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Active Contour Based Segmentation for Defect Identification in Glass Sheet

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Abstract--Defects on glass sheet reduce the quality of glass and demean to manufacturers. Several defects are produced like bubbles and inclusions, Stone and sand particles, Water stains, Scratches and cracks etc. It's not possible to inspect large no & bulky glasses manually. A set of digital image processing algorithm is used to detect the defective glass sheet. In this paper we have purposed region-based active contour technique. In the defect detection algorithm, the color space conversion of the image is carried out. As a result of the visibility test the RGB color space is chosen for the image at the input to the segmentation stage. Further RSF energy function is calculated in terms of contour and data fitting functions. This energy is then incorporated into a variation level set formulation with a level set regularization term. Then the data fitting functions are calculated which guide the motion of the contour and final contour is obtained. The image is then inverted and the defective part of the image is segmented out. Finally the defect has been identified. Purposed method has limitation of false edge detection. To overcome the said limitation canny edge detection algorithm is purposed.

Keyword:-Glass defects, Region-based segmentation, RSF energy function, Canny edge detection.

I. INTRODUCTION

Historically, the glass industry has had no well-established organization to support it in research and defend its viability, unlike other industries. Today it is Undergoing dramatic changes. As in other mature industries, initially the glass industry resisted change in its tried-and-true manufacturing processes [1]. Products of the right quality have to be delivered at short notice, within strictly defined time windows and in the requested volume [2]. In order to determine the true quality of the glass, correct classification of the detected defects is very important. But, the classification can only be as good as the quality and significance of the initial defect image detected by the inspection system. Low contrast images with little information content can lead to incorrect and vague defect size determinations [3]. It is, however, now considered a limiting factor in the inspection of products coming out from modern industrial production lines, where high working speeds and very limited tolerances are required. This is why in the production of glass, the introduction of artificial vision-based inspection system that is able to discover, and classify the defects present in glass sheets [4], has become a worldwide standard. Linear defects and the point defects are the most important quality challenges in the manufacturing of glass. Therefore it is important to detect them early in the manufacturing process. The automated system reliably identifies, similar to the human eye, the smallest point defects like bubbles or inclusions as well as tin defects and line defects on the glass [5]. The scientific research that has been devoted to automatic inspection techniques [6]. As a result, many inspection techniques have been proposed with the aim of increasing the productivity and improving the final product quality [7]. These analyses and methodologies employed to detect the defects in the glass sheets mainly use image processing techniques because of their higher precision and speed [8].

II. TYPE OF DEFECTS AND DETECTION METHODOLOGIES

This chapter includes the study of various types of defects that can be present in the glass sheets and the steps followed in detection of these defects.

a.) Type of Defects

Glass defects and contamination means that a high-quality, finished product cannot be delivered. Such defects must be avoided at all costs. The defects in glass can be severe or light. The various types of defects that can be present in the glass are given below:-

1 Foreign material: This defect has an appearance of a lump. It is an unmelted, opaque material embedded in the glass. For example:

a) Chemical residues: These are the remains of various chemicals used during the manufacturing process.
b) Stone and sand particles: These are small inclusions of any non-glass material i.e. piece of sand remaining from the manufacturing process which may look like bits of sand or a small stone.

2 Discoloration Defects: These defect areas are roughly defined as fairly large, several millimeters in diameter, and relatively dark and/or bright regions that stand out against the background. For example:

a) Water stains: These appear as white, foggy, or cloudy stains.
b) Low- Contrast Defects: The mainly occur due to illumination irregularities.

3 Line Defects: These are the marks or irregular patches on the surface [9]. These occur mainly during transportation within the factory. These can occur during the process of edge grinding and corner cutting. For **e**xample:

a) Scratches: These can be deep or light according to their severity which or may not score the surface of the glass.
b) Knot line: This refers to a wave like distortion on the surface of the glass.
c) Cracks: A crack goes completely through the piece to affect the structural integrity of glass which is immediately visible upon inspection of the piece. It can be a hair line i.e a narrow crack which does not affect the structural integrity of the piece and which is not immediately visible.

4 Edge defects: Edge defects are the main cause of glass breakage during its production. They can be prevented by detecting them at an early stage and rejecting suspicious sheets. Production line uptime will increase; production costs will be reduced accordingly. For example:

a) Jagged edges: This is an edge defect caused during cutting or grinding.
b) Chips: A chip is an area where glass has been broken off. It can be deep enough into the piece to be visible immediately and can be easily felt with a finger.

5 Point Defects: These are the inclusions trapped inside glass as a defect during its production. For example:

a) Bubbles: It can be a tiny or a stretched bubble.
b) Stone: It is a small inclusion of any non-glass material like piece of sand remaining from the manufacturing process which may look like bits of sand or a small stone.

6 Surface defects: These are the surface defects which cause major problems for manufacturers, particularly when the production process includes a surface treatment stage. For example:

a) Holes: This refers to small indentations or pits which are apparent on the surface of the glass. A pitted area affects the appearance of a glass sheet.
b) Spots: These appear as some dark or light colored spots on the glass surface which may be light or dark in appearance.

b.) Defect Detection Methodology

The various possible defects that can be present in a glass sheet can be identified as following:

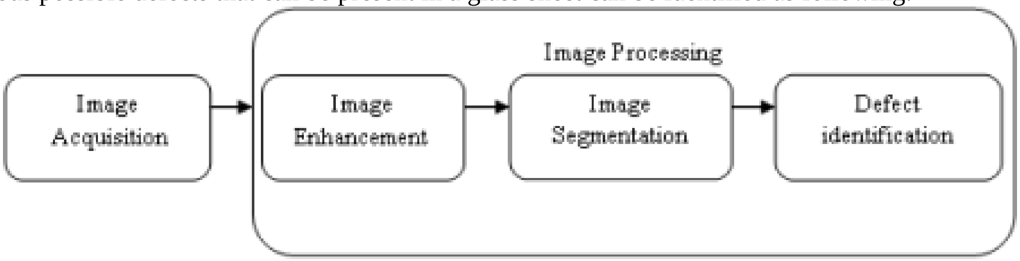

Fig 1 Methodology of Defect Detection

a. Visibility Test-Color Space Selection

The input image is first converted into the four color spaces namely: Gray scale, NTSC, HSV and YCbCr after the formatting as per the requirement.

b. Five- Point Likert Scale Analysis

Once the conversion is done, each color space is assigned a level from 1 to 5, known as Five point Likert scale. These levels are assigned according to the degree of visibility of defects in the input image, in each color space, that objectively agrees with human visual perception. The color space with highest degree of visibility of the defect is marked 5, with a lower degree as 4 as so on and the color space with least degree of visibility is assigned as 1. These results are also shown in table 1. This evaluation corresponds, on average, with the visual assessment of glass by a group of inspectors.

Table-1 Color space conversion

Color Spaces	**Level assigned according to Likert Scale**	**Rank Assigned according to Likert Scale**	**Conversion Time (secs)**
RGB	Level 5	Rank 1	-
Gray	Level 4	Rank 2	0.022918
NTSC	Level 3	Rank 3	0.029325
YCbCr	Level 2	Rank 4	0.039399
HSV	Level1	Rank 5	0.01512

c.) Analysis of conversion Time from RGB color Space to other color spaces

The time taken for conversion from RGB color space to other color spaces is calculated for each image in the database. Some of the typical results covering each type of defect considered in this study are presented in the figure 2.

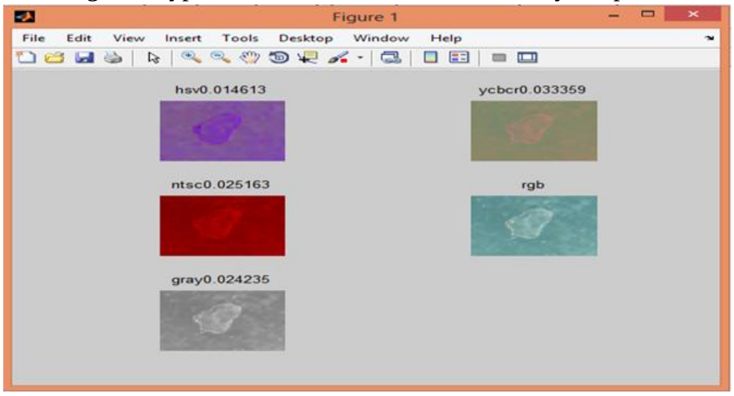

Fig 2 Color Space Conversion

III. IMAGE SEGMENTATION

Image segmentation is the key step of the process from image processing to image analysis [10]. The purpose of image segmentation is to divide the image into a number of significant regions based on some characteristics (intensity in homogeneities here), making these characteristics to display similarity in single region and display difference between different regions.

In the process of detecting defects in glass, region based active contour model in a variation level set formulation has been implemented for segmentation [11] which uses intensity in-homogeneity as a region descriptor to identify the region of interest that is to be segmented. The region-scalable fitting energy functional is defined in terms of a contour and two fitting functions that locally approximate the image intensities on the two sides of the contour. These fitting functions are the averages of local intensities on either side of the contour. The region-scalability of the RSF function is due to the kernel function with a scale parameter, which allows the use of intensity information from small neighborhood to the entire domain at a controllable scale. This energy obtained is then incorporated into the variation level set formulation with a level set regularization term. In the resulting curve evolution equation, the intensity information is used to compute the two fitting functions which help in guiding the motion of the contour towards the object boundaries. As result, the segmentation of the images with intensity inhomogeneity is done. The advantages of using active contour model for image segmentation are:

1. Smooth and closed contours for defect recognition
2. Detects weak defect boundaries
3. Reasonable accuracy
4. Reasonable computational time
5. Easy formulation

Active contours have been used for image segmentation and boundary tracking.

Image Segmentation steps

The steps followed during image segmentation using the region-based active contour technique are as below:

a. Region-scalable Fitting energy

Let Ω be the image domain

C be a closed contour in the image domain Ω,

Ω_1 is the region outside(C)

Ω_2 be the region inside (C)

Then for point $x \varepsilon \Omega$ local intensity fitting energy is given as:

$$\varepsilon_x^{fit}\left(C, f_1(x), f_2(x)\right) = \sum_{i=1}^{2} \lambda_i \int_{\Omega_i} K(x-y)|I(y) - f_i(x)|^2 \, dy \qquad (1)$$

Where

λ_1 and λ_2 are positive constants

$f_1(x)$ and $f_2(x)$ are the values that approximate intensities in Ω_2 and Ω_1 regions of image respectively

I(y) are the intensities in the local region centered around point x

K(x-y) is the weight assigned to the each intensity at y

ε_x^{fit} is the weighted mean square error of the image intensities I(y) outside and inside C by fitting values $f_1(x)$ and $f_2(x)$ respectively

K is a non-negative kernel function chosen to be a Gaussian kernel given as:

$$K_\sigma(u) = \frac{1}{(2\pi)^{n/2}\sigma^n} e^{-|u|^2/2\sigma^2} \qquad (2)$$

With a scale parameter $\sigma > 0$

b. Level Set Formulation

Level set formulation is basically done to handle the topological changes. The figure 3 on the next page describes various important ideas about the level set method. In the upper-left corner we see a shape; that is, a bounded region with a well-behaved boundary.

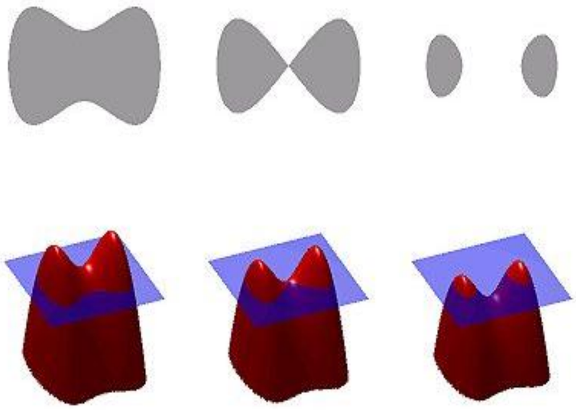

Fig 3

Results for defective images

In the figures shown below, the image in the upper-left corner is the original image, which is input into the segmentation algorithm. The upper-right hand figure shows the final contour of the defect obtained after 60 iterations. The original image is converted to gray scale and the curve evolution begins from the initial contour. The curve continues to evolve to indicate the area of intensity in-homogeneity as the number of iterations increase and the defective area is highlighted with the red colored contour. The image is then inverted and the defect is distinctly given out as shown in the bottom-left corner image in the said figures.

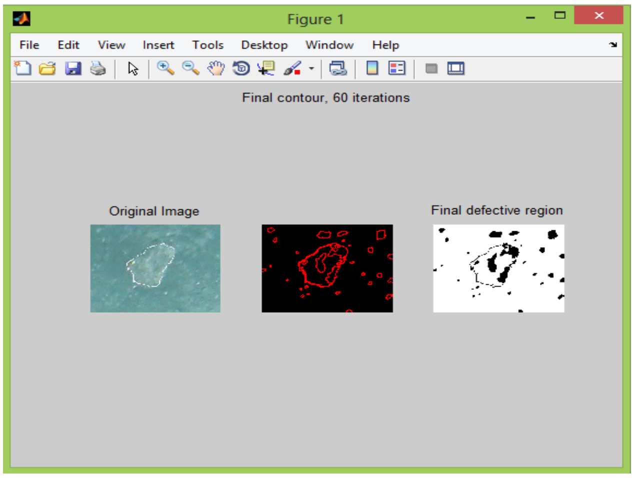

Fig.4 Discoloration Defect

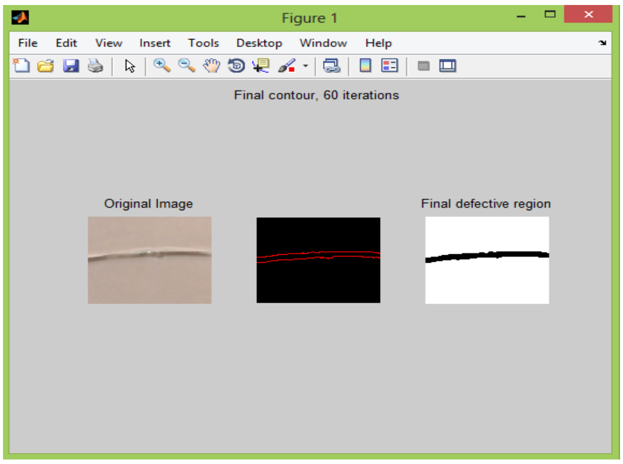

Fig.5.12 Line Def0ect

IV. CONCLUSION AND FUTURE SCOPE

In this paper, research work has been concluded and future work has been described. Section 1 describes the conclusion and section 2 explains the future scope of our research work.

1. Conclusion

In this research work, the analyses and methodology employed to detect the defects in the glass sheets use image processing technique because of its higher precision and speed. The detection of defects in glass was carried out in two main phase: The visibility test for selection of an appropriate color space followed by the region-based active contour segmentation. The various defects detected by technique were: surface defects, foreign materials, discoloration defects, line defects, point defects and edge defects. The Five-Point Likert Scale and conversion time from RGB to other color spaces are the performance parameters considered for analyzing the results of visibility test. The results suggest that the defects are best visible in RGB color space and RGB–Gray color space conversion would give the best results, in terms of accurate detection of defects in glass.Thus, it can be concluded that the implementation of this algorithm to the glass sheets for detection of defects enables:

a) Detection of any kind of major defects present in the glass sheet
b) Good quality inspection
c) High precision
d) Reasonable accuracy
e) Reasonable defect detection time

This would offer manufacturers with an opportunity to significantly improve the quality of their glass products as well as reduce costs. Significant and clear detection of the different glass defects would enable production staff to trace back to the cause of the defect without delay ensuring high product quality and customer satisfaction.

2. Future Scopes

The work done on the implementation of the algorithm as part of this thesis has future implications where in:

a) The results can be further generalized if database includes higher number of images of glass sheets which have more defects to run the algorithm on.
b) The segmentation algorithm can be improved for the accurate detection of edge defects and identification of the low contrast defects.
c) The efficiency of the technique can be improved by testing the algorithm on higher number of images.
d) The results can also be used as a foundation to develop functionality for the classification of defects based on their characteristic features**.**

REFERENCES

[1] C.Philip Ross, et.al "Glass Melting Technology: A Technical and Economic Assessment", A Project of the Glass Manufacturing Industry Council with the US Department of Energy-Office of Industrial Technologies, October 2004.

[2] Ton Backx, et.al "Application of Model Predictive Control for Quality Control of Glass Melting Processes", IPCOS Technology, Bosscheweg 145a, 5282 WV Boxtel, The Netherlands.

[3] Dr.Schenk, et.al "The New Generation of Flat Glass Inspection", TechNote, www.drschenk.com, October 2006.

[4] F. Adamo, et.al "An Automated visualinspection system for the glass industry", Proc. of 16th IMEKO TC4 Symposium, Florence, Italy, Sept. 22–24, 2008.

[5] Walter Mayer, et.al "100% Inspection of Float Glass", Press News, Isra Vision, Germany, Release No. 105, 24.10.2006, pp.1-4.

[6] M.A.Coulthard, et.al "Image Processing for Automatic Surface Defect Detection," Surface Inspection Ltd, UK, pp.192-196.

[7] K.H.Rew, et.al "Enhancement of Illumination Irregularity for the 2D Blot Detection under Low Contrast," Journal of the Korean Society for Precision Engineering, 2007, Vol. 24, pp. 29- 35.

[8] Zhang Yepeng, et.al "Application of Digital Image Process Technology to the Mouth of Beer Bottle Defect Inspection", The Eighth International Conference on Electronic Measurement and Instruments, 2007, pp. 2-905-2-908.

[9] Francesco Adamo, et.al "A low-cost Inspection system for online defects assessment in satin glass," www.elsevier.com/locate/measurement, 2009, pp. 1304-1311.

[10] Wang Yuedong, et.al "Studies on Color Space Selection and Methods of Segmentation Quality Evaluation", 1st International Conference on Information Science and Engineering, IEEE Computer Society, 2009, pp.1437-1440.

[11] Chunming Li, et.al "Minimization of Region-Scalable Fitting Energy for Image Segmentation", IEEE Transaction on Image Processing, Vol. 17, No. 10, October 2008, pp. 1940-1949.

[12] Abhishek Acharya, et al. "FPGA Based Non Uniform Illumination Correction in Image Processing Applications Vol 2",pp.349-358,2009.

