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Regular article

A categorization method of infrared polarization and intensity image fusion algorithm based on the transfer ability of difference features

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HIGHLIGHTS

- The infrared polarization and intensity images fusion algorithms are analyzed.
- The features of fusion algorithms are described.
- The difference feature transform ability evaluation vector is proposed.
- The fusion algorithms are effectively classified by vector.
- The categorization provides effective basis for the selection algorithm.

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ABSTRACT

The fusion of infrared polarization and intensity image can significantly improve the detection performance of target, and the fused image is more suitable for human visual perception and further image-processing tasks. In this paper, a new categorization method of infrared polarization and intensity image fusion algorithm based on the transfer ability of difference feature is proposed. Firstly, the difference feature between two kinds of image and the characteristics of different fusion algorithms are analyzed and summarized. Second, an evaluation vector of fusion algorithm for difference feature transform ability is constructed. Thirdly, the transfer ability of fusion algorithm for difference feature is estimated by the evaluation vector, and the degree of transfer ability of fusion algorithm for difference feature is analyzed. Finally the fusion algorithms are classified by the degree of transfer ability of fusion algorithm for difference feature. The results shows that the proposed fusion algorithm categorization method helps select fusion algorithms in actual scene.

1. Introduction

By detecting the thermal difference of objects, infrared thermal imaging system can distinguish the different objects [1]. When the temperature of object is the same as or close to the adjoining objects, the target can be missing. The infrared polarization imaging can improve the performance of target detection by infrared polarization properties, and it can obtain multi-dimensional polarization information [2]. As infrared polarization imaging has relationships with a number of factors, including material, geometry, environment factors and so on. So the fusion of infrared polarization and intensity image can effectively improve the quality of target detection and recognition [3]. The fusion of two kinds of image has been used in many important applications, such as battlefield reconnaissance, early warning, the sea rescue, and disaster prevention, it has become one of hotspots in the infrared information processing.

So far, the research of image fusion are mainly about infrared and visible images fusion, multi-focus images fusion, and multi-modal medical images fusion, many fusion algorithms had been developed [4–6]. Due to characteristics of different fusion algorithm are different, in order to select suitable fusion algorithm to meet the requirements of fusion, the fusion algorithms are classified, and the performance of algorithms is evaluated. According to the level of fusion, fusion algorithms can be categorized into pixel, feature, and decision levels [7], and most of image fusion algorithms belong to the pixel level. According to the fusion processing, fusion algorithms can be categorized into the spatial domain and transform domain. The spatial domain fusion techniques primitive include pixel averaging method (PA), maximum value selection (MVS), and PCA [8,9], while the common transform

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domain techniques include Laplacian pyramid transform (LP) [10], discrete wavelet (DWT) [11,12], stationary wavelet (SWT), and dual-tree complex wavelet (DTCWT) [13,14]. Due to the wavelets conduct decomposition over a limited dictionary in which the two dimensional bases simply consist of all possible tensor products of one-dimensional basis function, various multi-scale geometrical analysis methods, including non-subsample contourlet transform (NSCT) [15–17], and non-subsample shearlet transform (NSST) [18–20], have been developed. Furthermore, some novel multi-scale geometrical analysis methods that combine the characteristic of preserving edge have been proposed, such as multi-scale bilateral filter transform (MSBT) [21,22] and multi-scale guider filter transform (MSGT) [23–25]. The performance of different fusion algorithms are also evaluated by using different quality metric of fused image [26], then the fusion quality of different fusion algorithm is distinguished, and the fusion algorithms can be selected according to the value of metric. The general framework for multi-resolution image fusion is developed to reframe the multi-resolution-based fusion methodology into a common formalism [27,28].

With the development of infrared polarization imaging, the infrared polarization and intensity image fusion is an increasing concern in the infrared information processing domain. Some fusion algorithms are applied to the infrared polarization and intensity image fusion, such as DWT [29–31], SWT, NSCT [32–34], and NSST [35], and then how to select suitable algorithms for meeting needs of infrared polarization and intensity images fusion becomes critical in the infrared image information domain. However the current categorization methods and quality evaluation of fusion algorithms focused mainly on the infrared and visible images fusion, multi-focus images fusion, and multimodal medical images fusion, and the current categorization methods are general summary of different components of algorithm, and the changes of performance of the algorithm is bigger, when the source images are changed, while the fusion ability of different fusion algorithms for different features between infrared polarization and intensity images is merely researched. So the current categorization methods and quality evaluation of fusion algorithms is not suitable to provide evidence for the selection of fusion algorithms in the different infrared polarization and intensity images fusion.

In this paper, a novel method to solve the above problems is proposed. Firstly, the difference features between images and the characteristics of algorithm are analyzed. Then difference feature transform ability of fusion algorithm is proposed to describe the characteristics of algorithm and the difference feature transform ability evaluation vector is constructed. Next, difference feature transform ability of the fusion algorithm is evaluated by using the difference feature transform ability evaluation vector. Finally, the different fusion algorithms are categorized based on the difference feature transform ability. The result shows that this categorization method helps the select suitable fusion algorithm in the infrared polarization and intensity image fusion.

2. The analysis of the characteristics of fusion algorithm

2.1. The analysis of difference features between infrared polarization and intensity image

Infrared polarization and intensity images have obvious difference. Infrared polarization image have salient high-frequency features, such as edge and texture, while infrared intensity images have salient low-frequency features, such as brightness and contour. Fig. 1 displays the original images obtained from our team, namely the vehicle and building infrared polarization images (shown Fig. 1(a) and (c)) and the vehicle and building infrared intensity images (shown Fig. 1(b) and (d)). Fig. 1(a) and (c) are darker, while Fig. 1(b) and (d) are lighter. Fig. 2 is the edge image of infrared polarization and intensity images detected by canny algorithm [36], namely the edge image of infrared polarization images (shown Fig. 2(a) and (c)) and the edge image of infrared intensity images (shown Fig. 2(b) and (d)). Fig. 2 clearly shows that infrared polarization image has the salient edge information and richer detail information, and infrared intensity image has the better all over contour feature.

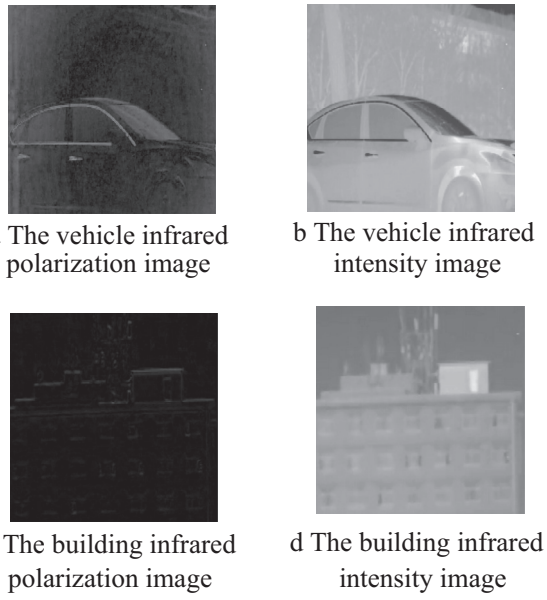

Fig. 1. The infrared polarization and intensity image.

Based on the above analysis, the difference features between infrared polarization and intensity image mainly are brightness, contour, edge, and texture difference. Human visual system is the most sensitive to the brightness of the image features, so two kinds of image fusion should the most completely retain the brightness feature of infrared intensity, as well as, two kinds of image fusion also must retain the structure features of objects in two types of image and details features in infrared polarization image to completely describe the target information.

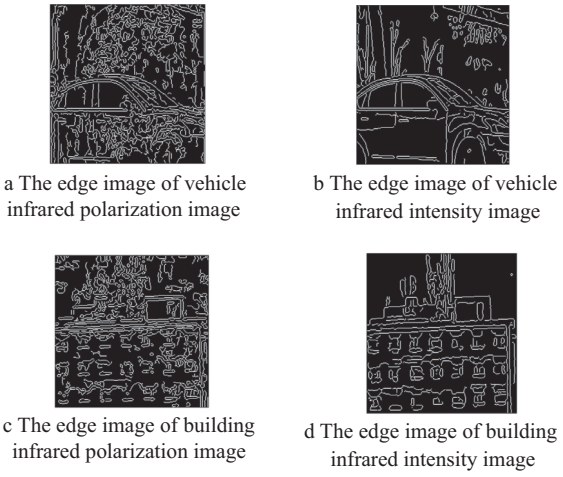

Fig. 2. The edge image of infrared polarization and intensity image.