Low Contrast Image Enhancement Using Adaptive Filter and DWT: A Literature Review

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Abstract

Image enhancement refers to accentuation, or sharpening of image features such as edges, boundaries or contrast to make a graphic display more useful for display and analysis. One of the most common defects of photographic or digital images is poor contrast resulting from a reduced, and perhaps nonlinear, image amplitude range. This paper reviews different algorithms particularly based on adaptive filtering techniques. Weighted filter algorithm, particle swarm optimization(PSO) algorithm, algorithm using hybrid combination of particle filter and wavelet, algorithm using combination of three techniques (median filtering, CLAHE and morphological operation), local tone mapping algorithm and Non-linear adaptive (NLA) algorithm are discussed and compared. This paper concludes about better algorithm which may be the field of research.

Keywords: Contrast enhancement; PSO; Adaptive filter; Discrete wavelet transform.

1. Introduction

One of the most common defects of photographic or digital images is poor contrast resulting from a reduced, and perhaps nonlinear, image amplitude range [8]. Contrast is the difference in visual properties that makes an object (or its representation in an image) distinguishable from other objects and the background. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. In other words, it is the difference between the darker and the lighter pixel of the image, if it is big the image will have high contrast and in the other case the image will have low contrast [9]. Algorithms based on adaptive filtering techniques such as Weighted filter algorithm[1], Particle swarm optimization(PSO) algorithm[2], algorithm using hybrid combination of particle filter and wavelet[3] [4], algorithm using combination of three techniques (median filtering, CLAHE and morphological operation)[5], Local tone mapping algorithm[6] and Non-linear adaptive (NLA) algorithm[7] are analyzed and compared.

2. Literature review

This paper reviews various algorithms based on adaptive filtering techniques for low contrast image enhancement.

2.1 *Weighted filter algorithm*

In this paper [1] the proposed algorithm uses a weighted filter for enhancing global brightness and contrast of images and wavelet transform to enhance the color information. The flowchart of the proposed method is shown in Fig.1.

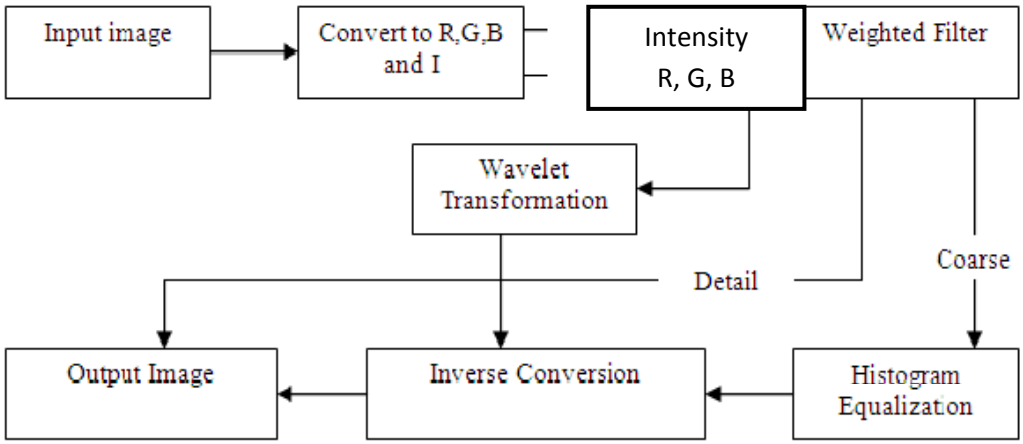
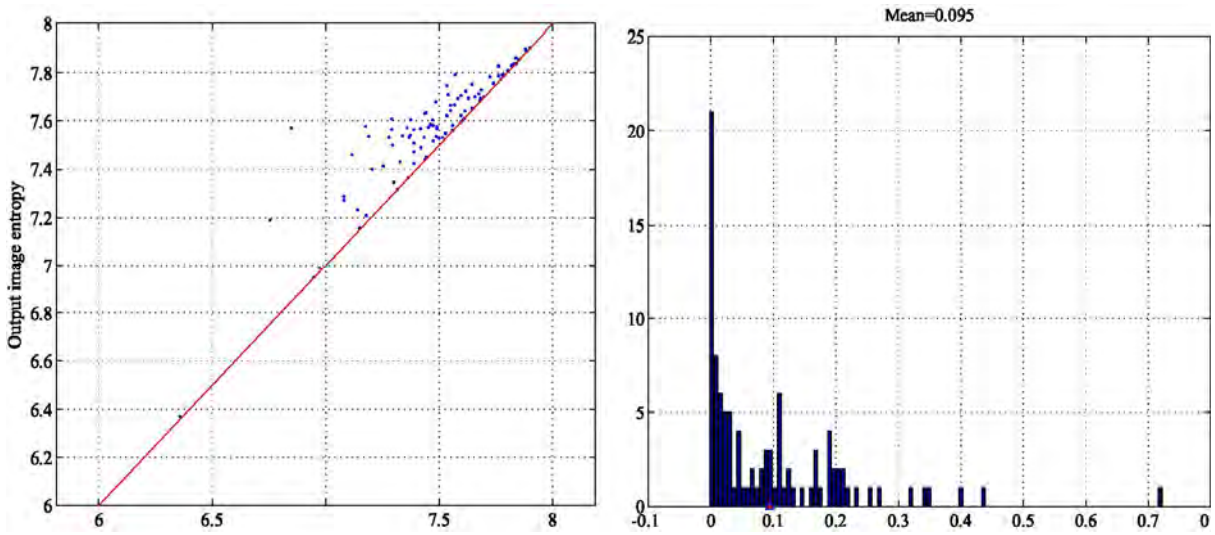


Fig. 1. Weighted filter algorithm [1]

This paper concludes that the proposed method [1] performs better than the auto-level function in the commercial image-editing software. It not only brightens the darker area but also preserves the details in highlighted area and removes noise.

2.2 *Particle swarm optimization algorithm*

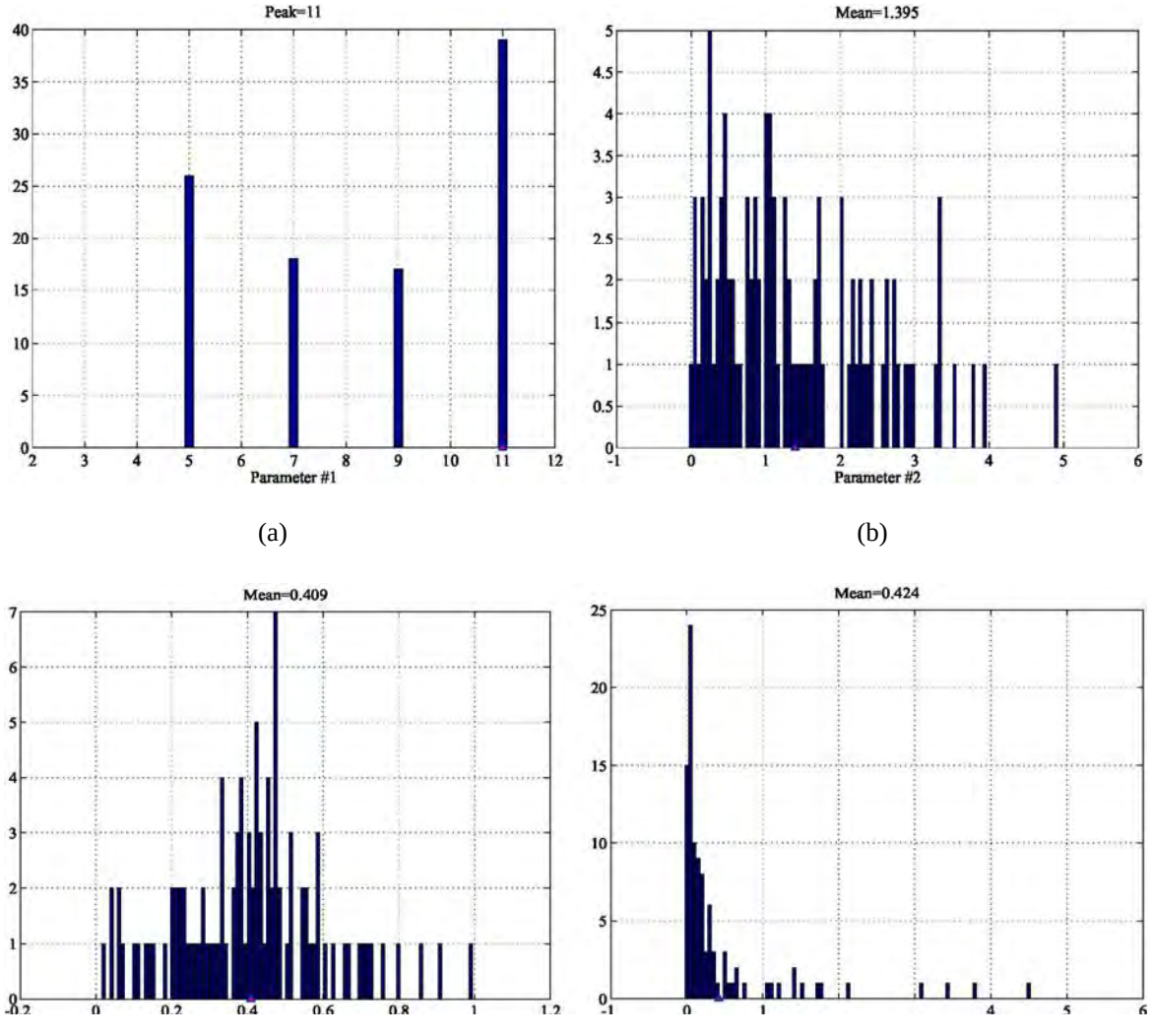
In [2] the parameters of the UMF (unsharp masking filter) are determined by adopting an adaptive algorithm i.e. particle swarm optimization (PSO) to obtain satisfactory image contrast enhancement. The effectiveness of the proposed adaptive unsharp masking method is shown in Fig.2 (a) by plotting the relative gain in entropy where the resultant entropies are above the diagonal line. In Fig.2 (b) the distribution in information gain is plotted and the average improvement is 0.095.



(a) (b)

Fig. 2 Gain in entropy (a) comparison between input and filtered images (b) distribution of entropy gain [2]

The distribution of the filter parameters are also depicted in Fig.3. It can be envisioned that pixels whose intensities are at the low end or high end are receiving smaller magnification as those pixels in the mid intensities.



(a) (b)

(c) (d)

Fig. 3. Statistics of filter parameter values; (a) averaging kernel width w, (b) gain k, (c) Gaussian kernel mean value μ,(d) Gaussian kernel standard deviation σ [2]

2.3 *Algorithm using hybrid combination of particle filter and wavelet*

In [3] [4], particle filter along with wavelet transform and particle filter respectively were used for image restoration. Particle filter effectively restores image suffering from space-variant blur, non-Gaussian noise and non-linearity due to sensors but is less efficient in suppressing Gaussian noise component. This limitation is overcome by using a combination of particle filter along with DWT.

2.4 *Algorithm using combination of three techniques (median filtering, CLAHE and morphological operation)*

In [5] the color image background enhancement has been carried out by the combined approach of 3 techniques such as median filtering, CLAHE and morphological operation of 2 methods are used to detect background of color image. The proposed algorithm works iteratively.

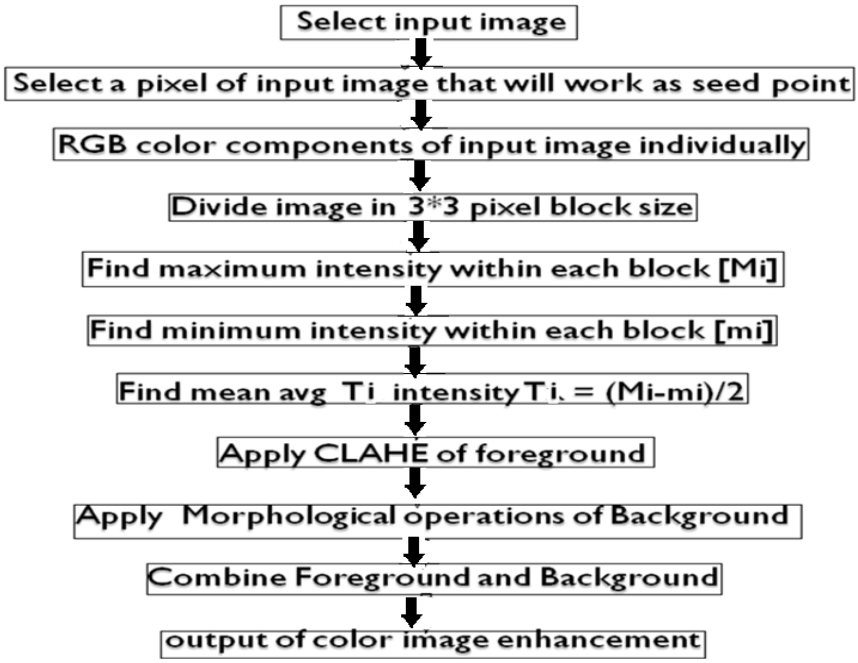
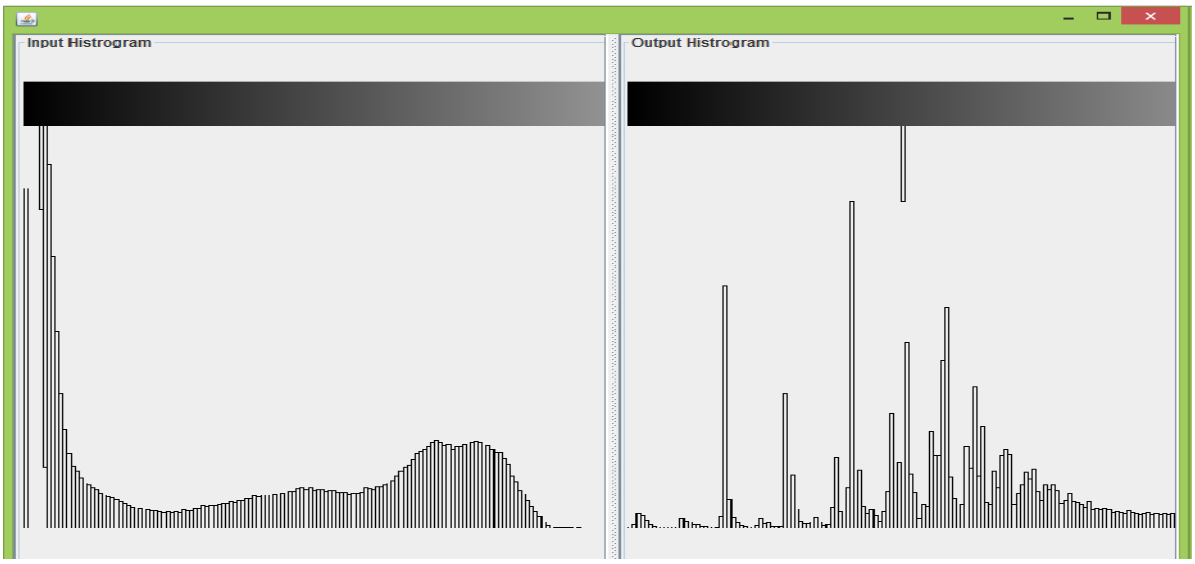


Fig. 4. Algorithm using combination of three techniques (median filtering, CLAHE and morphological operation) [5]

This paper concludes that after enhancement the histogram curve becomes smoother. In future new color model can also be chosen for better comparison purposes.



(a) (b)

Fig. 5. (a) Original image histogram (b) Enhanced image histogram [5]

2.5 *Local tone mapping algorithm*

In [6], a noise reduction method and an adaptive contrast enhancement for local tone mapping has been proposed. Computer simulation with noisy HDR images shows the effectiveness of the proposed local TM algorithm in terms of visual quality as well as local contrast. Table1 shows the performance comparison of the 4 conventional algorithm and proposed algorithm in terms of the smoothness M_s. The smoothness M_s of proposed algorithm is higher due to the reduction of coarse-grain noise using a bilateral filter and soft thresholding.

Table1. Comparison of smoothness measure of original and tone mapped images by five tm algorithms [6]

TM algorithm	HDR image	*Reinhard et al* [2]	*Li et al.* [5]	iCAM [6]	*Shan et al.* [11]	Proposed
Smoothness	4.04	9.96	3.80	6.23	5.36	11.43

Table 2 shows the performance comparison of the proposed and four conventional methods in terms of relative computation time. The computation time of proposed algorithm is smaller than iCAM and *Shan et al.* algorithm but larger than *Reinhard et al.* and *Li et al.* algorithm.

Table 2. Comparison of computation time of tm algorithm [6]

TM algorithm	*Reinhard et al* [2]	*Li et al.* [5]	iCAM [6]	*Shan et al.* [11]	Proposed
Relative time	1	16.25	56.15	45.34	21.17

2.6 *Non-linear adaptive algorithm*

In [7], a new image enhancement algorithm i.e. using NLA (non-linear adaptive) filters was proposed to enhance night images or very low luminance images. This robust algorithm is more resilience and improves dark region in digital image by luminance and contrast enhancement. Table 3 shows the comparison of NMSE (normalized mean square error) values of NAL algorithm with MSR algorithm and HE.

Table3. NMSE values for night image and enhanced images resulted from HE, MSR algorithm and NAL algorithm [7]

Image	Night image	HE	MSR	NAL
NMSE	0.3801	0.1740	0.1640	0.1421

3. Comparison of Existing Algorithms

Comparison of observations given in all reference papers is discussed here.

Table4. Comparison between algorithms based on adaptive filtering techniques

S. No	Reference papers	Algorithm using adaptive filter	Measurement parameter	Advantages	Limitations
1.	A new enhancement approach for enhancing image of digital cameras by changing contrast [1].	Algorithm using weighted filter along with wavelet transform.	_	Enhances the high contrast images effectively. It not only improves global brightness and contrast but also preserves details and removes noise.	-
2.	Adaptive scale adjustment design of unsharp masking filters for image contrast enhancement [2].	Particle swarm optimization. (PSO)	Gain in entropy	Satisfactory contrast enhancement has been achieved.	Difficulty in finding accurate threshold value.
3.	(a) Image restoration using hybrid combination of particle filtering and wavelet denoising [3]. (b) Particle filter for image restoration [4].	Algorithm using a combination of particle filter and DWT.	ISNR (dB)=5.4722	Efficient in suppressing Gaussian and non-Gaussian noise. Image degraded from space-variant blur and non-linearity due to sensors has been restored satisfactorily.	Algorithm is limited only for noise and blurs removal.
4.	Color image background enhancement using proposed algorithm [5]	Algorithm using a combination of 3 techniques- Median filtering, CLAHE and morphological operation.	Computation time	The histogram curve becomes smoother.	Limited for suppressing binary and impulse noise.
5.	Noise reduction and adaptive contrast enhancement for local tone mapping [6].	Local tone mapping algorithm.	Ms (smoothness measure)= 11.43	Reduces coarse-grain noise and enhances local contrast.	As the no. of decompositi on levels increases, the signal such as edge and texture degrades.
6.	Night image enhancement by using non-linear adaptive filter [7].	NLA algorithm	NMSE= 0.1421	Enhances low lightness or night images.	Specifically used for enhancing night images.

Above table concludes that NLA algorithm only enhances low lightness or night images, Local tone mapping algorithm enhances local contrast as well as reduces coarse-noise but as the decomposition levels increases the edge and texture degrades. Algorithm described in [5] is capable of making histogram curve smoother but is only limited for suppressing binary and impulse noise. With PSO algorithm satisfactory contrast enhancement has been achieved but is quite difficult to find accurate threshold value used in the algorithm. Algorithm using particle filter and DWT is efficient but limited only for noise and blur removal. Algorithm using DWT and

weighted filter enhances high contrast images and also preserves details and removes noise, so it is necessary to design a proper algorithm to overcome these problems.

4. Conclusions

Literature review concludes that with particle swarm optimization (PSO) algorithm satisfactory contrast enhancement has been achieved. As Discrete Wavelet transforms is the very good technique for the image denoising and input images always faces the noise during image processing so in future work there is scope of applying Discrete Wavelet transform along with the above algorithm to further improve the image contrast.

References

[1] Dr.Muna F-Al Samaraie, (2014):A new Enhancement approach for enhancing image of digital cameras by changing the contrast, International Journal of advanced science and technology, Vol.32, pp.13-22.

[2] Ngaiming Kwok, Haiyar Shi, Gu Fang, Quang Ha, (2013):Adaptive Scale Adjustment Design of Unsharp Masking Filters For Image Contrast Enhancement, Production of IEEE International Conference on Machine Learning and Cybernetics, Tianjin, Vol.02, pp.884-889.

[3] Yan Zhai, Mark Yeary, Victor De Brunner, Joseph P. Havlicek and Osama Alkhouli, (2005): Image Restoration using A Hybrid Combination Of Particle Filtering And Wavelet Denoising, IEEE International.

[4] S. Ibrahim Sadhar, P.Y. Praveen Kumar, A.N. Rajagopalan, (): Particle Filters for Image Restoration.

[5] Ashvinee R. Rathod, Prof. A. B. Deshmukh, and Prof. M.D. Tambhake, (2014): Color Image Background Enhancement Using Proposed Algorithm, International Journal Of Advanced Scientific & Technical Research, Issue4, Vol.2, pp.878-887.

[6] Ji Won Lee, Rae-Hong Park, SoonKeun Chang, (2012): Noise Reduction and Adaptive Contrast Enhancement for Local Tone Mapping, IEEE transactions on Consumer Electronics, Vol.58, No.2, pp.578-586.

[7] Fatma I Abbas, (2011): Night Image Enhancement by using non Linear Adaptive Filter, pp. 157-163.

[8] William K. Pratt, “Digital Image Processing”, John Wiley and Sons, Inc. 2001.

[9] Cristain Ordyo Casado. Assoc. Prof. Antoaneta Popova, (2010): Image Enhancement Methods”, Sofia.