Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 9-10, 2024

Automatic detection of hotspot for condition monitoring using algorithm

Jun-Su Lee [a], Ju-Sik Kim [b], Jun-Hee Park [a], Joo-Hyung Kim [a*]
[a] *Dept. of Mechanical Eng., INHA Univ., Inha-ro 100, Incheon, Korea*
[b] *Korea Hydro & Nuclear Power Co.,Ltd., Yuseong-gu, 34101, Daejeon, Korea*
**Corresponding author: joohyung.kim@inha.ac.kr*

Keywords : Infrared Thermal Imaging, Algorithm, Condition monitoring, Clustering, Hot spot region

1. Introduction

Thermal imaging monitoring is extensively utilized across various sectors for the early detection of anomalies. Through the analysis of data collected by thermal imaging devices, it is possible to easily identify hotspots or thermal anomalies within the areas of interest. Segmenting hotspot areas in thermal images is a pivotal process for diagnostic and analytical objectives. Historically, thermal image analysis has predominantly relied on the knowledge and experience of certified experts. However, the interpretations by experts can vary, which may influence the reliability of hotspot diagnostics [1,2].

As computer vision technologies have advanced, a plethora of techniques have been incorporated into thermal image analysis, acting as invaluable tools to support professional diagnostic decisions. Nonetheless, differentiating hotspot areas affected by reflection poses a significant challenge. Areas influenced by reflections are often characterized by sudden temperature changes and can be segmented through the analysis of gradient values across pixel data. This study introduces a method for segmenting reliable hotspot areas using a clustering model and subsequently separating areas influenced by reflection with a differentiation algorithm.

2. Methods and Results

2.1 Hotspot region segmentation

An ensemble cluster algorithm was used to segment the hotspot region. This algorithm is one of the unsupervised learning methods and is very effective in clustering given data. Cluster algorithms form natural groups or clusters based on each pixel in a thermal image. Among the various clusters formed in this way, the group most closely related to the fever area is selected. These selected clusters are assigned as mask areas to distinguish the hotspot regions distinctly. This approach greatly aids in determining the exact location and boundaries of hotspot region in thermal images.

This method proposed an ensemble model comprising various clustering algorithms specifically designed for the segmentation of hotspot regions. By harnessing the strengths of each distinct clustering algorithm, the ensemble model aims to generate a unified result, optimizing the accuracy and reliability of hotspot area segmentation[3].

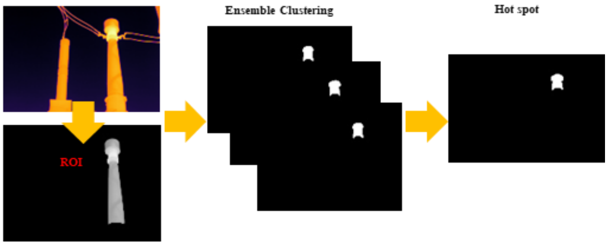

Fig. 1. Ensemble clustering process.

2.2 Reflected hotspot region segmentation

In classified exothermic regions, differential analysis was performed to determine the thermal gradient. This analysis is essential to determine whether the area represents actual heat generation or has been misinterpreted as heat generation by reflections from the surrounding environment. The presence of thermal gradients identifies and clearly distinguishes areas suspected of being reflective.

2.3 Segmentation of actual hotspot region

Within the segmented hotspot regions, a differentiation algorithm was employed to isolate areas generated by reflections. If the Intersection Ratio of a reflected hotspot region exceeds a predetermined threshold, it is classified as a reflection area. Figure 2 illustrates the structure of the proposed framework for detecting thermal regions. Figure 3 depicts examples of various color spaces utilized in the input data for the proposed method. The proposed method's accuracy was evaluated using temperature values from thermal imaging raw data and different color spaces as inputs [4,5].

Table I displays the accuracy test results for the proposed method based on input data. The highest performance in distinguishing between hotspots and reflections was achieved by utilizing input values from the RGB color space and temperature data (raw data). The outcomes across different color spaces and temperature (raw data) are compared in Figure 4.

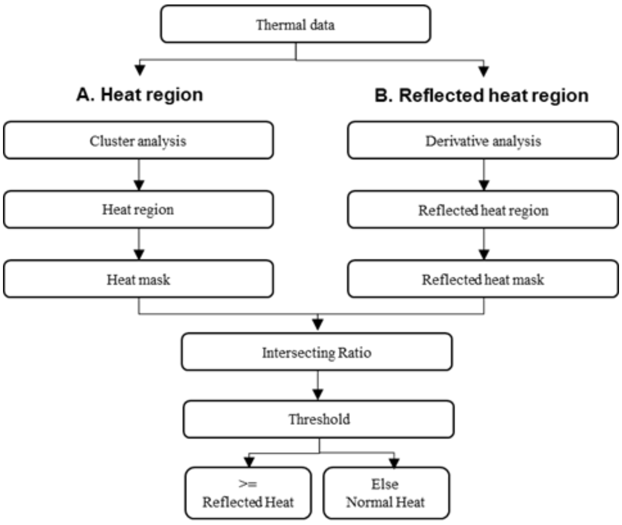

Fig. 2. Flowchart of proposed method.

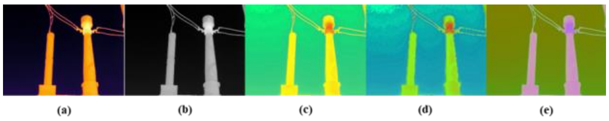

Fig. 3. IR image samples in different color spaces : (a) RGB color space, (b) Gray color space, (c) HSV color space, (d) HIS color space, and (e) Lab color space

Table I: Test results obtained using input data.

	RGB color	Gray color	HSV color	H S I color	Lab color	Temp (Raw)
Accuracy	0.818	0.739	0.335	0.069	0.662	0.822

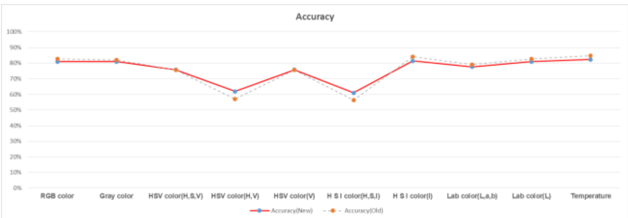

Fig. 4. Accuracy of different color space on model

3. Conclusions

Through this study, we successfully developed an algorithm that accurately identifies actual hotspot regions based on thermal gradient analysis. Traditionally, hotspot area segmentation in various image datasets has been performed by converting the input data to the gray color space using clustering techniques. Based on the comparison of test results with different input data, this study proposes a more efficient method for hotspot segmentation. Moreover, this study demonstrates that separating reflection areas through the differentiation of segmented regions allows for the isolation of more reliable hotspot region.

REFERENCES

[1] A. S. N. Huda and S. Taib, Suitable features selection for monitoring thermal condition of electrical equipment using infrared thermography, Infr. Phys. Technol., Vol. 61, pp. 184-191, Nov. 2013.

[2] R. A. Osornio-Rios, J. A. Antonino-Daviu and R. de Jesus Romero-Troncoso, Recent industrial applications of infrared thermography: A review, IEEE Trans. Ind. Informat., Vol. 15, no. 2, pp. 615-625, Feb. 2019.

[3] Prakash, R. M., Bhuvaneshwari, K., Divya, M., Sri, K. J., & Begum, A. S., Segmentation of thermal infrared breast images using K-means, FCM and EM algorithms for breast cancer detection. In 2017 International conference on innovations in information, embedded and communication systems (ICIIECS), pp. 1-4, IEEE March. 2017.

[4] P. Hankare, K. Shah, Deepthy Nair and Divya Nair, Breast Cancer Detection Using Thermography, International Research Journal of Engineering and Technology, pp. 1061-1064, 2016.

[5] A. T. Wakankar and G. R. Suresh, "Automatic Diagnosis of Breast Cancer using Thermographic Color Analysis and SVM Classifier", Advances in Intelligent Systems and Computing Intelligent Systems Technologies and Applications 2016, pp. 21-32, 2016.