# Method for detecting the top of a mountain by using Fractal technique

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**ABSTRACT**

In this paper, we consider the method that detects the top area of a mountain to decrease the research area in the image processing system.

The curved surface of image brightness (CSIV) on ground background forms in a woods, a rock , a crookedness of the ground and so on . The curved surface of image brightness (CSIV) on sky background generally forms in the relatively very great clouds group.

Therefore, the curved surface of image brightness (CSIV) on sky background generally forms in great patterns, the curved surface of image brightness (CSIV) on ground background relatively forms in small patterns.

On the basis of consideration about the fractal characteristics between the sky and ground background, the top area of a mountain where the appearance probability is very great was detected by using calculation of fractal dimension between sky and ground.



*Keywords:* Fractal, Fractal Dimension, target detection

## 1. Introduction

Today, the fractal and wavelet analysis are widely applied for analyzing the characteristics of object in the object identification fields[1].

In a word, the fractal characteristic of object is a characteristic that characterizes the invariability of measurement index about object witch is a nonlinear complex system and the nature of self similarity.

On the basis of conception and category about the local and global of object, the tiny and global observation, the quantitative and qualitative change, the simplicity and complexity, the decision and contingency, the inhalation and rejection and so on, the fractal characteristics is a characteristics that characterizes the inside and outside characteristics of object, and the self similarity and complexity of nature.

Here, the self similarity is a similitude characteristics that is the value of property of object(inside and outside characteristics) between the local and global of object.

The index witch characterizes the fractal nature in qualitative is a fractal dimension[1]. (In a short, it is called a fraction dimension.) The fractal nature can represent the forms of object, the function of object, and the information of object, these three sides in self similarity individually or simultaneously.

In the preceding literatures, many detection methods that use fractal feature were introduced.

For example, nowadays many small target detection schemes are using the fractal dimension of target. An effective small target detection scheme was proposed in [7] based on multi-fractal analysis of the time series radar data. A detection strategy using integral test based on multi-fractal analysis was proposed in [8].

A joint fractal-multi-resolution based detection of small targets was proposed in [9], [10], [11].

In [12], fractal analysis was performed in frequency domain for target detection. The performance of most of the above mentioned fractal analysis based schemes depend on background state and viewing geometry. In [13], a better detection scheme based on normalized Hurst exponent was suggested but at the expense of training to estimate statistical parameters.

In this paper, we proposed the method for detecting the top of mountain by using Fractal method. For this purpose we induced the difference of fractal dimension between different backgrounds and mathematical model and then described the process of detecting the real top of mountain.

In section 2, we think the image surface of which height is the brightness and have a Fractal analysis for estimating the difference of brightness between the sky background and land background.

In section 3, we mentioned about the Fractal dimension briefly for analyzing the difference of brightness between sky and land.

In section 4, we proposed the method that the image is partitioned in vertical direction and the border between sky and land background is detected in each partitioned region.

For this purpose, we divided each region in horizontal direction again and then calculate the Fractal dimension of each block, detected the border between the sky and land background by using the binsearch method, as the maximum variance ratio criterion.

In conclusion, we summarized the proposed method and orientation of research work in the future.

## 2. Fractal analysis of the top of a mountain of Image

If we think a curved surface of image witch is in height that is the brightness of each image pixel $\{f(x, y)\}$ on input image $(x, y)$, the curved surface of image Brightness (CSIV) considerably differs the sky from ground background.

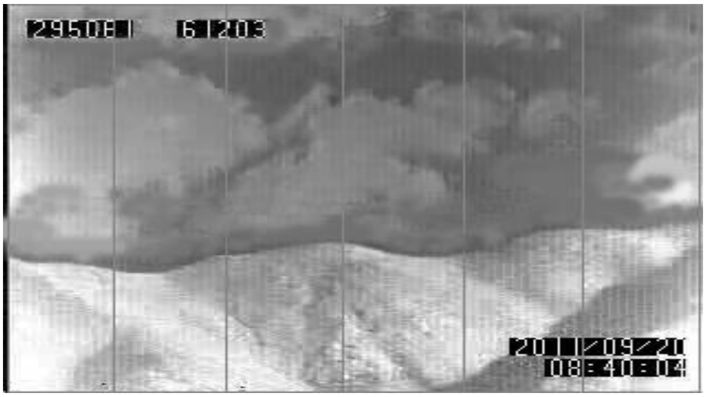

Fig. 1. Image of the top of a mountains

The curved surface of image brightness (CSIV) on ground background forms in a wood, a rock, a crookedness of the ground and so on.

The curved surface of image brightness (CSIV) on sky background generally forms in the relatively very great clouds group.

Therefore, the curved surface of image brightness (CSIV) on sky background generally forms in great patterns, the curved surface of image brightness (CSIV) on ground background relatively forms in small patterns.

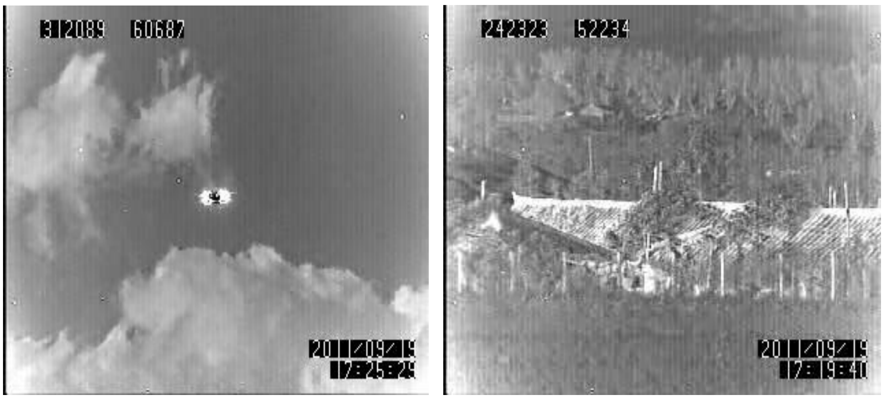

Fig. 2. Sky and ground background

Therefore, if we divide the curved surface of image brightness (CSIV) into a small blocks, the brightness change of the sky background blocks slows than the brightness change of the ground background blocks.

We can therefore estimate this difference between sky and ground background by fractal dimension qualitatively, and can detect the neighboring area of sky background and ground background.

## 3. Fractal dimension of image

Let's think CSIV on the bottom dimension S.

We divide the bottom dimension S into a small square a true square where the length of a side is r individually.

Now, let's place that the brightness of image pixel(a node pixel) is $f(x_0, y_0)$, $f(x_0, y_0 + r)$, $f(x_0 + r, y_0)$, $f(x_0 + r, y_0 + r)$.(Fig. 3)

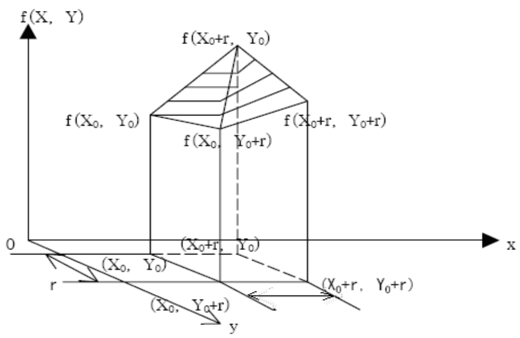


Fig. 3. Area calculation of the curved surface of brightness on individual small area

Now, we compose the two group brightness value set as following, and then

$$\{f(x_0, y_0), f(x_0 + r, y_0), f(x_0, y_0 + r)\}$$

$$\{f(x_0 + r, y_0), f(x_0, y_0 + r), f(x_0 + r, y_0 + r)\} \quad (1)$$

calculate the sum of area of two triangle witch individually compose into three extension line.

And then we place it into a area of the curved surface of brightness witch is a unit (small area of $r \times r$ dimension), and place the total sum into A(r).

If while we change the yardstick r in scope of (1, L), we calculate A(r),the yardstick and A(r) form the sample point column as following.

$$\{\lg r, \lg A(r), r = 1, \cdots L\} \quad (2)$$

Generally, if we decrease a yardstick factor, the area A(r) of the curved surface of image brightness increases as a result it, the result differs from the change degree of the curved surface of image brightness[3].

The slower the brightness change, the smaller a degree of A(r) increment.

If the brightness change extremely is no, although the yardstick factor decreases, the change of A(r) is no.

Therefore, the relationship between the yardstick factor r and the area A(r) which is decided by r, can qualitatively estimates the aspect of brightness change in image.

Justly, the fractal dimension is a characteristic quality which qualitatively determines the relationship between a yardstick factor r and a area A(r) of the curved surface of image brightness determined by r.

If we apply the definition of fractal dimension to the relationship [r – A(r)] in image, the following formula realizes[1].

$$\lg A(r) = -D_p \lg r + C \tag{3}$$

Here, $D_p$ is justly a fractal dimension. In other words, in this case the fractal dimension means the gradient of relationship curved line $\lg r - \lg A(r)$.

If the brightness curved surface of image has the complete self similarity (the geometric fractal nature), the relationship between $\lg r$ and $\lg A(r)$ is fully linear.

But, because the brightness curved surface of image which reflects the surface state of natural world body is not complete linear, the point group is not fully a straight line.(Fig. 4)

Therefore, we might deduce a linear recurrence line

$$\lg A(r) = \hat{\beta}_1 \lg r + \hat{\beta}_0 \tag{4}$$

on the sample point rows in statistic linear recurrence analysis.

If we compare the formula 3 and formula 4, we know that the fractal dimension of the brightness curved surface of image is just determined by

$$D_p = -\hat{\beta}_1 \tag{5}$$

In other words, the fractal dimension characterizes the gradient of relationship curve line $\lg r - \lg A(r)$.

Here, $\hat{\beta}_1$ is determined as following.

$$\hat{\beta}_1 = \frac{N\sum_{n=1}^{N}\lg r_n \lg A(r_n) - \sum_{n=1}^{N}\lg r_n \sum_{n=1}^{N}\lg A(r_n)}{N\sum_{n=1}^{N}(\lg r_n)^2 - (\sum_{n=1}^{N}\lg r_n)^2} \tag{6}$$

Here, N is a number of sample points in sample point rows.

The characteristics quality determined by the formula 6 is called a probability similarity dimension[7]. We show this relationship as Fig. 4.

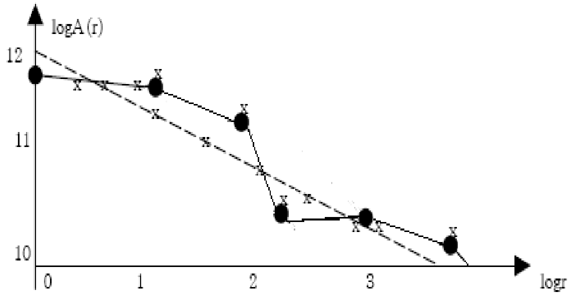


Fig. 4. The relationship between lg $r$ and lg $A(r)$

Sometimes, we can use the relationship $d\lg r - d\lg A(r)$ instead of $\lg r - \lg A(r)$ in the digital image.

Here,

$$\begin{aligned} d\lg r &= \lg(r+1) - \lg r \\ d\lg A(r) &= \lg A(r+1) - \lg(r) \end{aligned} \tag{7}$$

In essence, this relationship is the relationship between a delta of yardstick factor and a delta of the brightness curved surface of image.

We define a new characteristic quality

$$dDH_r = -\frac{|\lg A(r+1) - \lg A(r)|}{|\lg(r+1) - \lg(r)|} \tag{8}$$

as a quality which characterizes this relationship, call a Digital Hausdroff Dimension(DHD)[2].

As above shown, the Digital Hausdroff Dimension(DHD) also characterizes the gradient of relationship curve line $\lg r - \lg A(r)$.

The average gradient of this relationship curve line is determined by

$$dDH_{\mathrm{rm}} = \frac{1}{N}\sum_{n=1}^{N} dDH_r(r_n) \quad . \tag{9}$$

Here,

$$dDH_r(r_n) = -\frac{|\lg A(r_n+1) - \lg A(r_n)|}{|\lg(r_n+1) - \lg(r_n)|} \tag{10}$$

Here, $\{r_n\}$ is frequently taken as {1, 2, 3, …N}.

In practice, the Digital Hausdroff Dimension $dDH_r$ is often used than the probability similarity dimension.

The slower the change of brightness curved surface, the smaller the fractal dimensions such as the probability similarity dimension or the Digital Hausdroff Dimension as above pointed, the faster the change of brightness curved surface, the greater the fractal dimensions.

## 4. Detection of the top of a mountain area by using fractal analysis

As above pointed, the top area of a mountain is the neighbor area of sky and ground background.

The curved surface of image brightness (CSIV) on ground background forms in a woods, a rock , a crookedness of the ground and so on, and the curved surface of image brightness (CSIV) on sky background generally forms in the relatively very great clouds group.

Therefore, the curved surface of image brightness (CSIV) on sky background generally forms in great patterns, the curved surface of image brightness (CSIV) on ground background relatively forms in small patterns. Consequently, the curved surface change of image brightness (CSIV) on sky background is slow, reversely the curved surface change of image brightness (CSIV) on ground background is relatively fast.

Therefore, the fractal dimension of the curved surface of image brightness (CSIV) on sky background is small, the fractal dimension of the curved surface change of image brightness (CSIV) on ground background is relatively great.

We can distinguish the ground background from the sky background with these fractal dimension and can detect the top of a mountain area where is it’s neighbor.

To detect the top area of a mountain, we divide input image into length part images of same interval as Fig. 5.

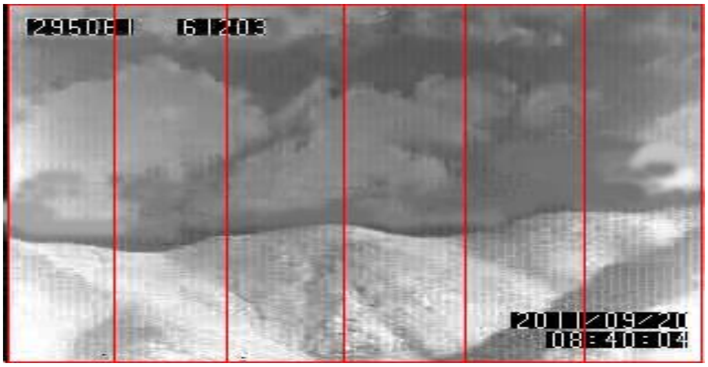


Fig. 5. The top of a mountain image

We progress the detection of the top of a mountain with the length part image unit. And then, we divide each length part image in across direction with same interval part.

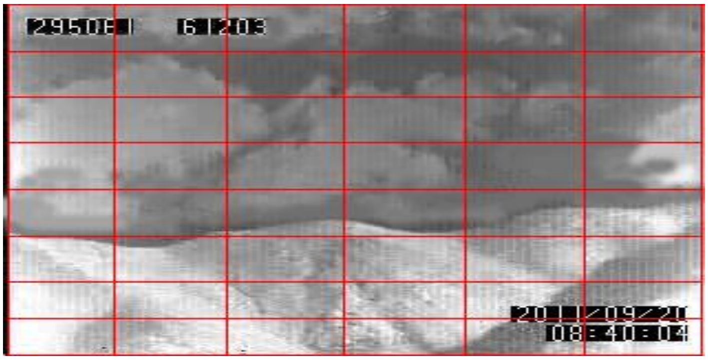


Fig. 6. The top of a mountain image

And then, we calculate the fractal dimension for each image block.

Justly, we split the sky background from the ground background each length part images by using these fractal characteristics.

We progress this division by the divergence ratio maximum standard method below.

Now, let's present the fractal dimension of each blocks of a length part image as following $dDH_{rm}(l)$ $(l = 1, 2, \cdots, L)$. (Formula 10)

Here, $l$ is a number of block, we attach the number to increase up from bottom in tern one. ( Fig. 7)

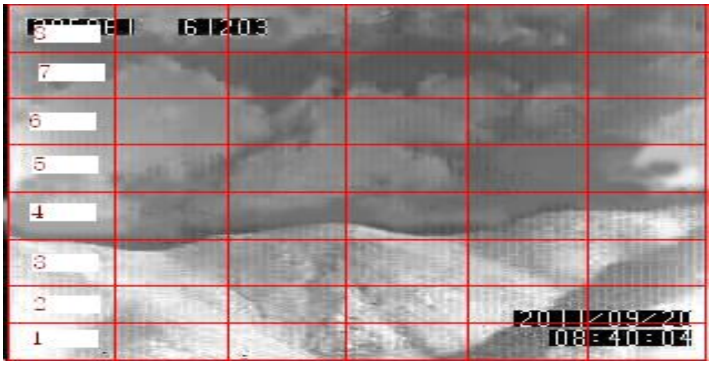


Fig. 7. The top of a mountain image

And then, if we assume any number $l^*$ into a boundary block of the sky and ground background, we can determine the average value and divergence of fractal dimension of group $\Omega_1$ which is the ground background group as following.

$$\bar{D}_1 = \frac{1}{l^*}\sum_{l=1}^{l^*} D(l) \tag{11}$$

$$\sigma_1^2 = \frac{1}{l^*}\sum_{l=1}^{l^*} [D(l) - \bar{D}_1]^2 \tag{12}$$

We can determine the average value and divergence of fractal dimension of group $\Omega_2$ which is the sky background group as following.

$$\bar{D}_2 = \frac{1}{L - l^*}\sum_{l=l^*+1}^{L} D(l) \tag{13}$$

$$\sigma_2^2 = \frac{1}{L - l^*}\sum_{l=l^*+1}^{L} [D(l) - \bar{D}_2]^2 \tag{14}$$

If this division is exact, the inner divergence of group is small, the divergence between groups is great. But if this division is not exact, inversely the inner divergence of group is respectively great, the divergence between groups is small.

Therefore, the estimation function for best division is as following.

$$V_{l^*} = \frac{\sigma_1^2 + \sigma_2^2}{(\bar{D}_1 - \bar{D}_2)^2} \tag{15}$$

And then, we calculate $l^*$ which is to minimize $V_{l^*}$, we take it to the number of boundary block[3].

In the same manner, if we progress each across part images, we can take the boundary blocks of the sky and ground background.

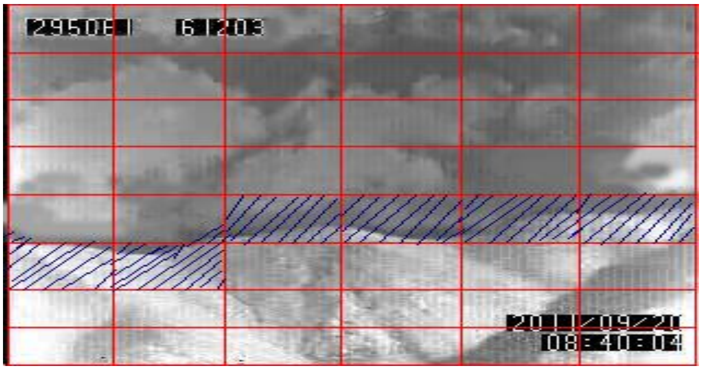

Fig. 8. The detected top area of a mountain image

Then, if we take one more blocks where are respectively in upper and below of the boundary block, just this area is the top area of a mountain.(Fig. 8)

## 5. Conclusions

In this paper, we suggested the method for detecting the top area of a mountain by using the fractal method.

In order to that, first, we discuss how the fractal dimension differs from each different background, and then we guide the mathematical model of fractal dimension of image.

Then we really described the process for detecting the top area of a mountain. For this purpose, we induced the difference of fractal dimension between different backgrounds and mathematical model and then described the process of detecting the real top of mountain. Generally the preceding literatures for detecting such targets as ship target in the sea and airplane and missile in the sky by using the fractal dimension have already been introduced and have been using widely.

In this paper we proposed the method for detecting the top of mountain by using Fractal dimension.

In the future we will intensify the studying about the method for detecting the special region by using the Fractal dimension, specially about the method for estimating the Fractal dimension that less amount of operating is used and more precision measuring is obtained.

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