Contrast Enhancement –Linear & Nonlinear Stretching

Contrast

One of the most important quality factors in satellite images comes from its contrast. Contrast enhancement is frequently referred to as one of the most important issues in image processing. Contrast is created by the difference in luminance reflected from two adjacent surfaces. In visual perception, contrast is determined by the difference in the color and brightness of an object with other objects. Our visual system is more sensitive to contrast than absolute luminance; therefore, we can perceive the world similarly regardless of the considerable changes in illumination conditions. If the contrast of an image is highly concentrated on a specific range, the information may be lost in those areas which are excessively and uniformly concentrated. The problem is to optimize the contrast of an image in order to represent all. Sometimes during image acquisition low contrast may be result due to one of the following reasons: poor illumination, lack of dynamic range in the image sensor and wrong setting of the lens aperture. The idea behind contrast stretching is to increase the dynamic range of gray levels in the image being processed. Linear and nonlinear digital techniques are two widely practiced methods of increasing the contrast of an image.

Linear contrast enhancement

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

1 Min-Max Linear Contrast Stretch

When using the minimum-maximum linear contrast stretch, the 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. Consider an image with a minimum brightness value of 45 and a maximum value of 205. When such an image is viewed without enhancements, the values of 0 to 44 and 206 to 255 are not displayed. Important spectral differences can be deselected by stretching the minimum value of 45 to 0 and the maximum value of 120.this method is applying with respect to image application type. g(x, y)=(f(x,y)-min)/(max-min))*No. of the intensity level (1) where, g(x,y) represents the images, on the left side it represents the output image, while f(x,y) it represents input image. In this equation the "min" and "max" are the minimum intensity value and the minimum intensity value in the current image. Here "no. of intensity levels" shows the total number of intensity values that can be assigned to a pixel. For example, normally in the gray-level images, the lowest possible intensity is 0, and the highest intensity value is 255. Thus "no. of intensity levels" is equal to 255.

2 Percentage Linear Contrast Stretch

The 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. A standard deviation from the mean is often used to push the tails of the histogram beyond the original minimum and maximum values.

3 Piecewise Linear Contrast Stretch

When 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. This method of contrast enhancement is called a piecewise linear contrast stretch. A piecewise linear contrast enhancement involves the identification of a number of linear enhancement steps that expands the brightness ranges in the modes of the histogram. This type can be expressed by:

$$f(x, y) = \begin{cases} ax, & 0 \le x \le x_1 \\ b(x-x_1) + y_{x1}, & x_1 \le x \le x_2 \\ c(x-x + y_{x1}, & x_2 \le x \le B \end{cases}$$

Where: f(x, y) is the Piecewise Linear Contrast Stretch in the image, a, b, and c are appropriate constants, which are the slopes in the respective regions and B is the maximum intensity value. 2.1 Nonlinear Contrast Enhancement Nonlinear contrast enhancement often involves histogram equalizations through the use of an algorithm. The nonlinear contrast stretch method has one major disadvantage. Each value in the input image can have several values in the output image, so that objects in the original scene lose their correct relative brightness value. There are three methods of nonlinear contrast enhancement:

1 Histogram Equalizations

Histogram equalization is one of the most useful forms of nonlinear contrast enhancement. 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).Contrast is increased at the most populated range of brightness values of the histogram (or "peaks"). It automatically reduces the contrast in very light or dark parts of the image associated with the tails of a normally distributed histogram . Histogram equalization can also separate pixels into distinct groups, if there are few output values over a wide range. histogram equalization is effective only when the original image has poor contrast to start with, otherwise histogram equalization may degrade the image quality. to this case the adaptive histogram equalization is improve this case.

2 Adaptive Histogram Equalization

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. Depending on the nature of the nonuniformity of the image. Adaptive histogram equalization uses the histogram equalization mapping function supported over a certain size of a local window to determine each enhanced density value. It acts as a local operation. Therefore regions occupying different gray scale ranges can be enhanced simultaneously.

The image may still lack in contrast locally. We therefore need to apply histogram modification to each pixel based on the histogram of pixels that are neighbors to a given pixel. This will probably result in maximum contrast enhancement. According to this method, we partition the given image into blocks of suitable size and equalize the histogram of each sub block. In order to eliminate artificial boundaries created by the process, the intensities are interpolated across the block regions using bicubic interpolating functions.

3 Homomorphic Filter

Homomorphic filter is the filter which controls both highfrequency and low-frequency components. homomorphic filtering aims at handling large of image intensity, it has a multiplicative model .When images are acquired by optical means, the image of the object is a product of the illuminating light source and the reflectance of the object, as described by:

$$f(x, y) = I(x,y)\rho(x,y) \qquad ...(3)$$

Where I is the intensity of the illuminating light source, f is the image, and $0 \le \rho \le 1$ is the reflectance of the object. In order to enhance an image with poor contrast, we can use the model and selectively filter out the light source while boosting the reflectance component. The result will be an enhancement of the image. In order to separate the two components, they must be additive.

We therefore transform the image into the log domain, whereby the multiplicative components become additive, as

$\ln(f) = \ln(I) + \ln(\rho)$ ...(4)

Since the natural logarithm is monotonic, $\ln(I)$is low pass and $\ln(\rho)$ is high pass. Now we have an image $f = \ln(f)$, which has additive components and can therefore be selectively filtered by a linear filter.

In order to enhance an image, the homomorphic filter must have a higher response in the high-frequency region than in the low-frequency region so that the details, which fall in the high frequency region, can be accentuated while lowering the illumination component.

4 Unsharpe Mask

The unsharp mask method is the technique to increase the sharpness in the image contrast.unsharp masking can be expressed by:

$y(m,n) = f(m,n) + a*g(m,n)$ ...(5)

Where: f is the input image,y is the sharpened image and g is the gradient image. a is the contrast constant greater than zero.