Construction of Information Capacity Model for Evaluation on the Land Surface Complexity using Remote Sensing Imagery

Wang XuHong, Zhang zhe, Li Fei
College of Urban and Environmental Science,
Northwest University
No. 129, Taibai Road, BeiLin District, Xi'an 710069, China
jqy_wxh @163.com

Abstract—**An new model--Information Capacity was proposed in this study, which characterizing effectively the land surface (landscape complexity) by used remote sensing imagery. Information capacity is a quantity unit of pixel density information. Center pixel and neighboring pixels will all be taken into account in the calculation of information capacity. The value of Information Capacity is closely related to the image gray levels. The more the gray level is, the greater the information capacity value will be. Thus, information capacity can objectively and effectively characterize the land surface spatial structural complexity. However, the core of the information capacity theory is the selection of the constraint domain and the determination of parameters. In this study, two different constraint domains of information capacity were designed and analyzed.**

1 INTRODUCTION

Information capacity is a quantity unit of pixel density information in the field of image processing. It can be used for image quality evaluation by statistics of the cumulative frequency of the local scatter of two-dimensional histogram [1-3]. However, remote sensing imagery is highly structured and contiguous pixels of spatial domain have strong correlations, which contains abundant information of the land surface structure features and electromagnetic radiation features [4]. In this model, the features of the local region of pixels are taken into account in the calculation. So it can represent objectively land surface features and spatial characteristics.

2 METHODOLOGY

Calculation of information capacity

Information capacity is obtained by the followed definition: Generally, the cumulative sum of a k-dimensional logarithmic peak normalized histogram within constraint domain $\omega \subseteq \Omega$, is defined as the information capacity. The cumulative sum of the histogram is logarithmically transformed, which can be expressed as follows:

$$C_{info} = Log_2[1+\sum_{\omega} Norm_{Log}(G_1, G_2, ..., G_k)] \quad (1)$$

where C_{info} represents information capacity, the unit is bit. Cumulative constraint domain ω represents measure of the histogram definition domain.

Constraint Domain of Information Capacity

The constraint domain of information capacity is a measure domain of a histogram. If a constraint domain is selected large enough, and the correlation coefficient of the histogram within the domain is higher, the evaluation results of information capacity will be consistent with human vision. However, if the constraint domain is too large, it would loss visual response characteristics. Because the low-frequency information of imagery in the calculation of information capacity has first visual response, the peak value of a normalized histogram should be cumulated and then transformed logarithmically. The constraint domain evaluating on image quality and describing image complexity is expressed as follows:

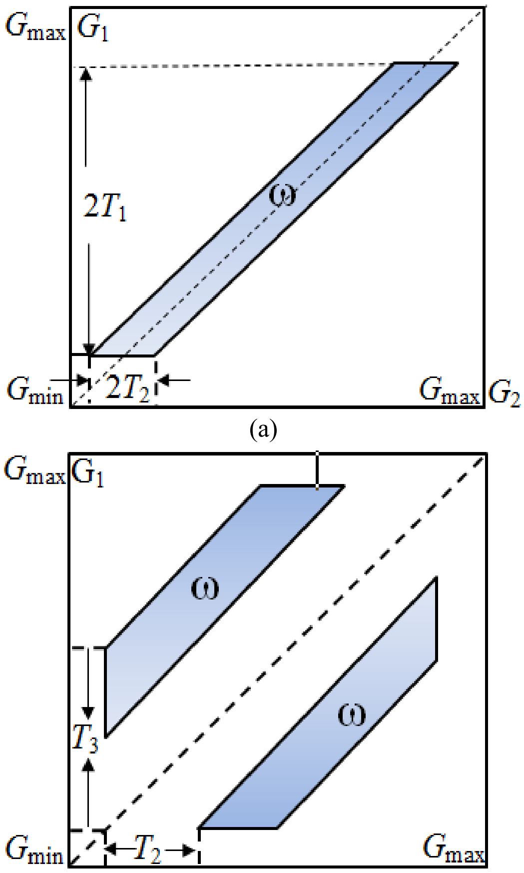
$$\omega = \begin{cases} \left| G_1 - \frac{1}{2}\left(G_{max} + G_{min}\right) \right| \le T_1 \\ \left| G_1 - G_2 \right| \le T_2 \end{cases} \quad (2)$$

with the transformation processes of histograms, information capacity can not only be suitable to human vision, but it can also reflect the sensitivity of local gray leap and adaptability of the whole image (as shown in Figure 1-a).

In order to improve the effectiveness of information capacity describing the land surface complexity in flat landform areas, such as Plain, Basin and Loess Plateau. Another algorithm of information capacity constraint domain had been proposed. Taking into account the higher correlation coefficient of gray in a histogram's diagonal domain, the constraint domain is expressed as follows:

$$\omega = \begin{cases} \left| G_1 - \frac{1}{2}(G_{\max} + G_{\min}) \right| \le T_1 \\ T_2 \le |G_1 - G_2| \le T_3 \end{cases} \quad (3)$$

where T_1 represents the difference between maximum and minimum of gray values of the image; T_2 and T_3 represents the difference of gray values of two adjacent pixels. And both T_1 and T_2 are non-negative in the formula. The constraint domain ω is near diagonal within a parallelogram (as shown in Figure1-b).



(b)

Figure 1. Constraint Domain based on two-dimensional histogram of the remote sensing image (G_1 is the vertical axis, G_2 is the horizontal axis, Fig.1-a, 1-b, indicates Constraint Domain)

3 RESULTS AND ANALYSIS

By elaborating the scientific characterization of information capacity theory, two constraint domains were proposed which can be used to evaluate image quality and describe spatial complexity of the imagery. After experimental examining the ETM+ and SPOT5 imagery, we set the parameters of the two constraint domains, respectively. The algorithm of two constraint domains is developed and optimized. In this study, 56 different landform areas of Shaanxi province were selected as test areas, using ETM+ and SPOT5 as experimental data. Two different calculation method of constraints domain of information capacity were adopted by using comparative analysis and mathematical statistics, which analyzed constraint domain selection and spatial distribution of information capacity. All these experimental results show that information capacity can reflect the land surface spatial structure complexity to a certain extent.

4 CONCLUSION

In this study，information capacity is adopted to analyse remote sensing image information in geosciences. Based on quantitative analysis of information capacity, the relationships between information capacity and surface landscape complexity in different LULC areas have been studied. The main results show that there is strong correlation between information capacity and surface complexity. In principle, information capacity based on a multi-dimensional histogram is an expression of spatial form entropy in a broad sense, reflecting the quantity and proportionality of geographic area system elements. Finally, our results support the hypothesis that information capacity is a new index for characterizing image complexity, and has great potential in characterizing landscape patterns for global environmental studies using remote sensing imagery and describing terrain complexity for digital terrain analysis using Dem.

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