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# Image Contrast Enhancement using Combination of DWT & SWT with CLAHE

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***Abstract: In this paper, a novel image enhancement method, named Contrast Limited Adaptive Histogram Equalization (CLAHE) with Discrete Wavelet Transform (DWT) & Stationary wavelet Transform (SWT) is proposed, which combines the CLAHE with DWT & SWT. CLAHE is an effective algorithm to enhance the local details of an image. DWT and SWT is applied to the low resolution image that divides the image into approximation, horizontal, diagonal and vertical. We also propose an image resolution enhancement technique based on interpolation of the high frequency sub band images obtained by discrete wavelet transform (DWT) and the input image. The interpolated high frequency sub-band coefficients have been corrected by using the high frequency sub bands achieved by SWT of the input image. Then all these sub bands are combined to generate a new image by using inverse SWT (ISWT). The low resolution image is now enhanced to high resolution image by applying CLAHE. The quantitative and visual results show the superiority of the proposed technique over the conventional and state-of-art image resolution enhancement techniques.***
***Index Terms: contrast enhancement, image processing, low-low band, wavelet transform***

## I. INTRODUCTION

The basic aim of the image processing is to increase and improve low contrast of the image and minimize unwanted errors. The contrast enhancement techniques mainly focus on grayscale and frequency domain. The contrast enhancement can be easily performed in wavelet transform domain. Mainly there are two wavelet transform techniques namely “Discrete Wavelet Transform (DWT)” and “Stationary Wavelet Transform (SWT)”, used to decompose the low resolution input image into sub-bands: “Approximation”, “Horizontal”, “Vertical” and “Diagonal” which represents LL, LH, HL and HH bands respectively.

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The contrast limited adaptive histogram equalization (CLAHE) is modern image enhancement technique, which initially ivides the image into numbers of continuous and non-overlapped sub-blocks, then enhances each of these sub-blocks individually and finally uses “Bicubic Interpolation” method to reduce unwanted errors.

In this paper, we will first take an input image of resolution 512*512 and divide the image into Red channel, Green channel and Blue channel for complete details and proper enhancement of the image. We then applied DWT and SWT to each channel individually and each channel image got decomposed into four sub-bands. After applying DWT, the size of the image is lost so we use Bicubic Interpolation. After using interpolation, we combine all four sub-bands of DWT and SWT and then apply “Inverse Stationary Wavelet Transform(ISWT)” to obtain high resolution image. We then resize the image and adjust it to proper resolution. Then we combine all above results of each channel and then apply CLAHE method. After applying CLAHE we get highly enhanced final output image with maximum PSNR and minimum error.

## II. RELATED WORK

In this section, a brief review of the previous work is provided which is related to CLAHE-DWT.CLAHE is a local contrast enhancement technique which enhances the local details of image effectively. The main steps of CLAHE are as follows:

Step 1: Separation the image into tiles which are continuous and non-overlapped.

Step 2: Cliping the histogram of each tile above a threshold and evenly distribution the clipped pixels to all grey levels.

Step 3: Application of HE on each tile.

Step 4: Interpolation of the mapping between neighboring tiles. The resulting mapping at any pixel is interpolated from the intensity mappings of four neighboring tiles.

CLAHE is used to clip the part of histogram above a threshold and to redistribute the clipped pixels to each grey level. This operation can alleviate the noise enhancement phenomenon to some degree. However, the noise is still unacceptable for some applications i.e. it may lose details in some portions of the input image due to over enhancement.

## III. CLAHE-DWT IMAGE ENHANCEMENT ALGORITHM

An input image is taken and resized to 512*512. This input image is then fragmented into 3 different channels namely Red channel, Green channel and Blue channel.

Now, DWT is applied to each channels present. after applying DWT the image in all the three channels, it is subdivided into 4 regions. Interpolation is performed in DWT because the image size is reduced to 256*256. An interpolation is a technique that reduces the visual distortion caused by the fractional zoom calculation is the bilinear interpolation algorithm, where the fractional part of the pixel address is used to compute a weighted average of pixel brightness values over a small neighborhood of pixels in the source image. The image is again resized to 512*512.

Again SWT is applied to each of the 3 channels (RED, GREEN, BLUE). THE result of this and the previously applied DWT is added together. Inverse SWT is applied to combine the 4 regions back together forming a clearer image. The image is further resized using the library function 'imadjust'. Next CLAHE is applied to each of the channels.

In CLAHE, the contrast amplification in the vicinity of a given pixel value is given by the slope of the transformation function. This is proportional to the slope of the neighborhood cumulative distribution function (CDF) and therefore to the value of the histogram at that pixel value. CLAHE limits the amplification by clipping the histogram at a predefined value before computing the CDF. This limits the slope of the CDF and therefore of the transformation function. The value at which the histogram is clipped, the so-called clip limit, depends on the normalization of the histogram and thereby on the size of the neighborhood region.The 3 regions is combined together to finally display the output.

Consider a running sub image W of N X N pixels centered on a pixel P (i,j) , the image is filtered to produced another sub image P of (N X N) pixels according to the equation below

$$p_n = 255 \cdot \left( \frac{[\emptyset_w(p) - \emptyset_w(Min)]}{[\emptyset_w\ (Max) - \emptyset_w\ (Min)]} \right)$$

Where,

and Max and Min are the maximum and minimum intensity values in the whole image, while $\mu_w$ and $\sigma_w$ indicate the local window mean and standard deviation which are defined as:

$$\mu_w = \frac{1}{N^2} \sum_{(i,j)\in(k,l)} p(i,j)$$

$$\sigma_w = \sqrt{\frac{1}{N^2} \sum_{(i,j)\in(k,l)} (p(i,j) - \mu_w)^2}$$

As a result of this adaptive histogram equalization, the dark area in the input image that was badly illuminated has become brighter in the output image while the side that was highly illuminated remains or reduces so that the whole illumination of the image is same.

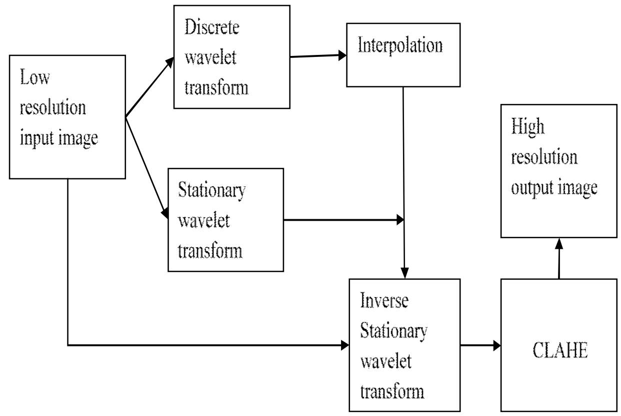


Figure1. Block Diagram of the proposed method

## IV. EXPERIMENTAL RESULTS AND DISCUSSION

The above-proposed system can be explained through some visual performance and effective observation. We conducted the above simulation of images on Matlab software. We took two parameters to evaluate the following images and their simulation: mean-squared-error(MSE) and peak signal-to-noise(PSNR).

The PSNR is calculated by,

$$PSNR= 10\ LOG_{10}\left(\frac{X^2}{MSE}\right)$$

where MSE represent the mean-squared-error and X represent number of maximum possible intensity of the image. PSNR for 8 bits image is approximately 30-50 dB and that of 16 bits image will be around 60-80 dB . The MSE can be calculated by the equation given below ,

$$MSE=\frac{1}{ab}\sum_{i=0}^{a}\sum_{j=0}^{b}[orignal(i,j)-result(i,j)]^2$$

Where original(i,j) and result(i,j) are the real image and result image whose width is a and height is b. MSE of the image should approximately be zero.


(a)


(b)

Figure 2. (a) original input image, (b) output enchanced image

## V. CONCLUSION

For the better quality of image, we have proposed contrast enhancement technique. The histogram equalization changes the brightness and contrast for the better view of our images. We performed contrast limited adaptive histogram equalization to enhance the contrast of the image in low-low band of wavelet transform. The same is applied to scale image intensity. After simulation, we find that the proposed method works better than the conventional method.

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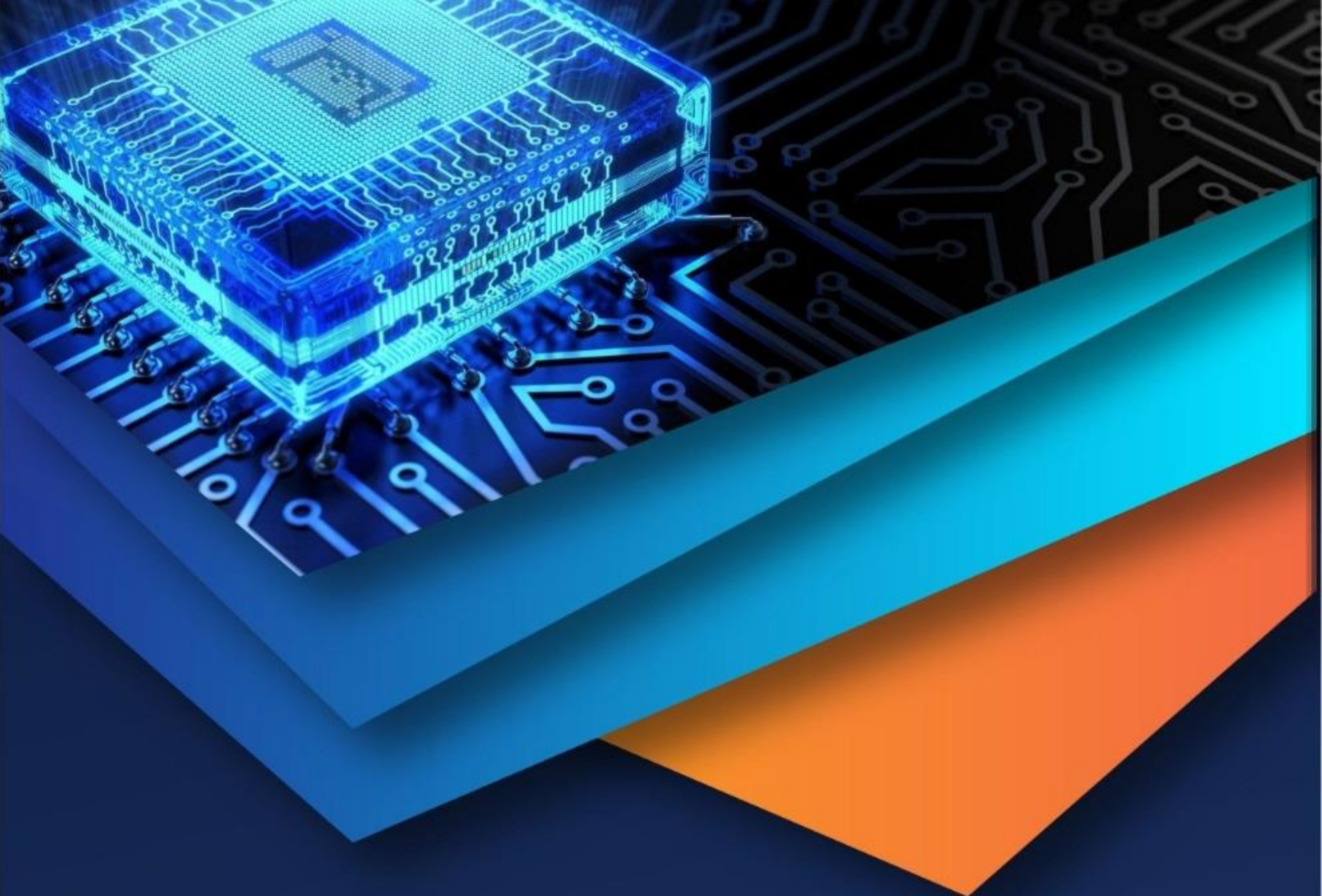


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