A project report on

IMAGE CONTRAST ENHANCEMENT USING MODIFIED DCT

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Master of Technology
In
Information Systems

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CERTIFICATE

This is to certify that **Neisakienuo Nelly Yhome (2K14/ISY/09)** has carried out the major project entitled "**Image Contrast Enhancement Using Modified DCT**" in partial fulfilment of the requirements for the award of Master of Technology Degree in Information Systems during session 2014-2016 at Delhi Technological University.

The major project is bonafide piece of work carried out and completed under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any degree or diploma.

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M.Tech (Information Systems)

ABSTRACT

Image enhancement plays a significant role in image processing. Devices are able to capture and process images from complex surveillance monitoring systems. However, the quality of captured images is degraded during the acquisition process because of poor lighting and incorrect setting of the aperture or the speed of shutter or both. Due to the deficiencies in image acquisition process the acquired image may have low contrast images which contain noisy background. In addition, there are several reasons for images to have poor contrast: due to the poor quality device used to capture the image, inexpertness of the operator or because of the unfavourable environmental condition at the time of acquisition. To overcome the artifacts, noise and unnatural enhancement an effective enhancement method for gray scale images is introduced. The proposed method consists of two parts. First, a global contrast enhancement method is introduced. This method uses sigmoid function and histogram to generate the distribution function for the input images. Then the distribution function is used to obtain the new image with improved global contrast. Second, the DCT coefficients of the previous improved contrast image are scale using entropy. The proposed method generate an enhance image with richer details and better contrast compared to the conventional methods.

Table of Contents

Title	Page no.
CERTIFICATE	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
Figures and Tables	vi
Abbreviations	viii
1. INTRODUCTION	**1**
1.1 Diffferent image enhancement techniques	1
1.1.1 Spatial domain techniques	2
1.1.2 Frequency domain techniques	3
1.2 Image enhancement based on contrast measure	5
1.3 Motivation	6
1.4 Goal of Master Thesis	6
1.5 Thesis Structure	7
2. LITERATURE REVIEW	**8**
2.1 Spatial domain based Image Enhancement	8
2.2 Frequency domain based Image Enhancement	9
3. .PROPOSED METHODOLOGY	**12**
3.1 Proposed Approach	12
3.1.1 Global Contrast Enhancement	12
3.1.2 Scaling High Frequency Coefficient	13
3.2 Summary Of Proposed Method	17
4. EXPERIMENTAL RESULTS	**18**
4.1 Qualitative Assessment	18
4.2 Quantitative Assessments	32
5. CONCLUSION	**35**
REFERENCES	**36**

Figures and Tables

Fig/Table	Title	Page no.
Figure 1.1	Image Enhancement Techniques	2
Figure 1.2	Spatial Domain of an Image	2
Figure 1.3	A simple histogram of an image where p(x) is number of pixel and gray level range from X_0 to X_{L-1}	3
Figure 1.4	Image Enhancement in Frequency Domain	4
Figure 3.1	Flowchart of proposed method	16
Table 3.1	Algorithm for global contrast enhancement	17
Table 3.2	Algorithm for scaling high frequency coefficient	17
Figure 4.1	Results with different α values input image, $\alpha = 1$, $\alpha = 1.2$, $\alpha = 2$. $\alpha = 3$, $\alpha = 4$	19
Figure 4.2	Comparison on the Pentagon image input image, HE, BBHE , SVD-DCT, Proposed method	21
Figure 4.3	Comparison on the Tank image input image, HE, BBHE , SVD-DCT, Proposed method	22
Figure 4.4	Comparison on the House image input image, HE, BBHE , SVD-DCT, Proposed method	23
Figure 4.5	Comparison on the Airplane image input image, HE, BBHE , SVD-DCT, Proposed method	24
Figure 4.6	Comparison on the Flower image input image, HE, BBHE , SVD-DCT, Proposed method	25
Figure 4.7	Comparison on the Lena image input image, HE, BBHE , SVD-DCT, Proposed method	26
Figure 4.8	Comparison on the Tree image input image, HE, BBHE , SVD-DCT, Proposed method	27
Figure 4.9	Comparison on the Pollen image input image, HE, BBHE , SVD-DCT, Proposed method	28
Figure 4.10	Comparison on the Slope image input image, HE, BBHE ,	29

	SVD-DCT, Proposed method	
Figure 4.11	Comparison on the Mars image input image, HE, BBHE , SVD-DCT, Proposed method	30
Figure 4.12	Comparison on the Car image input image, HE, BBHE , SVD-DCT, Proposed method	31
Table 4.1	Quantitative measurement results of DE	33
Table 4.2	Quantitative measurement results of EME	34

Abbreviations

HE	Histogram Equalization
LL	Low-Low
LH	Low-High
HL	High –Low
HH	High- High
DE	Discrete Entropy
GHE	Global Histogram Equalization
BBHE	Brightness Bi-Histogram Equalization
DSIHE	Dualistic Sub Image Histogram Equalization
MMBEBHE	Minimum Mean Brightness Error Bi-Histogram Equalization
AMBE	Absolute Mean Brightness Error
AHE	Adaptive Histogram Equalization
DFT	Discrete Fourier Transform
DWT	Discrete Wavelet Transform
DCT	Discrete Cosine Transform
SVD	Singular Value Decomposition
EME	Measure of Enhancement
JPEG	Joint Photographic Experts Group
MPEG	Moving Picture Experts Group

Chapter 1

INTRODUCTION

Image enhancement plays an important role in the application of image processing. Image enhancement is the process of changing an image such that the resultant image looks better than the original image for specific application [1]. The main goal is to provide an enhanced and good quality image by adjusting the contrast of an image to achieve an image that is more pleasant visually and more detailed.

The process of enhancement is used in several fields such as satellite images, aerial images, medical imaging, forensics and also real life photographs, etc which suffer from poor contrast. During the process of acquisition poor visual effects occurs from various factors like illumination, noise and equipments, etc. Hence, the quality of an image is degraded. So algorithms for image smoothing, noise removal or image detail enhancement are needed to present the details of image for image processing applications. These applications are commonly used to reduce noise while preserving the edge information. Poor contrast of an image occur due to the poor quality device used to capture the image, inexpertness of the operator or because of the unfavourable environmental condition at the time of acquisition.

1.1 DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Image enhancement techniques is broadly categorised into two groups as shown in Fig 1.1:

i. Spatial domain techniques
ii. Frequency domain techniques

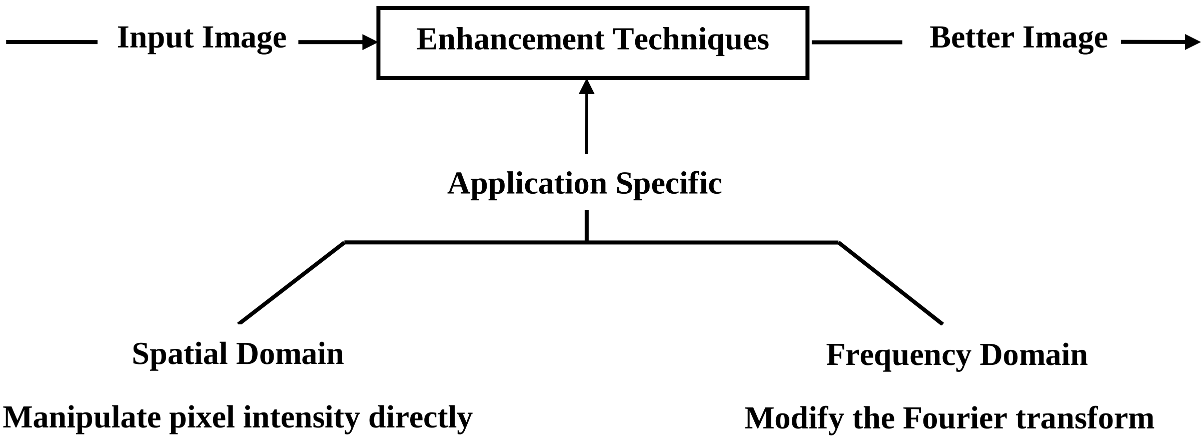


Fig 1.1: Image enhancement techniques

1.1.1 SPATIAL DOMAIN TECHNIQUES

In spatial domain techniques, operations are applied directly on the pixel of image. The pixel intensity is adjusted to enhance the image. Spatial domain techniques are the most commonly used technique because it is easy to understand and the complexity is low. However, if there is a noise then the image is over-enhanced or it create undesirable artifact on the image. Fig 1.2 shows a 3 X 3 neighbourhood about a point (x, y) in an image.

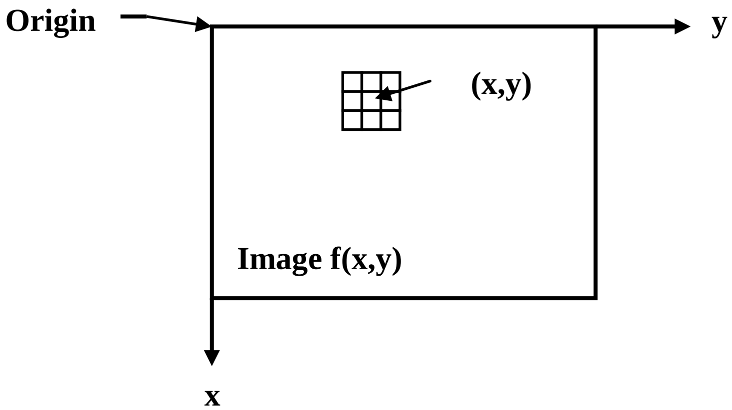
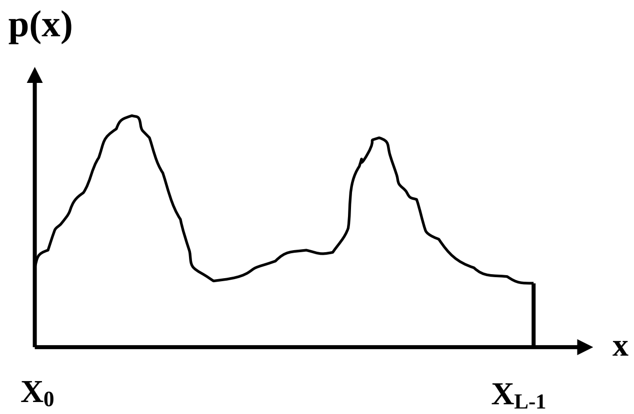


Fig 1.2: Spatial domain of an image

Histogram equalization is the most commonly used technique in spatial domain technique. Histogram of an image gives the number of occurrences of gray levels in the image with respect to the gray level values [1]. Enhancement of image aims to evenly distribute the gray levels of an image across the range. Histogram equalization technique is used because of its simple function and performance. It works by applying a uniform distribution function on the original image and by using the cumulative density function of the image the dynamic range of the gray level is stretched. Drawback of histogram equalization is brightness of the original image is changed and the output image gives some annoying artifacts thus it become unsuitable for consumer electronic product [3].



p(x) – number of pixel

$X_{0,}$ X_{L-1}- Gray level of image

Fig 1.3: A simple histogram of an image where p(x) is number of pixel and gray level range from X_0 to X_{L-1}

In Fig 1.3, the histogram equalization of image that maps the original image into a dynamic range using the cumulative density function is shown.

1.1.2 FREQUENCY DOMAIN TECHNIQUES

In frequency domain techniques, the image is first transform into a frequency domain using Fourier transform. Then, the result of Fourier transform is multiplied with a filter transfer function. Finally, inverse Fourier transform is applied to get the resultant image as shown in Fig 1.4.

In frequency domain analysis is done with respect to the frequency and operations are applied directly on transform coefficient of the image. Some of the transform functions used are Fourier transform, DWT and DCT. Frequency domain techniques have low complexity and the frequency is manipulated. However it cannot enhance all part of image efficiently at the same time and it is difficult to provide an automated image enhancement [2].

Wavelet transform is capable of both time and frequency analysis simultaneously. The discrete wavelet transform is an implementation of wavelet transform in which the wavelet is sampled discretely. The resultant coefficient of discretely sampled wavelets is called discrete wavelet transforms.

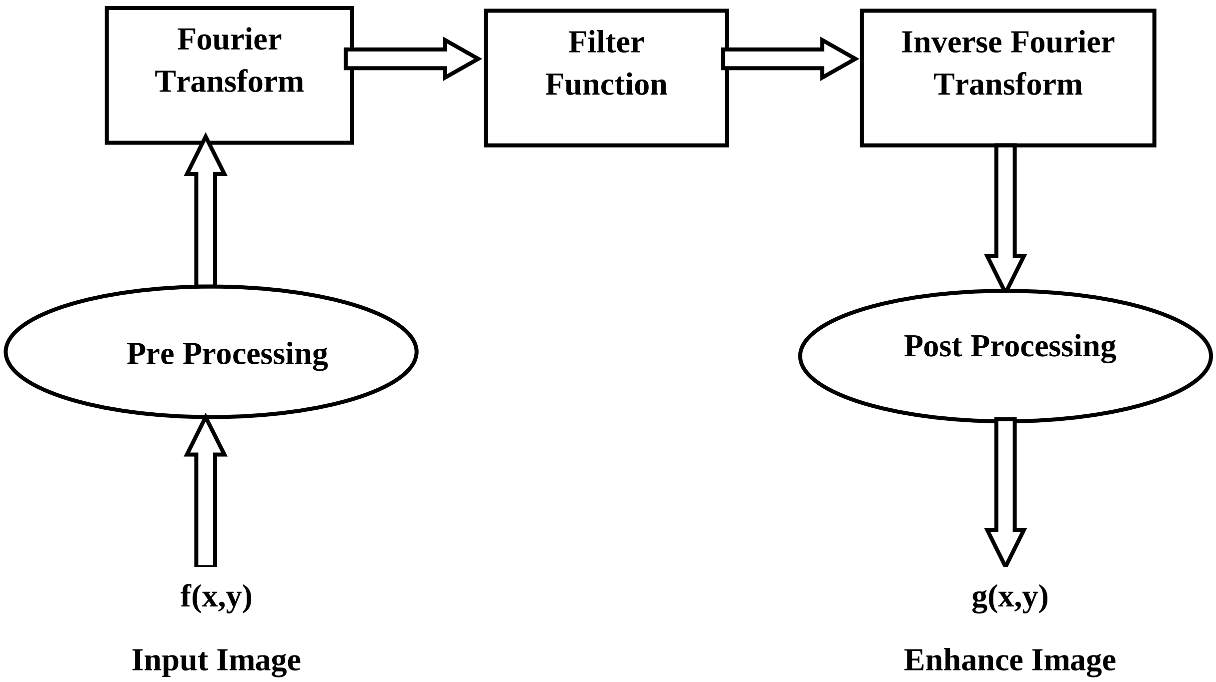


Fig 1.4: Image enhancement in frequency domain

Decomposition of images into various frequency ranges allows the isolation of the frequency into sub-bands. The 2D wavelet decomposition is performed by first applying 1D DWT along the rows of image, then, the image are decomposed along the columns. This decomposition results in four sub-band images called as low-low, low-high, high-low and high-high [7].

DCT separate the image into sub-bands depending on the image visual quality. DCT transforms signal from spatial domain into frequency domain. DCT is equivalent to the real part of DFT. DCT compacts the energy of the signal into low-frequency bins. 1D DCT is defined as:

$$D(u) = c_u \sum_{p=0}^{N-1} A(p) \cos\left(\frac{\pi(2p+1)u}{2N}\right) \quad (1)$$

Where,

$D(u)$ is the DCT output

A is the input

u is the index of output coefficient calculated from 0 to N-1

N is the number of element being transformed

$$c_u = \sqrt{\frac{1}{N}} \text{ , when } u = 0 \text{ and } c_u = \sqrt{\frac{2}{N}}\text{ , when } u \neq 0$$

In DCT, the input signal is converted into a combination of cosine waves. In the DCT matrix, the first DCT coefficient is called as the DC component and it is proportional to the mean of all the input signals and the remaining coefficient are called as the AC component. Many researchers are attracted to processing the image in DCT because of its JPEG and MPEG compression method. Another advantage of using compress domain is the possibility to enhance feature using different frequency component differently.

The disadvantages of processing the image in DCT domain is that since the blocks are independently processed blocking artifacts become visible in the processed data and redundant edges appear in the image due to discontinuities of distribution at the boundaries.

1.2 IMAGE ENHANCEMENT BASED ON CONTRAST MEASURE

The local image enhancement techniques which enhance the contrast of an image by establishing the criterion of contrast measure and improve the contrast of an image directly are called direct image enhancement method.

In direct image enhancement method, the primary step is to establish a contrast measure. Two of the most commonly used contrast measures are Michelson contrast measure [16] and Weber contrast measure [17].

Michelson contrast measure is defined as,

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} \tag{2}$$

Where,

I_{max} is the maximum luminance

I_{min} is the minimum luminance

Michelson contrast measure is used measure the contrast of an image where both the bright and dark feature is equivalent such as sinusoidal grating.

Weber contrast measure is defined as,

$$\frac{I - I_B}{I_B} \tag{3}$$

Where,

I is luminance of feature

I_B is luminance of background

Weber contrast or Weber fraction is used to measure contrast where small feature are present on a large uniform luminance background.

But both Michelson contrast measure and Weber contrast measure are unsuitable for complex measure.

1.3 MOTIVATION

Images are used in different application but due to various factor poor quality images are acquired which become unsuitable for the application. An image may be taken in a very dark or very bright situation thus the details of image are lost.

For example, in a satellite image the image is captured from a far distance thus the image is very dark and has narrow contrast. The problem is how to improve the quality of image so that the hidden information is retrieved. As the memory of a system is limited there is a need to reduce the space for storage and also increase the speed of computation. So there is a need to develop semi-automated or automated system with reduced storage for computation and less computation time to perform image enhancement as per the application.

1.4 GOALS OF MASTER THESIS

Our main goal is to improve the quality of an image that brings out hidden image details and increase the contrast of an image with a dynamic range. In this work, image contrast enhancement is performed using modified DCT. Global Histogram Equalization (GHE) is used to get a global contrast image. DCT is applied on the global contrast image to get the coefficient. Then, the high co-efficient are enhanced using entropy which gives the feature of image. Therefore the image is enhanced globally and local details are also enhanced.

1.5 THESIS STRUCTURE

The thesis is structured as follows:

- Chapter 1 introduces the issues of image and gives the motivation, goals and structure of the master thesis.
- Chapter 2 gives the previous work done in this field and the various image enhancement techniques.
- Chapter 3 presents the proposed method of image enhancement by using modified DCT
- Chapter 4 presents the results of our approach and analysis of the experiments.
- Chapter 5 summarize the conclusion from this work and future work.

Chapter 2

LITERATURE REVIEW

2.1 SPATIAL DOMAIN BASED ON IMAGE ENHANCEMENT

Some of the spatial domain based image enhancement techniques reported in the literature is briefly listed below:

In 1987, Stephen M. Pizer, Amburn E. P, Austin J. D, Cromartie R, Geselowitz A, Greer T, Ter Haar Romeny B, Zimmerman J. B, Zuiderveld K [26], proposed a technique called Adaptive Histogram Equalization (AHE) for images where the contrast of an image vary. In this method, the input image is first divided into different regions. Next, the histogram of gray level of all the regions is generated. Finally, each pixel of the image is transformed by using the transformation function derived from the neighbourhood region. In this method, the amount of noise is reduced and also overcome some limitations of global min-max windowing method. AHE improves the local contrast and enhancing the edges of each region. In 1992, W. M. Morrow, R. B. Paranjape, R. M. Rangayyan, J. E. L. Desautels [14] proposed a method in which each pixel in the image is used as a seed to grow a region. The contrast of each region is computed with respect to its individual background. Then, the contrast is enhanced by applying empirical transformation based on each region seed pixel value, contrast and background.

In 1997, Yeong-Taeg Kim [23] proposed an extension of histogram equalization to overcome the problem of histogram equalization. In this method, using the mean gray level of the original image the input image is first decomposed into two sub-images. Then, HE method is applied separately on both the sub-images. This method produces an output image in which the brightness of the image is preserved. This method is called Brightness Bi-Histogram Equalization (BBHE) and it enhances the image by preserving the brightness of an image significantly. In 1999, Yu Wan, Qian Chen and Bao-Min Zhang [24] proposed a technique called Dualistic Sub Image Histogram Equalization (DSIHE) which is similar to BBHE. However, in this method, the image is decomposed into two sub-images with cumulative density function equal to 0.5. Then, the two sub-images are equalized respectively and finally the enhanced image is obtained after the processed sub-images are composed into one image.

This method, not only enhance image details effectively but also keep the luminance of original image same.

In 2000, Andrea Polesel, Giovanni Ramponi, and V. John Mathews [19], proposed a method based on adaptive unsharp masking to enhance the image. In this method, an adaptive filter is used to control the sharpening such that contrast enhancement occurs at areas which contain high details and no sharpening occurs at smooth areas. The main drawbacks of this method are the system becomes very sensitive to noise due to the presence of high-pass filter which results to distortion of image and unpleasant artifacts appear on the output image since it enhances the high contrast areas more than the low contrast areas. In 2003, Soong Chen, Abd. Rahman Ramli [25] proposed an extension as BBHE referred to as Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE). In this method the separation of input image histogram is based on threshold level which gives the minimum Absolute Mean Brightness Error (AMBE). This method gives the best result on images with very low, very high and medium mean brightness.

In 2009, Arici T., Dikbas S., Altunbasak Y. [15], proposed a method in which contrast enhancement constitute as an optimization problem. In this method the level of contrast enhancement is adjusted using some specifically designed penalty terms. In 2013, Shashi Poddar, Suman Tewary, Deewakar Sharma and Vinod Karar [8], proposed a method which is independent of parameter setting. In this method, modified histogram is used and two variants namely the variant which preserve the brightness of original image and the other which increase the brightness of image adaptively.

2.2 FREQUENCY DOMAIN BASED IMAGE ENHANCEMENT

Some of the image enhancement based frequency domain and its variant reported in the literature are briefly discussed below:

In 1990, E. Peli [17] proposed a method which gives a contrast value to all the point in the image as a function of spatial frequency band. The contrast for each frequency band is calculated using the ratio of high bandpass filtered at that frequency to the lowpass filtered below the same frequency. In 2001, S. S. Agaian, K. Panetta, and A. M. Grigoryan [18] proposed a method based on orthogonal transforms and new enhancement operators. In this method the fast trigonometric systems is used for finding the transform coefficients manipulation operations.

In 2003, J. Tang, E. Peli, and S. Acton [9] proposed a method based on the contrast measure. In this method a new contrast measure is used. The contrast measure is defined as the ratio of high-frequency component to low-frequency component in the DCT matrix. In 2004, J. Tang, J. Kim, and E. Peli [10] proposed an algorithm which enhances the contrast of an image in the DCT domain by weighing the quantization table in the decoder. This algorithm increases the contrast in all bands of frequencies by an equal factor. In 2007, S.K Lee [11] proposed a colour image contrast enhancement method based on retinex theory. In this method, the DCT coefficient is first separated into illumination and reflectance components. Then, based on the retinx theory [12] the illuminance component is adjusted to compress the dynamic range. The reflectance components are modified based on a measure of spectral content of image to enhance the contrast.

In 2008, Jayanta Mukherjee [13] proposed a method in the compressed domain which takes both luminance and chromatic component into consideration. In this method, the same scale factor is used not only for AC and DC coefficient of DCT matrix but also scale the chromatic component with the same factor. In 2008, Hasan Demirel, Gholamreza Anbarjafari and Mohammad N. Sabet Jahromi [4] proposed an image enhancement technique based on Singular Value Decomposition (SVD). In this method the input image is converted into SVD domain and after normalizing the singular value matrix the image is reconstructed into the spatial domain using the updated singular value matrix.

In 2010, Hasan Demirel, Cagri Ozcinar, and Gholamreza Anbarjafari [5] proposed an algorithm which is an extension of [4]. In this method, the intensity of an image is equalized by equalizing the singular value matrix since the singular value matrix contains the intensity information of the given image. In this method, the input image is first decomposed into low-low (LL), low-high (LH), high-high (HH) and high-low (HL) frequency sub-bands using DWT. Next the singular value is estimated from the LL sub band and finally the enhanced image is reconstructed into spatial domain using inverse DWT. In 2013, Eunsung Lee, Sangjin Kim, Wonseok Kang, Doochun Seo, and Joonki Paik [6], proposed an algorithm which computes brightness of adaptive intensity transfer functions using the low-frequency component of the wavelet domain and the transfer function is computed based on the transforms intensity values. In this method, DWT is first perform on the input image and the using the log-average luminance the LL sub-band is decomposed in low, medium and high intensity layer. The intensity transfer function is estimated using gamma adjustment function based on the dominant brightness level and the knee transfer function. After the intensity transformation, the enhanced image is obtained using the inverse DWT. However this method require appropriate setting of the parameter which make it unfit for practical purpose.

In 2011, A. K. Bhandari, A. Kumar and P. K. Padhy [21] proposed a technique based on Singular Value Decomposition (SVD) and DCT. In this technique, the input image is converted into SVD-DCT domain and after normalizing the singular value matrix the image is reconstructed into the spatial domain using inverse DCT. In 2015, Xueyang Fu, Jiye Wang, Delu Zeng, Yue Huang, and Xinghao Ding [20] proposed a method using regularized histogram equalization and DCT. In this method, first, a global contrast image is obtained by using global contrast enhancement method. Next, the DCT coefficients of the previous improved image are adjusted automatically to enhance the local details of the image.

Chapter 3

PROPOSED METHODOLOGY

The implementation details of the proposed image contrast enhancement are presented in this chapter. The proposed algorithm is based on the combination of GHE and DCT.

3.1 PROPOSED APPROACH

In the proposed technique the general procedure is as follows. First the input image, A is processed using GHE to generate Â. Then the enhanced image Â is transform using DCT and the high frequency coefficient are scaled using the entropy.

3.1.1 Global Contrast Enhancement

Consider an input image A of size $M \times N$ pixel with a dynamic range$[a_{min}, a_{max}]$, where $a(i,j) \in [a_{min}, a_{max}]$ and K is the number of gray levels. The goal is to produce a global contrast enhanced image $\widehat{A}$ having a dynamic range$[\hat{a}_{min}, \hat{a}_{max}]$, where $\hat{a}(i,j) \in [\hat{a}_{min}, \hat{a}_{max}]$. Thus for a b-bit image, $\hat{a}_{min} = 0$ and $\hat{a}_{max} = 2^b - 1$.

The global contrast enhancement of the input image is done using histogram equalization. Traditional HE gives over-enhanced images if there exist histogram spikes therefore the distribution function should be adjusted to avoid this problem. Sigmoid function has the compression and smoothness characteristic thus the over-enhancement and artifact problem can be avoided. Therefore, a new distribution function using sigmoid function is generated as

$$f_d(k) = s(k)\left(1 + h_a(k)\right) \tag{4}$$

Where h_a is the normalized input histogram, $k = 1, \cdots\cdots\cdots, K$.

Sigmoid function s is given as

$$s(k) = \frac{1}{1+e^{-(k-1)}} - \frac{1}{2} \tag{5}$$

Normalized distribution function is obtained as given below

$$\widehat{f_d}(k) \leftarrow f_d(k)/\sum_{t=1}^{K} f_d(k) \tag{6}$$

The cumulative distribution function is obtained from the normalized distribution function as

$$f_c(k) = \sum_{t=1}^{k} \widehat{f_d}(t) \tag{7}$$

The transformation function is given as

$$T(k) = \lfloor f_c(k)(\hat{a}_{max} - \hat{a}_{min}) + \hat{a}_{min} \rfloor \tag{8}$$

Where,

$\lfloor . \rfloor$ rounds the element to the nearest lower integer.

The global contrast enhanced image $\widehat{A}$ can be expressed as

$$\widehat{A} = \{\widehat{A}(i,j)\} = \{T(A(i,j)) | \forall A(i,j) \in A\} \tag{9}$$

Where, $0 \leq i \leq M - 1$ and $0 \leq j \leq N - 1$.

3.1.2 Scaling High Frequency Coefficient

To enhance the local detail of an image the global enhanced image, $\hat{A}$ is transformed using DCT and the DCT coefficient are further adjusted. DCT transform an image or signal from a spatial domain to frequency domain. The 2-D DCT coefficient C of size $M \times N$ are computed by

$$D(u,v) = c_u c_v \sum_{p=0}^{M-1} \sum_{q=0}^{N-1} \widehat{A}(p,q) \cos\left(\frac{\pi(2p+1)u}{2M}\right) \times \cos\left(\frac{\pi(2q+1)v}{2N}\right) \tag{10}$$

Where, $u < M - 1$ and $v < N - 1$.
c_u and c_v are computed by

$$c_u = \begin{cases} \sqrt{\frac{1}{M}}, & u = 0 \\ \sqrt{\frac{2}{M}}, & 1 \leq u \leq M - 1 \end{cases}$$

$$c_v = \begin{cases} \sqrt{\frac{1}{N}}, \; v = 0 \\ \sqrt{\frac{2}{N}}, \; 1 \le v \le N-1 \end{cases} \quad (11)$$

The coefficient $D(0,0)$ is the DC coefficient and the remaining is the AC coefficient. The DC coefficient has low frequency and represents the mean value of the image whereas the AC coefficients are the high frequency component.

Let $D_{AC}(u, v)$ and $D_{DC}(u, v)$ be the high frequency coefficients and low frequency coefficient. A local contrast measurement can be defined as the ratio of the AC coefficient to the DC coefficient [2].

Contrast measurement of the image at location (u, v) is defined as

$$C(u, v) = \frac{D_{AC}(u,v)}{D_{DC}(u,v)} \quad (12)$$

Local entropy of an image extract the feature of an image and our aim is to enhance the contrast measure by modifying the $D_{AC}(u, v)$ which is achieved by local entropy scaling. Local entropy is defined as

$$E_L(u, v) = -\sum p_{\hat{A}}(u, v) \log_2 p_{\hat{A}}(u, v) \quad (13)$$

Where,

$p_{\hat{A}}(u, v)$ is the probability density function of image, $\hat{A}$

Normalized local entropy is obtained as

$$\rho(u, v) = \frac{E_L(u,v)}{\sum_{k=0}^{M-1} \sum_{l=0}^{N-1} E_L(k,l)} \quad (14)$$

Assume that the contrast of an image is enhanced uniformly, then

$$C_{new}(u, v) = \alpha(1 + \rho(u, v))C(u, v) \quad (15)$$

Now, eqn. (15) can be expressed as

$$\frac{D_{new,AC}(u,v)}{D_{new,DC}(u,v)} = C_{new}(u, v) = \alpha(1 + \rho(u, v))C(u, v)$$

$$\frac{D_{new,AC}(u,v)}{D_{new,DC}(u,v)} = \alpha(1+\rho(u,v))\frac{D_{AC}(u,v)}{D_{DC}(u,v)} \tag{16}$$

Let $H(u,v) = \frac{D_{new,DC}(u,v)}{D_{DC}(u,v)}$ then the above equation can be expressed as

$$D_{new,AC}(u,v) = \alpha(1+\rho(u,v))\, H(u,v) D_{AC}(u,v) \tag{17}$$

Where $\alpha \geq 1$

The enhanced DCT coefficient can be obtained as

$$\widehat{D}(u,v) = \alpha(1+\rho(u,v))\, H(u,v) D(u,v) \tag{18}$$

Finally, the inverse 2-D DCT is applied to get the enhanced image in the spatial domain. The inverse 2-D DCT is defined as

$$ID(u,v) = c_u c_v \sum_{p=0}^{M-1} \sum_{q=0}^{N-1} \widehat{D}(p,q) \cos\left(\frac{\pi(2p+1)u}{2M}\right) \times \cos\left(\frac{\pi(2q+1)v}{2N}\right) \tag{19}$$

Flowchart of the proposed algorithm is shown in Fig. 3.1.

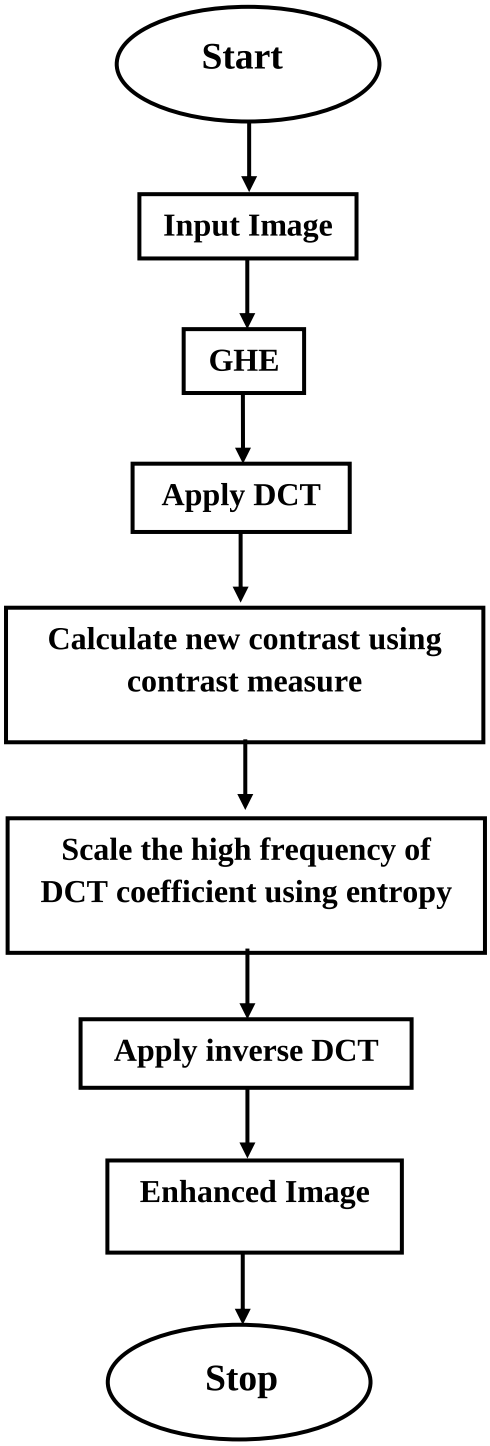


Fig.3.1. Flowchart of proposed method

3.2 SUMMARY OF PROPOSED METHOD

In the proposed method, the coefficient scaling is done on the AC coefficient since it contains the high frequency. The coefficient scaling is done using the local entropy scaling. The algorithm of the proposed method is given in Table 3.1 and Table 3.2.

Table 3.1

Algorithm for global contrast enhancement

Input: Input image: A,

Output: Global contrast enhanced image: $\widehat{A}$

1) Calculate the normalized histogram of the input image.
2) Calculate the distribution function $f_d(k)$ using sigmoid function and histogram of input image in (4).
3) Normalised the distribution function.
4) Obtain the cumulative density function using the normalised distribution function in (7).
5) Obtained the global contrast enhanced image using (9).

Table 3.2

Algorithm for scaling high frequency coefficient

Input: Global enhanced contrast image: $\widehat{A}$

Input parameter: Automatic parameter: α

Output: Enhanced image

1) Obtain the DCT coefficient $D(u, v)$ using (10).
2) Compute $C(u, v)$ using (12).
3) Determine $\rho(u, v)$ using (14).
4) Calculate the new AC coefficient $D_{new,AC}(u, v)$ using (17).
5) Obtained the enhanced DCT coefficient using (18).
6) Obtained the enhanced image using (19).

Chapter 4

EXPERIMENTAL RESULTS

In order to demonstrate the performance of proposed work, it is tested on different gray scale images. All experiments have been performed using MATLAB R2009B on a system with the following configurations:

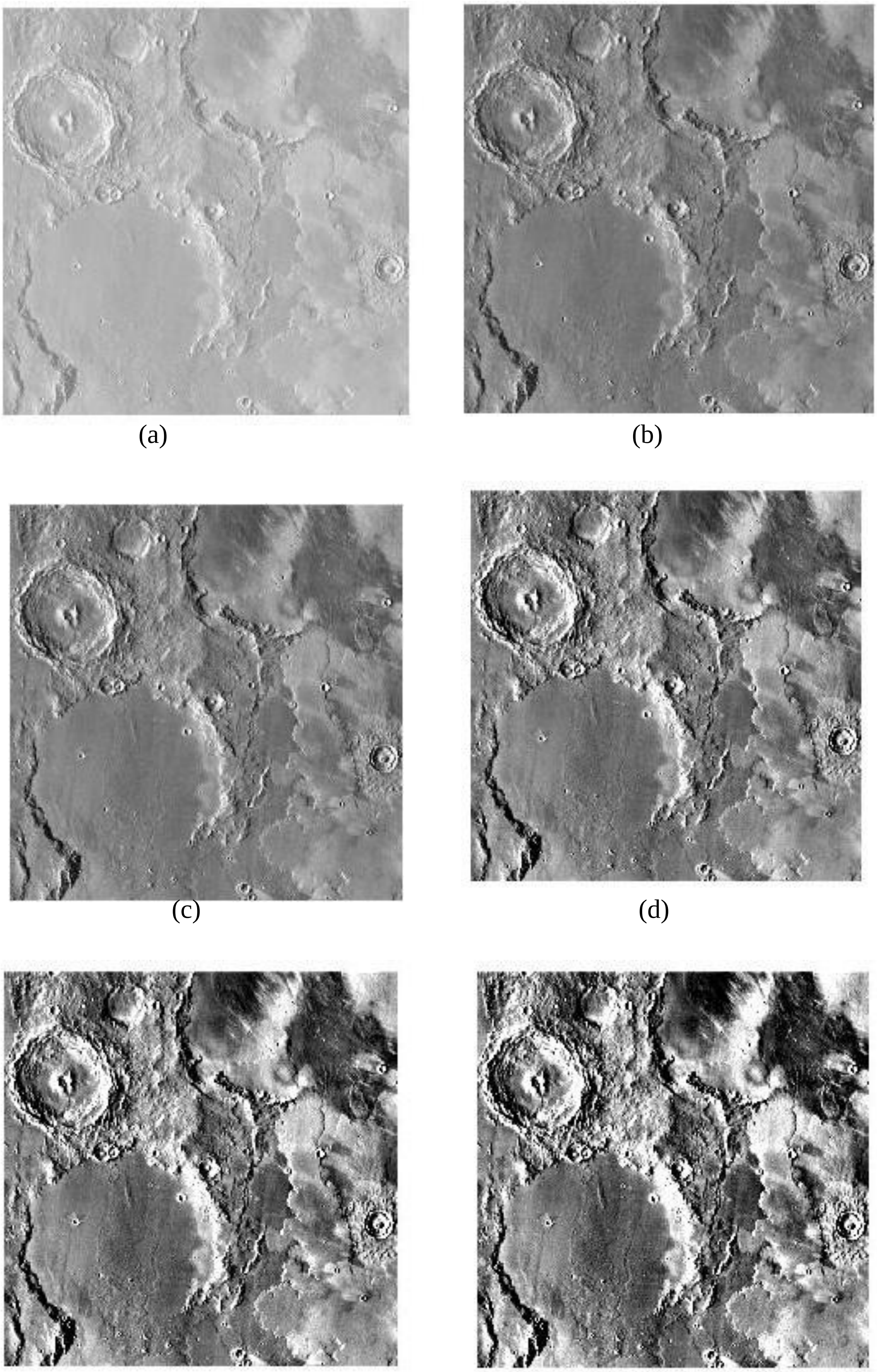
- Processor: Intel Core i3
- Clock Speed: 2.27 GHz
- Main Memory: 2 GB
- Hard Disk Capacity: 256 GB
- System Type: 32-bit operating system

The proposed method is evaluated on data set comprising of images from [22]

4.1 QUALITATIVE ASSESSMENTS

Different image enhancement techniques such as HE [1], BBHE [3], and SVD-DCT [21] are compare with the proposed method on a set of gray scale images. The performances of these methods are measured quantitatively in terms of human vision perception.

Fig 4.1 shows the image enhancement results for greyscale test image according to various α values such as 1, 1.2, 2, 3 and 4. The α value affects the brightness of the background. All enhanced results are obtained using $\alpha = 1.2$.



(a) (b)

(c) (d)

(e) (f)

Fig4.1. Results with different α values. (a) Input image. (b) $\alpha = 1$. (c) $\alpha = 1.2$. (d) $\alpha = 2$. (e) $\alpha = 3$. (f) $\alpha = 4$.

Figs. 4.2–4.12 give the resulting image and their corresponding histogram of the test images obtained by various existing method and the proposed method. All input images have low contrast and the local details cannot be observed clearly as shown in Figs. 4.2(a) – 4.12(a). The traditional HE [1] improve the global contrast but local details are not enhanced enough. The traditional HE gives unnatural looks and the image is over enhanced and artifacts appeared in Figs. 4.2(b) – 4.12(b). The BBHE method [3] gives better result than traditional HE but this method also have the problem of over enhancement of image and unwanted noise appeared in resulting image as shown in Figs. 4.2(c) – 4.12(c). The SVD-DCT method [21] gives fairly good results but creates more saturation artifacts in Figs. 4.2(d) – 4.12(d), particularly in white regions. In this method depending on the different input image the resulting image is either under enhanced or over enhanced. Figs. 4.2(e) – 4.12(e) are the enhanced results produced by the proposed method. Compared with the other three methods, the proposed method has produced results with global contrast and rich local details. For example, as shown in Fig. 4.2(e), sufficient details are revealed and the gradients are clearly visible.

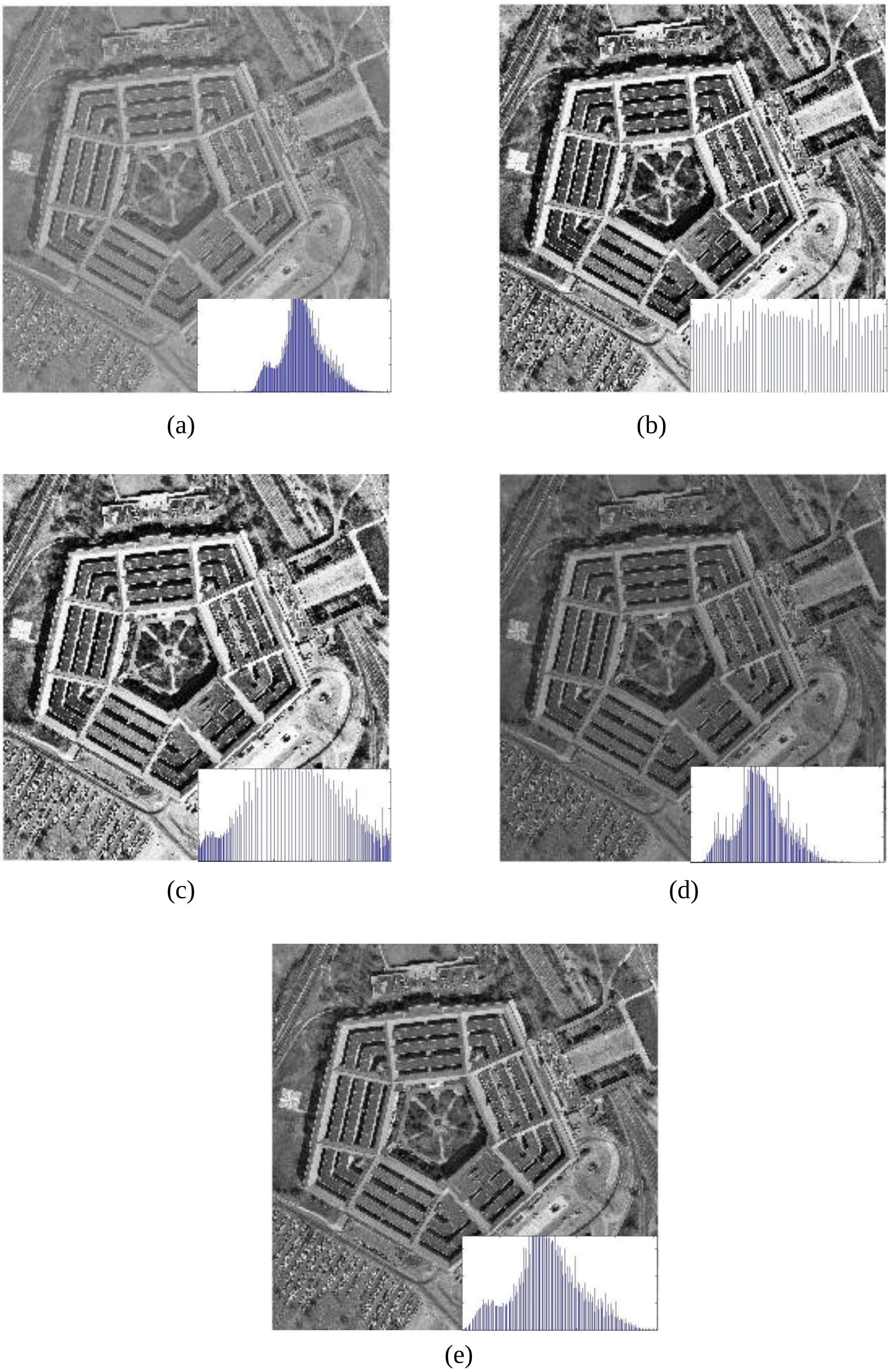


Fig4.2. Comparison on the *Pentag*on image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

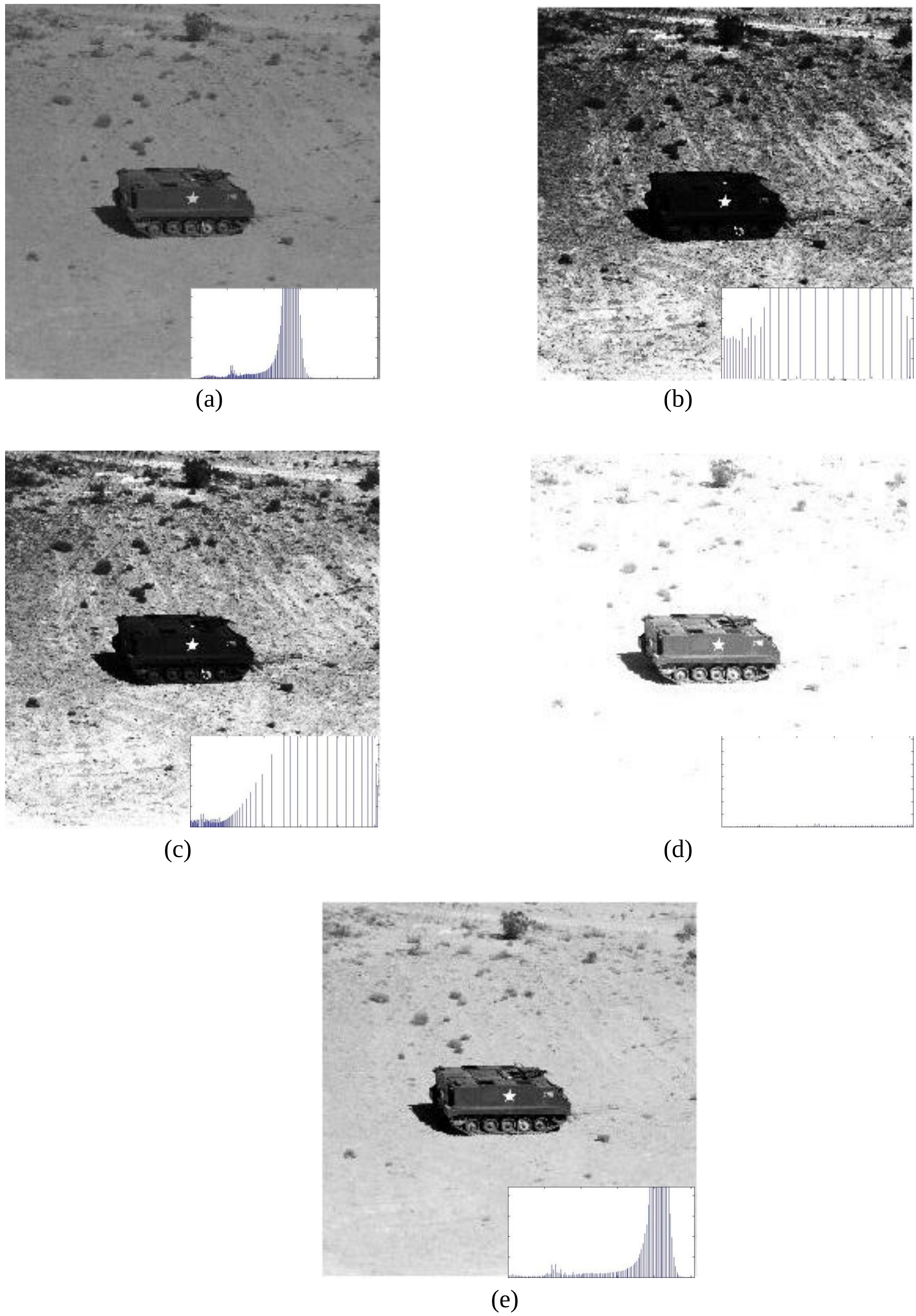


Fig4.3. Comparison on the *Tank* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

(a)

(b)

(c)

(d)

(e)

Fig4.4. Comparison on the *House* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

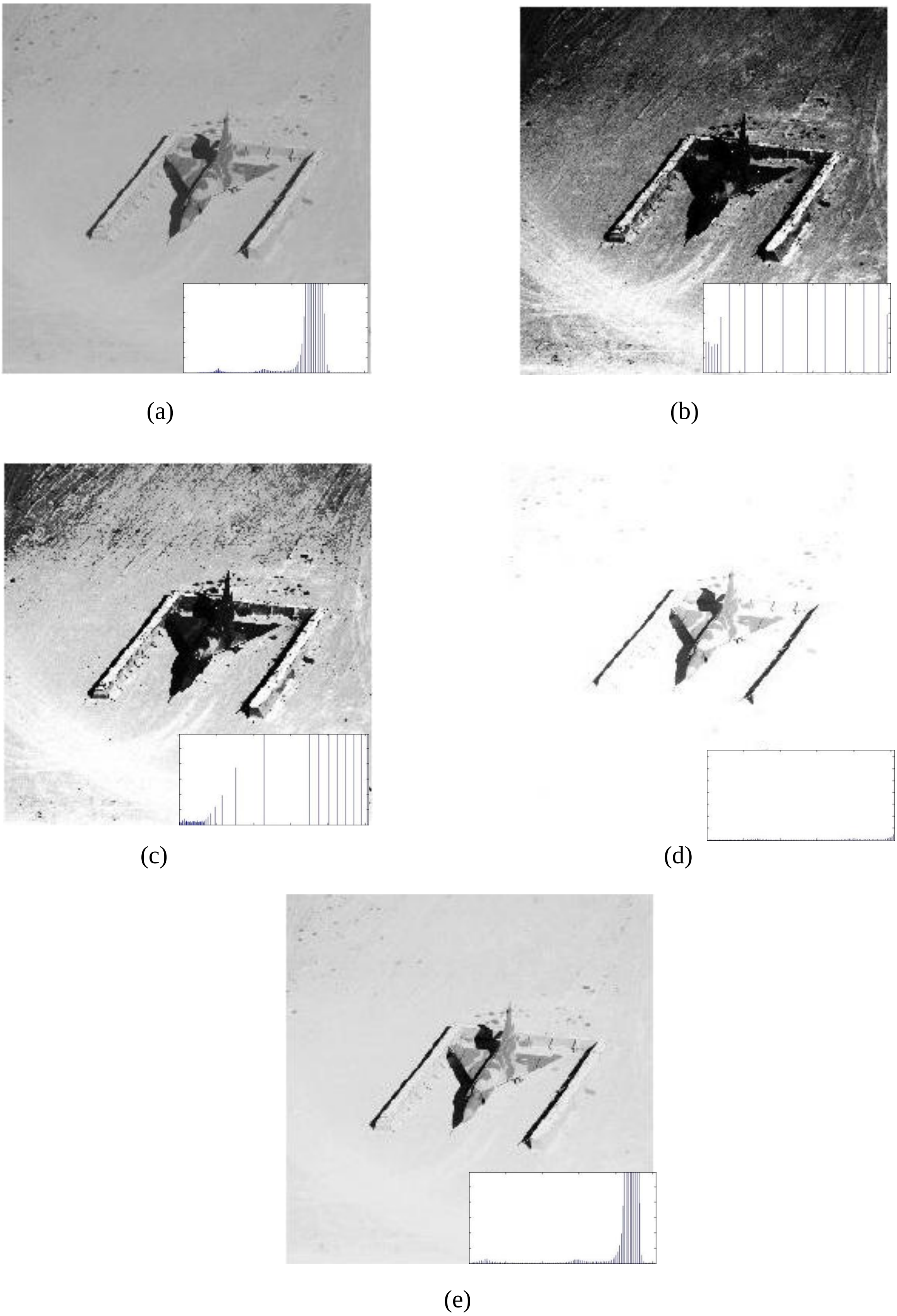
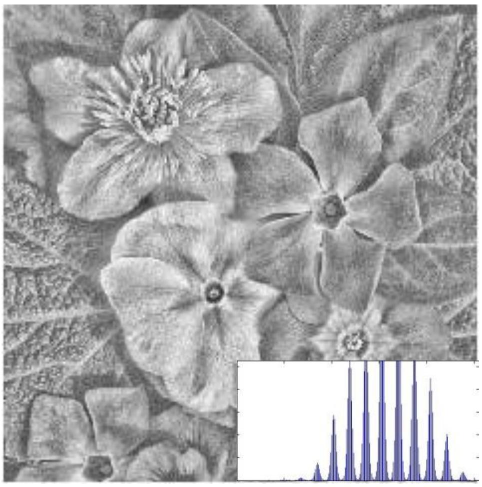
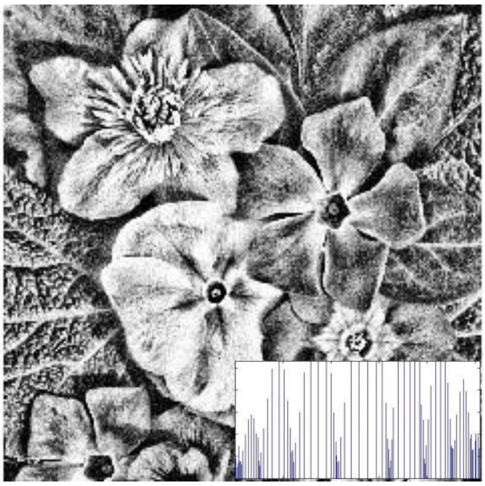


Fig4.5. Comparison on the *Airplane* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

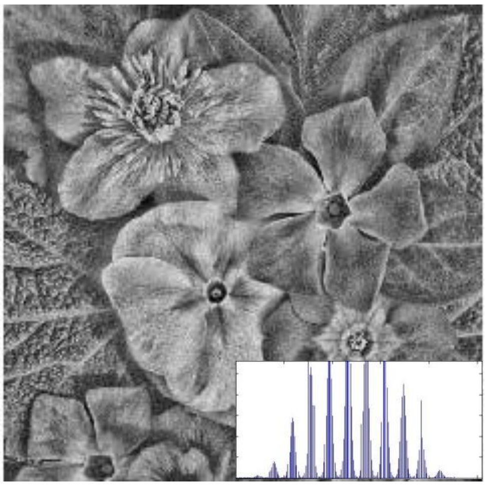


(a)

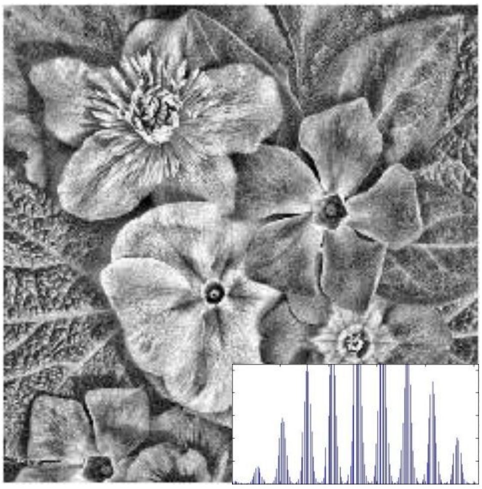
(b)



(c)



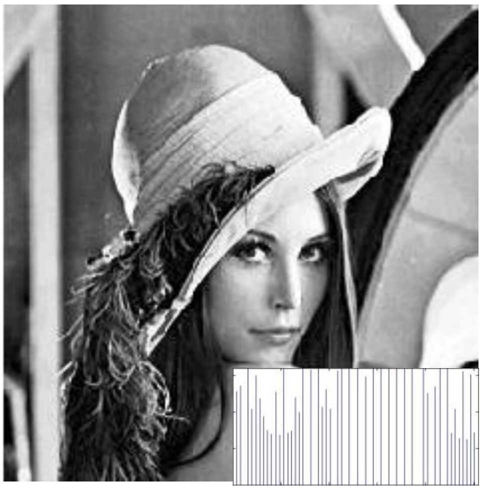
(d)



(e)

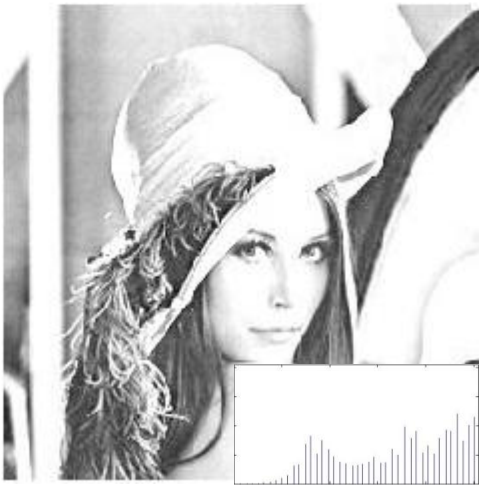
Fig4.6. Comparison on the *Flower* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

(a)



(b)

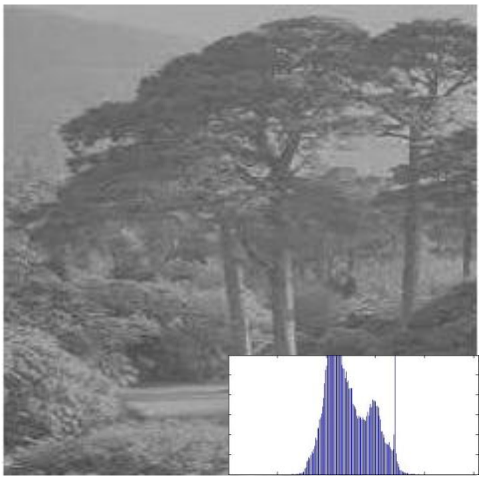
(c)



(d)

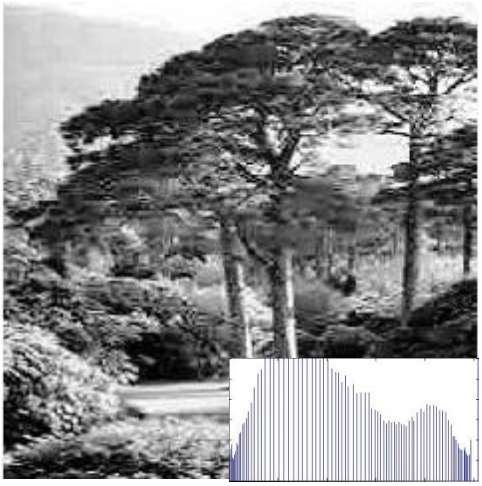
(e)

Fig4.7. Comparison on the *Lena* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

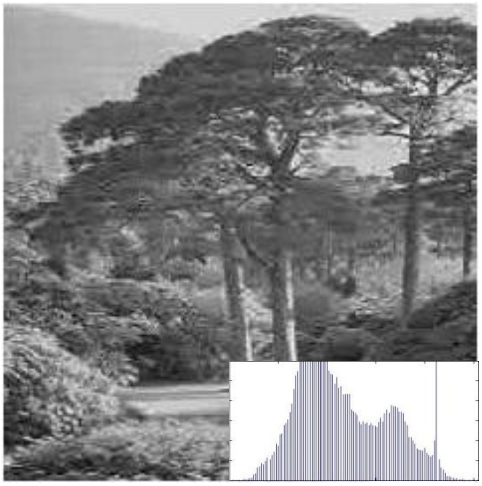


(a)

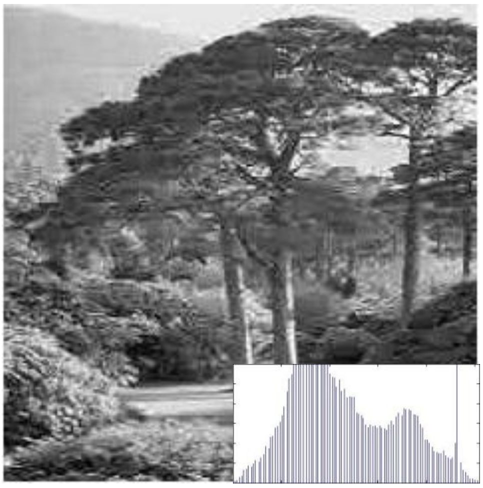
(b)



(c)

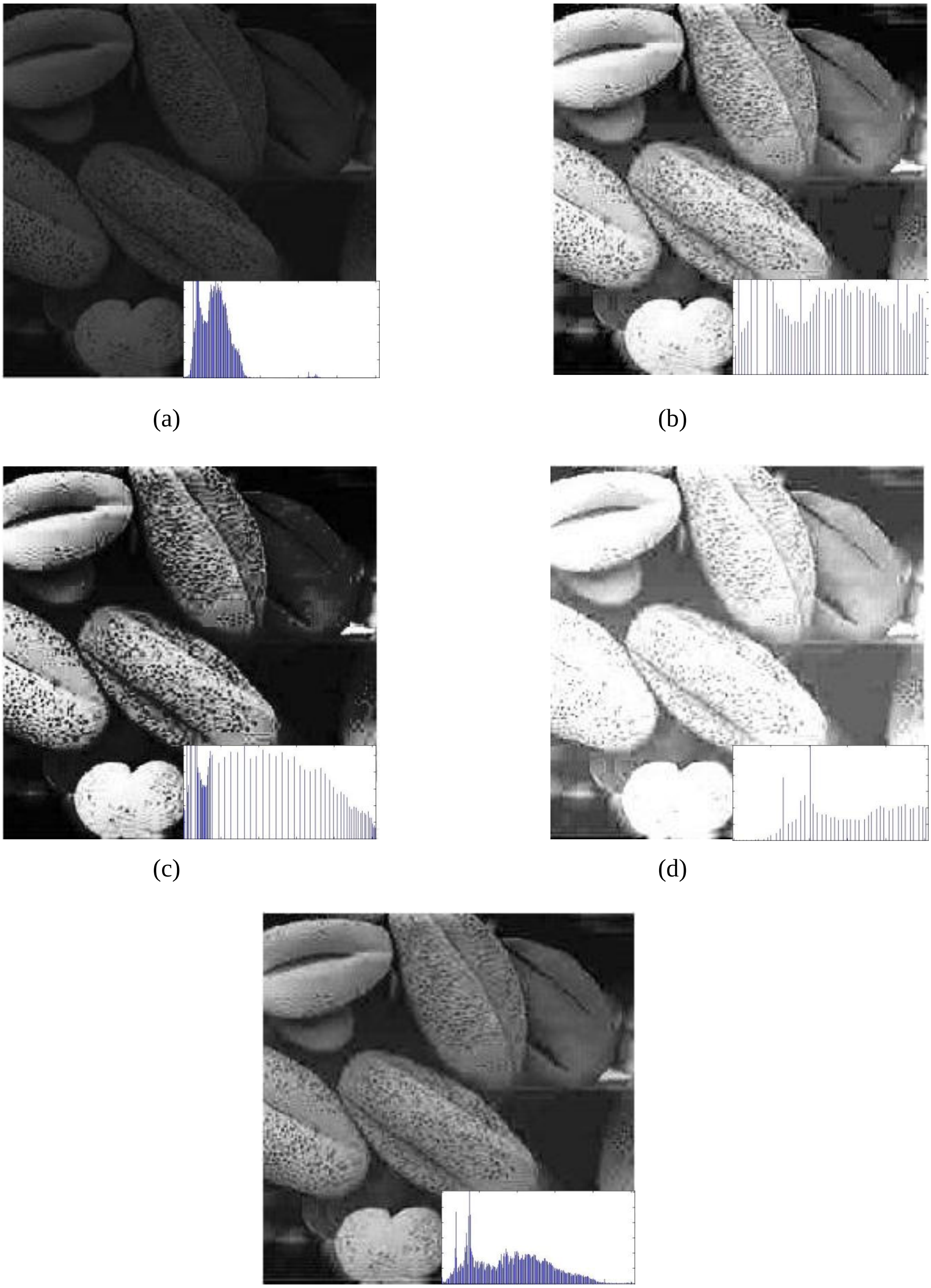


(d)



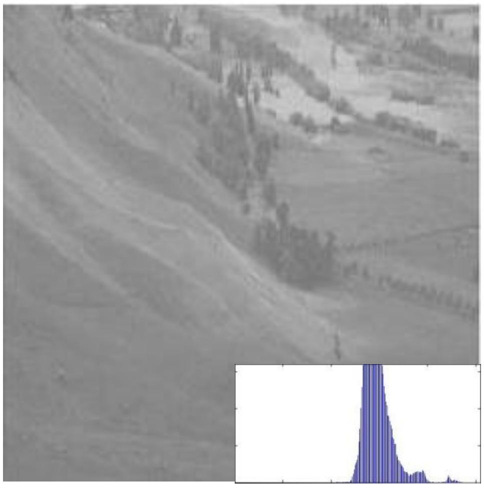
(e)

Fig4.8. Comparison on the *Tree* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

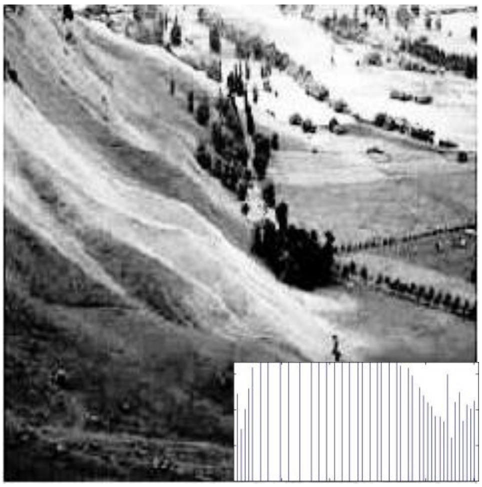


(a) (b) (c) (d) (e)

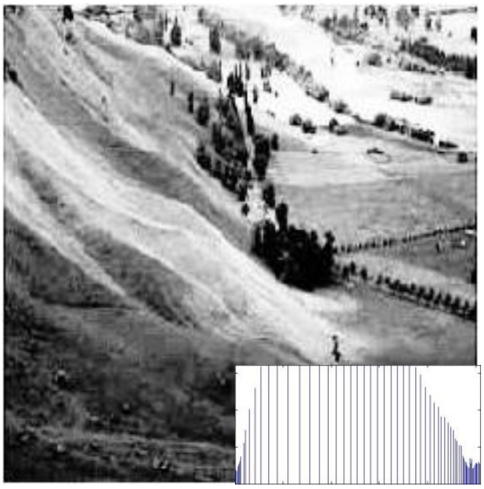
Fig4.9 Comparison on the *Pollen* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.



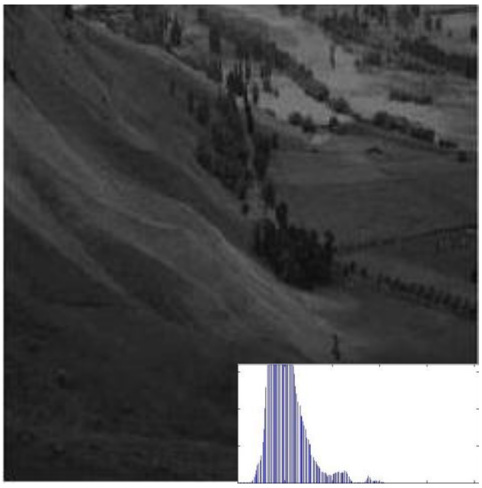
(a)



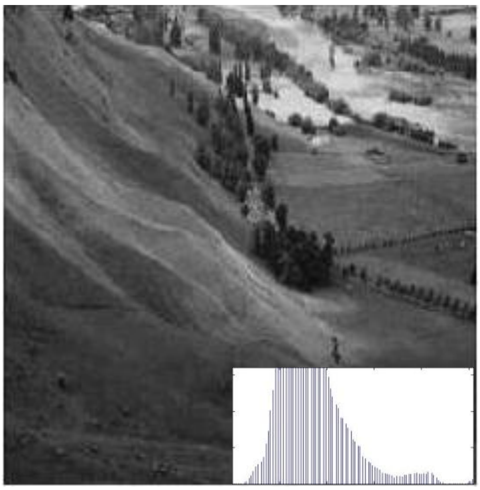
(b)



(c)

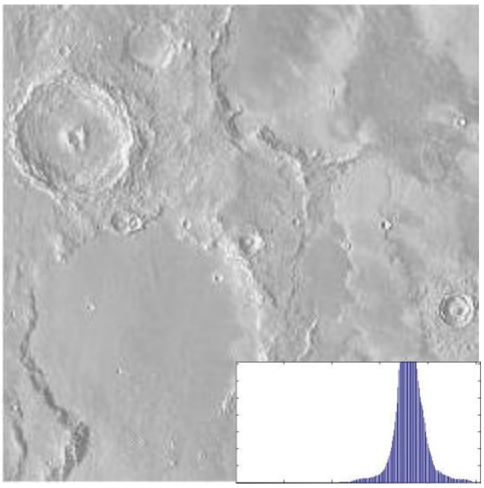


(d)

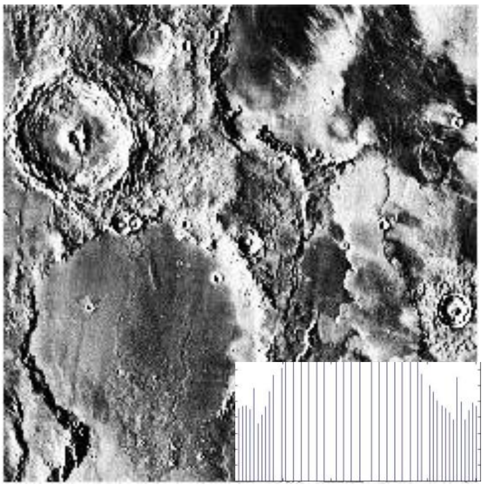


(e)

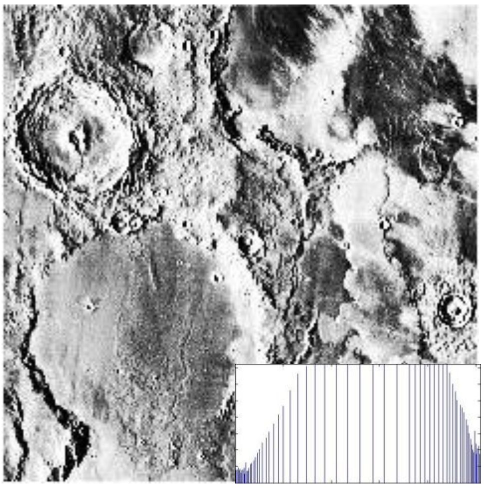
Fig4.10. Comparison on the *Slope* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.



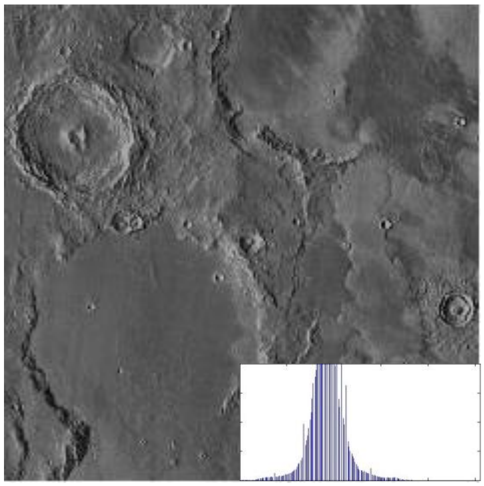
(a)



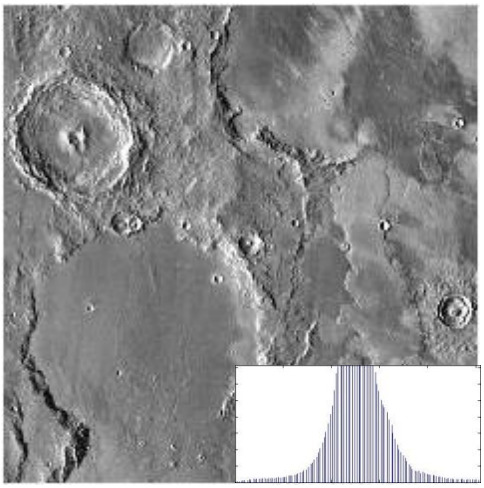
(b)



(c)



(d)



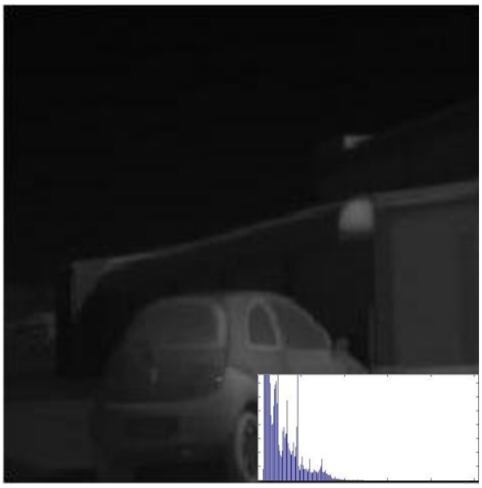
(e)

Fig4.11. Comparison on the *Mars* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

(a)

(b)

(c)



(d)

(e)

Fig4.12. Comparison on the *Car* image. (a) Input image. (b) HE. (c) BBHE. (d) SVD-DCT. (e) Proposed method.

4.2 QUANTITATIVE ASSESSMENTS

Two measures such as discrete entropy (DE) and measure of enhancement (EME) are used to quantitatively assess the performance of the different methods. Discrete entropy is computed by

$$DE(A) = -\sum_{k=1}^{K} p(a_k) \log p(a_k) \quad (20)$$

Where $p(a_k)$ is the probability of pixel value a_k, calculated from the image histogram. Higher value of DE indicates richer details of an image. Table 4.1 shows the comparison of DE values between existing method and proposed method for a set of images. As shown in Table 4.1, the proposed method achieved the highest DE value which implies that the proposed method provides more useful information.

The measure of enhancement (EME) divides the image into non overlapping blocks. Then, find the maximum and minimum intensity value in each block and average the values which give an average contrast in the image. EME is computed by

$$EME = \frac{1}{k_1 k_2} \sum_{l=1}^{k_2} \sum_{k=1}^{k_1} \frac{A_{max}\ (k,l)}{A_{min}\ (k,l)} \log \frac{A_{max}\ (k,l)}{A_{min}\ (k,l)} \quad (21)$$

Where k_1, k_2 are the blocks which the input image is split.

A_{max} , A_{min} are the respective maximum and minimum of the image inside the block.

Comparison of EME values is shown in Table 4.2. The table shows that HE gives the highest value comparing to BBHE, SVD-DCT and the proposed method. The proposed method gives higher EME values than SVD-DCT. It is analyzed that the resultant image of proposed method has high contrast. Experimental results show that the proposed method for various test images enhances the contrast and gives richer local detail and outperforms existing method both qualitatively and quantitatively.

TABLE 4.1

QUANTITATIVE MEASUREMENT RESULTS OF DE

Image	**Original**	**HE**	**BBHE**	**SVD-DCT**	**Proposed**
Mars	4.0384	3.7208	3.8928	3.8695	**4.0338**
Slope	3.9392	3.6917	3.8623	3.9192	**3.9227**
Toy car	3.8636	3.5500	3.8185	3.7976	**3.8632**
Tree	4.4206	4.0665	4.3612	4.4106	**4.4164**
Flower	4.3679	3.9467	4.2351	4.2693	**4.3502**
Grain	4.1266	3.9354	4.0619	3.0425	**4.9371**
Tank	3.5028	3.1645	3.4089	0.8232	**3.4767**
House	3.7557	3.5481	3.6899	3.1588	**3.7417**
Lena	3.9486	3.7766	3.9248	2.7903	**3.9447**
Cake	2.7184	2.7027	2.7021	1.7397	**2.7085**
Einstein	3.1898	2.8287	3.1574	3.0457	**3.1818**
Pout	4.4298	4.0582	4.3639	4.1357	**4.4007**
Drain	3.8610	3.6834	3.8174	3.8415	**3.8501**
Aerial	4.1618	3.9045	4.0791	4.1418	**4.1573**
Toy	4.2333	3.8368	4.1318	1.6600	**4.1480**
Tank2	3.8094	3.4422	3.7358	1.1682	**3.8070**
Airplane	2.7757	2.5970	2.7217	0.5120	**2.7739**
Girl	5.0305	4.1320	4.8574	5.0033	**4.8905**
Mandrill	5.1004	4.1407	5.0060	5.0195	**5.0819**
Pentagon	4.6667	4.1038	4.5912	4.5292	**4.6642**

TABLE 4.2
QUANTITATIVE MEASUREMENT RESULTS OF EME

Image	**Original**	**HE**	**BBHE**	**SVD-DCT**	**Proposed**
Mars	0.1787	**97.8875**	54.8350	1.0191	3.8753
Slope	0.1107	**52.6098**	31.2757	0.8065	1.2420
Toy car	0.0362	**4.1052**	3.1083	0.2737	0.4841
Tree	0.3851	**64.4201**	42.7835	1.9565	2.0753
Flower	0.6724	**93.1501**	60.6206	1.7771	2.3840
Grain	3.1305	**34.3878**	30.2660	4.4427	24.4588
Tank	0.4478	12.6753	6.1338	0.7512	**47.6301**
House	1.4448	**38.1726**	42.2416	1.7383	7.5781
Lena	0.2619	**71.6657**	55.4890	1.9267	8.4709
Cake	0.0696	1.4510	1.6510	1.1088	**2.0142**
Einstein	0.0912	**101.0184**	62.5329	1.4135	1.4874
Pout	0.2794	**30.2003**	20.3092	1.1374	4.5211
Drain	0.7842	15.6805	**18.5611**	1.7538	3.9071
Aerial	0.2188	**54.2100**	30.4137	1.1757	4.0215
Toy	2.3027	**3.7760**	2.8499	2.8699	1.3979
Tank2	0.4672	**14.6571**	9.7249	0.5390	0.3188
Airplane	0.2492	**21.1478**	8.6147	0.2877	0.2590
Girl	0.7128	**19.3509**	12.7702	1.2525	9.1128
Mandrill	2.3892	**70.9519**	39.7068	2.4143	6.6212
Pentagon	0.4984	**62.7947**	36.9249	1.5837	6.0554

Chapter 5

CONCLUSION

In the work presented, image contrast enhancement is done using DCT in which the coefficient of DCT is scale using entropy. The proposed method consists of two steps. In the first step, the input image is enhanced by using sigmoid function and histogram as the distribution function and global contrast enhanced image is obtained. In the second step, the high-frequency coefficients in the wavelet domain are scale using entropy. The experimental result shows the effectiveness of proposed method with other existing contrast enhancement method. The obtained images of proposed method produce natural looking images with more sharpness, which are pleasing to human eye and artifact free. The proposed method can be used for images such as remote sensing images and real life photographic pictures which suffer from poor contrast during its acquisition.

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