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Defect Detection using Active Contour Method

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Abstract: This paper reports on the non-destructive (NDT) method to inspect industrial equipment's quality and anomalies by using infrared thermography techniques to identify defects in an artifact such as water, oil or other fluid materials and any disruption or sub-surface fractures by using different types of procedure to recognize defects. Here we discuss various types of thermography techniques, quadratic frequency modulated thermal wave post-processing and region-based active contour image segmentation technique.

Index terms: Defects, Infrared thermography, Edge detection; Image processing, Region-based segmentation, Non-destructive testing

I. INTRODUCTION

Defect detection and classification are the major factor we want to discuss in this paper. In order to detect the defects in a non-destructive (NDT)[1] manner by using the thermography techniques by Mapping the contrast temperature over the artifact caused by the binding defect toward the thermal object. In this thermography they are two types approaches active and passive thermography. In passive thermography thermal response or a mapping of an object is captured, and the surface defects were observed and analyzed. But its Uncontrolled stimulation and its failure to produce deeper defect to produce better results. Whereas the active thermographic method has emerged as a robust qualitative and quantitative surface layer and sub-surface testing procedure evaluation with its controlled heat stimulation and well-supported processing techniques. In active approach, the temperature contrast is induced by excitation through regulated external stimulation, and the surface's temporal thermal map was reported. It has been shown that active thermography is a reliable tool for defecting internal cracks. Several researches have been conducted to carried out qualitative and quantitative analysis. One of the most popular thermal imaging applications is the ability to detect internal faults in many objects. Most of the defects are in the subsurface which are not viewable from outside. Ignoring these defects, however, may inevitably result in serious consequences as they may degrade continuously and ultimately result in catastrophic breakdown. Active thermography has been proposed to anticipate, identify and evaluate the cracks in order to identify these invisible defects.

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II. PRE PROCESSING

Active thermography involves non-contact and non-intrusive inspection, the ability to detect internal defects, and a quick and portable process. There are lock-in thermography [4, 7], pulse thermography [2, 3], quadratic frequency modulated thermal wave imaging pulse phase thermography (PPT) [8, 9] these techniques are widely used in the aircraft and various industries. In Pulse thermography a short thermal energy peak was projected towards the object. Using thermal cameras captured the test item and the temporal temperature map. The variation of the temperature in the sample object is used for anomaly detection in Pulse Thermography. As same as Pulse thermography test on the object was carried in order to find Pulse phase thermography, but analysis of the temperature mapping was carried by the ST Fast Fourier Transform and defect detection can be carried out by phase grams.In thermography lock-in means that the dissipated energy in the subject under observation is frequently amplitude-modulated, a thermo camera operating with a certain frame captures the resultant surface temperature modulation.

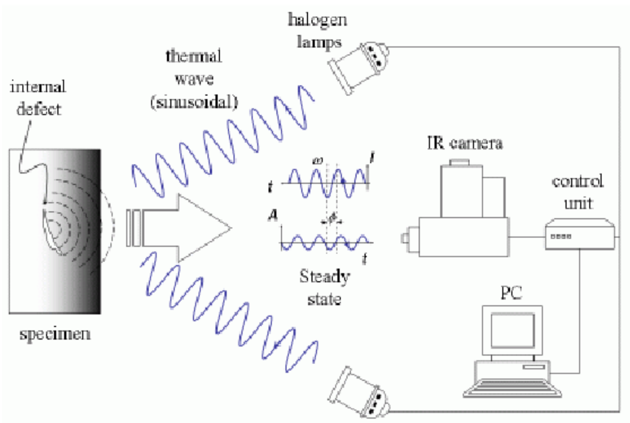

Fig. 1 Experimental setup of pre-processing

Quadratic frequency modulated wave provides more deposition of energy which uses multiple frequency modulated wave. It provides better depth resolution and good dynamic range. In this paper we use quadratic frequency modulated thermal wave in pre-processing as this process include multiple frequencies which are used to extract the data of different range of subsurface defects than the other techniques.

III. POST PROCESSING

There are many post processing techniques in thermography which are used to reduce noise so that images extracted are then segmented using various algorithms. In this paper we use phase analysis technique.

Phase Analysis: -

The process of the frequency domain, fast Fourier transformation is used over mean extracted thermal profiles of compression artifacts in each frequency, the phase value is obtained by adding the phase values for their respective pixel position. The phase images obtained reflect phase contrast as a result of a differential phase delay resulting from different depth thermal waves of anomalies obtained from phase difference [5,6,22-25].

$$f = Fs\ m/N \tag{1}$$

Fs=Frequency sampling rate.

N=Number of samples.

m=Number of phase image.

We obtain the frames which contains the intensity variation of defect and surface in the image we can progress further, also each frame contains defects at different locations due to the heat variations. As the image segmentation is used to obtain the data on the region of interest so we go for image segmentation here to extract the defect from the image to analyse parameters like size, location etc.

IV. IMAGE SEGMENTATION

Segmentation is a process of extracting useful data from the given data based on different application of interest which are later used for further processing. Image segmentation can be defined as dividing the meaningful information present in the image depending on region of interest. The region of interest may be a boundary pixels of different shapes like circle, curve, any irregular shape. It is an image processing in image analysis because it provides path for furthur processing of images.

Active Contour:

In this method we detect defects in an artifact, by an active contour model based on region-based edge detection was implemented for segmentation using intensity of an area to define the area of interest is segmented. The region-basedfitting functional is defined as a contour and there are mainly two functions on both sides of the contour, which locally approximate the magnitude of the object. Such fitting functions are an average of local intensities on either side of the contour. The region-based of the RSF function allows to use of intensity data from small neighborhoods to the entire region at a controllable level due to the kernel function with a scale variable. This energy obtained is then integrated with the formula of the level-set phrase. In the resulting curve evolution formula, the strength information is used to evaluate using the twosuitable functions that help us the motion of the contour towards the object's boundaries. Finally, object segmentation is carried out using images of inhomogeneity frequency[22].

The advantages of using the active object segmentation contour model include Smooth and closed contours for identification of defects, Identification of weak defect borders, Reasonable accuracy, Reasonable processing time, Easy formulation. Active contours are used for segmentation of artifacts and identification of boundaries. Object segmentation using an active contour technique is as follows:

Let the image region be μ,

A is the closed region present in the image region μ

region outside(A) be $\mu_{1,}$

the region inside (A) be μ_2

For the point $y \varepsilon \mu$ the local intensity fitting energy is given as:

$$\varepsilon_y^{fit}(a, g_1(y), g_2(y)) = \Sigma_i{}^2{}_{=1}\beta_i \int \mu_i\ W(y-x)|M(x) - g_i(y)|^2 dx \tag{2}$$

where

β_1 and β_2 are constants which are positive

$g_1(y)$ is the intensity approximation values in region µ1 and $g_2(y)$ is the intensity approximation values in region µ2

M(x) is the intensity of point x in the local region

W(y-x) is the assigned weight at x for each intensity

$\varepsilon_a^{fit}$is the error (weighted mean square) of the image intensity M(x) outside and within C is adjusted by f1(x) and f2(x) values respectively

W is a kernel function which is greater than or equal to zero given by:

$$W_\sigma(v) = \frac{(2\pi)^{2\sigma_2}\ e^{-|v|2}/2\sigma^2}{(2\pi)^{\,n}} \tag{3}$$

SNR (Signal to Noise Ratio): -

Signal-to-noise ratio is defined as the ratio of the mean defect region value minus mean non defect region value by the standard deviation of non-defect region

$$SNR = \frac{\mathrm{Td} - \mathrm{Tnd}}{\mathrm{SD}}$$

Where

Td=mean of intensities in defective region.

Tnd=mean of intensities in non-defective region.

SD=Standard deviation.

V. RESULTS AND DISCUSSION

In order to detect a defect in a material first we need to obtain the heat patterns of it through thermal cameras using various preprocessing methods. Here we use quadratic frequency modulated thermal wave which contains different frequencies used to detect defects of different depths which is carried out by postprocessing technique. The post-processing approach used in this paper is phase analysis technique, of frequency domain, and finally fast Fourier transformation is applied in order to reduce noise and acquire images. Frames which are obtained are taken as inputs to image segmentation algorithms as shown in the below figures. Active contour global region based segmentation method was used in this paper to segment the image inorder to find the defect. In fig 1 the frame 1 image obtained contains defects in the 1st column, after the algorithm used the output segments the defect with defect as black and the surface as white or vice versa using a mask filter of binary form. The input image undergoes many iterations to cover all regions. The idea behind going for segmentation for multiple frames is, the heat patterns captured are not similar in all frames. Similarly, Fig 2,3,4 contains frame 1, frame 2, frame 3 having other defect locations and their segmented defects as shown below.

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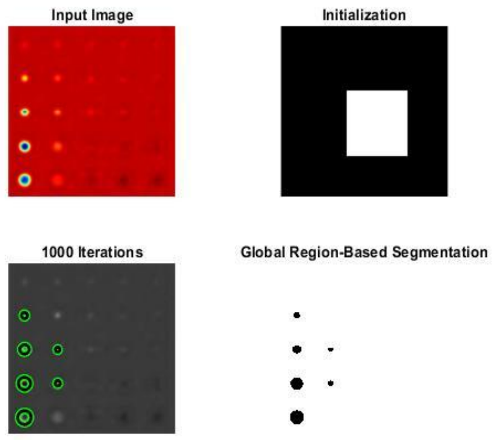

Fig. 2 Segmentation of defect for frame 1

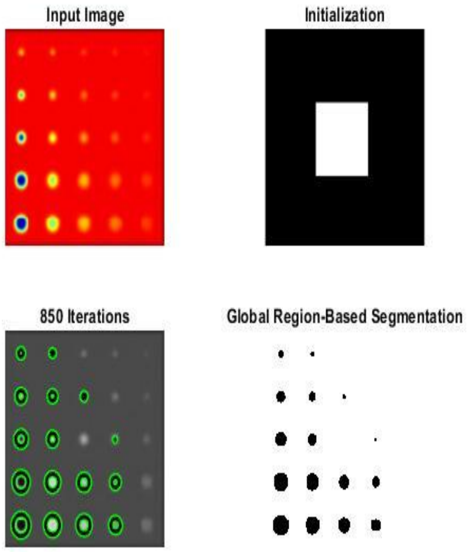

Fig. 3 Segmentation of defect for frame 2

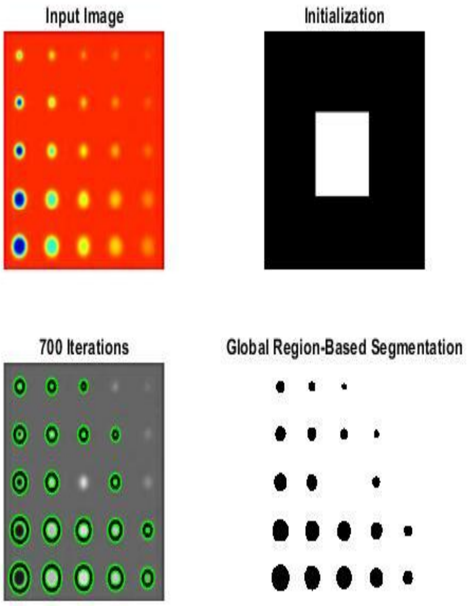

Fig. 4 Segmentation of defect for frame 3

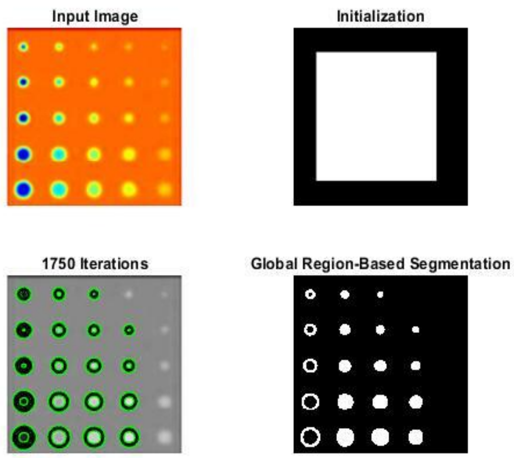

Fig. 5 Segmentation of defect for frame 4

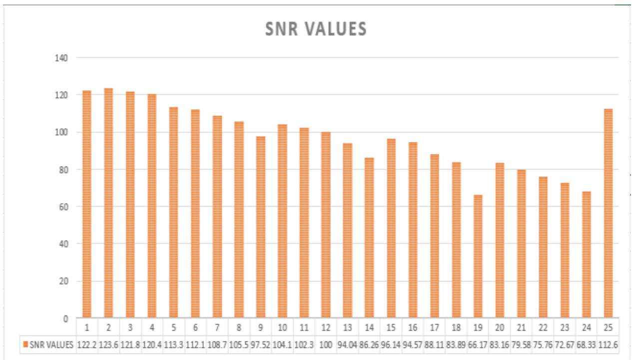

Fig. 6 Signal to noise ratio

VI. CONCLUSION

Many real-life applications the cracks, air bubbles or defects visible which may be present inside the material which are not visible to human eye. In order to obtain the location of defects with their size, we go for infrared thermography. Infrared thermography provides the data with respective to temperature with thermal cameras and the data is heat patterns. The proposed region based active contour provides better defect detection based on heat patterns obtained.

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