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Performance Analysis of Multispectral Color Composite Image Enhancement Technique using Decorrelation Stretching and Histogram Equalization Methods

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Abstract— Multispectral images are taken from remote sensing sensors which are used in wide variety of application including earth observation, distortion management and so on. An interpretation of those images for different type of applications needs to enhance for more accurate processing. In this study, we have taken the multispectral image of LANDSAT dataset which has seven bands. The color composite image is derived through combining different bands of this dataset and it is act as single color composite multispectral image. The enhancement of this multispectral color composite images is done through decorrelation stretching and the performance of this method is explained and compared with other methods such as various histogram based methods.

Keywords*:* Multispectral Image, LANDSAT, Image Enhancement, Histogram Equalization, Contrast Enhancement.

I. INTRODUCTION

The earth observation satellites capture the earth from the multiple sensors which placed in various satellites. These sensors are used to capture the same place of earth with different wavelength which produce the different bands. The remote sensing images are classified as multispectral, hyperspectral and panchromatic images. Among these, the multispectral images are widely used and the analysis of those images is done through converting color composite of multispectral images. The three bands from the multispectral image is mapped to the Red, Green and Blue planes to derive the color composite images [1]. This type of color composite images is the optimal way to interpret the multispectral images. Particularly, these composite images are used to identify surface features.

The main problem of remote sensing images is that the range of reflectance values collected by a sensor may not match the capabilities of the color display devices. Contrast is defined as the range of brightness values occurred in an image. Contrast enhancement techniques are very useful for good visual perception and color reproduction. The low contrast images are need to be enhanced for effective information retravel that can be used in variety of applications [2]. The aim of enhancement in satellite images is to view the hidden information which is not clearly visible [3]. The high concentration of contrast is lied only on specific range, which initiated the problem of low quality images. By enhancing these images with the color composite image of multiband or multispectral images, further analyzing and interpretation is simplified. In this paper, we have taken the LANDSAT image with seven bands and the color composite image is acquired from reading the 3,2 and 1 bands. We apply the decorrelation stretch on those images and the performance of this method is compared with other enhancing methods such as linear contrast stretching, General Histogram Equalization (GHE) and Adaptive Histogram Equalization named Contrast limited Adaptive Histogram Equalization (CLAHE).

Rest of the paper is organized as follows, Section I contain the introduction about our paper, Section II contains necessary background details needed for pursuing about report including multispectral images, image enhancement, contrast enhancement. Section III explained about various multispectral image enhancement methods. In Section IV, the results of those methods are discussed with explanations and we concluded our paper in Section V.

II. BACKGROUND

A. *Multispectral Images:*

There are number of remote sensing satellites are available for different kind of applications. Each satellite has its own sensor for capturing image. Each of the sensor is characterized by the wavelength bands and it has following resolution characteristics such as Spectral resolution, Radiometric resolution, Spatial resolution and Temporal resolution. The wavelength intervals can be defined by the spectral resolution. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band. Radiometric resolution describes the discrimination of very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitivity to detecting small differences in reflected or emitted energy. The representation of each pixel can be described by the spatial resolution. It is one of the important characteristics of the sensor. Particular area can be repeatedly acquired for particular time interval is known as temporal resolution.

For our study, we have taken the LANDSAT multispectral images. Especially, the LANDSAT 7 is taken. Landsat 7 carries the Enhanced Thematic Mapper Plus (ETM+), with 30-meter visible, near-IR, and SWIR bands; a 60-meter thermal band; and a 15-meter panchromatic band. Delivered Landsat 7 ETM+ thermal data are resampled to 30 meters. Landsat 7 still acquires radiometrically and geometrically accurate data around the world.

1) Spectral band combination:

The combination of Band 1, 4 & 7 or band 1,2, and 3 produce water surface. The urban area can be viewed by the combination of band 1, 4, and 7. Farmland area can be viewed by the band combination of 1, 2, and 3. The combination of band 1, 4 and 7 display forest area. The salt scaled area can be viewed by the combination of band 1, 2, and 3. Combination of Band 1, 4, and 7 shows remnant vegetation area. The irrigated vegetation area can be viewed by the combination of band 1, 4, and 7.

B. Image Enhancement:

Image enhancement is the foremost process in the field of Digital Image Processing (DIP) [4]. It is very useful in increasing the clarity, sharpness and extraction of features in an image. The main aim of image enhancement is to manipulate the actual image where the processed image should well suited for any specific kind of applications. The image enhancement methods are classified into spatial and frequency domain methods [5]. The techniques which has direct manipulation of the pixels are known as spatial domain techniques. Spatial domain processes are defined by the following expression.

$$g(x, y) = T[f(x, y)] \qquad (1)$$

where, $g(x, y)$ is input image, $f(x, y)$ is the processed image and the T is transformation function.
The frequency domain method includes several transformation based methods such as Fourier Transform, Discrete Cosine Transform (DCT), KLT, Discrete Wavelet Transform (DWT).

C. Contrast Enhancement

Contrast enhancement is necessary for various image processing fields including satellite images and medical images [6]. to Contrast is defined as the range of brightness values occurred in an image. Contrast enhancement techniques are very useful for good visual perception and color reproduction. Contrast ratio of an image is calculated by the following expression.

$$Contrast\ Ratio = \frac{Maximum\ Brightness\ Value}{Minimum\ Brightness\ Value} \qquad (2)$$

Contrast Enhancement is very much appreciable when the subjective quality is more important for the interpretation of an image. The satellite images especially multispectral images mainly affected by the contrast related problem due to the luminance factor. Therefore, the contrast enhancement on multispectral images plays a vital role and so it is useful for efficient information retrieval on such images.

III. MULTISPECTRAL IMAGE ENHANCEMENT METHODS

A. Histogram Equalization

Histogram Equalization is a non-linear contrast enhancement technique. It is well known contrast enhancement method that compiled with the sample distribution of the images [7]. In Histogram Equalization method, the Probability Density Function (PDF) is calculated for a given image using the following expression.

$$p(x_k) = \frac{n^k}{n} \qquad (3)$$

for k= 0,1, …...L-1. where L is maximum intensity value. x_k is known as the histogram of x.
Based on the Probability Density Function, the cumulative density function (CDF) is defined using the following expression.

$$c(x) = \sum_{j=0}^{k} p(x_j) \qquad (4)$$

Then, the transformation function is defined using computed CDF and applied on the image to get the histogram equalized image. The transformation function is.

$$f(X) = x_0 + (x_{L-1} - x_0)\, c(x) \qquad (5)$$

B. Contrast limited Adaptive Histogram Equalization (CLAHE):

Contrast limited Adaptive Histogram Equalization (CLAHE) is a variant of Adaptive Histogram Equalization. It is a well-known method for reducing the noise amplification [8]. It is a best method to enhance the shape of the image [9]. The steps involved in CLAHE are,

Step 1: The grid size is calculated based on maximum dimension
Step 2: The grid points are identified throughout the given image
Step 3: histogram for each point is calculated against the neighbouring regions.
Step 4: the histogram is clipped for the given clip level and this is used to calculate CDF.
Step 5: Based on the CDF the transformation function is applied on each grid points with neighbouring pixels.

C. Contrast Stretching

Contrast Stretching is a linear method to enhance the image [10]. The steps involved in Contrast Stretching are as follows.

Step 1: Identify the upper and lower limit of intensity of an image
Step 2: The limits of the actual image is also identified using the histogram
Step 3: Each pixel value r is then mapped to the output intensity value s using the following function

$$s = (r-c)\left(\frac{b-a}{d-c}\right) + a \qquad (6)$$

where,
a, b is lower and upper limit of intensity values
c, d is lower and upper limit of an actual image
r is the actual intensity value of a pixel
s is the output intensity value of a pixel

D. Decorrelation Stretching

Decorrelation Stretching was introduced by Soha and Schwartz [11]. Decorrelation Stretching exaggerate the less correlated portions of an image selectively. It enhances the color separation and the exaggerated colors are very useful in human visual interpretation and the feature discrimination. Moreover, it worked based on the Principle Component Transform [12]. The steps involved in Decorrelation Stretching is given below.

Step 1: Determine the covariance matrix and calculate eigen vectors
Step 2: Transform the image from radiance space to Principal Component (PC) space.
Step 3: The PC images are separately contrast stretched
Step 4: The inverse transform is applied to the stretched data
Step 5: Stretched PC images themselves mapped Red, Green and Blue for the display

IV. RESULTS & DISCUSSION

The input LANDSAT datasets used in our study is taken from the United States Geographical Surveys (USGS) [13]. The four 8-bit LANDSAT datasets are tested with the above discussed methods. Aforementioned, the color composite images are derived from the datasets and for the quantitative evaluation purpose, the Mean and Standard Deviation are calculated for all the methods such as Global Histogram Equalization, CLAHE, Contrast Stretching and Decorrelation Stretching. These results are further compared against the original values. The resultant enhanced multispectral images are depicted in the Figure. 1. In Figure 1., the first column contains the original color composite multispectral image and further columns contains the resultant images after applying the Histogram Equalization, CLAHE, Contrast Stretching and Decorrelation Stretching respectively. The Figure 2. Shows the corresponding histogram of the above mentioned images.

Column 1 in Figure 2. Contains the histogram of the original image and other columns contains the histogram after applying Histogram Equalization, CLAHE, Contrast Stretching and Decorrelation Stretching respectively. By observing the resultant image and the corresponding histograms on Figure 1 and Figure 2, Decorrelation Stretching enhance the color separations in the image efficiently and discrimination of details is also very perceptible to the human visual system.

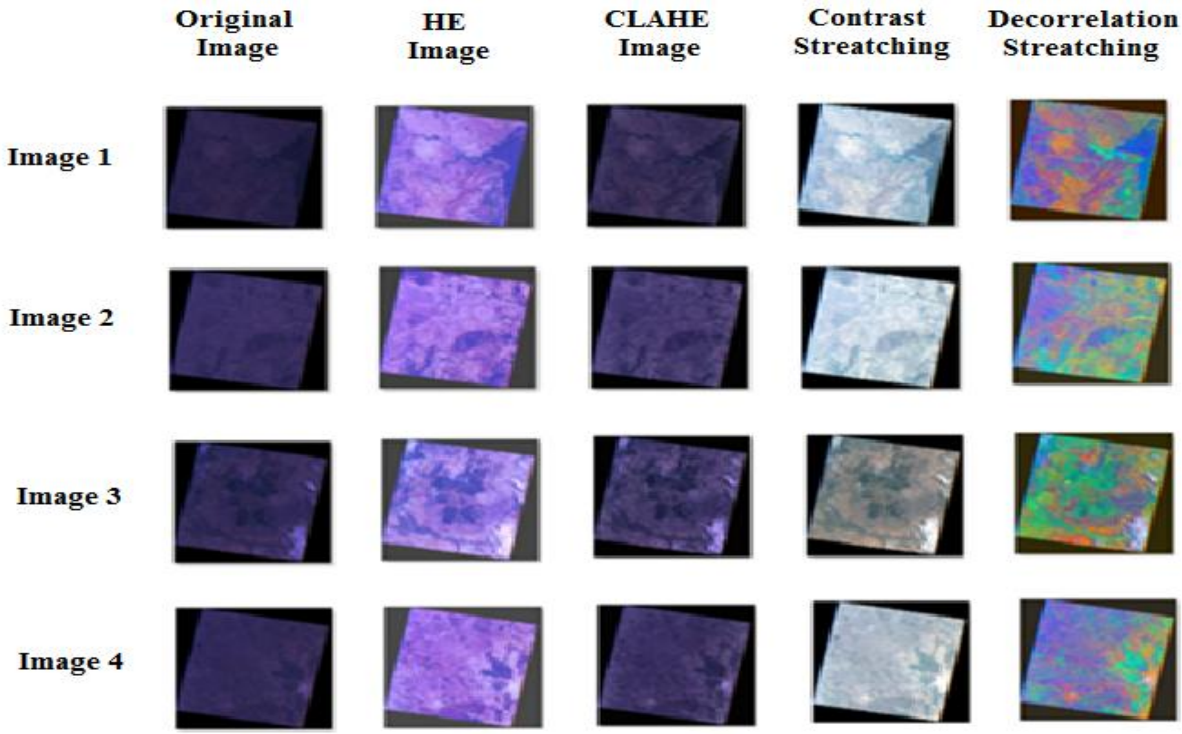

Figure 1. Resultant images

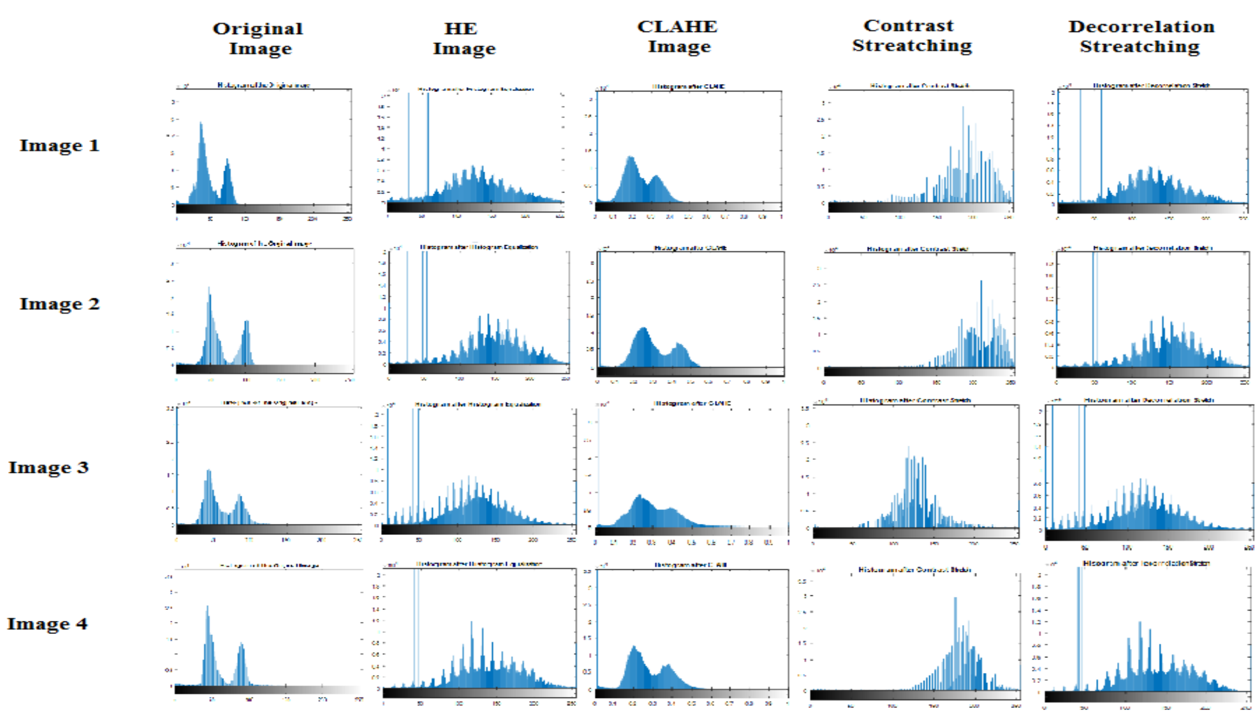

Figure 2. Histogram for resultant image shown in Figure.1

V. CONCLUSIONS

Remote sensing images has its wide spectrum of its applications. In this paper, we reported about the concept of contrast enhancement and various kind of approaches to perform such enhancement on the multispectral images. The LANDSAT image was taken and the popular contrast enhancement methods such as Histogram Equalization, CLAHE, Contrast Stretching and Decorrelation Stretching are executed and their performance are evaluated. With our performance analysis, we can conclude that decorrelation stretching gives better performance over the other methods. It exhaustively leads to enhance the surface details through enhancing the color separation.

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