Dynamic Non-Linear Enhancement using Gamma Correction and Dynamic Restoration

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ABSTRACT

This paper has proposed a new integrated image enhancement algorithm by integrating non linear image enhancement technique with dynamic restoration. Image processing plays a vital role in visualization application. It improves the visibility of poor images. Different techniques have been proposed so far. To improve image quality image enhancement can selectively enhance and restrain some information about image. It is a method which decreases image noise, eliminate artifacts, and maintain details. Its purpose is to amplify certain image features for analysis, diagnosis and display. The overall objective of this paper is to propose an integrated technique which will integrate the nonlinear enhancement technique with the gamma correction and dynamic restoration technique. The proposed algorithm is implemented in MATLAB. Experimental results have shown quite significant results over the available methods.

Keywords

Image enhancement, human visual perception, Visibility, Dynamic restoration, gamma correction

1. INTRODUCTION

In image processing, the process of improving the quality [2] of a digitally stored image by manipulating the image with certain methods. Advanced image enhancement techniques also support many filters for altering images in various ways. Programs specialized for image enhancements are sometimes called image digital image filters [5].

Image enhancement techniques acting as an important part in image processing. Somebody click image from common environment with elevated dynamic range include both dark and bright regions. Due to go outside in dynamic range of human eyes sensing, those image are not easy to distinguish by human eyes [7]. Image enhancement is a general approach to get enhanced quality of those images in terms of human visual observation. There are two techniques for image enhancement one is spatial domain and second is transform domain methods. In spatial domain method [9] an image is enhance by straight dealing with the intensity value in an image. In transform domain enhancement method it transforms the image intensity data into a specific domain by using different techniques like DFT, DCT, etc. Figure 1 is showing the poor visible input image. It is clearly shown in the image that it will not give much information to observers and, it may contain poor results for further processing.

Figure 1. Input image [12]

Figure 2 is showing the enhanced image. It is clearly shown in the figure that all the objects are enhanced and image is now providing quite more information to the observers.

Figure 2. Enhanced Images [12]

Transform domain enhancement method engage mapping the image intensity data into a given transform domain by using transforms such as the 2-D discrete cosine transform (DCT). The main idea for using this technique is to improve the image quality by manipulating the transform coefficients. The main drawbacks of the transform-based image enhancement techniques are: they establish assured artifacts, they cannot concurrently enhance all pixels of the image properly and it is very hard to computerize the image enhancement procedure [9][6]. Color image enhancement plays a vital role in Digital Image Processing. The reason of image enhancement is to get better details of an image and highlight the helpful information. If a person takes an image by using a digital camera or mobile phone, in sunlight or dark room that image cannot be a good image. As a result of that image, it cannot be proper visualized for human eyes [13]. An image enhancement technique is generally used for the upgrading of the quality of a vague image. Among many image enhancement approaches, the nonlinear image enhancement (NIE) method has a simple structure and can obtain a good processing effect [14].

2. IMAGE ENHANCEMENT TECHNIQUES

The main objective of image enhancement is to improve some characteristic of an image to make it visually better one. Color image enhancement plays an important role in Digital Image Processing. The purpose of image enhancement is to get finer details of an image and highlight the useful information. If a person acquires an image by using a digital camera or mobile, the brightness such as glowing lamp in a room or sunlight in an open air is proper to be uneven and uncontrolled [13].

2.1 Image Enhancement using HSV Color Space

The color images are always represented in RGB color space. HSV space is nearer to human observation, the (H) refers to the spectral composition of color, saturation (S) defines the clarity of colors and (V) refers the brightness of a color or just the luminance value of the color [9][13]. The following equations are shows the conversion of RGB values into HSV values.

$$H = \begin{cases} H1, & if\ B \le G, \\ 360 - H1, & if\ B > G \end{cases}$$

where,

$$H1 = \cos^{-1}\left\{\frac{0.5[(R-G)+(R-G)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right\}$$

$$S = \frac{\max(R,G,B) - \min(R,G,B)}{\max(R,G,B)}$$

$$V = \frac{\max(R,G,B)}{255}$$

The basic range of (H) hue in equation is from 0 to 360 whereas saturation and values varies from 0 to 1. The Image enhancement process includes remove artifacts, advanced color correction, filter adding and reduction, image replacement, augmentation and creation [11].

2.2 Histogram Equalization

Histogram equalization is a common method for enhancing the appearance of images. Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This process typically increases the universal contrast of many images, mainly when the usable data of the image is represented by close contrast values. Every level should hold the same number of pixel values [2].

2.3 Contrast Enhancement

The main use of contrast enhancement is to accomplish the image brightness. Contrast enhancement firstly divide the value component image in HSV image space into lesser overlapping blocks and find the shape of the nonlinear transfer function for every pixel. In contrast enhancement process, for each pixel the amount of enhancement is depending upon the midpoint pixel itself and its neighboring pixel values [10]. A neighboring pixel-dependent contrast enhancement method is used to achieve enough contrast, even elevated than original image [3].

After conducting the literature survey it has been found that the transform-based image enhancement introduces some inconsistencies like:-

- Transform-based image enhancement cannot enhance all parts of the image simultaneously and it is hard to automate the image enhancement process.
- The main drawback of transform based image enhancement is that, after enhancement the image detail are degraded.

3. PROBLEM FORMULATION

In order to reduce the problems of the limitations of the exiting techniques a new hybrid non linear image enhancement technique is proposed. Proposed technique will integrate non-linear enhancement technique with image restoration. The proposed algorithm is seems to be significant as the transform-based image enhancement methods results in certain artifacts on the output enhanced image, so restoration technique will reduce these artifacts. The proposed algorithm will use HSV plane to enhance the image, as it is known H and S component need no modification for enhancement so alteration will be done on V (intensity) only.

The proposed method comprises three processes, i.e. adaptive intensity enhancement, contrast enhancement and color restoration. Adaptive intensity enhancement utilizes a particularly designed nonlinear transfer function which is proficient of reducing the intensity of light regions and at the same time enhancing the intensity of gloomy regions. Contrast enhancement tunes the intensity of each pixels magnitude based on its nearby pixels. Finally, color restoration process based on the chromatic information of the input image frame is applied to convert the enhanced intensity image back to a color image.

4. PROPOSED TECHNIQUE

The main objective of algorithm which will provide better results than existing algorithms to enhance the images. Dynamic image restoration using adaptive gamma correction and also adaptive smoothing technique will be integrated to the non linear enhancement method to provide more accurate results. By doing this we can hope that the detailed variance and background variance will be increased and decreased respectively. However dynamic restoration may come up with some potential overheads so we will try to reduce them. Figure 3 is showing the various steps to achieve the objectives.

Step 1: In step 1 image is passed to the system and some pre-processing operations are applied on it.
Step 2: In step 2 images is converted in HSV plane.
Step 3: As H and S component stay constant but V is the only factors which need some alteration while enhancing the images.
Step 4: Now overlapped window based local processing for dynamic range compression will be applied on V component.
Step 5: Now pixel neighborhood based contrast enhancement is applied on the image.
Step 6: Now re-convert given image to HSV to RGB again.
Step 7: Now apply dynamic restoration algorithm.
Step 8: Get output image.

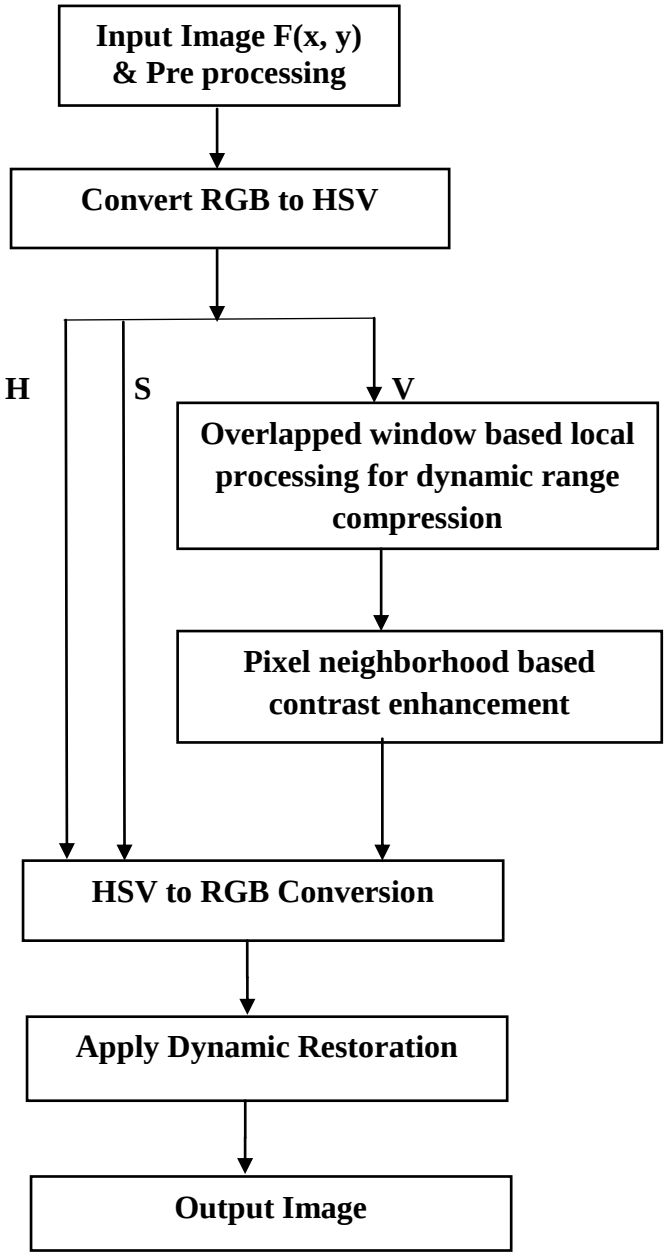

Figure 3. Proposed Algorithm

5. EXPERIMENTAL SET-UP

In order to implement the proposed algorithm; design and implementation has been done in MATLAB using image processing toolbox. In order to do cross validation we have also implement the histogram equalization and nonlinear enhancement technique. Table 1 is showing the various images which are used in this research work. Images are given along with their formats. All the images are of different kind and each image has different kind of the light i.e. more or less in some images.

Table 1. Experimental images

Sr.No.	NAME	FORMAT
1	image1	jpg
2	image2	jpg
3	image3	jpg
4	image4	jpg
5	image5	jpg
6	image6	jpg
7	image7	jpg
8	image8	jpg
9	image9	jpg
10	image10	jpg
11	image11	jpg
12	image12	jpg
13	image13	jpg
14	image14	jpg
15	image15	jpg
16	image16	jpg

6. EXPERIMENTAL RESULTS

For the purpose of cross validation we have taken 16 different images and passed to the histogram equalization, non-linear enhancement and proposed algorithm. Subsequent section contains a result of one of the 16 selected images to show the improvisation of the proposed algorithm over the other techniques.

Figure 4 has shown the input image for experimental purpose. The image has low brightness and some more effect of the green color. The overall objective is to improve the brightness of the image and also reduce the effect of the green channel.

Figure 4. Input image

Figure 5 has shown the output image taken by the histogram equalization. However the problem of this technique is found to be some artifacts which have degrades the quality of the image.

Figure 5. Histogram equalization

Figure 6.Nonlinear enhanced image

Figure 6 has shown the output image taken by the nonlinear color image enhancement technique. The image has contained too much brightness and some more effect of the green color. However the problem of this technique is found to be is the effect of the green channel has not been minimized as expected.

Figure 7. Integrated nonlinear enhanced image with gamma correction

Figure 7 has shown the output image taken by the integrated technique of the gamma correction with nonlinear enhancement. The image has contained too much brightness but still has more effect of the brown color.

Figure 8.Final proposed image

Figure 8 has shown the output image taken by the integrated technique of the gamma correction, dynamic restoration with nonlinear enhancement. The image has contained the balanced brightness and the effect of the green channel is also reduced. Comparing with other method the proposed has shown quite significant result with respect to all cases. The effect of the individual channel has also been normalized as well as the effect of the brightness is also normalized.

7. PERFORMANCE ANALYSIS

This section contains the cross validation between existing and proposed techniques. Some well-known image performance parameters for digital images have been selected to prove that the performance of the proposed algorithm is quite better than the available methods..

Table 2. Mean Square Error

Image Name	Histogram Equ.	Old Technique	Proposed Algorithm
Img1	39039	1322	854
Img2	12338	1302	1079
Img3	15031	1040	675
Img4	12466	1395	612
Img5	34256	1340	603
Img6	20359	1628	399
Img7	33411	1317	293
Img8	34822	967	240
Img9	27696	2277	204
Img10	16573	1435	195
Img11	13062	1907	169
Img12	19271	1415	174
Img13	56618	404	155
Img14	33158	1968	246
Img15	10471	1269	118
Img16	34409	2032	116

Table 2 has shown the quantized analysis of the mean square error. As mean square error need to be reduced therefore the proposed algorithm is showing the better results than the available methods as mean square error is less in every case

Table 3 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Table 3 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Table 3. Peak Signal –to- Noise Ratio

Image Name	Histogram Equ.	Old Technique	Proposed Algorithm
Img1	2.8110	16.9185	18.8162
Img2	7.2184	16.9847	17.8006
Img3	6.3609	17.9605	19.8378
Img4	7.1735	16.6851	20.2633
Img5	2.7834	16.8598	20.3276
Img6	5.0432	16.0143	22.1211
Img7	2.8919	16.9349	23.4621
Img8	2.7123	18.2765	24.3287
Img9	3.7066	14.5572	25.0345
Img10	5.9368	16. 5623	25.2303
Img11	6.9707	15.3273	25.8519
Img12	5.2818	16.6232	25.7253
Img13	0.6013	22.0670	26.2275
Img14	2.9249	15.1906	24.2215
Img15	7.9309	17.0962	27.4120
Img16	2.7641	15.0516	27.4862

Table 4 is showing the comparative analysis of the Maximum Difference. As Maximum Difference needs to be minimized; so the main objective is to reduce them Maximum Difference as much as possible. Table 4 has clearly shown that Maximum Difference is less in our case therefore the proposed algorithm has shown significant results over the proposed algorithm.

Table 4. Maximum Difference

Image Name	Histogram Equ.	Old Technique	Proposed Algorithm
Img1	254	9	3
Img2	254	18	3
Img3	254	52	3
Img4	204	28	3
Img5	254	23	2
Img6	254	40	3
Img7	254	75	0
Img8	254	43	3
Img9	219.0598	-13	0
Img10	254	26	3
Img11	254	17	3
Img12	254	31	3
Img13	254	20	3
Img14	254	3	1
Img15	254	27	3
Img16	254	0	7

Table 5 is showing the comparative analysis of the Maximum Difference. Mean Difference contains the average difference between input and output image. Table 5 has clearly demonstrated that the Mean Difference is quite less in the case of the proposed algorithm; therefore proposed algorithm is providing better results.

Table 5. Mean Difference

Image Name	Histogram Equ.	Old Technique	Proposed Algorithm
Img1	176.2400	35.4839	27.6155
Img2	95.3807	33.7947	27.7507
Img3	98.4194	26.4427	20.5744
Img4	104.6390	36.9264	22.7708
Img5	178.4211	34.6758	23.4465
Img6	130.2392	38.5495	17.7392
Img7	173.8735	33.7769	15.9162
Img8	160.3133	24.7230	11.3477
Img9	158.7783	47.2256	13.3805
Img10	101.9914	35.9558	10.1576
Img11	97.2257	43.1009	10.2456
Img12	114.7699	34.2727	10.1654
Img13	237.4300	16.1787	10.2520
Img14	177.0887	43.3806	15.0889
Img15	71.6922	32.5905	6.6922
Img16	181.1426	41.8341	9.3163

Table 6 is showing the comparative analysis of the Background Variance (BV) and Detailed Variance (DV). As background detail need to be reduced because human eyes does not focus on the background detail of the image. The table 6 has clearly shown that BV is less for most of the images therefore proposed algorithm is better in more cases. The Detailed Variance (DV) need to be maximized as human eyes focuses on the same. The table 6 has shown quite better DV than the available methods.

Table 6. BV and DV values for different enhancement methods

Image Name	Histogram Equ.		Old Technique		Proposed Algorithm	
	BV	DV	BV	DV	BV	DV
Img1	0.147	13.579	0.096	20.761	0.074	27.040
Img2	0.151	13.209	0.099	20.189	0.080	24.870
Img3	0.074	25.838	0.091	21.828	0.074	27.003
Img4	0.159	12.513	0.094	21.236	0.069	28.748
Img5	0.127	15.720	0.093	21.297	0.088	22.567
Img6	0.122	16.389	0.090	22.162	0.074	26.818
Img7	0.186	10.708	0.094	21.232	0.100	19.991
Img8	0.097	20.469	0.084	23.752	0.075	26.500
Img9	NaN	NaN	0.093	21.399	0.054	36.646
Img10	0.144	13.834	0.088	22.606	0.096	23.251
Img11	0.176	11.335	0.975	20.891	0.094	21.151
Img12	0.152	13.157	0.092	21.740	0.091	21.832
Img13	0.109	18.233	0.094	21.257	0.053	37.104
Img14	0.136	14.609	0.088	22.658	0.084	23.770
Img15	0.097	20.547	0.106	18.851	0.053	37.293
Img16	NaN	NaN	0.095	20.950	0.084	23.621

Figure 9 has shown the quantized analysis of the mean square error. As mean square error need to be reduced therefore the proposed algorithm is showing the better results than the available methods as mean square error is less in every case.

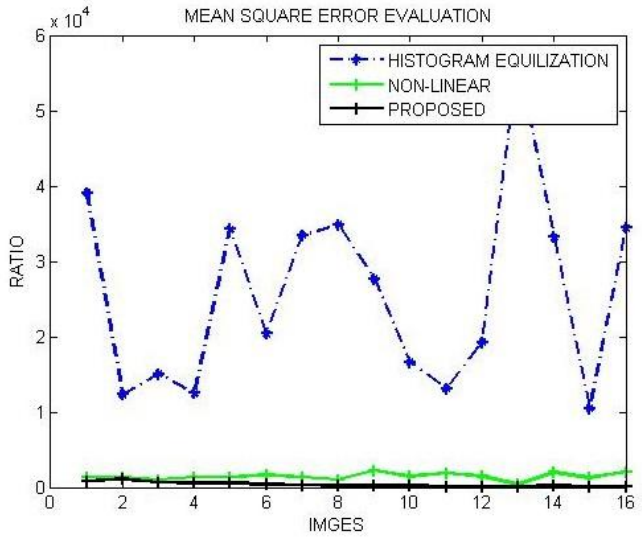

Figure 9.Mean Square Error

Figure 10 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Figure 10 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

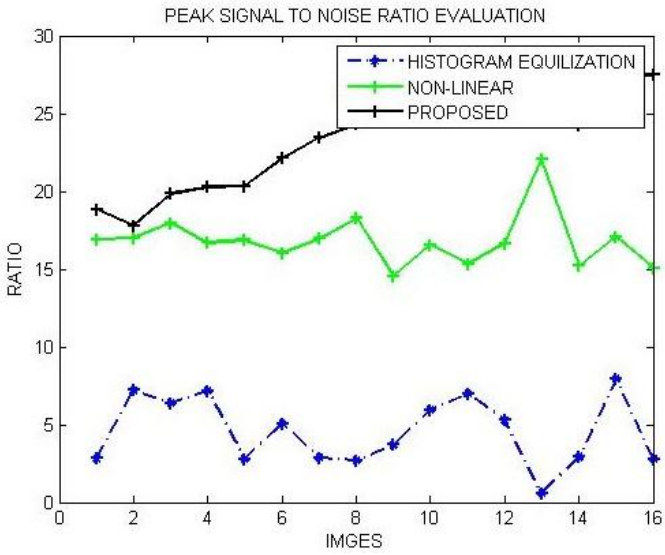

Figure 10.Peak Signal –to- Noise Ratio

Figure 11 is showing the comparative analysis of the Maximum Difference. As Maximum Difference needs to be minimized; so the main objective is to reduce them Maximum Difference as much as possible. Figure 11 has clearly shown that Maximum Difference is less in our case therefore the proposed algorithm has shown significant results over the proposed algorithm.

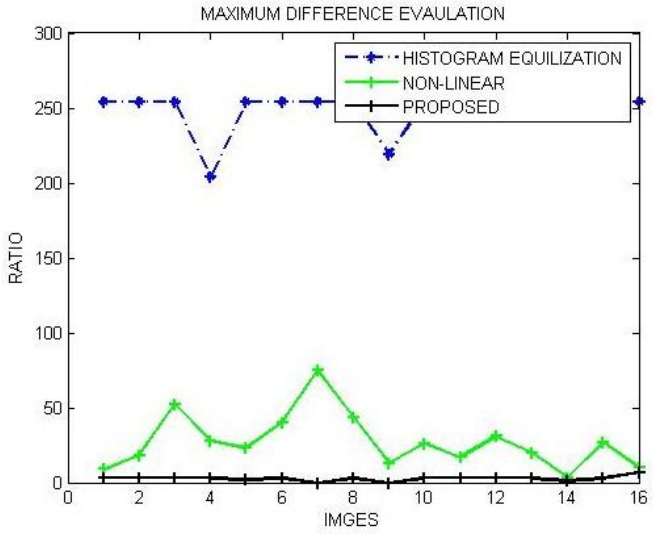

Figure 11. Maximum Difference

Figure 12 is showing the comparative analysis of the Maximum Difference. Mean Difference contains the average difference between input and output image. Figure 12 has clearly demonstrated that the Mean Difference is quite less in the case of the proposed algorithm; therefore proposed algorithm is providing better results.

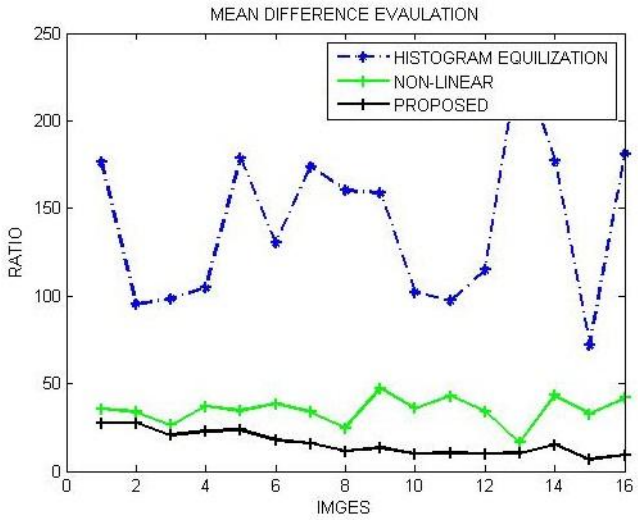

Figure 12. Mean Difference

Figure 13 and 14 is showing the comparative analysis of the Background Variance (BV) and Detailed Variance (DV). As background detail need to be reduced because human eyes does not focus on the background detail of the image. The Figure 13 has clearly shown that BV is less for most of the images therefore proposed algorithm is better in more cases. The Detailed Variance (DV) need to be maximized as human eyes focuses on the same. The Figure 14 has shown quite better DV than the available methods.

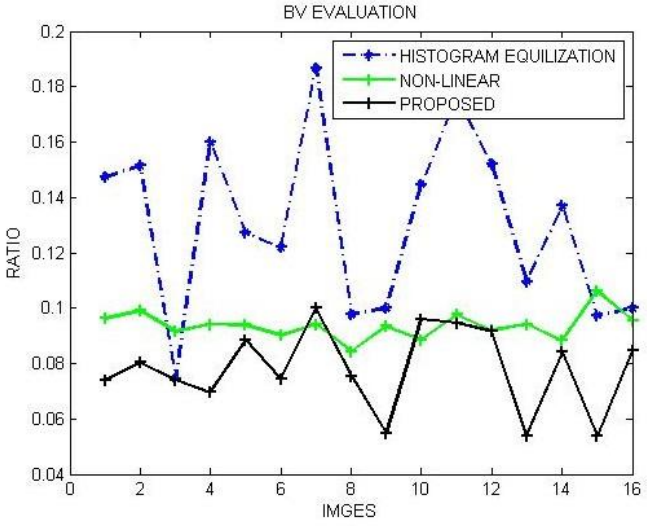

Figure 13.Background Variance

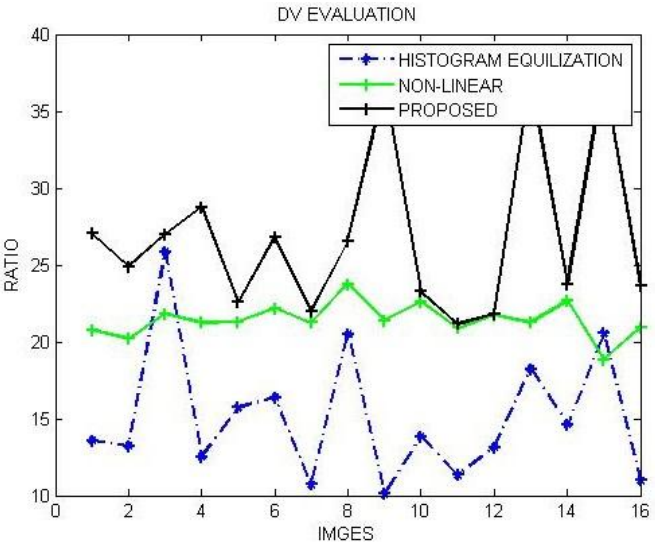

Figure 14.Detailed Variance

8. CONCLUSION AND FUTURE WORK

The image enhancements techniques play a significant role in digital image processing. It is shown in this paper that the nonlinear image enhancement can be used to improve the quality of a blurred image by using the concept of the light source refinement. This work has proposed an integrated enhancement algorithm to improve the detailed variance in images. The proposed solution has been designed and implemented in MATLAB using image processing toolbox. Different 50 images have been taken for experimental purpose and it is found that in most of cases the proposed algorithm provides better results. The performance evaluation has shown that the proposed algorithm provides slightly significant results over the available methods.

In near future we will use adaptive gradient smoothing will be used to provide more better and accurate results. However no filtering technique is used in this research work; so in near future some efficient filtering technique will also be used.

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