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Non Linear Image Enhancement using Digital Wavelet Transform

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Abstract
A human observer can clearly see individual objects both in the sunlight and shadowed areas, since the eye locally adapts while scanning the different regions of the scene. In human vision, first, the size of pupil adopts to accommodate different levels of radiance from different regions in a scene. When starting at a highly bright region in the scene, the pupil will shrink to compress the dynamic range. So, the eyes can deal with the dynamic range. Second, the major dynamic range compression process is taking place via the lateral processing at the retinal level. Finally, the early visual cortex is also found participating in some of the dynamic range processing. When attempting to display the image on a display, either the low intensity areas, which are underexposed, or the high intensity areas, which are overexposed, cannot be seen. To handle this problem, various image processing techniques have been developed. This research will propose an algorithm for image enhancement. In existing DWT with non linear interpolation and in proposed DWT and SWT with non linear interpolation is applied. By using the proposed algorithm, it will improve the value of PSNR (Peak Signal to Noise Ratio).

Keywords: *Image Enhancement, Linear Base, Non-Linear Based, DWT, SWT.*

I. Introduction

Image enhancement technique is the universal way of enhancing the quality of the image [1].Objective of image enhancement technique is to change the attributes of the image to improve its standard from the original. There are n number of image enhancement techniques have been introduced in both the domain of image enhancement technique i.e. Special domain and transfer domain. In special domain the intensity value are modified where as in transfer domain the Coefficient of transfer domains are modified [2].There are many method used for image enhancement without spoiling the original image. There are various image enhancing techniques are present in market which are removing noise, blurring, increasing contrast & increasing the details properties. The real image might have areas of very high and very near to the ground intensity which facade details are unhide by an adaptive enhancement algorithm. Adaptive algorithms correct their operation based on the image information (pixels) which is processed. In this scenario the sharpness (amount of blur removal), mean intensity, and contrast could be adjusted based on the pixel intensity statistics in various areas of the image.

Image enhancement is an important approach to improve the image quality and visual effect, offer a good condition for the subsequent image processing and video tracking and so on. Image enhancement mainly enhances image contrast, which define as the overall strength of the object edge. The edge is stronger, the visual effect of image is better. The decrease of image contrast relates with many factors, one important factor of which is the non-uniform distribution of external light. The actual image could be considered to be the response of reflective properties of the object and light intensity. Non-uniform illumination makes the image some dark regions or bright regions, while the details in the dark regions and the bright regions can not be observed by eyes. In fact, these regions of the image have many details, whose contrast is low. So enhancing contrast of these regions have important application value[3].

The traditional image enhancement methods always contain some linear methods, such as histogram equalization, linear transformation, Laplace sharpening and so on. These methods apply only to certain occasions. When the external environment changes greatly, these methods have some limitations [3].

II. Image Enhancement Types

Image enhancement can be broadly classified into two types such as contrast based and resolution based and these types are also further classified as:

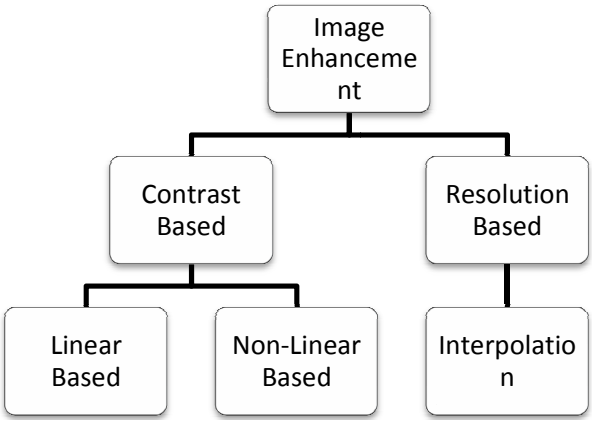

Figure 1: Image Enhancement Types

A. Contrast Based Enhancement

Contrast generally refers to the difference in luminance or grey level values in an image and is an important characteristic. It can be defined as the ratio of the maximum intensity to the minimum intensity over an image. Contrast ratio has a strong bearing on the resolving power and detect ability of an image. Larger this ratio, more easy it is to interpret the image. Satellite images lack adequate contrast and require contrast improvement.

Contrast is an important factor in any subjective evaluation of image quality. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in medical imaging. Among them, histogram modification and edge enhancement techniques have been most commonly used along with traditional methods of image processing.

Contrast enhancement is frequently referred to as one of the most important issues in image processing. The contrast is created by the difference in luminance reflected from two adjacent surfaces. Local contrast stretching (LCS) is an enhancement method performed on an image for locally adjusting each picture element value to improve the visualization of structures in both darkest and lightest portions of the image at the same time [4]. LCS is performed by sliding windows (called the KERNEL) across the image and adjusting the center element. Partial contrast is an auto scaling method. This is a linear mapping function that is usually used to increase the contrast level and brightness level of the image. That technique will be based on the original brightness and contrast level of the images to do the adjustment. The dark stretching is known as part of partial contrast stretching, the dark stretching is a reverse process of bright stretching process .Bright stretching is a process that also used auto scaling method which is a common linear mapping function to enhance the brightness and contrast level of an image [4].

a. Linear Contrast Stretch

This is the simplest contrast stretch algorithm. The grey values in the original image and the modified image follow a linear relation in this algorithm. A density number in the low range of the original histogram is assigned to extremely black and a value at the high end is assigned to extremely white. The remaining pixel values are distributed linearly between these extremes. The features or details that were obscure on the original image will be clear in the contrast stretched image.

The linearly expands original digital values of the remotely sensed data into a new distribution. When expanding the original input values of the image, total range of sensitivity of the display device can be utilized. The linear contrast enhancement also makes subtle variations within the data more obvious [5]. All these types of enhancements are best applied to remotely sensed images with Gaussian or near-Gaussian histograms, the meaning and all the brightness values fall within a narrow range of the histogram and only one mode is apparent. The three methods of linear contrast enhancement are as [5]:

- **Min-Max Linear Contrast Stretch**

By using the minimum-maximum linear contrast stretch, original minimum and maximum values of the data are assigned to a newly specified set of values that utilize the full range of available brightness values.

- **Percentage Linear Contrast Stretch**

Percentage linear contrast stretch is similar to the minimum-maximum linear contrast stretch except this method uses specified minimum and maximum

values that lie in a certain percentage of pixels from the mean of the histogram
.

- **Piecewise Linear Contrast Stretch**

By the distribution of a histogram in an image is bi or remodel an analyst may stretch certain values of the histogram for increased enhancement in selected areas. That method of contrast enhancement is called a piecewise linear contrast stretch.

b. Non-Linear Contrast Enhancement

In these methods, the input and output data values follow a non-linear transformation. The general form of the non-linear contrast enhancement is defined by y = f (x), where x is the input data value and y is the output data value. The non-linear contrast enhancement techniques have been found to be useful for enhancing the colour contrast between the nearly classes and subclasses of a main class.

A type of non linear contrast stretch involves scaling the input data logarithmically. This enhancement has greatest impact on the brightness values found in the darker part of histogram. It could be reversed to enhance values in brighter part of histogram by scaling the input data using an inverse log function.

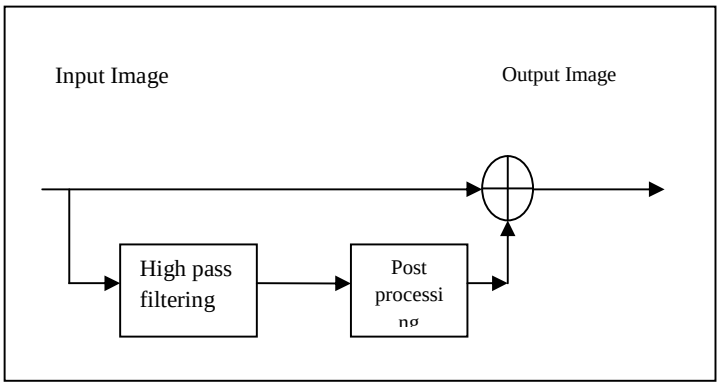

Figure 2: A typical scheme for image enhancement where Post-processing could be simple scaling (linear) or other complex non-linear operations. [6]

There are three methods of nonlinear contrast enhancement:

- **Histogram Equalizations**

When an image's histogram is equalized all pixel values of the image are redistributed so there are approximately an equal number of pixels to each of the user-specified output gray-scale classes (e.g., 32, 64, and 256).

- **Adaptive Histogram Equalization**

The adaptive histogram equalization where you can divide the image into several rectangular domains; compute an equalizing histogram and modify levels so that they match across boundaries.

- **Homomorphic Filter**

Homomorphic filter is the filter which controls both high frequency and low-frequency components. Homomorphic filtering aims at handling large of image intensity; it has a multiplicative model [5].

III. Resolution Based [7]

Resolution has been frequently referred as an important property of an image. Images are being processed in order to obtain super enhanced resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. Interpolation has been widely used in many image processing applications. Interpolation in image processing is a method to increase the number of pixels in a digital image. Image interpolation is widely used resolution enhancement method for various applications. Image interpolation is the process of using known data to estimate values at unknown locations. Interpolation method select new pixel from surrounding pixels.

Mainly there are two types of interpolation algorithms

1. Adaptive algorithms-these algorithms changes depending on what they are interpolating.
2. Non adaptive algorithms- include linear interpolation algorithms.

Traditionally there are three techniques for image interpolation namely Linear, Nearest Neighbor and Bicubic. Nearest Neighbor result in significant ―Jaggy edge distortion [8]. The Bilinear Interpolation result in smoother edges but somewhat

blurred appearance overall [8]. Bicubic Interpolation look's best with smooth edges and much less blurring than the bilinear result [8]. Linear interpolation includes nearest neighbour, bilinear, Bicubic interpolation. But images obtained by these linear interpolation technique produces many artifacts like blurring, blocking etc. To avoid these problems non linear interpolation algorithms are used for resolution enhancement. Computational problem is increase as interpolating factor is increases. Transform domain determine which transformations used in the enhancement. Transform theory plays a fundamental role in image processing, as working with the transform of an image instead of the image itself may give us more insight into the properties of the image. Two dimensional transforms are applied to image enhancement, restoration, encoding and description. Various types of transforms are used for the image enhancement [9].

In this image resolution enhancement method using swt and dwt is introduced. The main loss in image resolution enhancement by using interpolation is on its high frequency components (i.e., edges), which is due to the smoothing caused by interpolation. Edges plays very important role in image. To increase the quality of the super resolved image, it is essential to preserve all the edges in image. In [10] work, DWT has been employed in order to preserve the high frequency components of the image(i.e. edges). The redundancy and shift invariance of the DWT mean that DWT coefficients are inherently interpolable. In this correspondence, one level DWT (with Daubechies 9/7 as wavelet function) is used to decompose an input image into different subband images. Three high frequency subbands (LH, HL, and HH) contain the high frequency components of the input image(i.e. edges). In this technique, bicubic interpolation with enlargement factor of 2 is applied to high frequency subband images. Information loss occur due to down sampling in each of the DWT subbands caused in the respective subbands. That is why SWT (Stationary Wavelet Transform) is used to minimize this loss.

The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input – so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients. The interpolated high frequency subbands and the SWT high frequency subbands have the same size which means they can be added with each other. The new corrected high frequency subbands can be interpolated further for higher enlargement. Also it is known that in the wavelet domain, low pass filtering of the high resolution image produce the low resolution image. In other words, low frequency subband is the low resolution of the original image. The quality of the super resolved image increases using input image instead of low frequency subband. Figure illustrates the block diagram of the used image resolution enhancement technique.

By interpolating input image by 3, and high frequency subbands by 2 and in the intermediate and final interpolation stages respectively, and then by applying IDWT, as illustrated in Figure, the output image will contain sharper edges than the interpolated image obtained by interpolation of the input image directly. This is due to the fact that, the interpolation of isolated high frequency components in high frequency subbands and using the corrections obtained by adding high frequency subbands of SWT of the input image, will preserve more high frequency components after the interpolation than interpolating input image directly.

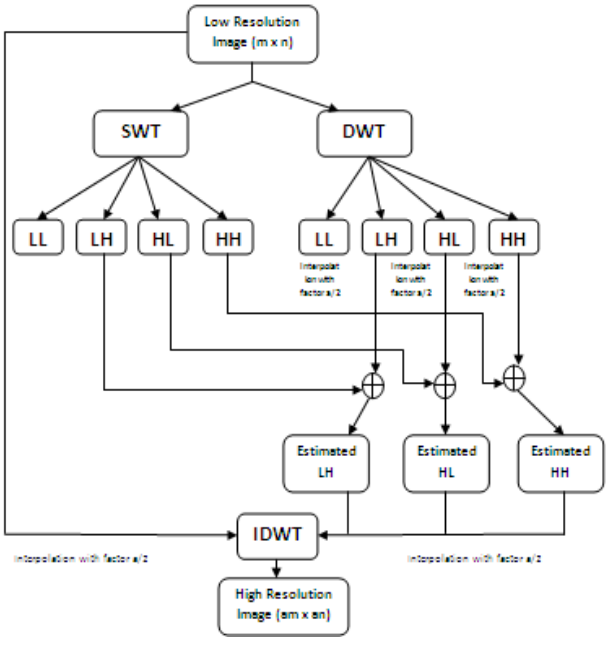

Figure 3: Block Diagram of Image Resolution Enhancement Method Using SWT and DWT

IV. Results

The implementation of proposed techniques is done by using the MATLAB. The proposed technique is analyzed on various images, few of them shown below.

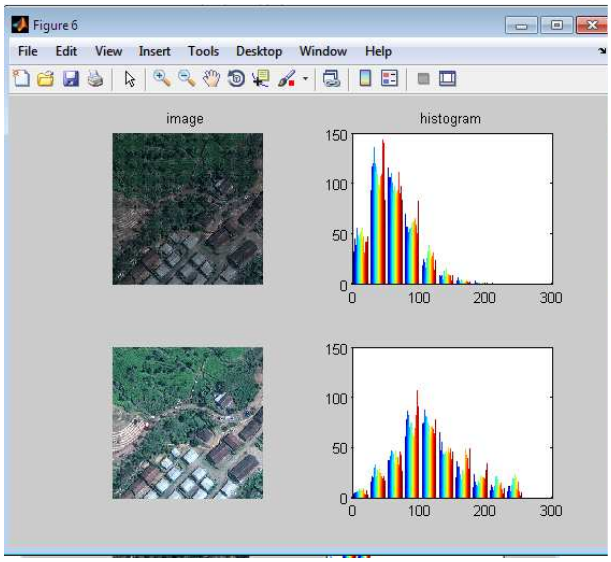

Figure 4: Resolution Enhancement of image 1 by existing

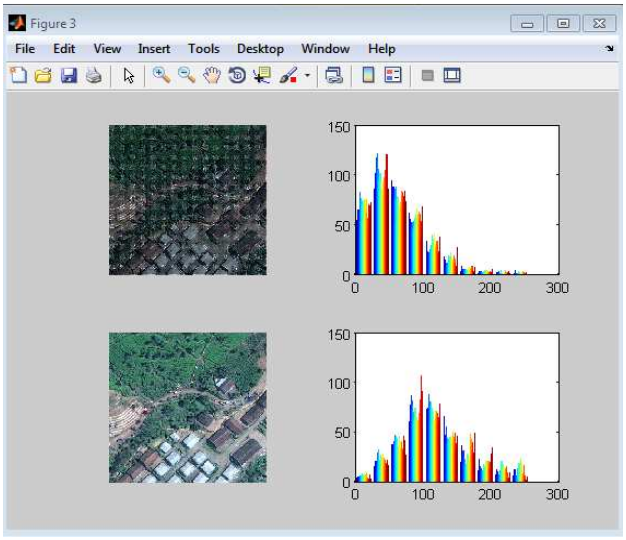

Figure 5: Resolution Enhancement of image 1 by Proposed

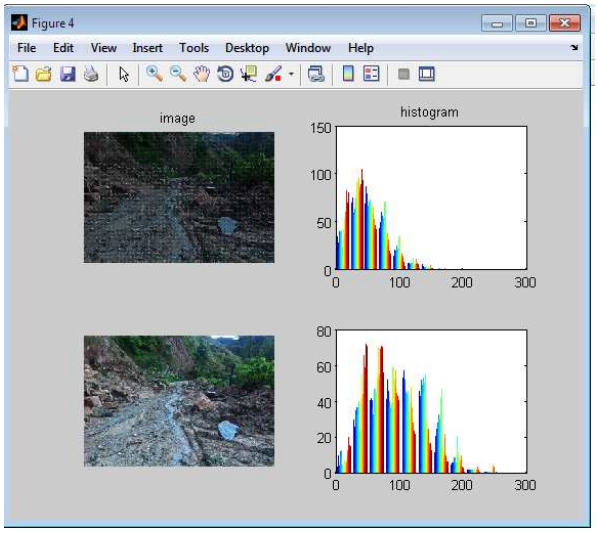

Figure 6: Resolution Enhancement of image 2 by Existing

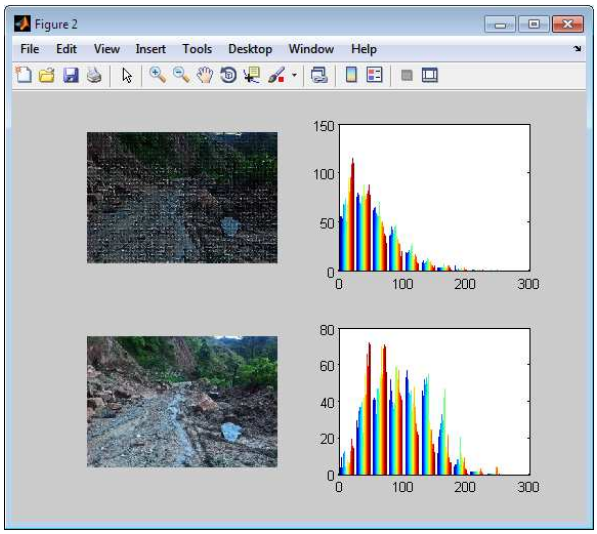

Figure 7: Resolution Enhancement of image 2 by Proposed

Table 1: PSNR values by using Proposed Algorithm

Image Name	Existing	Proposed
Image 1	11.99	15.44
Image 2	13.51	15.41
Image 3	13.51	15.41

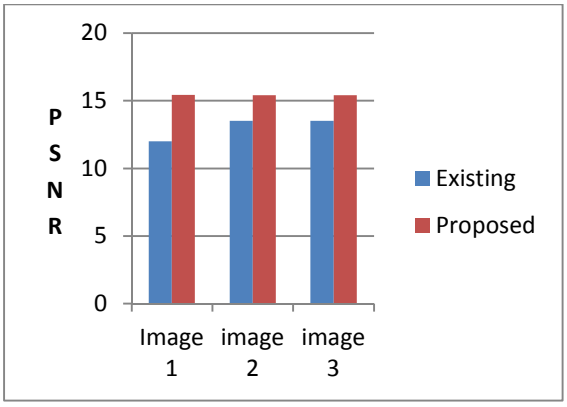

Figure 8: PSNR Comparison

The PSNR value of Existing is less than the proposed. The histogram also confirms the better results of proposed technique.

V. Conclusion

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. The point processing methods are most primitive, yet essential image processing operations and are used primarily for contrast enhancement. Image Negative is suited for enhancing white detail embedded in dark regions and has applications in medical imaging. Power-law transformations are useful for general purpose contrast manipulation. For a dark image, an expansion of gray levels is accomplished using a power-law transformation with a fractional exponent. Log Transformation is Useful for enhancing details in the darker regions of the image at the expense of detail in the brighter regions the higher-level values. For an image having a washed-out appearance, a compression of gray levels is obtained using a power-law transformation with γ greater than 1. Wavelet-based resolution enhancement methods improve the image resolution by estimating the high-frequency band information. Wavelet-based methods enhanced the image resolution by estimating the preserved high frequency information from the given images. They were based on the assumption that the image to be enhanced was the low frequency subband among wavelet-transformed subbands of the original one and the target is to estimate the high frequency subbands of wavelet transform, so that a resolution-enhanced image can be obtained. Because the analysis filter bank used in the wavelet transform has a poor frequency characteristic such as wide transition region, some information of high-frequency band is remained in the low frequency band. The resolution enhancement methods in wavelet domain are very significant not only for enlarging the image size but also for in-band scalable video coder. In this paper, algorithm for image enhancement is proposed. In existing DWT with non linear interpolation and in proposed DWT and SWT with non linear interpolation is applied. In proposed noise is somewhat compressed resulting increased PSNR. In future, The technique can be extended by using the SVD . The technique can be extended by using neuro-fuzzy agents. The technique can be extended to get secure against attacks.

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