A Comparative Study of Region Growing & Morphological Edge detection segmentation Techniques to detect the flaws in weldments

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Abstract

A comparative study of morphological edge detection and region growing segmentation technique on NDT radiographic images of weldment is presented in this paper. With the help of these techniques the extraction of flaws, produced during the welding process is done, which is further used to measure the dimensions of flaw. This paper will describe the segmentation methods which are based on the discontinuity and homogeneity criteria of gray levels and intensity of pixels of an image. In edge detection method different morphological methods like dilation and erosion are use to obtain best results. Similarly in region growing, multiple seed technique is used to find best results. These methodologies are compared and concluded to be effective for different types of weld flaws extraction after being successfully tested with 30 images (Standard defect radiographic images of welds in steel obtained from EURECTEST, International scientific Association Brussels, Belgium).

Key words- Radiographic images, weld flaw, segmentation, region growing and morphological edge detection.

1. Introduction

Image understanding aims at finding interpretations of images, these interpretations would explain the characters or contents present in an image. Segmentation and analysis of an image having different structures is a step towards the understanding of an image which is of importance in a variety of image analysis and computer vision applications including pattern recognition and in Industrial image processing to optimize the quality and prize of the final product. Inspection of welded structure is essential to ensure that the quality of weld must meet the requirements of the design and operation, which assure safety and reliability

Image segmentation is the process by which individual image pixels are grouped into partitions, according to some intrinsic properties of image i.e. gray levels, contrast color texture, shape etc.

1.1 Segmentation

Image segmentation is one of the most widely used steps to detect useful information in an image. During image processing, image segments plays a very important role. The image segmentation is based on the discontinuity and continuity or similarity in the intensity of image. Partition of image is done on the basis of abrupt changes in intensity or on homogeneity. There is a wide range of image segmentation techniques. These are broadly grouped into the following four categories [1].

1) Thresholding- if an image object is well separated from background, the range of brightness in original image can be defined, then the threshold range of pixels of background can be selected while other are repeated to segment an image.

2) Edge-based Technique - Image edges are detected using appropriate edge detectors and then grouped into contour or surface that represents the boundaries of an object in image. Usually filters are used to get first or second order image gradient and to remove the unwanted information to find the edges with the help of thresholding the gradient used in noisy images.

3) Region based technique- the criteria are to detect the regions satisfying predefined homogeneity criteria. It is of two types - Split and Merge and Region growing Split and merge process begins with entire image divided in small regions. In each step, heterogeneous regions are divided into small regions and so on till all regions are homogeneous. Now the merging process starts in this process & all similar neighboring homogeneous regions are unified. While region growing starts from pixel level and in each step unifies similar pixels one by one and continues till no similar character pixel is left to add.

4) Hybrid technique- Hybrid method combines edge and region based segmentation techniques.

Segmentation techniques for (black and white) gray scale images can be categorized into two approaches :-

- ☐ Region base
- ☐ Boundary finding

In boundary finding method discontinuities are marked. Where there are abrupt changes in gray scale the boundary is marked so it depends on the non homogeneity of an image while region growing is a process where homogeneity is the characteristic used for growing a region. Different approaches to image segments having different characteristics are presented in [2-8].

2. Edge detection technique using morphological methods

Edge detection is the first step in image segmentation. Edges tell where objects are, their shape and size, and something about their texture. An edge is where the intensity changes abruptly. Edge detection is used to create dazzling image outlines. Edge detection rely on derivative operators that produces large values at pixels where intensity changes abruptly. There are many operators to detect edges. Derivative operators like laplacian operators, canny, soble are used commonly. The first order edge detectors produce thick edges specially in case of slowly ramping edge there are directional in nature, so to get better edge location second order detectors are preferred. These have stronger response to fine detail such as thin lines and isolated points. They enhance fine detail. The most common problem of edge-based segmentation is caused by image noise or testable information in an image because these produce edges where they are not present actually. The canny edge detector is optimal to white noise and give respond to fine changes [9]. These derivatives locate pixels where there are abrupt changes in intensity. If we search for edges based on intensity changes between adjacent pixels or within a small region, few artificial edges will be produced due to noise or digitalization effect. Edges produced by edge detection cannot be used as segmentation result as the obtained edges are cracked and they need to combine. The morphological process like dilation and erosion are used to get (smooth edges and used to link crack edges) output in the form of contours. The image is dilated first and then eroding is performed [10-11] which helps in disappearing of high contrast lines, fills the small holes (gaps) and narrow gulf, and smooth the edges to preserve the original size.

The output of an edge detector can be added back to original image to enhance the edges of the image. Output of few images with edge detection are shown in figs.

3. Region Based method

This method rely on the homogeneity, and is based on finding parts of images which are homogeneous for a given set of properties. Region based methods always provide closed contour regions and make use of relatively large neighborhoods for decision-making. Users select a point, which is known as 'seed', and a region grows out from this seed until some criteria stopping growth are met.

Unlike gradient and laplacian detection methods the borders of regions found by region growing are perfectly thin and connected. It is stable with respect to noise while boundary tracking technique which gives connected edges are joined, there is no gap between them. The produced regions are coherent so

the edges are joined, there is no gap between them.

It works from the inside out, instead of the outside in. The question of which object a pixel belongs to is immediate, not the result of point-in-contour test it produces as few regions as possible but the regions produced are coherent regions allowing some flexibility of variation with in the region.

Although it is often more difficult to apply region growing segmentation as compared to edge-detection and cannot find objects that span multiple disconnected regions but gives close contour [11-12].

3.1 Basic idea of Region Growing

Region growing is a boundary extraction approach. It's a procedure that groups pixels or sub-regions into large regions based on pre-defined criteria. The goal of region growing is to use image characteristics, which can be found with the help of histogram, to map individual pixels in an input image to sets of pixels called region. Regions grow by Linear Filtering. Filtering is a technique for modifying or enhancing an image. An image can filter to emphasize certain features or remove other features. Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels.

The basic approach is to start with sets of 'seed' values and from these grow regions in all directions to the neighboring points satisfying predefined properties similar to seed (specific range of gray level or colour.

In region growing segmentation, an image is first divided into many small usually equal size pixels. These pixels are than repeatedly merged to form large regions. Unlimited number of merges will produce a homogeneous region.

Basic formula for region growing segmentation is,

Let R represent the whole image and R is partitioned in x sub regions, R_1, R_2.....R_n such that

a) $R=U^{N}_{i=1}\ ^{n} R_i$ i=1,2,.....n

b)R_i is a connected region, i=1,2.....n

c) R_i R_j= for all i and j, i j

d) $P(R_i)$ = TRUE for i= 1,2.....n

e)$P(R_iU\ R_j)$= FALSE for any adjustment regions R_i and R_j

Here, P (R_i) is a local predicate defined over the prints in set R_i and is the null set [13-14].

So according to rules each pixel presents a region and these pixels will be connected in a region in some predefined sense. In next step the regions having different properties will not join together. Next condition (c) deals with the properties that must be satisfied by the pixels in a segmented region e.g. all pixels have same gray level and if it is different they don't join.

The seed value can be chosen without a prior knowledge by computing histogram and choosing the gray-level values corresponding to strongest peaks. Similarly criteria to grow the region after choosing seed can be based on the homogeneity Characteristics of the regions in image such as average intensity, variance, color, texture, motion, shape and size [15].

4. Results and discussion:

Region Growing & Morphological Edge detection segmentation Techniques are applied on about 30 images and the segmented images are obtained to detect the flaws in weldments. A comparison of these segmented images is done to find the accuracy or segmentation techniques on particulate type of flaw. The results are shown below and further analysis and results are given in table 1 .

Fig1.(a) Original image having Incomplete penetration type flaw

(b) Segmented image superimposed on original image after using edge detection technique

(c) Segmented image superimposed on original image after using region growing technique

Fig.2 (a) Original image having Incomplete penetration type flaw

(b) Segmented image superimposed on original image after using edge detection technique

(c) Segmented image superimposed on original image after using region growing technique

Fig.3 (a) Original image having Incomplete penetration type flaw

(b) Segmented image superimposed on original image after using edge detection technique

(c) Segmented image superimposed on original image after using region growing technique

Fig 4 (a) Original image having worm hole type flaw

(b) Segmented image superimposed on original image after using edge detection technique

(c) Segmented image superimposed on original image after using region growing technique

Fig 5 (a) Original image having Weaving fault type flaw

(b) Segmented image superimposed on original image after using edge detection technique

(c) Segmented image superimposed on

Fig 6 (a) Original image having Incomplete penetration type flaw

(b) Segmented image superimposed on original image after using region growing technique

(c) Segmented image superimposed on original image after using edge detection technique.

5. Conclusion

Edge detection morphological method and region growing technique can be used to characterize the flaws in weldment NDT images in different categories like lack of fusion, slag inclusion, incomplete penetration, crack, porosity, wormholes, undercuts, slag line etc. It is very difficult to measure different parameters like area, length and perimeter of flaw due to crack by edge detection methods but they can be analyzed better in case of region growing method. The images obtained after region growing are showing more and small details of the image. In edge based segmentation the shape of the flaw is not proper and accurate in shape and few flaws having light contrast are missing in while the region growing segmentation is giving better results in these cases but having over segmentation problem.

Many test images, around 30 images (Standard defect radiographic images of welds in steel obtained from EURECTEST, International scientific Association Brussels, Belgium), were taken to observe the performance of edge detectors using morphological method and region growing technique, but the results for six images are given in "Table1".

Figure no.	Morphological edge detection method	Region- growing method
Fig 1	Good results, showing flaws but the shape of flaws is not proper	Better results with proper shape so will be more accurate at the time of measuring flaw dimensioned
Fig 2	Good results but few flaws are not defined properly	Better more flaws are seen
Fig 3	Flaw is very clear Better results	Few parts are missing
Fig 4	Some lighter portion of flaw is missing good	More detail of flaw and closed contour better
Fig 5	Some are very clear but few are missing good	All flaws are clear better
Fig 6	Flaw is clear	Flaw is clear but some extra contours are also present

Table 1: comparative results of segmentation techniques

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