Object Identification in Steel Container through Thermal Image Pixel Analysis

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***Abstract*—**Thermal image of the steel container with different types of objects is captured using the thermal camera. The surface temperature variations have been captured using thermal camera. In this paper, we propose to analyze objects inside steel containers with thermal images. The thermal imaging camera is employed to read the heat signature of objects inside steel containers. The acquired thermal images are compared, based on the hypothesis that different materials possessing different thermo-physical properties, should produce a unique thermal signature. The acquired thermal image has been filtered and segmented in cluster. Further, pixel difference matrix map is calculated. The feature vector is extracted from the scatter plot of pixels. The average value of the vector can be used as a reference standard to identify the object.

Keywords—thermal image, steel container, thermal signature, thermal camera, surface temperature, thermo-physical properties, pixel difference, feature vector

1. INTRODUCTION

Thermal cameras have been of interest mainly for military applications. Increased resolution and quality of the image combined with decreased size and cost during recent years however, have opened up new application areas. They are now widely used for civilian applications, e.g., within industry, to search for missing persons, in automotive safety, as well as for medical applications. Thermal infrared cameras are becoming increasingly popular as prices and size decrease while image resolution and quality increase. An increasing number of people understand the potential and advantages of thermal infrared cameras. For example, their in-variance to illumination changes and ability to see in total darkness. Steel is a widely used material for fabrication of machinery and equipment in almost all the industries. Maintaining these equipment may become very expensive and time consuming if it requires de-assembling, inspection and then re-assembling. This thesis addresses the problems of detection specifically for thermal infrared imagery and assists in the identification of objects within the steel container.

2. LITERATURE SURVEY

A method of detecting and segmenting regions of interest (ROIs) of the thermal image of electrical installations is proposed. These regions are very important in diagnosing the thermal condition of electrical equipment [1]. A new method is proposed to improve the performance of image segmentation in thermal imagery. The proposed scheme efficiently utilizes nonlinear intensity enhancement technique and Unsupervised Active Contour Models (UACM). The nonlinear intensity enhancement improves visual quality by combining dynamic range compression and contrast enhancement, while the UACM incorporates active contour evolutional function and neural networks [2]. A real-time diagnostic and control technique has been developed for use in electronic circuits whose thermal signature can be correlated to their operating status. Successful implementation of this diagnostic scheme in proof-of-concept experiments required the incorporation of several technological issues into a complete system that has the capability to detect potential fault modes in the system under observation [3]. An automatic diagnosis system for testing electrical equipment for defects is proposed. Based on nondestructive inspection, infrared thermography is used to automate the diagnosis process. Thermal image processing based on statistical methods and morphological image processing technique are used to identify hotspots and the reference temperature [4]. Thermal anomalies in electrical equipment can be extracted if its infrared image is segmented properly. However, segmenting the infrared image is a very challenging task due to blur and low quality of the obtained images. So, it is very important to enhance the image prior to segmentation. An image enhancement method by adjusting the intensity of the image is proposed. Firstly, the intensity of the original image is inverted. Then, the warm region is enhanced by subtracting the original image with the inverted image [5]. The neural network is used in infrared thermography to classify defects, such as air, oil, and water, which can degrade material performance. A finite element method and experiment were adopted to simulate air, water, and oil ingress. Raw data, and thermographic signal reconstruction coefficients were used to train, and test the two multilayer, feed-forward NN models. Quantitative comparisons showed that the model using coefficients as features performed better than the one using raw data

[6]. A feature extraction pipeline namely Difference Matrix Projection (DMP) for pedestrian detection was proposed. The goal is to design an effective feature set that can efficiently be computed. This feature consists of pixel differences at different scales and orientations coupled with average pooling and block normalization. A formulation that computes the difference maps and local average using global image projection instead of an iterative filtering was developed [8].

3. REQUIREMENTS

A. Fluke Visual IR Thermometer

Fig. 1. Fluke Visual IR thermometer

It is a compact and intuitive visual IR thermometer that blends a visual image with infrared heat map overlay. It features NEAR and FAR mode that automatically aligns visual and thermal lenses to correctly locate issues. It includes a centre measurement box showing the exact area of temperature measurement on the screen.

B. Smart View

It is a powerful, modular suite of software gear for viewing, annotating, modifying and studying infrared images. It can generate completely customizable and professional-searching reviews in a few clean steps. It provides full assist for IR-Fusion Technology and lets us edit pictures in 5 viewing modes It is easy to use, yet offers high-end analysis performance.

C. Matlab

MATLAB (Matrix laboratory) is used in this thesis to implement software computation also considered as programming language It is developed by MathWorks, always allows matrix manipulations, other plotting of functions and data, implementation of maths algorithms, creation user interfaces, and interfacing the output.

4. PROPOSED SYSTEM

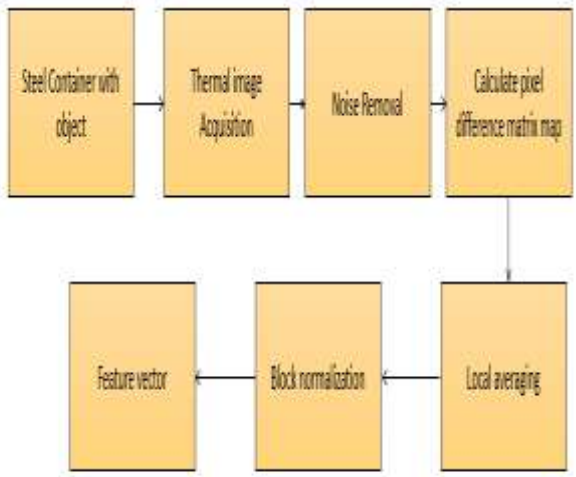

Fig. 2. Block diagram of proposed system.

A. Acquisition of Thermal Images

Thermal images of the steel box with different types of objects is captured using thermal camera. The captured thermal images are processed with the smart view software. The thermal images are obtained in bitmap format.

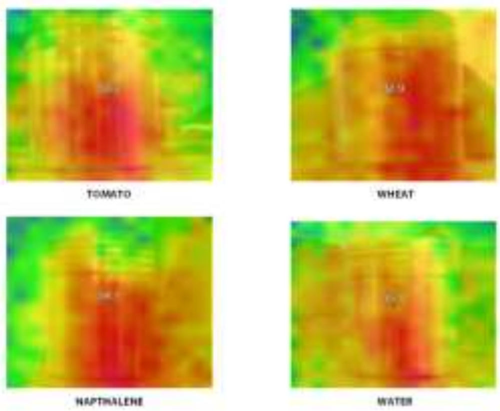

Fig. 3. Acquired thermal images of different objects within steel

B. Noise Removal

Noise removal algorithm is that the process of removing or reducing the noise from the image. The noise removal algorithms reduce or remove the visibility of noise by smoothing the whole image leaving areas near contrast boundaries. Noise is usually presents in digital images during image acquisition, coding, transmission, and processing steps. Filtering image data may be a standard process utilized in almost every image processing system. Filters are used for this purpose. They remove noise from images by preserving the details of the same. The choice of filter depends on the filter behaviour and type of data.

Gaussian high pass and low pass filter can be used for the removal of noise from the acquired thermal image. It is a widely used effect in graphics software, typically to scale back image noise and reduce detail.

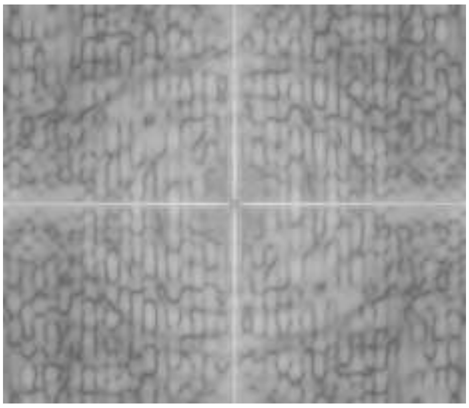

Fig. 4. Filtered thermal image

C. Pixel difference matrix map

Before presenting the features, we briefly introduce how to formulate the pixel difference computation into matrix multiplications. In fact, this formulation can be applied to any feature computation that involves pixel or region differences and summations. It computes features by global matrix projection with pre-constructed projection matrices and, as a result, avoids pixel-wise scanning operations. Pixel differences are commonly computed by convolving the image with a block-based filter where a scanning of the entire image cannot be avoided.

D. *Cluster based segmentation*

Clustering involves the finding of a structure in a collection of unlabelled data. It is the process of organizing objects into groups whose members are identical in some way. A cluster is therefore a collection of objects which are identical between them and are not identical to the objects belonging to other clusters. Fuzzy C-Means (FCM) algorithm can be used to cluster the image. It is a clustering algorithm which allows a piece of data to belong to two or more clusters.

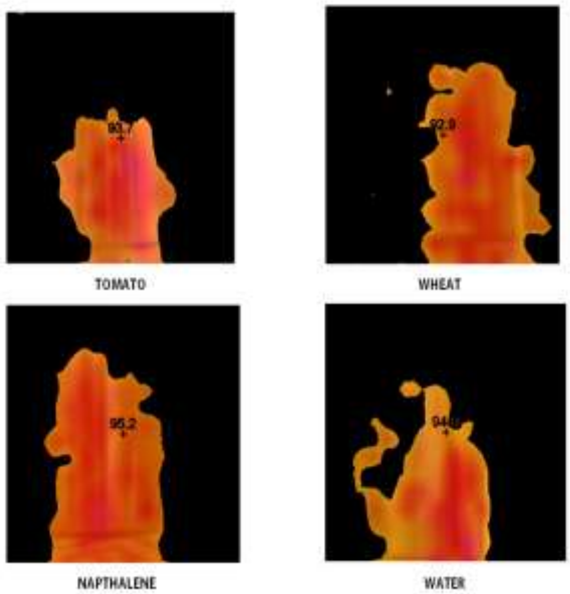

Fig. 5. Cluster image of various objects inside steel

E. Block normalization

Normalization of features can introduce tolerance to illumination change. In this paper, the features are normalized on a block basis. Each block contains 2□ cells, and the stride is one cell for both horizontal and vertical directions. The block features are normalized and concatenated into a single feature vector. Because of the overlap of blocks, each cell participates in four different blocks and is normalized accordingly.

F. Feature vector extraction

The multi-orientation information is incorporated in the pixel differences along different directions. The local statistical information is extracted by average-pooling, which can be efficiently computed by applying the averaging projection matrices

G. Scatter plot

A scatter plot is used either when a continuous variable which is under the control of the experimenter and another depends on it or when both continuous variables are independent. A parameter which is systematically incremented or decremented by the other is known as the control parameter, which is customarily plotted along the horizontal axis. The dependent or measured variable is customarily plotted along the vertical axis. If only independent variable exists, either sort of variable are often plotted on either axis and the degree of correlation between two variables will be illustrated by this plot.

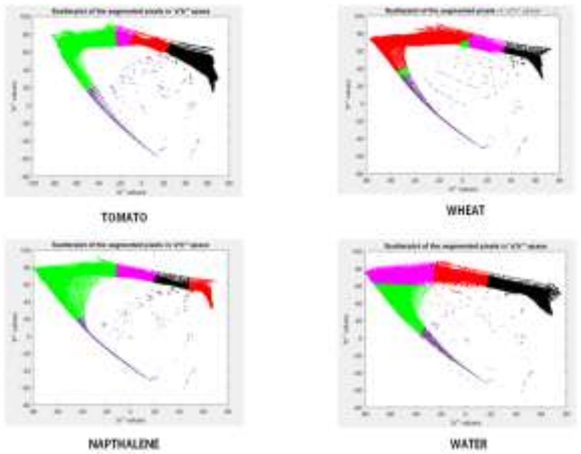

Fig. 6. Scatter plot for different objects within steel container

Based on the calculated feature vector, the unknown object behind the container can be identified.

TABLE I. FEATURE VECTOR FOR VARIOUS OBJECTS

Different objects	Feature vector
Wheat	[3.30, 72.33]
Rice	[5.15725, 70.6185]
Wheat and Rice	[-6.4425, 72.9405]
Tomato	[20.695, 67.3515]
Stone	[11.419, 69.138]
Naphthalene	[30.253, 64.4395]
Empty	[13.16, 71.256]
Wheat and Naphthalene	[-0.6735, 73.827]
Water	[1.296, 71.62]
Oil	[-31.867, 75.165]
Water and oil	[4.287, 71.482]

5. CONCLUSION

The objects' thermal changes inside steel walls is evaluated with pixel analysis method. The pixel analysis method is selected to get a benchmark method in thermal analysis. The analysis is developed based on the thermal signature from steel objects area, focusing on the Region Of Interest.

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REFERENCES

[1] M. S. Jadin, K. H. Ghazali, and S. Taib, “Detecting ROIs in the thermal image of electrical installations,” in IEEE International Conference on Control System, Computing and Engineering, 2014, pp. 496–501.

[2] F. A. Albalooshi, E. Krieger, P. Sidike, and V. K. Asari, “Efficient thermal image segmentation through integration of nonlinear enhancement with unsupervised active contour model,” in SPIE 9477, Optical Pattern Recognition XXVI, 2015, p. 94770C.

[3] S. Merryman and R. Nelms, “Diagnostic technique for power systems utilizing infrared thermal imaging,” IEEE Trans. Ind. Electron., vol. 42, no. 6, pp. 615–628, 1995.

[4] Y. Chou and L. Yao, “Automatic diagnosis system of electrical equipment using infrared thermography,” in International Conference of Soft Computing and Pattern Recognition, 2009, pp. 155–160.

[5] M. S. Jadin and S. Taib, “Infrared image enhancement and segmentation for extracting the thermal anomalies in electrical equipment,” Electron. Electr. Eng., vol. 120, no. 4, pp. 107–112, 2012.

[6] Yuxia Duan, Shicai Liu, Caiqi Hua, Junqi Hu, Hai Zhang, Yiqian Yan, Ning Tao, Cunlin Zhang, Xavier Maldague, Qiang Fang, Clemente Ibarra-Castanedo, Dapeng Chen, Xiaoli Li and Jianqiao Meng, ” Automated defect classification in infrared thermography based on a neural network”, NDT and E International 107(2019), published by Elsevier Ltd.

[7] Makoto Miwa, Rune S�re, Yusuke Miyao, Jun’ichi Tsujii,” A Rich Feature Vector for Protein-Protein Interaction Extraction from Multiple Corpora”, Proceedings of the 2009 Conference on Empirical Methods in Natural Language Processing, pages 121–130, Singapore, 6-7 August 2009.

[8] Xing Liu, Kar-Ann Toh, “A Novel Set of Pixel Difference-based Features for Pedestrian Detection”, 2018 IEEE 4*th* International Conference on Identity, Security, and Behavior Analysis (ISBA).

[9] Yang R, He Y, Mandelis A, Wang N, Wu X, Huang S. Induction infrared thermography and thermal-wave-radar analysis for imaging inspection and diagnosis of blade composites. IEEE Trans. Ind. Inf. 2018;14(12):5637–46.

[10] Zeng Z, Tao N, Feng L, Zhang C. Hidden heterogeneous materials recognition in pulsed thermography. AIP Conference Proceedings 2012;1430:705–12.

[11] Chen D, Zeng Z, Tao N, Zhang C, Zhang Z. Liquid ingress recognition in honeycomb structure by pulsed thermography. Eur Phys J Appl Phys 2013;62