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A Genetic Algorithm Based Approach for Segmentingand Identifying Defects in Glass Bottles

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Abstract: -This work mainly aims at designing and developing a suitable tool for identifying defects in glass bottles through visual inspection based on Segmentation algorithm. The defect identification is done in three stages. These are Image acquisition, Pre-processing and filtering and Segmentation. In the Image acquisition stage, samples of real time images are taken and are converted into 512x512 monochrome images. In the Pre-processing and filtering stage, the image acquired is passed through median filters. The Proposed filter is Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) because it produces a high value of Peak to Signal Ratio (PSNR) of 60-75db.The de-noised images is further sent to the third stage which is Segmentation. In this work, Segmentation is done using Genetic Algorithm (GA). The defects in the images are segmented and highlighted. Thus the areas of defects are spotted out. The Genetic segmentation has produced high Sensitivity, high Specificity and high Accuracy of 92%, 93% and 93% respectively. Thus the Proposed work produced effective results and hence this tool shall be useful for food processing industries for the Quality Inspection of the glass bottles.

Keywords: - *Genetic algorithm, Segmentation, defects in glass, Modified decision based unsymmetric trimmed median filter, computer aided vision*

I. INTRODUCTION

The Term Digital Image Processing refers to the processing of a two dimensional picture by a digital Computer. A digital Image is an array of real or complex numbers represented by a finite number of bits. An image given in the form of a transparency, slide, photograph or an X-ray is first digitized and stored as a matrix of binary digits in computer memory. Importance and necessity of digital image processing stems from two principal application areas are 1. Improvement of pictorial information for human interpretation.2. Processing of scene data for autonomous machine perception. Digital Image processing has a broad spectrum of applications such as remote sensing, image storage and transmission for business applications, medical imaging,acousticimaging and automated inspection of industrial parts. Images required by satellites are useful in tracking of earth resources, geographical mapping, prediction of agricultural crops, urban growth, weather, flood and fire control.

Quality is a very important factor in Glass industries that has to be considered during the production of glass bottles. During different processing stages,there are possibilities of occurring cracks or breaks or bubbles or accodomation of any other external materials such as hair, dust etc. on the glass surface. Here the main defect under consideration is the accommodation of external materials on the surface of the glass bottle.

1.1 Components of Image Processing

1.1.1 Image Acquisition

Image acquisition is the process of capturing the images. Image capture devices or sensors are used to view and reproduce images of the sample. These devices include scanners, ultrasound, X-ray and near infrared spectroscopy. In camera vision most commonly used is CCD (charge coupled device) i.e. Camera. However recent developments in technologies have seen an adoption of digital camera which in turn reduces the additional component required to convert images taken by photographic and CCD cameras. Images captured by all of the above 2 devices maintain the features of the images with little noise due to its variable resolution. Its name specifies definition. To get any image from any source especially hardware based any source is called as image acquisition in the image processing because without image receiving/acquisition, the processing on the image is not possible. It is the first step in the work flow. It is created typically from a physical scene. The term assumed to imply or include processing, compression, storage, printing and display of such image.

1.1.2 Image Pre-Processing

This mainly refers to initial processing of raw image. The Image captured through sensors is transferred in to computer. These are then converted in to digital image. Digital Images are digits which are readable by computer and are converted in to tiny dots or picture elements representing the real objects. In some cases pre-processing are done to improve the image quality by removing the undesired distortions referred as noise. Each or a combination of the digits of the image in digital form represents a small partition of the image called picture element(Pixel).Objects are described as black and white picture which are represented by digits ranging from 0-255 where 0 is black and 255 is white. Each pixel in coloured Image is represented by 3 digits RGB (Red, Green, Blue) components with each being (0 to 255) darkest to lightest RGB. An arrangement of these digits in row-column format gives a representation of the image. With this arrangement image analysis can be done using matrix theory and other mathematical techniques

1.1.3 Segmentation

Image segmentation is a process of cutting adding and feature analysis of images aimed at dividing an image in to regions that have a strong co-relation with objects or area of interest using the principal of matrix analysis. Segmentation can be achieved through the following techniques such as Thresh holding, Edge based segmentation, Region based segmentation. Thresholding is a process where only the dark region of interest ,the other regions are converted in to background colours in the threshold image before further processing. This process is useful in colour 3 (Maturity) and feature based (Defect and Damage detection) sorting. Edge based segmentation relies on detection by edge to edge operators, which detects discontinuities in gray level, the pixel colour, texture etc. Edge detection is useful in shape and size sorting. Region based segmentation involves the grouping together and extraction of similar pixels to form region representing single objects with in the image. In this process, the other regions are deleted leaving only the feature of interest.

1.1.4 Components of Computer aided vision

Fig 1 shows the components of the computer vision system that can be used to find out the defective portion of the material coming under the test which highlights the defects.

The hardware configuration of computer vision systems is relatively standard. Typically a computer vision system consists of

- An illumination device, which illuminates the sample under test.
- A solid-state charged coupled device array camera, to acquire an image.A frame grabber, to perform the A/D (Analog to Digital) conversion of scan lines in to picture elements or pixels digitized in an N row by M column Image.
- A personal computer or microprocessor system, to provide disk storage of imagesandcomputational capability with software and specific applicationprograms

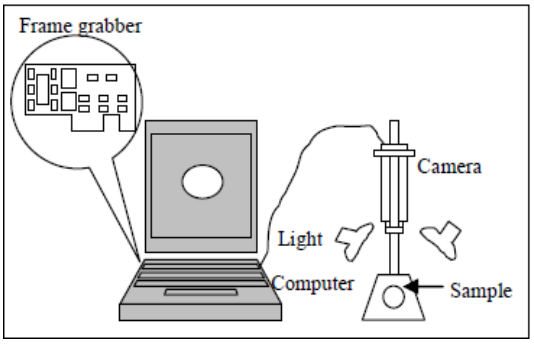

Figure 1 Components of computer aided vision system

II. INSPECTION OF GLASS BOTTLES THROUGHIMAGE PROCESSING

The Proposed block diagram for the inspection for the inspection of glass bottles can be shown below.

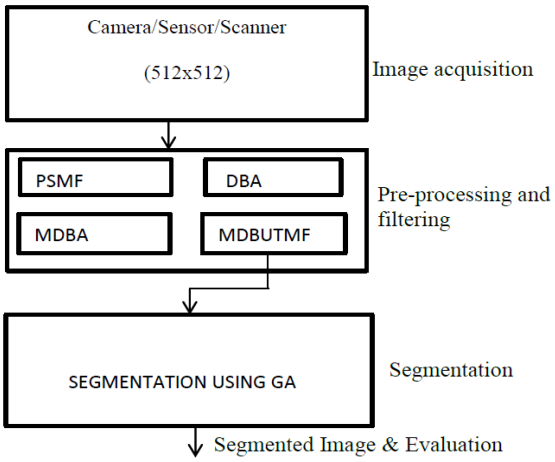

Fig 2 Inspection of glass bottles through Image processing

With reference to the figure 2, After the Image acquisition process through camera/scanners, it is then subjected to the following stages[9]

1.2Filtering Stage

Noise is any undesirable signal. Noise is everywhere and thus we have to learn to live with it. Noise gets introduced into the data via any electrical system used for storage, transmission, and/or processing. Filtering is perhaps the most fundamental operation of image processing and computer vision. In the broadest sense of the term filtering, the value of the filtered image at a given location is a function of the values of the input image in a small neighbourhood of the same location. In a wide variety of image processing applications, itis necessary to smooth an image while preserving itsedges. The different filters used are…

2.1.1 PSMF-Progressive switched median filter

A new median-based filter, Progressive Switching Median (PSM) filter, is proposed to restore images corrupted by salt-pepper impulse noise. The algorithm is developed by the following two main points: 1) switching scheme-an impulse detection algorithm is used before filtering, thus only a proportion of all the pixels will be filtered; and 2) progressive methods-both the impulse detection and the noise filtering procedures are progressively applied through several iterations. Simulation results demonstrate that the proposed algorithm is better than traditional median-based filters and is particularly effective for the cases where the images are very highly corrupted.[2]

2.1.2 DBA-Decision based Algorithm

It is a fast and efficient decision-based algorithm for the restoration of images that are highly corrupted by Salt-and-Pepper noise. The new algorithm utilizes previously processed neighbouring pixel values to get better image quality than the one utilizing only the just previously processed pixel value. The proposed algorithm is faster and also produces better result than a Standard Median Filter (SMF), Adaptive Median Filters (AMF), Cascade and Recursive non-linear filters. The proposed method removes only the noisy pixel either by the median value or by the mean of the previously processed neighbouring pixel values. Different images have been tested by using the proposed algorithm (PA) and found to produce better PSNR and SSIM values.

2.1.3 MDBA-Modified Decision Based BinaryAlgorithm

It is a modification applied to DBA. The first phase is a noise detection phase where a nonlinear decision based algorithm is used to detect impulse noise pixels. The second is a noise filtering phase where a new algorithm based on performing vector median first in RGB. The results of simulations performed on a set of standard test images on a wide range of noise corruption show that the proposed method is capable of detecting all the impulse noise pixels with almost zero false positive rates and removes noise while retaining finer image details.Proposed filter

2.1.4 MDBUTMF-Modified Decision Based Unsymmetric Trimmed Median filter

The Modified Decision Based Unsymmetric Trimmed Median Filter (MDBUTMF) algorithm processes the images by first detecting the impulse noise. The processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by MDBUTMF. In this the noise free and noisy pixels are classified based on empirical multiple threshold values. Then the median filtering technique is applied. So that noise free pixels are getting preserved and only noisy 30 pixels get restored. The proposed Modified Decision Based Un symmetric Trimmed Median Filter (MDBUTMF) algorithm removes this drawback at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR) and Image Enhancement Factor (IEF) values than the existing algorithm.[10]

2.1.4.1 Proposed Algorithm

The proposed Modified Decision Based Un symmetric Trimmed Median Filter (MDBUTMF) algorithm processes the corrupted images by first detecting the impulse noise. The processing pixel is checked whether it is noisy or noisy free. That is, if the processing pixel lies between maximum and minimum gray level values then it is noise free pixel, it is left unchanged. If the processing pixel takes the maximum or minimum gray level then it is noisy pixel which is processed by MDBUTMF. The steps of the MDBUTMF are elucidated as follows

The algorithm includes

Step 1: Select 2-D window of size 3 3. Assume that the pixel being processed is p_{ij}.

Step 2: If then is an uncorrupted pixel and its value is left unchanged.

Step 3: If or then is a corrupted pixel then two cases are possible as given in Case i) and ii).

Case i): If the selected window contains all the elements as 0's and 255's. Then replace with the mean of the element of window.

Case ii)**:** If the selected window contains not all elements as 0's and 255's. Then eliminate 255's and 0's and find the median value of the remaining elements. Replace with the median value.

Step 4: Repeat steps 1 to 3 until all the pixels in the entire image are processed

A small modification is made to this algorithm as follows

- If the value of the last processed pixel is not 0 or 255, then the current pixel is considered as a noisy pixel. However in this case, simply using the last processed pixel to replace the noise pixel may not be consistent with the property of the local region.
- In order to ensure the preservation of fine details and textures, the proposed method first checks theproperty of the region defined by a window of size 3x3. If a noise-free median is found in the neighbourhood defined by this processing window, then it can be said that, replacing the noise pixel with the last processed pixel value will result smooth transition. Else, the window size is increased to 5x5. When a noise-free median is found in the larger window (5x5), the noise pixel is replaced by the last processed pixel. Otherwise, the noise pixel is replaced by the mode of the local neighbourhood.
- On the other hand, if the value of the last processed pixel is 0 or 255, then the local region is considered to have the maximum or minimum value in the dynamic range as a property of the original image. In this case, the mode of the local 3×3 neighbourhood is used as the correction term. The use of mode in this stage facilitates preserving smooth transitions in the restored image.

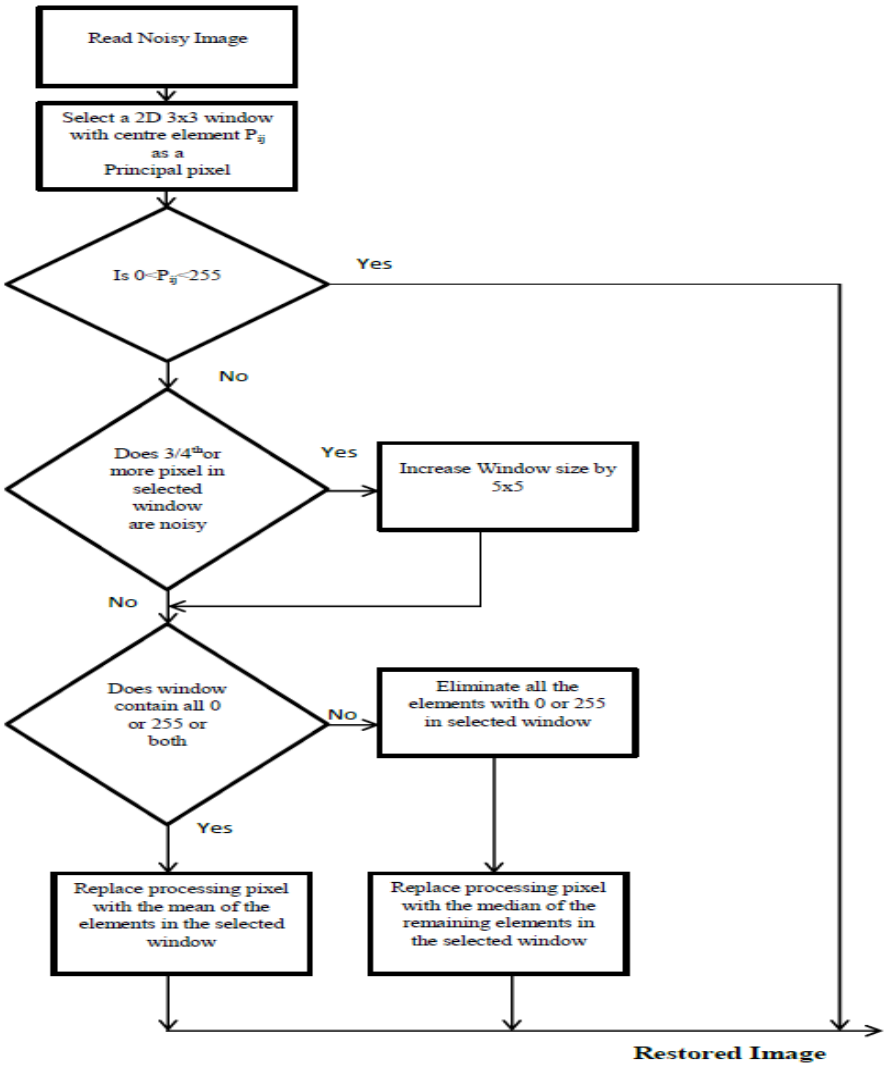

Fig.3 Flowchart of MDBUTMF

Noise %	PEAK SIGNAL TO NOISE RATIO			
	PSMF	DBA	MDBA	MDBUTMF(Proposed Filter)
0	82.13	82.13	39.85	77.29
10	53.14	53.14	39.86	63.84
20	49.71	49.71	39.85	60.28
30	47.55	47.55	39.86	58.42
40	46.46	46.46	39.86	54.45
50	46.31	46.31	39.86	50.56
60	58.07	58.07	39.87	46.32
70	34.44	39.88	34.44	42.68
80	32.25	32.25	39.92	38.47
90	30.56	30.56	40.02	34.21
100	29.18	29.18	34.51	29.17

Fig.4 Comparison chart between various filters based on PSNR

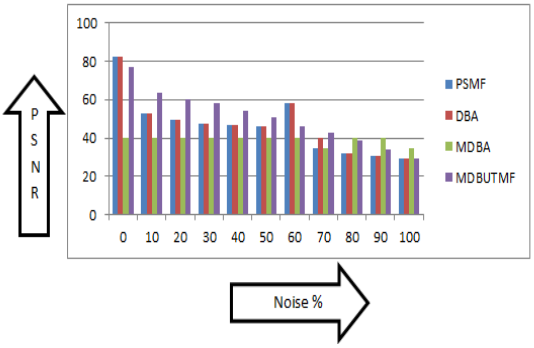

Fig.5 Graphical chart between various filters based on PSNR

III. SEGMENTATION USING GENETIC ALGORITHM

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyse.Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

2.2.1 Genetic algorithm

In a genetic algorithm, a population of candidate solutions (called individuals, creatures, or phenotypes to an optimization problem is evolved toward better solutions. Each candidate solution has a set of properties (its chromosomes or genotype) which can be mutated and altered; traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible.

The evolution usually starts from a population of randomly generated individuals, and is an iterative process, with the population in each iteration called. a generation. In each generation, the fitness of every individual in the population is evaluated; the fitness is usually the value of the objective function in the optimization problem being solved. The more fit individuals are stochastically selected from the current population, and each individual's genome is modified (recombined and possibly randomly mutated) to form a new generation. The new generation of candidate solutions is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population.

A typical genetic algorithm requires:

1. a genetic representation of the solution domain,
2. a fitness function to evaluate the solution domain.

2.2.2 Image Segmentation using Genetic Algorithm

The aim of segmentation is to obtain a new image in which it is easy to detect regions of interest, localize objects, or determine characteristic features such as edges. As a result, the image obtained by the segmentation process is a collection of disjoint regions covering the entire image whereby all the pixels of a particular region share some characteristic or property such as colour, intensity, or texture.

After the segmentation process, in order to access its result, the evaluation parameters such as Sensitivity, Specificity and accuracy have been calculated. They are calculated on the basis of TP, TN, FP and FN. They can be given by:

$$\text{Sensitivity} = \left(\frac{TP}{TP+TN}\right) * 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{Specificity} = \left(\frac{TN}{TP+TN}\right) * 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{Accuaracy} = \left(\frac{TP+TN}{TP+FN+TN+FP}\right) * 100\% \quad \ldots\ldots\ldots\ldots (5)$$

The objective function is given by

value=Minimise((-x(1).*sin(abs(x(1)).^0.5)-
x(2).*sin(abs(x(2)).^0.5))…….. (6)

Here the lower band limits are (- 500 <obj<-500). The upper band limits are 500 <obj<500.

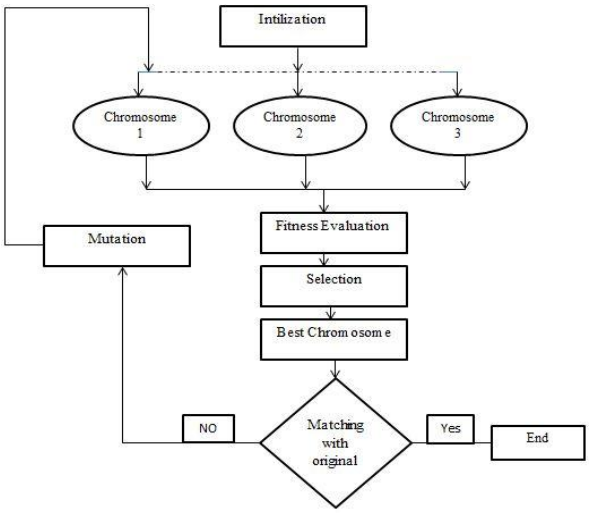

Fig.6 Proposed Flowchart of Image segmentation

- In this GA, the genes (pixels) from the denoised image are represented in binary form (chromosomes).
- Chromosomes thus obtained and the fitness evaluations of these chromosomes are done.
- Based upon the bounds defined in the GA, the suitable field is selected and the best chromosomes are taken
- A Comparison with the parent image is being done and the areas if match with the defined original pixels are turned to black.
- If it does not match, next chromosome is taken and same process is repeated. Hence the defective portion of the image is spotted out as white area

IV. RESULTS AND DISUSSIONS

A sample of 43 images has been taken. Mainly the images taken consist of the side view of the glass bottles. In this sample images the main objective is to segment those areas which seems to be defective by means of genetic algorithm. The images are mainly captured through camera at a distance of approximately 50 cm and are taken under proper illumination. These images taken contain defective bottles as well as non-defective bottles. A defect that will be associated with the glass bottle defect , or any other extra particles sticked on bottles, fine granules of dust on surface, hair or any other third party granules etc.

The images passed through the four different filters acquired a satisfied PSNR values. Salt and Pepper noise is the main noise that are considered here because it is the noise that are mainly added in the real time system. Suitable percentage of noise can be added manually and depending upon the filter efficiency it will de-noise. Mainly four filters are taken for the de-noising purpose The proposed filter MDBUTMF-Modified decision based unsymmetrical Trimmed median filter processed a high value of PSNR as compared to the existing other advanced filters PSMF,DBA and MDBA. The MDBA filter even though produced a low value of PSNR when compared to the proposed filter, it maintained an average constant range of PSNR value when subjected to the different variations in noise. For the DBA and the PSMF filter for a zero percentage of the noise, the PSNR values were high as compared to the other filters. But as the noise percentage increased, the PSNR value for the proposed filter MDBUTMF became high and stood at the top as compared to the other filters. The image passed through the proposed filter MDBUTMF is subjected to genetic algorithm. The genetic algorithm mainly concentrates on the pixel and threshold values defined. The main requirement for applying genetic algorithm is that the problem domain has to be converted to a mathematical language and hence a fitness function is defined for the image taken such that genetic algorithm can be applied to those image.

A pixel by pixel comparison is being carried out and the pixels that violate the threshold will be considered for the optimisation. The final result obtained after the Segmentation is mainly the calculation of TP, TN, FP and FN. All these parameters are evaluated and calculated for the algorithm. These parameters will determine the overall sensitivity, specificity and segmentation accuracy of the algorithm. These parameters will be used to compare with the results of the algorithms taken for the comparison purpose and finally a ROC curve will be plotted that relates the different algorithms in terms of their Specificity, Sensitivity and accuracy.[7]

Fig.7 Segmentation through Genetic algorithm

The Image filterd through MDBUTMF is subjected to segmentation using Genetic algorithm and thus found out areas of the defective portion of the glass bottle as shown in Fig. 7 which corressponds to hair,dust etc.The Sensitivity ,Specificity,accuracy has been found out.

Sensitivity =92.31%
Specificity =93.33%
Accuracy = 92.86%

FOR 10% of SALT AND PEPPER NOISE						
SL NO.	IMAGES	NOISY IMAGE	MDBUTMF IMAGE	MDBUTMF PSNR	MDBUTMF MSE	SEGMENTED IMAGE
1				65.1	0.02	
2				68.92	0.01	
3				71.7	0	
4				73.51	0	
5				74.64	0	
6				64.79	0.03	
7				67.5	0.01	

Fig.8 Segmentation on various glass images through GA

V. CONCLUSION

The segmentation using Genetic algorithm generates TP,FP,TN and FN values of the segmented image.Using the values obtained the Sensitivity,Specitivity and Accuracy is calculated.The Proposed filter MDBUTMF performs a smooth functioning of the salt and pepper noise that will be added in the real time.Compared to existing segmentation methods,Genetic algorithm shows more efficiency in segmenting and evaluation of the Image.Thus using this algorithm the defective portion of the glass bottle is highlighted and thus the area of defect is being found out.

The Proposed filter is Modified Decision Based Unsymmetric Trimmed Median Filter(MDBUTMF) because it produced a high value of Peak to Signal Ratio(PSNR) of 60-75db.

The defects in the images are segmented and highlighted. Thus the areas of defects are spotted out. The Genetic segmentation has produced Sensitivity, Specificity and Accuracy of 92%, 93% and 93% respectively. Thus the Proposed work produced effective results and hence this tool can be used for food processing industries for the Quality inspection of the Glass bottles and thus the productivity can be increased.

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