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Estimation of Metal Surface Defect Using CD Segmentation

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Abstract-Analysing metal surfaces of massive metal instruments like boilers are tedious process, which also require very specialized equipments. To employ the surface analysis schemes at a lower cost, image processing facilitates many processing methodologies. Using the camera captured live images of the metal surface from the massive metal equipments, image processing techniques can be applied and similar results can be obtained as like the specialized analysing equipments. To improve the image processing techniques, series of methodologies are proposed and implemented to analyse the metal surface image for any defect found. The proposed system employs noise removal, false negative removal followed by segmentation using the proposed clustering method. The results obtained by the proposed system are encouraging and are comparable with other existing image processing methodologies.

***Keywords:*-Clustering, Defect, Segmentation, Texture.**

I. INTRODUCTION

Image segmentation is an important stage in computer vision as a preliminary step towards higher level analysis and recognition stages. C.julie et, al. Proposed a graph based segmentation algorithm for 3D surface information suited to poorly illuminated scenarios and inexpensive strobe lights [1] Siti Noraini Sulaiman et,al. presented Adaptive FuzzyK-means(AFKM) clustering for image segmentation which applied to general images and specific images. The results of proposed AFKM produced better segmented images and it preserved important features on digital images[2] Mohmound ramze razaee et,al. showed an unsupervised image segmentation, which combined pyramidal image segmentation with the fuzzy-c means clustering algorithm. It gave a good performance in detecting LV Lumen in MR images [3]A.Ortiz et,al. Contributed a classifier based on growing hierarchical self organising map. Classifier used in this method is the ability to discover the inherent hierarchy of the data[4]. Benjamin Root et,al. presented a strong point analysis(SPA) for general purpose feature detection for tracking of storm cells in radar images. In this approach, the thresholds were determined dynamically rather than using predetermined quanta [5].Ahmed et,al. used Through-the-wall radar imaging(TWRI) scheme for target detection using segmentation by classification, including exploitation of target polarization signatures. The super pixels were grouped into cluster are classified using decision tree. The proposed technique proved better performance than techniques that depend only on pixel intensity [6].Turgay Celik et,al. proposed a novel unsupervised algorithm for segmentation sides can sonar images of sea floor. The algorithm uses undecimated discrete wavelet transform for multiresolution analysis. The proposed algorithm is 150 times faster than the active contours [7].Samira Chebbout et,al. presented a comparative study on the effectiveness of three clustering methods namely k-means, PAM(partitioning around medians) and SOM(self organizing map methods). To evaluate these 3 techniques cluster validation techniques were used (connectivity(c), dunn index(d), and silhouette for image segmentation among CIEL*a*b and HSV colour spaces[8]. P.Anthony et.al, demonstrated an automatic segmentation method that incorporates both polarimentry and non Gaussian analysis and gave a good results for both simulated and several real world data sets. Goodness-of-fit test is used for splitting and merging of cluster, this not only improves the fit of the model, also results in automatically determining the number of cluster [9].Xiuli Wang et.al, proposed an improved image segmentation method combining L^I-sparse reconstruction with the normalised cut method. Spectral clustering is a new hot research in recent years, which can be used as a global image segmentation method based on the graph theory. Ncut is a method in spectral clustering, which provides a standardized segmentation criteria. This method sometimes leads to over-segmentation. The combination of L^I-sparse reconstruction with the normalised cut method not only preserves the advantages N-cut method, also overcomes the drawbacks of over-segmentation. The paper is categorized as five sections [10]. The first section deals with introduction followed by the proposed system the third section explains about the experimental result. The remaining sections state the conclusion followed by the list of references.

II. PROPOSED SYSTEM

The resultant of the system that utilizes the wavelet frequency value and Bartlet variance testing gives the area of defect in the metal surface image (Fig 1a). The binary values got as the result were identified as defected regions (Fig 1b). The defect of the metal images mostly takes some factors of area, depth and impact dimension to measure the defect level. The proposed methodology takes advantage over the previously proposed system. Considering the regions identified in the binary image as the defected regions and the proposed work investigates the factors that can be measured from the image. The binary image contains defect information along with the noise and some false negative information. To make the estimation a better one, the noise and the false negative

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information present in the binary image have to be removed.

Fig 1a

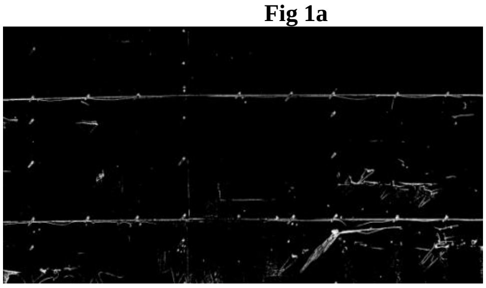


Fig 1b

The noise removal process is a two step process, which utilizes the morphological operations. A morphological closing is done on the image that acts similar to the noise removal operation. This closing eliminates the enclosed information, which is considered to be noise. Also, the binary content of the input image is presented by the morphological closing operation. After the closing operation, input is subjected to proper noise removal. The binary image contains proper noise, that are resistant of the textual regions, which is similar to the rest of the information in the metal image. The proper noise removable may not affect the mass regions, as the proper noise is removed as a lower level of one or two pixel dimensions. The result of the closing operation followed by the proper noise removal gives a clear image that holds the defect markings. These defect markings are unknown and mostly form a group cluster. The second level of improving the binary image is to remove the false negative information. The filtered binary image contains many defect regions, out of which some false negative information is removed using segmentation techniques. The segmentation is done using the mass (pixel count) as the key value. The following steps explain the process flow of the proposed false negative removal technique.

Step 1:

In the image I , block i of size 2*2 is taken.

Step 2:

In i mark the signal points as 1(graph number) and non signal point as 0.

Step 3:

In I, move the block traversal of i, to next block and reformulate i.

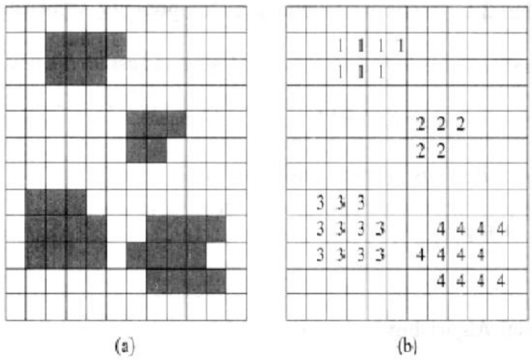
Step 4:

If the signals in i, are marked with group number, then mark the remaining signals with the same group number else, start new group number, with last used group number.

Step 5:

Continue the steps 3 and 4, till all blocks in I is reached.

Step 6:



Now I has N group marked with 1 to N for each group signals.

Step 7:

Form an array A, the accumulator of size N, which holds the count of signal elements in each group.

Say if group1 has 20 signal points, then A_1 =20, i.e,

$A_1 + A_2 + \dots + A_n$ = S (total signal point in I)

Step 8.

Form a N_q array B, with each element as

$$B_i = \frac{A_i}{S}$$

Each value in B will be ranging from 0 to 1.

Step 9.

Based on the considered problem a threshold T is set to eliminate the false negative values. In our case T =0.25, so the value below 0.25 is rejected.

$$B_i = \begin{cases} \geq 0.25, \text{ accept} \\ > 0.25, \text{ reject} \end{cases}$$

Step 10.

Now the corresponding groups in I, has to be reformed with respect to B. This gives a new image that is eliminated with false negative.

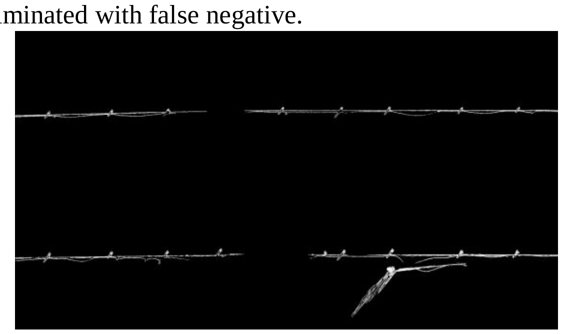


Fig 2

The false negative eliminated image (Fig 2) have only the defect marked regions. As shown in Fig 1b, the regions in the input image have much false areas that are removed in the resultant image shown. The resultant image has regions that denote the defect made due to the disjoint plates. On the detailed view, the elimination of noise particles is also visibly seen. Now, the defect

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identified image has to be estimated for each regions present in it. To facilitate the estimation segmentation technique is proposed that utilizes the proposed CD clustering methods. In most part of the segmentation, the defect areas are identified which is to be confirmed for estimation. Since the defected regions does not resemble a definite shape, and counts a modified clustering of regions need to be adopted. The mass information of the defected regions in image I is calculated and the grouping of clustering is done based on the mass and distance in each grouped regions. Unlike other clustering technique, the proposed CD clustering does not predefine the number of clusters. The number of cluster is determined by the system based on the mass units present in the binary image. The below steps explains the proposed segmentation technique that utilizes the CD clustering methods.

Step 1.Follow the steps 1 to 6 in the procedure1.0 resulting in I with N groups numbered from 1 to N.

Step 2.Now calculate the centre position of each region x_n, y_n in I for each region, i.e. for each region n in N of I. The centre coordinate will be x_n, y_n.

Step 3.Calculate the mass m, as the count of pixels in each regions in I, i.e. for the group n in N of I, mass is represented as m_0. The group will have coordinates as x_n, y_n and count of signal pixels as mass(m_n)

Step 4. Calculate the diameter, d for each region in N by calculating the maximum distance between the boundary pixels in each region. Let the boundary be d_n for the region n in I.

Step 5.Take the group with maximum mass and make it as a current region.

Step 6.Find the distance between its centre to all the other regions as P, i.e. distance $P_1, P_2, \ldots\ldots\ldots\ldots P_{N-1}$.

Step 7.If any of the distance with other region, is less than the diameter d of the current region, then the corresponding region will be made as the current region and the N decremented by the count of regions which join the current region.

Step 8.Now change the current region to the next region, with the next greater mass m

Step 9.Continue the steps 6 to 8, till all the regions are traversed.

Step 10.The resultant image (Fig 3) has N cluster regions, with newly formed mass and diameter.

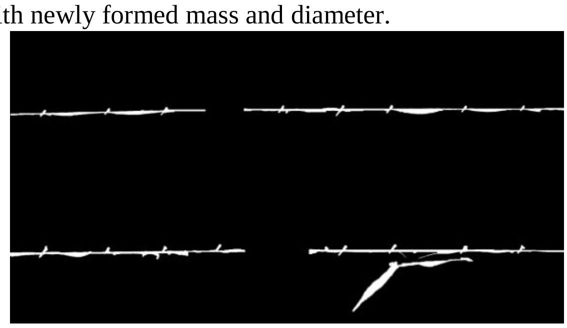
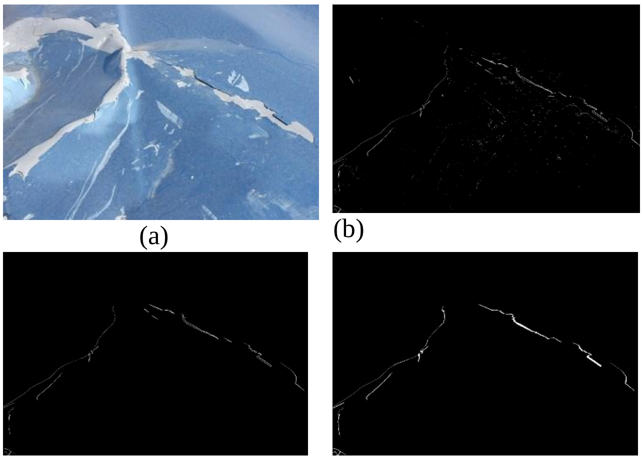


Fig 3

The mass m, of the regions in the image I is the area of the defect regions. Mostly the regions will be one, if there is one defect found. If the defect arise are more in the metal surface, then the regions thus found will be more in number.

III. RESULT AND DISCUSSION

Utilizing the result of the proposed system that detects the defect region (Fig 4a,4b) in the metal images, following the series of operations are done to estimate the amount of defect occurred. The estimation done after removing the noise and false negative region present in the image (Fig 4c). Then, a modified clustering is applied to form final defect region.



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

Fig 4

There are many series of techniques available to measure the orientation, area and centre of gravity for the defects in metal surface images. The proposed technique is applied over the image obtained from database. The database contains 26 images that vary from 100X100 pixels to 10000X10000 pixels in size. These images are treated according to the proposed system and the final results are proposed below.

Image Type	No of Image	No of Cluster	Defect mass
Plain Plate	15	9	20,000 (1500 app)
Welding Plates	7	18	62,535 (5043 app)
Shutter	4	0	0

On analysing the results obtained in various images types, the defect found on the plain plates, were easily identifiable. The plain plates easily exposed the defect regions, in the form of textures that were captured using the analysing scheme. The clustering techniques also made a note of the non-defective regions and removed them from the image, resulted in an accurate estimation. In case of welding plates the defect regions were

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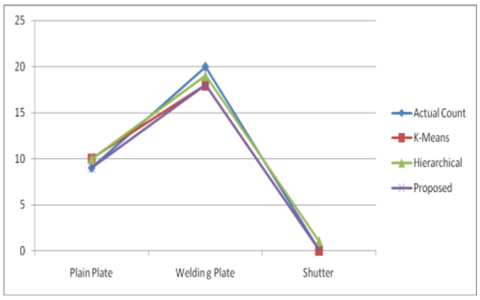
commonly not visible. The plates had welded areas, where welding and defects might look same. Distinguishing the defects from welded areas had to be done with specialised operations. The proposed analysing scheme took advantage of the textures signals exhibited by the defect regions in the metal images. The false negative information that were present due to the welded areas considered as defect were removed by the proposed false negative removal operations. Then the clustering mechanism identified the defect region group fast and accurate. In the considered problem, many metal images had one defect that was scattered throughout the metal images. So, our proposed system was in a state to identify and estimate the defect naturally and should result as what was present. Most of the metal images were clearly identified with the defect as its counted n the metal images, which was tabulated below.

Image Type	No of Image	Actual Defect count	Defect identified by proposed system	%
Plain Plate	15	9	9	100
Welding Plates	7	20	18	90
Shutter	4	0	0	100

On verifying with the existing clustering techniques the proposed clustering technique was processed for the 26 images with plain and defect regions. The binary images that had the defect regions were identified. The proposed clustering and the existing clustering operation were applied over the image was eliminated with noise and false negative information. We had considered the binary k-means, hierarchical and proposed with the same set of 26 binary images. The cluster regions formed by the considered methods and the result were tabulated below.

Image Type	No of Image	Actual Count	K-means	Hiera rchical	Pro posed
Plain Plate	15	9	10	10	9
Welding Plates	7	20	18	19	18
Shutter	4	0	0	1	0



The graph visibly shows superiority of the proposed system, that the existing systems are comparable with results obtained. For the plain plates, the k-means and hierarchical system are close to the required result. As the proposed system is equal to what is required. In case of welding plates, k-means and proposed system are similar and hierarchical system shows slightly high level response to the clustering. Hierarchical shows a faulty clustering result where the k-means and the proposed system give an accurate result.

IV. CONCLUSION

The proposed defect estimation methodology identifies the defects in the metal image by utilising the technique of wavelet and statistical testing using bartlet test followed by the noise reduction, false negative reduction and the proposed clustering technique. The results that are obtained have cluster of defect, which gives information about the areas of defect in ratio to the original metal surface and the image taken. Other information related to the defects, like orientation length, width, centre of gravity can be found by applying the common mathematical formulas to find the corresponding ratio values with respect to the metal surface image. The proposed technique can be extended in future to identify various defect types and its image impact level on the metal surfaces. The information obtained may facilitate an automated defect identifying mechanism to analyse the metal surface through the camera captured images.

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