Local Feature Descriptor for Multispectral Image Matching of a Large-Scale PV Array

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***Abstract*—Possible faults in the photovoltaic modules must be detected early in order to preserve their long-term reliability while maximizing power output. Aerial thermal image inspection is frequently used to detect and locate photovoltaic module hotspots. However, noises can make it difficult to detect a hotspot from this image, causing the hotspot to be incorrectly located due to thermal reflection from the environment. Examining both visual and thermal images of photovoltaic modules appears to be one of the solutions. The multispectral image matching of photovoltaic modules is presented in this paper. The absolute structure map *(SMi)* and the directional structure map *(DSMi)* are proposed. The local region of each interest point is then described using a histogram of the oriented gradient based on the *SMi* and *DSMi*. For the *SMi*, the Gabor wavelet filter is applied, whereas the average filter is applied to the *DSMi* for the construction of the histogram bins. Finally, the normalized feature vectors are merged. Experiments were carried out to evaluate the performance of the proposed structure map feature descriptor. According to the findings, this approach could give precision and recall up to 0.82 and 0.97 respectively.**

Keywords—feature matching, hotspot, local feature descriptor, multispectral image, photovoltaic

I. INTRODUCTION

The image matching task based on feature descriptor has been used for many years. For various matching applications, plenty of feature descriptors have been suggested as numerous researchers involved in the study of feature descriptors in recent decades. Among these methods, the speeded-up robust feature (SURF) and scale-invariant feature transform (SIFT) are the most successful and popular algorithms. Both rotational invariance and scale invariance descriptors can achieve excellent performance in a wide variety of image matching applications due to their robustness. However, these two approaches frequently fail to achieve good performance on aerial multispectral image matching tasks. This is due to the fact that both methods are robust to changes in viewpoint and illumination, yet sensitive to nonlinear intensity variations [1], [2].

Researchers have designed many feature descriptors that are robust to image nonlinear intensity changes to cope with the crucial nonlinear intensity differences issue in multispectral images. Among these feature descriptors, a large number of methods are improvements to the classic methods [3]–[5], which are usually specific to the application. Dong *et al.* proposed normalized gradient SIFT [5] which is the modification to SIFT approach. This method uses normalized gradients to calculate feature vectors as the feature points' description in multispectral images to achieve robustness against nonlinear intensity variations. An approach which combined the robust point matching and partial intensity invariant feature descriptor by employing the SURF detector [6] enhances the multimodal retinal images' matching performance. Unlike these improved algorithms, many methods [7]–[9] are designed specifically for multispectral images and have higher efficiency as well as robustness than SURF or SIFT based methods.

An edge-oriented histogram feature descriptor [7] is proposed for image matching between the long-wave infrared images and visible images. The method shares the same idea with the edge histogram descriptor in which the feature description is constructed using the edge points distribution of four directional edges and one non-directional edge. However, this method has difficulty in extracting highly similar edges although it can describe image contour information from multispectral images. The multi-oriented Sobel filters used in the edge-oriented histogram are replaced by the multi-oriented and multi-scale Log-Gabor filters in the Log-Gabor histogram descriptor [8] to overcome this deficiency. This method suffers from low efficiency and high dimensionality although it can obtain richer and more robust feature representation in multispectral images. In order to overcome this shortcoming and increase efficiency, a modification method called multispectral feature descriptor was proposed [9]. This approach can drastically minimize the dimension of the feature while retaining the description of feature capabilities.

II. METHODOLOGY

The key feature to characterize structures that the image gradients can usually express is the contour information of an image. However, the gradient directions in multispectral images are inconsistent due to nonlinear intensity changes, leading to the failure of similar structures being obtained [10]. In order to solve this issue, an isotropic extractor is proposed to construct the structure guidance image that is