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Feature extraction and classification for detecting the thermal faults in electrical installations

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ABSTRACT

This paper proposed an effort to investigate the suitability of input features and classifier for identifying thermal faults within electrical installations. The features are extracted from the thermal images of electrical equipment and classified using a multilayered perceptron (MLP) artificial neural network and support vector machine (SVM). In the experiments, the classification performances from various input features are evaluated. The commonly used classification performance indices, including sensitivity, specificity, accuracy, area under curve (AUC), receiver operating characteristic (ROC) and *F*-score are employed to identify the most suitable input feature as well as the best configuration of classifiers. The experimental results demonstrate that the combination of features set T_{max}, T_{delta} and DT_{bg} produce the best input feature for thermal fault detection. In addition, the implementation of SVM using radial basis kernel function (RBF) produces slightly better performance than the MLP artificial neural network.

1. Introduction

The use of infrared thermography (IRT) in condition monitoring is gaining importance in various industrial fields. The trends show that IRT is now being employed in diverse fields of applications, such as in physics, electrical and electronics engineering, material science and engineering, mechanical engineering, medical and structural engineering [1,2]. This tool can help plant and maintenance engineer to predict any potential failure, fault or defect in machineries and the process, thereby appropriate planning for maintenance and repair can be made.

In recent years, IRT has become an interesting tool, particularly for monitoring the condition of electrical equipment [3]. It can reveal various types of problems in electrical equipment by sensing the emission of infrared energy (i.e. temperature) of the equipment. Abnormalities within the equipments occur when their internal temperatures exceed their normal operating limits. Consequently, the overheating of electrical equipment can lead to subsequent failure and can potentially result in unplanned outages, injury and fire hazard. In addition, the efficiency of an electrical grid reduces prior to power failure, thus energy is spent generating heat, causing unnecessary loss [4]. IRT can be one of the useful tools in conducting this inspection. Various problems can be detected especially in the central power installations of buildings and local switchboards. Within this unit where poor connections, short-circuits, overloads, load imbalances, improperly installed electrical components, etc. could be easily identified [2,5]. Fig. 1 depicts an example of a circuit breaker and its corresponding infrared image. This image has an early indication of a connection problem between the circuit breaker and cable. The red colour or high-intensity pixels (for grayscale images) indicate the warmer object while

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0263-2241/

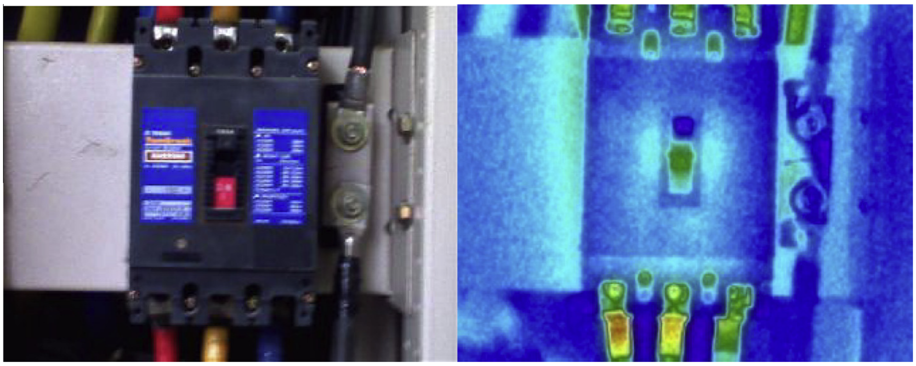

Fig. 1. Image of a circuit breaker and its corresponding infrared image.

the dark blue or low-intensity pixels indicate the cold object.

Although it seems simple, nevertheless, analysing the IRT images needs a complete understanding of the inspection procedures [6–8]. Moreover, a large amount of data needs to be analysed and evaluated. Thus, the recent trends have indicated an interest in employing an automated system for monitoring the status of electrical equipments [6,9–19]. This will improve the data processing time and gaining a more reliable inspection result. However, developing such a system needs to identify suitable input features that will be fed into a classifier. The classifier also should be well configured with the optimal parameter settings. Each input feature should be tested and the classifier should be tuned at the optimal configuration. There are several feature extraction techniques were used for detecting and evaluating the thermal fault via infrared IRT image analysis. Usually, the relevant features are extracted after the images were properly segmented and then followed by a decision-making process for determining the thermal condition of the equipment [6].

The goal of this paper is to investigate the effectiveness of using different input features and classifiers for assessing the thermal condition of electrical installations. We explore the utility of various input features and tested for two types of classifiers. The remainder of this paper is organized as follows: Section 2 discusses the related works of the previous study. In Section 3, the proposed method for feature extraction, feature selection and classification is presented. Experimental results and discussions are presented in Section 4 including the analysis of various types of input features and classifiers. Finally, concluding remark appears in the last section.

2. Related work

By far, there are several feature extraction techniques have been explored for identifying the thermal fault in electrical equipments. The simplest and widely used technique is to extract the actual thermal profiles of the selected regions within the image. The maximum temperature difference between the hotspot and its adjacent region, which normally assigned as the reference region is calculated [9]. In other research, Neto et al. used temperature values along the surge arresters as the input features for a neural network classifier [10]. However, neglecting some important parameters can lead to an inaccurate decision. Therefore, Prazzo et al. proposed to include the absolute temperature, maximum difference temperature and maximum admissible temperature values to evaluate the region's condition [11]. Lu et al. extracted the feature from pixel intensity values of the grayscale image of zero resistance insulators. Several parameters are calculated which consist of the maximum, minimum and average grayscale values from the segmented image of the insulator string area, the insulator plate area and the background image. To reduce the effect of environmental factors such as ambient temperature and wind speed, three other parameters are added, including the variance of gray scale distribution in the insulator area, the maximal difference of gray scale in the insulator area and the maximal difference of gray scale between the plate and the background [20].

Another feature extraction technique is based on the statistical moments of the hotspot areas. A few studies have been carried out to examine the effectiveness of geometric moment [12,13] and Zernike moment features [14]. However, this technique has a drawback due to the inconsistency of the hotspot shape and may be applicable to a certain electrical equipment with a specific fixed image acquisition setting [6]. Another technique of feature extraction is by taking RGB pixel values of the infrared image [15]. These pixel values are fed directly into a classifier for identifying the condition of electrical equipments. Although this method is quite straightforward, however, it has a problem with high processing time due to large feature vectors to be computed by classifiers such as a neural network [6]. Other techniques are based on similarity or matching based between a template image and the target image of electrical equipments to be inspected. The thermal fault is detected by examining the index of similarities between the target electrical equipment and the reference template [16,21,22].

A more advanced method was proposed by Laurentys Almeida et al., which considered various input parameters for diagnosing the surge arresters. The variables used in the system can be subdivided into two groups: identification variables and measurement variables. The identification variables (surge arresters rated voltage, material,