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Infrared and visual image fusion through infrared feature extraction and visual information preservation

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HIGHLIGHTS

- A novel framework is proposed for infrared and visual image fusion.
- An efficient and effective infrared feature extraction method is proposed.
- Our algorithm well integrates infrared features and preserves visual information.
- Our algorithm is simple, fast yet effective for infrared and visual image fusion

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ABSTRACT

The ideal fusion of the infrared image and visual image should integrate the important bright features of the infrared image, and preserve much original visual information of the visual image. To achieve this purpose, we propose a simple, fast yet effective infrared and visual image fusion algorithm through infrared feature extraction and visual information preservation. Firstly, we take advantage of quadtree decomposition and Bézier interpolation to reconstruct the infrared background. Secondly, the infrared bright features are extracted by subtracting the reconstructed background from the infrared image and then refined by reducing the redundant background information. To inhibit the over-exposure problem, the refined infrared features are adaptively suppressed and then added on the visual image to achieve the final fusion image. In this way, the fusion image could not only reveal the invisible but important infrared objects by integrating the infrared bright features, but also show good visual quality by preserving much original visual information. Experiments performed on the commonly used image sets validate that the proposed algorithm outperforms several representative image fusion algorithms in most of the cases.

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1. Introduction

Various types of optical sensors could capture different perspectives of circumstance information, fusion of which is helpful for percieving the supervised circumstance [1–5]. For instance, multimodal medical image fusion [6,7] could assisst surgeons to diagnose diseases, satellite image fusion [8] could produce images with more detailed geomorphic information, and multi-focus image fusion [9,10] could produce more clear image. As for infrared and visual image fusion [11,2,12–15], it holds an important place in the field of image fusion and has been widely used in military actions and civil surveillance systems. Therefore, developments of effective infrared and visual image fusion algorithms are necessary and meaningful.

In general, the visual image contains most of the visual information, which is suitable to percept by the human vision system. While the infrared image often reveals the potential but invisible objects in the visual image, which however is very crucial for fully understanding the actual scene [3]. Therefore, the ideal fusion result of the infrared image and visual image should not only substantially integrate the important features (often bright features) of the infrared image to reveal the potentially suspicious objects, but also preserve much original visual information of the visual image to let us better percept the scene [15].

In recent years, many algorithms have been proposed to fuse the infrared image and visual image, and usually can be classified in two categories: the region based algorithms and the multi-scale scheme based algorithms. The region based algorithms [12]

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firstly segment the source images into multiple regions, and then combine the salient regions together to achieve the fusion image. This kind of algorithms can hardly obtain accurate segmentation result, which therefore leads to unsatisfactory fusion effect. While the multi-scale scheme based algorithms are most popular among the recently presented infrared and visual image fusion algorithms, such as the pyramid based [16–18], wavelet based [19,20,13,21] and morphology based algorithms [3,14,22]. These algorithms extract the salient features from the infrared image and visual image in some kind of scale space, and then the multi-scale image features, which often refer to the sharp features, are integrated together to produce the final fusion image. Their fusion results are usually pleasant for the perception of human vision systems. However, the fusion images of these algorithms often suffer from blurring effect or losing much visual image information [15], which would impact the visual quality of the fusion images.

Infrared and visual image fusion is mostly in need for supervising the low-light circumstance, under which the visual image captures much visible information of the supervised circumstance and the infrared image usually captures few invisible but important information. Besides, under the low-light circumstance, the infrared image and visual image will often have low correlation, thus an intuitive way to fuse the infrared image and visual image is by directly injecting the bright features of the infrared image to visual image. Therefore, according to the above idea, we propose a novel infrared and visual image fusion algorithm through infrared feature extraction and visual information preservation, which is designed especially for the low-light circumstance. The proposed algorithm is simple, fast yet effective, and achieves state-of-the-art results on the testing dataset.

In our algorithm, quadtree decomposition and Bézier interpolation are firstly utilized to reconstruct the infrared background, which is then subtracted from the infrared image to extract the infrared bright features. Secondly, the infrared features are refined through background reduction and over-exposure suppression. Finally, the visual image and refined bright features are integrated together to produce the final fusion image. Because of the effective infrared feature extraction and image fusion strategies, the produced fusion image by our algorithm could well integrate the useful bright features from the infrared image, while preserving much visual information from the visual image. For the better perception of our algorithm, the general framework of our algorithm is illustrated in Fig. 1. Finally, the contributions of this paper can be concluded in two aspects: firstly, we proposed a novel framework for infrared and visual image fusion, which is beneficial for the integration of the infrared features and preservation of the visual information; secondly, we proposed an efficient and effective method for infrared feature extraction, which is crucial for infrared and visual image fusion.

This paper is organized as follows. In Section 2, the proposed algorithm is introduced in detail. Then, experimental results and discussions are described in Section 3. Finally, conclusions are made in Section 4.

2. Proposed algorithm

As depicted in the above section, the proposed algorithm mainly includes three procedures, i.e., infrared feature extraction, infrared feature enhancement and image fusion. In this section, we introduce our algorithm following these three procedures, and finally make some discussions about parameter settings.

2.1. Infrared feature extraction

Through observing large amount of infrared images most of which were captured under low-light circumstance, we find that the infrared background is usually smoother and darker than the useful bright features due to the characteristics of the infrared imaging system. Thus, the infrared image features could be extracted following the idea that the background of the infrared image is firstly reconstructed, and then the infrared bright features are extracted by subtracting the background from the infrared image.

As is known, morphological operators (opening and closing) and Bézier interpolation are two basic and widely used techniques for background reconstruction. Morphological opening operator could be used to efficiently estimate the infrared background, but the estimated background often yields blocking artifacts which impact the accuracy of infrared feature extraction. While Bézier interpolation could generate one smooth convex background, which is much similar to the actual background and desirable for extracting the infrared bright features. In addition, a visual comparison example of the opening operator and Bézier interpolation method in reconstructing the infrared background is illustrated in Fig. 2, which shows Bézier interpolation method is more superior and suitable for reconstructing the infrared background than the morphological method.

Therefore in this paper, we adopt the Bézier interpolation method [23] to reconstruct the infrared background. In essence, Bézier interpolation is one method to restore a large-scale matrix by interpolating some already known control points, which can be adapted to

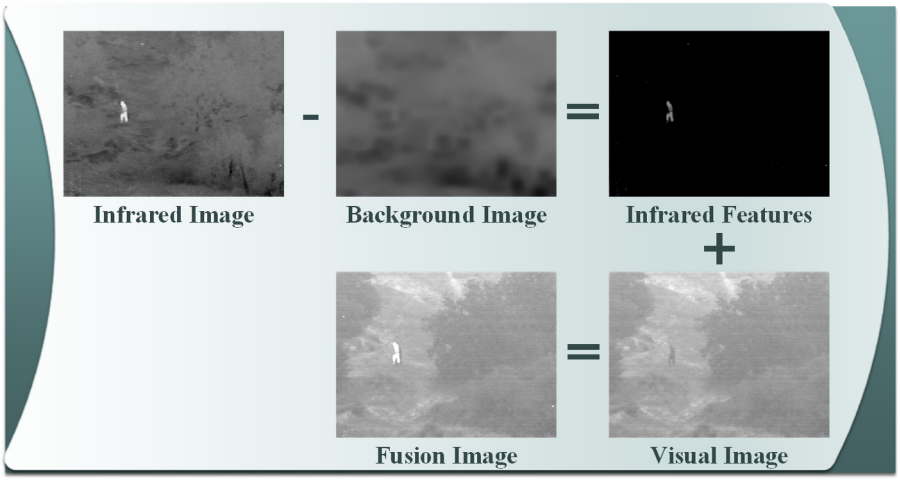

Fig. 1. General framework of the propose algorithm.

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