

Investigation of Rectangular Shape Object Detection and Classification Using Python

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ABSTRACT – The existing fishcake machine can perform tasks to increase the productivity of fishcakes in the market. However, high productivity is not the only main purpose of a successful food manufacturing industries. The quality of the food itself need to accommodate the standard quality that has been lined by authorities to ensure that the quality of the food product must be at the best standard along with its high productivity. The objective of this work is to develop a monitoring method for detection of irregular shape and foreign particles of the fishcake during the fishcake production. This work will implement and uses both hardware and software elements to provide the best solution for the purpose of fishcake quality sustainability. Real-time image processing is the method used in this study by developing python program through Raspberry Pi 4. The algorithm of the programming is the main concern in this research. The library used for this study is OpenCV which is a common API used for computer vision.

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INTRODUCTION

This study focuses on how to develop a method to monitor and to ensure the quality of fishcakes produce are at the top level. The existing fishcake machine still use human manpower to manually monitor the quality of the fishcake production. However, human is vulnerable to error and fatigue thus this factor might highly affect the quality of the fishcakes [1].

This project will investigate the solution to the problems that might be facing during the development of quality inspection system for fishcake machine. The fishcake machine consists of several processes that help to ensure the production of fishcake can be increased and can rapid up the production rate of fishcakes in a certain period of time. The process consists of dough pressing through two rollers and dough cutting process. Due to some unstable parameters, the dough could be not in the acceptable shape of a standard fishcake. Other than that, some foreign particles are also likely to appear due to environment of the machine. Therefore, the quality inspection system is introduced to complete the fishcake machine to accomplish a better quality of fishcake products according to standard.

METHODOLOGY

This part will introduce the framework of the investigation of the fishcake quality inspection system by using real-time image processing that will be included at the final stage of fishcake making process [2] [3]. The objective of this project is mainly to focus on the quality monitoring of fishcake products at the last stage of its process. In this research, the qualities that need to be inspected are the fishcakes' shape and the detection of foreign particles that will likely to appear on the fishcake's dough. Various methods could be implemented to fulfil the objectives for this project; however, the most cost - saving and efficient way is the only one that will be chosen.

The detection of irregular shape of fishcakes and foreign particles are based on shape and color detection. Using OpenCV, a cost-effective and simple technique of object detection and displacement measurement is thoroughly explained. In most applications, the automatic segmentation and counting in the image are accomplished using edge detection and a circular fitting technique [4].

Based on the information in this chapter, a flowchart of fishcake production from the first process to the fourth process, which is the final process is illustrated as in Figure 6. Then, a plan or Gantt Chart will be demonstrated to depict all of the functions required in developing the approach. In addition, it will be described how the process of producing fishcakes and the position of input and output or all components involved by showing engineering drawings. Furthermore, by displaying engineering drawings, it will be described how the process of creating fish cakes and the position of input and output or all components involved. Later in this chapter, an engineering drawing will show the components and parts needed to carry out processes involved in producing fishcakes that Controllino controls. At the end of the process, another stage is added for quality inspection of the fishcake by using computer vision.

ALGORITHM FOR IRREGULAR SHAPE DETECTION

In this section, the programming algorithm for irregular shape detection will be explained in detail. The algorithm is based on object detection has been explained in the previous section. This method is expected to be further investigate on the next stage of research observe and study what are the problems during the implementation of the quality inspection system on actual fishcake machine [5]. In some of the reports [6] [7], it has been reported that the enhancement process before the monitoring process is highly recommended as it improves the quality of the fishcake images and consequently increases the probability of the rectangular shape and foreign particles to be detected.

Specifying the Region of Interest (ROI)

In this project, the development of fishcake irregular shape detection system is made by specifying the region of interest (ROI). ROI is the region or area that is only captured by the camera for the real time video processing program to be executed. The sample will be moved by the conveyor from one process to another process. Hence, the last process will be the quality inspection system process in other words the irregular shape detection process. The movement of the conveyor is assumed to be intermittent for this study to be carry on which means that there is a moment that the conveyor will be static and the sample on it will also be static.

The samples are also assumed to be static exactly at the area where the detection process will be carried on. At the quality inspection system area, videos of samples are captured by the camera in a wide viewing angle. To ensure that the accuracy of area measurement of samples is acceptable, the wide viewing angle issue needed to be solved by specifying the region of interest. This is because at different position of samples, the area in pixel is different although the real samples area is the same at all position. To identify the region of interest, the size of region in pixels need to be specified by using a program that can specifies the pixels coordinate.

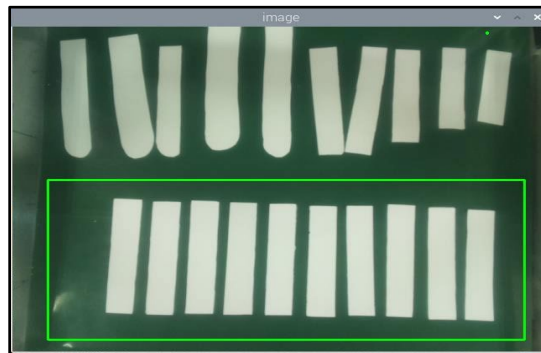


Figure 1 Region of Interest

Image blurring using Gaussian Blur function

Sharper portions of the sample image lose detail as a result of blurring and smoothing. The goal here is to reduce the amount of noise and detail in an image by using a low-pass filter. This implies that each pixel in the image is mixed in with the intensities of the pixels around it. Blurred pixel is created by a "mixture" of pixels in a neighborhood. While this look is normally undesirable in images, it is highly useful when performing image processing activities.

Smoothing and blurring is a critical preprocessing step in detection process. We can reduce the quantity of high-frequency material, such as noise and edges, in an image by smoothing it before applying algorithms like edge detection or thresholding. While it may appear counter-intuitive, lowering the detail in an image allows us to discover objects of interest more readily. This also permits us to focus on the image's major structural objects. Equation (1) is the 2-Dimensional gaussian functions. The values returned by this function will be used to generate the convolution matrix or kernel that will be applied to each pixel in the original image.

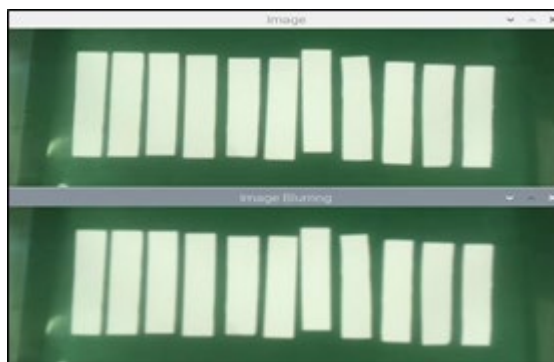


Figure 2 Image Blurring

Converting image's color to grayscale

Color information does not help the algorithm detect all the essential edges (changes in pixel value) or other properties that the image may have, hence grayscale is largely used for irregular shape detection applications. There are, however, certain exceptions. For example, if there is a hue edge that is difficult to detect in grayscale, or if we need to recognize items of already known hue, then color could be the key to success. Therefore, this project had used the application of converting RGB to grayscale for its better image processing performance particularly for edge detection.

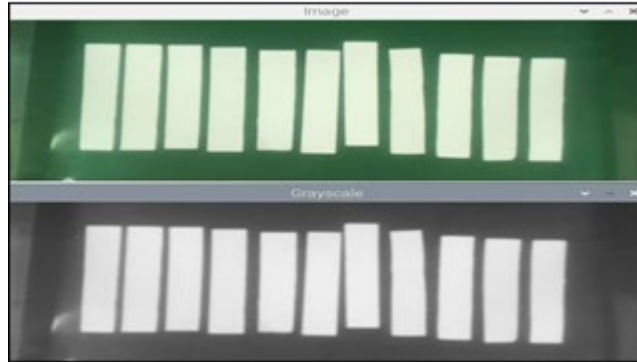


Figure 3 Grayscale image

Detetecting the edge of the objects using Canny Edge Detection function

The next significant step for this project is to detect the edge of the objects by using canny edge detection function. The Canny edge detector is an edge detection operator that detects a wide range of edges in images using a multi-stage approach. It was created in 1986 by John F. Canny. Canny also developed a computational theory of edge detection that explains why the method works. This is important for this project because it will differentiate the edges that is desirable for the detection process and for measurement of area in an enclosed contour area.

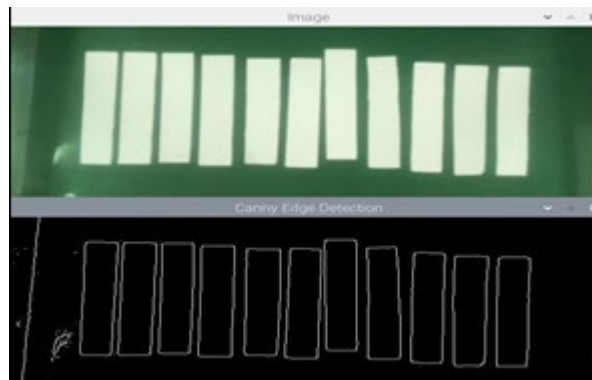


Figure 4 GCanny Edge Detection

Drawing contour on the masked object

After the object color has been filtered, the next step is to draw contour on the filtered object. If the filtered object is rectangular object than the draw contour function will be drawn on the rectangular object. This is a major step where the drawn object will decide the shape that are wanted to be detected. However, there will be noise occur because of the previous step which is the maskin g function. To overcome the noise, there is a dedicated process need to be executed which will be explained in the next

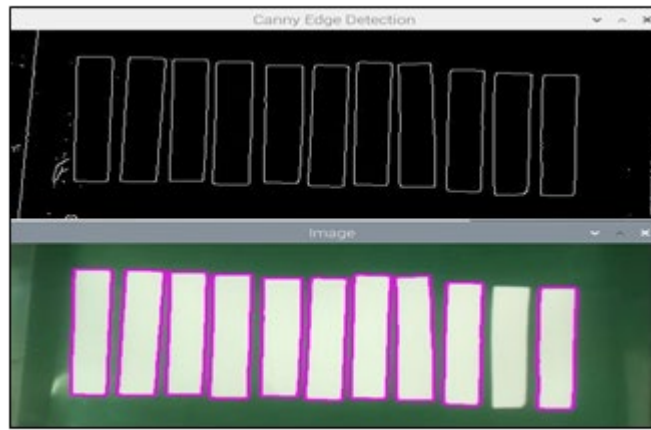


Figure 5. Drawing Contour at detected edge

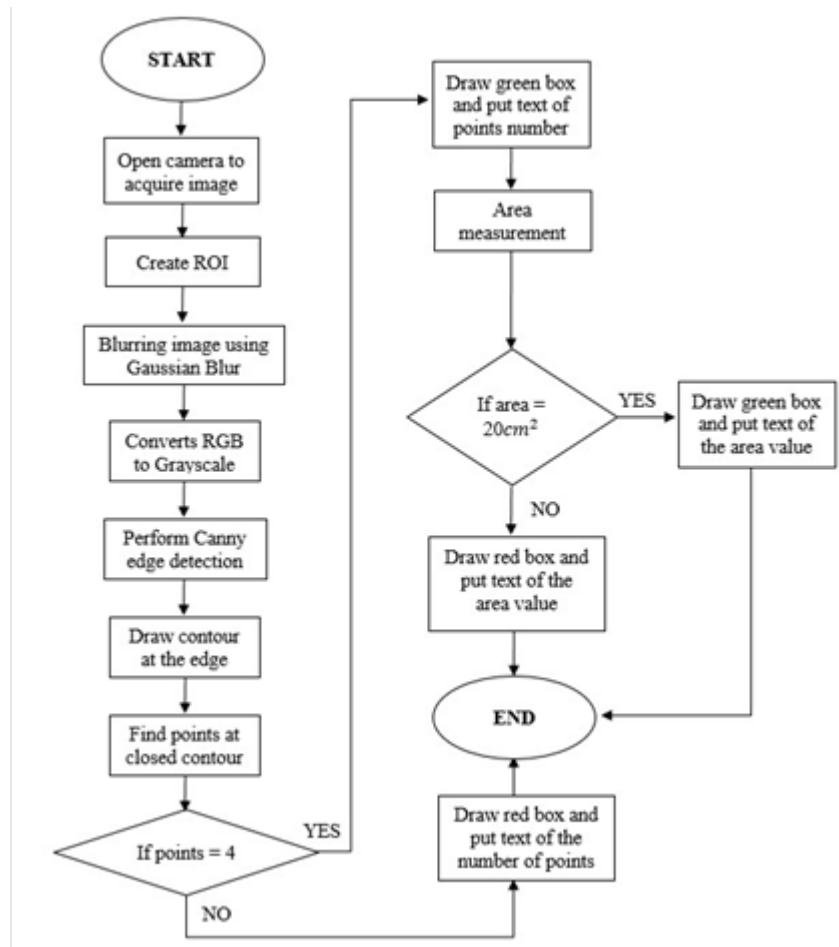


Figure 6. Flow chart of irregular shape detection algorithm

Shape approximation function.

Lastly, when the noise is erased, the shape can be sometime detected not in a perfect geometry. For example, the rectangular shape can be not look like the exact rectangular shape due to view angle and any other factor. By using this function, the shape can be approximate to the real geometry of the shape and show the dimension of the fishcake shape. This can be done by determining the number of points in the detected shape.

Object area measurement

To achieve the second objective of this project, the acceptable dimension of fishcakes will be based upon the measurement of area in pixels. After knowing the area of the detected objects in pixels, the acceptable area in pixels is recorded. To do this, all the objects with the standard size of 2cm width and 10cm of length will be used for the recording of accepted area in pixels. Figure below shows the example of area detection process.

Identification of acceptable and unacceptable shape

Next, the final outcome of the project is to detect the irregular shape by identifying the acceptable and unacceptable shape and dimension of fishcakes. This step is done by drawing green box if the shape and size meet the requirement and red box if it does not follow the standard shape and size of fishcakes. The bounding box is a clear visualization to the operator to indicate which fishcakes are to be removed. This is very good for the quality inspection system so that the fishcake machine follows the standard quality of fishcakes available in market.

RESULTS AND DISCUSSION

Results of irregular shape detection by separating two Region of Interest (ROI)

The two main objective of this research is to detect the irregular shape of fishcakes by two categories which are the geometrical shape and the real measurement of the detected object. The objects that need to be detected by the camera are positioned on a moving conveyor. In this experiment, the conveyor is assumed to be in intermittent movement implying that there will be a period that the object is static under the camera for data acquisition. On the conveyor, the camera is capable to acquire video of a wide detection area due to its viewing angle parameter specified in chapter 3. The problem with a wide detection area is that it will decrease the accuracy of real time measurement of the object dimensions. To cater the problem, the real time video processing algorithm will be focused in Region of Interest (ROI) with a certain size of pixels area. In this section the ROI is separated to two ROI and each ROI carries out different function which are to detect geometrical shape of objects by identifying points of enclosed contour area and to detect real measurement of rectangular shape area by identifying the area of pixels. Figure below shows the result of the detection process in both ROI.



Figure 7. Result of detection process in two ROI

Table 1. Geometrical Shape Detection Result with ROI.

Object	Distance between object (mm)	Length an object (mm)	Shapes	Points	Object Detection	Status
1	5	100	Rectangle	4	Detected	Accept
2	5	180	Rectangle	4	Detected	Accept
3	5	190	Rectangle	4	Undetected	NA
4	5	180	Rounded Rectangle	6	Detected	Reject
5	5	170	Triangle	3	Detected	Reject
6	4	100	Rectangle	4	Undetected	NA

In the second ROI, the detection process program was developed to focus on the real time measurement of the rectangular shape area. The measurement is to allow the program to achieve of the research objective which is to detect irregular shape detection by its dimension. The acceptable size of fishcakes is 2cm x 10cm for the production. Therefore, other sizes will be rejected. To measure the size of object, the programming technique used in this study is by identifying the area in pixel and converted to the area in cm square. With the fix height between camera and detection area at the conveyor, pixel area for actual acceptable size can be achieved. For instance, if the object has a real measurement of 2cm

x 10cm or in area is 20cm², the area in pixel will be known at different position. Although all object's area is 20cm², the pixel area will be different at every position because of the viewing angle of the camera.

Table 2. Pixel area range for acceptable area of fishcakes for each subregion

Subregion	Area in Pixel (px ²)		Difference (px ²)
	Min	Max	
1	5960	6105	145
2	6080	6230	150
3	5810	5940	130
4	5590	5815	225
5	5750	5850	100
Average difference of area in pixel (px ²)			150

Results of irregular shape detection in single ROI

In this approach, there is only one ROI for the detection process which is both geometrical shape detection by points is combined with the real measurement detection by area in pixel. This combination of two functions is possible because the ROI does not separate more to 5 subregions for the real measurement detection. Result and data will be presented.

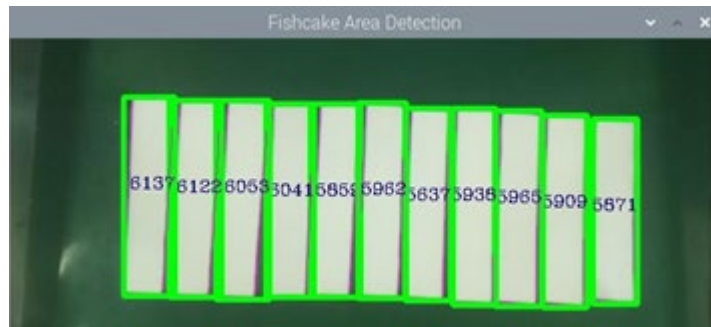


Figure 8. Real measurement detection in single ROI



Figure 9. Area measurement with results with different sizes

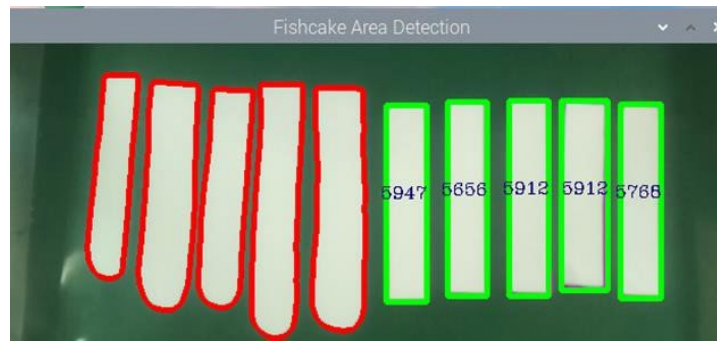


Figure 10. Geometrical shape detection combined with area measurement in single

Table 3. Summary of Geometrical Shape Detection Result with One ROI.

Object	Distance between object (mm)	Length of object (mm)	Shapes	Points	Object Detection	Status
1	5	100	Rectangle	4	Detected	Accept
2	5	180	Rectangle	4	Detected	Accept
3	5	190	Rectangle	4	Detected	Accept
4	5	180	Rounded Rectangle	6	Detected	Reject
5	5	170	Triangle	3	Detected	Reject
6	4	100	Rectangle	4	Undetected	NA

The result of detection capability for geometrical shape detection with one ROI. One of the limitations for this approach is the spacing between one object to another. The minimum distance between object is 5mm. The dimension of the object itself is relatively higher compared to the first approach which is 190mm maximum of vertical length to allow the system to identify acceptable and unacceptable geometric shape of the objects.

Table 4. Pixel area range for acceptable area of fishcakes for each one region

Region	Area in Pixel (px^2)		Difference (px^2)
	Min	Max	
1	5610	6250	640

CONCLUSION

This study is carried out to investigate the result that will be achieved to reach the objectives which are to identify acceptable and unacceptable geometrical shape of fishcakes and to identify the accepted measurement or dimension of fishcakes in area. The system will be integrated in a fishcake machine for quality inspection system. Method used for this research is by using Python programming with OpenCV application programming interface. To get the result that satisfy the objectives, there are two approaches of algorithm being developed and the results are discussed in previous section. As for further improvement, enhancement pre-processing [8] would be placed in the main process workflow to improve the image quality and thus increase the probability of detecting the rectangular shape and the foreign particles.

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