# Contrast limited Adaptive Histogram Equalization and Discrete Wavelet Transform Method Used for Image Enhancement

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***Abstract*— Image enhancement has found to be one of the most important vision applications because it has ability to enhance the visibility of images. Contrast limited adaptive histogram equalisation (CLAHE) is a good contrast enhance algorithm, but it faces over stretching and noise problems. To solve these problems, a new contrast enhancement method is implemented which is named as Contrast limited adaptive histogram equalisation (CLAHE)-discrete wavelet transform (DWT), these technique combines two methodologies DWT and CLAHE. This new method implemented in three main step: First, using DWT decomposes original image into low frequency and high frequency components. Then apply CLAHE to low-frequency coefficients and to control noise enhancement, high frequency coefficients are kept unchanged. This is due to high frequency components which have all information about the image and also contains noises of original image. Finally, using inverse DWT reconstructed the image by taking new coefficients. To eliminate over enhancement, weighting average of reconstructed image and original image is calculated using weighting factor matrix. The weighting operation is done to control the enhancement level of region along with different luminances in original image. This is most important because bright parts of image are usually unnecessary to be enhanced in comparison with the dark parts. Hence these implementation shows that this method performs well to suppress noise and to control over enhancement. Finally the enhanced image obtained using CLAHE-DWT for checking the quality of enhanced image, Peak Signal to Noise Ratio (PSNR) ,MAE,LEI,NE is calculated and these simulations are done using MATLAB-2015.**

***IndexTerms*— Histogram equalization, Contrast limited adaptive histogram equalisation (CLAHE), Discrete wavelet transform (DWT), Local entropy increment (LEI).**

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## I. Introduction

Image enhancement play a very important role in image processing where people will select the image with respect to image information. Image enhancement forms which comprise noise reduction, side enhancement and also distinction enhancement. Enhancement is one of the better ubiquity technology of a electrically saved image. To make image lighter or darker or to develop or slash contrast. Image enhancement which gives a strength to the sensitivity of information in images for human vision ,or to present enhancement input image for other image processing procedure. The contrast enhancement one of the significant kind of processing technology for images and also for videos. It can effectively improves the visual quality of an image for human recognition and perception. Along with this, preprocessing method is important for automatic pattern recognition and also for machine video, to get essential features in videos and images and also for other applications. To improve the contrast of an image many contrast enhancement technology has been introduced.
These contrast enhancement procedure can be divided into two categories
1) Spatial domain based method
2) Transformation domain based method
Spatial method refer to image plane itself, and this approaches are based on direct manipulations of pictures in an image .Transformation method are based on the fourier transform modification of an image. In image enhancement Histogram equalization is one of the basic method[2]. In this method contrast adjustment can be done using image histogram in image processing. By applying a gray level transform the global contrast of an image increase and also which makes resulting histogram flatten. Histogram equalization which applies best on over or under exposed image, which have narrow contrast range. Since the Histogram equalization is applied on the entire image, the local details are not enhanced adequately. To reduce these drawbacks, local histogram equalization based techniques are proposed.

One of the local histogram equalization based image enhancement method is contrast limit adaptive histogram equalization (CLAHE)[3]. In CLAHE method which clip the histogram above the clip limit and also distributed to the some other histogram of varies regions which will have histogram value below the clip limit. But this method faces noise enhancement problem and contrast overstretching problems .To overcome this problem a new method is defined ,which is a novel image enhancement technique, named as contrast limit adaptive histogram equalization discrete wavelet transform(CLAHE-DWT). CLAHE-DWT technique is also one of the contrast enhancement method which uses both DWT and CLAHE. This method uses DWT first which divides the input image into low frequency coefficient and high frequency coefficient. These two component refer to approximation and detail information of original image, respectively. In this high frequency component most of the noise is present hence kept this component unchanged and only low frequency component enhanced using CLAHE which reduces the enhancement of noise viably. Finally, by using inverse DWT reconstructed image from new coefficient and also calculate the weighted sum of original image. The weighting coefficient is proportional to the intensity of original image. This makes the region with various luminances enhanced suitably and in this manner eases over-enhancement[1].

## II. PROPOSED HAS METHOD

In this method used to remove over enhancement or noise removal in image system. For enhancement process we use both contrast limited adaptive histogram equalization - discret wavelet transform. To make it more understandable, we then further explain the DWT and weighting operation in our proposed method. The procedures of the CLAHE-DWT algorithm are given as follows:

Step 1: Decompose the original image into low-frequency and high-frequency components by N-level DWT using Haar wavelet. The Haar wavelet is simple and thus suitable for hardware implementation. The choice of parameter N is discussed in detail later.

Step2: Enhance the low-frequency coefficients using CLAHE and keep the high-frequency coefficients unchanged.

Step 3: Reconstruct the image by inverse DWT of the new coefficients.

Step4: Finally, take the weighted average of the reconstructed and original images using The originally proposed weighting coefficient makes the regions with different luminances enhanced appropriately and thus alleviates over-enhancement effectively[1].

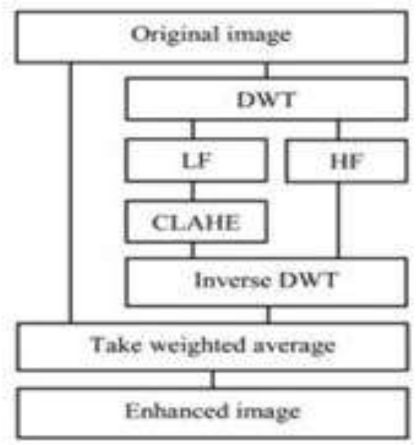


Fig.1: Overall flow of the proposed CLAHE-DWT based image enhancement method.

### *2.1 Explanation about DWT*

Using DWT decompose the input image into four sub band images, which can be defined as Low-Low(LL), Low-High (LH), High-Low (HL), and High-High (HH).Sub bands with its frequency components cover the full frequency spectrum of the original image. Theoretically, in order to generate different sub band frequency images,a filter bank should be operated on that image. For estimating edges in higher frequency sub bands, model is prepared using edges identified in lower frequency sub bands and only the coefficients with significant values are considered as the evolution of the wavelet coefficients[5].

### *2.2. Explanation about CLAHE*

In some cases, when grayscale distribution is localized, it may not be tempted to transform low contrast images by Histogram Equalization approach. Hence, in these cases adjusting the curve may include fragments with high slope implies two grayscale may be mapped to fundamentally unique grayscales. This issue can be solved by limiting the contrast using Histogram Equalization and the strategy utilized for this condition is known as CLAHE (Contrast Limited Adaptive Histogram Equalization). Though on applying AHE[4], the noise get more enhanced in the region where it has small intensity but there might be a few relics on that region. CLAHE is the reasonable technique that is utilized to confine those old relics.

1) Get all the inputs: Image, Number of row and column directions of region, Number of bins used in form image transform function for the histograms, Clip limit taken normally from 0 to 1 for contrast limiting.

2) Pre-process the inputs: if necessary find the real clip limit from the normalized value, before splitting image into it region pad the image.

3) Process each tiles thus forms gray level mappings: Take a single image region, utilizing the specified number of bins makes a histogram for this region, clip the histogram using clip limit and also create and create a mapping(transformation function) for this region.

4) Interpolate gray level mappings in order to form final CLAHE image: take cluster of 4 neighboring mapping functions, process image region which is partly overlapping each of the mapping tiles, extract a single pixel, apply four mappings to that pixel, and interpolate between the results to obtain the output pixel; repeat over the entire image.

*2.3. Explanation about Luminance component value V of image:*

The new CLAHE-DWT method can be easily extended to enhance color images by applying it on the luminance component of image. The luminance component value T of image can be calculated using the following equation

$$T=\frac{\max(R_{in},G_{in},B_{in})}{255} \qquad (1)$$

Where ( $R_{in},G_{in},B_{in}$ )are the RGB values of input image. In order to prevent color distortion, the final enhanced color image is obtained using the following operation

$$R_{out}=R_{in}*\frac{T_E}{T_{in}},\ G_{out}=G_{in}*\frac{T_E}{T_{in}},\ B_{out}=B_{in}*\frac{T_E}{T_{in}} \qquad (2)$$

Where ( $R_{out},G_{out},B_{out}$ )are the RGB values of output image and $T_E$ is the enhanced version of T using CLAHE-DWT.

*2.4. Explanation about Weighting average:*

To mitigate over enhancement, we take the weighted average of the reconstructed and also original image as follows

$$I_e=I_o*K+\alpha*I_r*(Matrix_{one}-K) \qquad (3)$$

where ' * ' denotes a point-to-point multiplication operation. $I_o,I_e,I_r$ are, respectively, the original, reconstructed and final enhanced images. $\alpha$ is brightness compensation factor, which is used to compensate the decreased luminance of image because of the weighting operation. In our method, the value of $\alpha$ ($1<\alpha<2$) is chosen empirically according to the luminance of original image. $Matrix_{one}$ is a matrix of all ones. K and $Matrix_{one}-K$ are the weighting coefficients of $I_o$ and $I_e$ respectively. The weighting factor matrix K is defined in the following way

$$K=\begin{pmatrix} K(1,1) & \cdots & K(1,n) \\ \vdots & \ddots & \vdots \\ K(m,1) & \cdots & K(m,n) \end{pmatrix}_{m\times n}$$

$$=\begin{pmatrix} f(I_o(1,1))^{\beta} & \cdots & f(I_o(1,1))^{\beta} \\ \vdots & \ddots & \vdots \\ f(I_o(m,1))^{\beta} & \cdots & f(I_o(m,n))^{\beta} \end{pmatrix}_{m\times n} \qquad (4)$$

The size of both $I_o$ and K are $m\times n$ $I(p,q)=(p=1,2,\ldots m\ q=1,2,\ldots n$.is the greyscale of pixel (p, q ) in the original image. $I_o$ ,β is a regulatory exponent . The function f is defined as follows

$$f(I_o(p,q))=\frac{I_o(p,q)-I_{o\min}}{I_{o\max}-I_{o\min}} \qquad (5)$$

$I_{o\max}$ and $I_{o\min}$ denote the maximum and minimum grey scales of original image, respectively.

As we can see from (3),( 4) and (5) image is enhanced more using CLAHE-DWT with a greater regulatory factor β. When β=0 we have $I_e=I_o$.In the other extreme case when β=+∞ we have $I_e=\alpha I_o$.Hence, CLAHE-DWT may unable to enhance the image sufficiently when β is too small and it may face over enhancement problem when β is too big.

Local entropy increment (LEI) to calculate the optimal β value.

$$LEI(\beta)=\frac{1}{m_1m_2}\sum_{l=1}^{m_1}\sum_{k=1}^{m_2}20\ln\frac{Entrop_e(\beta)}{Entrop_o} \qquad (6)$$

$$Entrop = -\sum_{m=0}^{255} p(m)\log(p(m)) \qquad (7)$$

where $m_1$ and $m_2$ are the row number and column number of blocks $Entrop_o$ and $Entrop_e(\beta)$ are the entropy of original image and CLAHW-DWT image enhanced image with regulatory factor β in a given block and p(m) is the probability of the $m_{th}$ = (0, 1, 2,.....255)grey level.

The optimal value of á in [0, 5] can be obtained by the following equation

$$\beta = \underset{\alpha\in[0,5]}{\arg\max}\{LEI(\beta)\} \quad (8)$$

In our extensive experiments, the parameters β obtained using (6) produces good subjective quality in most cases.

## III. EXPERIMENTS RESULTS

On this section, we examine our method with Histogram Equalization (HE) qualitatively and quantitatively and notice the effects of parameters involved. The operation on HE is converting the RGB colorspace into HSV after which converting back to the RGB colorspace. The operation executed on the V channel of the HSV colorspace. Instantly manipulating OF each of every RGB channel leads to visually inconsistent with the actual images. In terms of visual quality and time cost our method is most significant.

Fig. 2a: First row is inputs i.e image1,image2,image3,image4

Fig. 2b: Second row represented CLAHE output

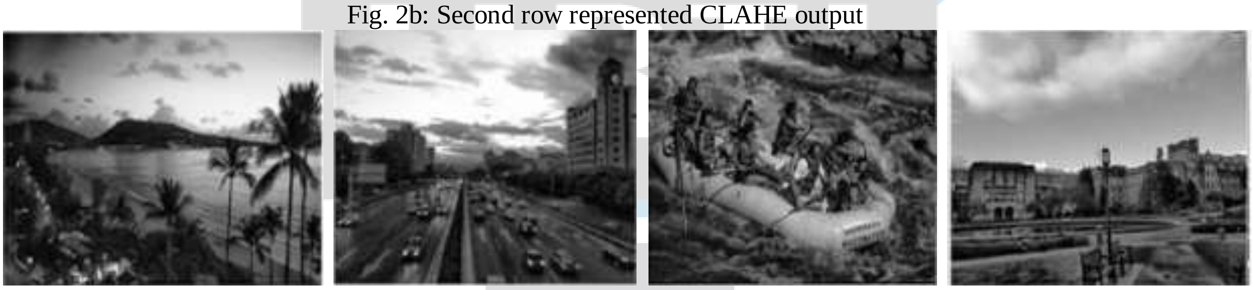

Fig. 3c: Third row is weighting average CLAHE-DWT output

Figure1 shows the each step of CLAHE-DWT.CLAHE-DWT only enhances the low-frequency component and keeps the high-frequency component which contains most of the noise in original image unchanged. It also can be observed that some details in the bright parts of enhanced images using CLAHE are lost because of over enhancement. The over enhancement phenomenon is alleviated in our method .To compare these image enhancement methods quantitatively, four objective evaluation indexes, that is, LEI, noise estimation (NE), peak signal to noise ratio (PSNR) and mean absolute error (MAE) are used .The LEI is adopted to measure the content of an image and a higher value indicates the image with richer details. Both NE and PSNR are adopted to quantify the artefacts or noise generated during contrast enhancement process. MAE is the absolute difference between the input and output mean intensitie

Table 1: Various input image and its parameter

| Input | MAE | PSNR | NE | LEI |
|---|---|---|---|---|
| Image1 | 1 | 29.309 | 0.67079 | 7.5342 |
| Image2 | 1 | 30.7218 | 0.94198 | 7.3836 |
| Image3 | 1 | 27.3752 | 0.58877 | 7.2171 |
| Image4 | 1 | 30.4535 | 0.5657 | 7.6188 |

It is difficult to construct such datasets, for the sake of objectiveness, we have to choose a reliable a datasets. we also adopt the results of four parameter result as reference. Table shows a MAE,NE,PSNR,LEI of different images compared with the HE. Figure2 From that, we observe our method is significantly outperform the others. The results obtained by CLAHE-DWT are more popular and closer to the references than the others.

## IV. CONCLUSION

Image enhancement is one of the method for improvement of image appearance by increasing some dominance features or by decreasing a ambiguity between different regions of the image. Image enhancement processes which have many number enhancement technique which improves visual quality of a image or convert image into other better form which suited for the analysis of human or machine. Many application which uses image enhancement method but images suffer from poor contrast ,hence it is necessary to enhance the contrast. One of the better contrast enhancement is CLAHE-DWT which combines two methodologies DWT and CLAHE. In this method decompose the image into low frequency and high frequency component using DWT .Take only low frequency for further enhancement. Because low frequency component having approximation details of image and high frequency which having more noise and also detail information about image. Hence high frequency component kept unchanged. Finally find the weighting sum of reconstructed image and original image to eliminate over enhancement by using weighting factor matrix. This method which gives good quality of enhanced image than the other enhancement method. In this project image enhancement is implemented with the various method and comparisons are performed by considering MSE, PSNR, NE,MAE,LEI to identify quality of enhanced image.

## V. ACKNOWLEDGEMENT

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