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Enhancing Of Images Using Min/Max Butterworth Filters

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Abstract: This paper presents a new image enhancement algorithm based on combined local and global image processing using filters. Images are very useful for variety of purposes or to solve real life problems. This approach uses the fact that the relationship between stimulus and perception is logarithmic. The basic idea is to apply Fast Fourier Transform (FFT) histogram matching with spatial equalization approach on different image blocks. The resulting image is a weighted mean of all processing blocks with using of filters. The weights for every local and global enhanced image driven through optimization of measure of enhancement peak signal to noise ratio (PSNR), structural similarity index (SSIM). Experimental results illustrate the performance of the proposed algorithm on images in comparison with the traditional methods.

Index Terms – FFT, Histogram Equalization (HE), BBHE, DSIHE, RS-ESIHE, R_ESIHE, PSNR, SSIM, BRISQUE, NIQE &PIQE

I. Introduction

Image enhancement is to enhance the image so that resultant is more suitable than specific applications. Enhancement approach can be classified into two categories: spatial and frequency domain methods. The first group use spatial domain image processing which directly manipulates the pixels. Many spatial image enhancement methods are based on histogram analysis and modification; other methods are based on the local contrast transformation.

To use the image enhancement, we must understand what is contained in the image or the problem in terms of what underlies us to use the image repair method, whether from detail, color, lighting, and others. Sometimes we initially want to improve the image but instead aggregate the image. With this, we must estimate what image improvement method is needed.

The most popular image enhancement method is histogram equalization. It is a global processing approach, so the entire tone of the image has been changed like more bright or dark image. In many cases, these methods extend the dynamic range of an image in local regions, leading to artifacts and overall tonal change of the image.

The second group use transformation in the frequency domain through modification magnitudes and altering the frequency content of the image. These enhancement techniques use frequency transform such as Fourier transforms and etc. Sometimes the image properties such as low and high- frequency coefficient's histograms may be so tightly packed that distinguishing them from one another may be impossible. Logarithmic transform allows improving the difference between levels of images.

Adaptive histogram equalization (AHE) is an image processing technique used to improve contrast in images. An adaptive version of this algorithm called contrast limited adaptive histogram equalization (CLAHE). This approach is wildly used for improving the local contrast for thermal and infrared images. The enhancement quality in these methods is not natural for many real type scenes and may be improving for a thermal image with the following properties: irregular lighting and brightness gradient.

II. Image Enhancement

1) Point based enhancement

Digital images always contain very important value which is known as pixels. Some basic operations can be performed on digital images for enhancing the pixel value. Some major approaches in point-based approaches are as:

2) Brightness Modification

In this approach some kind of constant should be added in existing image. Value of constant should be change according to the image. For increase the brightness of the image we add some fix or constant value in the image.

M (i, j) = N (i, j) + W (1)

For reduction in the brightness we should decrease the pixels of the image by subtracting constant value

M (I, j) = N (i, j) –W (2)

3) Contrast Adjustment

This method illustrates to upsurge the contrast of the image by multiplying some constant value of the image.

M (I, j) =N (i, j) ∗W (3)

4) Image negative or inverse transform

This approach is very useful in particular medical imaging. In several time inverse of the image is very crucial for identifying the diseases. This is a very old technique to enhance the digital image. Here the dark and light shade replaced with each other. Inverse obtained by subtracting original image from 255.

M (i, j) = 255 - N (i, j) (4)

5) Histogram based techniques

Due to its precision and simplicity, histogram equalization is the furthermost esteemed and extensively used in contrast enhancement. It is accomplished by employing its cumulative density function to normalize the intensity distributions, which increases the contrast of an input image and produces a consequent image with a uniform intensity distribution.

The image histogram is the foundation for many spatial domain processing algorithms. It can be used for picture improvement, compression, and segmentation, as well as providing relevant image statistics. Calculating it in software and even hardware implementations is straightforward. Histogram Equalization (HE) creates an image with equally likely intensity levels over the entire image.

III. Algorithms

As seen in literature survey some issues still not resolved in earlier approaches, like low light images still not enhance by the existing approaches and we also improve PSNR value. The proposed model works all types of images either color images or gray scale images. Also enhances the low light images very efficiently. In proposed methodology we proposed hybrid approach for image enhancement and introduce model for edge or corner detection.

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A. Adaptive Histogram Based Approach (AHE)

This is the very popular algorithm for image enhancement. After capturing the image, it contains several types of noise in image. Various histogram-based approaches are already introduced by the researchers.

AHE is the variation in histogram-based approach. In histogram-based techniques some issues arise like we cannot manage the contrast of the image. After enhancement, resulting images diminished contrast as compare with the original image.

Adaptive histogram-based technique deals in small regions, where normal histogram-based approach works on the entire image. Adaptive nature of the algorithm is very useful in all types of images like medical images and many more.

AHE approach uses the image in small regions or tiles, and later on all regions combined together to get the resultant image. Here bilinear interpolation is used to eliminate the boundaries which are induced in the resultant image. In AHE the noise present in the image is also get more contrast to avoid this situation we use CLAHE to avoid noise amplification which is get more enhance in the image enhancement process. Algorithm for the thermal image is depicted in Fig. 1: The procedure for the proposed algorithm is expressed as following steps:

Step 1- Input - Original Image

Step 2 – Image splitting.

We split image in moving windows on disjoint blocks with different sizes (8 by 8, 16 by 16, 32 by 32 and, i.e.)

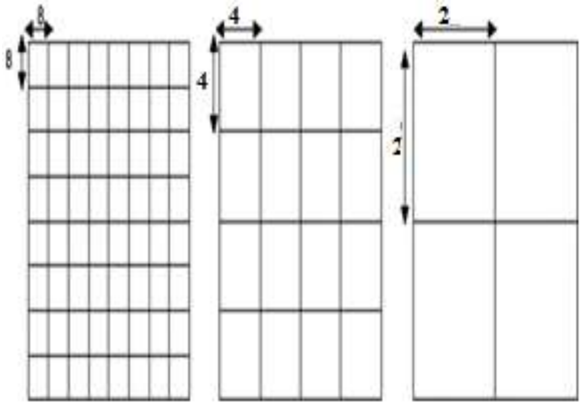


Figure 1. Image splitting.

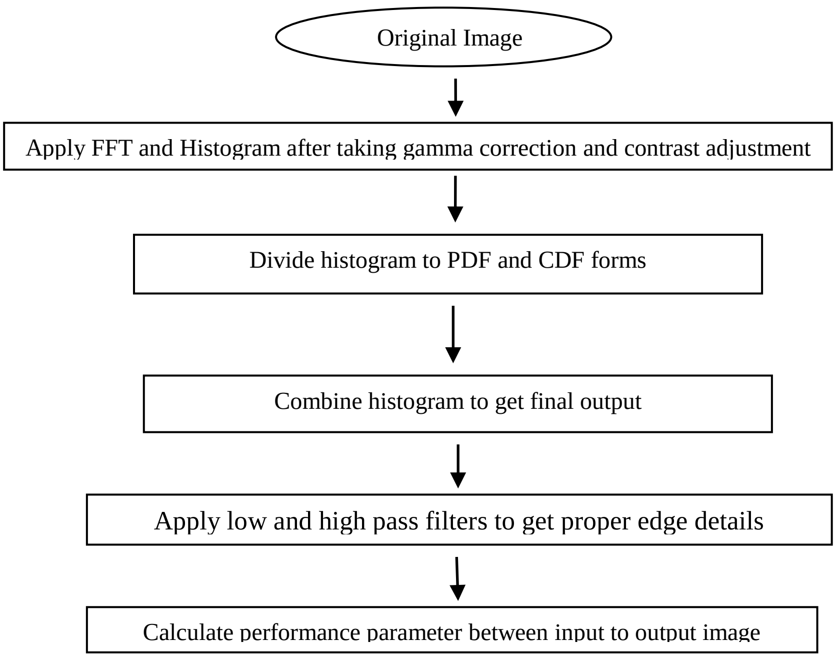
Step 3 – Enhancement Processing

For every sub-image, we use the frequency domain enhancement method based on the logarithmic transform histogram matching with spatial equalization. The block diagram of the enhancement processing shows in Figure 1.We performs image transformation, which needs to be enhanced, then manipulated the transform coefficient, and then perform the inverse orthogonal transform. Histogram mapping is a more generalized version of histogram equalization which allows us to specify to generate a processed image that has the shape of the histogram that we wish the processed image to have. The method used a specified histogram is called histogram matching or histogram specification.

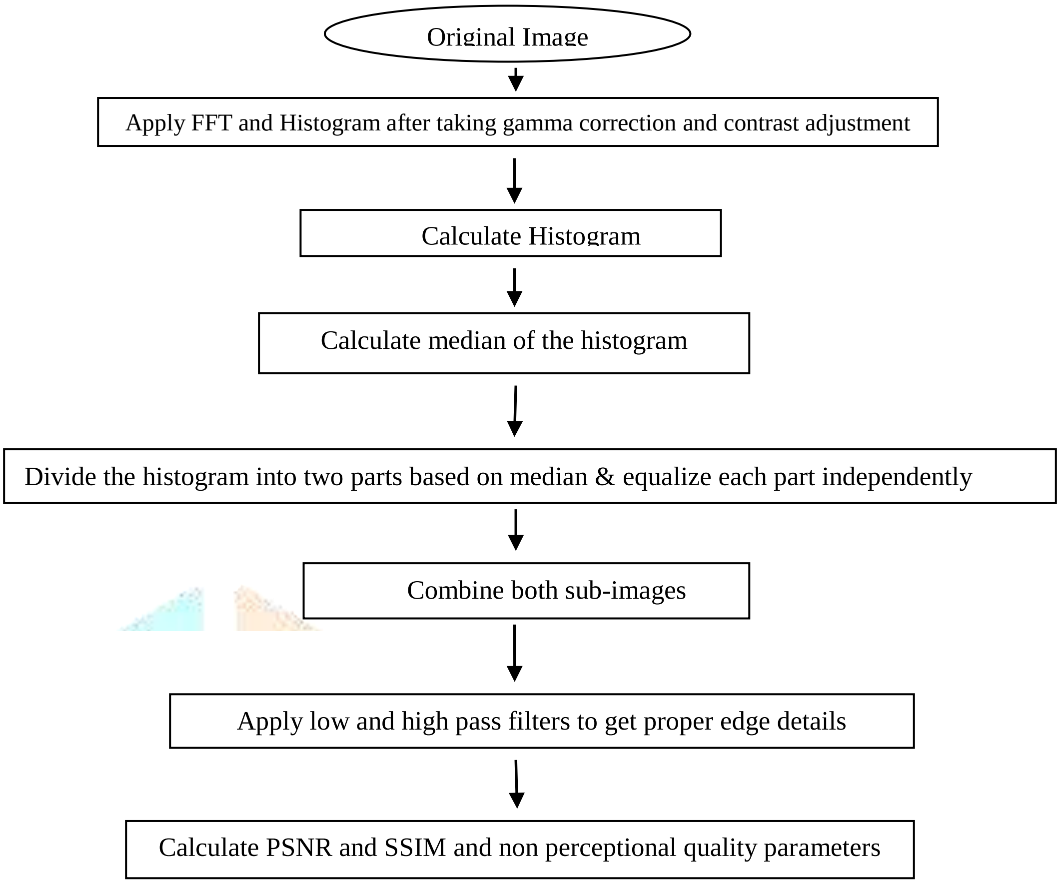
Four types of Histogram Equalization Algorithms considered to get quantitative results are

a) **BBHE-** Brightness Preserving Bi-Histogram Equalization
b) **DSIHE-** Dualistic Sub Image Histogram Equalization
c) **R_ESIHE-** Recursive Exposure based Sub Image Histogram Equalization
d) **RS-ESIHE-** Recursively Separated Exposure based Sub Image Histogram Equalization

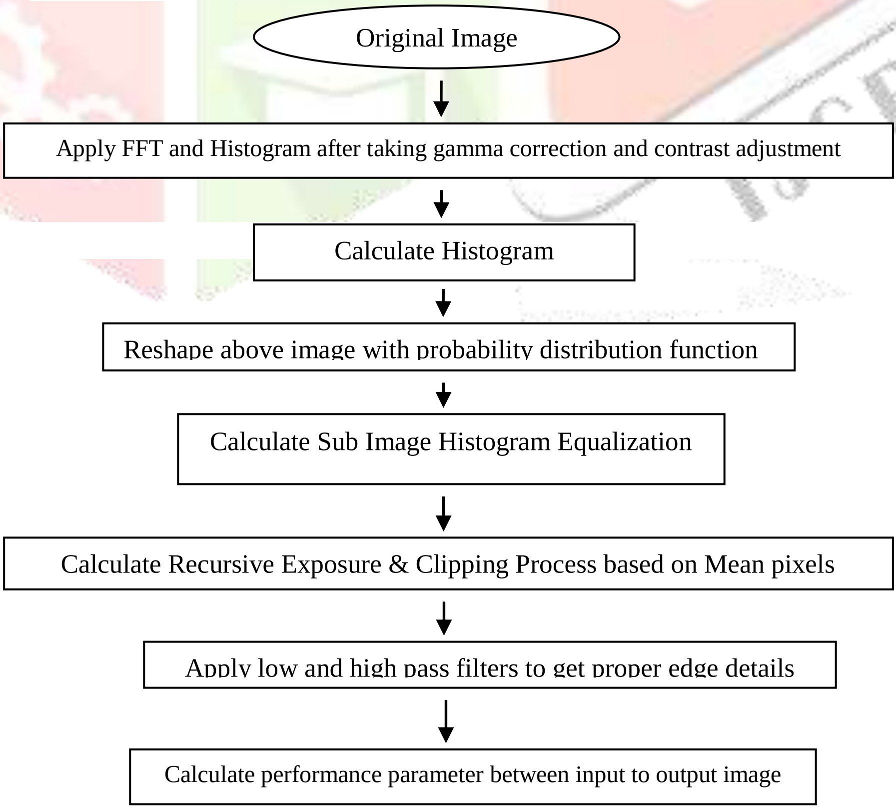
BBHE algorithm Flow Chart



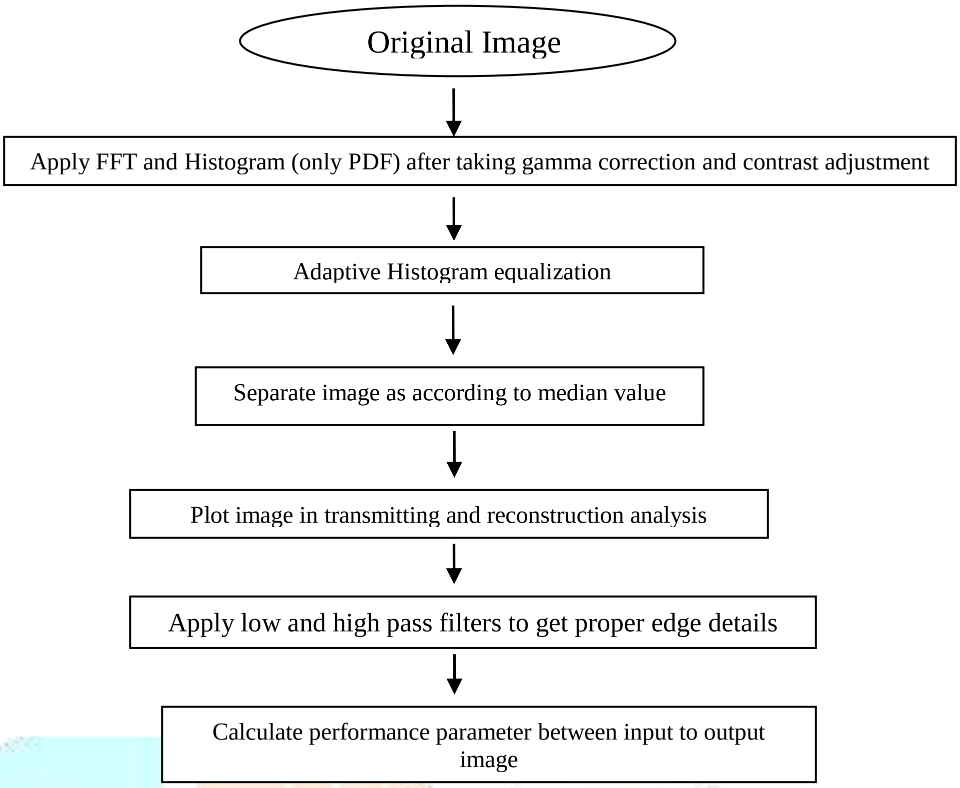
DSIHE Algorithm Flow Chart



R_ESIHE_ALGO Flow Chart



RS-ESIHE algorithm Flow Chart



We can get the enhanced images and also compute some parameters like PSNR, SSIM with including non perceptional quality parameters. SSIM, PSNR give the objective measure of the image; BRISQUE, PIQE, NIQE parameters give the no reference measure of the image

IV.Performance parameters

Main parameters that were discussing with measuring the performance of the system are

a) Structural Similarity Index Measure (SSIM)

1. It is a method for predicting the perceived quality of digital television and cinematic pictures, as well as other kinds of digital images and videos. It is also used for measuring the similarity between two images.
2. An index that evaluates the structural similarity of two images by integrating image contrast, structural difference, and brightness
3. Examines similarities between their luminance, contrast and structure. Then combine these components to yield an overall similarity measure,i.e.,S(x,y)=F(I(x,y),c(x,y),s(x,y))
4. Quality assessment index is based on the computation of three terms, namely the luminance term, the contrast term and the structural term.

$$SSIM(x, y) = [l(x, y)]^{\alpha}\cdot[c(x, y)]^{\beta}\cdot[s(x, y)]^{\gamma}$$

Where

$$L(x, y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1},\ c(x, y) = \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2},\ s(x,y) = \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3} \quad (5)$$

Where μ_x, μ_y, σ_x, σ_y, and σ_{xy} are local means, standard deviations, and cross-covariance for images *x, y*.

If $\alpha = \beta = \gamma = 1$ (the default for Exponents), and $C_3 = C_2/2$ (default selection of C_3) the index simplifies to:

$$SSIM(x, y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (6)$$

When you specify a non-integer value for "Exponents", the SSIM function prevents complex valued outputs by clamping the intermediate luminance, contrast, and structural terms to the range [0, inf].

5. SSIM is a non-linear metric which results from 0.97 to 1 show minimal degradation, results from 0.95 to 0.97 represent low degradation and results below these ranges indicate medium and heavy degradation.

b) PSNR (Peak signal to noise ratio)

In enhancement process always retain its original looks it means noise level should not magnify in the enhanced image. PSNR is the ratio of signal power and input power. A higher PSNR indicates the noise level should be eliminated and reconstruction of the image is higher intensity value.

This model has a combination of Image enhancement and Edge detection mechanism which provides uniqueness and some specialty into existing methodologies.

c) No reference quality parameters:

i) **BRISQUE (Blind/Reference less Image Spatial Quality Evaluator):**

1. Calculates the no-reference image quality score for image A using the Blind/Reference less Image Spatial Quality Evaluator (BRISQUE). It compares default model computed from images of natural scenes with similar distortions.
2. A smaller score indicates better perceptual quality.

ii) **PIQE (Perception based Image Quality Evaluator (PIQE)):**

1. Calculates the no-reference image quality score for image A using a perception based image quality evaluator.
2. A smaller score indicates better perceptual quality.

iii) **NIQE (Naturalness Image Quality Evaluator (NIQE)):**

1. Compares A to a default model computed from images of natural scenes.
2. A smaller score indicates better perceptual quality.

V. Simulation Results

A) RS-ESIHE algorithm has more peak signal to noise ratio and less SSIM than compare to remaining algorithms as shown in Table 1. There is an edge contours and image quality improvement for the above mentioned algorithm as shown in Fig 2

Table 1: Comparison between algorithms

S.No	Method or algorithm	PSNR	SSIM
1	BBHE	31.5037dB	0.5120
2	DSIHE	31.5037 dB	0.5120
3	R_ESIHE	32.0147 dB	0.5194
4	RS-ESIHE	32.0147 dB	0.5194

Simulation output between HE algorithm types

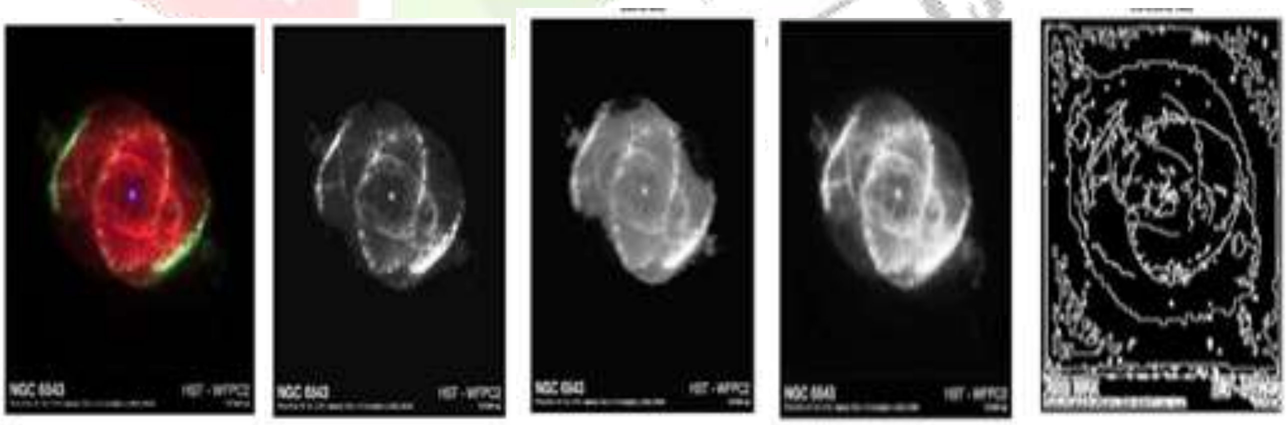


Fig2: simulated images a) original; b) BBHE; c)DSIHE; d)R_ESIHE;e) RS-ESIHE

B) MIN/MAX Butterworth Low Pass Filters

After applying butterworth low pass filter to original HE algorithms there will be an improvement in Peak signal to noise ratio and less similarity between input and output images as according to table2; RS-E-SHIE algorithm simulated output image contains smoothed edge contours than remaining algorithms as shown in Fig3.

Table 2: Comparison between algorithms with MIN/MAX butterworth low pass filters

S.No	Method or algorithm	PSNR	SSIM
1	BBHE	31.5037dB	0.512
2	DSIHE	31.5037 dB	0.512
3	R_ESIHE	32.0147 dB	0.5194
4	RS-ESIHE	40.5356 dB	0.0973

Simulation output between HE algorithm types

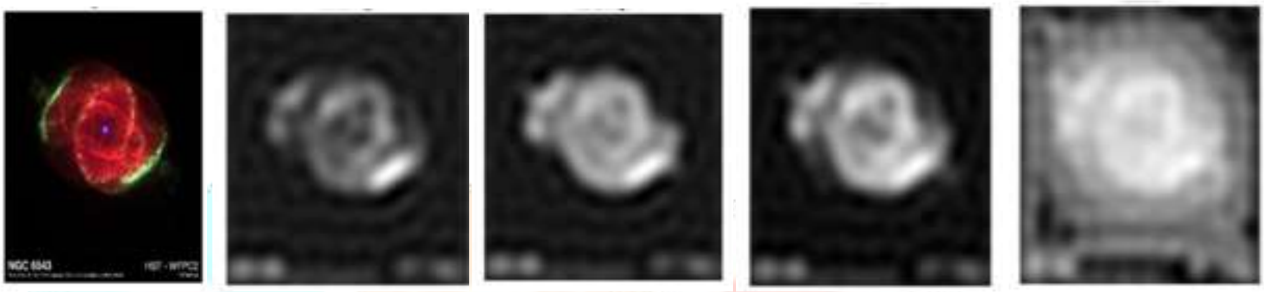


Fig3: simulated images a) original; b) BBHE; c)DSIHE; d)R_ESIHE;e) RS-ESIHE

c) MIN/MAX Butterworth High Pass Filters

After applying butterworth high pass filter to original HE algorithms there will be an improvement in Peak signal to noise ratio and less similarity between input and output images as according to table3; RS-E-SHIE algorithm simulated output image contains sharp edge contours than remaining algorithms as shown in Fig4.

Table 3: Comparison between HE algorithms with MIN/MAX butterworth high pass filters

S.No	Method or algorithm	PSNR	SSIM
1	BBHE	31.5037 dB	0.5120
2	DSIHE	31.5037 dB	0.5120
3	R_ESIHE	31.5220 dB	0.5153
4	RS-ESIHE	40.7643 dB	0.1088

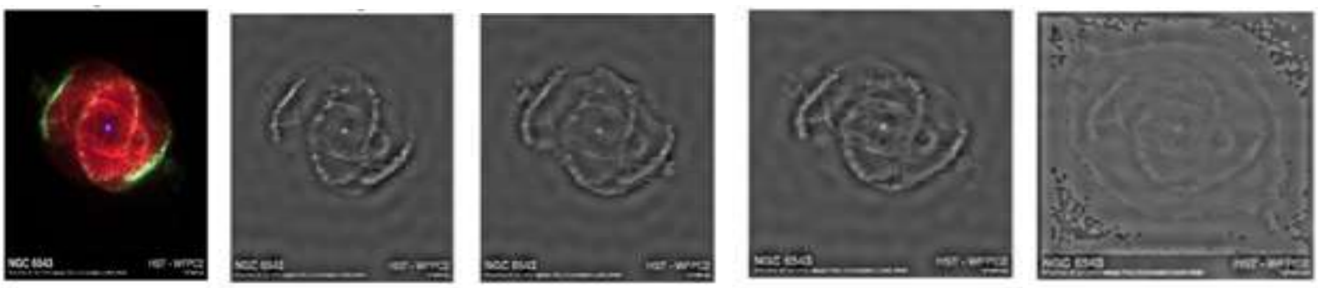


Fig4: simulated images a) original; b) BBHE; c)DSIHE; d)R_ESIHE;e) RS-ESIHE

V conclusion

Peak signal to noise ratio increased for RS-ESIHE algorithm with butterworth high pass filters than remaining. Similarly Structural similarity Index less for using low pass filters than compare to remaining. Peak signal to noise ratio increased for R_ESIHE algorithm butterworth high pass filters than remaining. Similarly Structural similarity Index less for using high pass filters than compare to remaining. Peak signal to noise ratio same for BBHE and DSIHE and less than remaining algorithm than remaining. Similarly Structural similarity Index is same for BBHE and DSIHE less than compare to remaining. BRISQUE parameter EXCELLENT/efficient for BBHE than RS-ESIHE with 2.50259 value, R_ESIHE with 2.1576 value and DSIHE with 13.134 value; RS-ESIHE excellent but using separating values it might be not efficient compare to BBHE. PIQE parameter EXCELLENT/efficient for RS-ESIHE than remaining with 0.4409 value. NIQE parameter EXCELLENT/efficient for RS-ESIHE than remaining with 0.4965 value.

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