The Internet of Things Beverages Bottle Shape Defect Detection using Naïve Bayes Classifier

N.N.S. Abdul Rahman[2], N.M. Saad[1,2], A. R. Abdullah[1,3] and F. Abdul Wahab[4]

[1]Center for Robotics and Industrial Automation, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[2]Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[3]Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[4]Infineon Technologies Sdn. Bhd., Free Trade Zone, 75710 Batu Berendam, Melaka

norhashimah@utem.edu.my

Abstract—**This paper presents an automated computer vision system using internet of things (IoT) platform for shape defect detection. The proposed system used beverage bottles as a tested product. Morphological operation is applied to segment the image using erosion and dilation process. The features of shape bottle such as area, perimeter, major axis length and extend are extracted. Naïve Bayes classifier is implemented to classify the shape of bottle either pass or rejects based on the estimated extend parameters. All the images are taken using webcam and the captured image is stored in server for wirelessly access. The analysis is done by using image processing toolbox using Matlab in real-time. The result demonstrate that the tested product based on shape is achieved 92% accuracy for good bottle and 90% accuracy for defect bottle using 100 sample images. It shows that the proposed system can be applied for beverages quality control application.**

Keywords—computer network; shape detection; morphological operation; naïve bayes

I. INTRODUCTION

Product quality inspection is a vital step in the manufacturing and the production line process. Since the product realibility is the most important part, the process of attempting the 100 % inspection of all parts, subassemblies, and finishing is oftenly being attempted. The performance of human based inspection is generally inadequate, very subjective and commonly allow error during inspection. TheVisual inspection process on the other hand requires a thorough observation and they will be observing the same type of the image repeatedly to inspect the product [1]. As a result, the accurary of the human visual inspection will always decline due to dull andendless routine job. The process is slow and will effect the inspection process [2].

Moradi et al., proposed statistical histogram fuzzy c-means (SHFCM) algorithm to detect the defect of apple. The experimental results show that SHFCM algorithm contributes a fast processing time compared to the conventional FCM.

However, the proposed algorithm is complex compared to conventional FCM [3]. Liu et al., recommended a defect detection system to inspect film capacitor using machine vision. Shape and gradient detection are applied to segment and to identify the shape defect of film capacitor. The limitation of the proposed technique is that it could not detect the small defect on the film capacitor surface [4].

A studied made by Haniff et al. [5], suggested that the inspection system is to inspect glue process defect using the shape-based matching technique. The proposed method achieved 85% accuracy. But, the proposed system is manually set the matching score value. Different to Mu et

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al., they presented inspection for wood quality using median filter and log operator. The results show that this study is efficient and reliable to help wood production in order to produce high quality of wood. However, the proposed system could not be implemented in real-time [6].

Ramli et. al [7] compared two erosion-based methods which can be used for automated classification system. Regular erosion and partial erosion are applied to segment the shape of bottle. From experimental results, both methods achieved more than 80% of accuracy. Unfortunately, the effect of erosion must be set manually that makes the proposed technique is inefficient to be used for automated inspection system.

Although an extensive research has been carried out in this field, there is a few studies have been conducted in real-time due to difficulty integration between algorithm and hardware. The aim of this project is to develop a computer network inspection system to inspect the quality of shape of the bottle for beverage bottles in real-time. Fig. 1 shows the layout of automated visual inspection system using IoT platform.

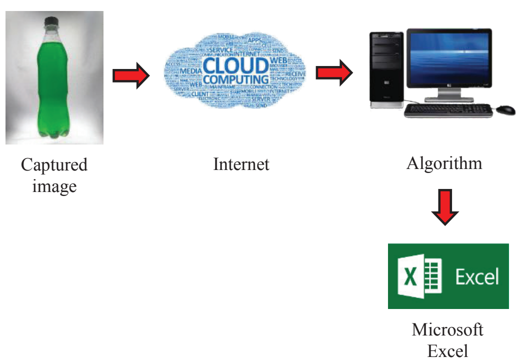


Fig. 1. Internet of things (IoT) beverages bottle inspection system

II. METHODOLOGY

The analysis framework of shape detection is shown in Fig 2. In this system, the sample image is captured using webcam with high resolution to produce a high quality image. Then, the captured image is pre-processed to enhance the image. Morphological operation is applied during segmentation process to segment the shape of the bottle. In extracting the shape features, geometric method is used. The shape of bottle is classified using Naïve Bayes classifier to classify the shape of bottle either pass or reject.

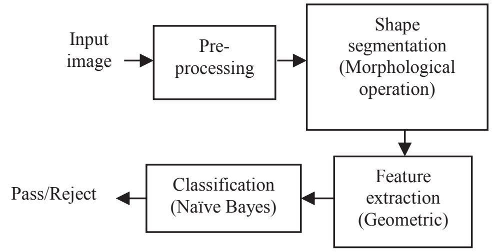


Fig. 2. Framework analysis

A. *Image Acquisition*

A 12 megapixel webcam is used to capture the sample images of the bottle. The place is setup properly to reduce complexity in acquiring sample image as shown in Fig 3. The distance between bottle and camera is set to 20 cm because of the suitable position to capture the image. It is important to find a suitable position of the camera in order to produce high quality image [8]. An appropriate illumination position is placed behind the bottle is designed to spread out the illumination over the bottle surface which is purposed to avoid reflection of light [9].

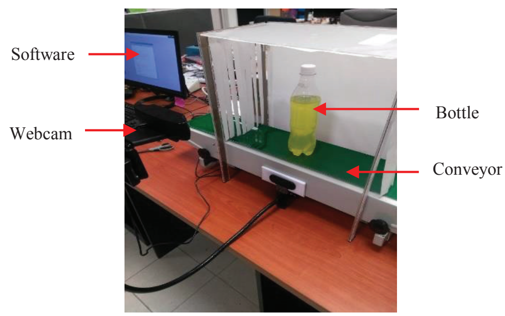


Fig. 3. Image acquisition setup

B. *Pre-Processing*

The image is went through a pre-processing stage to improve the quality of the image by eliminating noise and by adjusting the contrast of the image [10]. Pre-processing also reduce the complexity of the image for further analysis.

C. *Morphological Operation*

Morphological operation method is used to segment the bottle and to remove the background of the image. It involved mathematical operation on sets of pixels [12]. The element of the pixel is structured which contains foreground and background values. Four basic morphological process includes erosion, dilation, opening and closing. Tthe usesd of this method, make the quality of the image increased while the noise is reduced [13]. The opening process will smooth the edges, break narrow block connectors and remove small protrusions of the input image. While closing process is applied to smooth the edges, combine narrow block connectors and fill the holes of the image [14]. Both operations are given smoothing process for the image contour.

D. Feature Extraction

In this system, area, perimeter, major axis length, and extent are extracted from the sample image which is illustrated in Fig. 4. All of these features are important for the classification process.

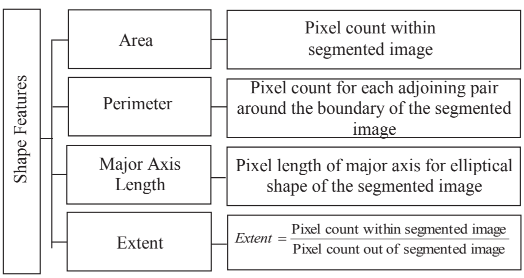


Fig. 4. Feature extraction parameters

E. Naïve Bayes Classification

Naive Bayes is used in this system to classify the condition of the shape bottle either pass or reject. It can solve two-class or multiclass classification problem. Naive Bayes offer low in computational complexity compared to neural networks and support vector machine [11].

Naive Bayes is assumed the target value by calculating it as $P(y1|x)*P(y2|x)$ [12]. The posterior probability, $P(y|x)$, from $P(y)$, $P(x)$ and $P(x|y)$ is expressed as

$$P(y \mid x) = \frac{P(x \mid y).P(Y)}{P(x)} \quad (1)$$

where
$P(x|y)$ is the likelihood which is the probability of predictor given class
$P(y)$ is the prior probability of class
$P(x)$ is the prior probability of predictor

F. Hardware Development

In this system, four components which are conveyor, infrared sensor (IR), webcam and Raspberry Pi are used in development stage. Fig. 5 illustrates the block diagram for the hardware system process. The python code is applied to control the movement of conveyor and webcam using raspberry pi [13]. The process started by running the conveyor to move the bottle from one place to another place. Once the sensor sense the present of bottle, the conveyor will stop from running for few seconds. Then, the bottle image is captured using webcam. By using IoT platform, the captured image will be stored in Apache server. After that, MATLAB will access the captured image from the server to be analysed. Lastly, the results of bottle shape is displayed in GUI. The same process is repeated for the next image bottle.

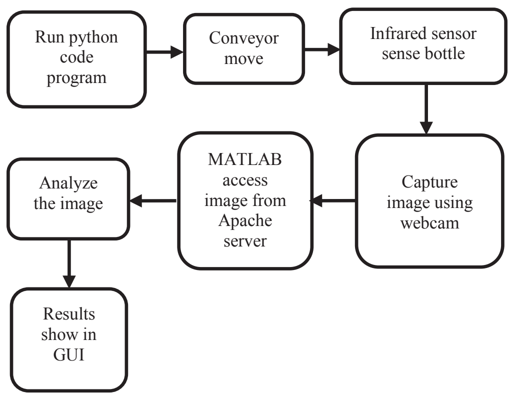


Fig. 5. Hardware system process

G. Webcam

The Logitech C910 webcam is used to capture the bottle image because it provides a high quality image. The HD Pro C910 offers sharp autofocus and automatic low light correction to reduce the noise in the image. It also boasts 1080p with its new 5MP image sensor.

H. Raspberry Pi

Raspberry Pi model B is used as a controller to control conveyor and webcam. The used of

Raspberry pi in this system because it is low cost and low power consumption level [14]. It consists WIFI and Bluetooth 4.1 or BLE module which can be connected with other devices. The pins used are gpios, Vcc and ground ports.

I. Conveyor

A conveyor is a mechanical handling which used to move the bottle from one place to another place. The conveyor is installed with motor driver used to run the conveyor. The motor driver used a low-current control signal and then amplified it into a higher-current signal. In order to facilitate the webcam to capture the bottle image, conveyor is applied to move and stop the bottle in the predetermined position which can make webcam to capture the image easily.

J. Infrared Sensor Module

The infrared sensor (IR) module is applied to detect the presence of the bottle. IR sensor is an electronic component which is used to transmit and receive signal the bottle presence. IR sensor will send the signal to raspberry pi in order to stop the movement of conveyor.

K. Apache Server

Apache server is used to store the bottle image. Open free source HTTP server makes this server is chosen to be implemented in this system. It is also reliable and secure server which provides HTTP services in sync with current HTTP standards. The modification is needed to meet the requirement in many different environments by using extensions and modules.

III. RESULTS

To monitor the proposed system, graphical user interface (GUI) is developed using MATLAB software. Fig. 6 and Fig. 7 illustrate the GUI layout and complete system design.

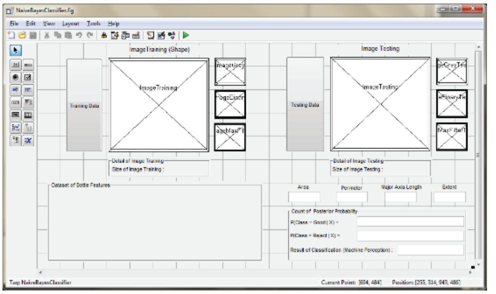


Fig. 6. GUI layout

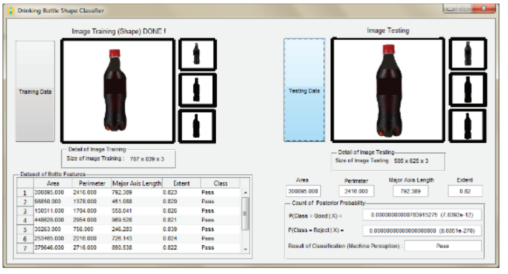
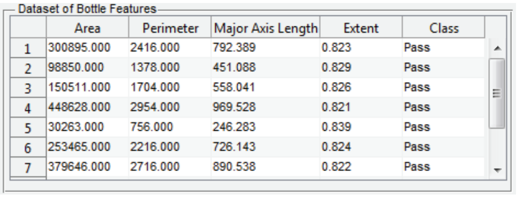


Fig. 7. GUI of complete system

The shape of bottle parameters such as area, perimeter, major axis length and extent are tabulated in Fig. 8. The extent parameter value will be used as an input training for classification process.



Dataset of Bottle Features

	Area	Perimeter	Major Axis Length	Extent	Class
1	300895.000	2416.000	792.389	0.823	Pass
2	98850.000	1378.000	451.088	0.829	Pass
3	150511.000	1704.000	558.041	0.826	Pass
4	448628.000	2954.000	969.528	0.821	Pass
5	30263.000	756.000	246.283	0.839	Pass
6	253465.000	2216.000	726.143	0.824	Pass
7	379646.000	2716.000	890.538	0.822	Pass

Fig. 8. Dataset of feature extraction

The classification result is determined by calculating the expected and the variance value based on the statistical probability. Fig. 9 shows the classification result using Naive Bayes classifier. The shape of bottle is classified either pass or reject depends on the count of the posterior probability value.

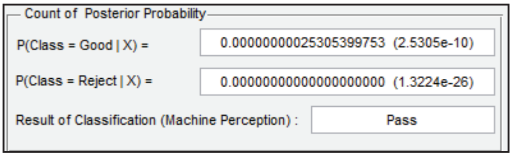


Fig. 9. Naive Bayes classification result

Fig. 10 and Fig. 11 show the condition of bottle shape which is pass and reject. Based on Fig. 10, the result of classification of bottle shape is PASS. It is because of the P (class = Good | X) value is higher than P (class = Reject | X) value. Different with Fig. 11, the shape of the bottle is classified as reject condition because of the P (class = Reject | X) value is higher than P (class = Good | X) value.

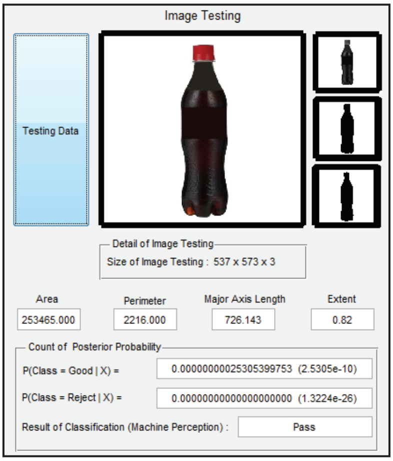


Fig. 10. Pass condition

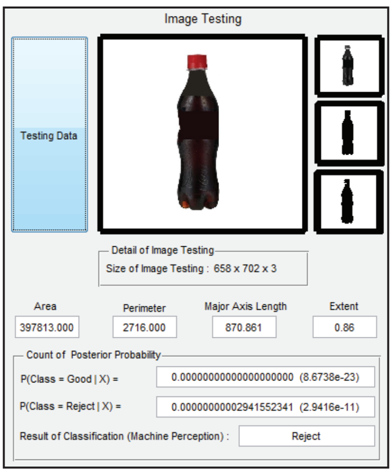


Fig. 11 Reject condition

A 150 sample images are used in this system by using 50 samples as a training image and 100 samples as a testing image. The accuracy graph of shape detection is shown in Fig. 12. Based on Fig. 12, 92% and 90% accuracy is achieved for good bottle and reject bottle using Naive Bayes classifier. The accuracy of the system is depending on the number of training image.

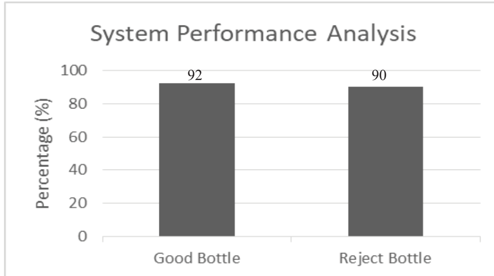


Fig. 12. Accuracy graph

IV. CONCLUSION

In conclusion, computer network bottle product quality inspection system is proposed to inspect the shape of the bottle. The image analysis involved pre-processing, segmentation, feature extraction and classification. Morphological operation technique is used to segment the shape of bottle by using erosion and dilation process. The parameters such as area, perimeter, major axis length and extent are extracted from the bottle shape to be used as input during classification process. Naïve Bayes classifier is applied to classify the shape of bottle either good or reject condition. The system performance is verified in terms of accuracy. Tthe experimental results, shows that 92% and 90% accuracy is obtained for good bottle and reject bottle using 100 sample images. Therefore, the proposed system shows the capability to be implemented for product quality application in manufacturing industry. For future work, the system can be added with color concentration and liquid level defect detection.

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