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Scene-based nonuniformity correction based on bilateral filter with reduced ghosting

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HIGHLIGHTS

- We determine whether the movement of the scene exists to decide to update the parameters or not.
- We decrease the update rate of correction factors in high brightness regions.
- We speed the update of correction factors in regions with brightness decreased sharply.

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ABSTRACT

In order to correct the nonuniformity noise of the IR imaging system, a nonuniformity correction deghosting algorithm based on high-brightness region detection was proposed. Firstly, the bilateral filter was used to filter the image. The high-brightness regions in the result image were detected, and the correction factors corresponding to the regions were reduced. And then, the positions were detected which are high-brightness pixels in former frame but are not in current frame, and the correction factors corresponding to the regions were enlarged. Thus, the wrong update of the correction factor caused by high-brightness region of both the current frame and the previous frame was reduced. The correction method was validated using a real image sequence. The experimental results showed that the suppression effect of the proposed algorithm on the 'ghost' effect caused by the high-brightness region is better than the other two algorithms named SLTH-NUC and BFTH-NUC, respectively. Moreover, the proposed algorithm can also suppress the 'ghost' effect caused by the sharp edge of the scene.

1. Introduction

The staring infrared imaging system plays more and more important role in military and civil applications because of its high sensitivity, strong detection ability and simple structure. Although infrared imaging technology has developed to a higher level, but due to the influence of infrared optical system, infrared focal plane arrays (IRFPA) materials and manufacturing processes, even under the condition of uniform infrared radiation, the responses of different detectors are nonuniform, that increases the space noise greatly, and reduces the image quality seriously [1]. Therefore, non uniformity correction must be performed before the infrared imaging system is put into use.

In recent years, the scene-based nonuniformity correction algorithm has been a hot point. New scene-based nonuniformity correction technologies constantly appear. Among them, more representative algorithms are the temporal high pass filtering algorithm [2,3], the constant statistics algorithm [4,5], the neural network algorithm [6], and the registration-based algorithm [7]. Due to the low computational complexity, good real-time performance and the ideal correction effect, the temporal high pass filtering algorithm has been widely studied and applied. However, when pursuing a higher processing speed, the 'ghost' effect occurs. In order to solve this problem, many effective algorithms have been proposed, such as the space low-pass and temporal high-pass (SLTH) algorithm presented by Qian [8], the bilateral-filter-based temporal high-pass (BFTH) algorithm presented by Zuo [9]. Although these algorithms can suppress the 'ghost' effect to a certain degree, but when a high temperature object with slow motion appears in the scene, it happens that the high-brightness region contributes too much while the correction factors updating. In this situation, the 'ghost' effect still exists and the accuracy of correction algorithm will decrease.

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The goal of this paper is to present a deghosting algorithm based on high brightness region detection when correcting the nonuniformity. The first step is to determine whether the scene is moving. If motion doesn't exist, the correction factor will not be updated, but the correction is still carried out using what has been learned so far. If motion is present, the image is filtered by the bilateral filter. A detector which can detect two kinds of special regions starts to work and the correction factors of the corresponding positions are adjusted. Through these procedures, the wrong update of the correction factor can be avoided and the 'ghost' effect can be suppressed.

The paper is organized as follows: In Section 2, a brief review of the BFTH algorithm is presented, and its shortcoming is analyzed. In Section 3, a novel algorithm to suppress the 'ghost' effect is put forward and a detailed description of the working principle of the algorithm is given. In Section 4, the proposed algorithm is validated using the real infrared sequences. Finally, a summary of the paper is carried out.

2. The BFTH algorithm and its shortcoming

2.1. BFTH algorithm

ZUO in literature [9] analyzes the SLTH algorithm, and points out that the SLTH algorithm reduces the effect of the scene information on the correction factors to suppress the 'ghost' effect by only using the high frequency information of the image. But the algorithm exists three aspects of defects in the implementation process: (1) it is difficult to find a suitable threshold to distinguish between the nonuniformity noise and the edges of the scene; (2) due to effect of the average filter, the halo effect appears in the high-frequency part of the image; (3) the element of the high frequency part which is larger than the threshold is set to zero, and does not participate in the calculation of nonuniformity, so that the nonuniformity parameter may not be updated in a long time, and the convergence rate of the algorithm is reduced. But in fact, these positions still contain nonuniformity noise.

In order to solve the above problems, ZUO means to use the bilateral filter, instead of QIAN's average filter, to process the image. The bilateral filter can effectively protect the edge information of the scene by taking not only the spatial distance but also the similarity of gray value into account between two pixels. The algorithm can be expressed as follows:

$$y_n = x_n - f_n \tag{1}$$

$$f_n = \frac{1}{M}x_n^{BFr} + \left(1 - \frac{1}{M}\right)f_{n-1} \tag{2}$$

$$x_n^{BFr} = x_n - x_n^{BF} \tag{3}$$

where y_n is the correction result image. f_n is the correction factor. x_n is the input image. x_n^{BF} and x_n^{BFr} are the output of bilateral filter and the residual image. $\frac{1}{M}$ is the update rate of f_n. The BFTH algorithm greatly reduces the scene edge information in the residual image x_n^{BFr}, and further reduces 'ghost' effect which arises in the SLTH algorithm.

2.2. Its shortcoming

Although the bilateral filter protects the edge of the scene in a certain extent, but some scene information which cannot be ignored still exists in the residual image x_n^{BFr}. In other words, the bilateral filter cannot separate the nonuniformity noise and the scene information completely. The residual scene information existing in the x_n^{BFr} affects the normal updating of the correction factor f_n, and reduces the correction effect. As is shown in Fig. 1, Fig. 1(a) is the raw image with nonuniformity from an infrared video sequences. Fig. 1(b) is the residual image x_n^{BFr} obtained using a bilateral filter, in which the nonuniformity is mainly presented in the form of interlaced stripes. We can see that the shape of a man

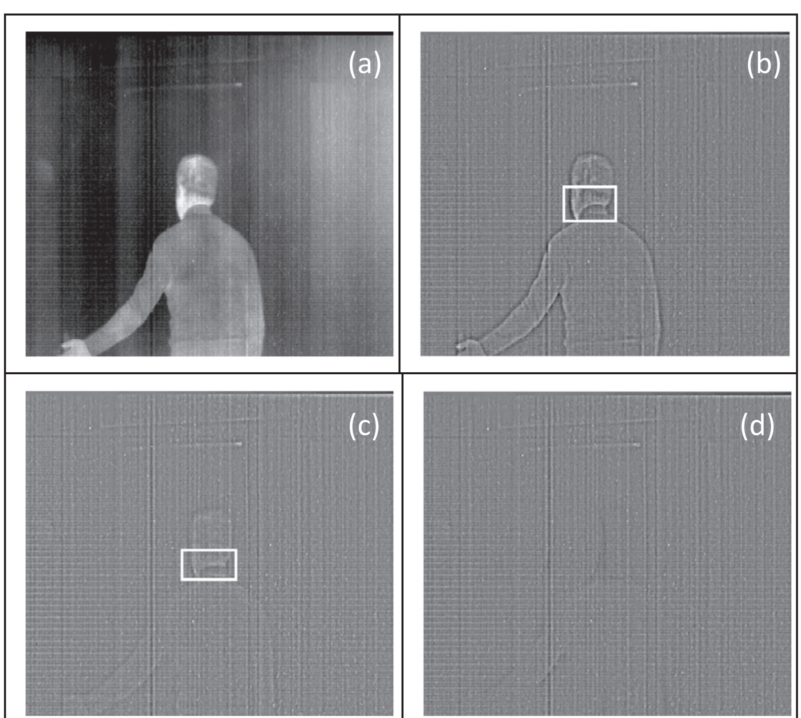

Fig. 1. Image separation result. (a)–(d) are the raw image, the residual of the bilateral filter, the correction factor obtained with BFTH algorithm and the correction factor obtained with proposed algorithm, respectively.