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"Fault Prediction in Electrical Equipments using Thermographic Inspection"

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***Abstract*—Electrical power system deals with various new technologies, Also most part of electrical system in various industrial applications is automated. To maintain the reliability it is essential to carry out maintenance procedures. Temperature is one of the important parameter that should be taken into account in the maintenance, because higher temperatures indicate loss of energy in the form of heat. As temperature audits have much importance in the maintenance, now a day Thermo-graphic audits are carried out in many industries. Thermography is nothing but temperature profiling of a surface of electrical equipment. One of the major advantages of this type of technique is that this is contactless monitoring of electrical equipment without actually shutting down the equipment which gives reliable and fast prediction of faulty part of the system. In this paper image processing techniques are used for the analysis of thermal images of the faulty equipments. this paper deals with the study and analysis of Thermography as one of the fault prediction technique.**

Keywords—Electricalequipments;heat loss ;Thermography.

I. INTRODUCTION

Heat energy is an important factor in electrical equipment fault detection as electrical current passes through a resistive component and generates heat. Thermal energy generated from an electrical component is directly proportional to the square of the current passing through it and resistance (I2R Loss) [1]. Therefore, an increase in electrical resistance results in an increase in heat. Electrical installations face deterioration with the time due to many reasons such as oxidation, cracks to the equipments. Along with the electrical fault such as load imbalance, higher voltages etc there may be problem in the working of equipment due to loose connections , mechanical friction, improper crimping etc. As component deteriorates, its resistance increases and also generates more heat. The increase in heat energy can cause the failure of electrical equipment. By utilizing thermographic inspections the equipment under inspection, can be identified and classified by its level of temperature. Infrared thermography makes use of this heat which is produced in the electrical equipment for fault detection. The thermal profiles of electrical equipment and connectors are captured by using a thermal imager. Image of equipment consists of image itself with temperature scale. The different colors of temperature scale represent the different temperature spots of the equipment. Components having comparatively higher temperature appear bright in the image many times thermovision camera has the settings to select the color of the heated area but by default it appears as red.

II. METHODOLOGY

A. *Thermography*

This paper mainly aims to find the faults in the electrical equipment using thermographic and image processing technique. For finding out the fault in the system first step is to decide the inputs. In this paper input used for fault detection is a thermal image. Thermal imager is used to conduct thermo audit. Images of the faulty parts of the system are captured. From the captured images we can find out the actual temperature of the faulty part of the system and accordingly we can take corrective action and restore the faulty system. Practices used for maintenance procedures in industries sometimes include shut down of the system Thermography has advantage over conventional system that using thermographic technique it is possible to carry out maintenance procedure without shutting down the system.

B. *Role of Image processing*

Color that human eyes perceive in an object is determined by the nature of the light reflected by the object. Visible light is composed of relatively narrow band of frequencies in the electromagnetic spectrum. No color in the spectrum ends abruptly but smoothly blends in the other color. Use of color in the image processing is mainly due to two factors First, color is powerful descriptor that often simplifies object identification and extraction from the scene. Second, humans can discern thousands of color shades and intensities compared to about two dozens of shades of gray. Thermo graphic images that are being captured using thermo vision camera are preprocessed using morphological techniques. basic color model used in this paper are RGB color model and HSV color model

Feature Extraction[2] is a method of capturing visual content of images for indexing & retrieval. Primitive or low level image features can be either general features, such as extraction of color, texture and shape or domain specific features. Haralick defines fourteen textural features measured from the probability matrix to extract the characteristics of texture statistics of remote sensing images. In this paper haralick feature extraction technique is used feature extraction and Neural network is used as classifier to detect fault and temperature of the system.

III. EXPERIMENTAL PROCEDURE

Thermography audit were carried out in different industrial premises for indoor and outdoor electrical installations to detect the fault in electrical equipment. Thermovision camera used for capturing the images was TESTO. Thermovision camera while capturing the images was directly facing the

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equipment. Emissivity was default set to 0.95. As temperature conditions effects the result of thermography audit for outdoor substations, audit was carried out in the evening for outdoor installations. Ambient temperature during audit was 30-34 degree Celsius. Each equipment was examined by thermal imaging camera and report was generated for the fault if any. After image acquisition all the images were saved in JPEG format and digital image processing techniques were implemented on the captured images are as follows:

A. Image Acquisition:
This is the first step of digital image processing. Image acquisition could be as simple as being given an image that is already in digital form [3].five hundred images of the faulty equipments in different substation were collected having different temperature range for further processing.

B Image preprocessing:
Image preprocessing [3] involves extracting ROI (Region of interest) as we are working mainly on the faulty part of the equipment, converting image to grayscale image, image resizing and image enhancement. Image enhancement is nothing but manipulating image so that result is more suitable.

C Image segmentation:
Segmentation is done to decompose an image into meaningful parts for further analysis, resulting in a higher level representation of the image pixels like the foreground objects and the background Segmentation procedure partition an image into its constituent parts or objects. More accurate the segmentation more likely recognition is to succeed. In the segmentation process the image is converted to Binary.

D. Morphological operations:
Morphological processing deals with tool for extracting image components that are useful in the representation and description of the shape and noise removal from the images using structuring elements. We can find out connected objects in the image and using various matlab commands we can remove the isolated pixels from the image.

E. Mapping to color ROI:
In this step binary image is being mapped to color ROI.binary image has one channel only while mapping it to color ROI we have created three channels and we multiplied it with the original image. At the output of this stage we get the color ROI.

F. Feature Extraction:
Statistical Features using GLCM [4] implemented in this paper are as follows and formulas are listed in the table:

G is the number of gray level used.

1. Contrast: This measure of contrast or local intensity variation will favors contributions from P(i, j) away from the diagonal.

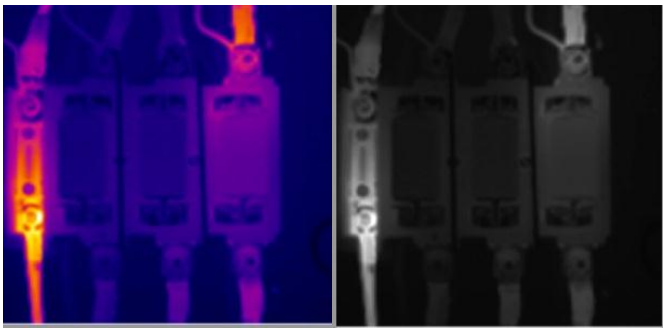
2. Entropy: Entropy shows the amount of information of the image that is needed for the image compression. Entropy measures the loss of information or message in a transmitted signal.

3. Homogeneity Angular Second Moment (ASM): ASM is a measure of homogeneity of an image. A homogeneous scene will contain only a few gray levels, giving a GLCM with only a few but relatively high value. Thus, the sum of squares will be high.

4. Sum of squares: This feature puts relatively high weights on the elements that differ from the average value of p(i,j)

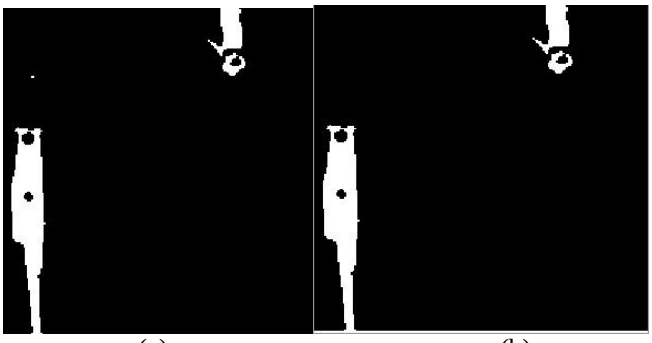
G. PREDICTION: Using neural networks output is displayed in terms of temperature range [5].

Fig 1: SFU original thermal image.



(a) (b)

Fig 2: Image preprocessing on SFU (a) Image ROI (b) Enhanced Image



(a) (b)

Fig 3: (a) Segmented Image (b) Noise removed

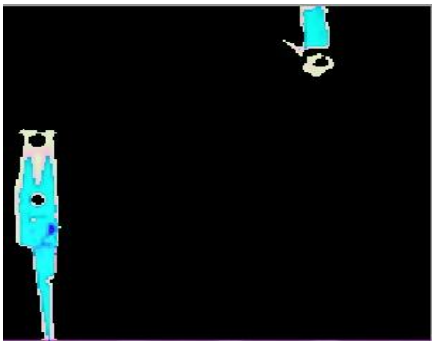


Fig 4: HSV Image

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Sr No	Feature	Fromula
1	Contrast	$\sum_{n=0}^{G-1} n^2 \sum_{i=1}^{G} \sum_{j=1}^{G} p(i,j)$
2	Entropy	$-\sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i,j)\, x\, log\, (p(i,j))$
3	Homogeneity	$\sum_{i=0}^{G-1} \sum_{j=0}^{g-1} \{p(i,j) * p(i,j)\}$
4	Sum of squares	$\sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (1-\mu)^2 p(i,j)$

Table1: Formulas for Feature Extraction

All the extracted feature values are stored in a matrix and given as input to neural networks. All the images that are being captured are loaded to the neural network model with class mentioned in it to identify the temperature class of the given image. Main advantage of using neural networks is it learns to identify pattern which exists in a given set and it can handle very complex interactions.

Neural network[4] make use of back propagation network which is very common method for training it. This network consist of input layer, output layer and 10 hidden layers which is created using matlab command

Net = newff(R,S,{'tansig','purelin'})

Where tansig = transfer function of hidden layers Purelin = transfer function for output layer. The data in the network flow from the input layer to the output layer crossing the intermediate layers (called hidden layers) without feedbacks, then the network is called forward". Units are connected in feed-forward fashion and input units are completely connected with the hidden units. Therefore at the output neural network gives the image with temperature mentioned in it.

CONCLUSIONS

In this paper thermal imaging camera is used to identify the overheating in electrical equipments present in the substation Image processing techniques were implemented on set of images region of interest were selected, segmented and transformed to HSV(Hue Saturation Value).features extracted are given as input to neural networks. The multilayer perceptron has been shown as effective tool for prediction and classification with approximately 90-95% accuracy.

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