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Combined Linear And Nonlinear Image Enhancement

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Abstract— **Image Enhancement is a commonly used approach for de-blurring the image. In general, image enhancement is to increase the contrast and remove noise so that the processed image is more suitable for special applications. There are two approaches for this – linear and nonlinear. Each method has its own advantages and disadvantages. But studies over the years showed that real applications use both methods simultaneously. So in this paper, we propose an approach which combines linear and nonlinear image enhancement. For linear image enhancement we used Piecewise Linear contrast enhancement and for nonlinear we used method based on opportunity cost with some modifications. At the end, we proposed a combination algorithm which combines the results of both methods, and the results show that the combination of these methods are better than each alone. We used PSNR [6] as a basis for determining the quality of images.**

Keywords— **piecewise linear contrast enhancement, nonlinear image enhancement, opportunity costs, clipping, scaling**

I. INTRODUCTION

Image enhancement accentuates or sharpens image features such as edges, boundaries and contrast. Enhancement does not increase inherent information or content of data in image, rather it increases the dynamic range of data so that enhanced image is more suitable for special purposes. Nonlinear image enhancement scheme [1] used in this paper solves problem of parameter selection of clipping and scaling used in nonlinear enhancement. The modification of nonlinear method explained in [1] is used in this paper. For linear image enhancement, Piecewise linear contrast enhancement [2] is used. This method is used in linear enhancement as this is best among other linear enhancement methods [3]. Both process are done parallely on image. The basic method is shown in figure1.

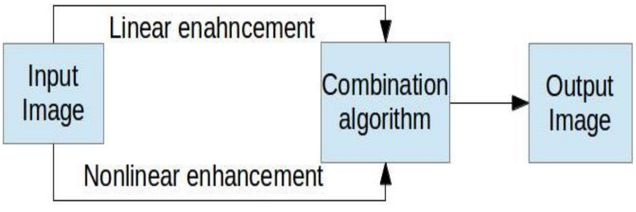


Fig. 1 Basic line diagram of proposed method

Actually proposed algorithm takes multiple images as input and enhances them at the same time. All images given as input go through both the processes one by one and then combination algorithm is applied on corresponding outputs of two algorithms.

Nonlinear image enhancement with opportunity costs solves the problem of selecting clipping and scaling parameters. While choosing the higher clipping parameter, the image becomes blurring, and when higher scaling parameter is selected it appears ringing [1]. Selecting best combination of these parameters for a particular image is easy. But when we are given multiple images at same time, selecting optimum pair of these parameters for all images combined is a task to be taken care off. This is where opportunity costs [4] come into play. Using opportunity cost algorithm, scaling and clipping parameters are selected. Basically nonlinear algorithm is boosting the image by enhancing its high frequency component. This method is explained in detail in section II.

In Piecewise linear contrast enhancement, each input image is enhanced based on parameters provided by user as input. This is basic and most effective method of linear image enhancement. This is summarized in section III.

Section IV explains combination algorithm which combines outputs of both linear and nonlinear methods to produce final output. Section V has results and experimental observations. Then I will conclude in section VI.

II. NONLINEAR IMAGE ENHANCEMENT USING OPPORTUNITY COSTS

Algorithm used in this paper for nonlinear image enhancement is explained in [1]. A modification of this is used in this paper. The basic idea of this algorithm is to extract high frequency component from input blurred image and then to apply nonlinear operator on that high frequency part. This is due to the fact that in blurred images, generally high frequency component is not that significant. This algorithm is summarized in the following steps:

1) Input blurred image is passed through averaging low pass filter of size 3x3.
2) Low frequency image obtained in step (1) is subtracted from original blurred image to gain high frequency component of image.
3) Nonlinear operator [1] is applied on this high frequency component.
4) Output matrix obtained in step (3) is multiplied by 2 to further boost the high frequency component.
5) Output of step (4) is finally added to original image to gain the output enhanced image.

This process is shown in figure 2.

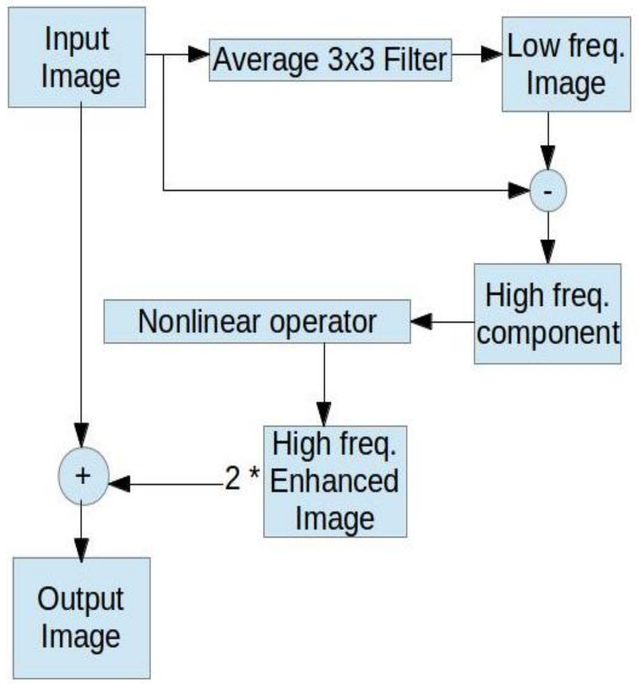


Fig. 2 Non linear enhancement method[1] modified version

Scaling and Clipping parameters are used in nonlinear operator which boost high frequency component. Scaling range from 1 to 10 while clipping values range from 0.1 to 1.0.

Whenever we have multiple options, we have to select one from them which is best for us. Opportunity cost [5] is based on same theory. Opportunity cost is the profit those discarded options can generate. While selecting scaling and clipping values pair, we have to select one which when used gives best quality image or generates minimum opportunity cost. PSNR(Peak signal to noise ratio) is used to find image quality.

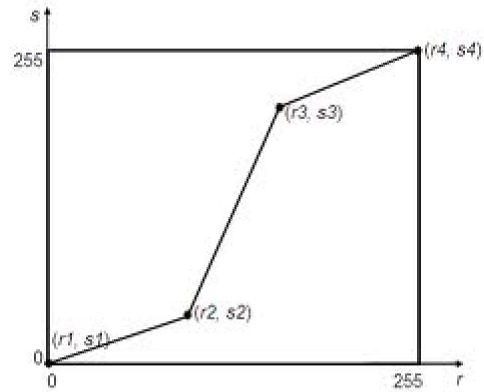
The optimal parameter selection algorithm [1] is summarized below:

1) For each image, calculate PSNR for each combination of parameters.
2) Select maximum value of PSNR for each image, which is the best quality that particular image can get.
3) Calculate what each image is losing if those parameters are not selected which are best for it by subtracting max PSNR obtained in step (2) from each of its PSNR.
4) For each combination of parameters, add PSNR of each image for that parameters to calculate opportunity cost for that parameter.
5) Finally choose those parameters for which opportunity cost found in step (4) is minimum.

Thus we get enhanced output image by nonlinear image enhancement.

III. PIECEWISE LINEAR CONTRAST ENHANCEMENT

This is conventional method for linear image enhancement and is best among others in league like max-min linear contrast stretch, percentage linear contrast stretch [3]. In this, input image is enhanced to different level based on different range of input image pixels. It involves the identification of number of linear enhancement steps that expands the brightness ranges in the modes of the histogram. Normally in linear enhancement, pixels in input image are within a short span of intensity. By applying linear enhancement, we expand the pixel intensity value of image to cover complete range of intensity available. This process is shown in figure 3.



.Fig. 3 Piecewise Linear Contrast Stretching

To calculate the output pixels intensity, we can use following formulas [2]:

$$S(x) = \begin{cases} \frac{s2}{r2} * x & \text{if } (r1<=x<=r2) \\ \frac{s3-s2}{r3-r2} * (x - r2) + s2 & \text{if } (r2<x<=r3) \\ \frac{255-s3}{255-r3} * (x - r3) + s3 & \text{if } (r3<x<=255) \end{cases}$$

Thus for each of the input pixel, one of the above cases is selected and corresponding output intensity for that pixel is found using the formula above. Finally we get complete image which is the enhanced image and is the output of linear image enhancement.

IV. COMBINATION ALGORITHM

This algorithm combines the output of linear and nonlinear enhancement methods. Input to this algorithm is three images namely original image, output of linear enhancement, output of nonlinear enhancement. Output will be combination of these images according to following algorithm:

1) Take an empty matrix of size equal to input image.
2) For each pixel in input image, compare the pixel value of output of linear enhancement and non linear enhancement with input image pixel.
3) Pixel value which is nearer to pixel value of input image is taken as final output pixel intensity.
4) Put this value in output image matrix.
5) Once all pixels of an image goes through above procedure, then output matrix is added to original image to get final resultant matrix.
6) Repeat above process for each of the input image.

TABLE I
PSNR OF INPUT IMAGES FOR 9 DIFFERENT C AND S PARAMETERS

Parameters		**PSNR(db)**		
c	**s**	**x1**	**x2**	**x3**
0.1	1	7.5	12.7	12.8
0.1	2	9.1	15.6	15.1
0.1	3	11.1	19.6	15.8
0.2	1	9.1	15.5	15.4
0.2	2	13.4	25.4	17.5
0.2	3	17.4	18.4	12.2
0.3	1	11.1	19.7	18.4
0.3	2	17.9	19.2	15.3
0.3	3	12.1	10.3	8.6

TABLE III
OPPORTUNITY COST FOR 3 IMAGES FOR DIFFERENT C AND S VALUES

Parameters		**PSNR(db)**			**opportunity cost**			
c	**s**	**x1**	**x2**	**x3**	**cost(x1)**	**cost(x2)**	**cost(x3)**	**min cost**
0.3	2	17.9	19.2	15.3	0	6.2	3.1	9.3
0.2	2	13.4	25.4	17.5	4.5	0	0.9	5.4
0.3	1	11.1	19.7	18.4	6.8	5.7	0	12.5

V. RESULTS

Three standard gray images are taken and blurred. Then algorithm described in this paper is applied on those images. Comparison of PSNR obtained by this method and that of Piecewise Linear contrast enhancement and nonlinear image enhancement [7] using opportunity cost shows that the proposed method is better. For simulation purpose we have taken three different value of clipping and scaling parameters, c=0.1 to 0.3 and s=1 to 3.PSNR value of three output images are 36.1, 37.1, 40.4 respectively. The clipping and scaling parameters attained as output are c=0.2 and s=2. For Piecewise linear image enhancement value of angles given are 15,30,15 and r2=20 and r3=40. PSNR value of images output from nonlinear method alone were 14.9, 17.2, 16.4 respectively and for linear method alone it was 25.2, 29.3, 28.3 respectively for three images. Table I shows PSNR value for all 9 combinations of clipping and scaling parameters. Table II shows opportunity cost of three images with different clipping and scaling parameters.

VI. CONCLUSION

This paper is based on combination of two image enhancement methods. Both methods used in this paper that is Nonlinear method based on opportunity cost and Piecewise contrast enhancement are themselves are the best methods in their respective category. But results showed that combination of these methods according to combination algorithm is better than each of them alone. PSNR value of image which is enhanced with proposed method is better than PSNR obtained with each method applied separately.

REFERENCES

[1] Lung-Jen Wang and Ya-Chun Huang, *"Non Linear Image Enhancement Using Opportunity cost", pages 256-261,2010,2nd International Conference On Computational Intelligence, Communication Systems & Networks.*

[2] Yao, Heng, Shuozhong Wang, and Xinpeng Zhang. "Detect piecewise linear contrast enhancement and estimate parameters using spectral analysis of image histogram." *Wireless Mobile and Computing (CCWMC 2009), IET International Communication Conference on*. IET, 2009.

[3] Praveena, G., and M. Venkatasrinu. "A Modified SVD-DCT Method for Enhancement of Low Contrast Satellite Images."

[4] Wale, Edilegnaw. "A study on financial opportunity costs of growing local varieties of sorghum in Ethiopia: Implications for on-farm conservation policy."*Ecological Economics* 64.3 (2008): 603-610.

[5] Wale, Edilegnaw. "A study on financial opportunity costs of growing local varieties of sorghum in Ethiopia: Implications for on-farm conservation policy."*Ecological Economics* 64.3 (2008): 603-610. (2002) The IEEE website. [Online]. Available: http://www.ieee.org/

[6] Kipli, Kuryati, et al. "Full reference image quality metrics and their performance." *Signal Processing and its Applications (CSPA), 2011 IEEE 7th International Colloquium on*. IEEE, 2011.archive/macros/latex/contrib/supported/IEEEtran/

[7] Wang, Lung-Jen, and Ya-Chun Huang. "Combined opportunity cost and image classification for non-linear image enhancement." *Complex, Intelligent and Software Intensive Systems (CISIS), 2012 Sixth International Conference on*. IEEE, 2012.