TEXTURAL ANALYSIS FOR REMOTELY SENSED IMAGERY

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ABSTRACT

According to defined the texture as the measurement of image gradient of gray, two parameters can be obtained to describe remote sensing image quantitatively. Which are the texture intensity and the texture density.The texture intensity is used to show the differences of one pixel with its neighbours, while the texture density is used to show the frequency of changes of gray level.

In addition the relative gradient are defined to describe the texture characteristic of image from the relative changes of gray level. The producted texture images from this method include both the information of space and part of information of spectrum. So the texture structures in the some over bright and dark areas can be shown obviously.

In this paper, we also discuss how to select the size of the moving windows.

INTRODUCTION

The texture extraction techniques is important for the image analysis. So far, there are various approaches to texture extraction. Rosenfeld.A(1975), Haralick. R. N(1979) have thoroughly discussed and generalized these approaches to different types of imagery which included aircraft or satellite multispectral scanner images and microscopic images of cell culture or tissue samples, etc.

This paper concentrates on the approaches to texture analysis of remotely sensed imagery. Giving the texture of remotely sensed imagery a specific definition, it introduces the concepts of texture intensity and texture density, and their corresponding extraction techniques. From the differences and gradient of gray level between neighboring pixels, the generated images of texture intensity and texture density reflect properties of the original image's texture. The paper also introduces the relative gradient approach, which uses the variation of gray level between pixels to signify the structure of tiny texture, to enhance the coarse texture of the original image and to display the structure of texture within the highly bright and dark areas.

THE PROPERTIES OF TEXTURE OF THE REMOTELY SENSED IMAGERY

The remotely sensed imagery records the information of electromagnetic waves radiated from the earth surface. The variation of gray levels within the imagery is reflected by the spectral features of different objects on the earth surface. While the structure of the image texture is decided by difference between different gray levels. The structure shows the distribution of radiation from the earth which relates to time and location. So the texture structure of the image is random and irregular. Based on these properties, we define the texture of remotely sensed imagery as "measurement of the rate of spatial variation of gray levels within the image". The textural statistical value I is defined as

$$I = j\left(\frac{dD}{dL}\right) \tag{1}$$

where dD is difference of gray levels between neighboring pixels, dL is distance between the pixels.

Based on this definition, two measurements are proposed to characterize textural structure of image. They are,

- Texture intensity　gradient of gray level variation of pixels in the window. It discribe the difference gray level between neighboring pixels of image.
- Texture density　distribution of gradient of gray levels of pixels in a two dimensional area. It discribe frequency of variation of the pixel gray level.

The two measurements are mutually independent, but they complement each other in characterizing the textural features. Since tone and texture are interrelated concepts, calculating the value of relative gray level variation of pixels, i.e. the relative gradient, can be used to extract textural structure of remote sensing images.

APPROACHES TO EXTRACT TEXTURE

Texture Intensity Approach

Calculating the gradient of gray level variation of pixels in the moving window. The textural statistical value I is defined as

$$I_{ij} = \frac{dD_{ij}}{dL} \tag{2}$$

or

$$I_{ij} = \frac{D_{ij+1} - D_{ij}}{L_{ij+1} - L_{ij}} \tag{3}$$

dL and $L_{ij+1} - L_{ij}$ in (2), (3) are vectors.Apparently texture intensity is vector.

If we let $L_{ij+1} - L_{ij} = 1$ then

$$I_{ij} = D_{ij+1} - D_{ij} \tag{4}$$

There are three approachs to texture extraction according to their mathematic methods.

Intensity sum approach Take the sum of differences of gray level between pixels in a certain direction in the moving window as the textural statistical value and center it on the window, to construct the texture intensity image.

Calculating the statistical value along horizontal / vertical orientation, texture in vertical / horizontal orientation can be characterized. Adding textural statistical values in both horizontal and vertical orientation, texture in all direction are characterize. It is

$$I = I_H + I_V \tag{5}$$

Maximum / Minimum approach Take statistics on maximum and minimum gray levels of pixels in the moving window,

$$I_{ij} = MaxD_{ij} - MinD_{ij} \tag{6}$$

Absolute value approach Assume window as nXn pixels

$$I_{ij} = \sum_{1}^{n}\sum_{1}^{n} |D_{ij} - \bar{D}| \tag{7}$$

where $\bar{D}$ is the average of gray levels of pixels in the moving window.

The three approaches to extract texture intensity above, have different ways of taking statistics, but they have similar results. That is: textural statistical values increase / decrease as deviation of gray levels of pixels in the moving window increase / decrease.

In the texture intensity approach, edge information in images can be enhanced by choosing small moving windows, coarse texture can be enhance by choosing large windows. As shown in fig.2, fig3.

fig.1 Su Jia Dian region, Shandong Province of TM band 5 image

fig.2 Texture image generated using maximum / minimum approach from fig.1 (3x3 window)

fig.3 Texture image generated using absolute value approach from fig.1 (7x7 window)

Texture Density Approach

This approach extracts the quantity of differences of gray level of pixels in a moving window that are greater or equal to a certain threshold. It can be accomplished by multi–order statistics.

First order texture density approach This approach takes statistics on the quantity of intensity values of gray level of pixels that are greater or equal to a certain threshold in a moving window within original image.

Along horizontal / vertical orientation in the moving window, if differences of gray level of pixels are greater or equal to a certain threshold, then textural statistical value I = 1, otherwise I = 0. Centering sum of all of these on the window, the texture image is generated. e.g. assume threshold T = 2, 3 by 3 window as fig.4(a). Take statistics on the quantity of pixels whose texture intensity are greater than or equal to threshold along horizontal orientation, see fig.4(b); Take statistics on the quantity of pixels whose texture intensity are greater than or equal to threshold along vertical orientation, see fig.4(c).

e.g.

threshold T = 2, 3x3 window

fig.4(a)

6	9	7
5	8	7
9	8	6

(b) horizontal

6	9	7	→ 2
5	8	7	→ 1
9	8	6	→ 1

(c) vertical

6	9	7
5	8	7
9	8	7
↓ 1	↓ 0	↓ 0

Texture statistical value I is:

$$I_H = 2+1+1 = 4$$
$$I_V = 1+0+0 = 1$$
$$I_{ALL} = I_H + I_V$$

Threshold in this approach is estimately calculated according to absolute average of differences of gray levels between neighboring pixels along horizontal or vertical orientation in the original image.

fig.5 First order texture density image of Su Jia Dian region (9x9 window, T = 7)

Second order texture density approach This approach takes second statistics on texture intensity image which is generated by small windows.

Calculating the quantity of pixels whose gray levels are greater than or equal to a certain threshold in a moving window, texture density image is generated.

fig.6 Second order texture density image of Su Jia Dian region (9x9 window, T = 27)

The percentage of strong texture in image can be decided according to histogram of texture intensity image, this value can be seen as threshold.

Usually, if a large threshold is selected, only strong texture is taken into statistics. If a small threshold is selected , strong and weak texture are all taken into statistics.

RELATIVE GRADIENT APPROACHES

Calculating ratioes of difference of gray levels between a certain pixel and its neighboring pixels in the moving window and its own gray level, this approach extracts textural properties according to the relative variation of gray level of pixels. The mathematical description is,

$$I = \frac{D_{ij+1} - D_{ij-1}}{D_{ij}} \quad (8)$$

enhance texture in vertical orientation

$$I = \frac{D_{i+1j} - D_{i-1j}}{D_{ij}} \quad (9)$$

enhance texture in horizontal orientation

$$I = \frac{D_{i+1j+1} - D_{i-1j-1}}{D_{ij}} \quad (10)$$

enhance texture in right diagonal orientation (45 degree)

$$I = \frac{D_{i+1j-1} - D_{i-1j+1}}{D_{ij}} \quad (11)$$

enhance texture in left diagonal orientation (135 degree)

Mathematical properties of these four functions illustrate that relative gradient approach can eliminate side effects on texture by solar irradiation caused by different terrain. Comparing fig.1 and fig.7(texture image of Sun Jia Dian region that generated by relative gradient approach), we find that texture in high gray level area and low gray level area can be recognized clearly in fig.7. Blurring and tiny texture in other area are also enhanced. Usually, we choose small moving windows in this approach to enhance the textural structure and to preserve the spectral information of the image to be processed.

CONCLUSION

In this paper, giving texture of remotely sensed imagery a specific definition and proposing two physical measurements, texture intensity and texture density, we explicitly use the gradient of gray level variation of pixels and the frequency of gray level variation of pixels to characterize features of textural structure of images . In texture intensity approach, size of the moving window is decided by the type of texture to be enhanced. In texture density approach, threshold decides the types of texture will be taken into statistics.

We proposed Relative gradient approach in this paper. On remotely sensed imagery, there are some bright and dark areas. Which is caused by solar irradiation of different terrains. Using relative gradient approach, texture of these area can be emerged, tiny and blurring textural structure in other areas can also be enhanced. The processed image does not only have its textural structure signified but also has its spectral information preserved.

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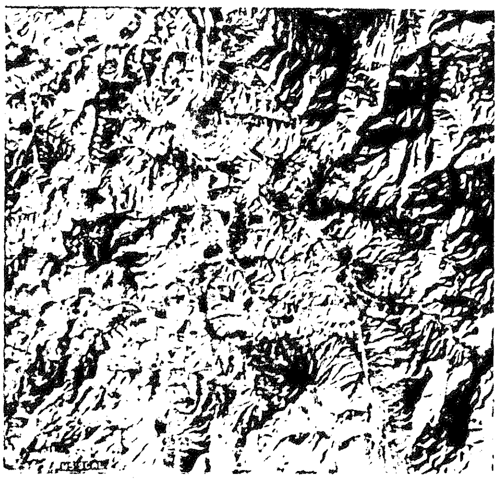

fig.1 Su Jia Dian region, Shandong Province of TM band 5 image

fig.2 Texture image generated using maximum / minimum approach from fig.1 (3x3 window)

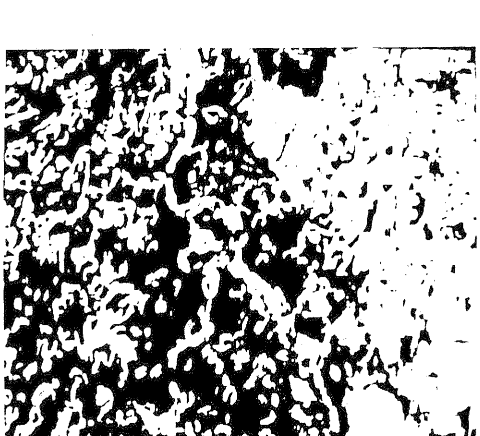

fig.3 Texture image generated using absolute value approach from fig.1 (7x7 window)

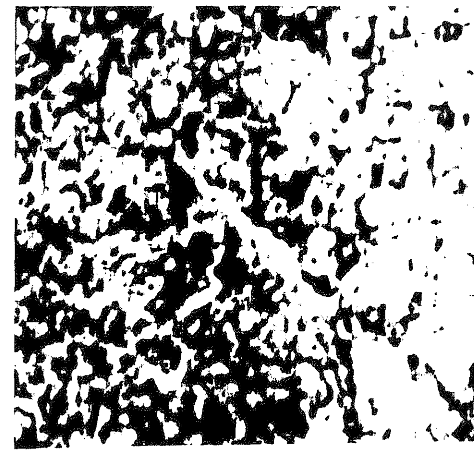

fig.5 First order texture density image from fig.1, (9x9 window, T = 7)

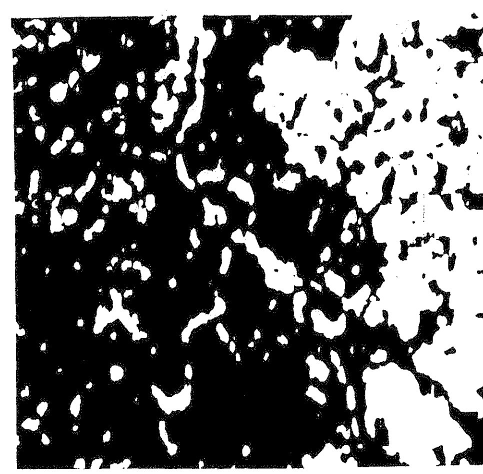

fig.6 Second order texture density image from fig.1, (9x9 window, T = 27)

fig.7 Texture image of relative gradient approach from fig.1