Remote Sensing Image Contrast Enhancement using Dominant Brightness Analysis

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Abstract- **This project proposes the contrast enhancement approach for Remote sensing images using dominant brightness level analysis and adaptive intensity transformation. This method using the low-frequency luminance component for computing brightness-adaptive intensity transfer functions in the wavelet domain. It transforms intensity values according to the transfer function. In this process, the discrete wavelet transform (DWT) performs on the input images. It decomposes the Input Image into four sub bands. Then the LL sub- band into low-, middle-, and high-intensity layers using the log-average luminance. This is known as dominant brightness level analysis. Adaptive intensity transfer function was performed on three layers by using knee transfer function and gamma adjustment function based on the dominant brightness level of the each layer. Then we perform image fusion and inverse discrete wavelet transform for getting the reconstructed enhanced image. In the literature, various histogram equalization approaches have been proposed. But they were degrade the overall image quality by distorting the image details and produce artifacts at some regions. But adaptive intensity transfer function overcomes these problems and produce good results. Finally the results show that the proposed method enhances the overall image contrast and local details visibility also better than the techniques used in previous. This technique can effectively enhance the contrast of low quality remote sensing images also suitable for images acquired by a satellite camera and for other various imaging devices such as photo realistic 3-d reconstruction systems and computational cameras.**

Key Words---- Adaptive intensity transfer function, contrast enhancement, discrete wavelet transform, dominant brightness level analysis, remote sensing images

I. INTRODUCTION

Remote sensing images have played an important role in today. For this purpose high quality remote sensing images are created using contrast enhancement techniques. These methods are also required for better visual perception and color reproduction. Histogram equalization (HE) [1] is the most popular approach for remotely sensed image contrast enhancement. This method used in various areas like object tracking, speech recognition and medical applications also. This histogram equalization based methods cannot maintain the average brightness level.So the artifacts will be produced. These artifacts are under or over saturation. For overcoming these drawbacks, bi-histogram equalization (BHE) [2] and dualistic sub image Histogram equalization [3] methods have been proposed by using decomposition of two sub histograms. For further improvement, another improved bi histogram equalization method was used.This method is known as recursive mean-separate Histogram equalization (RMSHE) [4].This method performs the Bi histogram equalization and produces separately equalized sub histograms. But the optimal contrast enhancement cannot be achieved by this operation.Recently, the gain-controllable clipped histogram equalization (GC-CHE) is the proposed method invented by Kim and Paik [5].This also controls the gain of the reconstructed image.Demirel is the proposed modified histogram equalization for contrast enhancement.This is based on the singular-value decomposition. Here the singular value decomposition matrix was applied to the low level sub band.Although improved contrast of the image, this method distorting the image details at low- and high-intensity regions.

In remote sensing images, existing contrast enhancement methods caused over or under saturation. These artifacts must be minimized because pieces of important information are widespread throughout the image in the sense of both spatial locations and intensity levels. For this reason, enhancement techniques for satellite images known as remote sensing images not only improve the contrast but also reduces the pixel distortion in the low and high intensity regions.

To achieve this goal, the recent contrast enhancement technique for remote sensing images using dominant brightness level analysis and adaptive intensity transformation was preferred.This algorithm does not produces the artifacts. This also preserves the color and produces high quality images.Adaptive transformation overcomes the drawbacks present in the existing methods.This is adaptable to all kind of remotely sensed images.So,it was preferred than the existing techniques.

II. PROPOSED METHOD

This proposed contrast enhancement algorithm first performs the discrete wavelet transform on the input image into a set of band-limited components, known as HH, HL, LH, and LL sub bands. Because the LL sub band has the entire information about the original image, the log-average luminance is computed in the LL sub band for computing the dominant brightness level analysis. The LL sub band is decomposed into low, middle, and high intensity layers based on their dominant brightness level by using log average luminance formula for analyzing the dominant brightness. The adaptive intensity transformation is computed in the low middle and high intensity layers using the dominant brightness level. Adaptive intensity transformation has two main functions such as knee transfer function, and the gamma adjustment function.By using these functions adaptive intensity transfer function is applied. The reconstructed enhanced image is obtained by the inverse discrete wavelet transform and image fusion operations.

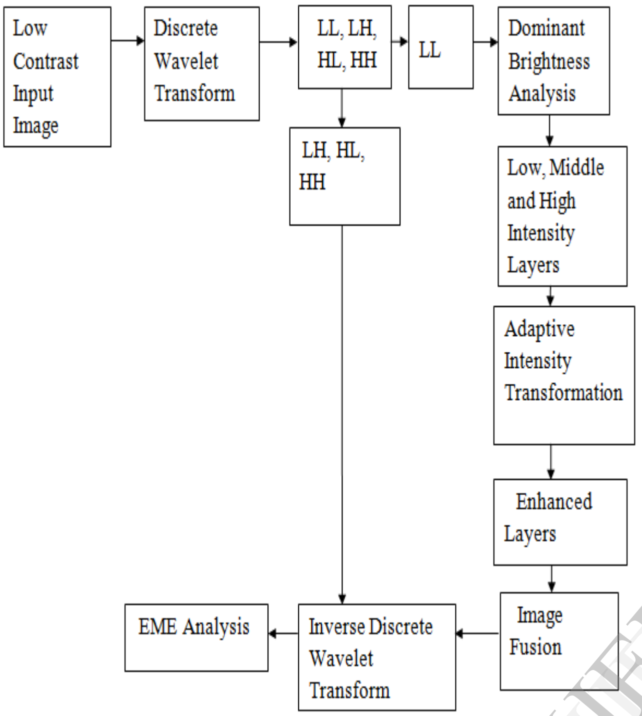


Fig. 1. Block diagram of the proposed contrast enhancement algorithm.

In this case, the image was applied to enhancement algorithm after decomposition operation.Finally the inverse wavelet transform produces the reconstructed image with improved contrast.

A. Input image

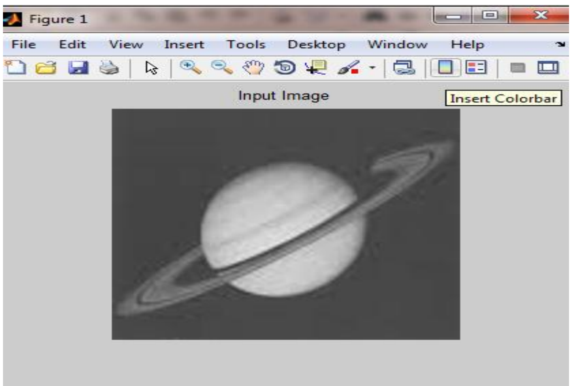


Fig. 2.Low contrast Input image

Fig.2 represents the low contrast satellite image.This image was obtained in the form of photograph or video frame.It's image details are not in clear.If we increase the contrast by using the enhancement transformations, the output image having more data compared to the input image.

III. IMAGE DECOMPOSITION

Image decomposition is the process that performs several tasks, with the end result being that a strongly blended image is separated into components both in the sense that it determines the parameters for each component, such as a Gaussian model and that it physically assigns each pixel in the image to an individual object. The products of these two operations are called the component list and the component map, respectively. The fitting process which determines the component list and the pixel decomposition process which determines the component map are designed to work cooperatively to increase the efficiency and accuracy of both. The algorithm behind the decomposition uses a contouring procedure whereby a closed contour designates a separate component. The program first separates the image into clearly distinct regions of blended emission, then contours each region to determine the areas constituting each component and passes this information on to the fitter, which determines the component list.

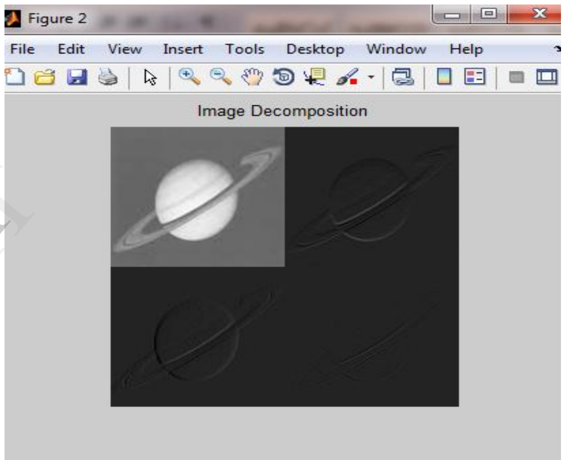


Fig.3. Decomposed image by discrete wavelet transform

It shows the image was decomposed into four sub bands. Here the low frequency sub band has the brightness property. Other bands maintain the edge details. In this figure, the first part known as low frequency band contains all the components of an image. This decomposed low band was used for the enhancement algorithm.The algorithm enhances the low frequency components.This transforms the image into wavelet domain.Low frequency components preserves the entire image brightness.

IV. ANALYSIS OF BRIGHTNESS LEVELS

Existing methods cannot prevent the edge details. So, the purpose of improve the demand for remote sensing images, the proposed method was used. This method contains two techniques, such as dominant brightness level analysis and adaptive intensity transformation. In the previous methods, image details were lost at low middle and high intensity regions. For overcoming these drawbacks, we divide the low frequency sub band into three layers for reducing the process complexity.We can only use the low-frequency luminance components, for estimate the dominant brightness level using the log-average luminance.Because these components contain the complete information of an image.

A. Log Average Luminance method

Because bright areas having high intensity values and the darker regions having low intensity values.The dominant brightness at the position (x, y) is computed as,

$$D(x,y) = \exp\left(\frac{1}{N_l}\sum(x,y) \in S\{\log L(x,y) + \varepsilon\}\right) \quad (1)$$

Where, S represents a rectangular region encompassing (x, y), $L(x, y)$ represents the pixel intensity at (x, y),N_l represents the total number of pixels in the rectangular region S, and ε *is* the small constant.This constant also used for avoiding overflow or saturations.

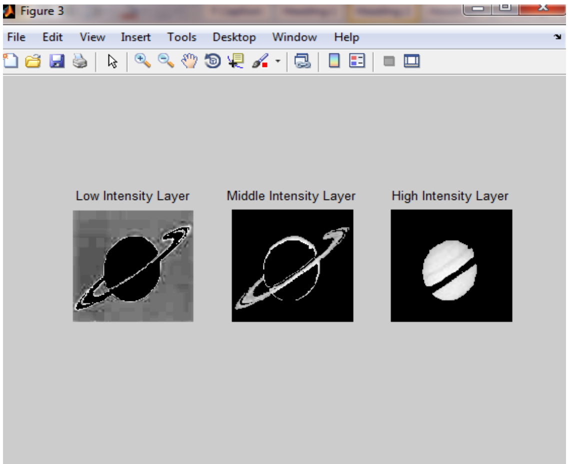


Fig.4.Low, middle, and high intensity layers using Dominant Brightness analysis

This shows the result of dominant brightness level analysis by using the log average luminance formula.

V. ADAPTIVE INTENSITY TRANSFORMATION

Based on the dominant brightness in each decomposed layer, the adaptive intensity transfer function is generated. Because of the remote sensing images have spatially varying intensity distributions, we estimate the better transfer function in each brightness range known as adaptive contrast enhancement.The knee transfer and the gamma adjustment functions are the two main functions of adaptive intensity transformation.

A. Knee Transfer Function

For the global contrast enhancement, the knee transfer function enhances the low-intensity range by determining knee points according to the dominant brightness of each layer as,

shown in Fig4.In the low intensity layer, a single knee point is computed by the formula,

$$P_l = b_l + w_l(b_l - m_l) \quad (2)$$

Where, b_l denotes the low bound, w_l represents the tuning parameter in the low intensity layer, and m_l *is* the mean of brightness in the low-intensity layer.For the high intensity layer, the corresponding knee point is computed as,

$$P_h = b_h - w_h(b_h - m_h) \quad (3)$$

Where, b_h represents the high bound, w_h *is* the high intensity layer tuning parameter, and m_h represents the mean brightness in the high-intensity layer.

In the middle-intensity layer, two knee points are computed. These two knee points are calculated as,

$$p_{ml} = b_l - w_m(b_{ml} - m_m) + (P_l - P_h) \quad (4)$$

$$P_{mh} = b_l + w_m(b_{mh} - m_m) + (P_l - P_h) \quad (5)$$

Where, w_m and m_m represents the mean brightness in the middle intensity layer mean brightness and the tuning or adjusting parameter.

The global image contrast is determined by the tuning parameter w_i for $i \in \{l, m, h\}$.b_l and b_h represent the low and high bounds respectively.Although the contrast is more enhanced as the w_i increases, the resulting image is saturated and contains intensity discontinuity.Here w_i represents the common tuning parameter which encompassing w_l, w_m, and w_h.In this case, we can adjust only the middle intensity tuning parameter w_m for reducing such artifacts.Since the knee transfer function leads to distort image details in the low and high intensity layers, additional compensation technique is performed using the gamma adjustment function.The modified gamma adjustment function is obtained from the original gamma adjustment function.

B. Gamma Adjustment Function

This was obtained from the scaling and translation operation which is incorporate into the knee transfer function as,

$$G_k(L) = \left\{\left(\frac{L}{M_k}\right)^{\frac{1}{\gamma}} - \left(1 - \frac{L}{M_k}\right)^{\frac{1}{\gamma}} + 1\right\} \quad (6)$$

Where, M represents the size of each section of an image, such as $M_l = b_l$, $Mm = b_h - b_l$, and $M_h = 1 - b_h$, L represents the intensity value at low, middle, and high intensity regions.The pre specified constant value is denoted by, γ. This γ can be used to adjust the local details of an image for improve the contrast.If γ increases, the resulting image is saturated at some regions in the range $b_l/2$, $b_h - b_l/2$, and $1 - b_h/2$. Therefore, the γ value is selected by computing maximum values of adaptive transfer function in ranges $\{0 \le L < (b_l/2)\}$, $\{b_l \le L < (b_h - b_l/2)\}$, and $\{b_h \le L < (1 - b_h/2)\}$, which are smaller than $b_l/2$, $b_h - b_l/2$, and $1 - b_h/2$, respectively.The proposed method of adaptive transfer function is obtained by combining the knee transfer function and the modified gamma adjustment function.Three intensity transformed layers are obtained by the adaptive intensity transfer function.These layers are fused to make the resulting contrast enhanced image in the wavelet domain.We extract two most significant bits from the low, middle, and high intensity layers for generating the weighting maps, and we compute the sum of the two bit values in each layer.We select only two weighting maps that have two largest sums of the two most significant bits.In this operation for removing the unnatural borders of fusion, gaussian boundary smoothing filter was used with the weighting maps.The fused image F is estimated as,

$$F = W_1 * C_l + (1 - W_1) * \{W_2 * C_m + (1 - W_2) * C_h\} \quad (7)$$

Where, W_1 represents the largest weighting map, W_2 represents the second largest weighting map, C_l represents the contrast enhanced brightness in the low intensity layer, C_m

represents the contrast enhanced brightness in the middle intensity layer, and C_h represents the contrast enhanced brightness in the high intensity layer.Since (7) represents the point operation, the pixel coordinate (x, y) is omitted.The fused LL sub band undergoes the IDWT together with the unprocessed HL, LH, and HH sub bands to reconstruct the finally enhanced image. Here the smoothing filters are used with the weighting maps.Finally the reconstructed contrast enhanced image was obtained.This enhanced image will be equal to the original image visually. But the reconstructed image has more details compared to the original image.

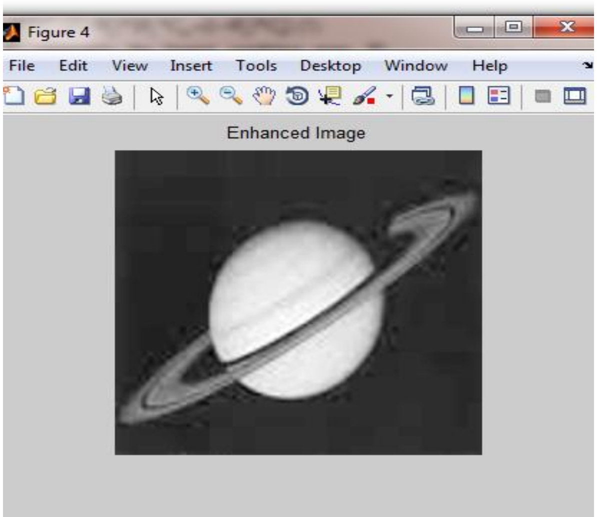


Fig. 5.Contrast enhanced image by using adaptive intensity Transformation

Amount of enhancement from the original image = 0.0275

Fig.5 represents the output image which has the improved contrast and brightness.The amount of contrast improvement from the original image was measured.

C. Enhancement measurement

For performance evaluation, we used the measure of enhancement (EME) , which is computed by *EME*,

$$EME = \frac{1}{k_1 k_2} \sum_{l=1} \sum_{k=1} \frac{1}{[I_{\max} / I_{\min} + C) \ln(I_{\max} / I_{\min} + C)]} \quad (8)$$

Where, k_1, k_2 represents the total number of blocks in an image, $I_{\max(k,\ l)}$ represents the maximum value of the block, $I_{\min(k,\ l)}$ represents the minimum value of the block, and C represents a small constant to avoid dividing by zero. Here we used 8 × 8 blocks and C = 0.0001.

This method provides better amount of enhancement compared to other enhancement methods and it will not distorts the image details at low and high intensity regions.This will adopt to all remote sensing images at various situation.It will not change the mean brightness of the original image.So the essential features of an original image will not be affected.

TABLE.1.EME VALUES OF DIFFERENT ENHANCEMENT TECHNIQUES

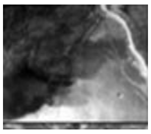
	Enhancement amount		
Remote sensing Images	Histogram equalization	RMS-histogram equalization	Proposed method
	0.020	0.010	0.786
	1.023	0.944	2.126
	0.689	0.680	0.703

Table.1 shows the different enhancement methods and their contrast improvement amount for three satellite images. Here the proposed method has the dominant value compared to the other methods.

D. Parameters Analysis

The Peak signal to noise ratio was measured by using the formula,

PSNR = 10*log10(255*255/MSE) (9)

Mean Square Error was obtained by,

$$\text{MSE} = sum(sum(X - dec).^{\wedge}2))/(M * N) \quad (10)$$

Here, X and dec Represent the intensity Values of the input image and the output image respectively.M and N denotes the row and the column values of the corresponding image.

The entropy H of an image is defined as,

$$H = -\sum_{k=0}^{M-1} p_k \log_2(p_k) \quad (11)$$

where M is the number of gray levels and p_k is the probability associated with gray level k. Maximum entropy is achieved in the case of a uniform probability distribution. If $M=2^n$, then p_k is constant and given by,

$$p_k = 1/M = 2^{-n}$$

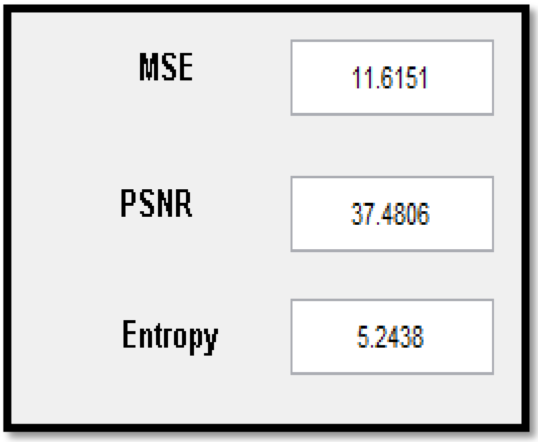


Fig.6.Analyzed Parameters for the Contrast Enhanced Image.

The image quality is characterized by some parameters such as, PSNR, MSE, and Entropy.These will determine the noise performance and the efficiency of the output or enhanced image.

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