International Journal of Engineering Research in Electronic and Communication Engineering (IJERECE) Vol 3, Issue 5, May 2016

Side Surface and Bottom Surface Inspection of Bottles Using Image Processing

[1]Yamuna D S, [2]K V Suresh, [3]Sachin K J
[1], [2] Dept of ECE, Siddaganga Institute of Technology, [3] Aspire Business Solutions
[1]Yamuna.jyothi1@gmail.com,[2] sureshkvsit@sit.ac.in.com, [3]sachin@aspireb2b.com

***Abstract*— inspecting the empty glass bottles in food manufacturing or in beverage industries is very essential. The cracks in bottles may spoil the contents due to the creation of moisturizing effect inside the bottle. It is necessary to detect such cracks in the bottle. Manual inspection system detects these cracks, which will be inaccurate and time consuming. To overcome this problem many automatic crack detection algorithms are developed. This paper aims at developing empty bottle inspection system using image processing. The empty bottles are tested for defects automatically. The methods developed will detect the cracks on the side surface and bottom surface of the bottle. The image of the defected bottle acquired undergoes pre-processing such as gray scale conversion, noise removal and edge detection. This pre-processed image is analysed for the presence of cracks on the bottles. Adaptive thresholding followed by Raster scan method is used for the analysis of presence of cracks. Algorithms are developed using python which runs on Raspberry pi processor.**

***Index Terms*— Adaptive thresholding, Canny edge detection, Gray scale conversion, Mean filtering, Raster scan, Raspberry pi processor.**

I. INTRODUCTION

Modern consumer product companies dealing with pharmaceuticals and food or beverages have little tolerance for moulded container defects. Inspection of empty bottles by human results in low speed and efficiency, because the whole inspection process is subjective and very tedious. The effectiveness of the detection is greatly affected by environment and the worker's emotion. Fig.1 represents the traditional human inspection system.

Fig.1: Traditional human inspection system.

The problem of packaging bottles may cause the beverages metamorphosing, or even cause food explosion and affects the health of the consumer. It is very necessary to detect the quality of glass bottles automatically before they reach the filling stations. To overcome these problems many inspection systems are developed. In this paper as a replacement of human inspector, an empty bottle inspection system is introduced which detects the defects on the side surface and bottom surface of the bottle.

II. LITERATURE REVIEW

Many bottle inspection algorithms were developed in recent years. The main approaches of the algorithms was to detect the defects in the bottle before they reach the consumers. In this section, a brief literature review is given.

In paper [1], the authors developed a glass bottle defect detection system. In this system, the bottle neck surface is checked for the imperfections or for the cracks, as most of the defects lie in the upper part of the bottle neck surface. The images captured are subjected to Adaptive Gray correction. During Gray correction, there will be stronger noise developed along the sides of bottle due to the shading effect introduced by the bottle itself. This leads to a serious problem to detect the defects with obvious gray changes. In this paper the authors mainly concentrated on detecting the defects of upper portion of the bottle and the bottle neck.

In paper [2], the authors have developed a Real-time machine vision system for bottle finish inspection. In this system, the authors introduced two different methods for inspection of defects on the upper part of the bottle surface. The methods are: Detection of cracks by determining the area of interest and Inspection using neural network. In the first method that is detection using determination of area of interest, the area under consideration was captured and subjected to image pre-processing like de-noising and edge detection. Later the conventional Hough transform technique was applied to locate the centre of the area. Since the area of interest considered was ring like region, locating the centre was difficult and very time consuming. To reach the specified time constraint the radius of the area under consideration need to be reduced which was challenging. Due to this limitations this method was not suitable for real time applications.

In paper [3], the authors introduced an inspection system called Algorithm Research on Location of Bottle Mouth and Bottom in Intelligent Empty Bottle Inspection System. In this approach only the defects across the bottle mouth and the bottom surface of the bottle is considered. Initially image pre-processing steps are carried out such as image de-noising, image contrast enhancement and later followed by the edge detection. Here Canny edge detector is employed to detect the edge of the bottle bottom surface. After locating the edges, chain code tracing technique is employed to remove the unnecessary edges, which will affect the accuracy of locating defects in the bottle bottom surface.

In paper [4], the authors developed an inspection system called Development of a computerized method to inspect empty glass bottle. The region of area of interest in image was marked and located. This method adopted morphological methods and wavelet transform technique to extract the features of the bottle surfaces. These features were classified using fuzzy support vector machine using neural network. Later the back propagation algorithm is adopted to optimize the parameter of the fuzzy support vector machine.

In paper [5], the authors developed an inspection system called Development of glass bottle inspector based on machine vision. In this method the captured images are initially pre-processed such as noise removal and edge detection. Then the edge detected image is segmented using watershed segmentation. The morphological gradient of image is computed by dilation and erosion methods before applying watershed segmentation to avoid the over segmentation. Then the bottle finish features are extracted by methods based on wavelet transform. The features extracted from the images are classified using fuzzy support vector machines ensemble. The fuzzy support vector machines [SVMs] synthesize the fuzzy theory and SVMs, and the parameters are optimized by the Genetic algorithms.

In paper [6], the authors developed an inspection system called Empty bottle inspector based on machine vision. In this method, the histogram thresholding is adopted to select the centre of area of interest. This method overcomes the problem of time constraint that was arrived by using the Hough transform technique. In this method the authors also used successive scanning method to scan the pixel values from left to right and top to bottom. In this method the sudden rise of pixel values compared with the neighbouring pixel values, indicates the presence of cracks on the bottle. Here the use of canny edge detector is avoided due to its errors along with its good ability to detect the edges.

In paper [7], the authors developed an inspection system called Online detection of glass bottle crack based on evolutionary Neural network and computer vision. In this method inspection of bottles to detect defects was done by adopting neural network back propagation algorithm. Initially image was acquired using CCD(charged coupled devices) camera. The obtained image was subjected to image prepossessing steps such as modifying the luminance of the images, smoothing the noise, sharpening the images and median filtering. In this process, back propagation algorithm is adopted to detect the cracks. Initially a training set is used to train the system. When the test pattern was given, the system detected the cracks comparing the test pattern set with the trained ones.

III. METHODOLOGY

The main objective of empty bottle inspection system using image processing is to detect the defects in the bottle with less human interventions, their by rejecting the defective ones before reaching the next stage for filling. This helps to provide protection against spills or leaks, preserve the flavour of beverages.

The proposed method initially performs pre-processing of data samples, edge detection followed by histogram based segmentation called Adaptive thresholding and finally Raster scanning. Fig.2 gives the methodology of the proposed technique.

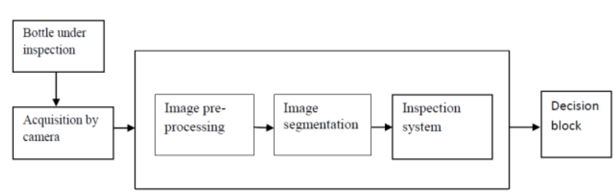
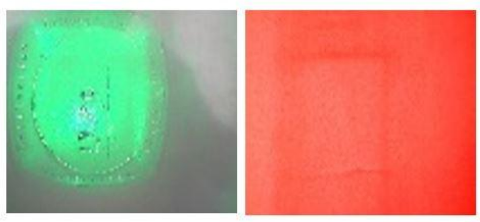


Fig.2: Bottle side surface and bottom surface inspection system.

The defective image is captured using a camera. The captured image is subjected to the image pre-processing, where initially the image is converted to Gray scale. Noise is removed using Mean filters followed by canny edge detector is applied to detect the edges. The edge detected image is subjected to Adaptive thresholding which is scanned by raster scanning technique in the later process.

a. Image Acquisition

The bottles under inspection are captured using CCD camera. This images are captured under the presence of green light and red light. Using green light it is even possible to detect the hair line type of cracks. Fig.3 shows the acquired images of the defected bottles for preprocessing.



(a) (b)

Fig.3: (a) Cracks on bottom portion of the bottle, (b) Cracks on side surface of the bottle

b. Pre-processing

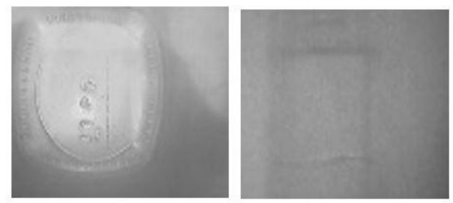
Initially the image of the defected bottle is acquired using CCD camera and is pre-processed. The major pre-processing steps are gray scale conversion, mean filtering and edge detection using Canny edge detector. Fig.4 shows the image of a bottle with defects on the surface portion.

Fig.4: Image of a bottle with defects on the side surface.

c. Mean Filtering

Initially the captured image is converted to Gray scale image. The image is then subjected to mean filtering. A filter of size 5x5 is considered.

If (i, j) is the pixel in the image, then a sub-image around (i, j) of the same dimension as the filter is considered for filtering. The centre of the filter should overlap with (i , j). The pixels in the sub-image are multiplied with the corresponding coefficients in the filter. This yields a matrix of the same size as the filter. In mean filtering the centre value of the sub-image is replaced by its mean value. Figure.5 shows the output of Mean filter



(a) (b)

Fig.5: (a),(b) Represents the output obtained after applying mean filter

d. Canny edge detector

After removing the noise using mean filter, the image is applied with Canny edge detection method. This technique is used to find the edges present in the image. It includes some of the steps such as applying the Gaussian filter, finding the Gradient magnitude and angles of the image.

Smoothening the input image using Gaussian filter. Let f(x,y) denote input image and G(x,y) denote the Gaussian function, then the smoothed image is formed by convolving the input image with Gaussian function as shown in the equation [2].

$$G(x,y) = \frac{1}{2\Pi\sigma^2}\exp\left(-\frac{(i-(k+1)^2)+(j-(k+1)^2)}{2\sigma^2}\right); 1 \le i, j \le (2k+1) \quad (1)$$

Where G(x,y) is a equation for a Gaussian filter with kernel size $(2k+1)\times(2k+1)$.

$$f_s(x,y) = g(x,y) * f(x,y) \quad (2)$$

Compute the gradient magnitude and angle in an image as in equation (3) and (4) respectively.

$$M(x,y) = \sqrt{g_x^2 + g_y^2} \quad (3)$$

$$\alpha(x,y) = \tan^{-1}\left[\frac{g_x}{g_y}\right] \quad (4)$$

e. Adaptive Thresholding

The canny edge detected image is applied with local Adaptive thresholding, which Histogram based segmentation

Where it divides the image into number of sub-images. Each sub-image is set with a threshold hence it is more advantageous over Otsu segmentation. Adaptive thresholding takes either color image or gray scale image as input and outputs a binary image. In this paper Mean distributions is used as a local distribution. Fig.7 represents the output of Adaptive thresolding

T= Mean of Maximum and minimum value.

$$T = \frac{\max + \min}{2} \qquad (5)$$

(a) (b)

Fig.7: (a) Adaptive thresholding output of lower surface of bottle, (b) Adaptive thresholding output of side surface of bottle.

f. Raster Scanning

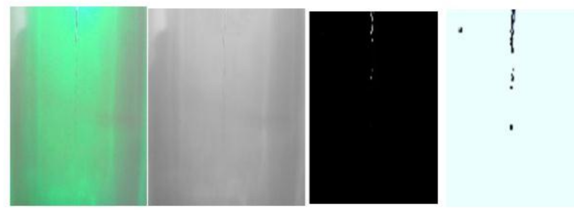
The edge detected image is subjected to histogram based segmentation called Adaptive thresholding. After segmenting the image raster scanning technique is used. In this raster scan technology the image is scanned from top left corner of the image to bottom right corner, pixel by pixel. All the pixel values are noted and observed for sudden raise or falling edge in the obtained set of the pixel values. Later examining the pixel values a decision is made whether the bottle is free from its defects as in (6).

$$Pixel\ \ values = \begin{cases} 1, & defected\ \ bottle \\ 0, & free\ \ from\ defects \end{cases} \qquad (6)$$

IV. EXPERIMENTAL RESULTS

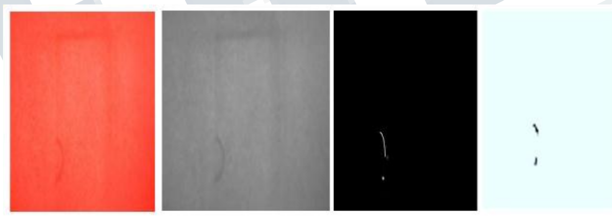
The proposed method detects the defects efficiently. It could even possible to detect the hair line cracks using this algorithm. The sample of bottles that needs to be examined are captured under the presence of green and red light. Under green light it is possible to detect any type of cracks. So it is more advisable to use green light with suitable intensity adjustments.

Fig 8: Representing the image with cracks.



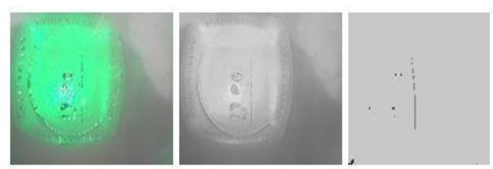
(a) (b) (c) (d)

Fig.9: (a) Side surface image with hair line crack captured under controlled environment, (b) Mean filtered image, (c) Canny edge detected image and (d) Adaptive threshold output.



(a) (b) (c) (d)

Fig.10: (a) Side surface image captured under controlled environment, (b) Mean filtered image, (c) Canny edge detected image and (d) Adaptive threshold output



(a) (b) (c)

Fig.11: (a) Image of bottom surface of bottle captured under controlled environment, (b) Mean filtered image and (c) Adaptive threshold output.

From fig.(9),(10) and (11), illustrates that the proposed algorithm can efficiently detect any type of cracks on the side surface and bottom surface of the bottle.

V. CONCLUSIONS

The proposed algorithms for bottom surface and side surface inspection system using image processing detects the cracks of the bottle efficiently and the same is shown in the results. This algorithm can be applied for different sized bottles with plain surface. As a future work this algorithm can be implemented for detecting the defects such as chipping effect on the upper surface(mouth surface) of the glass bottles.

REFERENCES

[1] Hui-Min Ma, Guang-Da su, Jun-Yan Wang, Zheng Ni, “A Glass bottle defect detection system without touching", *in Proc. IEEE International Conference on Machine Learning and Cybeneics*, Bejing, pp.628 632, November 2002.

[2] FengDuan, Yaonan Wang, Huanjnn Lin, “A Real-time Machine Vision System for Bottle Finish Inspection", *IEEE International Conference on Control, Automation, Robotics and Vision*, Kunming, China, pp. 842-846, December 2004.

[3] Sile Ma, Bin Huang, Huajie Wang, Junmei Guo, “Algorithm Re-search on Location of Bottle Mouth and Bottom in Intelligent Empty Bottle Inspection System", *IEEE International Conference on Automation and Logistics*, Shenyang, China, pp. 819-824, August 2009.

[4] Huan-jun Liu, Yao-nan Wang, “Development of A Computerized Method to Inspect Empty Glass Bottle", *IEEE International Symposium on Computer Science and Computational Technology*, pp. 118-123, 2008.

[5] Huanjun Liu, Yaonan Wang, “Development of Glass Bottle Inspector Based on Machine Vision", *IEEE 10th International Conference on Control, Automation, Robotics and Vision*, Hanoi, Vietnam, pp. 785-790, December 2008.

[6] Feng Duan, Yao-Nan Wang, Huan-Jun LIU, Wen Tan, “Empty bottle inspector based on machine vision", *in Proc. IEEE 3rd International Conference on Machine Laming and Cybemetics*, Shanghai, pp. 3845-3850, August 2004.

[7] Feng Duan, Yao-Nan Wang, Huan-Jun LIU, Wen Tan, “Empty bottle inspector based on machine vision", *in Proc. IEEE 3rd International Conference on Machine Laming and Cybemetics*, Shanghai, pp. 3845-3850, August 2004.

[8] Shijie Li, Dapeng Oliver Wu, “Modularity Based Image Segmentation", *IEEE Transactions on Circuits and Systems for Video Technology*, pp. 4070-4086, April 2015.

[9] Le Wang, Gang Hua, Jianru Xue, Jianru Xue, “Joint Segmentation and Recognition of Categorized Objects from Noisy Web Image Collection"', *IEEE Transactions on Image Processing*, pp. 570-581, September 2014.