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NOVEL IMAGE SEGMENTATION TECHNIQUE FOR LOW CONTRAST BUILDING THERMOGRAPHS

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Abstract—Infrared Thermography (IRT) is the widely used Non-Destructive Testing (NDT) technique for health monitoring of buildings. IRT uses an IR camera that captures the temperature variations and maps it into thermographs. Under normal conditions, temperature distribution is uniform. On the other hand an abnormality appears either as hot or cold spot. Hence interpretation of these thermographs provides information about the abnormality. Various image segmentation techniques are cited in literature for abnormality detection in visible images. However an efficient domain specific segmentation algorithm for thermographs is yet to be evolved. Local Intensities Operation (LIO) based segmentation is already proposed for thermal image segmentation. However, it has failed miserably for low contrast thermographs. Hence an enhanced approach is proposed in this paper that performs contrast stretching based LIO for segmentation. From subjective analysis, it is found that the proposed technique provides better results even for low contrast thermal images.

***Keywords**-Non-Destructive Testing (NDT), Infrared Thremography (RT), Image processing, Segmentation, Building Thermographs*

I. INTRODUCTION

Buildings and structures are vulnerable to the atmospheric and climatic changes. Condition Monitoring (CM) is process by which the health of a system is derived by measuring/monitoring the parameters that are indicative of the health of the system [8]. CM provides a non-destructive means of the analyzing the 'health' of equipment whilst delivering the end user with key information on the state of the system [7]. Infrared thermography (IRT) is a non-contact, non-invasive technique used in Non Destructive Testing (NDT) [3]. The NDT methods have distinct importance for the monitoring, maintenance and conservation studies of historic structures and buildings. Thermography is nothing but the temperature profiling of a surface or point. As the name suggests, infrared thermography is based on Infrared (IR) technique. The principle underlying this technique is that every object emits certain amount of IR energy and the intensity of this IR radiation is a function of temperature. IRT can be used to assess the condition and quality of buildings. It produces thermal map called thermograph of the area under investigation. The defective portion of the building will be recorded with variations in the temperature. When compared to the sound area temperature, if the temperature is high in the defective region then, it is considered as hotspot or hot defect (defect due to heat sources). On the other hand, if the temperature is less then it is considered as cold defect (defect due to the presence of water content). Interpretation of defects from thermographs plays a vital role in assessing the condition of specimen under investigation. Manual interpretation is subjective in nature affected by operator fatigue dependent on the expertise of the individual. So automated analysis is the need of the hour. Digital Image Processing (DIP) is one way of achieving automated defect detection and analysis of thermographs. One of the image processing techniques to separate the specific region from the image is called as image segmentation. Many automated segmentation algorithms have been proposed in the past to analyze the visible images; but there is very few, dedicated modality specific segmentation approaches are cited.

In this paper an enhanced thermograph segmentation technique has been proposed and successfully implemented for isolating the abnormality even from low contrast thermal images. The performance of the proposed technique is compared with two conventional approaches namely Otsu's thresholding and LIO.

In [1] Local Intensities Weighting (LIW) was introduced, as a preprocessing step in order to highlight the defective area, and then Otsu thersholding scheme is applied to segment them from the sound area. In this paper, the suitability of LIW based pre-processing technique followed by Otsu thersholding for detecting moisture defect in the passive thermographs of building walls is analyzed. Modifications in the algorithm are also proposed in order to isolate the moisture defect from the thermographs simply and efficiently.

II. IMAGE DATABASE

The thermal images were acquired using FLIR® T335 thermal imaging camera, which has the spectral range of 7.5-13µm, IR resolution of 320x240 pixels and object temperature range from -20°c to +1200°c. In order to capture the moisture defect and water intrusions into the building walls, the images were taken a day after a rainfall. In this paper, to bring out the effectiveness of the proposed algorithm four thermal images were considered. Fig. 1 – Fig. 4 are the thermal images showing the presence of moisture content/water intrusion in the building wall. Even though all the images showing the same moisture defect there are notable differences between them. The cold region (low temperature regions) in Fig. 1 shows the clear indication of presence of water content, which can be easily identified easily by the temperature distribution. But in the other images Fig. 2 – Fig. 3, the presence of moisture cannot be identified easily because of the less thermal contrast among the defective and sound region.

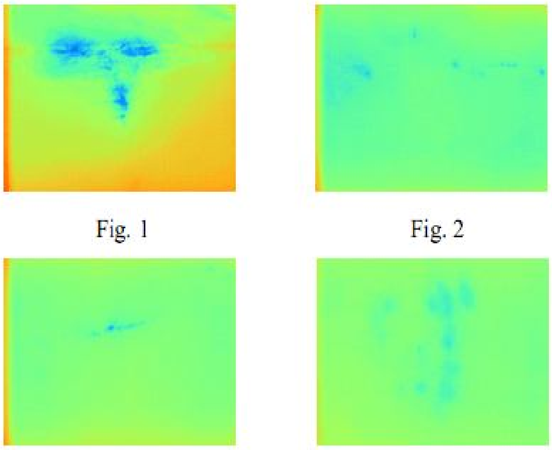
Fig. 1 Fig. 2

Fig. 1 – 4, Thermographs of a building wall showing moisture defect as cold regions

III. CONVENTIONAL APPRAOCHES

Image processing is a suitable soft NDT method for identifying and analyzing a defect in the thermal images. Many image processing techniques has been introduced in the past. Image thresholding is mostly used for image segmentation due to its intuitive properties and easy to implement [5].

A. Histogram based Thresholding

Histogram is the main tool in this separation process. Suppose that the gray-level histogram shown in Fig. 5 corresponds to an image f(x,y), composed of light objects on a dark background, in such a way that object and background pixels have gray levels grouped into two dominant modes. One obvious way to extract the objects from the background is to select a threshold T that separates these modes. A thresholded image g(x,y) from an image f(x,y) is defined as in equation (1)

$$g(x,y) = 1, \text{ if } f(x,y) > T$$
$$= 0, \text{ if } f(x,y) <= T \quad (1)$$

If the gray-level histogram is calculated from the entire image, then value T is called a global threshold. Otherwise, if the histogram derived from a local window pixel values then it is called a local threshold. If only one T value is needed then it is called bi-level thresholding, if more than one T values are needed than it is called multi-level thresholding [4], [5] & [6]

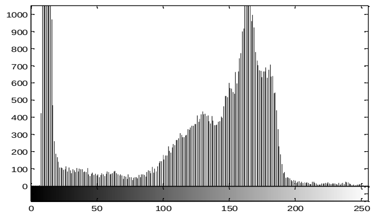

Fig. 5 Gray-level histogram of an Image

B. Otsu thresholding

Otsu's method is used to automatically perform histogram shape-based image thresholding. Otsu's method selects the threshold by minimizing the within-class variance of the two groups of pixels separated by the thresholding operator. It does not depend on modeling the probability density functions; however, it assumes a bimodal distribution of gray-level values.

C. Local Intensities Operation (LIO)

Local intensities operation (LIO) is based on the idea of local neighborhood operation [1]. LIO has two modes in its implementation

Local Intensities Weighting (LIW mode)
Local Intensities Lighting (LIL mode)

In the first mode, LIO will brighten the bright area and darken the dark area. This operation is called as LIW. In the second mode, the opposite action is performed; LIO will brighten the dark area and darken the bright area. This is called as LIL operation. In LIW, it is assumed that the defect is the brightest area, and the background or sound area is the darkest area. On the contrary, LIL assumes that the darkest area is the defective area while the brightest area is the sound area.

Consider a pixel f(i,j) in a thermal image with its 8-connectivity configuration as shown in Fig. 6

z1	z2	z3
z4	z5	z6
z7	z8	z9

⟺

f(i-1,j-1)	f(i-1,j)	f(i-1,j+1)
f(i,j-1)	f(i,j)	f(i,j+1)
f(i+1,j-1)	f(i+1,j)	f(i+1,j+1)

Fig. 6 8-connectivity configuration of a pixel f(i,j)
LIO operator is defined as

$$LIO = \alpha/\beta \quad (2)$$

For LIW operation,

$$\alpha = z1*z2*z3*z4*z5*z6*z7*z8*z9, \text{ and } \beta = 1 \quad (3)$$

For LIL operation,

$\alpha = 1$, and

$$\beta = z1*z2*z3*z4*z5*z6*z7*z8*z9 \quad (4)$$

IV. PROPOSED METHODOLOGY

The image segmentation algorithm developed for general digital image will not hold good for the thermal images [1]. Syed Abd. Rahman Syed Abu Baker [1] proposed a new pre-processing algorithm for defect visibility enhancement. In this algorithm, Local Intensities Operations (LIO) using 3x3 window neighborhood pixels was performed on the thermal images. Thresholding schemes like midway absolute thresholding (MAT), midway relative thresholding (MRT), and minimum frequency thresholding (MFT) are used to detect defect in thermal image after LIO pre-processing operation. This Algorithm works well for the thermal images with hot and cold defects. If the temperature variation is less, then this algorithm does not hold good. This is the serious drawback of this algorithm. In this paper contrast stretching is included as one of the pre-processing steps and the LIW based operation is considered. Finally, the traditional Otsu's thresholding is applied in order to detect the moisture defect from the thermal images. This approach is depicted in Fig. 7

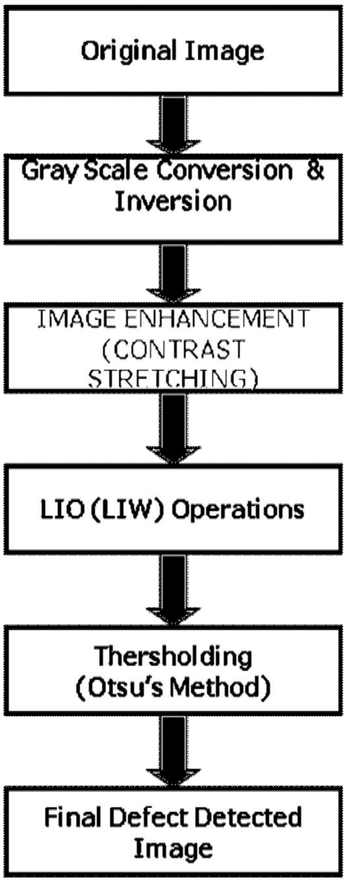

Fig. 7 Steps involved in the proposed method

In order to save the computational time and to make the algorithm simple, rather than working in a colored thermal image, this algorithm takes the advantage of using a gray scale thermal image, since the defective area is still obvious in this mode. Non-uniform illumination is one of the major problems when processing the passive thermal images. Contrast stretching is one of the methods used to correct the illumination issues in an image. Traditional Otsu's thresholding technique is applied to the processed thermal image as the final image processing step and the final segmented image containing defect regions is obtained.

V. RESULTS AND DISCUSSION

In this section the results obtained by applying Otsu thresholding, LIO with Otsu thresholding and the proposed algorithm to the images described in section II were compared. The results clearly show that the Otsu thresholding and LIO with Otsu thresholding are giving good results for thermal images with high thermal contrast between the defective region and the sound region. But the proposed algorithm yields better results with the thermal images having less thermal contrast between the defective region and the sound region.

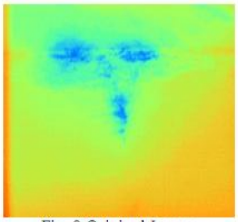

Fig. 8 Original Image

Fig.9 Otsu Thresholding

Fig. 10 LIO + Otsu Thresholding

Fig. 11 Proposed Algorithm

Fig. 12 Original Image

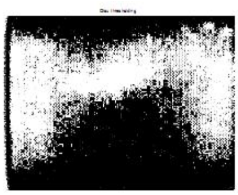

Fig.13 Otsu Thresholding

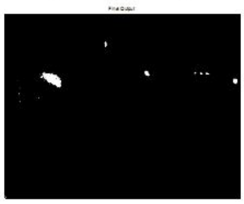

Fig. 14 LIO + Otsu Thresholding

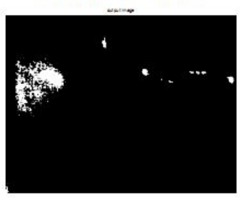

Fig. 15 Proposed Algorithm

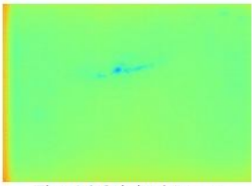
Fig. 16 Original Image

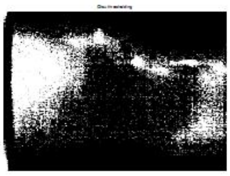
Fig. 17 Otsu Thresholding


Fig. 18 LIO + Otsu Thresholding


Fig. 19 Proposed Algorithm

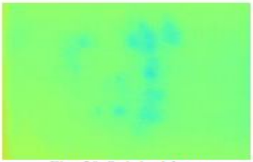
Fig. 20 Original Image


Fig. 21 Otsu Thresholding

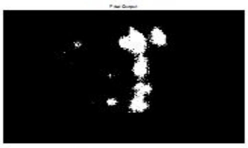
Fig. 22 LIO + Otsu Thresholding

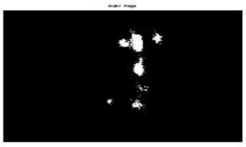
Fig. 23 Proposed Algorithm

VI. CONCLUSION

In this paper an enhanced thermograph segmentation technique has been proposed and successfully implemented for isolating the abnormality even from low contrast thermal images.

The performance of the proposed technique is compared with two conventional approaches namely

Otsu's thresholding and LIO. It is found that the proposed approach not only works well for high contrast thermal images but also for low contrast thermal images which was previously impossible with the conventional approaches.

REFERENCES

[1] Rudi Heriansyah, S.A.R. Abu-Bakar., Defect detection in thermal image for nondestructive evaluation of petrochemical equipments, NDT & E International, Vol. 42, Issue 8, December 2009, pp. 729-740

[2] Chang, J. S., Liao, H. Y. M., Hor, M. K., Hsieh, J. W., and Chern, M. Y., New Automatic Multi-level Thresholding Technique for Segmentation of Thermal Images, Image and Vision Computing, Vol. 15, 1997, pp. 23-34.

[3] Maldague, X. P. V. (2001). Theory and Practice of Infrared Technology for Nondestructive Testing. John Wiley & Sons, Inc.

[4] Chanda, B. and Majumder, D. D. (2000). Digital Image Processing and Analysis. New Delhi: Prentice-Hall of India Private Limited.

[5] Ritter, G. X. and Wilson, J. N. (2001). Handbook of Computer Vision Algorithms in Image Algebra. (2nd ed.). Boca Raton, Florida: CRC Press LLC.

[6] Gonzalez, R. C. and Woods, R. E. (2002). Digital Image Processing. (2nd ed.). Upper Saddle River, New Jersey: Prentice-Hall, Inc

[7] The Implementation of Condition Monitoring Techniques for the Automated Generation of Display Energy Certificates

[8] Rao, B. K. N. (1996). Handbook of Condition Monitoring, Elsevier Science