and Logistic Regression

According to journal [14], the writers have proposed binary classification of pine nuts using x-ray images where independent nutmeat x-ray images are extracted and two kinds of features are extracted from them as well. By using Gray Level Co-occurrence Matrices (GLCMs) set of features are produced to project statistical texture properties of that images. Histograms of images were obtained after using edge detection.

X-ray image of pine nuts were obtained by placing on an image plate under x-ray radiation exposure that leads to extraction of the independent nutmeats from the image. Then, threshold was applied and the image was converted into a binary image to separate the background and nuts. Regional properties were calculated using the binary image, as the properties include the centroid, bounding box and area of bounding box. The centroid provides the coordinates of the center of regions not only the nuts but as well as any external object around the background where the bounding box contains the position and the dimensions of a rectangle. For feature selection a set of features that contains the appropriate information about texture is the best choice.

Figure 12.1: a) thresholded image with multiple centroid

b) image with median filter

c) image with area threshold

d) nutmeat image extraction matching the centroid

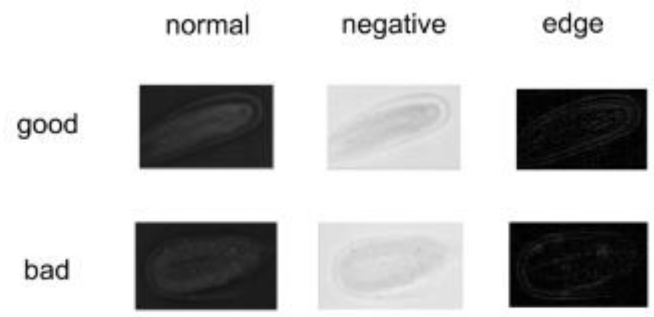


Figure 12.2: image with negative transformations and edge detection [14].

Histogram provides information about the frequency of the pixel intensities in the image, which was used as an reference to transform all images by negative transformation to visually enhance an in the figure above.

2.2.11 A genetic algorithm approach for feature selection and classification by computer vision

According to journal [15], the writers had done their studies on quality control that has improved over the last years with help of machine vision in making the classification task in different quality degrees. This paper classifies potatoes based on their external defects and diseases where some image processing techniques have been used to segment and analyze the potatoes. Classification is done to decide the group the potato belongs to. In the meanwhile, feature selection is carried out by designing an ad-hoc genetic algorithm which maximizes the classification percentage.

The idea was to use a matrix camera to capture the potatoes from different points of view, as they roll on the line. The segmentation process separates the potatoes from the background by detecting the areas of interest, then identifying those areas as objects, prevention of segmentation for the groups of touching potatoes into a single object. RGB colour space image was converted to HSV colour space and by removing the intense blue colour from channel H a new RGB image was built from S, V and the modified H channel. To classify the object authors have chosen Nearest Neighbor Classifier, because of its simplicity and robust performance.

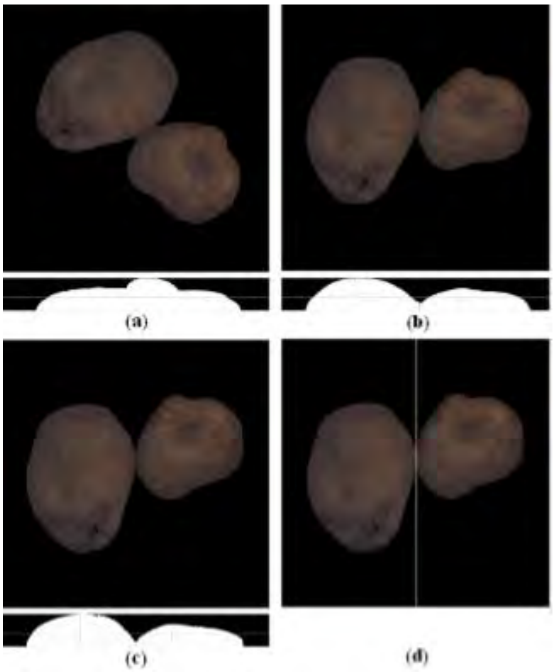


Figure 13.1: Touching potatoes [15].

Figure 13.2: Segmented image [15].

2.2.12 Statistical Pattern Recognition

According to the journal [16], this research is focusing on the application of computer vision and pattern recognition techniques for the problem of estimating the position of a robotic-cutter as the head remover of this automated fish butchering. Images of each fish head were captured into a vision workstation to record the important features such as eye-to-nose, eye-to-flap, eye-to-gill, eye-to-the center of the pectoral fin, eye-to-the edge of the pectoral fin for estimation of the point. Correlation identifies the important features, to reduce the redundant features from the estimation model which is known as factor analysis. In multiple regression there are several independent variables then in a simple regression, to estimate a dependent variable.

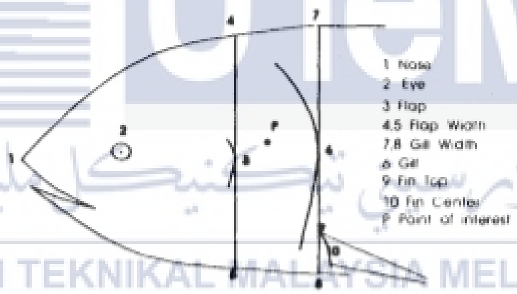


Figure 14.1: image of featured fish [16].

The image processing system extracts the required features from the fish images using an edge enhanced 2-D Gaussian-smoothed method to compute the features. The edges are enhanced using a Sobel operator in the direction of the feature.

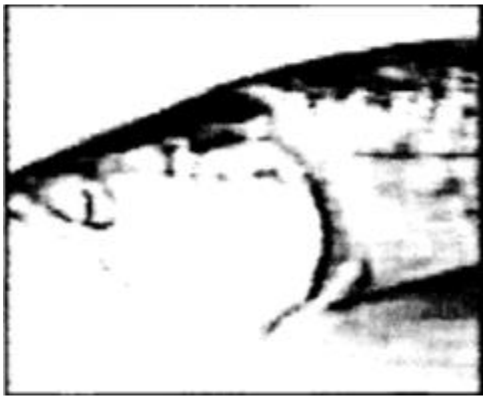


Figure 14.2: Fish image [16].

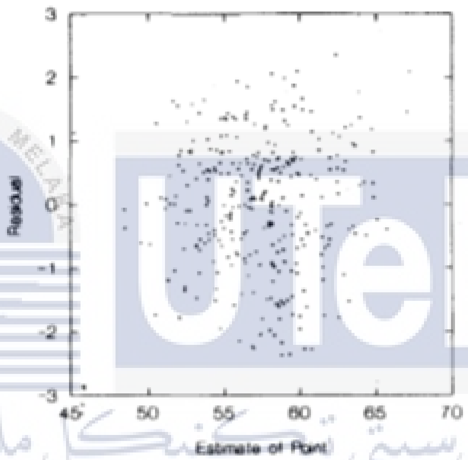


Figure 14.3: Residual of the point estimate [16].

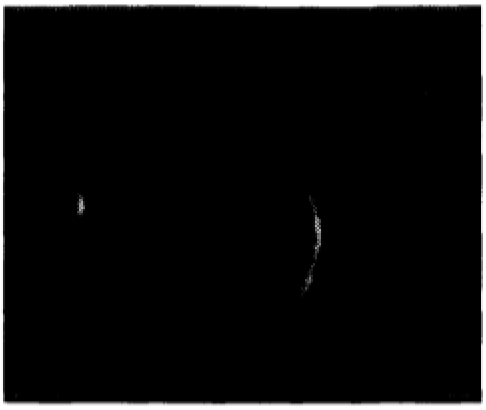


Figure 14.4: Enhanced edge image of the head [16].

2.2.13 Application of Image Processing Technology for Quality Control in the food industry

According to the journal [17], the authors have done their study to propose 3-D measurements of the different types and sizes of loaves using machine vision technique. The industrial PC with integral colour LCD display, fitted with a network interface card and PX510 frame grabber. Video cameras were placed to measure the length of the baguette and a fourth camera was also placed in union with a solid-state laser line generator to measure the perimeter. Image processing uses algorithms that can measure the perimeters of the baguette which is through laser triangulation technique. The position of the brightest point of the image is inserted into a list hence a threshold is used to remove the noise. The resulting point list approximates to the shape of the laser line.

Part of the baguette that laser line projected was segmented by repeating the list, from left to right, until vertical discontinuity is found so that it can be used to eliminate spurious points that caused by image noise. Projected laser lines are the image coordinates which 3x3 transformation matrix are used previous session to calculate in the calibration process. Convex hull of the complete perimeter is calculated by using the Graham Scan algorithm to remove any local concave regions caused by surface irregularities from the upper border. Precise edge detection is executed between two small sub-windows (30x30 pixels) on the, approximate position which is the center. A image of horizontal gradient modulus is created for each of the sub-windows.

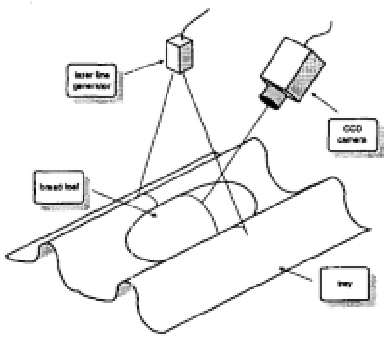


Figure 15.1: Configuration of the perimeter [17].

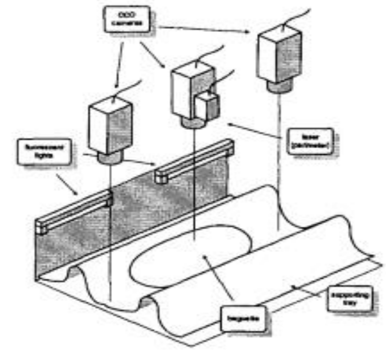


Figure 15.2: Configuration of the length [17].

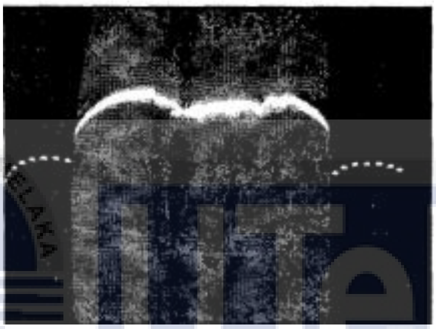


Figure 15.3: Image to measure perimeter [17].

2.3 Summary

Table 1.1: shows summary of journals

CRITERIAS	JOURNALS		
	Journal 5	Journal 6	Journal 7
Techniques	Image processing	Image processing	Image processing
Types of Food	Beef	Tomato	Rice/Grain
Pre-processing method	Cropping and thresholding	Set up chamber	Image register and noise removal
Image acquisition & color conversion	RGB color model - HSV model	Convert color model from RGB	RGB color model – grey image
Filters	Irradiating image	Morphological operation	Morphological and edge detection
Segmentation	Threshold and matrix multiply	Thresholding and histogram analysis	Thresholding and sobel operator
Feature extraction	GHM multi wavelet	Used a* from L*a*b*	Erosion and dilation
Classification of object or shape	Nearest Neighbor & Neural network	Observe correlation	Calculate average length and breadth ratio

CRITERIAS	JOURNALS		
	Journal 8	Journal 9	Journal 10
Techniques	Image processing	Image processing	Image processing
Types of Food	Pineapple	Object shape	Fruits (non -round)
Pre-processing method	Set up chamber	Image capture and color conversion	Image captured with camera
Image acquisition & color conversion	RGB model – HSV model	RGB model – HSL model	RGB model – grey scale
Filters	Median filter [9x9]matrix	Median filter [10x10] matrix	-
Segmentation	Otsu's threshold and sobel operator	Otsu's threshold and sobel operator	Otsu's with GSKm method
Feature extraction	Optimum threshold	Threshold of grey level	Calculation of threshold value
Classification of object or shape	Proximity parameter calculated	Calculate compactness	Calculate spread pixel level

CRITERIAS	JOURNALS		
	Journal 11	Journal 12	Journal 13
Techniques	Image processing	Image processing	Image processing
Types of Food	Object shape	Mango	Irregular objects (candy)
Pre-processing method	Compare pixels edge	Set up chamber	Obtain image & extract line
Image acquisition & color conversion	Uses standard deviation and [2x2] matrix	Obtain image in RGB model	Edge point acquired from ROI
Filters	Median filter	-	-
Segmentation	Uses standard deviation	Simple thresholding	Otsu's threshold
Feature extraction	Edge detector & median filter	Calculation of size	Background subtract with binarization
Classification of object or shape	Edge detector with filter	Maturity & fuzzy incremental	Otsu's dimensional method

CRITERIAS	JOURNALS		
	Journal 14	Journal 15	Journal 16
Techniques	Image processing	Image processing	Image processing
Types of Food	Pine nuts	Potato	Fish
Pre-processing method	-	Set up chamber	Image captured and recorded
Image acquisition & color conversion	Image obtained from x-ray radiation	RGB model – HSV model	Image obtained in CCD camera
Filters	Median filter [5x5] matrix	-	-
Segmentation	Threshold on the image	Threshold to detect AOI	Sobel operator and correlation analysis
Feature extraction	Using centroid and bounding box	Histogram and matrix calculation	Edge enhanced 2D Gaussioan & sobel
Classification of object or shape	Calculation of statistical & histogram	Nearest Neighbor method	Multiple regression

CRITERIAS	JOURNAL
	Journal 17
Techniques	Image processing
Types of Food	Baguette
Pre-processing method	Set up chamber
Image acquisition & color conversion	Image obtained in solid state to measure perimeter
Filters	Edge detection / Threshold
Segmentation	Threshold used
Feature extraction	Graham scan algorithm
Classification of object or shape	Through edge detection

2.3.1 Analysis between each technique used

By comparing all the journals most of them used food as a variable for the experiment of image processing technique. According to journal [5], [6], [7] they have used beef, tomato and rice grain to conduct the image processing technique. For the preprocessing method both in journal [5] and [6] have used a chamber to set up the procedures. In journal [5] they have set up in such a way to acquire color space transformation, cropping, thresholding and matrix multiplying. For journal [6] the set up"s are mostly in technical way which is camera adjustment and constant lighting with plain background. In journal [7] preprocessing method consists of image acquisition and noise removal technique which will be done later in different cases. Both journal [5] and [6] acquire image in RGB color space, where Red, Green and Blue which it needs to be converted for both journals. In Journal [5] the color space conversion takes place from RGN to HSV. This conversion allows a picture to be brighter. In journal [6] RGB color space is converted as well but it doesn"t require the conversion to HSV color space. In journal [7], they don"t have RGB color space conversion since they acquire image and filter them form noise to obtain smooth image. Types of filter used in journal [5], [6] and [7] are different. In journal [5] beef irradiating technique was used as a filter to minimize the noise. While in journal [6] morphological operation was performed on the images which consist of erosion and dilation. In the Journal [7] edge detection was used to remove the noise and to smooth the image. Then segmentation method for journal [5], [6] and [7] are quite different in each of them. All journals performed thresholding but varies in certain method of execution. In journal [5] the calculation used is matrix multiplying and in journal [6] the calculation was done through histogram analysis to segment the area of interest. For the journal [7] shrinkage algorithm was used to calculate the image by segmenting the black background from the image. Color and feature extraction in journal [5] GHM multi wavelet was used. While in journal [6], a* component from L*a*b* was used. Lastly in journal [7] erosion and dilation was used to extract feature from the image. After this the process continues with classification or recognition of object. In journal [5] nearest neighbor method was used via back propagation and neural network. In journal [6] by observing the ripeness of the fruit and the standard number of white pixels, it classifies the image. In journal [7] they classify through length and length breadth ratio which will be calculated as length breadth ratio. All camera required to be in high resolution to give quality output in capturing the image. Resolution of camera in journal [6] was 640x480 and in journal [7] the resolution was 640x380.

In journal [8] the type of food used for image processing experiment is pineapple. Similarly in journal [10] fruit with non-round shape such as banana, mango and many more was used. In journal [9], shape of object was used like circle, square, triangle and so on instead of fruits. Preprocessing method in journal [8] is the setup of the chamber with the controlled lighting and adjustment of the camera. In journal [9] image capturing and color conversion takes place while journal [10], image capturing is done under natural illumination as a preprocessing method. For image acquisition process all the journals undergo color space conversion but it varies in certain aspect of criteria according to the journal. In journal [8] the RGB color space of the image converts to HSV color space. But in journal [9] RGB color space of the image converts to HSL color space. In journal [10] the image conversion shows from RGB color space to grayscale. Types filters used in journal [8] and [9] are similar which is median filtering. It differs in matrix multiplying where in journal [8] it uses window 9x9 size while in journal [9] it uses 10x10 matrix. Segmentation process in journal [8], [9] and [10] are similar with each other which is Otsu"s threshold was performed in the experiments. Then feature extraction in journal [8] is performed through optimum threshold where it extracts the area of interest. In journal [9] with adequate threshold of gray level it extracts the area of interest while journal [10] calculates threshold value and extracts the area of interest from the background. After that classification of the image is done by calculating the proximity parameter in journal [8]. In journal [9], classification of the image is prepared through computing the compactness. While in journal [10] classification is done by calculating the spread of pixel level on both side of the threshold value. For resolution of the camera in journal [8] is 1536x2048 which has high resolution. In journal [9] the camera has resolution of 640x480 and journal [10] has used a digital camera which has a resolution of 400x400.

As mentioned above by overviewing all the journals, it can be seen that most of the experiments have been done with foods and only some are related to objects. In journal [11], [12], [13] and [14] they have utilized object shape, mango, irregular object (candy) and pine nuts for the experiments. The preprocessing method for journal [11] describes that pixels should be compared for the variances in order to identify the edge which includes certain attributes that is amplitude, location and orientation. In journal [12] an artificial illuminated chamber with motion and speed control was set up. In journal [13] the image is captured and extracts feature line from it. After that process, image acquisition plays its role by acquiring certain image together with color space transformation. In journal [11] standard deviation was used by measuring the spreading set of data from its mean to acquire the image. However in journal [12] image was acquired from the chamber in RGB mode. For journal [13] image was acquired through visual systems where the edge points were obtained from the region of interest. In journal [14] image obtained with an x-ray radiation exposure. Following this, types of filters used in journals are limited due to its requirements and complexibility. In journal [11] median filter was used to remove the impulse noise in the image. Similarly in journal [14] median filter was used as well which is 5x5 matrix window size. Then for the segmentation process, journal [11] used standard deviation as well as in image acquisition. In journal [12] simple thresholding was used to detect the defect pixels. In journal [13] threshold Otsu"s method was used to segment the region of interest from the image. However in journal [14] threshold was used to convert binary image to distinct from background and nuts. For feature extraction in journal [11] is done by proposed edge detector and median filter. In journal [12] feature extraction is done by calculating the actual length of major and minor axis length. In journal [13] feature extraction is performed by calculating image by viewing from all directions. For the journal [14] feature extraction is completed via corresponding centroid and bounding box from the image. The classification for each journal is done differently according to their experiment. In journal [11] classification is performed by removing salt and pepper noise by using edge detector and median filter. In journal [12], there are 2 methods to classify the image which is through the prediction of maturity level and fuzzy incremental. While in journal [13] the classification is made by using Otsu"s method which based on dimensional histogram. In journal [14], it is classified through calculation of statistical features and histogram feature. The camera resolution in journal [12] is 640x480.

For journal [15], [16] and [17] they have used potato, fish and baguette for image processing experiment. In preprocessing journal [15] has undertaken several steps to set up a color camera adjust halogen lamps for lighting and inspection of dust and sand on the potato. In journal [16] image obtained via vision workstation to record the important features of the head. In journal [17] hermitical sealed compartment was constructed to place camera, imagenation grabber, LCD display and more. For image acquisition process journal [15] captured the image in Red Green Blue color space which will be converted to Hue Saturation Value color space. In journal [16] image of the object acquired using CCD camera. Meanwhile in journal [17] camera acquires image via solid-state laser line generator to calculate the perimeter. Types of filters used in journal [17] are edge detector and threshold. Then segmentation process in journal [15] is done by using threshold to detect the area of interest. In journal [16] correlation was used to identify the important as a part of factor analysis in segmentation. In journal [17] threshold was used to remove the noise from the image in order to segment the image. After that process, feature extraction in journal [15] is performed by using histogram method and matrix calculations. For journal [16], edge enhanced 2-D Gaussian method was used using sobel operator to extract feature of interest and in journal [17] feature was extracted from the image using graham scan algorithm. Proceeding with the classification of the image in journal [15] is made via Nearest Neighbor due to its simplicity and robust performances. In journal [16] multiple regressions is used to classify the image by which to estimate a dependent variables. In journal [17] edge detection of baguette classifies the image through its arrays. The resolution of the lens that was used in journal [15] is 15MP and its camera resolution is 2456x2048 which is sufficient to produce quality images.

2.3.2 Comparison between preferred techniques

An overall view from the previous journals that were researched, there are some approaches that can be approached for this project. The concept of classification is reviewed among the journals to identify the best approach for this food automation project.

According to journal [5], [7], [8], [10], [11], [15] and [17] the findings were to classify the objects shape when undergoing image processing technique. For instance, in journal [7], [8] and [10] the classification of the shape is done as per standard data base this is through calculation of the pixels. In [7], classification is done by calculating the ratio of average length of rice and average breadth of rice. In [8] classifying extracted features from the object was done through calculating the proximity parameter by trial and error, given the number of established classes. Blue color(1^{st} class), red color(2^{nd} class-half ripe) and green color(3^{rd} class-ripe). In journal [10], classifying grayscale pixel in binary image was through the calculation of a spread pixel level on both side of threshold value. While in [5] classification of the object was done by Nearest Neighbor method and back propagation neural network whereas, it uses histogram to classify the object. While in journal [15] the classification was done by Nearest Neighbor method due to its simplicity and robust performances. Other than that, journal [11] classified the object through edge detector in addition with median filter to remove salt and pepper noise while in [17], classification of object of interest via edge detection as well.

The next technique utilized is the segmentation method that has contributed in [6], [7], [8], [9], [10], [13], [14] and [15]. Segmentation method does partitioning or divided digital image into various and recognizable image. It is done by locating the edges of the area of interest. Edges are the limitations areas on an image that contains significant info about the image. There are plenty of ways to do segmentation through a method called threshold. In journal [6] threshold was done to acquire black and white image from the object. In journal [7], segmentation was done by thresholding algorithm to segment the area of interest from the black background of the image. In journal [14] using threshold to convert image into binary image to separate the region of interest from the background and the object while in journal [15] threshold used to detect the area of interest for the segmentation.

Next in segmentation thresholds process some journals have focused on implementing Otsu‟s method which is related to threshold. In journal [10] Otsu‟s method with GSKM technique was operated to provide image with great accuracy. In journal [9], Otsu‟s threshold method was used from a grey level histogram. Having said that, journal [13] and journal [8] used the same Otsu‟s method for the segmentation process as well, in addition journal [8] has referred histogram for the process.

Last but not least, the final technique which focused on the types of filters used to rectify defect, smooth and remove noise from the image. Throughout all the journals [6], [7], [8], [9], [11] and [14] have implemented filter. In journal [8], [9], [11] and [14] have used median filter to reduce noise and smooth the image. But for each journal mentioned above have used different sets of matrix multiplying and window size for the median filter. In journal [8] median filter with window size 9x9 have been used, journal [9] median filter with 10x10 matrix multiplying have been used, in journal [14] median filter 5x5 matrix multiplying have been used and finally in journal [11] normal median filter has been used to reduce the impulse noise. Other than that, in journal [6] and [7] morphological operations have been conducted in the filtering process where it combines with erosion and dilation. In addition journal [6] has used an existing method as well which is 3x3 rectangular filtering.

2.3.3 Overall summary

As an overall analysis of the techniques used from all the journals that were researched some suitable method can be contrivance in this project with a little improvement. Primarily the concept of classification was reviewed among the journals to identify the accurate shape of the tart shell for this automation. According to the selected journals classifying the object and food shapes is done through certain methods such as standard data base which is calculation of pixels, calculating the ratio of the length and the breadth and to identify the classes through color analysis. With this technique and applying certain criteria of improvement it will surely process the shape of recognition smoothly.

Next by locating the edges of the area of interest through segmentation, it provides important information about the particular image. It implements threshold on the image as per the review from all the previous journals which is significant in order to make sure all the edges are connected properly from the object of interest. This determines the initiative will be taken to measure the centroid of each object shape when it is compared for the sorting process. Not only that, by improving certain aspects of filters to reduce noise it can produce quality image as mentioned in all the journal researched. Where by using median filter with appropriate matrix multiplying it can smooth the image to increase the contrast of the output image. It also adjusts the intensity when filter is applied on the image.

CHAPTER 3

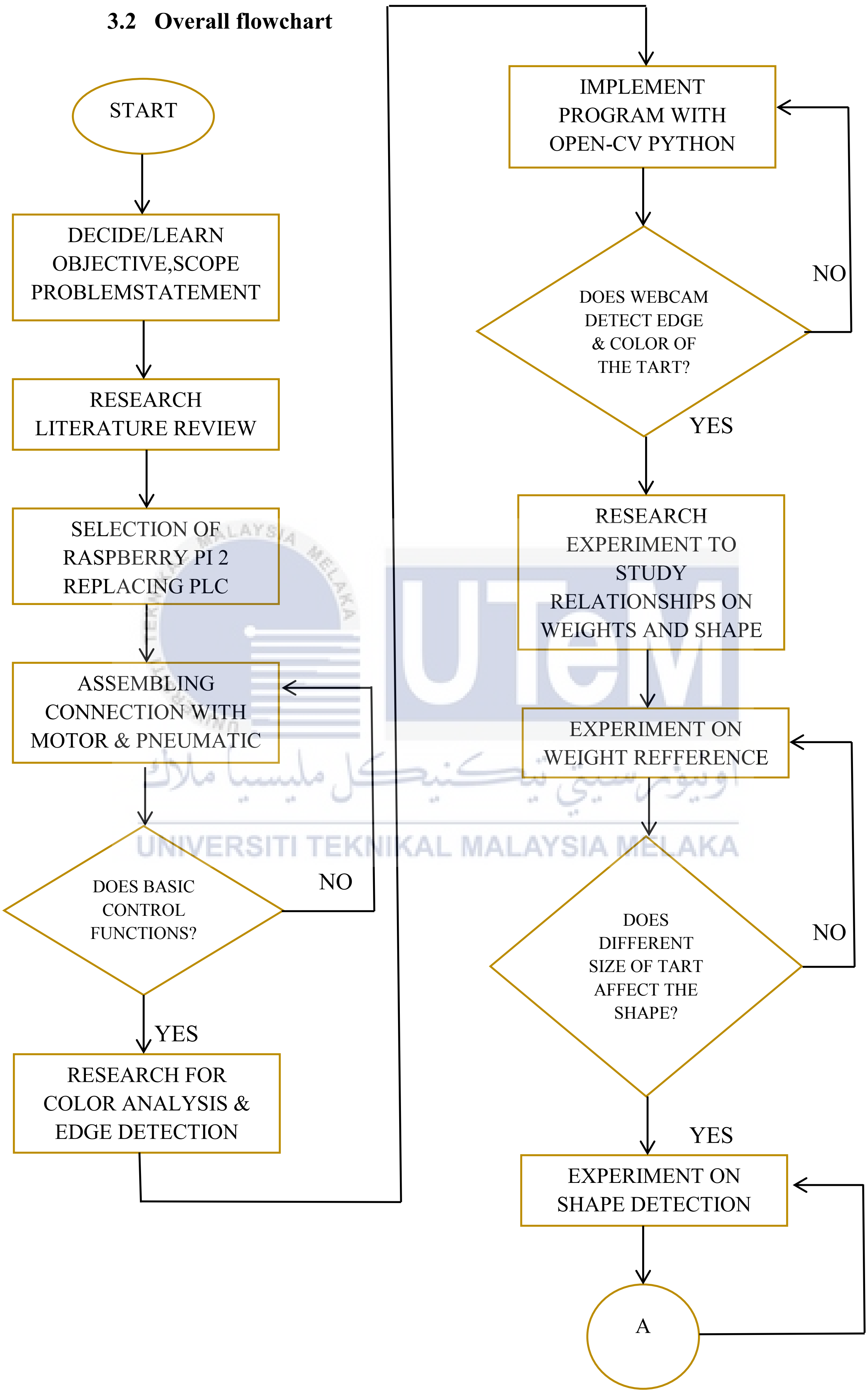
METHODOLOGY

3.1 Introduction

In this chapter, to achieve each objective as mentioned earlier the methods to carry out the project will be utilized throughout the whole project. First and foremost, this section covers the flowchart of the project and continued with the general flow of the experiment process. An overview of this project through a flowchart shows an idea on how the improvement of the food automation system is going to be implemented. To precede with this idea the selection of the hardware including the designation of the prototype varies not far from the original structure. Not only that, the method to be used for pressing will remain unchanged, while the analysis on the precise shape to be accepted or rejected remains same as well and additionally it does the analysis on the color of the tart shell to identify its freshness. This process is related to the second objective. For the third objective, experiments will be conducted that will focus on the specific configuration that will be required.

On the other hand, in order to complete the experiment some software will implemented such as Fluid SIM to design the circuit of the pneumatic system. Also, Solid work was used to design the hardware for the additional operation of the food automation system which is to justify objective 1 that is to improve the food automation system. Besides that, OPENCV-Python is used to synchronize the algorithm with the webcam camera for image processing. Lastly, implementation of Raspberry Pi was decided in order to operate the whole automation system replacing PLC controller in the previous project. It is used due to its portable size and inexpensive cost. Also, the programming of Raspberry Pi was researched thoroughly from all possible sources such as the journals and internet. This is to synchronize both Raspberry Pi and image processing through the webcam by capturing the image.

3.2 Overall flowchart



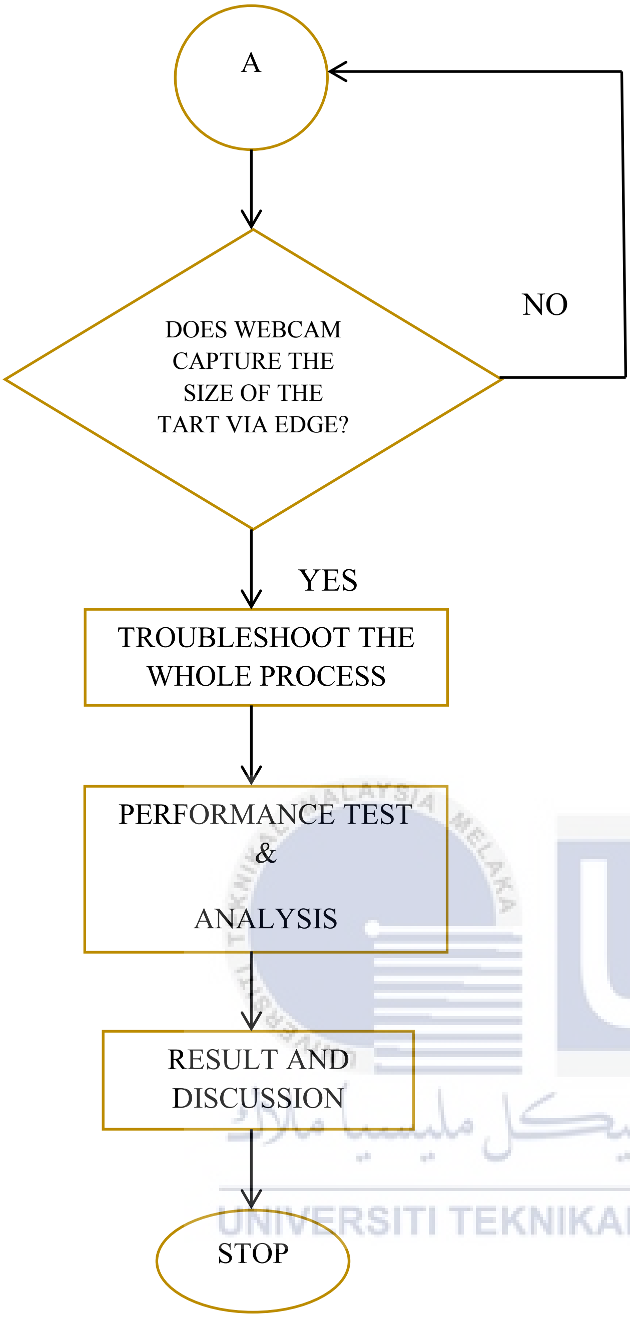


Figure 16.1: The flowchart of the overall process of the FYP1 and FYP2.

3.3 General process flowchart

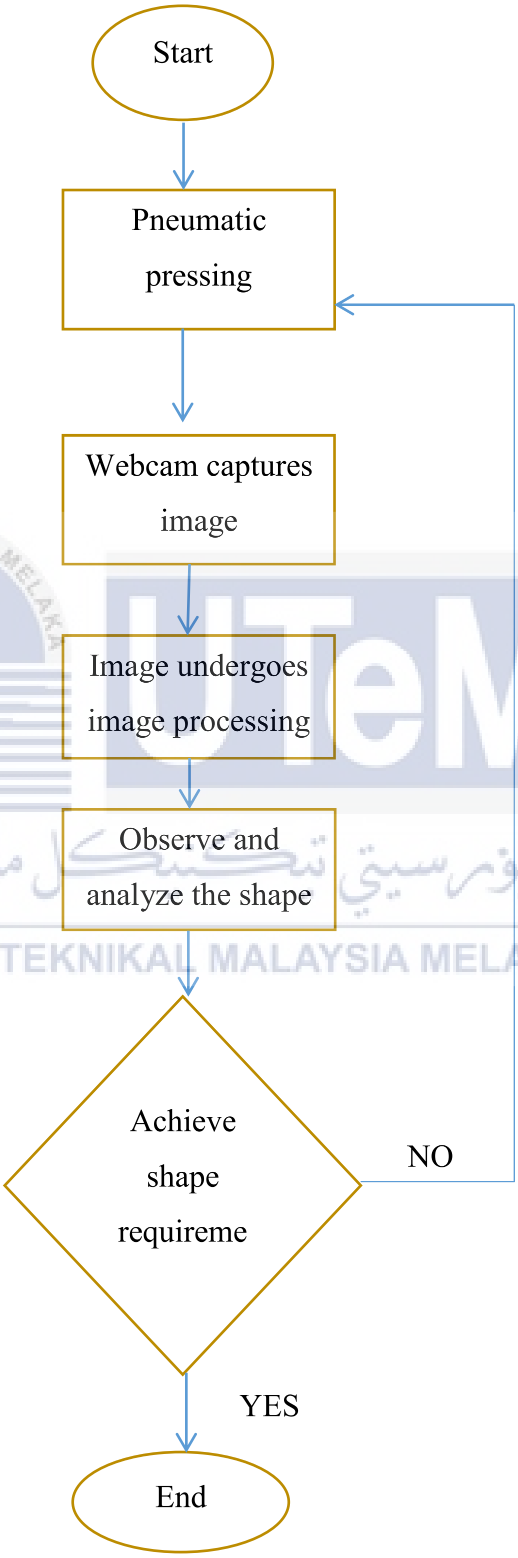


Figure 16.2: The flowchart of the general process.

Based on the above diagram, this automation experiment demands the cylinder to press the dough until it fits the mold form which is controlled by Raspberry Pi 2. Then, the webcam identifies the object and captures the image which is then uploaded for image processing techniques such as converting color space model, filtering, segmentation and classification of the shape. In the next step, the image is analyzed to fulfill certain conditions to be accepted or rejected by referring the shape of tart shell. If the image does not meet the requirement it will repeat the whole process until the desired shape is met.

3.4 Instrument selections for the design

3.4.1 Camera

This part covers the entire number of component that will be used while conducting this experimental operation. Short and brief explanations will be provided for each component and software‟s used throughout this whole project.

Figure 16.3: Webcam used in experiment

Throughout this project, an ordinary camera with 2 Megapixel with CMOS sensor has been used to capture the image. The resolution and the distance of the camera play an important part for the image acquisition where the camera stand was made flexible to adjust the distance. Even though the camera stand is flexible the angle which requires viewing the object will be taken into considerations. The webcam is connected to the Raspberry Pi 2 through USB connection provided in the Pi itself. Size of the camera comprises small amount of space since its dimensions are 71mm x 71mm x 263mm.

3.4.2 Cylinders

Figure 16.4: single acting cylinder for pressing process

For the system such as automation with a pressing process pneumatic cylinder plays vital role to generate motion and force. In this case it will used as single acting cylinder with a 3/2 way valve. Single acting cylinder functions by compressing the air on one side of the piston and venting the air on the other side. The most widely used single acting cylinder has internal spring that allows it to return to its actual position once the air is released from its chamber. For the project which is to press the dough in its mold to get accurate shape, this pneumatic cylinder would be appropriate. With this it can increase the consistency of the shape produced by the actuators.

3.4.3 Arduino Uno R3

Figure 16.5: Arduino Uno R3 used to control ultrasonic sensor

In this project Arduino Uno r3 has been chosen to operate both the ultrasonic sensors. In total arduino has 14 digital input and output pins, 6 analog pins, a USB connection, power jack, reset button and many more. The operational voltage for the Arduino is 5V and the DC current for input and output pin 40mA. The input voltage recommended for the Arduino is 6-20V and the clock speed of an Arduino is 16MHz. There are two ultrasonic sensors which have been integrated with the Raspberry Pi 2 in input pin of 7 and 15. The input and output pin of the Arduino which is (12,13) and (8,9) has been used as the trigger and echo pin for the ultrasonic sensors that integrates directly to the pin 7 and 15 of the Raspberry Pi 2.

3.4.4 Ultrasonic Sensors

Figure 16.6: Ultrasonic Sensors for mold platform detection

The figures show ultrasonic sensor where it detects the nearby object without any physical contact. In this experiment ultrasonic sensors are utilized as pit – stop to identify the mold platform when it reaches the pit – stop. In this project two ultrasonic sensors have been used. Ultrasonic sensor is a 4 pin module that consists of Vcc, trigger, echo and ground. It features two speakers that signifies Transmitter and Receiver where the signal will be transmitted when the ultrasonic detects an object and reflects back to receiver when the signal hits an object. This is how ultrasonic sensors detect object or measure the distance from an object. The ultrasonic sensors can be powered from the Arduino and it consumes around 15mA current which can be sufficient for the Arduino to power up. Same concept is applied in this project where the ultrasonic sensors detect the mold platform by sending and receiving the signal.

3.4.5 DC motor driver

Figure 16.7: 10A DC motor driver

10 A DC motor driver is designed to drive high current DC motor up to 13 A. In this project it drives power window motor driver which is fed through a DC power supply and controlling its movement through the Raspberry Pi 2. It supports voltage from a range of 5V up to 30V.and the maximum current it can hold up to 30A for 10 seconds and the minimal operating current with 13A. This motor driver is used because it has higher voltage and current capacity and it is capable of controlling the PWM frequency up to 20KHz. It is efficient and it does not require any heat sink. This motor driver is connected with Raspberry Pi 2 for the commands and connected with DC power supply to operate the power window motor smoothly.

3.4.6 L298 Dual H bridge motor driver

Figure 16.8: Motor Driver L298 for motor and pneumatic control

In the figure above, it shows the L298 motor driver which is used for controlling the pneumatic cylinder through Raspberry Pi 2. This motor driver can be used for the motors which have voltage range of 5V – 35V. The L298 motor driver is an integrated monolithic circuit that has suitable characteristics for high voltage, high current dual full-bridge driver which has been designed to accept relays, solenoids, DC and even stepper motor. There are four inputs connected to four outputs where the power source and the ground is available for the motor driver to function. Each input is given from Raspberry Pi 2 to the motor driver and to the power window motor and the pneumatic cylinder.

3.5 Design selection to achieve objective 1

Based on the 2 design above, the selected design for the hardware part in this experiment will be design 2. However the design may look the same but it varies in certain aspect of components to ease the automation system even better. There are certain factors needs to be considered why design 2 seems to be more preferable for implementing in this project by replacing the PLC with a Raspberry Pi 2. As we know the project operates to produce small and lite product such as tarts. Besides that, use of ultarsonic sensors helps to detect the tart for every single pit stop of the sensor. It increases the reliability of the sensor to stop the tart mold rather than programming the Raspberry Pi to stop the automation process each time. The selection of design 2 over design 1 was due to the replacement of the PLC with the Raspberry Pi 2. To run the Raspberry Pi safely without causing any damage an L298 H- bridge motor driver is required. Mostly Raspberry Pi runs on 5V where the power window motor runs on 12V which might damage the Raspberry Pi 2. To overcome this problem a motor driver is used to lower the voltage of the motor to the level of Raspberry Pi 2 which enables it to operate safely. In addition OPENCV-Python functions hand in hand with Raspberry Pi 2 where it is suitable for such application.

The actual flow of the process with this design starts by placing the dough manually into its mold platform. Before placing the dough it needs to be weighted for the exact quantity to prevent deformation in the shape. Then, the conveyor starts moving towards the pressing location and stops by the detection of the ultrasonic sensor. With that process being complete, the conveyor is on to the next phase where it starts moving again towards the webcam and stops by the detection of the second ultrasonic sensor where it passes through the webcam to capture the image and be able to identify the freshness of the tart by analyzing the color change and the perfect shape.

3.5.1 Why selection of Raspberry Pi?

Table 2.1: Comparison of controllers

Criteria	Raspberry Pi 2	Arduino
Speed of the processor	700MHz micro processor	16MHz
Usage of programming language	Can be programmed using variety of programming language	Only basic c/ c++ / arduino
Real time hardware	Accessing hardware is not real time	Can be used in real time
ADC	Not present	Present
Design of the hardware	No open source for hardware design	Open source for hardware design
Internet connection	Very easy to connect	Demanding for the connection but still possible

Choosing the Raspberry Pi 2 over PLC it is due to portable and high speed processor of the Raspberry Pi. Apparently, PLC designed to be robust construction according to the specific to the specific guidelines. It has input and output boards that are capable of performing digital and analog control. But, it is expensive and not portable for this kind of project. In the case of using PLC as the controller, it is quite complicated hardware with the connections of inputs and outputs which needs to follow the specific instructions in order for it to function efficiently. Moreover, the PLC is expensive compared to Raspberry Pi 2. In addition, for synchronizing image processing with PLC it requires laptop additionally but when using Raspberry Pi 2 it doesn‟t require another operating system since Pi is an operating system itself. Using Raspberry Pi 2 allows the prototype to be carried from place to place and differs in the case of PLC where it is heavy and rigid to be carried anywhere and complicated with connections. By comparing Arduino and Raspberry Pi 2 in the table (above no), Raspberry Pi outstands in most of the criteria that is essential in this experiment such as in the speed of the processor, various programming language availability and connecting to the internet. These criteria"s fills most of the requirement for the experiment which can be implemented for further process with fine modification.

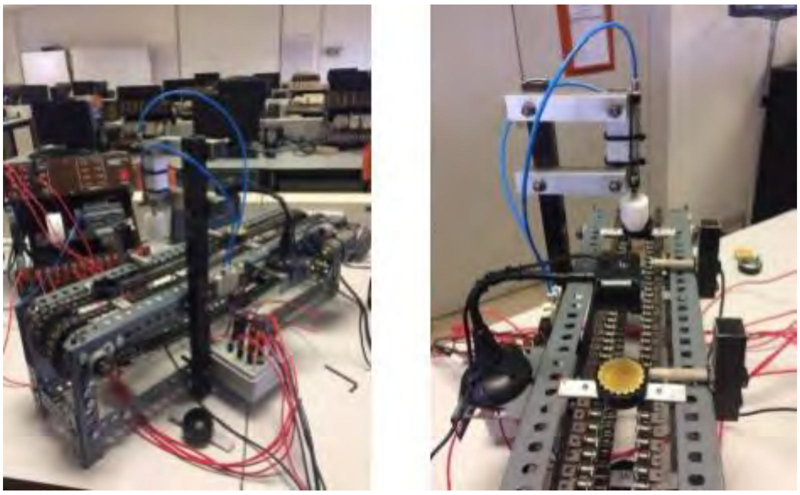


Figure 16.9: Previous designs and its structure with PLC.

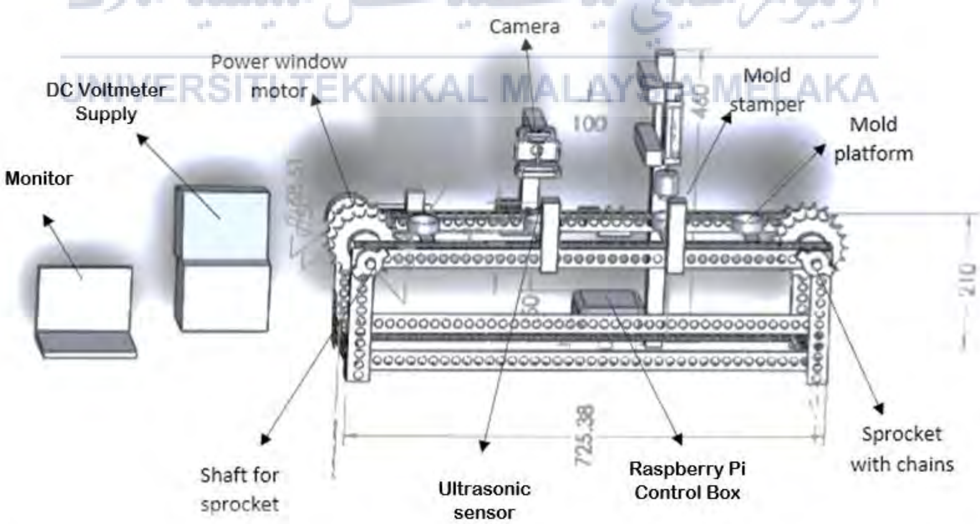


Figure 17.1: Design Improvement with Raspberry Pi 2.

3.6 Method of enhancement of Image processing technique to achieve objective 2

In order to achieve second objective, analyzing accurate shape by implementing image processing techniques to reject or accept the correct shape of the tart is mandatory. By connecting the Raspberry Pi 2 to the monitor through HDMI (High Definition Media Interface) cable, it acts as a display to portrait Raspberry Pi 2‟s functions and programs. As mentioned before, the dough will be placed into the mold then the pneumatic system presses the dough through a 3/2 way cylinder and proceeds for further process that is image acquisition. By calling the program in the library of the Raspberry Pi 2 for the image captured via webcam, it displays the image on the monitor for the image processing. Preceding that, the tart will be analyzed for a color change and for the shape of the dough.

During the pre-processing method webcam acquires the tart image and applies image processing techniques by starting with color space conversion that is from RGB color space to Grey scale image. Then, it continues with filtering using canny edge the particular image to remove the noise factor and smooth the image. Segmentation process continues after this where thresholding takes place from the grey level image. Thresholding is used in the part as well where the edge detection plays a vital role to extract the area of interest from the background. The program to do edge detection on the image has been preferred canny edge filter which is more accurate then Sobel filter. It depends on the image acquired and experimental requirement.

The next step is the classification or recognition of the shapes acquired. Through segmentation and filtering method on an image, a contour around the shape will be displayed to identify the values of the center points and radius. Then it is divided according to the algorithm in the image processing technique. To classify the object accurately we refer edge detection that is via the centroid of the object, canter points will be taken as well as the radius.

After determining the center points and the radius, the number of circle in the tart is calculated. By using the same method radius and the center points is obtained for each circle through the image processing algorithm. Among all the circles obtained from the experiment perfect tart reading is chose and compared with the actual values of an imperfect tart. By changing the HSV values of the program, it detects color of the tart which is being process which is yellow. The program will detect the color of the object along with the number of circles in the tart. It is detected when the conversion of color medium take place where from RGB to HSV. Then threshold can be applied to identify the required color from the greyscale image since the value of the image will be in the range of 0-255. The preferred color is among the greyscale value will be yellow for a tart as mentioned above. Throughout the survey the tart is identified with certain color traits such as yellow, orange and red where in most cases it is identified as yellow. The color can be identified by performing threshold for the exact color by programming the exact value of the color. Through this process, some considerations will be done to identify the deformation of the tart and its shape to be accepted or rejected.

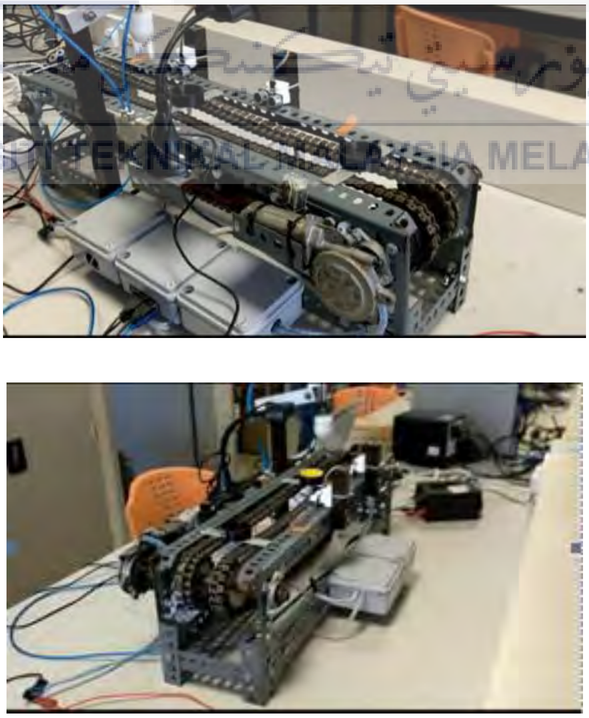


Figure 17.2: The real view of the system with Raspberry Pi 2.

3.7 Experiment setup to achieve objective 3

To achieve the last objective, two experiments will be carried out to analyze all the relationship that was issued. The experiment that needs to be conduct will be related to image processing where the first experiment will focus on the research, of the effect on the weight of the dough and the second experiment investigates the relationship between the distances of the webcam with the item to be identified for its resolution. The first experiment will be done to determine ideal weight to obtain the perfect shape of fulfilled dough while the second experiment is done to give good quality image at the output.

3.7.1 To study the relationship between the weight and its shape.

Learning Outcome;

At the end of this experiment, the investigator will be able to;

- Investigate on the result of the shape by the effect of weight used on the dough.
- Conduct image processing for the classification of the tart shape.

<u>List of Materials</u>

- ✓ Digital weight scale
- ✓ Symmetry tart mold
- ✓ Tart automation machine
- ✓ OpenCV-python
- ✓ Raspberry Pi 2 with HDMI cable
- ✓ Webcam
- ✓ Monitor

Procedure:

I. The dough‟s weight is measured using a Digital weighing scale.
II. The dough is rolled and fitted into the tart mold.
III. Image acquisition of the tart shell with its mold takes place via webcam after the pressing process.
IV. Image undergoes image processing technique in the Raspberry Pi through opencv-python for the classification of the shape.
V. Step 1-4 is repeated using different weights.
VI. The difference of classified shape in each weight is observed.

Experimental Documentation

The knowledge obtained from the experiment by using different weight for the dough is to see the result of the shape that gives a clear view of the relationship between the weight of the dough and the result of its shape. In a nutshell, weight of the dough has influence on the shape formation during outcome of the experiment. The more the weight of the dough, the more it will make the dough deform from its mold and vice versa.

3.7.2 To investigate the relationship between the distance and its resolution.

Learning outcome;

At the end of this experiment, the investigator will be able to;

- Inspect the difference in the resolutions of the object by the effect of the camera distance from the tart mold.
- Perform image processing for the image detected through webcam.

<u>List of Equipment</u>

- ✓ Opencv-python
- ✓ Webcam
- ✓ Raspberry Pi with HDMI cable
- ✓ Monitor

Procedure:

I. The distance of the camera is controlled by the flexible stand in order to detect the tart from different distances.

II. The mold of the tart shell is placed directly under the webcam at a fixed position.

III. Distance of the camera was changed by adjusting the flexible stand from the mold.

IV. The image was loaded for analysis in the Raspberry Pi through opencv-python with the resolution obtained.

V. Step 1-4 is repeated with different distance of the camera which is (12cm, 15cm and 18cm) for different resolution.

VI. Difference of resolutions obtained from the image processing technique, was recorded.

Experiment Documentation

The information obtained from the experiment by changing the distance of the camera and the resultant effect on the image resolution provides a clear view of relationship between the distance of the camera and the resolution of the image. This concludes that, the shorter the distance of the camera with a high resolution the purer the detected image will be with a high number of pixels and vice versa. The calculation of success rate that concludes perfect tart and imperfect tart is as follows where the value of „m‟indicates the value of pixels.

For obtaining perfect tart:

Success Rate $= \frac{Number\ of\ circles\ (\leq 5)}{Number\ of\ trials} x100$

For obtaining imperfect tart:

Success Rate = $= \frac{Number\ of\ circles\ (\geq 9)}{Number\ of\ trials} x100$

3.8 Block Diagram

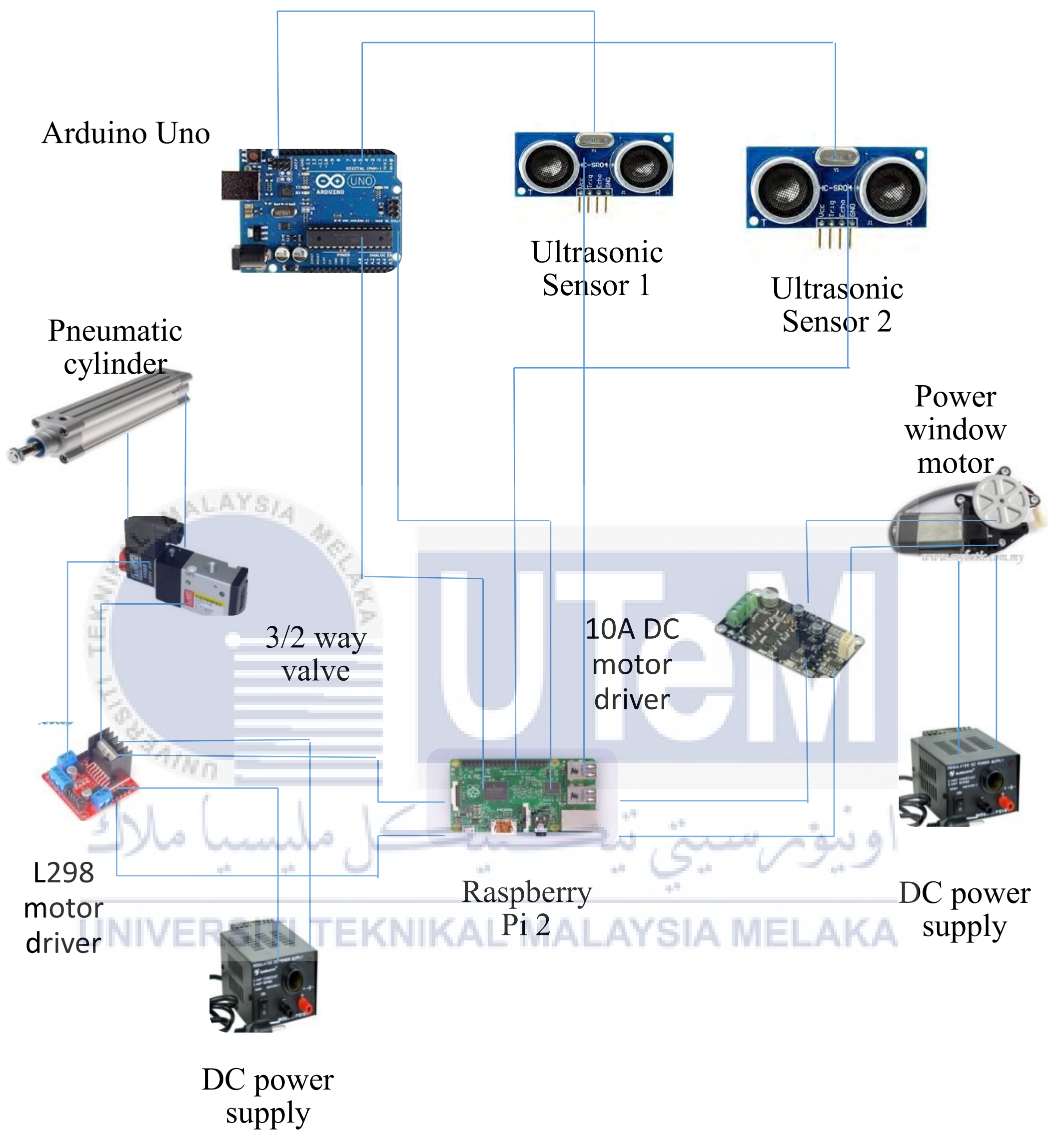


Figure 17.3: Block diagram of the automation connection.

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Introduction

This section discusses about the simulation of the single acting pneumatic cylinder by Festo FluidSim software. Other than that, it will also discuss about the result obtained using the Raspberry Pi 2 with automation system using image processing. This was executed by constructing the opencv-python program to control the movement of the motor rotates via the instructions from Raspberry Pi 2. To operate the power window motor a dual channel 10A dc motor driver was used. For the pneumatic press a L298 H-bridge motor driver was used to operate the pneumatic cylinder via Raspberry Pi 2. To display the Raspberry Pi 2 programming it was simply need to be connected with a HDMI monitor cable. Based on the title "Investigation of Automation on Tart processing system" the result obtained will be discussed mainly on the automation sequence and image processing techniques with the Raspberry Pi 2.

4.3 Basic Operation

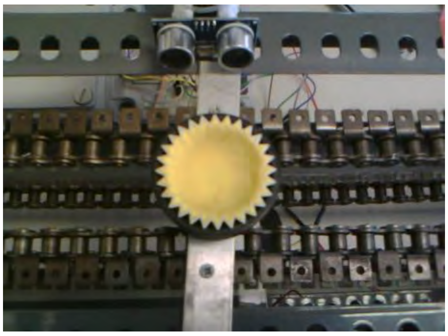
Based on the programing for the Raspberry Pi 2, the conveyor starts moving as the process begins by giving the command. The conveyor moves along with the mold where it stops at the first pit stop of the ultrasonic sensor. At 5 seconds of delay the pneumatic cylinder is actuated. The solenoid extends until it reaches the mold (S2). Then the solenoid retracts to its original position (S1) and the conveyor starts moving. When it reaches the second ultrasonic sensor the conveyor stops for the image processing by the Raspberry Pi 2. The webcam captures the image and performs all the necessary operations based on image processing to obtain the fresh and the perfect tart. After a delay of 9 seconds the conveyor repeats the process for more accurate image by doing the analysis.

During the process, the experiment was conducted and repeated for more than 50 times. This was to ensure the accuracy of the tart reading to identify the most accurate shape of the tart. In some cases, the tart reading falls off from the range of accurate reading which was taken from the experiment. During this situation, the tart may seem perfect in terms of shape for human visualization but it will be defect in terms vision process. To prove such theory this experiment was conducted to ensure that technology might be useful to identify a perfect tart shape which seems normal in human naked eye. In addition the experiment was given extra care in terms of the luminance because it has direct effect on the color of the tart. This might disrupt the reading taken for the tart when the color is detected. Different luminance provides different HSV value for a color which was taken into account before doing thie experiments. The experiments in certain phase show that vision implementation makes the work more efficient in terms of quality. The data obtain from the experiment is shown below.

4.4 Data and Discussion

15g dough

Camera Distance = 18cm



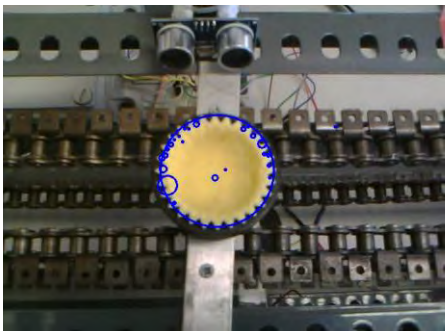


Figure 17.5: 15g perfect pressed dough with camera placed in 18 cm distance

Table 3.1: Data for perfect pressed dough of 18cm

Trial Number	Radius	Centroid value	No of Circles
1	74	310,239	4
2	75	324,259	3
3	77	320,261	2
4	76	302,253	3
5	76	322,262	5
6	75	327,260	3

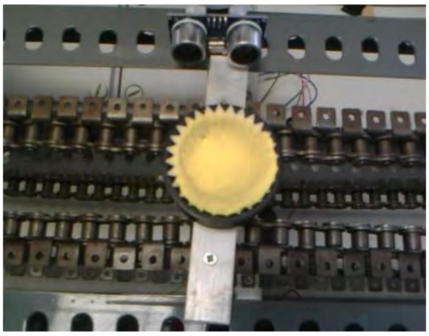
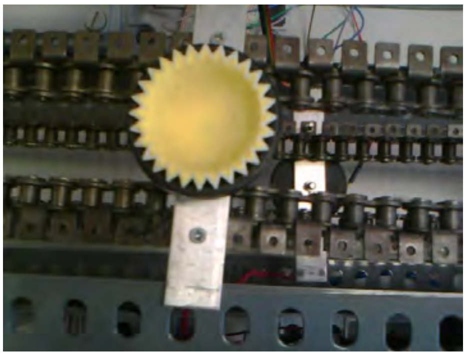


Figure 17.6: 15g imperfect pressed dough with camera placed in 18 cm distance

Table 4.1: Data for imperfect pressed dough of 18cm

Trial Number	Radius	Centroid value	No of Circles
1	80	326,224	10
2	81	330,226	11
3	81	326,224	9
4	83	335,225	7
5	83	329,226	18
6	80	331,219	18

Camera Distance = 15cm



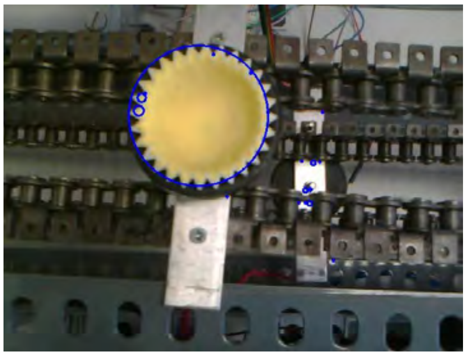


Figure 17.7:15g perfect pressed dough with camera placed in 15 cm distance

Table 5.1: Data for perfect pressed dough of 15cm

Trial Number	Radius	Centroid value	No of Circles
1	97	271,153	3
2	96	270,150	6
3	97	277,152	8
4	97	276,151	5
5	96	267,153	6
6	95	270,158	6

Figure 17.8: 15g imperfect pressed dough with camera placed in 15 cm distance

Table 6.1: Data for imperfect pressed dough of 15cm

Trial Number	Radius	Centroid value	No of Circles
1	105	305,183	9
2	106	302,184	7
3	105	301,180	5
4	104	305,186	8
5	105	302,179	6
6	103	303,187	5

Camera Distance= 12cm

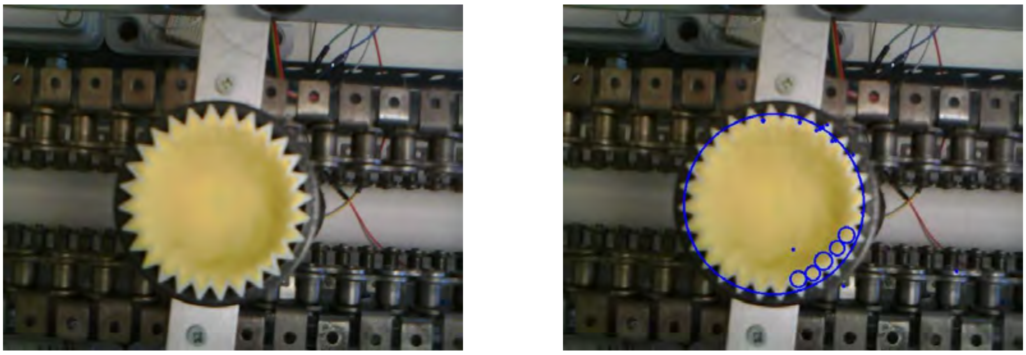


Figure 17.9: 15g perfect pressed dough with camera placed in 12 cm distance

Table 7.1: Data for perfect pressed dough of 12cm

Trial Number	Radius	Centroid value	No of Circles
1	128	327,255	3
2	129	331,256	6
3	125	293,275	3
4	129	299,271	4
5	122	255,243	6
6	125	293,277	6

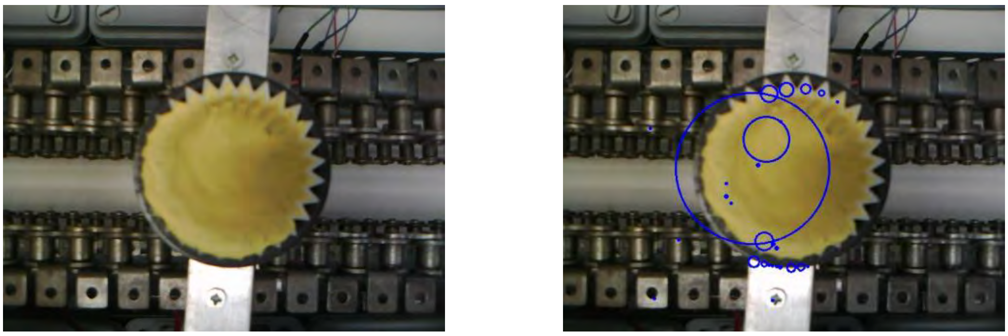


Figure 18.1: 15g imperfect pressed dough with camera placed in 12 cm distance

Table 8.1: Data for imperfect pressed dough of 12cm

Trial Number	Radius	Centroid value	No of Circles
1	111	274,240	10
2	49	227,202	15
3	53	291,215	13
4	67	336,136	14
5	85	305,155	8
6	100	302,165	5

According to the experiments shown above it was conducted repeatedly for 6 times to identify the perfect tart shape through the pixel values which is the radius and the centroid points. The experiment was done by changing the camera distance from time to time. The camera was kept in the in 18cm distance for the first round of the experiment, then gradually it was reduced to 15cm and 12cm to identify the perfect tart through the resolution. The reading of the perfect tart is compared with the imperfect tart to identify the exact value of the pixels. This indicates the difference between the pixel values in the perfect tart and the imperfect tar. In this experiment 15g dough was used which was measured through a digital weighing scale. During the experiment, the data from the experiment with the distance of 18cm shows that the number of circles varies for both cases. The number of circle indicates the amount of deformation present in a tart that helps to indicate the tart which is near to perfect. The number of circle for a good shaped tart should be less then and equals to 5. More than 5, it indicates that it has more deformation for a tart. The range of radius and centroid is nearly similar according to the data obtained. Out of the 6 experiment, it shows that pixel which lies within this range most likely to be accurate in terms of shape and has less deformation.

For the next step by placing the camera 15cm from the tart the result of the experiment was most likely to indicate that the range of radius varies in both cases. The range of radius for a good tart shape lays within 95-97 while for an imperfect tart shape it lies within 104-106. The number of circles to indicate a good tart in this experiment was equal and less than 6. Number of circles which exceeds the limit is considered to have deformation and hence is imperfect in terms of shape. In the 6 experiment conducted the reading of a tart which falls within the range is most likely to show that they are close to perfect in shape.

In the final round, by placing the camera in 12cm distance the reading of the centroid and radius was very different from the previous experiments. The reading for the number of circles of a good tart lies less than and equals to 6. The reading of the radius for the good shaped tart in this experiment was 122 to 129. The radius below than 120 is more likely to have more deformation. The number of circle if detected more than 6 it shows the shape of the tart is not perfect in shape according to the vision system even if it looks perfect in human naked eye. Thus it concludes that the lower the distance of the camera the higher the chances of identifying deformed tart.

20g dough

Camera Distance = 18cm

Figure 18.2: 20g perfect pressed dough with camera placed in 18 cm distance

Table 9.1: Data for perfect pressed dough of 18cm

Trial Number	**Radius**	**Centroid value**	**No of Circles**
1	**76**	**286,173**	**2**
2	**74**	**285,330**	**4**
3	**78**	**301,215**	**6**
4	**76**	**294,287**	**5**
5	**78**	**280,225**	**2**
6	**77**	**275,264**	**3**

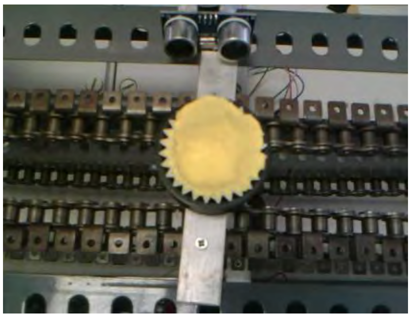
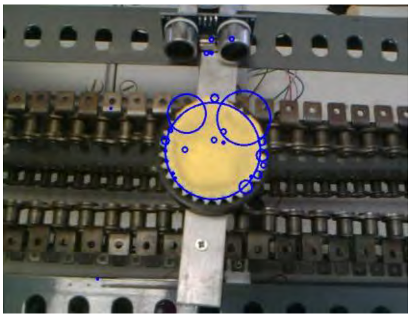
 

Figure 18.3: 20g imperfect pressed dough with camera placed in 18 cm distance

Table 10.1: Data for imperfect pressed dough of 18cm

Trial Number	Radius	Centroid value	No of Circles
1	83	338,220	9
2	81	327,225	18
3	85	331,227	16
4	79	339,220	14
5	80	331,217	15
6	80	328,226	13

Camera Distance = 15cm

Figure 18.4: 20g perfect pressed dough with camera placed in 15 cm distance

Table 11.1: Data for perfect pressed dough of 15cm

Trial Number	Radius	Centroid value	No of Circles
1	108	262,169	2
2	113	288,186	4
3	109	380,211	2
4	115	370,204	3
5	112	286,201	1
6	111	280,204	3

Figure 18.5: 20g imperfect pressed dough with camera placed in 15 cm distance

Table 12.1: Data for imperfect pressed dough of 15cm

Trial Number	Radius	Centroid value	No of Circles
1	105	299,179	6
2	103	327,198	11
3	104	298,186	6
4	104	328,195	8
5	105	299,206	7
6	102	298,194	10

Camera Distance = 12cm

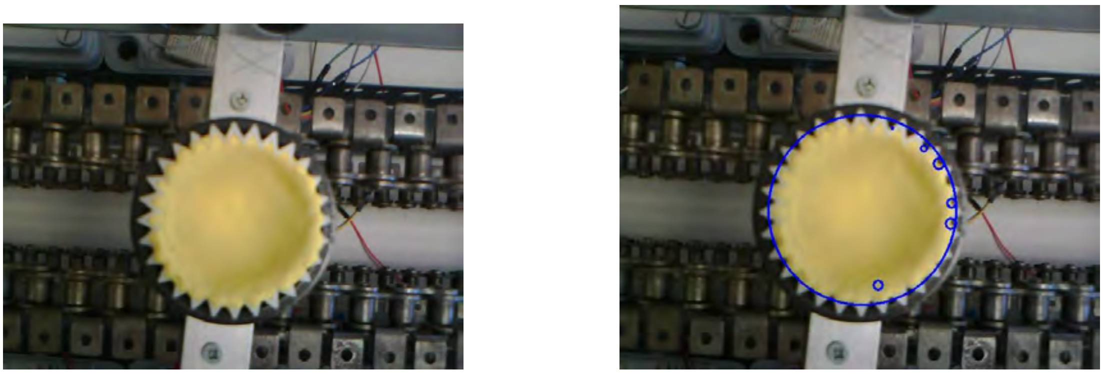


Figure 18.6: 20g perfect pressed dough with camera placed in 12 cm distance

Table 13.1: Data for perfect pressed dough of 12cm

Trial Number	Radius	Centroid value	No of Circles
1	130	338,176	5
2	123	297,249	3
3	121	293,250	4
4	125	323,269	5
5	127	321,271	3
6	127	283,272	3

Figure 18.7: 20g imperfect pressed dough with camera placed in 12 cm distance

Table 14.1: Data for imperfect pressed dough of 12cm

Trial Number	Radius	Centroid value	No of Circles
1	105	312,219	8
2	83	268,176	11
3	119	315,233	12
4	78	257,191	8
5	89	267,205	5
6	104	271,204	8

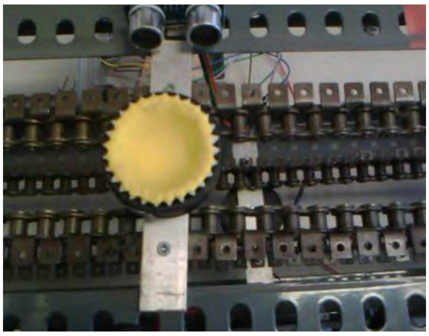
In the second phase, tart with different weight was brought to the experiment. A 20g tart was used with the same steps of experiment conducted in the previous 15g of tart. By placing the camera 18cm distance from the tart, the conveyor was on and the experiment was observed. It was noticed the radius for a perfect tart lies below 80 while the imperfect tart lies above 80. During the experiment, the number of circles varies for both cases. The number of circle indicates the amount of deformation present in a tart that helps to indicate the tart which is near to perfect. The number of circle for a good shaped tart should be less then and equals to 6. More than 6, it indicates that it has more deformation for a tart. Out of the 6 experiment, it shows that pixel which lies within this range most likely to be accurate in terms of shape and has less deformation. For cases that have same range of pixels, number of circles must be referred to identify the perfect shape of the tart. Out of the 6 experiment, it shows that pixel and radius values that lies within the range most likely to be accurate in terms of shape.

Next step the camera was placed in 15cm distance to observe the output of the experiment. It was most likely to indicate that the range of radius nearly similar in both cases. The range of radius for a good tart shape and irregular shaped tart lies within 102-113. To identify good shaped tart number of circles was referred which exceeds 4 it is considered to have deformation hence it is imperfect in terms of shape. In the 6 experiment conducted the reading of a tart which falls within the range is most likely to show that they are close to perfect in shape. The range of pixel values of X and Y lies within 200-400. This entire requirement should be met in order to classify a suitable tart shape. The experiment conducted 6 times to show the pixel values and radius that lies within the perfect tart reading.

Finally, the camera‟s distance was reduced to 12cm to obtain the reading from the experiment. The value of radius to obtain a good shaped tart was above 120. Values that fall below 120 considered to be irregular in shape. The number of circle determines the inner formation and deformation of tart which undergoes pressing process. Values below 5 for a number of circle indicates good shaped while more than 5 indicates defect in the formation. The tart might not be perfect in shape formation according to vision system even if it looks perfect in human‟s naked eye.

25g dough

Camera Distance = 18cm



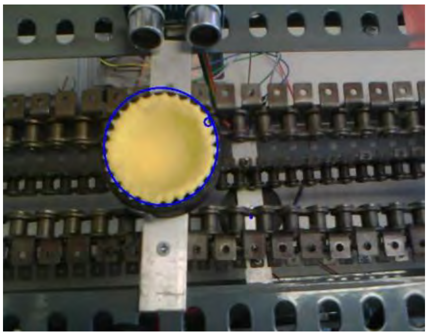
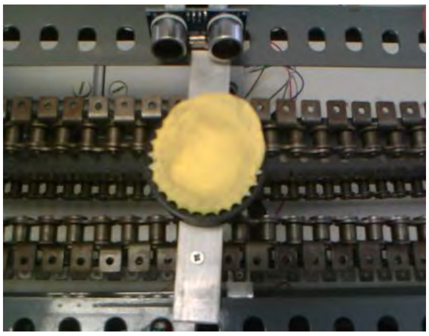


Figure 18.8: 25g perfect pressed dough with camera placed in 18 cm distance

Table 15.1: Data for perfect pressed dough of 18cm

Trial Number	Radius	Centroid value	No of Circles
1	81	311,302	6
2	76	303,295	5
3	77	258,284	4
4	84	240,226	6
5	85	239,208	3
6	82	253,256	4



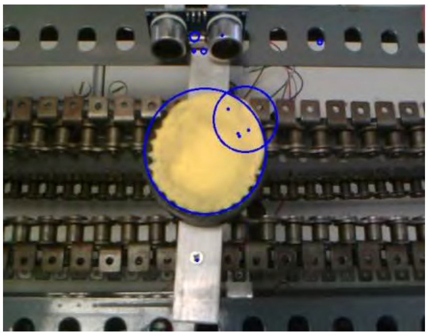
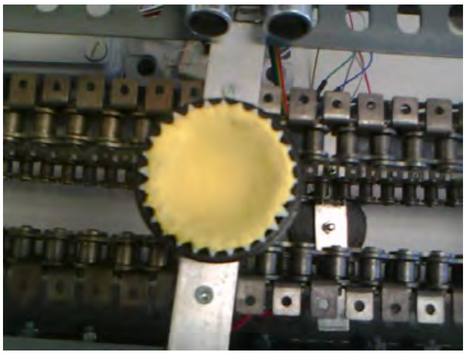


Figure 18.9: 25g imperfect pressed dough with camera placed in 18 cm distance

Table 16.1: Data for imperfect pressed dough of 18cm

Trial Number	Radius	Centroid value	No of Circles
1	85	308,260	12
2	69	331,165	20
3	61	284,224	21
4	88	328,227	11
5	90	306,215	7
6	84	332,228	20

Camera Distance = 15cm



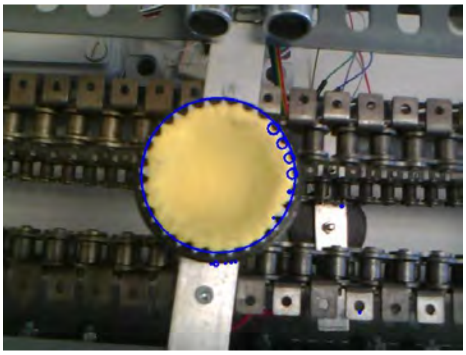


Figure 19.1: 25g perfect pressed dough with camera placed in 15 cm distance

Table 17.1: Data for perfect pressed dough of 15cm

Trial Number	Radius	Centroid value	No of Circles
1	106	307,237	5
2	105	301,234	3
3	109	347,237	5
4	116	333,202	4
5	112	331,221	3
6	110	315,290	5

Figure 19.2: 25g imperfect pressed dough with camera placed in 15 cm distance

Table 18.1: Data for imperfect pressed dough of 15cm

Trial Number	Radius	Centroid value	No of Circles
1	109	305,197	8
2	108	327,199	9
3	110	330,182	6
4	105	335,188	8
5	106	343,194	9
6	110	336,197	11

Camera Distance = 12cm

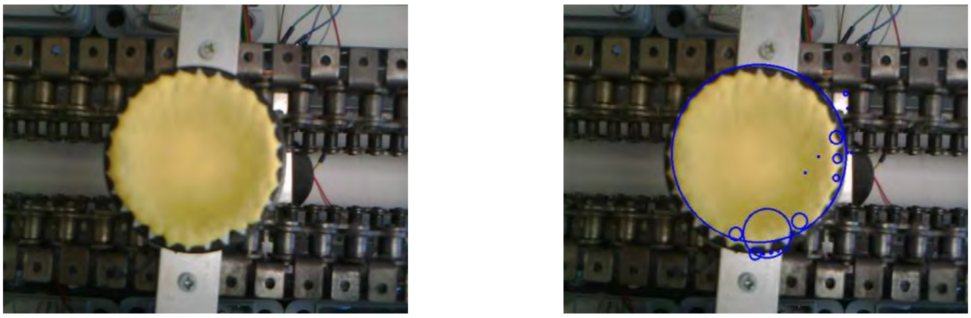


Figure 19.3: 25g perfect pressed dough with camera placed in 12 cm distance

Table 19.1: Data for perfect pressed dough of 12cm

Trial Number	Radius	Centroid value	No of Circles
1	129	287,250	8
2	130	283,252	5
3	132	286,273	7
4	133	326,257	7
5	131	334,256	8
6	134	340,259	6

Figure 19.4: 25g imperfect pressed dough with camera placed in 12 cm distance

Table 20.1: Data for imperfect pressed dough of 12cm

Trial Number	**Radius**	**Centroid value**	**No of Circles**
1	**64**	**230,230**	**12**
2	**49**	**271,167**	**15**
3	**65**	**231,232**	**13**
4	**63**	**259,193**	**10**
5	**66**	**235,207**	**12**
6	**60**	**292,217**	**14**

In the final experiment, 25g dough was used which was measured through a digital weighing scale. During the experiment, the data obtained from the experiment with the distance of 18cm shows that the number of circles varies for both cases. The number of circle indicates the amount of deformation present in a tart that helps to indicate the tart which is near to perfect. The number of circle for a good shaped tart should be less then and equals to 6 more than that it indicates it has more deformation. The range of radius and centroid is nearly similar according to the data obtained. Out of the 6 experiment, it shows that pixel which lies within this range most likely to be accurate in terms of shape and has less deformation.

The next step was by placing the camera 15cm from the tart the result of the experiment was most likely to indicate that the range of radius varies in both cases. The radius values and the pixel values lies within similar range for both the caeses. The number of circles to indicate a good tart in this experiment was equal and less than 5. Number of circles which exceeds the limit is considered to have deformation hence it is imperfect in terms of shape. In the 6 experiment conducted the reading of a tart which falls within the range is most likely to show that they are close to perfect in shape.

In the third step, by placing the camera in 12cm distance the reading of the centroid and radius was very different from the previous experiments. The reading of the radius for the well-shaped tart in this experiment was 129 to 134. The radius below than 70 is more likely to have more deformation. The reading for the number of circles of a good tart lies less than and equals to 8. The number of circle if detected more than 8 it shows the shape of the tart is not perfect in shape according to the vision system even if it looks perfect in human naked eye. Thus it concludes that the lower the distance of the camera the higher the chances of identifying deformed tart. Thus it concludes that the lower the distance of the camera the higher the chances of identifying deformed tart which can‟t be seen in the naked eye. At every single step of the experiments conducted, the luminance was brought to our attention. Different intensity lighting gives different values of HSV value for yellow color. Each time when the experiment was conducted lighting played a vital to detect the color of the tart hence the values of the pixel. Some calculations has been done to show the success rate obtain to be implemented in the graph.

15g at 18cm distance for perfect press

$$\text{Sr} = \frac{Number\ of\ circles\ (\leq 5)}{Number\ of\ trials} x100$$

$$= \frac{6}{6} x100 = 100\%$$

15g at 18cm dsitance for imperfect press

$$\text{Sr} = \frac{Number\ of\ circles\ (\geq 9)}{Number\ of\ trials} x100$$

$$= \frac{5}{6} x100 = 83.33\%$$

20g at 18cm dsitance for perfect press

$$\text{Sr} = \frac{Number\ of\ circles\ (\leq 5)}{Number\ of\ trials} x100$$

$$= \frac{5}{6} x100 = 83.33\%$$

20g at 18cm dsitance for imperfect press

$$\text{Sr} = \frac{Number\ of\ circles\ (\geq 9)}{Number\ of\ trials} x100$$

$$= \frac{6}{6} x100 = 100\%$$

25g at 18cm dsitance for perfect press

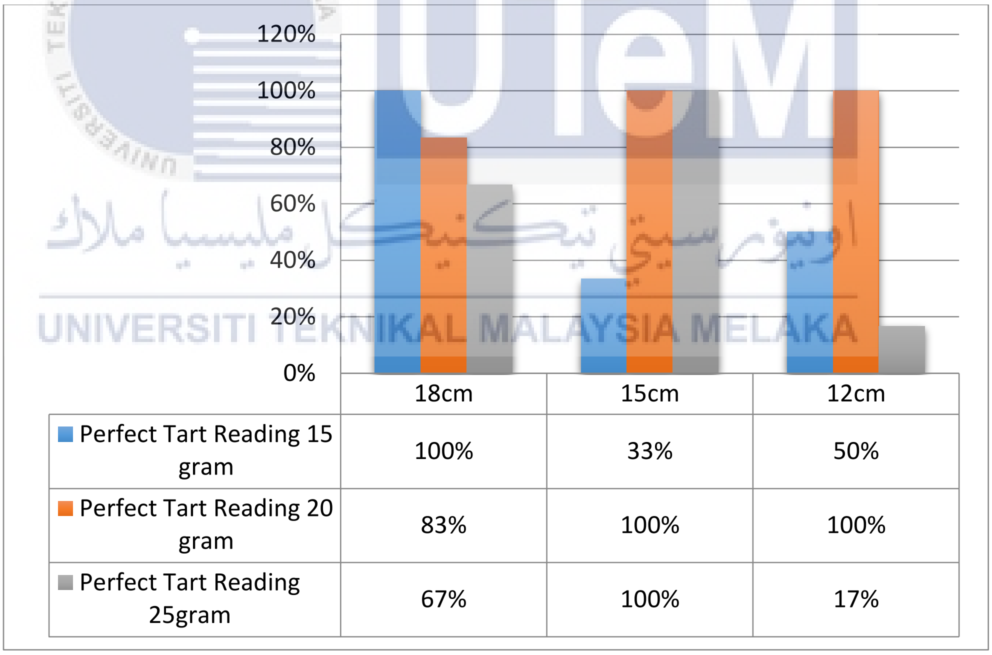
$$Sr = \frac{Number\ of\ circles\ (\leq 5)}{Number\ of\ trials} x100$$

$$= \frac{4}{6} x100 = 66.67\%$$

25g at 18cm dsitance for imperfect press

$$Sr = \frac{Number\ of\ circles\ (\geq 9)}{Number\ of\ trials} x100$$

$$= \frac{5}{6} x100 = 83.33\%$$



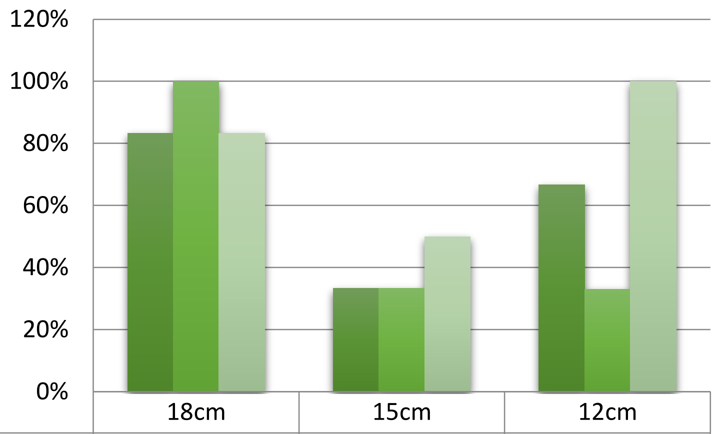
	18cm	15cm	12cm
Perfect Tart Reading 15 gram	100%	33%	50%
Perfect Tart Reading 20 gram	83%	100%	100%
Perfect Tart Reading 25gram	67%	100%	17%

Figure 19.5: The graph shows the different amount of success rate for the perfect tart press

The graph 19.5 depicts the overall result of the tart according to the experiments conducted. The graph indicates the tart process for 15g, 20g and 25g. From the graph we learn that human visualization and vision inspection differs in terms of probability, precision and efficiency. In terms of probability the 15g tarts shows that the possiblity to get perfect reading in all three cases which is in 18cm, 15cm and 12cm distances is decreasing gradually for each cases. The reading from 18cm distance gave a good reading compared to 12cm distance where the camera placement might not be accurate to obtain a good shaped tart reading. This might be also due to the reasoning of luminance effect and the weight of the dough throughout the experiment. While the probability at 18cm distance, the data shows a possible of gaining a perfect tart. Through this we can know the precision of the vision inspection is better than human judgement.

While for the 20g of tarts the data indicates that 15cm and 12cm distances are most likely to capture good shape of the tart compare to 18cm which is higher in distance. The precision of the vision system goes high when the camera is placed near to the object where the results most likely to be accurate. In certain experiment results that doesn"t satisfy was tested repeatedly due to luminance effect.

The 25g tart more or less similar result as in 15g tart experiment. The 15cm distance gives more accurate reading than 12cm and 18cm readings. As said earlier it can be due to luminance and pressing force of the pneumatic cylinder. Out of this three experiment conducted the 20g tart reading shows most likely to obtain goof tart reading despite the effect of luminace and efficiency of the pressing sytem.



	18cm	15cm	12cm
Imperfect Tart Reading 15 gram	83%	33%	67%
Imperfect Tart Reading 20 gram	100%	33%	33%
Imperfect Tart Reading 25gram	83%	50%	100%

Figure 19.6: The graph shows the different amount of failure rate for the imperfect tart press

The graph 19.6 shows the readings of the imperfect pressed tart or deformed tart of the experiments. By viewing the results of the whole process, the success rate of the imperfect tart to obtain good shape is very low and poor compared to perfect pressed tart. The reading of each tart from 15cm distance shows a slight possibility of gaining good reading in terms of shape. From this both graph 19.5 and 19.6 it indicates that the higher the deformation in a tart, the higher the success rate of the tart in terms of percentage formed in the circle. In some cases the number circles can be neglected if the reading is similar with the other reading of the circles. For such cases other parameters can be considered to determine the accurate shape of the tart by referring radius and the centroids. In overall with the consideration of some errors we can conclude that number of circles which is less than 7 is more likely to perfect in terms of shape while more than 7 it indicates more to deformation of the tart. With this it can be said that the resolution of the camera to capture the image can be affected by the distance and the weight used. It also shows that human judgement can be inferior to vision‟s perception since it has high precision and accuracy.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Conclusively the research throughout FYP 1 and FYP 2 are done to identify and understand the objective, scope of the project, surveying information for literature review, planning methodology and experimental trials for preliminary results and the final result based on the title chosen. As an overall view of the project, to achieve the first objective which is to improve the automation system and the tart shell production through pneumatic system by using Raspberry Pi was done by improving certain aspects of the hardware. This improvement provides ease for human effort that is without using PLC that can operate this system with Raspberry Pi 2 which is portable and easy to handle. This method helps to reduce time consumption unlike for PLC that requires time to provide connection from hardware to PLC and PLC to DC power supply and to the compressor. Raspberry Pi 2 overcomes all this restrictions by having reasonable connection for each inputs and outputs. It also consumes less manpower compared to PLC and the space required is very limited and comfortable to handle smoothly. This concludes the achievement of the objective number one.

The second and third objective is more to image processing basis that is visualize comprehending the situation. The result to get accurate shape can be recorded as an addition it can be used for color detection analysis of the object in this case the tart. This can give good result to identify the weight, edge and also color detection by using the appropriate algorithm for edge detection. Through various of experiments the second objective to enhance the image processing system to color detection and the third objective to analyze the relationship between weight and the resolution was done and was achieved as well.

5.2 Recommendation

Based on the data collected from the experiments by doing research, my point of view to make recommendations to improve the project for further development:

- Build a new system which can accept the perfect tart and reject deformed tart.
- Upgrade the conveyor by inserting heating compartment to cook the dough which can improve the analysis on the color detection.
- Use deep learning of open-cv python to give more accurate reading of the tart based on a template.
- For the vision part, to improve the resolution and the quality of the picture it is advisable to replace the webcam with high megapixel camera.
- During image capturing process, make sure to analyze the luminance of the environment by taking, luminance reading.
- Improve the ultrasonic sensors sensitivity to detect the mold more accurately.

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Appendices

Moving just the conveyor

```
import time
import numpy as np
import RPi.GPIO as gpio

gpio.setmode(gpio.BOARD)
gpio.setwarnings(False)

gpio.setup(35, gpio.OUT)
gpio.setup(12, gpio.OUT)

time.sleep(1)

gpio.output(35, 1)
gpio.output(12, 1)
time.sleep(0.5)

gpio.output(35, 0)
gpio.output(12, 0)
time.sleep(1)
```

Testing Pneumatic Press


```
import time
import numpy as np
import RPi.GPIO as gpio

gpio.setmode(gpio.BOARD)
gpio.setwarnings(False)

gpio.setup(11, gpio.OUT)
gpio.setup(13, gpio.OUT)

time.sleep(1)

gpio.output(11, 0)
gpio.output(13, 1)

time.sleep(2)

gpio.output(13, 1)
gpio.output(13, 0)
time.sleep(1)

gpio.output(13, 1)
gpio.output(13, 0)

time.sleep(1)
gpio.cleanup()
```

Identifying centroid of the tart

```
import cv2
import numpy as np
import cv2.cv as cv
import cv2 as cv2

#camera = cv2.VideoCapture(0)
#for i in range(6):
#     return_value, image = camera.read()
#     cv2.imwrite('opencv'+str(i)+'.png', image)
#     cv2.imshow("ori",image)


img = cv2.imread('opencv5.png')
gray=cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
blur=cv2.GaussianBlur(gray,(3,3),0)
canny=cv2.Canny(blur,30,255)

(cnts,_)=cv2.findContours(canny.copy(),cv2.RETR_EXTERNAL,cv2.CHAIN_APPROX_SI
MPLE)

sasi=img.copy()
cv2.drawContours(sasi,cnts,-1,(255,0,0),3)

for (i,c) in enumerate(cnts):
     (x,y),radius=cv2.minEnclosingCircle(c)
     center=(int(x),int(y))
     radius=int(radius)
     cv2.circle(sasi,center,radius,(0,0,255),2)

     cv2.imshow("image",sasi)
     print("radius",radius)
     print("center",center)
cv2.waitKey()
```

Mobilizing conveyor and stops at each sensor

```
import time
import numpy as np
import RPi.GPIO as gpio

gpio.setmode(gpio.BOARD)
gpio.setwarnings(False)

gpio.setup(35, gpio.OUT)
gpio.setup(12, gpio.OUT)
gpio.setup(16, gpio.OUT)
gpio.setup(18, gpio.OUT)
gpio.setup(7, gpio.IN)
gpio.setup(15, gpio.IN)

pwm=gpio.PWM(12, 200)
pwm.start(0)
time.sleep(1)

gpio.output(16, 0)
gpio.output(18, 0)
time.sleep(1)

while True:

    if gpio.input(7):

            gpio.output(35, 1)
            pwm.ChangeDutyCycle(0)
            time.sleep(3)

            gpio.output(16, 1)
            gpio.output(18, 0)
            time.sleep(2)

            gpio.output(16, 0)
            gpio.output(18, 0)
            time.sleep(2)


            pwm.ChangeDutyCycle(90)
            gpio.output(35, 1)
            time.sleep(1)

            while True:
                if gpio.input(15):

                    gpio.output(35, 1)
                    pwm.ChangeDutyCycle(0)
                    time.sleep(3)

                    pwm.ChangeDutyCycle(90)
```

```
                        gpio.output(35, 1)
                        time.sleep(1)
                        break

                else :
                        gpio.output(35, 1)
                        pwm.ChangeDutyCycle(90)


    else :
        gpio.output(35, 1)
        pwm.ChangeDutyCycle(90)


gpio.cleanup()
```

Color detection

```
import cv2
import numpy as np
import cv2.cv as cv
import cv2 as cv2
import time
import argparse


camera = cv2.VideoCapture(0)
for i in range(6):
    return_value, image = camera.read()
    cv2.imwrite('opencv'+str(i)+'.png', image)
    cv2.imshow("ori",image)

yellowLower=np.array([68,145,176],dtype="uint8")
yellowUpper=np.array([116,193,221],dtype="uint8")

img = cv2.imread('opencv5.png')
yellow=cv2.inRange(img,yellowLower,yellowUpper)
blur=cv2.GaussianBlur(yellow,(3,3),0)

(cnts,_)=cv2.findContours(blur.copy(),cv2.RETR_EXTERNAL,cv2.CHAIN_APPROX_SIM
PLE)

if len(cnts)>0:
    cnt=sorted(cnts, key=cv2.contourArea,reverse=True)[0]
    print("Color detected: Yellow")

    for (i,c) in enumerate(cnts):
        (x,y),radius=cv2.minEnclosingCircle(c)
        center=(int(x),int(y))
        radius=int(radius)
        cv2.circle(img,center,radius,(255,0,0),2)

cv2.imshow("Track",img)
cv2.imwrite("satya.jpg",img)
print("radius",radius)
print("center",center)

time.sleep(0.025)
cv2.waitKey(10000)
```

Combined system of conveyor and image processing

```
import time
import numpy as np
import RPi.GPIO as gpio
import cv2
import cv2.cv as cv
import cv2 as cv2
import time
import argparse

gpio.setmode(gpio.BOARD)
gpio.setwarnings(False)

gpio.setup(35, gpio.OUT)
gpio.setup(12, gpio.OUT)
gpio.setup(16, gpio.OUT)
gpio.setup(18, gpio.OUT)
gpio.setup(7, gpio.IN)
gpio.setup(15, gpio.IN)

pwm=gpio.PWM(12, 200)
pwm.start(0)
time.sleep(1)

gpio.output(16, 0)
gpio.output(18, 0)
time.sleep(1)
saasi=False


while True:

   if gpio.input(7):

                saasi=False
                gpio.output(35, 1)
                pwm.ChangeDutyCycle(0)
                time.sleep(3)


                gpio.output(16, 1)
                gpio.output(18, 0)
                time.sleep(2)

                gpio.output(16, 0)
                gpio.output(18, 0)
                time.sleep(2)


                pwm.ChangeDutyCycle(90)
                gpio.output(35, 1)
                time.sleep(1)


                saasi=True

                while saasi:
                        if gpio.input(15):

                                gpio.output(35, 1)
                                pwm.ChangeDutyCycle(0)

                                time.sleep(3)


                                camera = cv2.VideoCapture(0)
                                for i in range(6):
```

```
                                    return_value, image = camera.read()
                                    cv2.imwrite('opencv'+str(i)+'.png',
image)

                                    cv2.imshow("ori",image)
                                cv2.waitKey(100)


yellowLower=np.array([68,145,176],dtype="uint8")

yellowUpper=np.array([116,193,221],dtype="uint8")

                                satya=True

                                while satya:

                                    img = cv2.imread('opencv5.png')

yellow=cv2.inRange(img,yellowLower,yellowUpper)
                                    blur=cv2.GaussianBlur(yellow,(3,3),0)


(cnts,_)=cv2.findContours(blur.copy(),cv2.RETR_EXTERNAL,cv2.CHAIN_APPROX_SIM
PLE)


                                    if len(cnts)>0:
                                        cnt=sorted(cnts,
key=cv2.contourArea,reverse=True)[0]
                                        print("Color detected: Yellow")

                                        for (i,c) in enumerate(cnts):

(x,y),radius=cv2.minEnclosingCircle(c)
                                            center=(int(x),int(y))
                                            radius=int(radius)

cv2.circle(img,center,radius,(255,0,0),2)

                                    cv2.imshow("Track",img)
                                    cv2.imwrite("satya.jpg",img)
                                    print("radius",radius)
                                    print("center",center)
                                    cv2.waitKey(100)
                                    satya=False
                                cv2.destroyAllWindows()

                                pwm.ChangeDutyCycle(90)
                                gpio.output(35, 1)
                                time.sleep(1)
                                break

                        else :
                                gpio.output(35, 1)
                                pwm.ChangeDutyCycle(90)




    else :
        gpio.output(35, 1)
        pwm.ChangeDutyCycle(90)

gpio.cleanup()
```

Canny edge detector

```
import cv2
import numpy as np
import cv2.cv as cv
import cv2 as cv2

camera = cv2.VideoCapture(0)
for i in range(6):
    return_value, image = camera.read()
    cv2.imwrite('opencv'+str(i)+'.png', image)

img = cv2.imread('opencv5.png')
cv2.imshow('Original Image',img)

new_img = cv2.Canny(img, 0, 200)
cv2.imshow('new image', new_img)

cv2.waitKey()
cv2.destroyAllWindows()
```

Gantt Chart FYP 1&2

WEEKS / TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Title Selection														
Understanding project														
Surveying information														
Identifying Objective and scope														
Research on journals														
Draft 1(chapter 1)														
Draft 2(literature review)														
Draft Methodology														
Preliminary result testing & progress report draft														
Presentation & 2nd Test on preliminary result														
Submission of final report														

FYP 1

WEEKS / TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Continue on research														
Research on the program & software														
Hardware assembly														
Troubleshoot prototype														
Experimental operation														
Draft 1(methodology)														
Draft 2(Analysis and discussion)														
Draft 3 (Conclusion)														
Correction of final draft report														
Prepare for presentation of FYP 2														
Submission of final draft report														

FYP 2