VISION-BASED DEFECTS DETECTION FOR GLASS PRODUCTION BASED ON IMPROVED IMAGE PROCESSING METHOD

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ABSTRACT: Defect is a failure that harms the value, quality or function of a product. In glass manufacturing industry, production defects directly contributes to low quality and a failure for the organization. It will be tiresome process to have manual inspection especially for a large size of glass product. Furthermore, manual inspection processes are typically time consuming and exposed to human error. This article presents a vision-based inspection to detect glass defects using image processing techniques. The result obtained shows that defects can be successfully detected based on the method used.

KEYWORDS: *Vision Inspection; Defect Detection; Image Processing; Glass Production*

1.0 INTRODUCTION

Due to the impact of globalization, it is possible that manufacturers could receive large volume of orders from worldwide customers. In order to ensure customers' satisfaction, companies have to maintain the production of high quality products whilst increasing the throughput. The ability to yield high quality products depends on how efficiently the design process handled by the company. In the design of manufacturing systems, the main objective is to have an inspection mechanism capable of real-time monitoring and control to allow the recovery system whenever necessary [1].

Inspection is the critical activity for quality assurance in order to conform to the standards requirements, specifications and codes of manufacturing, quality assurances is mandatory [2]. Many medium and large size manufacturing companies have adopted automated visual inspection system compared to human inspection view or checking as automated inspectors system are always consistent and effective [3]. The contents consists in the image of products were identified by the automated inspector. Feature extraction of the image was investigated as to recognize the types and factors of the defects occur [3-4].

Image processing has been widely employed in numerous manufacturing sectors as to improve the visual inspection [5]. In addition, image processing technique is mostly used in various industry's sector include glass industry because of their accuracy and efficiency [6]. Basically, it refers to image processing to digitally extract the features of an image [7-8]. Besides, digital image techniques have been utilized to detect, identify and classify various types of defects based on the following level [9]:

- Low level- technique that deal directly with image with noisy pixels and edge detection.
- Middle level- algorithms that analyze data obtained from low level results. These include segmentation and edge linking.
- High level- methods capable to extract information from the analyzed data provided by the middle level.

This study aims in developing a vision-based inspection system for defects detection in glass production. However, there are specific problem that engineers face when designing vision inspection system for glass product. One of the issues is regarding the conventional image filtration technique that will mask the object. Thus, blur image will be produced and deteriorated the inspection condition. Therefore, technique that is capable of preserving the independence of gray level for each stripe must be proposed before the data could be extracted. The study focuses on improving the image processing by integrating a gradient direction technique for image filtration purpose. Furthermore, the algorithm with low computational requirement will be proposed so as to make the implementation feasible in small and medium size enterprises.

2.0 LITERATURE REVIEW

2.1 Type of Glass Defects

During the manufacturing process, the risk of a glass to been defected comes in many different forms. It may have same structure of defects but comes from different source of mechanisms [10-11].

There are various types of glass defect which commonly exist within the glass production. The types of defects are illustrated in Table 1.

Table 1: Types of glass defects [5-8]

Name of defects	Description
Foreign material	Opaque material embedded in the glass.
Low-Contrast Defect regions	Contain of elements or regions (dark and/or bright) that are relatively contrast against the background.
Scratches and spots	Marks or irregular patches on the surface.
Bubbles and inclusions	Contain an air bubble like material trapped inside a glass.
Hole and dirt	Major problem for the manufacturers, particularly when production process includes a surface treatment stage.

Manufacturers are monitor seriously during the glass manufacturing process to avoid error and defects present. Once it sent to defect detection division, inspection is carry out to test and validate the defects whether can proceed or not [11]. There are four categories of glass quality that can be classified from most to least serious [11-12]:

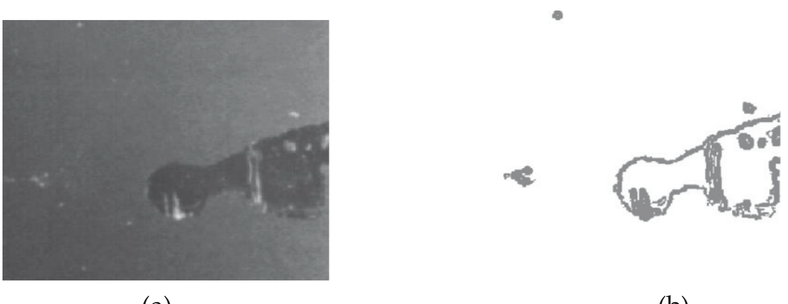
- Critical: present potential hazards as reliability of container compromised. Dangerous to handle and also risk product contamination:
- Major : Defects can lead container fail to function and simply reduce efficiency.
- Minor : Defects that not limit container functionality
- N/A : completely superficial and no impact on glass performance.

2.2 Related Works

There are some considerable research of glass defects detection work done had been discussed below. Nishu and Agrawal [7] had reviewed numerous defects for glass production. Consequently, possible automated inspection using any of the image processing techniques for defects detection that can bring benefit to manufacturing industry are investigated. They used canny edge detection method for defect detection operation.

Meanwhile, a method that can detect the foreign material on LCD in the inspection with the protective film without scratches or dust of the protective film on the surface has been proposed [13]. By having the proposed method that make use of the light-section method [14], a set of light-section time-series images is obtained by scanning the surface of the LCD with fan-beam laser light.

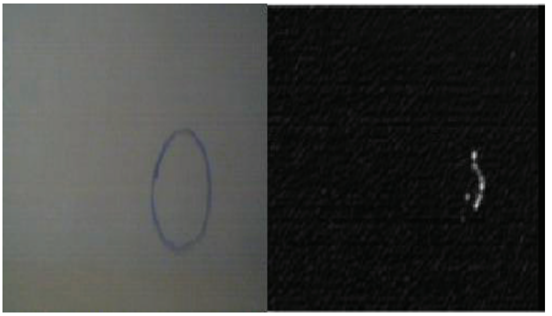
Furthermore, a PC-based inspection system has been proposed [14-16]. The system is capable to analyze the image of the glass surface that is capable to identify and classify defects and decide if the product is acceptable. The algorithm was applied to sample images of sheets and packaging. Spot defect has been identified as variation in structural parameter and deviation in size as shown in Figure 1.



(a) (b)

Figure 1: (a) Sample of spot defect identification; (b) Pixelated image [6, 12]

According to [8], glass images retrieved from a homogeneously illuminated medium will be processed by wavelet transform technique for image compression purpose. The processed images will need to be de-noised. Based on the results, defects occurred on the glass surface can be determined. These include defects like scratch and bubble as illustrated in Figure 2.



(a) (b)

Figure 2: (a) original image and (b) after wavelet evaluation image captured

3.0 METHODOLOGY

Glass product is very prone to reflections due to its character and structure. This will cause complication or failure to capture the image of the glass surface. As such, condition of lighting is very important during the image acquisition stage.

Consequently, after the image has been acquired, there is a need for the image to be processed. The main purpose is to ensure that the image is in appropriate condition to be extracted. This research proposes gradient direction technique for image filtration to prepare and to ensure the image is pure. This is done by eliminating noise elements such as burr and spike while preserving the defects features. This is obtained as gradient direction technique is capable to change the gray level significantly while maintaining the stripes direction of the image. As first introduced by Peng et al. [17], the gradient direction is represented as θ and the stripes direction, α = (90- θ). The formulation for the gradient direction filtration can be described as

$$f(i,j) = \left(\sum_{\Delta i = i-(k-1)/2}^{i+(k-1)/2} f(i+\Delta i, j+\Delta j) \right) / k \tag{1}$$

where f (i,j) represents the pixel need to be replaced. Meanwhile, increments in values of x-coordinate and y-coordinate are represented as Δi and Δj. Additionally, the gradient direction should be in perpendicular to the glass running direction. This is governed by

$$f(i,j) = \left(\sum_{\Delta j = j-1}^{j+1} (i, j + \Delta j) \right) / 3 \tag{2}$$

Upon the completion of the process, the features of the image will be extracted. Edge detection and binarization algorithms will be executed. Equations (3) and (4) provide the definition of the gradient and magnitude of the image respectively [18].

$$\nabla f(i,j) = \left[\frac{\partial f}{\partial i}, \frac{\partial f}{\partial j} \right] \tag{3}$$

$$\|\nabla f(i,j)\| = \sqrt{\left(\frac{\partial f(i,j)}{\partial i} \right)^2 + \left(\frac{\partial f(i,j)}{\partial j} \right)^2} \tag{4}$$

As for Equation (3), the gradient depends on the elements of discrete partial derivative for both x and y directions (represented as i and j) respectively.

Based on the extracted data, images will be classified. The overall research flowchart is shown in Figure 3.

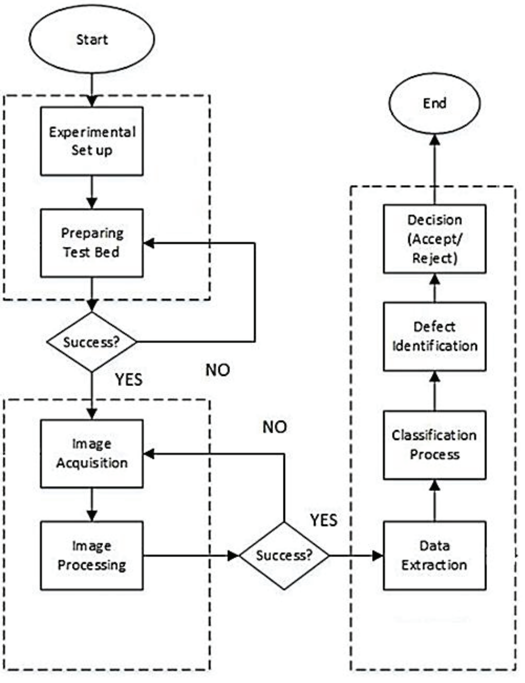


Figure 3: Overall research flow

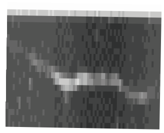
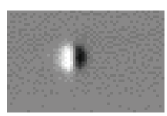
4.0 RESULT AND DISCUSSION

Based on the classification by Brazilian Association of Technical Norms–ABNT [19], glass defects could be classified into several types. Some of the defects are shown in Table 2.

In this experiment, camera once directly captured image of the glass bottle. Lighting mode was not too dark or too bright. However, there were some noise background were occur during the capturing process but it not disturbed the defect detection. Average filtering process applied on the image to remove the noise. The main objective of this study is to detect multiple defects on the same image. The noises on the image are carefully removed from the image to avoid tiny defects being removed too. Although defects have been successfully identified, images are still blur as shown in Figure 4.

Based on the experiments conducted, the average computation time for a sample is about 0.043 milliseconds. This could be considered as the acceptable time duration to fulfil the industrial requirement for real-time monitoring job.

Table 2: Defect images captured

Defects	Image captured
Scratches	
Bubbles	
Inner Crack	

(a) (b)

Figure 4: (a) original image and (b) after wavelet evaluation image captured

5.0 CONCLUSION

Automated inspection system can bring advantages to manufacturing industry. The accuracy and efficiency operation will help industry achieve a good result. The completed research proves that the proposed vision-based inspection system may be implemented to detect defects in glass production. As for future work, the fully experimental of multiple glass defect detection will be carried out with wavelet transform and will perform other advanced methods to improve the edge of images in segmentation process.

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