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Infrared Image Enhancement Using Normalization and Beta function

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ABSTRACT – *Infrared (IR) cameras are used in various night vision applications such as driver assistance system, surveillance system, military applications. During video acquisition, the IR frames are affected by different types of noises such as Gaussian, salt & pepper. This paper proposes a novel method for IR image enhancement using normalisation and beta function. This method which enhances the contrast of an image and its histogram is equalized. The histogram analysis and the psnr value indicate that the proposed method is superior over the existing techniques.*

I. INTRODUCTION

IR images are the source of information which is mainly used in night time applications, such as night vision driver assistance systems, military applications, surveillance systems etc. There are two types of IR images, Far infrared (FIR) and Near infrared (NIR) images. The FIR camera captures FIR images by detecting the heat radiation produced by the object. The NIR camera radiates an IR wave and the reflected wave from the object is used to capture the scene. The wavelength of FIR camera is 8 to 14µm and that of NIR camera is 800 to 900 nm. During night time video acquisition, the video is affected by various kinds of noises, such as salt & pepper, Gaussian etc. and is also affected by the atmospheric conditions, such as, rain, snow fall etc. This may affect the heat radiated by the object, i.e. the strength of the heat production will be very small, which will degrade the quality of the captured image. So in a night vision system, it is important to improve the quality of the image.

Histogram equalization [1], adaptive histogram equalization [2] and histogram matching [3] are the most common image enhancement techniques. These methods are easy to implement, but they do not give satisfactory enhancement for IR images. It is in this context we are proposing a novel method for the enhancement of IR images.

The remainder of this paper is organized as follows. In Section II, we describe the proposed IR image enhancement algorithm. Experimental results and related discussions are given in Section III. The paper is concluded in section VI.

II. IR IMAGE ENHANCEMENT ALGORITHM

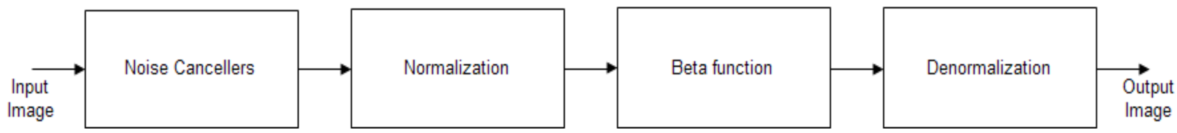

Figure 1. Overall System

Fig. 1 shows the overall system used for enhancing the IR images [4]. Noise cancellers are used for the cancellation of noise in the video [5]. For the noise cancellation, we can use median, wiener and homomorphic filters. After the Noise cancellation the next step is to normalize [6] the image. The algorithm for the enhancing section is shown below. The input gray-scale image pixel, I_{xy} is re-written as follows.

$$I_{xy} = I_{min} + T * (I_{max} - I_{min.}) * I \quad \ldots\ldots\ldots (1)$$

Where, I is the original image and I_{max} and I_{min} are the maximum and minimum intensity value of image. T is a small constant and its value is between 0 and 1.

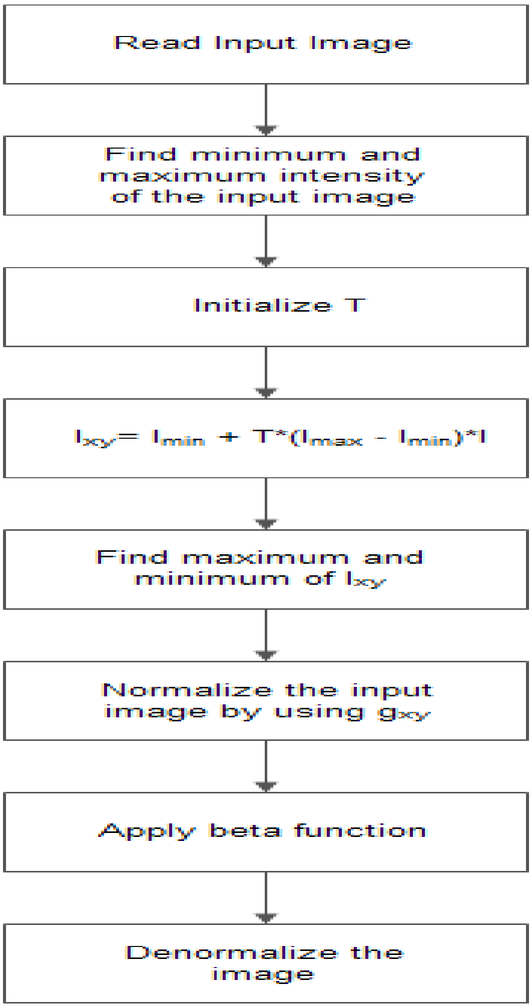

Figure 2 Flow chart of the enhancing section

Let i'_{max} and i'_{min} be the maximum and minimum values of I_{xy} respectively. Then we can apply the normalization equation (2). Then we get a normalized image, i.e. the pixel values in between 0 and 1.

$$g_{xy} = \frac{I_{xy} - i_{min}}{i_{max} - i_{min}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

The next step is to apply the beta function [3]. The normalized incomplete Beta function f(u) is given by

$$f(u) = B^{-1}(\alpha, \beta) \int_0^u t^{\alpha-1}(1-t)^{\beta-1} dt.. \text{(3)}$$

And $B(\alpha, \beta)$ is the Beta function defined as

$$B(\alpha, \beta) = \int_0^1 t^{\alpha-1}(1-t)^{\beta-1} dt\ldots\ldots\ldots \text{(4)}$$

Where α and β are optical coefficients. The optimized values of both α and β are 6 for NIR images and for FIR image both have value 3.

Then the non-linear transformation function is defined as f (u) $(0 \le u \le 1)$, and transform the original normalized image with the formula

$$G_{xy} = f(g_{xy}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

The value of G_{xy} ranges from 0 to 1. Assuming the output image gray value to be in the range [0,255], the denormalization treatment can be applied to the transformed image in (5) to obtain the enhanced image, I_{xy}.

$$I_{xy} = 255 * G_{xy} \quad \text{……………………….(6)}$$

III. EXPERIMENTAL RESULT

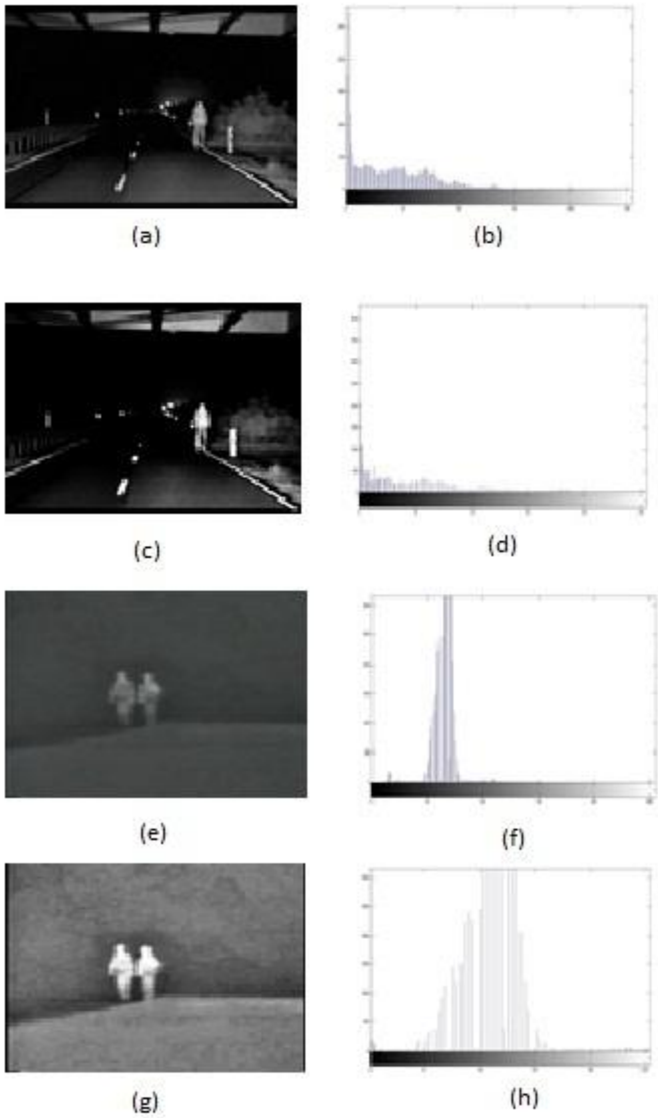

Figure.3. Enhancement results for an IR image (a) & (b) NIR image and its histogram. (c) & (d) Enhanced image and its histogram. (e) & (f) FIR image and its histogram. (g) & (f) Enhanced FIR image and its histogram.

To evaluate the performance of the proposed algorithm, we acquired several NIR and FIR images. The results obtained for these images are shown in Fig. 3. Fig. 3(a) is the input NIR image and Fig. 3(e) is the input FIR image, Fig. 3(b) and Fig. 3(f) are the corresponding histograms. NIR image is 2D in nature and FIR image is 3D in nature. The enhanced images using the proposed method are shown in Fig. 3(c) and Fig. 3(g). Fig 3(f) and Fig 3(h) are the corresponding histograms. Comparing the histograms of input images with the histograms of their corresponding output images, the output histograms are found to be equalized. The equalized histograms show that the contrast of the input NIR and FIR images have enhanced i.e. the images are enhanced.

The table 1 shows the various psnr values of different image enhancement techniques for NIR and FIR images. When using histogram equalization the psnr values for NIR and FIR images are 7.37dB and 8.85 dB. For adaptive histogram equalization the psnr values for NIR and FIR images are 15.942 dB and 22.40 dB. When using histogram matching the psnr values for NIR image is 8.508dB and for FIR image 12.3dB. In the proposed method the psnr values for NIR image is 25.498dB and for FIR image 22.02dB.

The below results shows that, when using the existing methods, viz. histogram equalization, adaptive histogram equalization and histogram matching, the enhancement is very poor i.e. the psnr values are very low . These methods give more enhancement in FIR image than in NIR image. The results of proposed method show that, it gives more enhancement than the other three enhancement techniques. The proposed method gives more enhancements in NIR images than the FIR images.

PSNR				
Type of image	**Histogram equalization**	**Adaptive Histogram equalization**	**Histogram matching**	**Proposed method**
NIR	7.37	15.942	8.508	25.498
FIR	8.85	22.40	12.3	22.02

Table 1. PSNR values of various image enhancement techniques for NIR and FIR images

IV. CONCLUSION

We proposed a new IR image enhancement algorithm. The algorithm consists of normalization, solving the beta function and denormalization. This technique enhances the contrast of the IR image. After analysing the histograms of input and output images and the PSNR values, it can be observed that the proposed method gives better enhancement when compared to the various existing methods. The proposed method gave better results for FIR images than NIR image.

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