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# Enhancement of Infrared Images using Nonlinear Model

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**Abstract:** This paper presents a new enhancement approach for infrared images. The idea behind this technique is based on that modifies the local luminance mean of an image and controls the local contrast as a function of the local Luminance mean of the image. The algorithm first separates an image into LPF (low pass filtered) and HPF (high pass filtered) components. The LPF component then controls the amplitude of the HPF component to increase the local contrast. The LPF component is then subjected to a non-linearity to modify the local luminance mean of the image and is combined with the processed HPF component. Finally, this approach is enhanced to get an infrared image with better visual details.

**Keywords:** Image Enhancement , Nonlinear Enhancement Model and Entropy.

## 1 Introduction

Image enhancement is a very popular field in image processing. Enhancement aims at improving the visual quality of an image by reinforcing edges and smoothing flat areas. Several researchers haveevaded this field using different approaches such as simple filtering, adaptive filtering, waveletdenoising, homomorphic enhancement and etc, [1-4]. All these approaches concentrate on reinforcing the details of the image to be enhanced. IR vision is a key technology in a variety of military and civilian applications ranging from night vision to environmental monitoring and biomedical diagnostics devices. Military applications include target acquisition, surveillance, night vision, homing and tracking. Non-military uses include thermal efficiency analysis, remote temperature sensing, short-range wireless communications, spectroscopy, and weather forecasting. IR astronomy uses sensor-equipped telescopes to penetrate dusty regions of space, such as molecular clouds to detect cool objects such as planets, of the and to view highly red-shifted objects from the early days universe[5-8]. They can operate also on infrared images, it is desirable to modify the local contrast and local luminance mean. For example, when an image with a large dynamic range is recorded on a medium with a smaller dynamic range, the details of the image in the very high and/or low luminance regions cannot be well represented. One approach to such a problem is a simultaneous contrast enhancement and dynamic range reduction that can be accomplished by modification of the local contrast and the local luminance mean. In this paper, we develop this model that modifies the local contrast and the local luminance mean in a specific method, and uses it in a lot of application problems.

## 2 Nonlinear Enhancement Model

An image can be used represented as addition of two components as following equation [4, 9] :

$$f(n1, n2) = f_L(n1, n2) + (n1, n2\ ) \qquad (1)$$

$f(n1, n2)$ **is** original infrared image, $f_L(n1, n2)$is local luminance mean,$f_H(n1, n2)$ **is** local contrast.

To enhancing the image, then, is to increase$f_H(n1, n2)$and decrease$f_L(n1, n2)$.the local luminance mean is modified by a nonlinearity resulted $f'_L(n1, n2)$ and local contrast is modified by multiplication factor $k\ (f_L)$resulted $f'_H(n1, n2)$. The specific functional form of $k\ (f_L)$ depends on the particular application under consideration, and $k\ (f_L) >$1represents the local contrast increase while $k\ (f_L) <$1 represents local contrast decrease.

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This modification used as follow takes a larger $k\ (f_L)$and choose the nonlinearity taking into account $f_L(n1,n2)$change and $f_H(n1,n2)$ increase. This approach modifies the local contrast and the local luminance mean in a specific method as shown in Figure1. The results are combined to obtain the enhanced infrared image, $g(n1,n2)$ with more details as in the following equation [9]:

$$g(n1,n2) = f'_L(n1,n2) + f'_H(n1,n2) \quad (2)$$

## 3 The Proposed Enhancement Approach

In this approach, modifies the local contrast and the local luminance mean in a specific method to reinforce its details. These steps of the proposed approach can be summarized as follows and are depicted in Fig. (1).

1. Apply the low pass filtering to the original infrared image , $f(n1,n2)$ to get the local luminance mean $f_L(n1,n2)$.
2. Perform a subtraction an operation$f_L(n1,n2)$from $f(n1,n2)$to get the local contrast $f_H(n1,n2)$.
3. Modify $f_H(n1,n2)$ by multiplying$f_H(n1,n2)$with a scalar factor$k(f_L)$, $f'_H(n1,n2)$.
4. Modify $f_L(n1,n2)$by non-linearity function, $f'_L(n1,n2)$.
5. Combine the modified local contrast and local luminance mean to get the enhanced infrared image $g(n1,n2)$.

## 4 Entropy

Entropy is a measure of the average amount of information content of an image. For an 8-bit gray-scale image, the maximum entropy is 8. The entropy of the processed image is defined as follows [10]

$$E = \sum_{i=0}^{255} -p_i\, log_2(p_i) \quad (3)$$

Where $p_i$is the probability occurrence of pixel in the image having intensity '$i$'. Suppose the number of pixels having intensity '$i$' is $n_i$ and the image contains $n$pixels$p_i = {n_i}/{n}$. The larger the number of levels in an image, the higher is the entropy.

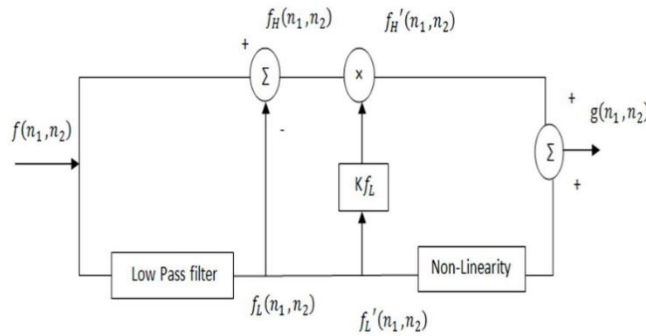


**Fig.1:** Steps of proposed algorithm

## 5 Experimental Results

In this section, two experiments are performed on two different infrared images to test the performance of the proposed enhancement algorithm. The steps of the algorithm mentioned in section (IV) are performed on these two images. For the purpose of evaluation metric for image quality is the entropy of the image. We use the entropy of the image of both the original infrared image and the enhanced one as an assistance tool with the visual evaluation. The results of the first experiment are shown in Fig. (2). Part (a) gives the original infrared image of gives the entropy of the original image before processing and Part (b) of the same figure gives the enhanced infrared image. We remark that the entropy of the original infrared image is 1.4605and the entropy of enhanced infrared image is 2.8655.it's clear the entropy of enhanced infrared image is larger than the entropy of the original infrared image. A similar experiment is carried out on another infrared image and the results are given in Fig. (3).From these results, due to the darkness of IR images, it is expected that their entropy will be small and entropy of enhanced image increased with a maximum of 8 bits. The proposed algorithm has enhanced the visual quality of the processed image as well as its entropy metric. It's shown that this technique has succeeded in the enhancement of the visual quality of that infrared image and more details have been obtained.

(a)Original IR image
E= 1.4605

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(b) Enhanced IR image
E= 2.8655

**Fig. 2:** Results of the first experiment.

(a)Original IR image
E= 1.4753

(b) Enhanced IR image
E= = 2.8949

**Fig. 3:** Results of the second experiment.

## References

[1] C . J. Zhang, F. Yang, X. D. Wang and H. R. Zhang, "An Efficient Non-Linear Algorithm for Contrast Enhancement Of Infrared Image" Proceedings of the Fourth International Conference on Machine Learning and Cybernetics, Guangzhou, 2005.

[2] M. S. Jadin, S. Taib ,” Infrared Image Enhancement and Segmentation for Extracting the Thermal Anomalies in Electrical Equipment”, **No. 4(120),** (2012).

[3] C. Zhang, X. Wang, H. Zhang, G. Lv, and H. Wei,”A Reducing Multi-Noise Contrast Enhancement Algorithm for Infrared Image”, Proceedings of the First International Conference on Innovative Computing, Information and Control, (2006).

[4] Rafael C. Gonzalez and Richard E. Woods. *Digital Image Processing*.

[5] M. Xia, and B. Liu, “ Image Registration by Super Curves,” *IEEE Trans. Image Processing* , vol. **13**, No.5, pp.720-732, May (2004).

[6] G. Piella and H. Heijmans, “ Multiresolution Image Fusion Guided By A Multimodal Segmentation,” in Proc. ACIVS, pp. S00-1 – S00-8, (2002).

[7] J. H. Shin, J. H. Jung, J.K. Paik and M. A. Abidi, “ Data Fusion-Based Spatio-Temporal Adaptive Interpolation For Low-Resolution Video,” in Proc. ICIP , (2001).

[8] R. Maini and H. Aggarwal,” A Comprehensive Review of Image Enhancement Techniques”, Journal Of Computing, VOL. 2, ISSUE 3, MARCH 2010, ISSN 2151-9617.

[9] Michael P. Ekstrom , Digital Image Processing Techniques, Academic Press , 28 oct. 1984 - 372 pages.

[10] D. Ramanan and K. E. Barner, “Nonlinear Image Interpolation Through Extended Permutation Filters,” in Proc. ICIP, (2002).

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