Analysis of The Shape of Pressed Tarts from Image Processing

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Abstract *–Monitoring quality of food processed in manufacturing industries is gaining its importance to ensure marketability in local and international markets. Food processed from manufacturing industries is usually graded in terms of quality; a shape defect would be regarded as a non-quality product and may be rejected or given away. In a semi or fully automated food manufacturing system, one of the most commonly used techniques is computer vision. This can be implemented by using a camera with a certain resolution and image processing to display results obtained. This project applies image processing technique to differentiate good and defective tart, according to its shape. The mold platform moves along with the conveyor by first reaching a pressing location (pneumatic cylinder) and later arriving under the view of the camera. A Raspberry Pi was used to connect the conveyor motor, pneumatic cylinder and the ultrasonic sensors. From the image acquired by the USB camera, the images are processed by edge detection and the number of circles identified for the tart and centroid position has been analyzed. The results show that a quality tart shape has number of circles less than 10, for the distance of the camera of 12, 15 and 18cm, with the 15cm distance from the camera gives a more accurate reading.*

Keywords*: Tart classification, food manufacturing, tart pressing, edge detection, segmentation*

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I. Introduction

With the rapid development of information and technology in the age of Industrial Revolution 4.0, industrial sectors have increased efficiency in production, including food manufacturing. As packed foods are gaining higher demands, the technology in place will improve productivity in terms of high volume production. Nevertheless, the quality of the product needs to be ensured. Automation and robotics fulfil the responsibility of providing high-quality and affordable food products for the consumers [1].

Inspection of quality of food products can be done via manual (human) labor or vision technology. The advantage of using vision technology is fast processing time. However, the vision system needs to be trained beforehand, i.e. pre-defined parameters need to be set to identify quality and non-quality products. Vision system has some advantages over human labor as it is not affected by fatigue.

Producing tart shell manually requires a lot of time, human effort and energy especially for subsidiary production. This is due to the various processes that are required, from tart pressing, filling insertion and baking. For tart pressing, the doughs are required to be pressed into its mold manually one at a time 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 robotics 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 [2].

Utilization of image processing techniques has been applied in various food classifications. For examples, color analysis and beef freshness level were determined by using thresholding, matrix multiplication and GHM multi-wavelet transformation [3]. The ripeness of tomatoes was also studied by using erosion, a morphological operation, with a structuring element of 7x7, with experiments conducted on green, turning and red tomatoes [4]. On a smaller scale, quality of rice grains has also been researched by image processing techniques to observe the grain size and shape [5]. Sobel operator was used for edge detection and later lengthbreath ratio was used to classify the rice grain. Researchers proposed image segmentation method based on k-means adaptive clustering to inspect quality of fruit products in shapes which are non-circular such as banana, mango and pineapple [6]. The quality of mango was also studied to determine the mango size gradation according to the length of mango major and minor axis [7]. Researchers calculated number of defective pixels to validate the gradation effect based on amount of surface defect while shape analysis was done based on Fourier Descriptor. Having said that, with the advanced robotic and machines in the production lines, a new benchmark could be set to speed up production.

Most of the image processing method was applied on fresh produce (fruits) but some even applied on meat and fish [8]. To the best of our knowledge, no research results have been presented on bakery products. In this case, focus will be given on the shape of tart after the pressing process as an indication of the quality of the tart.

II. Mini Tart Production System

For the purpose of the study, a simple conveyor system to move the tart mold to the pressing process which is later inspected by a vision system was constructed, as in Fig. 1 and 2. The pressing process was done by a pneumatic cylinder, while the inspection was done by a USB camera.

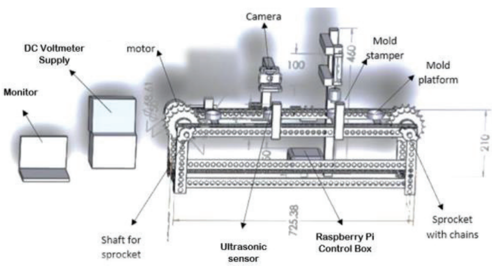


Fig. 1. Design of the mini tart production system

Fig. 2. Picture of the constructed mini tart production system

The mini tart production system shown in Fig. 1 and 2 involves only pressing and inspection process, and does not include baking or packing. The system is also equipped with ultrasonic sensors to detect the arrival of the mold platform to the pressing location and inspection point. The process is repeated after pressing and inspection for several molds. The main controller used was Raspberry Pi 2 and sensors were controlled by Arduino UNO. A simplified view of the connections is shown in Fig. 3.

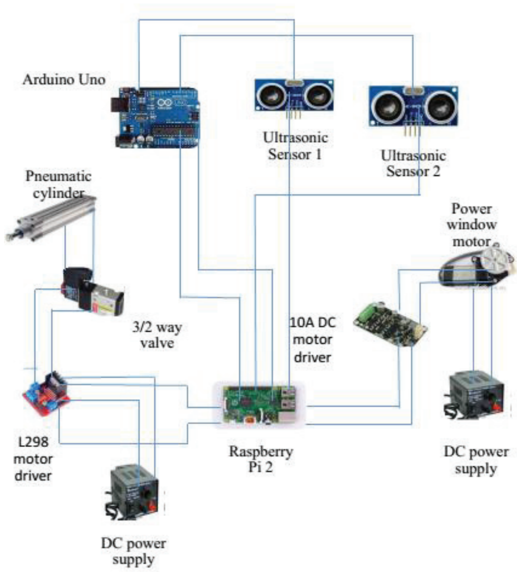


Fig. 3. Connections of the mini tart production system

III. Methodology

Fig. 4 represents the general process or flow of the vision inspection for the tart production.

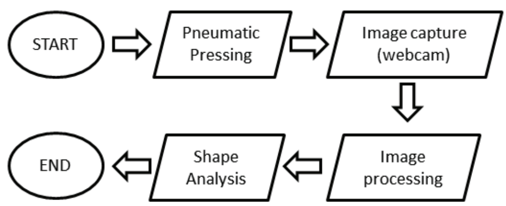


Fig. 4. Flowchart of vision inspection system of the tart production

Firstly, tart pressing is done by the pneumatic cylinder which presses the dough on the mold. After pneumatic pressing, the conveyor moves the mold to the station for inspection. At this point, the ultrasonic sensor will alert the controller to stop the conveyor and allow 3 seconds for the camera to acquire the image. The role of the vision inspection is performed by the USB camera which is then sent for processing by the Raspberry Pi and the OpenCV libraries used in Python programming.

The image processing starts after acquiring the image. Firstly, color space conversion from RGB to HSV and Gray scale image. It is followed by filtering using Canny edge to remove noise and smoothen the image. In the segmentation process, thresholding takes place. This is important as edge detection helps extract the area of interest from the background. The segmentation and filtering done on the image produce a contour around the shape, which is expected to be circular. Features taken from this process are centroid of the object and radius of the circle. In addition, it is expected that more than one circle will be detected, since the edges of the tart are not smooth and saw-tooth in shape. Thus, one other feature to analyze is the number of circles produced from the image processing.

There are two different settings for studying the shape of the pressed tart; the distance of the camera from the tart and the weight of the dough applied before the pressing process.

A. Distance of the camera from the tart

The distance of the camera from the tart is adjusted for three different conditions; 12cm, 15cm and 18cm. This is achieved by adjusting the flexible stand of the USB camera before turning on the tart production system. The distances were chosen based on the maximum, minimum and middle point of the stretch of the flexible stand. The camera is facing straight down vertically to the tart in the mold platform. Thus it is deemed that the view of the object can easily be recognized as a circular shape. When the mold platform reaches the detection range of the ultrasonic sensor, the conveyor stops and allow the camera to snap a still image and proceed with image processing by the Raspberry Pi controller. Then, the conveyor is allowed to move for the next tart in the mold to be inspected.

B. Weight of the dough applied on the mold

Another variable which affects the quality (shape) of the tart produced is the weight of the dough. A weight which is less than the minimum or maximum allowable range (depending on the size of the tart mold) could affect the quality of the tart. In human labor, the weight is roughly estimated by the human operator. For the size of the mold platform, the upper diameter is 4.5cm while the lower diameter is 3.5cm. In this study 15g, 20g and 25g weight of dough were studied. These weight values were verified by the baking staff at a store located in Melaka town. However, different sizes of the mold would incur different weight, which could be further studied.

Firstly, the dough's weight is measured using a Digital Weighing scale. The dough is then rolled and fitted into the tart mold. The conveyor then moves the mold to the pressing station. Image acquisition is performed after the pressing, once it reaches the vision system location. This means that different weights of the dough are applied before each pressing process.

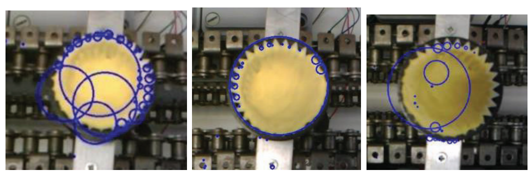
The tart in the mold consists of two types shape, a quality (perfect) tart shape and a defective (imperfect) tart shape. The defective shapes are affected by inaccurate pressing which result in the tart edges to be highly irregular. Both shapes are inspected by the vision system for the different camera distances and weight of the dough. For each tart mold, the experiment (image acquisition and processing) is repeated 6 times to measure consistency.

IV. Results

The results of the features of the images acquired for weights of 15g, 20g and 25g of dough are tabulated in Tables I to IV which summarize the 6 trials of each experiment. Fig. 5 – 10 indicate the sample images of the pressed tart after image processing.

(a) (b) (c)

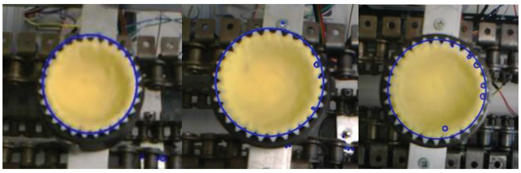
Fig.5. Picture of the 15g quality tart from distance of (a) 18cm, (b) 15cm and (c) 12 cm



(a) (b) (c)

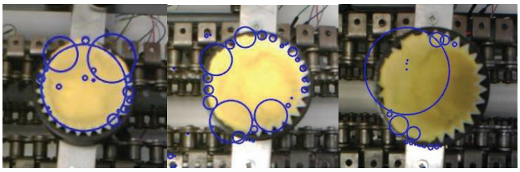
Fig.6. Picture of the 15g non-quality tart from distance of (a) 18cm, (b) 15cm and (c) 12 cm

Fig. 5 and 6 show the results for the 15g dough of quality and non-quality tarts at different camera distances of 18cm, 15cm and 12cm. It is evident that the quality tart shape at all three distances result in lower number of circles detected, from two to eight circles (Table I). While the non-quality tart shape exhibits between five to 18 circles detected (Table II). The radius and centroid values represent the largest circle detected which is displayed to indicate consistency in measured values (the circle is in the center view of the camera).



(a) (b) (c)

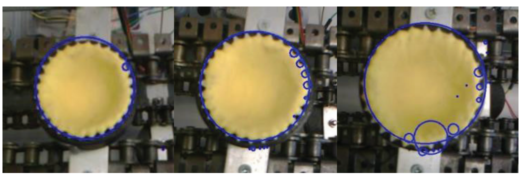
Fig.7. Picture of the 20g quality tart from distance of (a) 18cm, (b) 15cm and (c) 12 cm



(a) (b) (c)

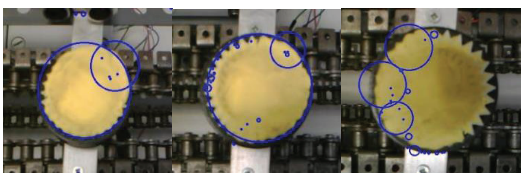
Fig.8. Picture of the 20g non-quality tart from distance of (a) 18cm, (b) 15cm and (c) 12 cm

From Fig. 7 and 8, the results for the 20g dough are almost similar. It can be seen that non-quality tart shape again exhibits larger number of circles of five to eighteen, compared to quality tart shape which is between two to six (Tables III and IV). Some of the circles for non-quality shaped tart does not match the mold and highly misplaced, as compared to quality shaped tart which covers at least 80% of the size of the mold.



(a) (b) (c)

Fig.9. Picture of the 25g quality tart from distance of (a) 18cm, (b) 15cm and (c) 12 cm



(a) (b) (c)

Fig.10. Picture of the 25g non-quality tart from distance of (a) 18cm, (b) 15cm and (c) 12 cm

For Fig. 9 and 10, the non-quality tart of 25 g of the dough shows that the edges are clearly non-uniform. Tables V and VI show that the number of circles for quality-shaped tarts ranges from three to eight whiles non-quality shaped tarts range from six to fifteen.

TABLE I

QUALITY TART FEATURE RESULTS FOR 15 GRAMS

Camera Distance (cm)	Radius (pixel)	Centroid Value (pixel)	Number of circles
18 cm	74-77	X - 310-324 Y- 239-262	2-5
15 cm	95-97	X – 267-277 Y – 150-158	3-8
12 cm	122-129	X – 255-331 Y – 243-277	3-6

TABLE II

NON-QUALITY TART FEATURE RESULTS FOR 15 GRAMS

Camera Distance (cm)	Radius (pixel)	Centroid Value (pixel)	Number of circles
18 cm	80-83	X – 326-335 Y- 219-226	7-18
15 cm	103-106	X – 302-305 Y – 180-187	5-9
12 cm	49-111	X – 227-336 Y – 136-240	5-15

TABLE III

QUALITY TART FEATURE RESULTS FOR 20 GRAMS

Camera Distance (cm)	Radius (pixel)	Centroid Value (pixel)	Number of circles
18 cm	74-78	X – 275-301 Y- 173-330	2-6
15 cm	108-115	X – 262-380 Y – 169-211	1-4
12 cm	121-130	X – 283-338 Y – 176-272	3-5

TABLE IV

NON-QUALITY TART FEATURE RESULTS FOR 20 GRAMS

Camera Distance (cm)	Radius (pixel)	Centroid Value (pixel)	Number of circles
18 cm	79-85	X – 327-339 Y- 217-227	9-18
15 cm	102-105	X – 298-327 Y – 186-206	6-11
12 cm	78-119	X – 257-315 Y – 176-233	5-12

TABLE V
QUALITY TART FEATURE RESULTS FOR 25 GRAMS

Camera Distance (cm)	Radius (pixel)	Centroid Value (pixel)	Number of circles
18 cm	76-84	X – 239-311 Y- 226-302	3-6
15 cm	105-116	X – 301-347 Y – 202-290	3-5
12 cm	129-134	X – 283-340 Y – 250-273	5-8

TABLE VI
NON-QUALITY TART FEATURE RESULTS FOR 25 GRAMS

Camera Distance (cm)	Radius (pixel)	Centroid Value (pixel)	Number of circles
18 cm	61-90	X – 284-331 Y- 165-260	7-21
15 cm	105-110	X – 305-343 Y – 182-199	6-11
12 cm	49-66	X – 231-292 Y – 167-232	10-15

V. Conclusion

Although the shape of a pressed tart is almost circular, the results of features, specifically the number of circles detected from the image processing proves that the process of identifying the quality and non-quality shaped tart is challenging, even with color detection. This is because the number of circles at times overlaps, for the 15 and 12cm camera distance. A tart of quality and non-quality could possess similar number of circles detected. However, it is clear that the non-quality tarts have five or more circles. With a distance of 18cm, the results are more reliable, with a clear difference between quality and non-quality shaped tarts.

Further investigation could be done to improve the vision inspection system, possibly with fusion of several features which are more deterministic. Vision inspection could also be used after the tart undergoes the baking process. This is because non-quality shaped tarts could be rejected right before packing or sell them to the customers.

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References

[1] Steve D., Ph.D. (n.d.). Robotics and Automation for the Food Industry.[Online],at:https://www.foodsafetymagazine.com/magazine-archive1/augustseptember-2014/ robotics-and-automation-for-the-food-industry/

[2] Chris C. "How Robots are changing the food Industry and Improving Fulfillment."[Online], at https://www.foodlogistics.com/3pl-4pl/article/12002261/how-robots-are-changing-the-food-industry-and-improving-fulfillment.

[3] D. Trientin, B. Hidayat, S. Darana, Beef freshness classification by using color analysis, multi-wavelet transformation, and artificial neural network, *International Conference on Automation, Cognitive Science, Optics, Micro Electro-Mechanical System, and Information Technology (ICACOMIT), pp. 181-185, Bandung, Indonesia, October 2015.*

[4] S.R. Rupanagudi, B.S. Ranjani, P. Nagaraj, V.G. Bhat, A cost effective tomato maturity grading system using image processing for farmers, *2014 International Conference on Contemporary Computing and Informatics (IC3I), pp. 7-12, Mysore, India, November, 2014.*

[5] B. Mahale, & S. Korde, Rice quality analysis using image processing techniques, *International Conference for Convergence for Technology, Pune, India, April 2014*

[6] M. M. R Dahapute,. K-mean Clustering for Segmentation of Irregular Shape Fruit Images under Various Illumination. *International Conference on Modern Trends in Engineering Science and Technology (ICMTEST 2016), Vol. 2* (Issue 5), pp 1-5, *Shahapur, Maharashtra, India,* May 2016.

[7] C. Sekhar, B. Tudu, and C. Koley. "A Machine Vision Technique for Grading of Harvested Mangoes Based on Maturity and Quality." *IEEE Sensors Journal, Vol. 16 (*Issue 16*): 6387-6396, August, 2016*

[8] L. B. Gama e, C. W. de Silva, and R. G. Gosine. Statistical Pattern Recognition for Cutter Positioning in Automated Fish Processing. *Department of Mechanical Engineering University of British Columbia Vancouver, Canada.1993 IEEE Pac Rim*