

Upgraded Dominant Brightness Level based Image Enhancement using Illuminate Normalization

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Abstract

Image enhancement is an algorithm used in vision applications for improving the visibility of the digital images. Recently much work is done in the field of remote sensing images to improve the visibility for improving their accuracy for further applications. It has been found that the most of the existing researchers have neglected many issues i.e. no technique is accurate for different kind of circumstances. The existing methods have neglected the use of radiant optimization to reduce the problem of noise which will be presented in the image. It is also found that the color artifacts which will be presented in the output image due to the transform domain methods, also neglected by the most of the researchers. Therefore, to overcome these issues, in this work, the present research work uses Dominant Brightness Level Analysis (DBLA) based image enhancement algorithm using Illuminated normalization for removing the uneven brightness of the images, Gradient optimization to preserve edges of enhanced images and Adaptive histogram stretching to remove the color artifacts. Moreover the performance of DBLA and proposed DBLA technique for enhancing the remote sensed color images has also been evaluated. The comparison has been done on the basis of various performance metrics which proves the efficiency of the proposed algorithm.

Keywords: Adaptive Histogram Equalization, Contrast Enhancement, Dominant Brightness Level Analysis

1. Introduction

Image Processing is any type of signal processing for which the input is an images or videos; the outcome of image processing may be either an image or a set of parameters that are related to the input image. Mainly this method can be used as a two-dimensional signal. Image processing can be divided into two categories:

1.1 Analog Image Processing

It is finished on analog signals. Analog Image processing can be performed on two dimensional analog signals. In this type of processing technique, pictures are handled by varying the electrical signal. The most usual illustration is the television image³.

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1.2 Digital Image Processing

It allocates with function of digital photograph via digital computer. It concentrated generally on photographs but also subfield of signals and systems. Processing is a computer system that is capable to implement processing on a picture¹. The input of to facilitate system is a digital image and the system process to facilitate image using well-ordered programs, and provides an image as outcome. Adobe Photoshop is the common example. It is one of the mainly used applications for processing on digital images².

1.3 Enhancement Techniques

Enhancement techniques can be mostly divided into two parts:

1.3.1 Spatial Domain Method

Which directly work on pixel? The procedure can be composed as $g(i, j) = T[f(i, j)]$, where g is the outcome, f is the input and T is a process on f defined above a few neighborhood of (i, j) . This technique is using the Eq. (1)⁴.

$$g(i, j) = f(i, j) * h(i, j) \quad (1)$$

1.3.2 Frequency Domain Method

Frequency domain method processes on the Fourier Transform method. Frequency domain picture improvement is clear-cut. The frequency filters established an image in the frequency domain. This category filtering method is very straightforward⁴.

1.4 Highlights of Work

1.4.1 DBLA (Dominant Brightness Level Analysis)

Dominant Brightness means that is effective or impressive technique for the images. Contrast enhanced images may contain intensity distortion and lose image information in various regions. To overcoming the problems of contrast enhanced images, to decompose the input image into several layers of single dominant brightness levels⁵. The image can be equally decomposed into different levels so that it can be easily handled. After that to execute the Discrete Wavelet Transform (DWT) on remote sensing images and then calculate the dominant brightness level by using the log-average luminance in the low-low sub band, to use the low frequency luminance components. DBLA has ability to preserve brightness level detail which was not there in existing approaches⁶.

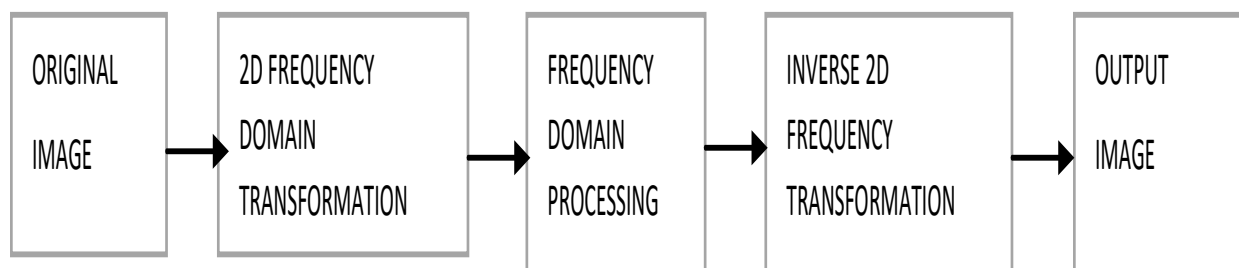


Figure 1. Frequency domain method process (adapted from⁷).

1.4.2 Adaptive Histogram Stretching

It has features to adjust images in such a way that the difference between lowest and peak intensity value is minimized. Therefore produce more consistent images^{5,8}.

1.4.3 Illuminate Normalization

Transform domain method may produce certain artifacts in images. Illuminate normalization has ability to overcome this issue by normalizing light source^{5,9}.

1.4.4 Gradient Optimization

Majority of existing techniques degrades potential edges while enhancing the contents. Therefore edge preservation is required to preserve potential edges for future vision^{5,10}.

2. Problem Definition

It has been found that the most of the existing researchers have neglected many issues; i.e. no technique is accurate for different kind of circumstances. The existing methods have neglected the use of radiant optimization to reduce the problem of noise which will be presented in the image. It is also found that the color artifacts which will be presented in the output image due to the transform domain methods; also neglected by the most of the researchers. So the present research work will use illuminate normalization and adaptive histogram stretching as the post processing function to enhance the results further.

So, the main objectives of our work are:

1. To enhance the DBLA based image enhancement algorithm using.
 - a. Illuminate normalization for removing the uneven brightness of the images.

- b. Gradient optimization to preserve edges of enhanced images.
- c. Adaptive histogram stretching to remove the colour artifacts.

2. To evaluate the performance of DBLA and proposed DBLA technique for enhancing the remote sensed colour images.
3. To compare the proposed and existing technique based on the following metrics:-
 - a. Mean square error
 - b. Root Mean Square Error (RMSE)
 - c. Cross correlation
 - d. Bit Error Rate (BER)
 - e. Peak Signal to Noise Ratio (PSNR)

3. System Architecture

We develop an integrated approach using DBLA, contrast limited adaptive histogram equalization and dark channel prior algorithm^{11,12}. The overall objective is to improve the results by combining the above approaches. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox¹³. An Improved Dominant Brightness Level Analysis algorithm (IDBLA) is introduced.

In this algorithm by applying different techniques of image enhancement on remote sensing images, the result will be shown in the form of enhanced image. There are different techniques used like DWTs¹⁴, Analysis of dominant brightness level, image decomposition on dominant brightness level⁵, etc.

Figure 2 is the main algorithm that shows the overall processing of proposed method.

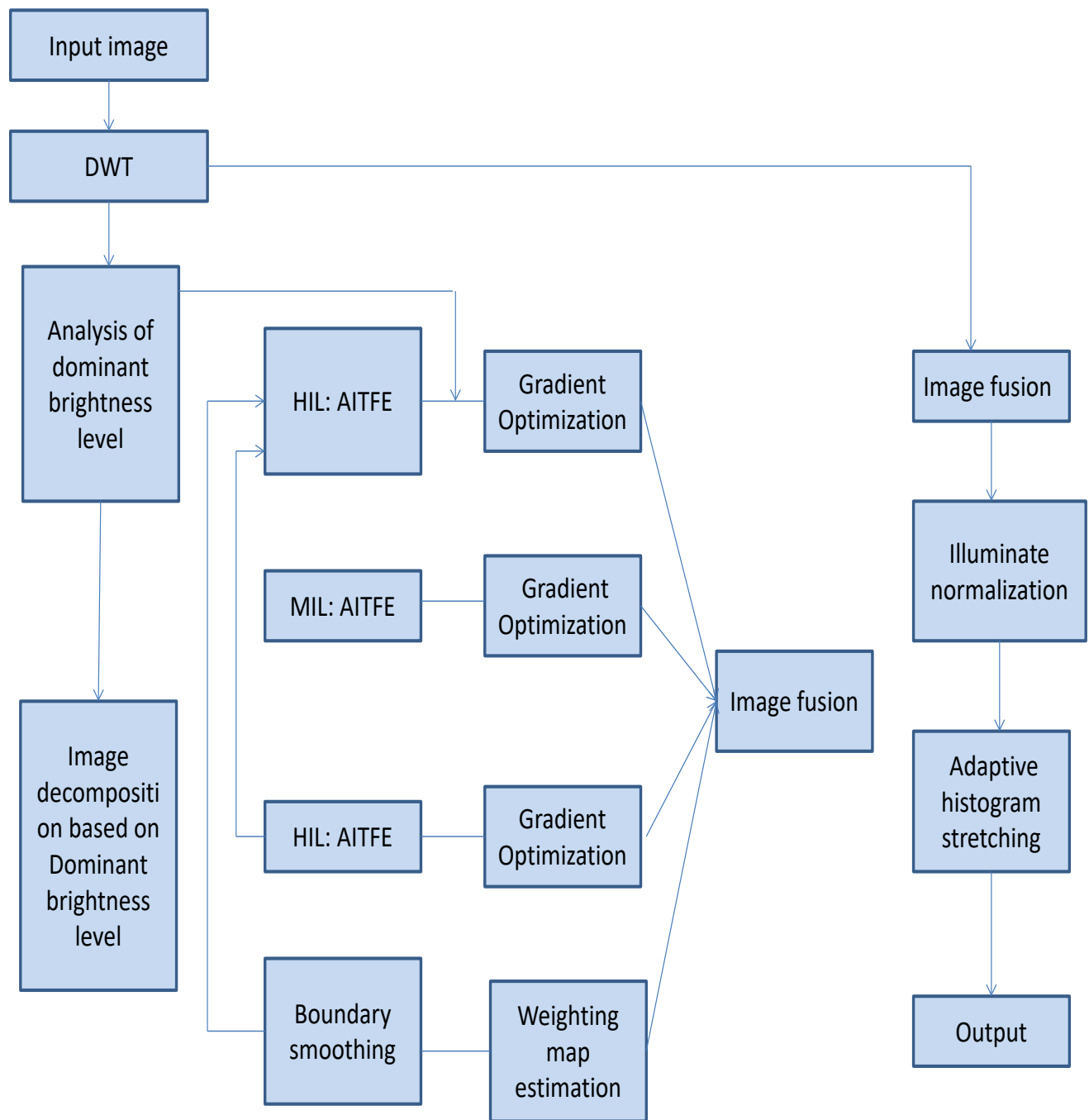


Figure 2. System architecture of proposed work.

Following are the steps:

- Step1.** Select an input image.
- Step2.** Apply DWT on an input image.
- Step3.** Then DBLA.
- Step4.** Divide an image based on DBLA into three intensity (low, middle, high) layers.
- Step5.** Then apply adaptive intensity transfer function on each layer and do boundary smoothing after smoothing weighting map estimation method applied on it.
- Step6.** After that Adaptive histogram equalization technique has been applied.
- Step7.** Then image can be fused means to combine the decomposed image into a single one.
- Step8.** Inverse DWT method has been applied on it.
- Step9.** Now color normalization will come in action to balance the colors and thus will reduce the color affects due to the DWT.
- Step10.** Then apply the method of radiant optimization to reduce the noise in an image.
- Step11.** Result has been shown in the form of contrast enhanced image.

In this algorithm there are different types of methods used to enhance an image. Some methods adapted

from existing techniques like DWT, DBLA, and adaptive intensity transfer function, after that add new steps like adaptive histogram equalization, color normalization and frost filter^{5,15-18}. At the end by integrating the base paper techniques and new methods a new method has been developed to enhance an image in more efficient manner. The motivation behind this integrated method is to improve the accuracy of image enhancement further.

4. Facilities Required for Proposed Work

Following are the facilities that are required for the proposed work.

- a. Hardware requirements
 - 1. Intel Core (TM) i3 processor
 - 2. 2.00 GB RAM
 - 3. 32-bit operating system
- b. Software requirements
 - 1. Platform independent
 - 2. MATLAB(2010)
 - 3. Image processing toolbox
 - 4. Mathematic toolbox
 - 5. Operating System Platform Independent

5. Performance Analysis

This section shows the performance analysis between existing and proposed techniques. These parameters are very important part of the digital image processing^{19,20}. In this we have used different parameters to show the performance of proposed method is better than the existing algorithm.

5.1 Mean Square Error Evaluation

In image processing mean square error is the most general measure for performance measurement of the existing method and the coded images. It is straightforward method to design system that decrease the MSE but cannot capture the impurities like blur artifacts. It is computed by using Eq. (2).

$$MSE = \frac{1}{MN} \sum_{i=1}^M \sum_{j=1}^N (f(i,j) - f'(i,j))^2 \quad (2)$$

Where $f(i,j)$ represents the original (reference) image and $f'(i,j)$ represents the distorted (modified) image and i and j are the pixel position of the $M \times N$ image. MSE is zero when $x(i,j) = y(i,j)$.

5.2 Peak Signal to Noise Ratio

PSNR measure the degree of image distortion. PSNR measures the quality between the original image and compressed image. If the value of PSNR is higher, then the quality of reconstructed image is better. PSNR represent the peak error. To measure the PSNR, at first complete the MSE. Signal in the case of image is the original data and when noise is introduced in the image it becomes error. PSNR can be calculated by using Eq. (3).

$$\begin{aligned} PSNR &= 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right) \\ &= 20 \cdot \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right) \end{aligned} \quad (3)$$

$$= 20 \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE)$$

5.3 Root Mean Square Error

The Root Mean Square Error (RMSE) is a generally used to compute of the difference among values predicted by a model and values actually observed from the surroundings that is being modeled. The RMSE of a model total with respect to the estimated variable X_{model} is defined as the square root of the MSE by using Eq. (4)

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (X_{obs,i} - X_{model,i})^2}{n}} \quad (4)$$

5.4 Bit Error Rate

The Bit Error Rate (BER) is the percentage of bits that have errors relative to the total number of bits received in a transmission.

6. 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 developed approach that compares against some well-known image enhancement techniques. Figure 3 shows the Input image, its respective Dominant Brightness Levels and corresponding proposed image.

7. Performance Evaluation

The proposed algorithm is checked on various images. The algorithm is applied using various performance indices Mean Squared Error (MSE), PSNR, BER and RMSE.

S. No.	Input Image	Dominant Brightness level Image	Proposed image
1	<input data-bbox="293 541 607 800" type="image"/>	<input data-bbox="639 541 964 800" type="image"/>	<input data-bbox="1021 541 1328 800" type="image"/>
2	<input data-bbox="293 947 607 1268" type="image"/>	<input data-bbox="639 947 964 1268" type="image"/>	<input data-bbox="1029 947 1320 1268" type="image"/>
3	<input data-bbox="285 1388 613 1654" type="image"/>	<input data-bbox="656 1381 950 1661" type="image"/>	<input data-bbox="992 1388 1356 1654" type="image"/>

Figure 3. Results showing input image, dominant brightness levels and proposed image.

In order to implement the proposed algorithm, design and implementation has been done in MATLAB using image processing toolbox. Result shows that our proposed approach gives better results than the existing techniques.

7.1 Mean Square Error

Table 1 is showing the quantized analysis of the mean square error. As mean square error needs to be reduced

therefore the proposed algorithm shows the better results than the available methods as mean square error is less in every case.

Figure 4 has explained that quantized analysis of the mean square error. As mean square error needs 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 1.

Images	Existing	Proposed
1	200	24
2	295	44
3	313	25
4	220	38
5	192	75
6	170	23
7	292	57
8	325	4
9	134	21
10	51	11

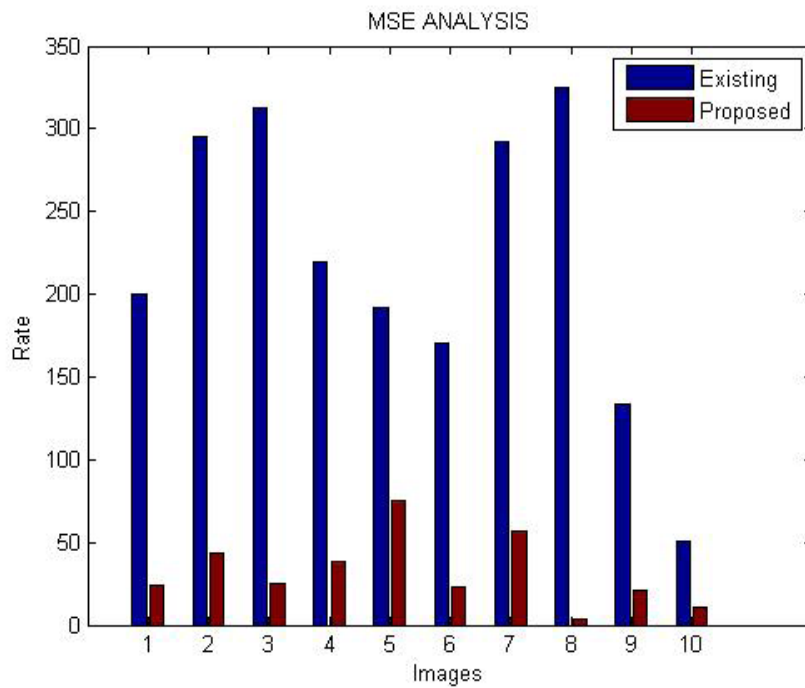


Figure 4. Analysis of mean square error.

7.2 Peak Signal to Noise Ratio Evaluation

Table 2 is showing the comparative analysis of the PSNR. As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible.

Table 2 clearly shows that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Table 2. PSNR evaluation

Images	Existing	Proposed
1	25.1205	34.3287
2	23.4326	31.6963
3	23.1754	34.1514

Table 2 Continued

4	24.7066	32.3330
5	25.2978	29.3802
6	25.8263	34.5135
7	23.4770	30.5721
8	23.0120	42.1102
9	26.8598	34.9086
10	31.0555	37.7169

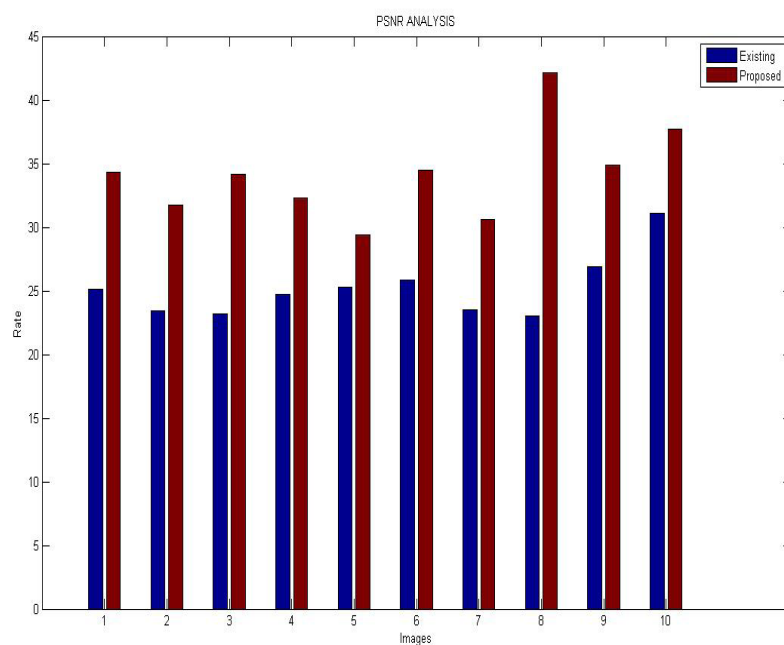


Figure 5. Analysis of peak to signal ratio.

Figure 5 is showing the comparative analysis of the PSNR. As PSNR is required to be maximized; so the main goal is to increase the PSNR as much as possible. It has clearly shown that the PSNR is maximum in the case of the DBL technique therefore it is providing better results than the available methods.

7.3 Root Mean Square Error

Table 3 is used to showing the RMSE values. As RMSE

need to be minimized; so the main goal is to decrease the RMSE as much as possible. Comparative analysis of RMSE in table represent as below:

Figure 6 is showing the comparative analysis of the RMSE. As RMSE need to be minimized; so the main goal is to decrease the RMSE as much as possible. This is clearly shown that the RMSE is less in dominant brightness level.

Table 3. RMSE

Images	Existing	Proposed
1	14.1421	4.8990
2	17.1756	6.6332
3	17.6918	5
4	14.8324	6.1644
5	13.8564	8.6603
6	13.0384	4.7958
7	17.0880	7.5498
8	18.0278	2
9	11.5758	4.5826
10	7.1414	3.3166

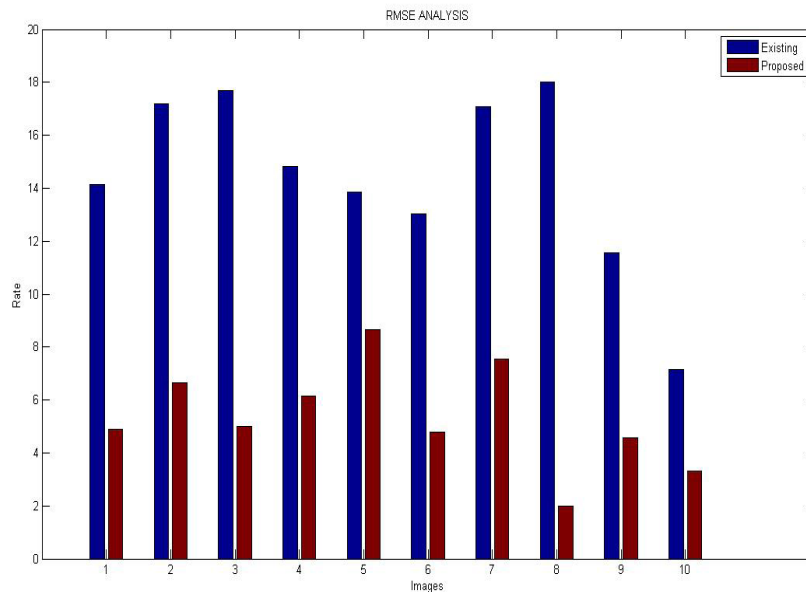


Figure 6. Analysis of RMSE.

7.4 Bit Error Rate

Table 4 is showing the comparative analysis of the BER. As BER need to be minimized; so the main goal is to decrease the BER as much as possible. Table 5 has clearly shown that the BER is minimum in the case of the proposed

algorithm therefore proposed algorithm is providing better results than the available methods.

Figure 7 is showing the comparative analysis of the BER. As BER need to be minimized; so the main goal is to

Table 4. BER

Images	Existing	Proposed
1	0.0398	0.0291
2	0.0427	0.0315
3	0.0431	0.0293

Table 4 Continued

4	0.0405	0.0309
5	0.0395	0.0340
6	0.0387	0.0290
7	0.0426	0.0327
8	0.0435	0.0237
9	0.0372	0.0286
10	0.0322	0.0265

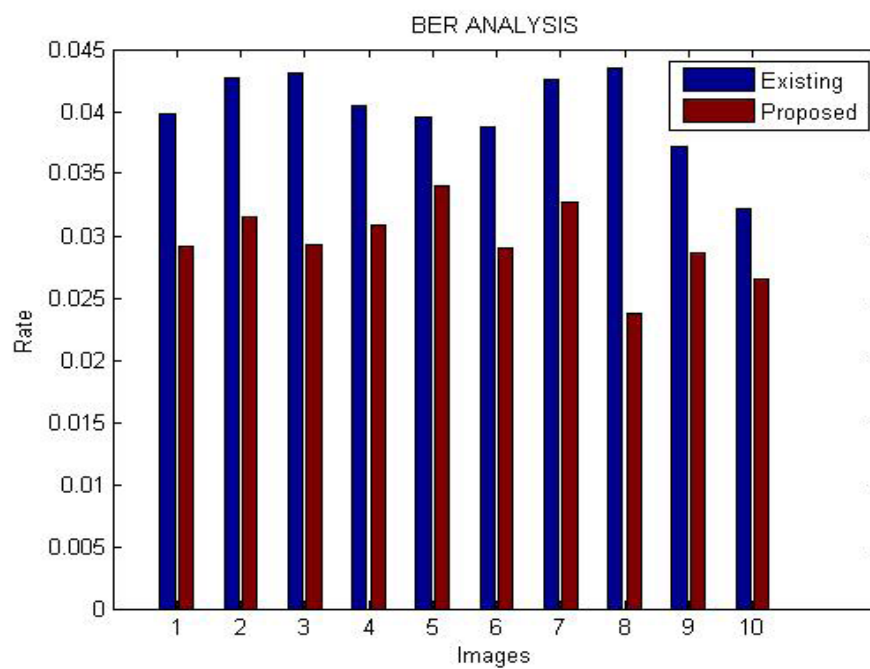


Figure 7. Analysis of BER.

decrease the BER as much as possible. It has clearly shown that minimum value of the BER.

8. Conclusion

In this work, illuminate normalization and adaptive histogram stretching has been used as the post processing function to enhance the results further for the image enhancement. The proposed algorithm has been designed and implemented in MATLAB. The comparison has been drawn on the basis of various performance metrics like Mean Square Error, RMSE, Cross Correlation, BER, PSNR and Normalized Absolute Error which proves the efficiency of the proposed algorithm.

This work has not considered any swarm intelligence based technique to enhance the results further. Also the effect of high density of noise is also ignored, so in near future suitable fuzzy based filter will be used.

9. References

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