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Multiscale infrared and visible image fusion using gradient domain guided image filtering

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Abstract: For better surveillance with infrared and visible imaging, a novel hybrid multiscale decomposition fusion method using gradient domain guided image filtering (HMSD-GDGF) is proposed in this study. In this method, hybrid multiscale decomposition with guided image filtering and gradient domain guided image filtering of source images are first applied before the weight maps of each scale are obtained using a saliency detection technology and filtering means with three different fusion rules at different scales. The three types of fusion rules are for small-scale detail level, large-scale detail level, and base level. Finally, the target becomes more salient and can be more easily detected in the fusion result, with the detail information of the scene being fully displayed. After analyzing the experimental comparisons with state-of-the-art fusion methods, the HMSD-GDGF method has obvious advantages in fidelity of salient information (including structural similarity, brightness, and contrast), preservation of edge features, and human visual perception. Therefore, visual effects can be improved by using the proposed HMSD-GDGF method.

Keywords: image fusion; gradient domain guided image filtering; multiscale decomposition; infrared and visible imaging; visual saliency

1. INTRODUCTION

Image fusion is one of the current research hotspots. It has been successfully applied in remote sensing, medical and surveillance fields [1], having shown a wide range of possible applications. Infrared and visible image fusion technology is an important branch of multisource image sensing. It can effectively improve the perception of a scene in addition to the ability of detecting and recognizing the target [2]. Concerning image fusion methods, there are different characteristics, and research in various application areas is being conducted. For surveillance applications, the aim is to improve the ability of both scene perception and target detection/recognition as much as possible. Therefore, by making full use of the overall details from a visible image and significant thermal targets from an infrared image, the fused images approach the human visual perception and the targets can be easily detected/recognized, even under a low-light-level condition (nighttime) or in bad weather caused by dust or fog. The mid-wave infrared (MWIR) or long-wave infrared (LWIR) camera is often used to detect targets in the dark or occluded regions for surveillance applications.

Pixel-level image fusion methods are the focus of this study. Currently, many fusion methods have been proposed. These are mainly based on multiscale decomposition (MSD) [3–19], sparse representation [20-22], pixel/transformation domain [23,24], and combinations of these three types [25,26]. The methods based on MSD can accurately extract the details and edge information at different scales. This property can help reduce the halo effect and aliasing artifacts in the fusion process to obtain better details and edge information [1]. The MSD method mainly has pyramid decomposition [3,4], wavelet transform decomposition [5–10], and edge-preserving filtering decomposition [11–19]. As the quality of edges will directly affect the human visual perception, it is important to preserve the edges from source images in the fusion process. Edge-preserving filtering is also effectively used in image classification [27,28]. The edge-preserving filtering decomposition has shift-invariance and a satisfactory edge preservation performance. Existing MSD methods based on edge-preserving are mainly bilateral filtering [11,18], guided filtering [12,14,15,19], nonlinear edge-preserving filtering with weighted least squares [13], cross bilateral filtering [16], and directional nonlocal means filtering [17]. Although the above methods have a certain degree of edge protection, the edge-preserving filters used in these methods do not have explicit edge-aware constraints; thus, the edges cannot be preserved well in the filtering process. This may cause loss of edges and result in reduced quality of the fused image. To enhance the visual effect in surveillance applications, further research is required to improve edge preservation in the fused image.

Gradient domain guided image filtering (GDGF) [29], which is an improved method of guided image filtering (GF) [30], has a better edge preservation performance. In addition, more details and edge information can be acquired at different scales using hybrid MSD methods. Thus, an infrared and visible image fusion method with hybrid MSD based on GDGF (HMSD-GDGF) is proposed in this study. In the proposed HMSD-GDGF fusion method, a saliency detection technology based on visual perception is used to extract important information at different scales. As the targets are always more important in infrared images, the weighted coefficients in a multiscale image combination are mainly based on the infrared image. At the same time, the details of the nontarget parts of the visible image, which are mainly the details of the scene, have to be retained as much as possible. Thus, better fusion results with important targets and easily perceptible scenes are achieved.