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# Dynamic Range Compression and Detail Enhancement Algorithm Based on Guided Filtering

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## Abstract

**In order to solve the problem of unreasonable contrast enhancement in high dynamic range infrared images and the problem of detail enhancement, a dynamic range compression and detail enhancement algorithm based on guided filtering was proposed. The base layer is compressed by the adaptive histogram equalization algorithm with limited contrast, and the detail layer is enhanced by the self-gain control. Finally, according to a certain weight, the first fusion is carried out to obtain the comprehensive subjective and objective experimental results of the enhanced detail image, relative to the histogram equalization BF&DDE and other algorithms, this algorithm can improve the contrast of infrared image in the process of dynamic range compression, highlight its detail information, and achieve good detail enhancement effect.**

## Keywords

**Guided filter; dynamic range adjustment and compression; image enhancement.**

## 1. Introduction

Because infrared radiation penetrates more than visible light in foggy weather, infrared detectors can work at night, and infrared images are used in more and more research fields, such as rock classification, medical diagnosis, aerospace, and so on Due to the long radiation wavelength, infrared images will be affected by various radiation in the atmospheric propagation, and there is a certain amount of attenuation in the process of transmission through the atmosphere, so infrared images obtained by infrared sensors have problems such as low resolution and poor contrast, and targets and details are easy to be covered up. The function of infrared image enhancement technology is outstanding people subjective some interested in infrared images or some characteristics of the target object, weaken or eliminate the infrared image without the interference of the information, so as to get a beneficial to the human eye observation or more suitable for computer analysis of infrared image processing. Therefore, research of infrared image enhancement technology is the key to the current infrared imaging.

In order to meet the requirements of different application fields and scenarios, the current infrared imaging system outputs original infrared images with 14-bit or higher bits. The current general display equipment's dynamic range of grayscale display is only 256 levels, so the original infrared data with 14-bit or higher bits obtained by the infrared imaging system needs to be compressed to 8.This is the dynamic Range Compression (DRC). If DRC is not compressed properly, it will lead to the possible loss of target details in the original 14-bit or higher infrared image, which will further degrade the quality of the original infrared image. Aiming at the problem of detail loss in dynamic compression and infrared image enhancement, this paper proposes a dynamic range compression and infrared image enhancement algorithm based on guided filtering.

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## 2. The Algorithm of the Paper

In this paper, the original 16-bit infrared image is used as the input image, and the image size is 640×480. The block diagram of the algorithm is shown in Figure 2. Firstly, the original high-dynamic range infrared image is guided filtering to obtain the image base layer, and then the obtained base layer is subtracted from the original image to obtain the image detail layer. Since the gray distribution of the original infrared image is often concentrated in a certain gray range, and the distribution in other gray range is few, the obtained base layer often has a low contrast and the image is dark[1]. In this paper, the adaptive histogram equalization with contrast restriction is used to process the base layer, which can enhance the contrast well. The detail layer is obtained by subtraction of the original image and the base layer. In this paper, the potential dim targets in the detail layer are enhanced by the self-gain control, and the 8-bit output image is obtained by adaptive fusion.

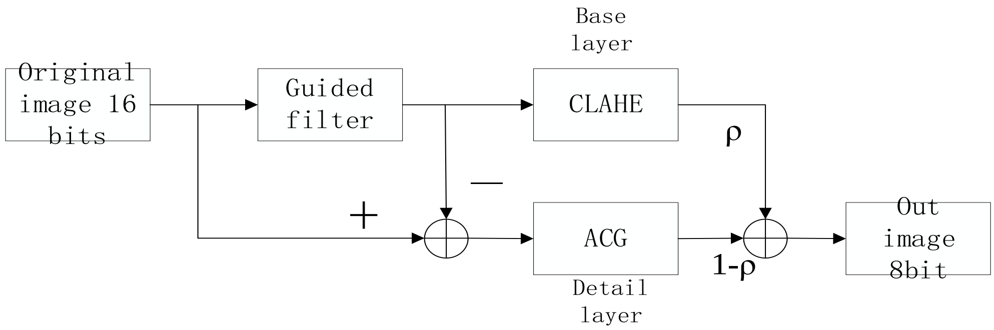


Figure 2 The algorithm framework of Original infrared image proposed in this paper

### 2.1. Guided Filter

Image edges and textures easily blur in the image processing, so we need a suitable layered method to preserve the image edge and texture Guide filtering according to guide the figure structure of image filtering, the input image as a guide when figure can achieve the goal of keeping the input image gradient structure, the image edge and texture by better protection. Based on this theory, compared with the previous algorithms, the guided filter further simplifies the relationship between the input image and the output image. In a local processing template, the guiding filtering(GIF)[2] algorithm defines the output image and the guiding image as a linear correlation model.

The boot filter can be defined in the following form:

$$q_i = \sum_j W_{ij}(I)p_j \tag{2.1.1}$$

Among them, the I to the window of the image to be processed at the center of the output pixels, j neighbors domain pixels, image I needed to guide filter guided imagery, $q_i$ is the output image after filtering, the output image with linear relationship in the input image. $W_{ij}$ is according to the weight value specified in the boot image I, the specific value generally through the derivation of the input image and the output image, its expression is as follows:

$$W_{ij} = \frac{1}{\|w\|^2}\sum_{k:(i,j)\in w_k}\left(1+\frac{(I_j-\mu_k)(I_j-\mu_k)}{\sigma_k^2+\epsilon}\right) \tag{2.1.2}$$

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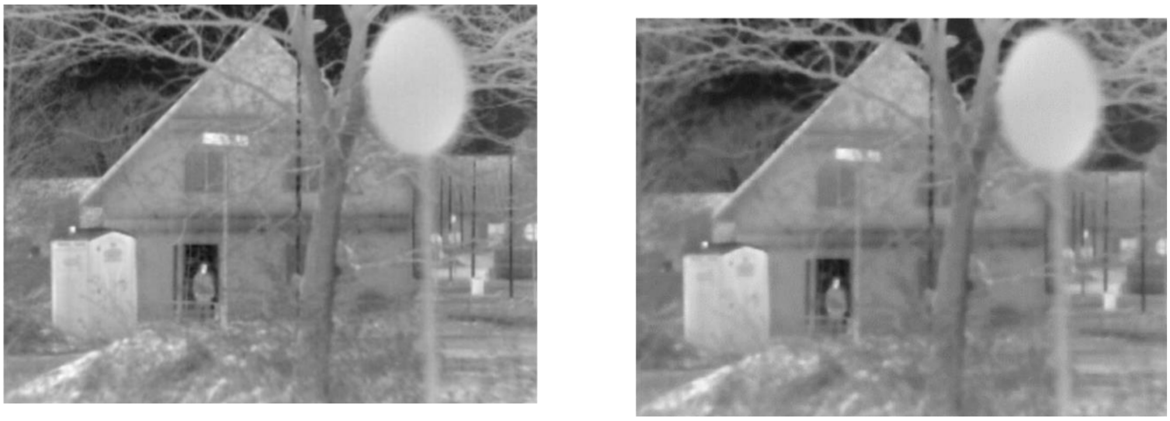
Where,$\mu_k$ is the mean value of pixels contained in the window; $I_j$ and $I_j$ are the values of two adjacent pixels; $\sigma_k^2$ is the variance of pixels in the table window; $\epsilon$ is the penalty coefficient, which exists to prevent the overall value from being too large. The filtered image is shown below, and it can be seen that the edges and textures of the original image are well preserved.



(a) (b)

Figure 2.1 (a)The infrared image.(b)the guided filter image

## 2.2. Contrast Limited Adaptive Histogram Equalization

Because the overall gray level of infrared image is concentrated in one area, the image contrast after filtering is too low, which makes it impossible to observe and monitor normally. The purpose of the histogram equalization (HE)[3] method is to compress the infrared image with high dynamic range into low dynamic range under the original histogram distribution, so that the compressed infrared image can be normally displayed on the device screen, but the edges and textures will be covered up. In order to ensure that in the process of high dynamic range image is compressed edges and textures are not conceal, is not because the grayscale decreases and the original for the details of the target in infrared image grey value and adjacent area lost caused by combining the grey value target, this paper adopts Contrast Limited Adaptive Histogram Equalization(CLAHE)[4] algorithm to the base layer is compressed, the result diagram as follows, it can be seen that after CLAHE processed. The image is clearer than the image after HE processing, the pixel distribution is more uniform, and the edges and textures are more obvious.

(a)The base layer processed by HE (b) The detail layer processed by guided filter

Figure 2.2 (a)The result comparison of base layer by HE and CLAHE

## 2.3. Automatic Gain Control for Detail Layer Processing

High dynamic range of the original infrared images are layered layer to get the details of the image for the high frequency part of original high dynamic range image contains the details of the scene required target not only, also contains a high dynamic range of the original infrared images in various types of noise, and because such as characterized by high frequency characteristics, noise and detail information, therefore, it is easy to detail enhancement. In this method, noise is mistaken for detail and enhanced, resulting in significant enhancement of noise in the composite image, which affects the visual effect[5].According to the above problems, in the processing of detail layer images, it is not only necessary to maintain or improve the edge information of detail layer, but also to prevent the algorithm from enhancing the noise which is also the high frequency component at the same time when the texture information of detail layer image is improved, so that the noise will have a great impact on the overall image. For the guided filtering algorithm, when I=p, that is, the input image to be processed and the guided image are the same image, the bilateral filtering algorithm becomes an edge-preserving filter. At this time,$a_k$,$b_k$ and $\epsilon$in GIF can also be represented as follows:

$$a_k = \frac{\sigma_k^2}{\sigma_k^2+\epsilon} \quad (2.3.1)$$

$$b_k = (1-a_k)\overline{p_k} \quad (2.3.2)$$

Where, E can be regarded as the threshold value defining the smooth region and the edge region. the above equation, the following conclusions can be drawn:

(1)If the region is relatively smooth in a filtering window, then the variance $a_k$ will be much smaller than $\epsilon$, $b_k \approx \overline{p_k}$.

(2)If there is an obvious gray value mutation point in this region, the edge is included, then the variance $a_k$ will be far greater than 1,$b_k \approx 0$.

From the above two cases, ax has the ability to distinguish smooth region and edge region for guiding filters, within the same filter window, all pixels of filtering weights are equal[6], but different weights of filtering window pixels in the filtering is different, for each pixel in infrared image (with the infrared image edge processing), its have different weighting coefficients So this article take as the adaptive gain coefficient of the detail layer image, the processing of the detail layer image can be expressed as shown in Equation (2.3.1)

$$I_{dp}(i,j) = (G_{max} \times a(i,j)_{avg} + G_{min}) \times IMG_{detail}(i,j) \quad (2.3.1)$$

$G_{max}$ and $G_{min}$ can linearly map the gain to an appropriate value, set $G_{max}$=5 and $G_{min}$=2.5, respectively. When there are edges or other details in the filter template, the $a(i,j)_{avg}$ is close to 1, while for the smooth region in the infrared image, it is close to 0, the edge location is well identified in the filtering process.

## 2.4. Linear fusion

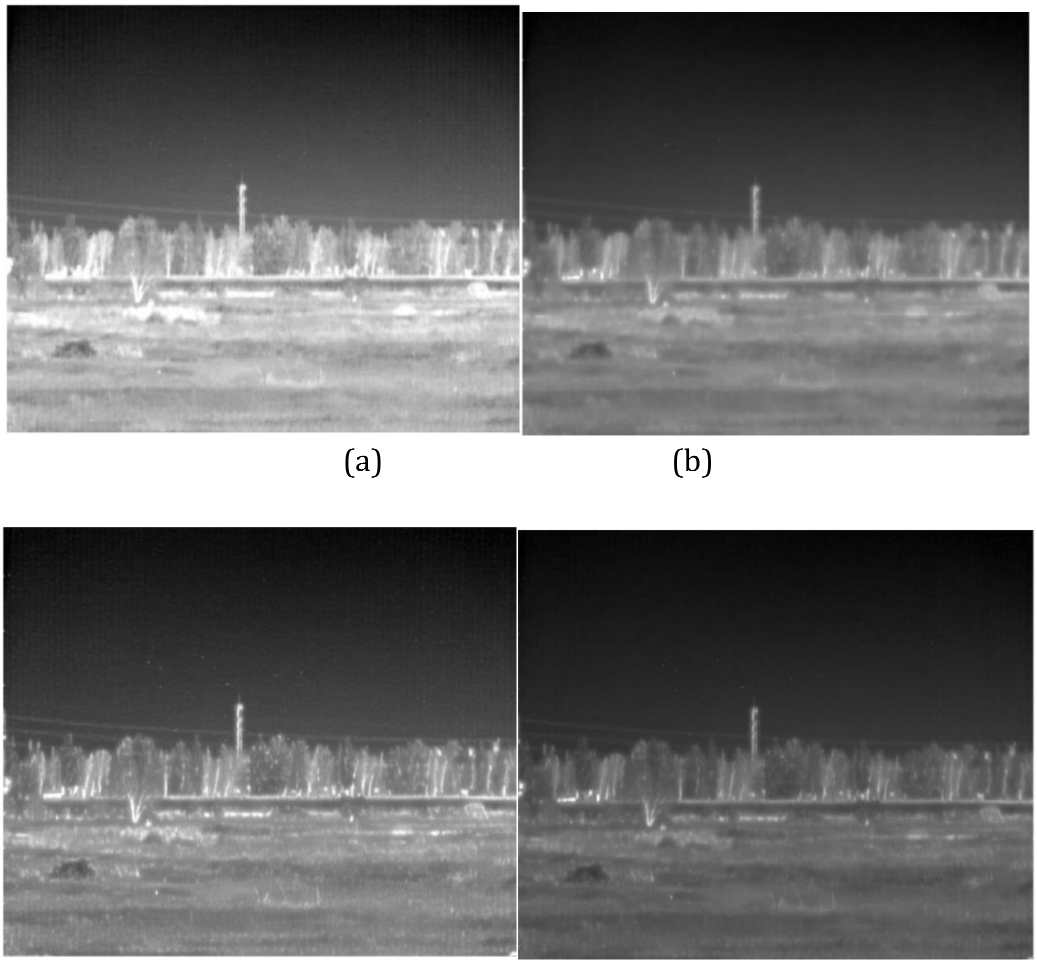
In this paper, the method of first fusion is adopted to fuse the enhanced base layer image and the enhanced detail layer image in different proportions[7]. The formula is as follows:

$$IMG_{out} = (1-p) \times I_{bp} + p \times I_{dp} \quad (1)$$

Where,$IMG_{out}$ is the output infrared image after fusion,$I_{bp}$ and $I_{dp}$ is the component of base layer and detail layer respectively,p is the fusion coefficient, and the range is (0,1) is the balance of detail enhancement effect and visual effect, and p=0.3 can get a better fusion effect.

# 3. Experiment Results

In order to verify the enhancement effect of the algorithm in this paper, the initial infrared image of 16bit,640×480,and using HE[6], BF&DDE[7],AGF&DDE[8] algorithm for comparison.



(a) (b) (c) (d)

Figure 2.2 The Results of Mixed scene image (a)HE(b)BF&DDE(c)AGF&DDE(d)The algorithm of this paper

As shown in figure (a), the tree texture in the distance appears brightness saturation in the HE algorithm shown in Figure (a), so that the tree texture is occluded. (b) The tree texture in the image is poorly displayed, while (c) and (d) the tree texture can be better displayed, and the strip noise in figure (d) is effectively suppressed, which proves that the algorithm in this paper has a good effect.

In addition, three objective evaluation indexes including information entropy, standard deviation and average gradient were used to objectively evaluate the enhanced images with different algorithms in three groups of different scenes, as shown in Table 1.From the test results, three scenarios algorithm in this paper has obtained the maximum image information office, the information entropy value shows that the greater the image information, the more the other after dealing with the algorithm in this paper the image standard deviation and average gradient also got a lot of ascension, illustrates the same after this algorithm enhance image details have made a lot of ascension.

Table 1 Four Algorithm Comparing

| | HE | BF&DDE | AGF&DDE | The algorithm of this paper |
|---|---|---|---|---|
| Entropy | 5.4769 | 5.6762 | 5.3824 | 5.8781 |
| Standard Deviation | 4.9421 | 4.8319 | 5.1027 | 5.2028 |
| 3Average Gradient | 3.3046 | 3.4973 | 3.5014 | 3.5057 |

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## 4. Summary

In order to improve the details of potential or dim targets in high dynamic range infrared images, noise suppression and contrast enhancement should be taken into account, a dynamic range compression and detail enhancement algorithm based on guided filter image layer was proposed. Through the simulation of infrared image processing effects of different algorithms under different scenes, it can be found that the algorithm in this paper can improve the contrast of infrared image target scene in the process of dynamic range compression, highlight its texture features, and achieve good detail enhancement effect, which has certain practical application value.

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