EDGE DETECTION AND CONTRAST ENHANCEMENT OF MEDICAL IMAGES FOR IoT APPLICATIONS

Thesis submitted in partial fulfillment of the

Requirements for the Degree of

MASTER OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

BY

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UNDER THE GUIDENCE OF

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JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

MAY 2023

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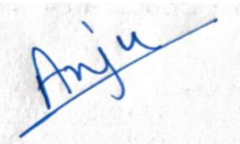
CAPTION **PAGE NO.**

DECLARATION

I hereby declare that the work reported in M.Tech dissertation Report entitled **“Edge detection and Contrast Enhancement of medical images for IoT applications”** submitted at **Jaypee University of Information and Technology, Waknaghat,** India is an authentic record of my work carried out under the supervision of **Dr. Nafis Uddin Khan**, Assistant Professor, ECE, JUIT Solan and Dr. Mohammad Wajid, Associate Professor, Aligarh Muslim University, Aligarh as an external mentor. I have not submitted this work elsewhere for any other degree or diploma.



Signature of Student

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This is to certify that the above statement made by the candidate is correct to best of my knowledge.

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ACKNOWLEDGEMENT

Above all, I thank God, the Almighty for providing me with this opportunity and granting me the capability to proceed successfully. The present work will remain incomplete unless I express myfeelings of gratitude towards several persons who delightfully co-operated with me in the process of the work. It is my privilege to express my sincere gratitude to Prof. Rajeev Kumar, Head of Department of Electronics and Communications Engineering Department, Jaypee University of Information Technology, Waknaghat, India, for their inspiration and motivation during my study. I am grateful to Dr. Mohammad Wajid for his support during the progress of this thesis. I solemnly express my earnest and humble thanks to my supervisor Dr. Nafis Uddin Khan, Department of Electronics and Communication Engineering, JUIT Waknaghat, for the encouragement, guidance, and valuable suggestion to accomplish this thesis work. Finally, I am thankful to my family members, friends, and all who have contributed to this thesis work directly or indirectly in completing my present study.

ABSTRACT

In this digital world, Image has become an indispensable part of our life. Image enhancement is one of the foundational parts of image processing. Now days with so much upgrading going on in this section of image processing, it gives us the ways that can help to get fruitful information from the image.

Contrast enhancement techniques are extensively used for enhancing features in low light images and bring out the undisclosed intricate information. Due to the inadequate visual quality of low light images, it is quite challenging task to enhance low gray level features under noisy environment. One of the appropriate techniques practiced for this purpose is Histogram Equalization. A combination of contrast enhancement with edge detection technique is proposed to help in the processing of dark or blurry images. The performance analysis has been performed on variousMRI images. This analysis is executed in two ways: first visual comparison and second on the basis of different evaluation metric parameters. The amalgamation of the two techniques will be boon for the processing in IoT applications. It will be beneficial for the medicos to diagnose a case quickly and accurately.

LIST OF FIGURES

LISTOF ABBREVIATIONS

Sr. No.	Abbreviation	Full Form
1	AMBE	average mean brightness error
2	BBHE	Brightness preserving Bi-histogram equalization
3	CLAHE	Contrast limited adaptive histogram equalization
4	CT Scan	Computerized tomography scan
5	DSIHE	Dualistic Sub Image Histogram Equalization
6	ESIHE	Exposure sub-image Histogram Equalization
7	GHE	Global Histogram Equalization
8	HE	Histogram Equalization
9	IoT	Internet of Things
10	IQM	Image Quality Metrics
11	LHE	Local Histogram Equalization
12	LoG	Laplacian of Gaussian
13	MRI	Magnetic Resonance imaging
14	MSE	Mean Square Error
15	PDF	Probability Distribution Function
16	PSNR	Peak Signal-to Noise Ratio
17	RTPCR	Reverse Transcription- Polymerase Chain Reaction
18	SSIM	Structural Similarity Index

CHAPTER 1

INTRODUCTION

1.1 Image Enhancement

Fundamental aim of image enhancement is to progress an image in such a way that resulting image is more appealing and specifically befitting to the particular application. Image enhancement can be explained as in this equation S= T(r) where S is output value of pixel after the transformation function 'T' used for the input of the gray level pixel from original image. To conform the image display according to the requirement of our application what becomes the essential part is image enhancement. Principally two types of approaches considered for image enhancement are named as Frequency and Spatial domain. Fourier transform of the image is modified in frequency domain but in spatial domain image's pixels are directly manipulated. Because pixels are directly involved so resources and time required are less. In spatial domain contrast enhancement with histogram equalization is discussed here. Few techniques such as GHE, LHE, BBHE, CLAHE, DSIHE and ESIHE are considered for the project.

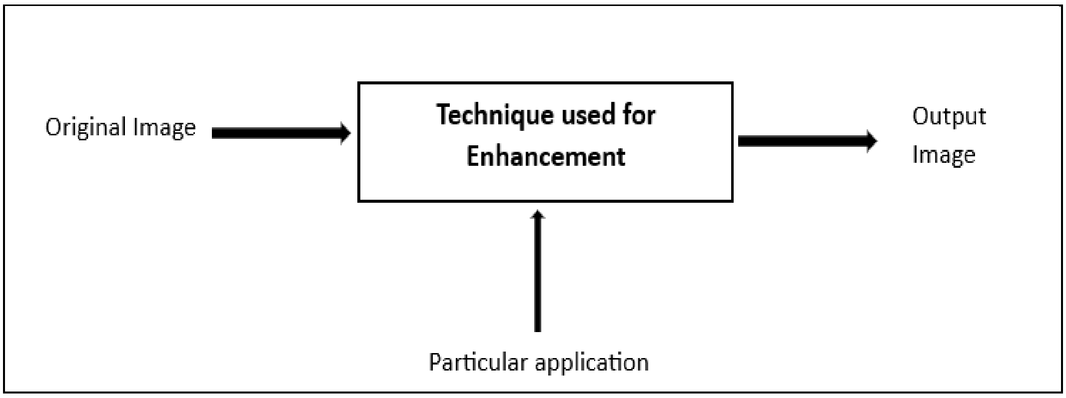
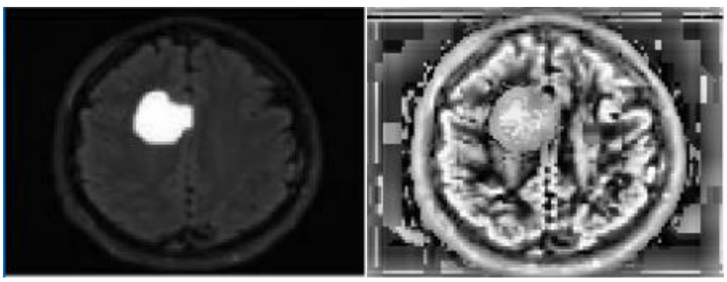


Fig 1. Image Enhancement of any image



Original Image Enhanced Image

Fig 2. Image enhancement as part of image processing

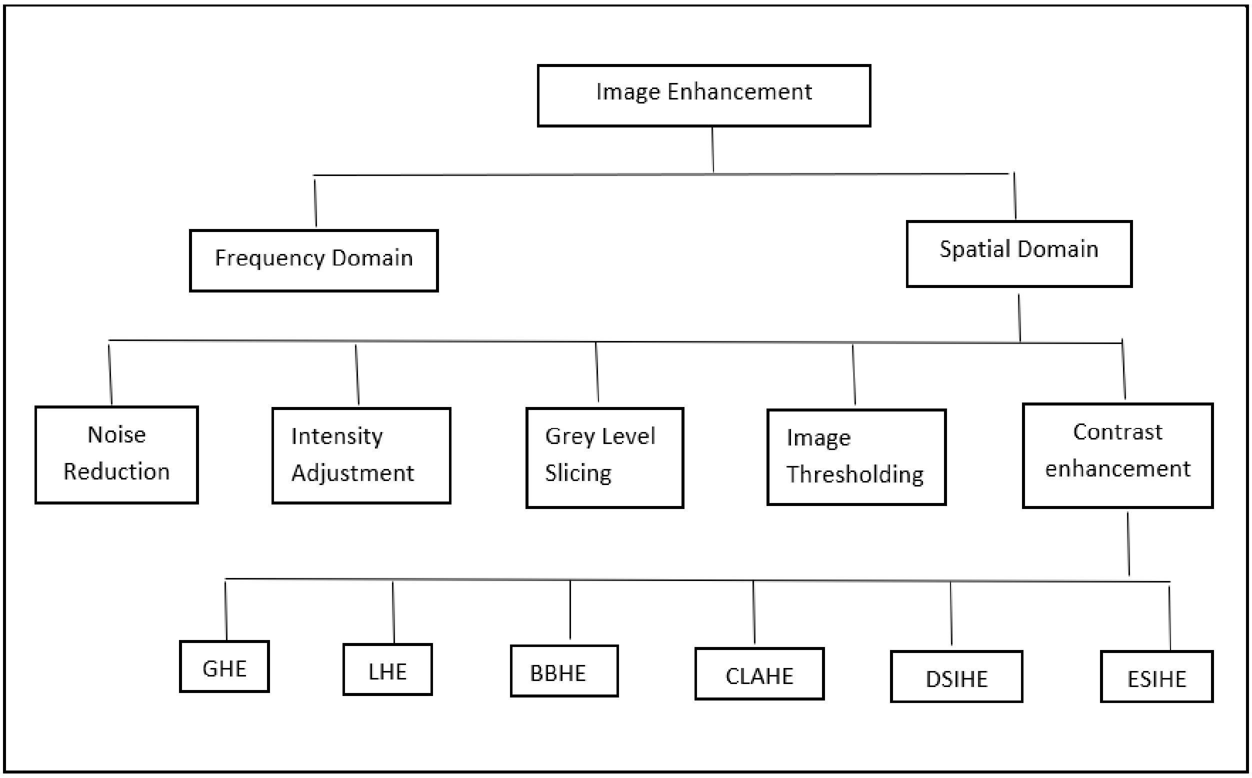
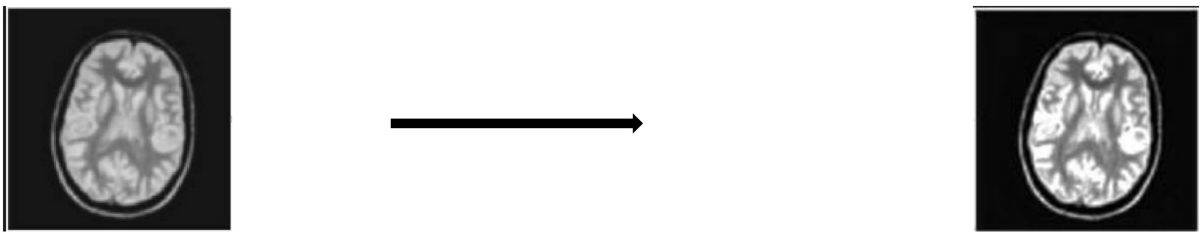


Fig 3. Flow chart of Image enhancement

1.2 Contrast Enhancement

Contrast enhancement plays a decisive role to alter the global brightness and contrast of digital low light images. In order to boost the dynamic range of images and videos, contrast enhancement methods are quite helpful. The major applications where enhancement of contrast is mostly required are medical imaging, underwater imaging and remote sensing images of moon and space components. All these types of images have dark background and invisible low gray level edges and boundaries which tend to degrade the quality of images and loss of information.

For blurriness, contrast adjustment, image smoothingand sharpening of any image we employ image enhancement. Other applications of image enhancement are reducing image noise, adjustments to brightness and to bring out details that are arduous to anticipate.



Input Image Output Image

Fig 4. Image before and after Contrast Enhancement

Following are the advantages of implementing contrast enhancement:

- Low contrast is replaced by high contrast
- Preservation of edges
- Removal of noise
- Increment of content of information

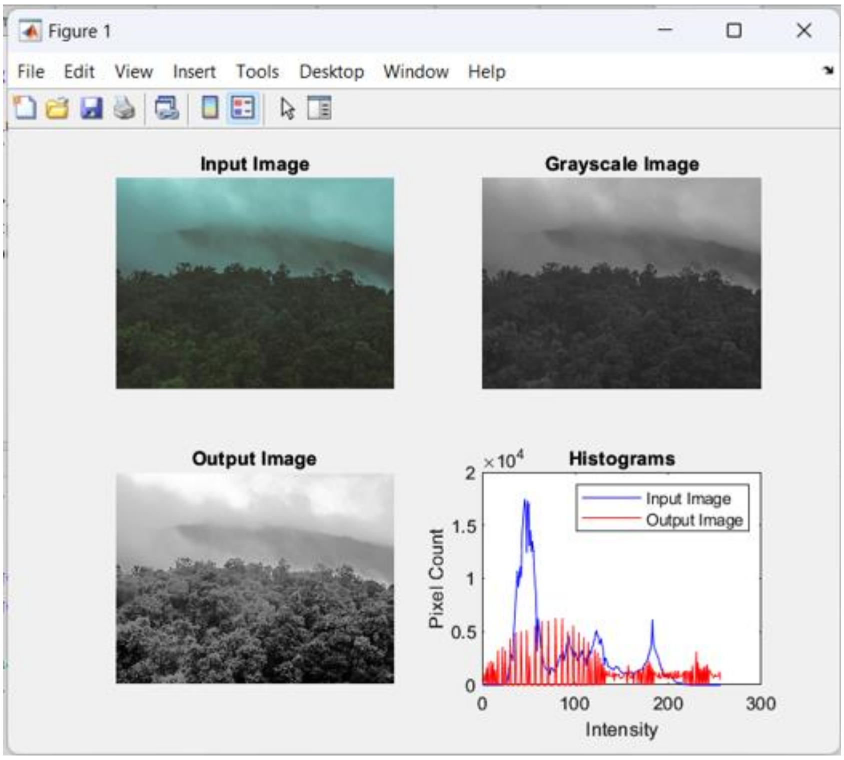


Fig 5. Output image after Contrast Enhancement with histograms

Some of the techniques like GHE, ESIHE, BBHE, CLAHE, DSIHE and LHE are used to compare the output enhanced images. These techniques are very effective in low light dark images from medical field, under sea images or images from space. When edge distinction is required then it becomes difficult as output image may suffer from noise distortion near the edges. Especially in medical images when distinction at edge is very crucial to know for medical professionals, it deteriorates the performance of these systems. Enhancing low contrast images can be achieved through various methods, including adjusting brightness and contrast, using image filters, or applying histogram equalization.

An experimental analysis has been made to compare various histogram equalization-based contrast enhancement techniques. Original input images are some brain MRI images [10], [11]. Few quality measuring parameters are also used such as PSNR (peak signal-to noise ratio), AMBE (average mean brightness error), SSIM (Structural Similarity Index) and entropy to measure the performances.

1.3 Image Processing basics

Image processing operates with the images which is a digital portrayal of any picture.In essence, image can be represented by an array which is two dimensional arranged in rows and columns. Primarily image is constituted with finite small elements, called pixels. Practical information according to the application is taken out by the mechanism of image processing.

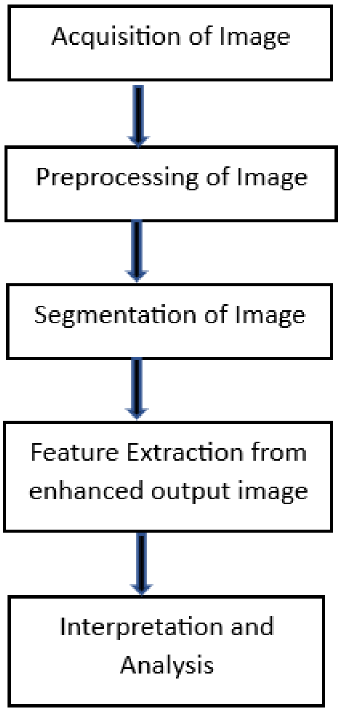


Fig6. Common steps in Image Processing

First step of image processing consists of image capturing with some device. Image conversion from color to gray scale also takes place here. Here input image can be the outcome of any scanner or digital camera. Preprocessing consists of image enhancement and image restoration processes. Image enhancement is unmistakably foundational part of image processing. Image segmentation reside with the image division and each part can be dealt separately. If image segmentation is taking autonomously then it is complicated. Analysis of each part can be performed independently and joined later. To describe or analyze the image features can be extracted in parts or from whole image. After analysis image can be used in various applications. Some of the IoT fields where it can be utilized are medical imaging, multimedia and computer vision.

1.3 Histogram Equalization

Histogram Equalization is the prominent procedurewhich is part of processfor contrast enhancement. In histogram graphical representation of image’s intensity distribution is shown.PDF (probability density function) is the basis of the whole process. Improvement of the dynamic range of histogram of low-contrast image is the main idea behind histogram equalization technique [1]. HE is very straightforward and certain in nature.

- Increment in the full range of image’s gray-levels where image is having contrast on the lower side. So, covering of full range of gray -level
- Smooth and explicit
- provides more perceptiblysatisfying results across an augmented range of images.
- Very fruitful exclusivelyif image is having nearby contrast values
- Calculation of data processing is not very demanding
- Histogram of original picture can be retrieved if it is known which HE technique is practiced
- Frequently used prominent technique applied in medical image enhancement is equalization of histogram. Here whole process is totally dependent on pdf (probability density function). The diversified list of techniques for equalization of histogram isaccessible depending on the demand of applications. Divergent sets of image data can be exercised for HE.
- Level of contrast in the original image is enlarged to the full range

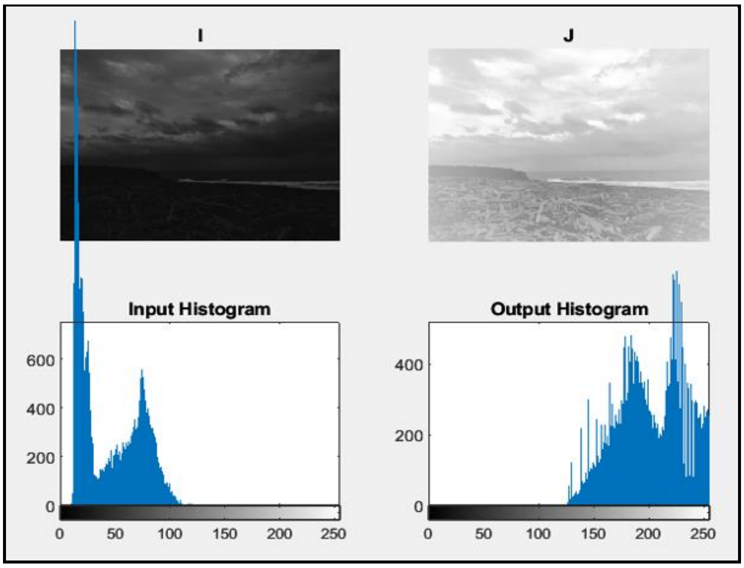


Fig 7. Example showing histogram equalized Image

1.5 Different Techniques of Histogram Equalization

1.5.1 GHE (Global Histogram Equalization):

Global Histogram Equalization: GHE is very straight forward procedure where only thing kept in consideration is that cumulative histogram is linear. Image contrast enhancement is done globally (whole image) by using global histogram equalization (GHE) technique [2]. Transformation function of GHE is configured by employing the input image's histogram information. RGB to gray scale conversion is implemented for analyzing contrast enhancement globally. GHE enhances the whole image contrast but fails to alter the brightness feature of input image. Shifting of average luminance i.e., mean brightness takes place. Sometimes noise is added and output image gets distorted because noise in the image also get enhanced.

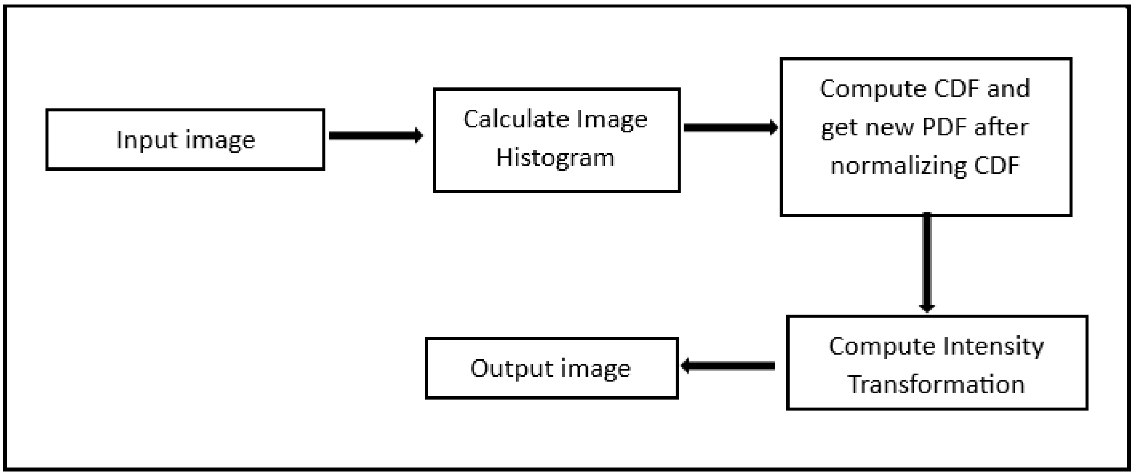


Fig 8. Flow chart showing GHE algorithm

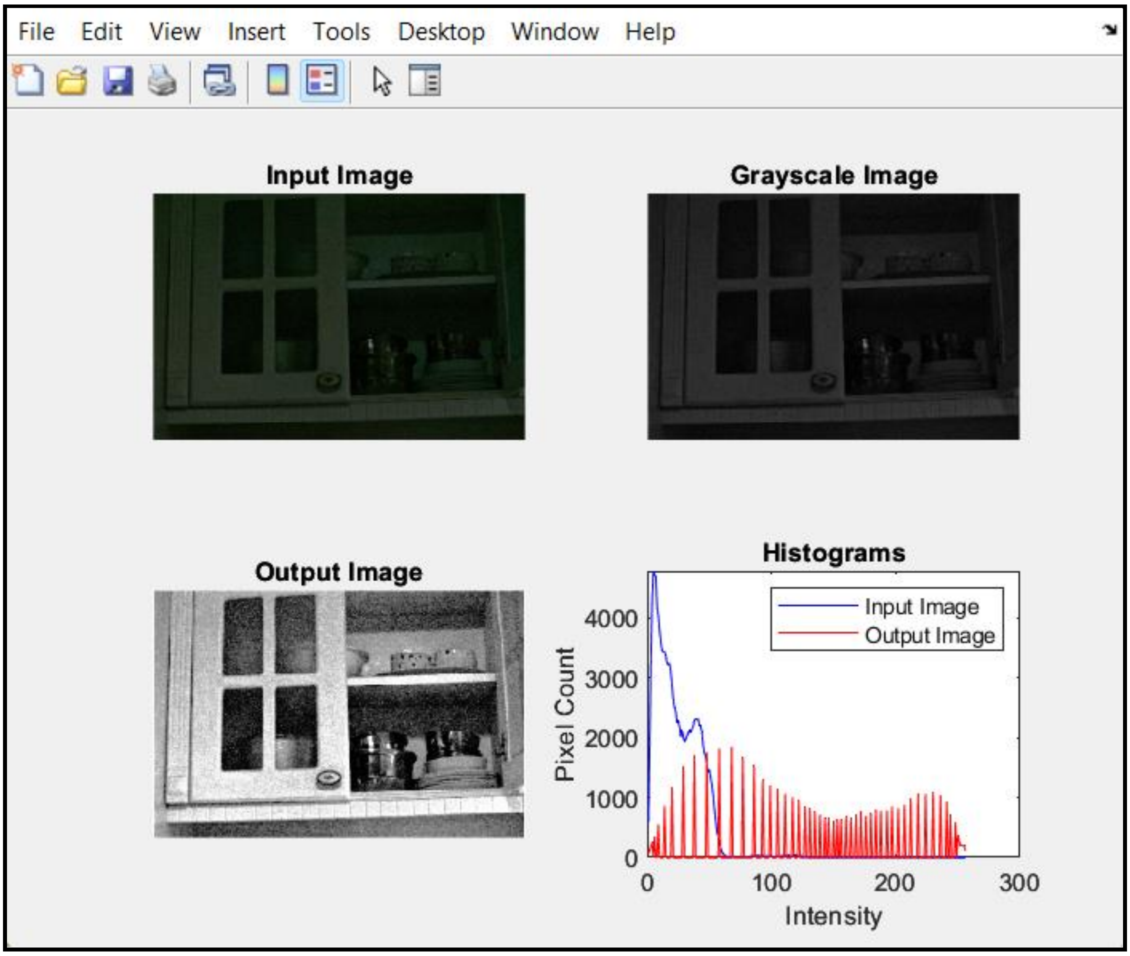


Fig 9. Example showing GHE equalized Image

1.5.2 LHE (Local Histogram Equalization):

The LHE technique can benefit small objects' contrast of any picture, including dimly lit images. LHE's primary objective is to heighten the contrast of each pixel in the image depending on its surrounding neighbors [3],[4]. A small window or contextual area is regarded as having that pixel in the center for local enhancement purposes. While sliding the window through image, coverage is done for all pixels in the image and the CDF is computed. A superior result can be obtained by changing the window size.

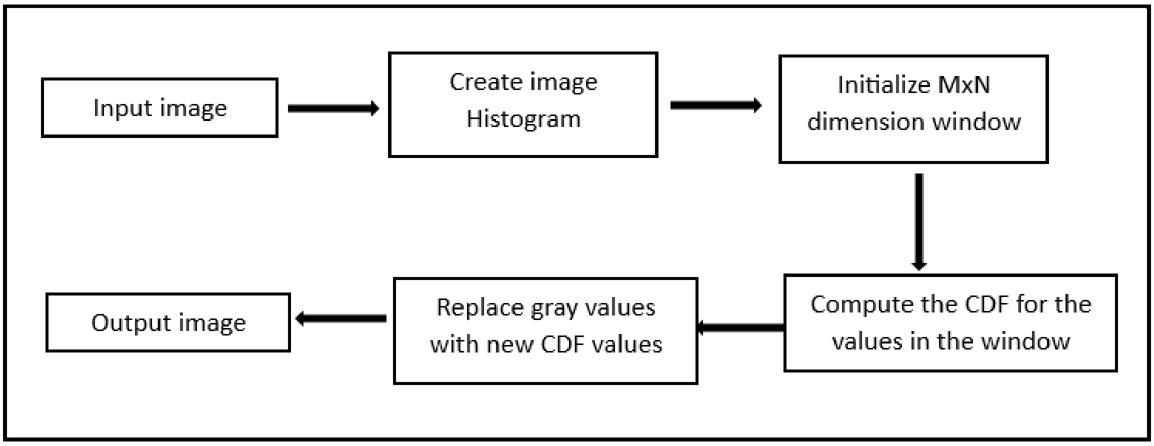


Fig 10. Flow chart showing LHE algorithm

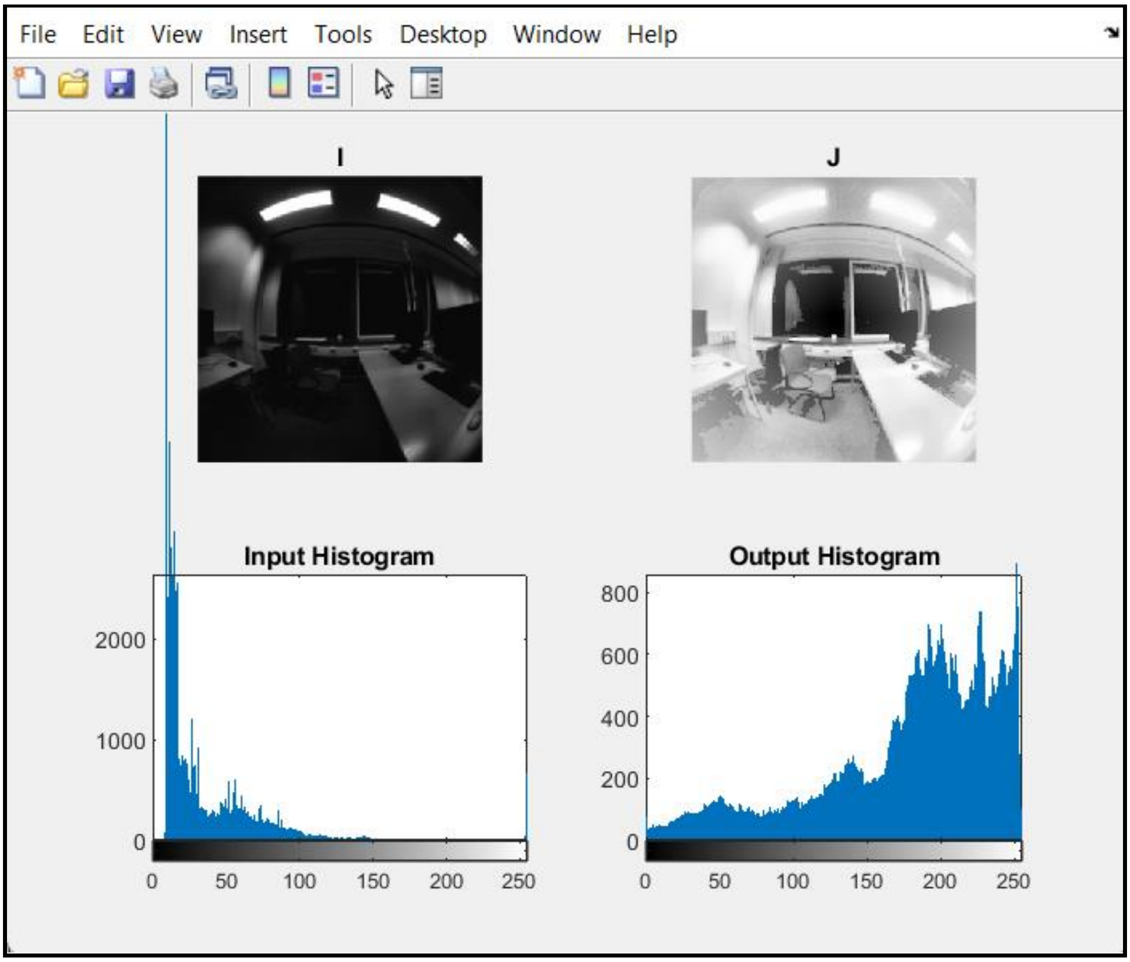


Fig 11. Example showing LHE equalized Image

1.5.3 BBHE(Brightness preserving Bi-Histogram Equalization):

Division in two parts is done in the BBHE approach but separation is done on the basis of its mean before equalizing [3],[5]. Each sub- histogram is equalized individually.After enhancing both sub-images are combined for output image. This method is very good in preserving brightness.

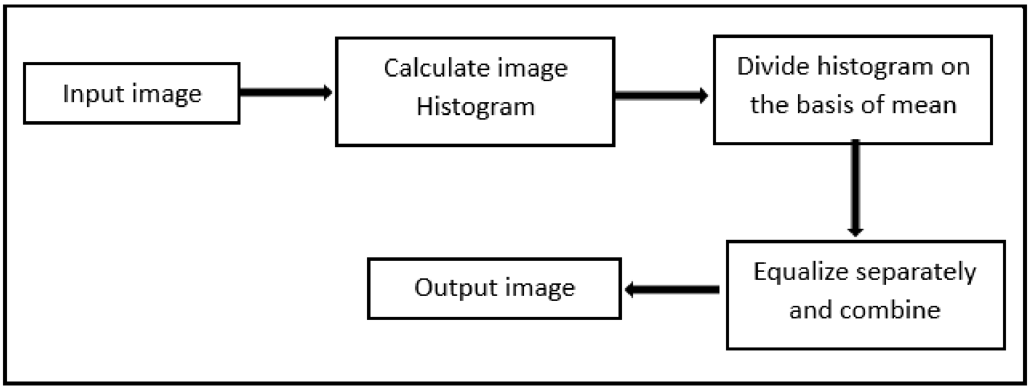


Fig 12. Flow chart showing BBHE algorithm

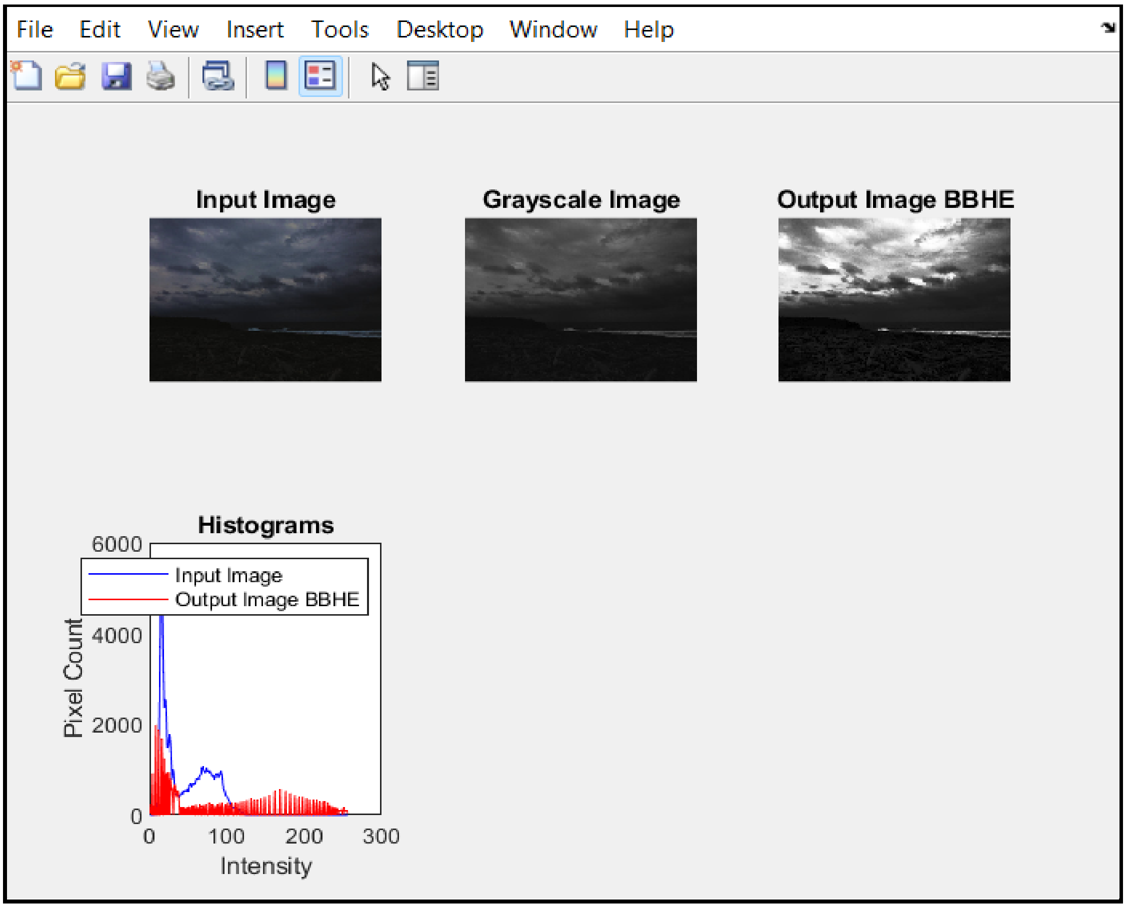


Fig 13. Example showing BBHE equalized Image

1.5.4 CLAHE(Contrast-Limited Adaptive Histogram Equalization):

Tile is the name given to the section made by the division in CLAHE and later these blocks are mapped after processing. The three main components of the CLAHE method are like, first tile generation then histogram equalization and after that bilinear interpolation. Each tile is subjected to histogram equalization using a pre-set value. Each tile's histogram consists of a collection of bins [7]. Higher clip limit histogram bin values are collected and distributed among other bins. Following that, CDF is determined for the histogram numbers. The input picture pixel values are used to scale and map the CDF values of each tile. To create an output picture with better contrast, the resulting tiles are pieced together using bilinear interpolation. CLAHE is excellent for increasing visibility in a hazy picture or video. To restrict the over amplification of noise generally CLAHE is used.

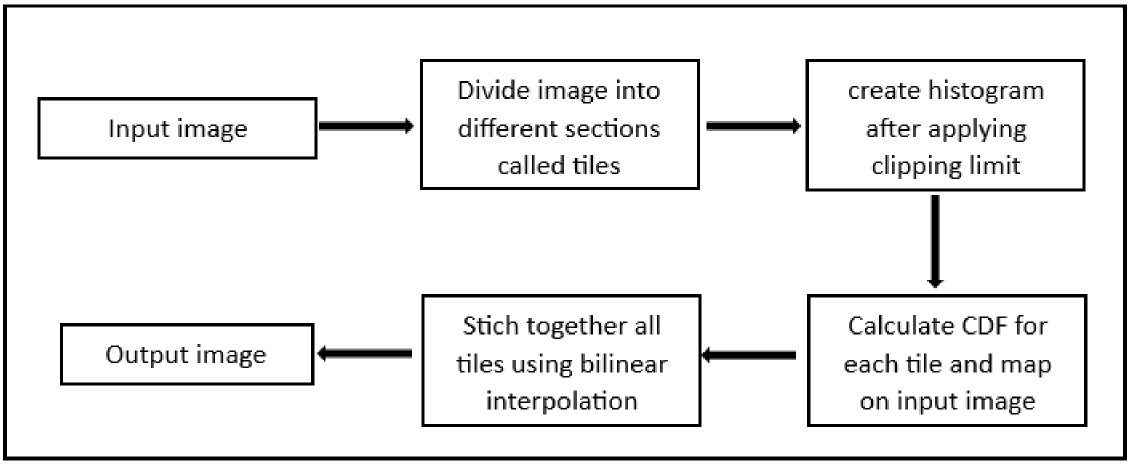


Fig 14. Flow chart showing CLAHE algorithm

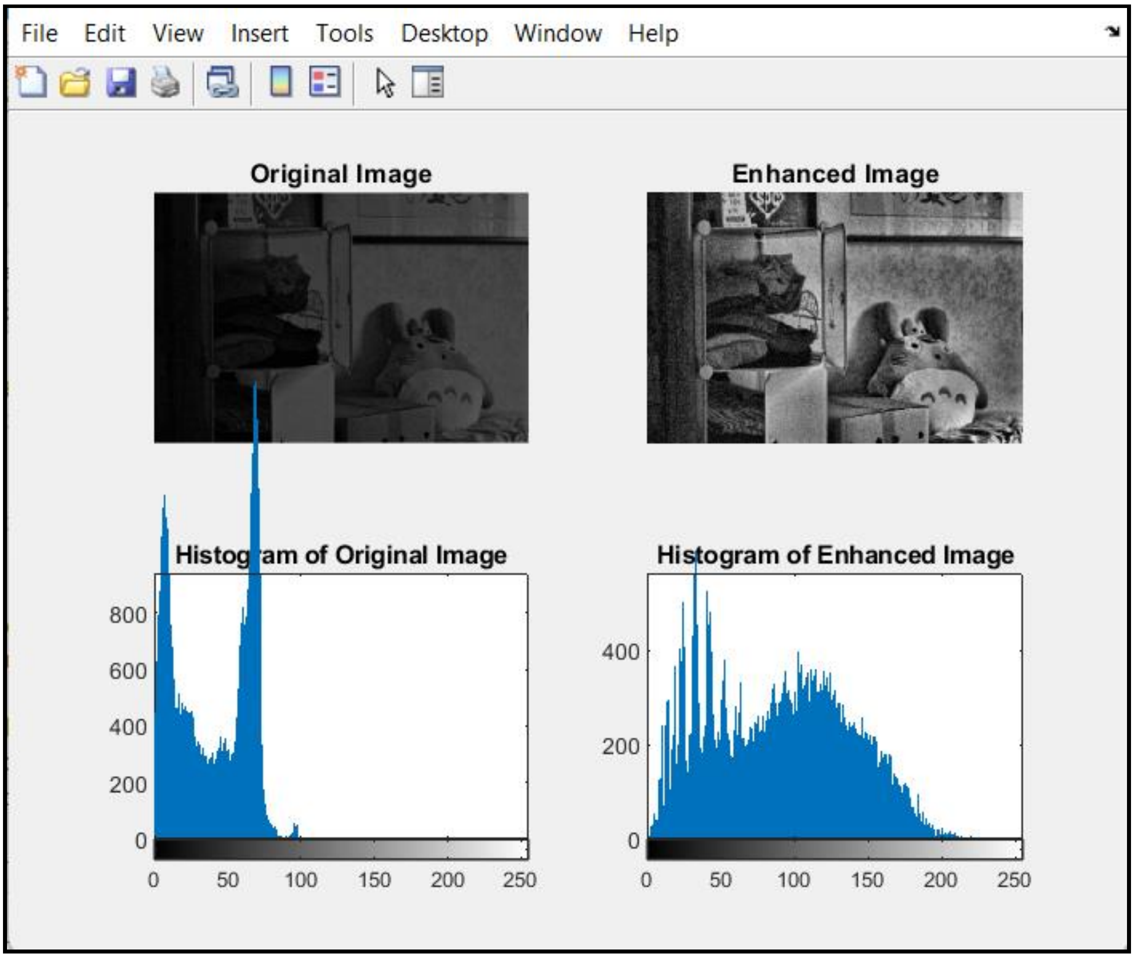


Fig 15. Example showing CLAHE equalized Image

1.5.5 DSIHE(Dualistic Sub-Image Histogram Equalization)

Division is also performed in DSIHE just similar to BBHE but DSIHE divides on the basis of median intensity [5]. It creates two sub-images using cumulative distribution function (CDF) based on median. We can vary that CDF value (normally CDF=0.5) to get the better outcome in image quality. DSIHE method decomposes the image with an aim to maximize the output image's entropy which is described by Shannon's theory. DSIHE not only preserve brightness but safeguard entropy too. Sub-images are of two types one dark and other bright. Both sub images are mingled together to create a single enhanced image.

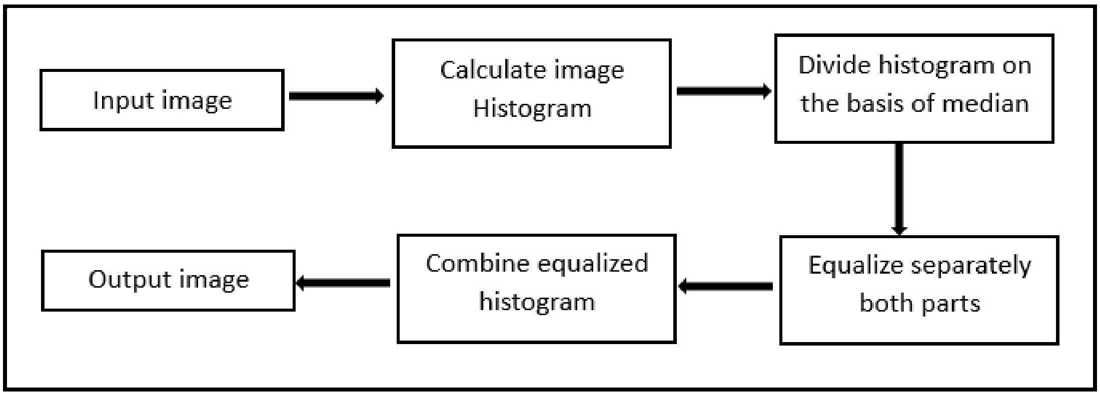


Fig 16. Flow chart showing DSIHE algorithm

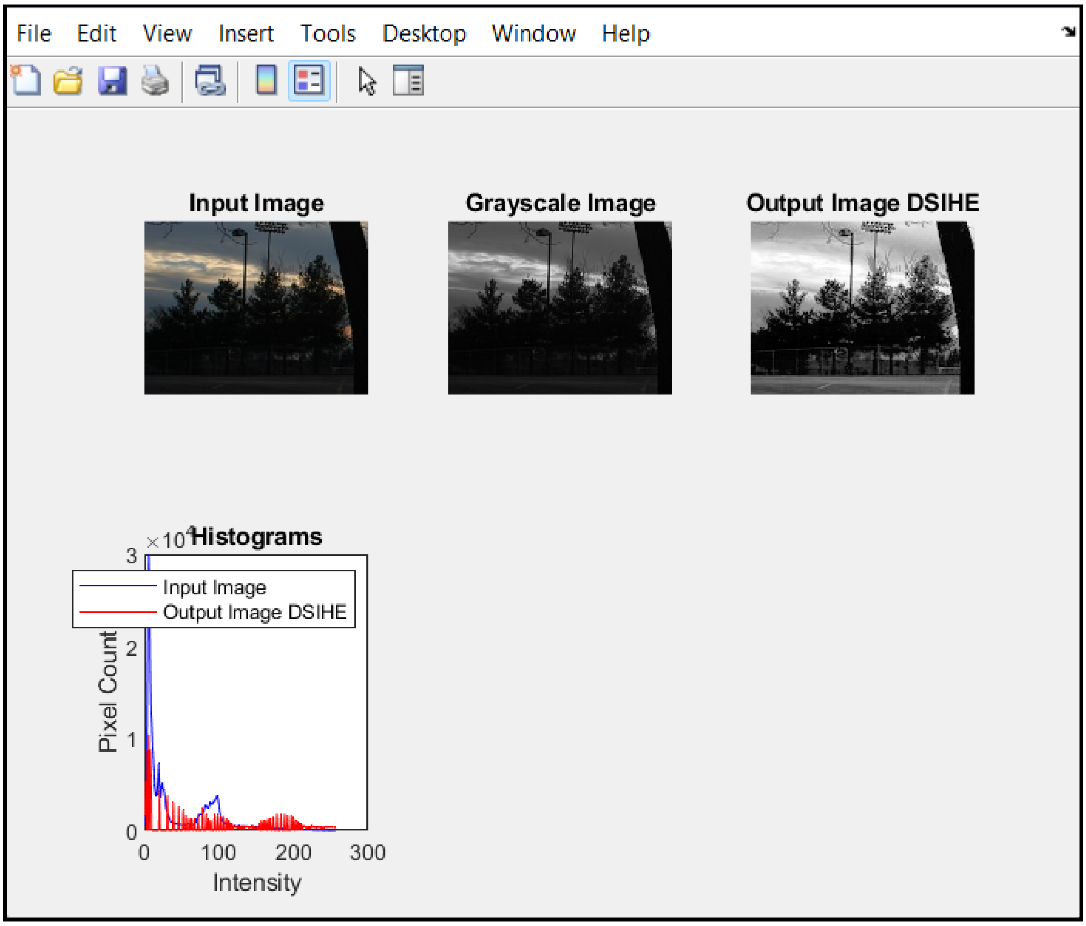


Fig 17. Example showing DSIHE equalized Image

1.5.6 ESIHE(Exposure based Sub-Image Histogram Equalization)

ESIHE procedure also divide the input image in parts and these sub- image parts can be more than two. This technique specifically works for low exposure grayscale images. In this technique exposure threshold value is calculated for each part of image [6],[8],[9].

Histogram equalization is done on each sub-Image separately. Histogram clipping can be done on the basis of threshold value to prevent over-enhancement. All sub-images will be combined to give one output enhanced image.ESIHE outperforms other HE methos in terms of visual quality, entropy preservation and better contrast enhancement.

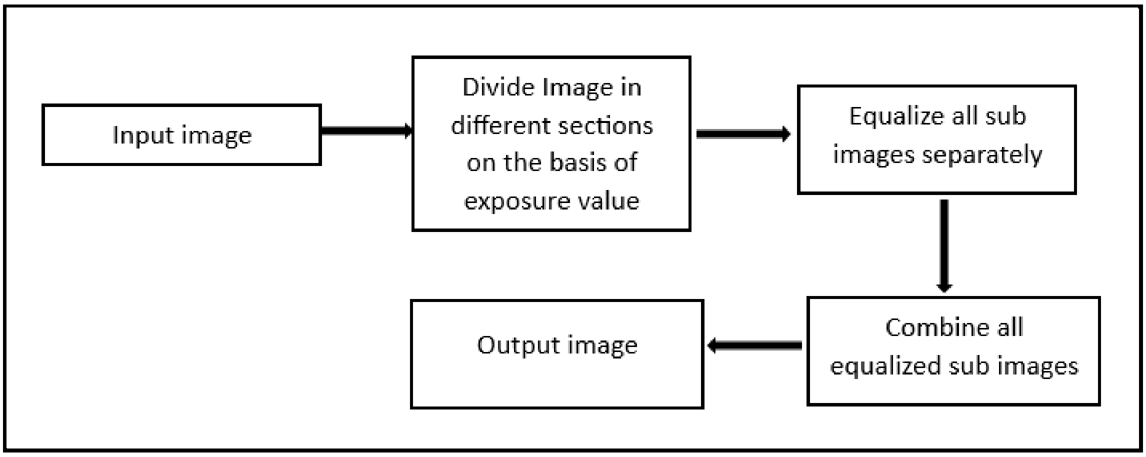


Fig 18. Flow chart showing ESIHE algorithm

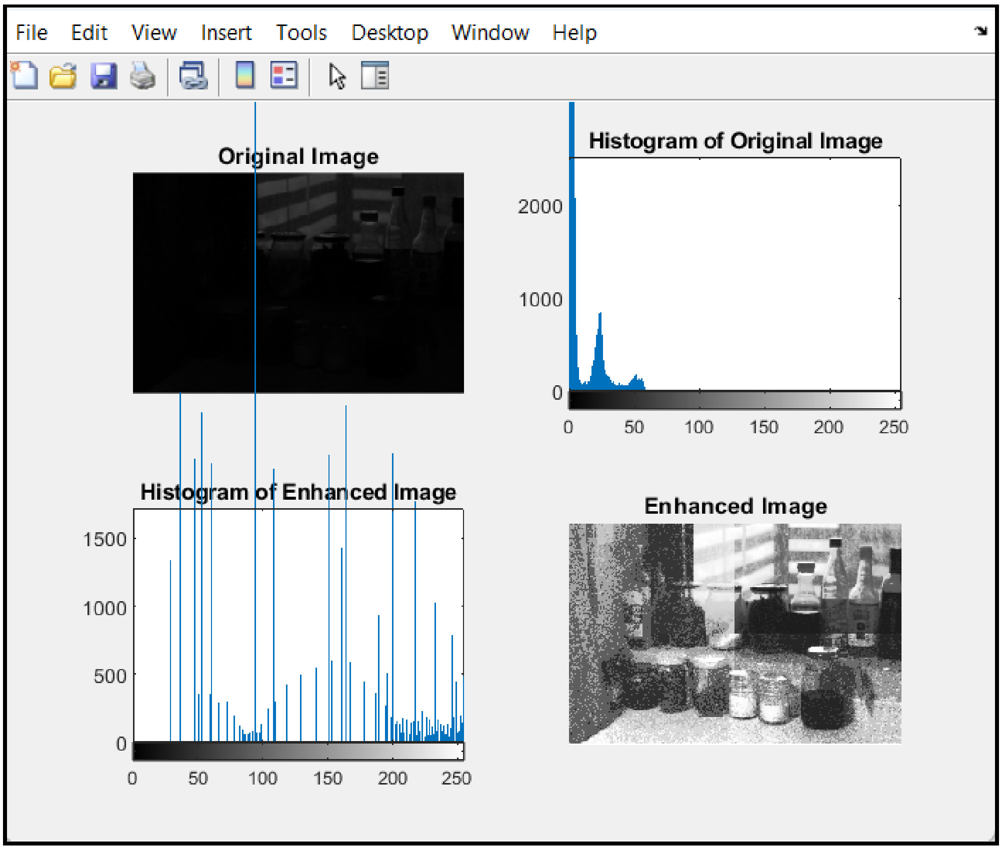


Fig 19. Example showing ESIHE equalized Image

1.6 Edge Detection

Edge detection is like contour drawing of an image where boundary is showing the distinguishable brightness difference. Edge detection facilitate to reduce the processed data which aids to reducing the processing time. Edge detection is the fundamental part of image processing, object detection and computer vision which is covered under IoT applications.

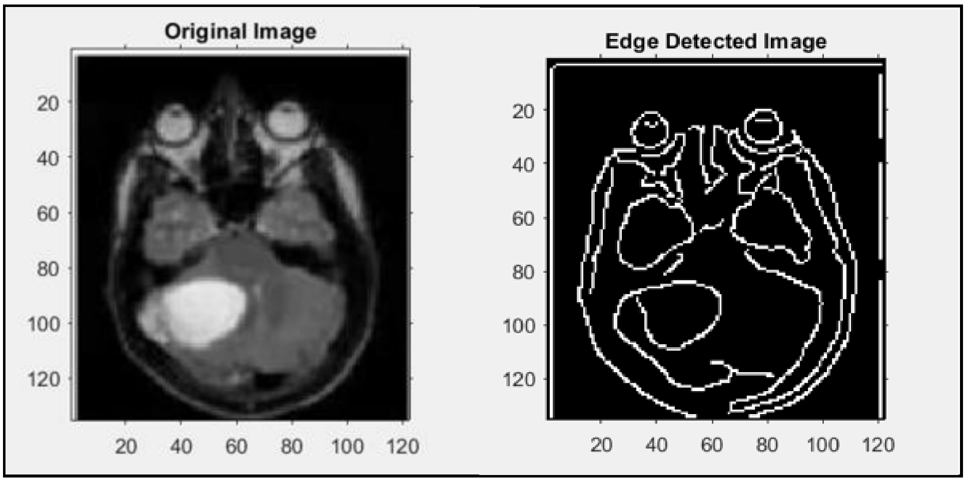


Fig 20. Edge detection done on a HE enhanced Image

CHAPTER 2

PROPOSED METHOD

Contrast enhancement techniques are appropriate for dark and unclear images. We get a noticeable outcome from these techniques. Also edge detection is very advantageous because processed data is reduced substantially. This makes machine vision uncomplicated as a benefit because of scaling down of processed data. Time consumption is shortened considerably. As output is processed by machines so human error is totally eliminated. Here I propose a method which will be for the betterment in the medical field.

My Proposal is: Output from the contrast enhancement technique will be fed to edge detection procedures. It will give a precise result of the contour from a very dark original image.

Achievement from this strategy will be for the advancement in the field of medicos and machine vision. Best combination of the techniques can be chosen according to the IoT application.

2.1 Contrast Enhancement with different Histogram Equalization Techniques

In my work, I have taken few contrast enhancement techniques which are based on histogram equalization. GHE, LHE, BBHE, CLAHE, DSIHE and ESIHE techniques are used for the experiment. Even parameters variation is also tried to get the best result for the respective algorithms.

2.2 Edge Detection Techniques Used after Enhancement

As per proposal, output image from above histogram equalization techniques will be fed to the different edge detection techniques. All these workings are shown in experiment analysis. Trial with different threshold values is also shown there. Canny, Sobel, Prewitt, Robert and zero-cross edge detection techniques are experimented here. A visual comparison has been done to find the best technique.

2.3 Experimental Analysis

All the above-mentioned histogram equalization techniques are processed through MATLAB. A proprietary of Math-works, MATLAB is developed for programming. It is used for plotting of functions, checking algorithms' performance.It also caters a bilateral interactive platform for designing, probing and research. In this project MATLAB -R2023a_win64 is used.

Contrast enhancement can be done on MATLAB using histogram equalization techniques. Parameters used in that particular algorithm can be changed by making changes in corresponding MATLAB code. Best values for the particular techniques can be decided which will cater to give finest output image.

Few dark medical images are reviewed here for the study of contrast enhancement techniques. These contrast enhancement techniques will help medical professional to diagnose about the ailments of patient more accurately even if the pictures are blurred or with poor visibility.

2.4Experiment with different parameter values for HE algorithms:

Medical images go through from following issues:

- Dark image due to low contrast
- Apparently, image features do not have clarity
- Complicated image from scanner like CT scan, X-ray and MRI

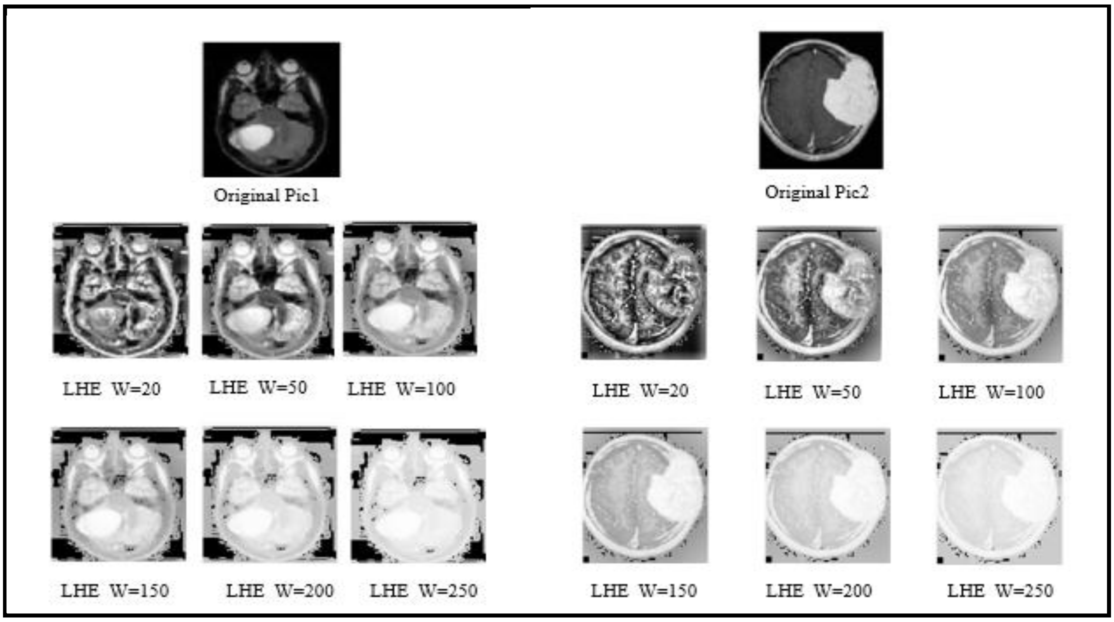
To study and identify the diseases in the human body the process followed is primarily the imaging. A rapid development is seen in medical imaging because they aid to diagnose quickly and so much advancement is happening in techniques used in image processing. Suitable treatment can be started expeditiously because all the images guide to have a swift decision [3].

Medical images are generally very dark because they are showing the inner organs of the body so it becomes imperative that analysis is not easy. So often low contrast images are only available to medicos. For the improvement of quality and brightness some methods are introduced.

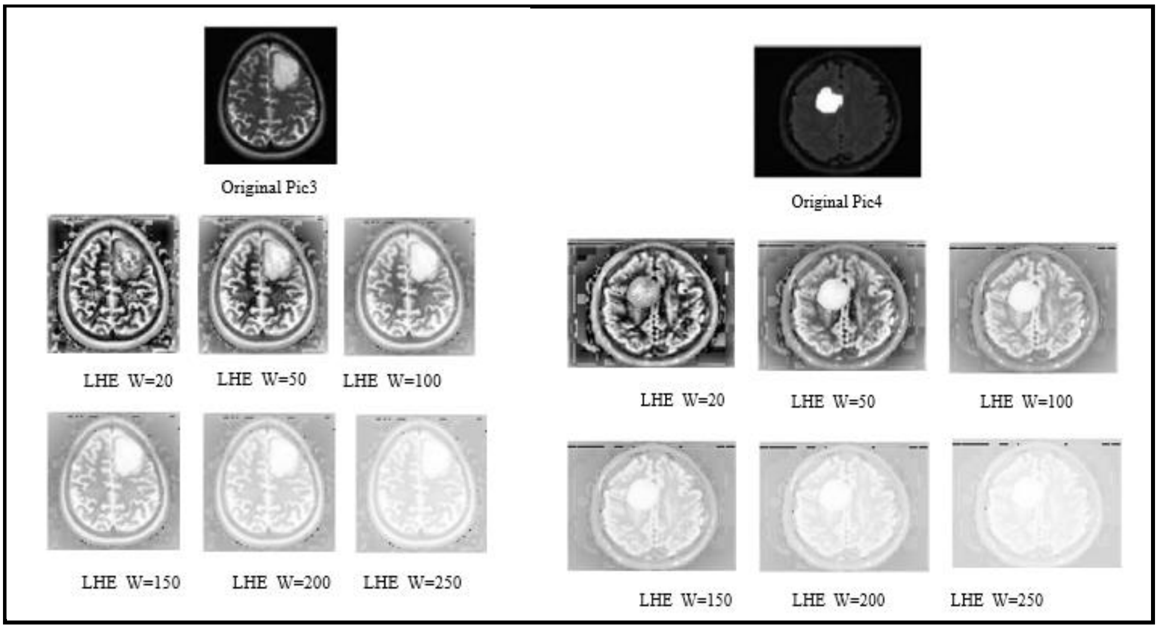
All the above algorithms are processed in MATLAB to give output image with histogram and performance parameter values. LHE output is shown in fig .21 for different window size [4]. CLAHE output is shown in Fig. 22 with different clip limit. In Fig.23 different value of CDF are used to clip the histogram in DSIHE technique. Different exposure values are tested in Fig. 24 for ESIHE algorithm. Input image pic1, pic2, pic3 and pic4 are used to test different algorithms (GHE, LHE, BBHE, CLAHE, DSIHE and ESIHE) and their output from MATLAB are shown in fig 25, 26, 27, 28, 29and 30 respectively.

2.4.1 LHE algorithm with different window size

LHE algorithm is associated with the moving of window over different regions of the image. It results in equal enhancement of all regions. Window size 50 is giving best result.



(a) (b)

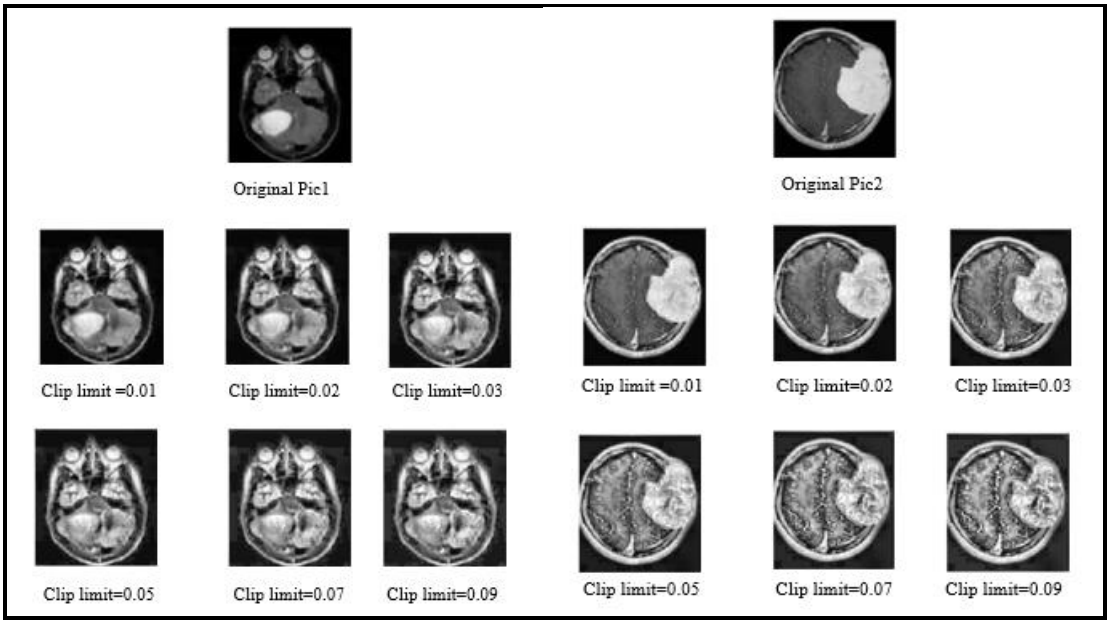


(c) (d)

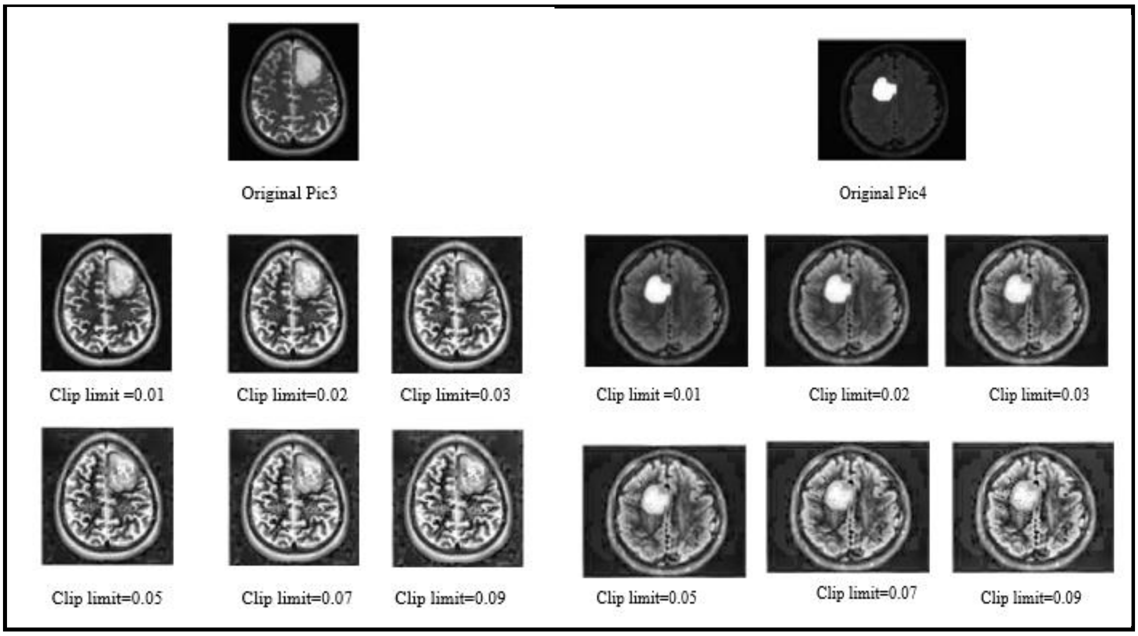
Fig 21. Different window size in LHE for pic1(a), pic2(b), pic3(c) and pic4(d)

2.4.2 CLAHE with different clip limit

CLAHE algorithm is engaged with the contrast limitation for which we can clip the contrast value. Fig.22 shows the output for different clip value.



(a) (b)

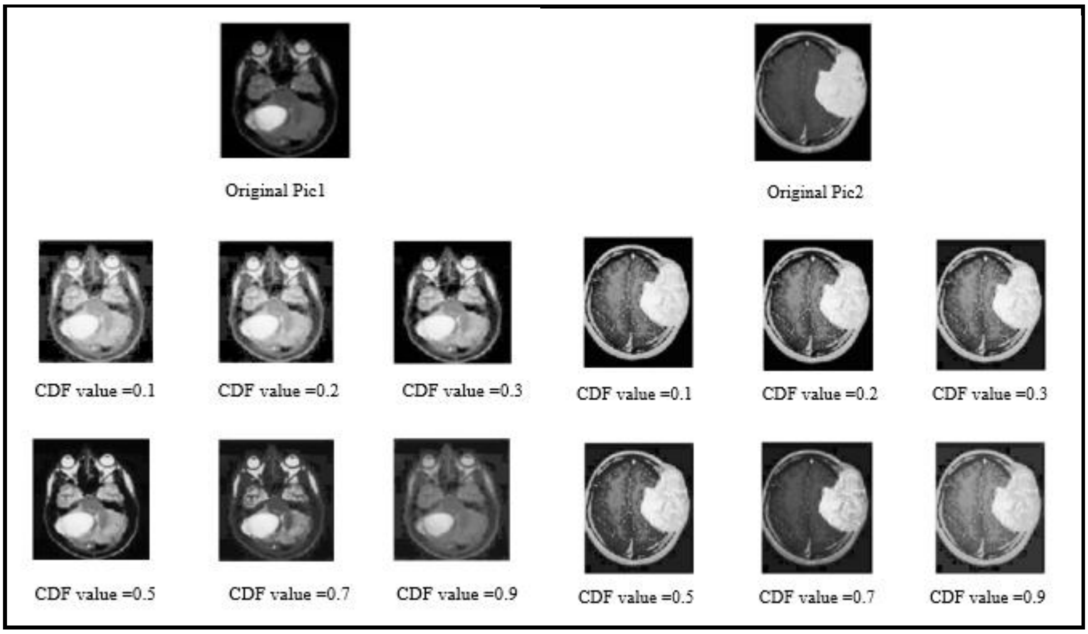


(c) (d)

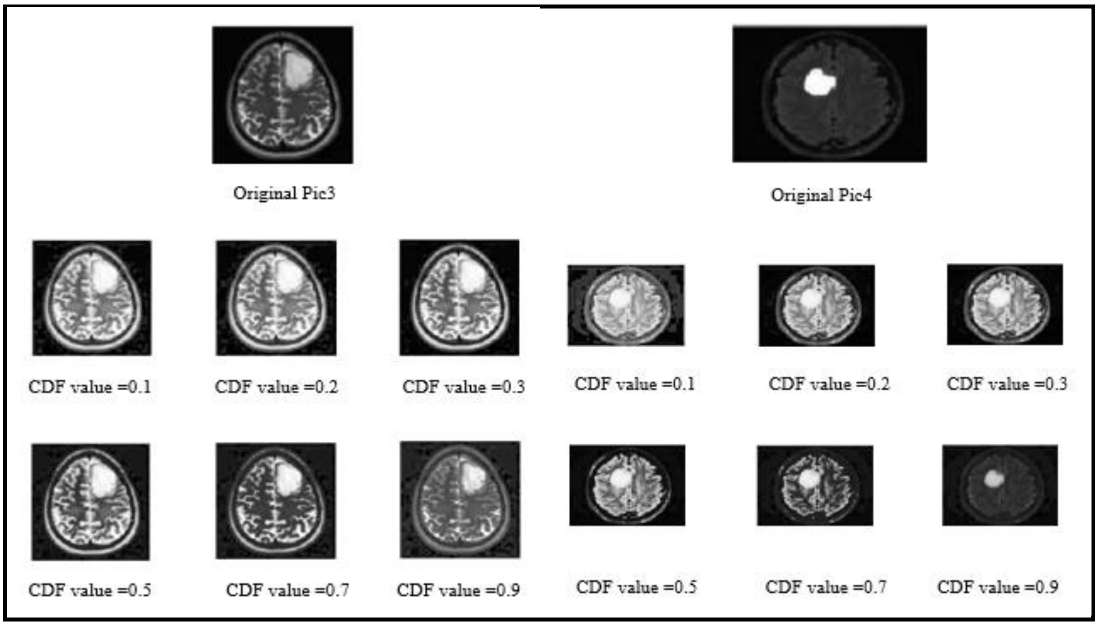
Fig 22. Different clip limit in CLAHE for pic1(a), pic2(b), pic3(c) and pic4(d)

2.4.3DSIHE with different CDF value

DSIHE algorithm divides the image in two parts on the basis of cumulative probability density. As experiment different CDF values are tried and found that CDF=0.3 is giving better results.



(a) (b)

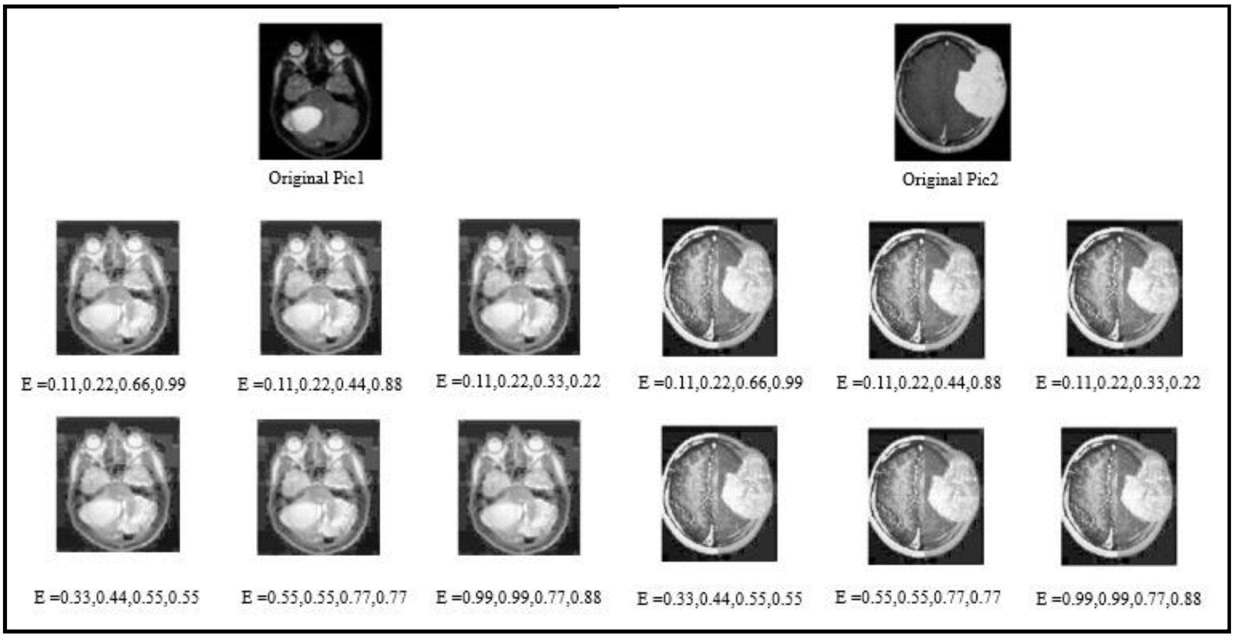


(c) (d)

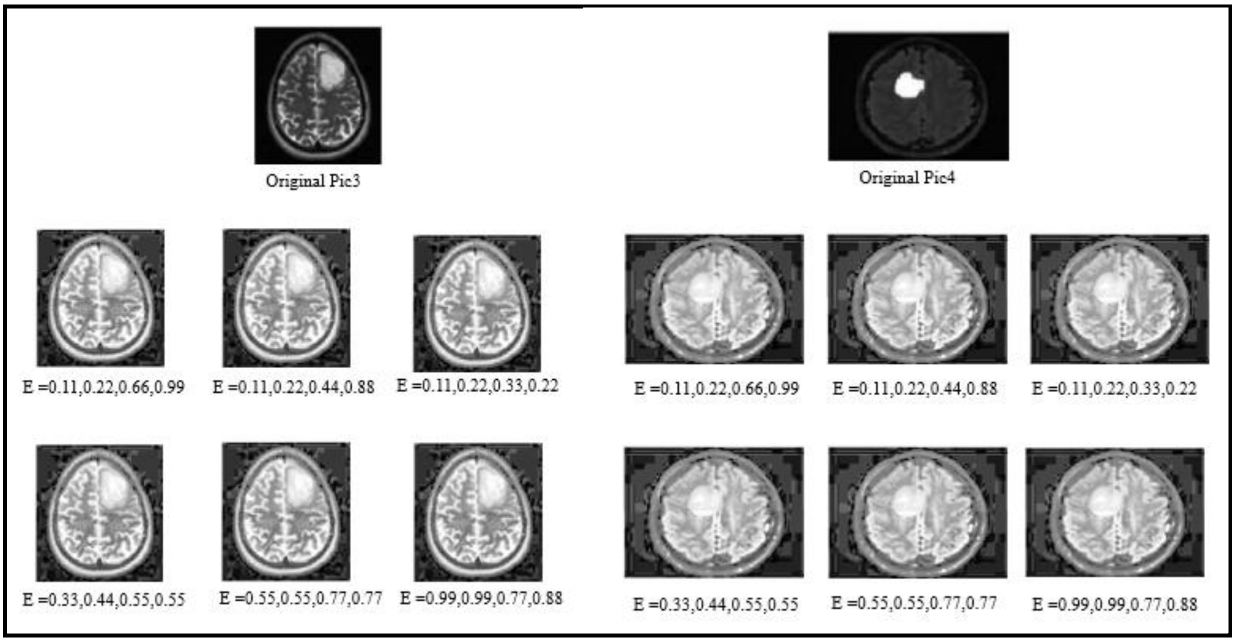
Fig 23. Different CDF values in DSIHE for pic1(a), pic2(b), pic3(c) and pic4(d)

2.4.4 ESIHE with different exposure value

ESIHE algorithm is engaged with the division on the basis of exposure value. Four sub images are tried for different exposure values.



(a) (b)



(c) (d)

Fig 24. Different exposure values in ESIHE for pic1(a),pic2(b), pic3(c) and pic4(d)

2.5Image Enhancement Output for different HE Techniques:

2.5.1 GHE algorithm output image with histogram

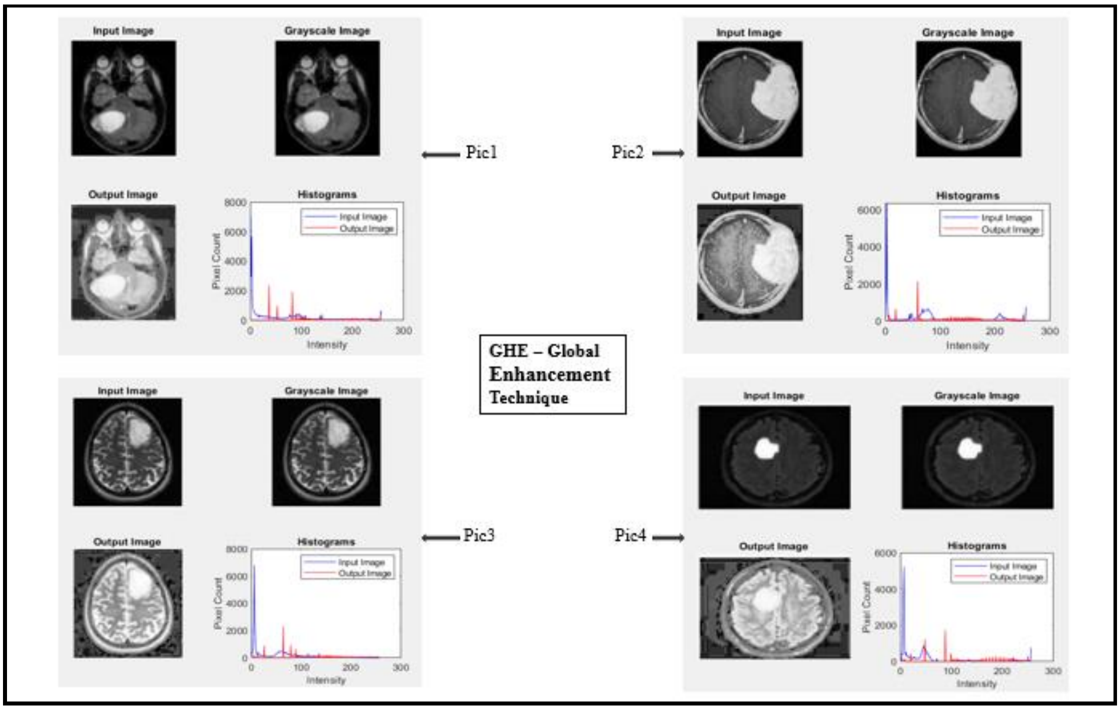


Fig 25. Global Histogram Equalization for pic1, pic2, pic3 and pic4

2.5.2LHE algorithm output image with histogram

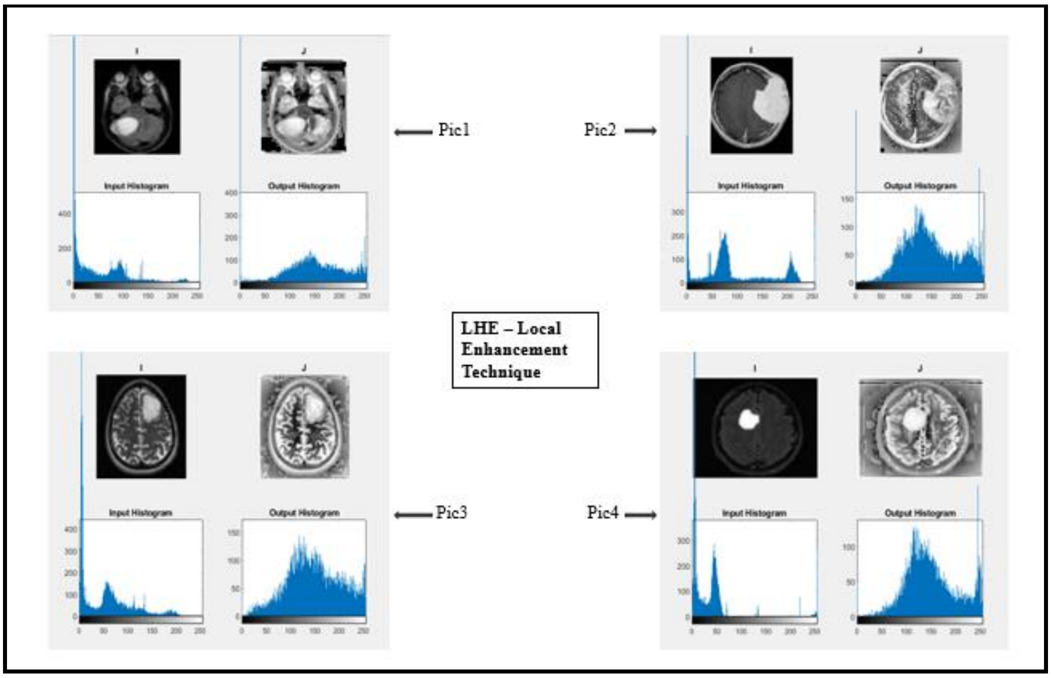


Fig 26. Local Histogram Equalization for pic1, pic2, pic3 and pic4

2.5.3BBHE algorithm output image with histogram

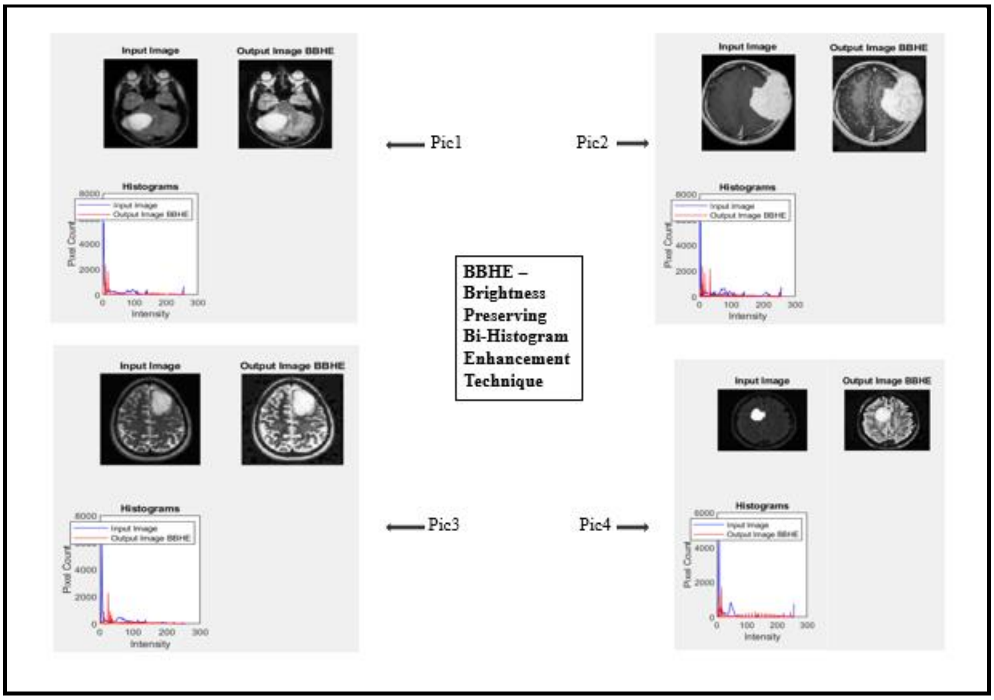


Fig 27. Brightness Preserving Bi-Histogram Equalization for pic1, pic2, pic3 and pic4

2.5.4CLAHE algorithm output image with histogram

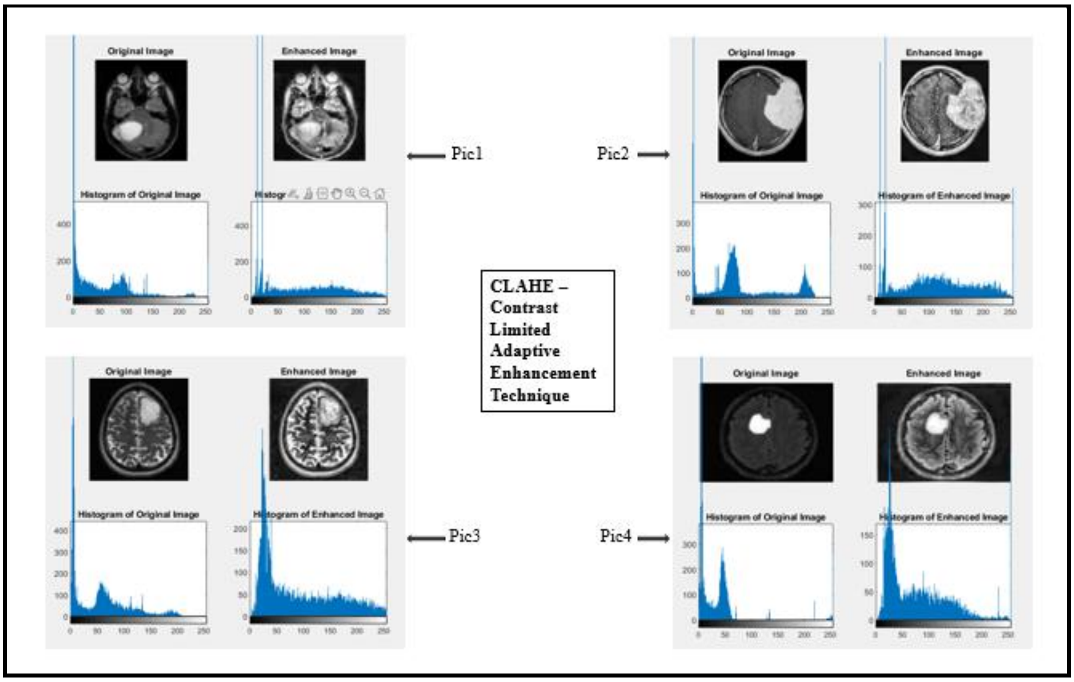


Fig 28. Contrast Limited Adaptive Histogram Equalization for pic1, pic2, pic3 and pic4

2.5.5DSIHE algorithm output image with histogram

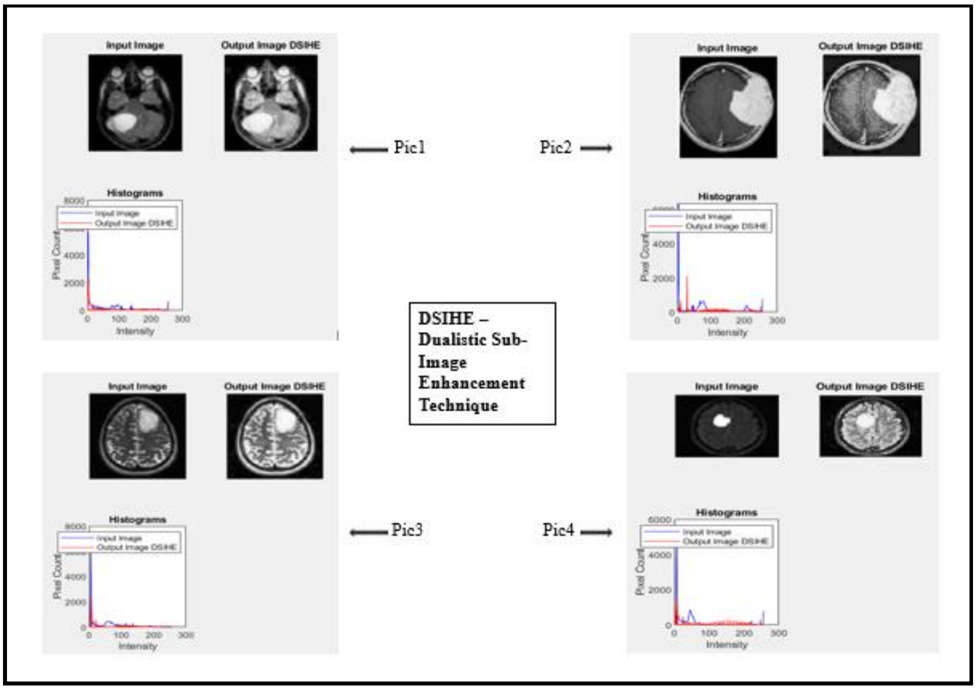


Fig 29. Dualistic Sub-image Histogram Equalization for pic1, pic2, pic3 and pic4

2.5.6ESIHE algorithm output image with histogram

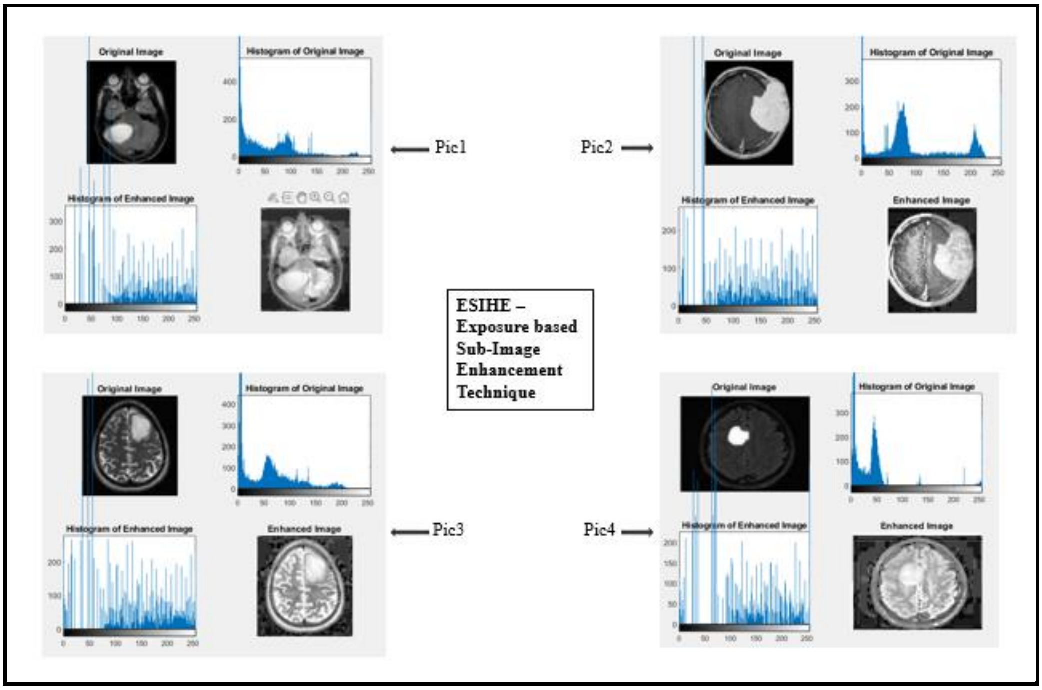


Fig 30. Exposure based Sub-Image Histogram Equalization for pic1, pic2, pic3 and pic4

2.6 Experiment with Edge detection Technique

Some edge detection techniques are taken for the study of edge detection of the images. During the examination various threshold values are considered for Sobel edge detection.

2.6.1 Testing with different threshold for Sobel edge detection

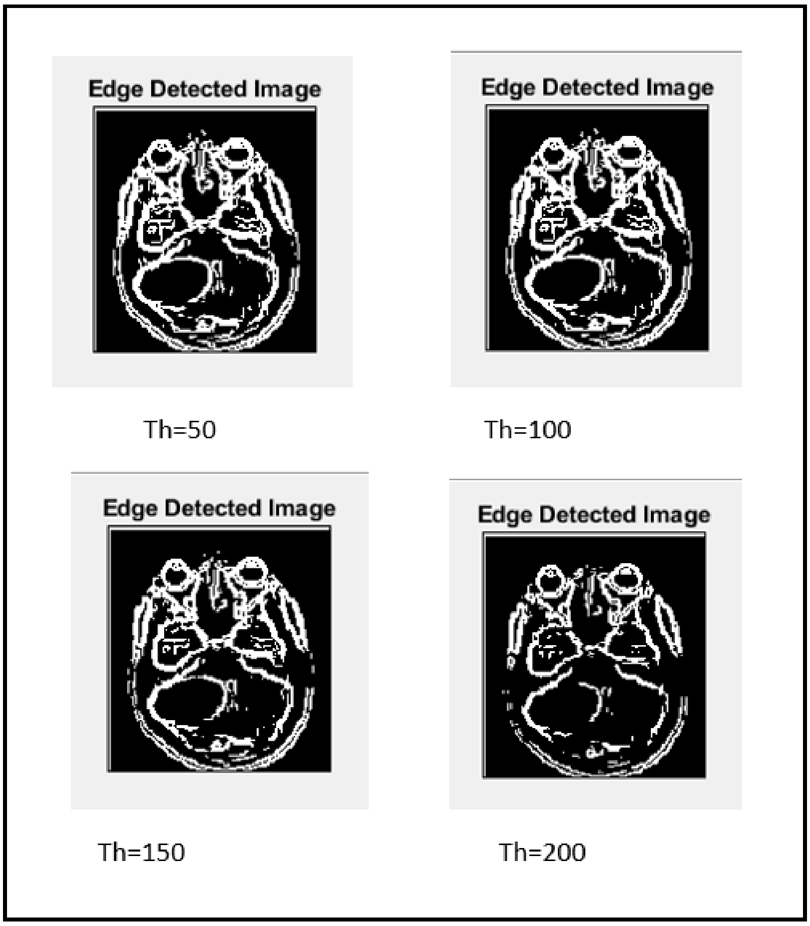


Fig 31. Different Threshold values for Sobel Edge detection for pic1

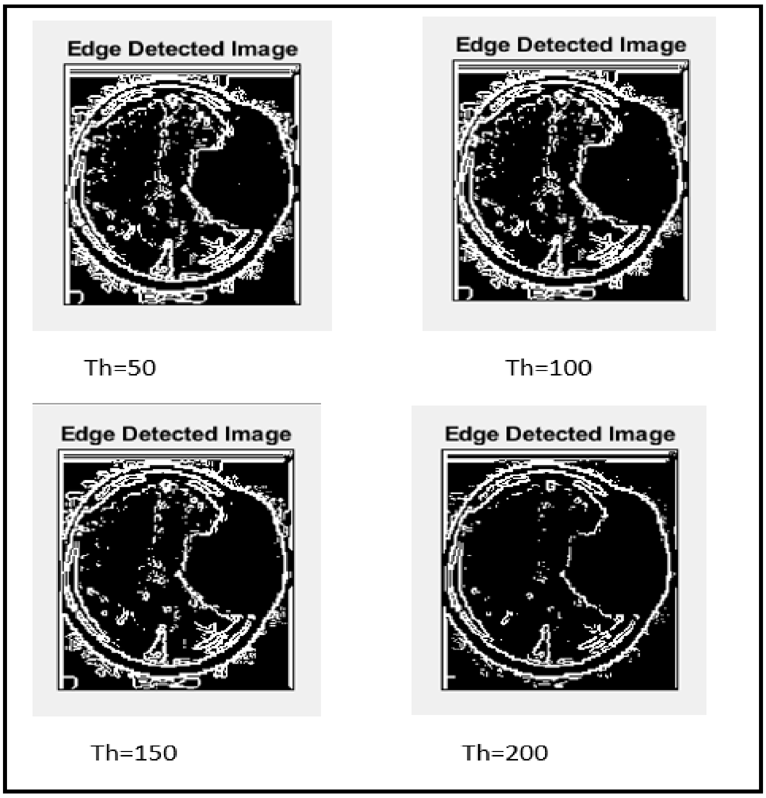


Fig 32. Different Threshold values for Sobel Edge detection for pic2

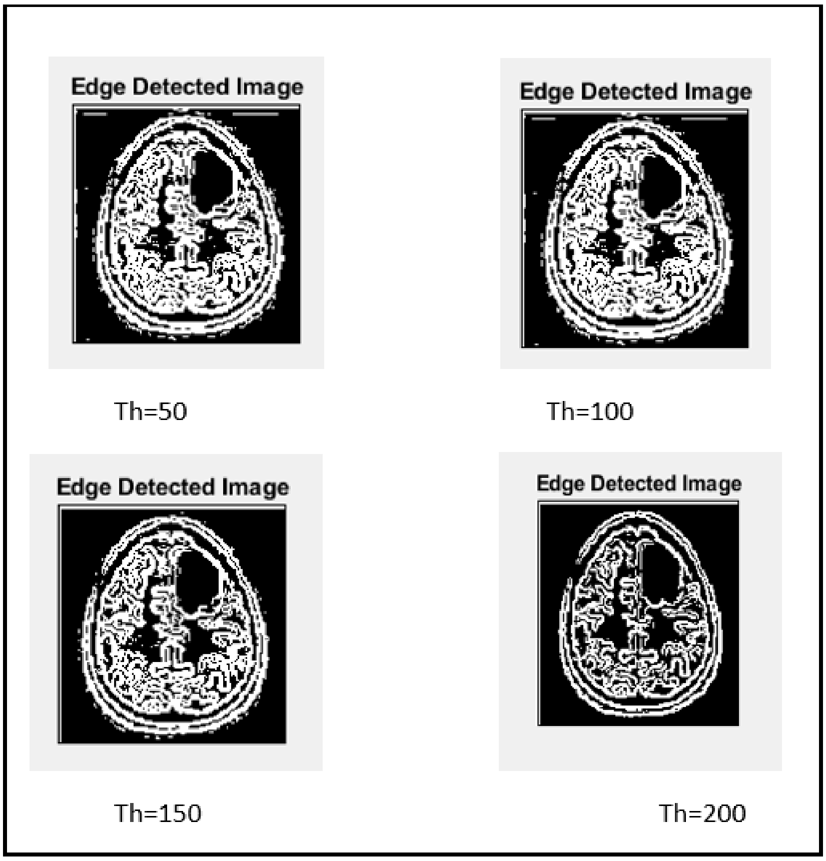


Fig 33. Different Threshold values for Sobel Edge detection for pic3

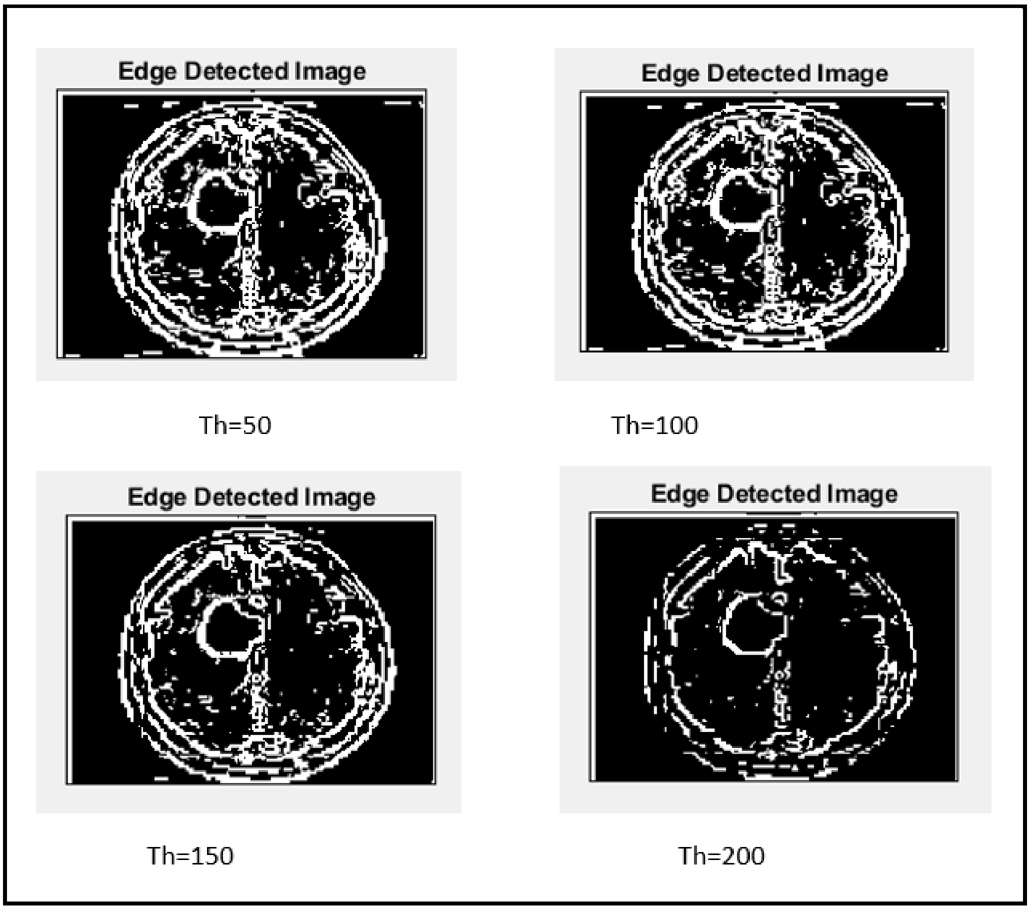


Fig 34. Different Threshold values for Sobel Edge detection for pic4

CHAPTER3

PERFORMANCE ASSESSMENT

Image quality is the determining factor because degradation happens while transmitting, storing or compressing the image. Although internal organs are not visible to medicos but they can diagnose about the patient disease after observing the images generated by different scanning technologies. As medical images are dimmed so it becomes essential to highlight the anomalies if exist in the images. Image quality can be enriched by changing some physical parameters only so operator can adjust it. But for the operator that range is decided by the research person only. Quality of an image can be judged by two methods: visual or quantitative. Here both assessments have been made.

3.1Visual comparison

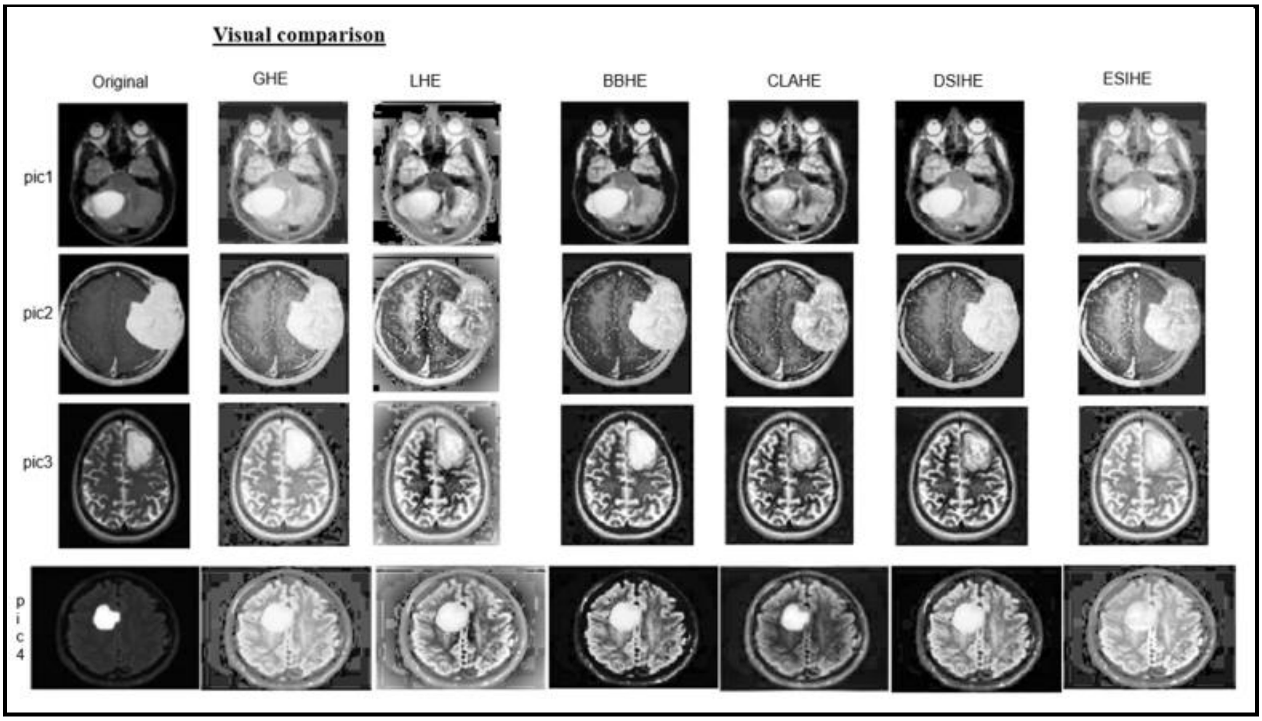


Fig 35. Visual comparison for HE techniques for pic1, pic2, pic3 and pic4

3.2Quality metric comparison

Measurement of quality is done by using some image quality metrics (IQM).PSNR, SSIM, Entropy and AMBE quality metrics becomes applicable to evaluate the output image quality.

3.2.1 PSNR

The Peak Signal to Noise Ratio, which depicts the picture quality, is the ratio calculated from maximum signal power to the power of corrupting noise [3]. To put it another way, PSNR is an engineering name for the proportion which is represented by signal's maximum power to the power of corrupting noise that degrades the accuracy. Typically, PSNR is presented on decibel meter. Because dynamic range is very broad as depicted by many signals, PSNR is typically shown on the logarithmic decibel scale. PSNR and visual quality were used to assess how well the proposed algorithms performed. The PSNR is frequently used to gauge how well a picture can be recreated. In this instance, the noise is the introduced error and the signal is the real image data. The PSNR can be computed as shown in Eq. (1):

$$PSNR = 10\, log_{10} \left[\frac{{MAX_i}^2}{MSE}\right]$$
$$PSNR = 20\, log_{10} \left[\frac{MAX_i}{MSE}\right]$$
$$PSNR = 20\, log_{10}\,(MAX_i) - 10\, log_{10}\,(MSE)$$

………………………….. Eq. (1)

Where, MAXi is the highest pixel number that the image can contain. MSE stands for Mean Square Error between the source and filtered images. High PSNR value indicates the great quality of image.

3.2.2 Absolute Mean Brightness Error (AMBE):

It is suggested to use an objective measurement to assess how well the initial brightness is preserved [5]. The absolute disparity between the mean brightness of the input and output images is known as the absolute mean brightness error, and its formula is: AMBE = E(X) - E(Y) as shown in Eq. (2). The input image and output image correspond to X and Y in above formula.

Absolute Mean Brightness Error = |E(A) - E(B) | ………………………….. Eq. (2)

Input and output mean brightness are shown by E(A) and E(B) respectively. Small value of AMBE means minimum brightness error which indicates better brightness preservation.

3.2.3 SSIM (structural Similarity):

An indicator of how similar two images are, is the structural similarity score [4]. The mean square error is calculated between the pixel of the input image and the matching pixel of output image. In contrast to MSE, SSIM will search for similarities between individual pixels, that is, whether the pixels in the two images are aligned or have comparable pixel density values. The percentage of pixels in the output picture that coincide with pixels in the original image is known as the similarity index. The Similarity Index (SI) range is from 0 to 1, where 0 signify 0% similarity and 1 signify 100% similarity. SSIM can be defined as in Eq. (3):

$$SSI(x,y) = \frac{(2\mu_x\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_x^2+\sigma_y^2+C_2)}$$ ………………………….. Eq. (3)

Where μ_x is the mean of image X, μ_y is mean of Y, σ_x is standard deviation of image x, σ_y is standard deviation of image y, σ_{xy} is squre root of covariance of image x and y, and C_1, C_2

3.2.4 Entropy:

The richness of the details extracted from the enhanced picture is measured using entropy [4]. Entropy represents the amount of information that can be compressed in the setting of image or video compression. Histogram equalization is typically associated with entropy, which is expressed as in Eq. (4):

$$E = -\sum_{x=0}^{L-1} p(x)\log_2 p(x) \quad \text{where} \sum_{x=0}^{L-1} p(x) = 1.0\text{, and } p(x) = h(x)/(M \times N).$$ …………………….. Eq. (4)

In the above equation for intensity x, probability density function is shown by p(x) and image histogram by h(x). High entropy indicates greater information on it thus good enhanced image.

All above metric parameters values are shown in following tables in Fig.36 and corresponding bar charts are displayed in Fig37.

PSNR						
Algorithm	GHE	LHE	BBHE	CLAHE	DSIHE	ESIHE
pic1	9.2673	8.2982	16.8514	14.0404	13.8227	9.3352
pic2	13.55	9.4847	20.0615	17.5998	17.522	13.2824
pic3	9.7605	7.7793	15.0042	15.0871	13.7523	9.9349
pic4	7.4406	6.4918	12.0087	13.5506	10.4547	7.6703

AMBE						
Algorithm	GHE	LHE	BBHE	CLAHE	DSIHE	ESIHE
pic1	82.4535	81.5148	26.3763	38.8223	39.208	80.1141
pic2	48.5522	62.4757	18.8977	22.3753	27.1302	44.5418
pic3	78.2492	93.1274	36.4703	35.7318	39.5847	73.9807
pic4	96.3301	111.5041	39.1942	41.7161	52.1221	90.3991

SSIM						
Algorithm	GHE	LHE	BBHE	CLAHE	DSIHE	ESIHE
pic1	0.40235	0.37744	0.64061	0.4809	0.66787	0.38817
pic2	0.61467	0.39835	0.6738	0.62324	0.66665	0.55559
pic3	0.45386	0.41792	0.6107	0.585	0.72413	0.45193
pic4	0.21896	0.16945	0.51233	0.41325	0.44744	0.22088

Entropy							
Algorithm	Original	GHE	LHE	BBHE	CLAHE	DSIHE	ESIHE
pic1	6.2847	5.9886	7.1689	5.9199	6.7309	6.0952	6.6342
pic2	6.5738	6.2116	7.5906	6.1964	7.1853	6.2172	6.82
pic3	6.5019	6.232	7.7277	6.1865	7.5145	6.3227	6.8568
pic4	5.4757	5.363	7.515	5.2029	7.2498	5.3208	6.4421

After analysing the above statistics and visual comparison enhancement techniques are doing good in this order: BBHE, CLAHE, DSIHE, ESIHE, GHE, LHE which is shown in the bar chart also.

Fig 36. Tabular display for metric parameters for pic1, pic2, pic3 and pic4

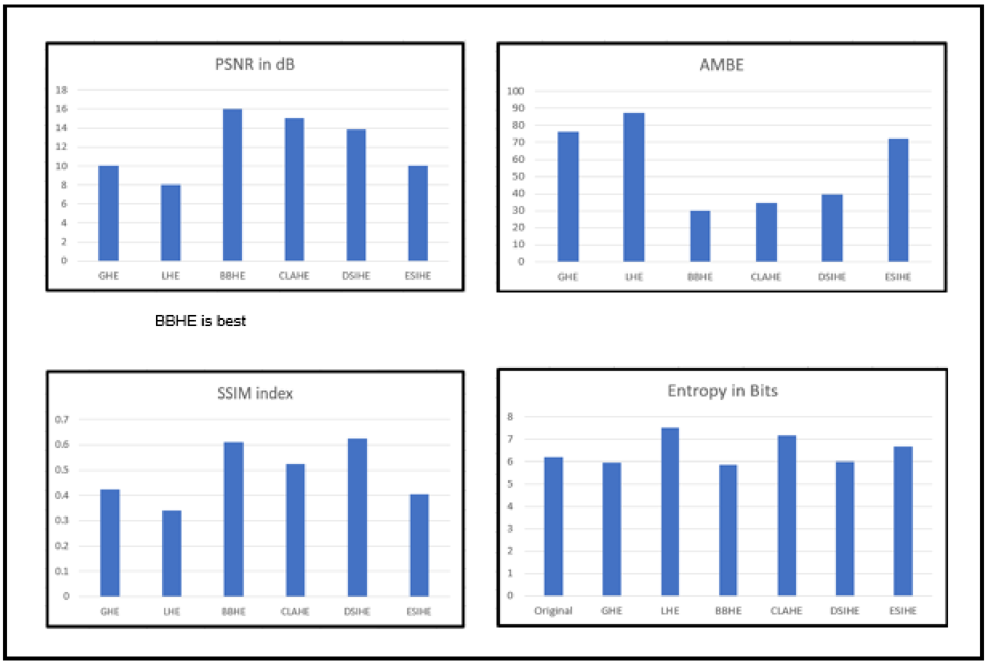
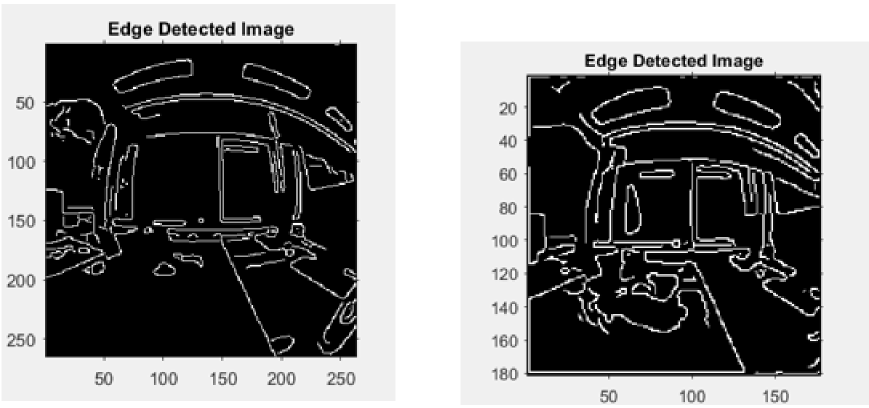


Fig 37. Bar chart display for metric parameters for pic1, pic2, pic3 and pic4

3.3 Edge Detection Techniques output

Image processing has elementary part as feature extraction. One of the imperative parts of computer vision is visual processing. Some of the applications we use are detection of face, recognition of face or object detection. Medical professionals'diagnosis is based on imaging largely. To get the idea of internal body organs is the key to their analysis of the patient disease. Edge detection helps a lot in medical imaging field [10]. Edge detection techniques play a crucial role in recent times as now a days number of images in hospitals have increased multifold. After the pandemic sometimes number of patients was so high that hospitals could not handle it. So, it was very crucial that medical professional take a quick and correct diagnosis.

Edge detection in image can be defined in three ways and those are: Horizontal Edges, Vertical Edges and Diagonal Edges. So various methods are adopted to look for edge detection.



Applied on original   applied on enhanced image

Fig 38. Edge detection applied on original and enhanced image

3.3.1 Canny Edge Detection Technique

Edge detection by Canny algorithm works on images with ample range of edges. It works on the intensity gradient. First noise is eliminated by using the Gaussian filter. Potential edges are detected by applying double threshold. Strong edges are taken after suppressing the weak edges.

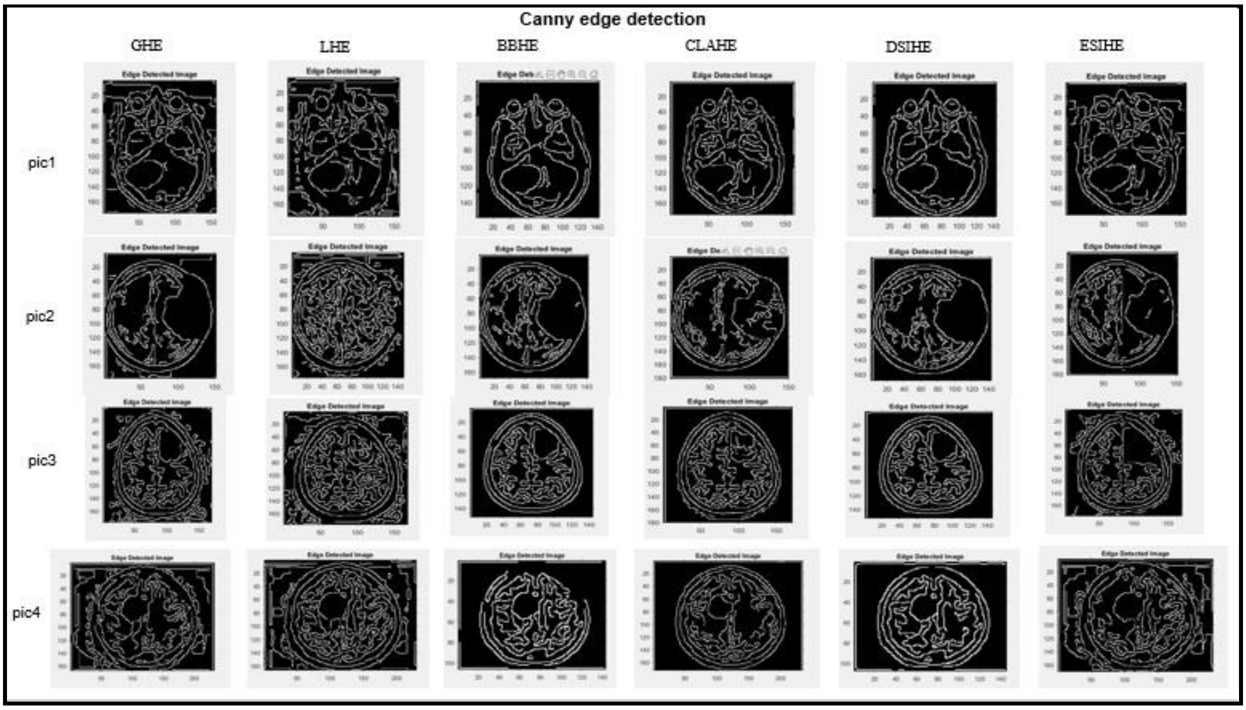


Fig 39. Canny Edge detection applied on different HE output for pic1, pic2, pic3 and pic4

3.3.2 Sobel Edge Detection Technique

Sobel edge detection works on the principle of Sobel filter. In this computation of gradient is executed by change in first derivative in x and y direction.Two masks are used to find horizontal and vertical components of gradient of edges. Masks of 3x3 are used. Sobel operator yields orientation also apart from detecting the edge. Sobel has the dominance on other edge detection techniques because it is uncomplicated and time efficient.

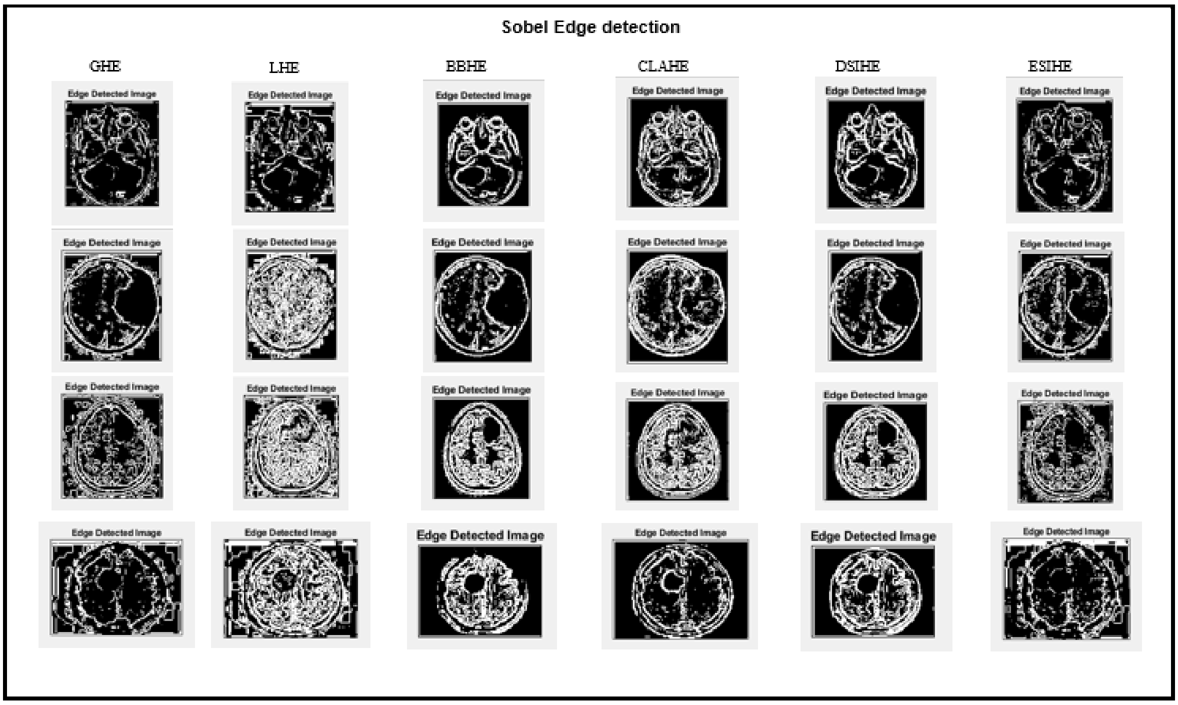


Fig 40. Sobel Edge detection applied on different HE output for pic1, pic2, pic3 and pic4

3.3.3 Prewitt Edge Detection Technique

Prewitt method adopt the idea of horizontal and vertical filter which are used in sequence to find the edges. Summation of the output of two filters is done for the formation of the result.

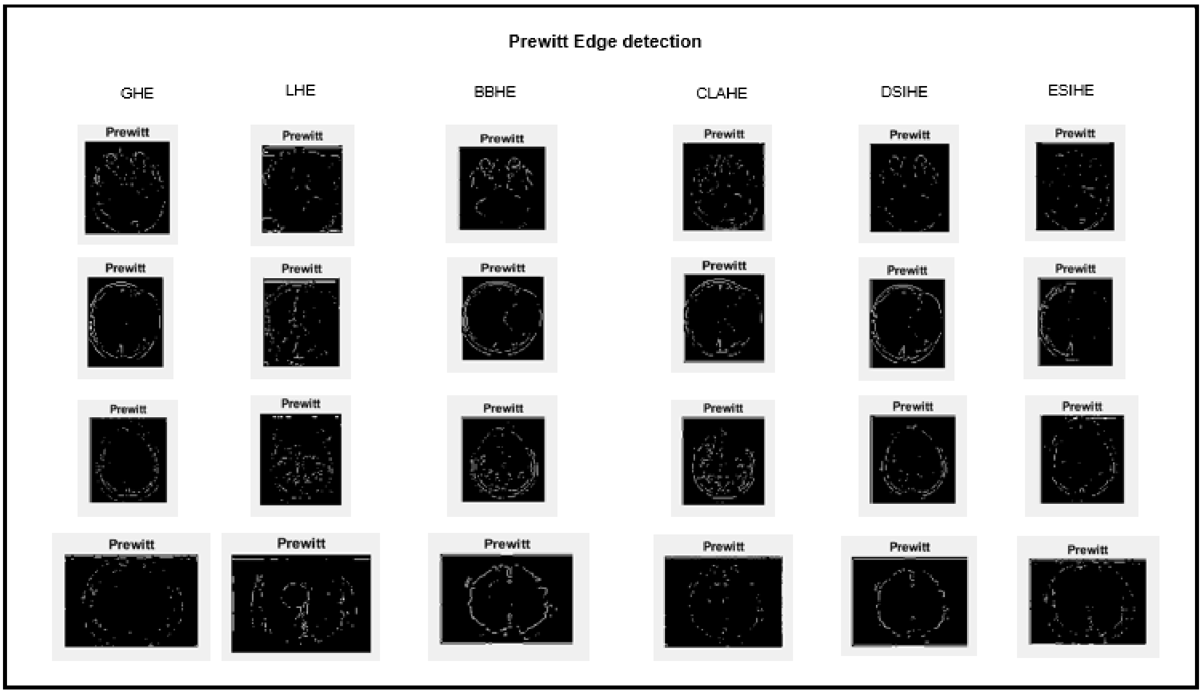


Fig 41. Prewitt Edge detection applied on different HE output for pic1, pic2, pic3 and pic4

3.3.4 Robert Edge Detection Technique

Robert edge detector via discrete differentiation approximates the gradient of the picture fed to the algorithm. Gradient is measured in 2-D spatial. Absolute value of gradient magnitude and orientation to relative pixels is calculated. To determine the change in the x and y directions, 2x2 matrix is used.

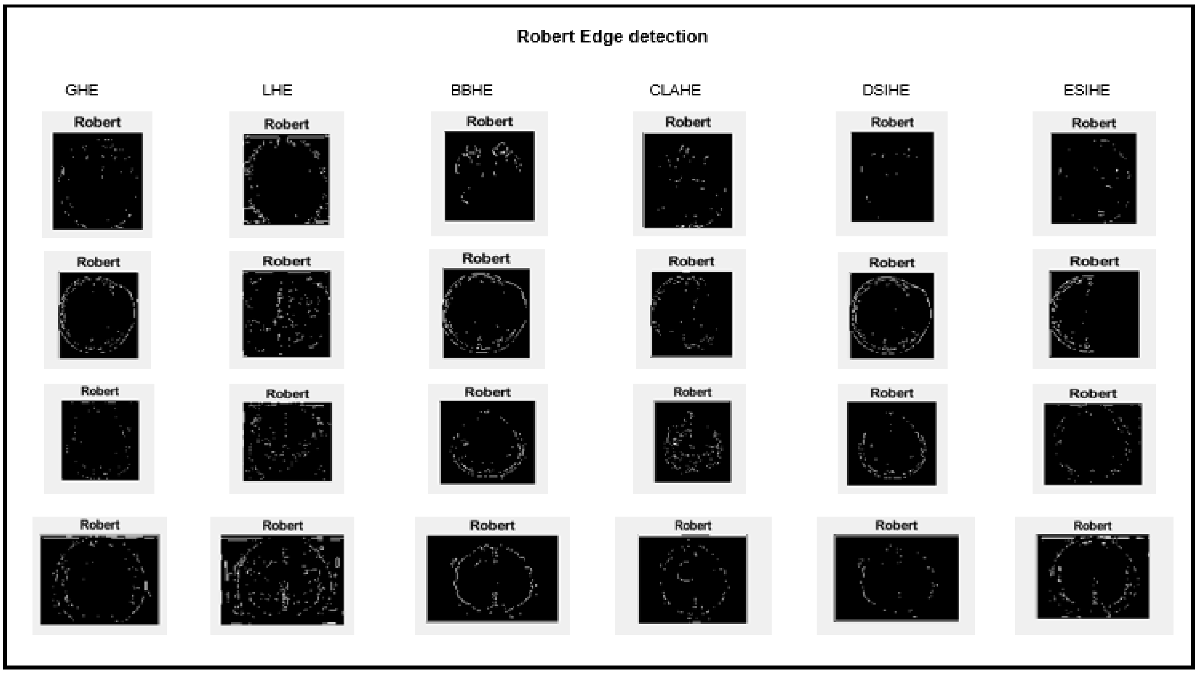


Fig 42. Robert Edge detection applied on different HE output for pic1, pic2, pic3 and pic4

3.3.5 Zero-Cross Edge Detection Technique

Zero crossing detector works on the principle that intensity changes rapidly where Laplacian of an image crosses the zero or changes sign. To approximate the second derivative of intensity, some convolution matrices are used. These matrices correspond to Laplacian filter. If image is constant the intensity gradient will be zero. So,LoG response will give positive value for dark side of the picture and negative response will corresponds to lighter side of image. As these are very sensitive to noise so high frequency noise components are reduced.

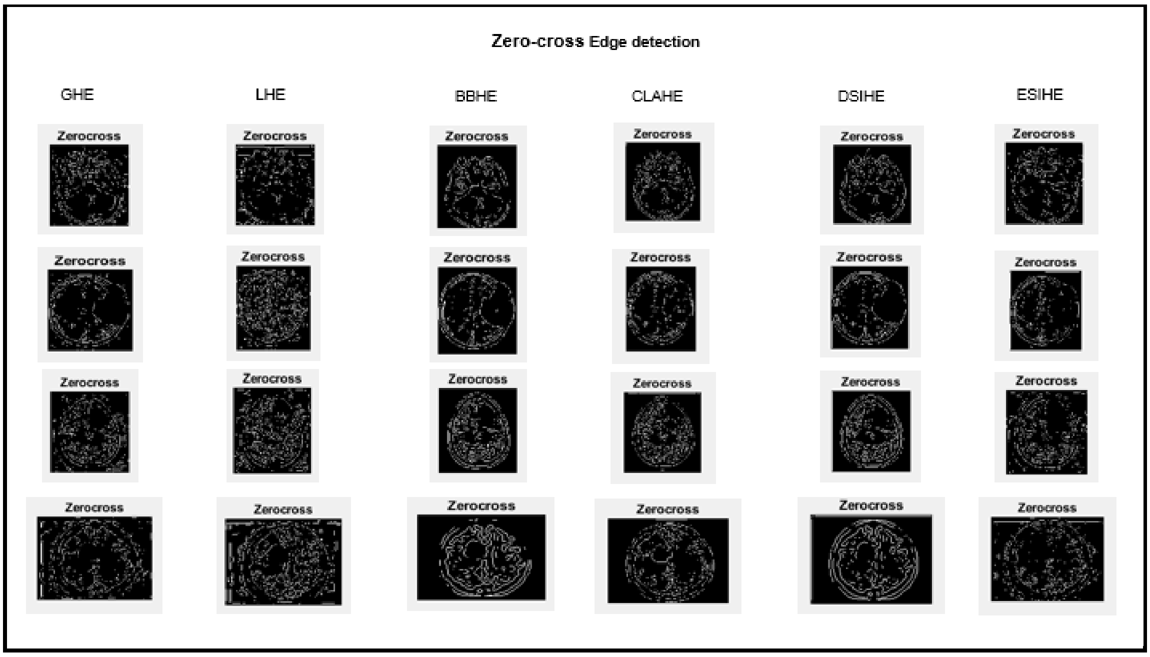


Fig 43. Zero-cross Edge detection applied on different HE output for pic1, pic2, pic3 and pic4

CONCLUSION

Images received from medical scanners, drones, security cameras, space and deep sea are largely low contrast and hazy images. In my experimental analysis, images from MRI scanner are considered.Few techniques like GHE, ESIHE, LHE, BBHE, CLAHE and, DSIHE are tried for contrast enhancement. Out of these techniques BBHE and CLAHE are giving the better results than other techniques. This result is supported by visual comparison and statistical analysis also. After achieving the enhancement result from the processing of the above mentioned HE techniques, it is fed to the edge detection techniques. Among all other techniques Canny and Sobel are providing good results.

Above mentioned techniques give an excellent combination like BBHE with Canny Edge detection. Some other combination like BBHE with Sobel, CLAHE with Canny and CLAHE with Sobel are also producing satisfying results. If these results are fed to the computer vision or any other IoT application, then it assists in following ways:

- Processing is very fast so time saving
- Chances of manual error are removed
- Processed data is reduced so less cumbersome

One real example happened in corona time. When number of patients were tremendously high and medical professionals and equipment were not in abundance. In case of shortagefor RTPCR kit, doctor had to diagnose with the medical images only. Because even the slight delay could be fatal for the patient.

Doctors receive dark images of X-ray, MRI and CT-scan in their daily diagnosis of disease. To give more clarity to a picture, especially medical images which needs minute detailing of the dark picture for their analysis, these techniques will help them a lot as I hope.

PUBLICATIONS:

1. Anju Malik and Nafis Uddin Khan**,** "A Comprehensive Survey on Histogram Equalization Techniques for Contrast Enhancement," Proceedings of ***3rd International Conference on Emergent Converging Technologies and Biomedical Systems (ETBS-2023),*** May 15 – 17, 2023, Jaypee University of Information Technology, Solan, India

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[2] Ming Zeng, Youfu Li, Qinghao Meng, Ting Yang, Jian Liu, *"Improving Histogram based image contrast enhancement using gray-level information histogram with application to X-ray images"*, DOI: 10.1016/j.ijleo.2011.05.017, April 2011

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[10] Asra Aslam, Ekram Khan, M.M. Sufyan Beg "*Improved Edge Detection Algorithm for Brain Tumor Segmentation*" DOI: 10.1016/j.procs.2015.08.057, August 2015

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