Journal of Physics: Conference Series

**PAPER** • **OPEN ACCESS**

# Dem and valley segmentation in remote sensing image based on region growing algorithm

To cite this article: Sun Xianchen *et al* 2020 *J. Phys.: Conf. Ser.* **1693** 012174

# Dem and valley segmentation in remote sensing image based on region growing algorithm

**Sun Xianchen, Wang Baoyun*, Liu Kunxiang**

Yunnan Normal University, Kunming, Yunnan Province, 650500, China

Corresponding author: Wang Baoyun, 4556@ynnu.edu.cn

**Abstract**. Aiming at the characteristics of Dem and remote sensing images, this paper proposes a method for segmentation of Dem and remote sensing images based on region growing algorithm. First, using normalization and median filtering methods to preprocess the Dem image; secondly, setting appropriate seed points and thresholds based on the region growing algorithm to perform preliminary river recognition on the Dem image. Then, on this basis, constructing the circumscribed rectangle of the valley according to the length and width attributes of the valley. Finally, according to the valley information of Dem, we aligned, corrected and segmented the remote sensing image. The research results show that this method can realize the segmentation of valleys in Dem and remote sensing images, and provides a favorable data basis for the research of valley topography and characteristics.

## 1. Introduction

The seed region growing algorithm is a region-based segmentation algorithm, which was first proposed by Adams R[1] and others. Then many scholars use region growing algorithm to identify and extract objects in the image. Li Jianfei[2] and Yu Jie[3] proposed a high-resolution remote sensing image road extraction based on a region growing algorithm to achieve effective road extraction from remote sensing images. Yan Dongyang [4], Su Tengfei [5], etc., aiming at the problem that the traditional seed region growth algorithm can only extract objects with simple textures, proposed an improved region growth algorithm to segment the target features in high-resolution remote sensing images. Xu Ling [6] et al. proposed a hydrological image segmentation method based on HSV color model and region growth, which solved the problem of connectivity and proximity between hydrological image pixels. The extraction and segmentation of valleys in Dem and remote sensing images are widely used in debris flow valleys [7] and river basins [8,9].Most scholars extract the network of valleys based on the characteristics of the valleys in Dem and remote sensing images , and the extracted results cannot fully show the full picture of the valleys. Based on the region growing algorithm, this paper first roughly identifies the river in the Dem image, then constructs the circumscribed rectangle of the valley, and finally divides the Dem image and the remote sensing image. The experimental results show that the method can completely and accurately obtain the slice of each valley image.

## 2. Principle of Region Growth Algorithm

The region growing algorithm is an algorithm that gathers points with small pixel values in an image. The basic idea is to combine pixels with similar criteria to form a connected area with a certain growth rule and discrimination basis. First, find a seed point in the area to be divided as the starting point for growth. Then determine the appropriate threshold value as the criterion for growth, compare the seed point and the pixel points of the adjacent eight neighborhoods, if the pixel difference between the seed point and the adjacent pixel point is less than or equal to the growth threshold, merge the adjacent element and the seed point into In the same set, simultaneously continue to search for adjacent pixels. Finally, a growth termination condition is set, until there is no merging of pixels that meet the conditions, and the region growth ends. The algorithm diagram is shown in Figure 1.

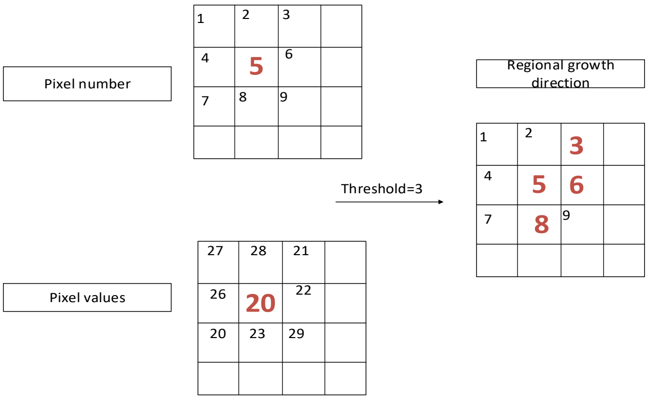


Fig.1 Schematic diagram of region growing algorithm

## 3. Image source and preprocessing

### *3.1. Data Sources*

In this study, the geographic scope of Dem and remote sensing images are both in the Nu River basin. The Dem image data comes from the website of the US Geological Survey (http://www.usgs.gov/), and the remote sensing image data comes from the website of the Remote Sensing Mart (http://www.rscloudmart.com/).

### *3.2. Image normalization*

Image normalization is to determine the parameters of the transformation function by using the characteristics of the image's moment of invariance to the affine transformation, and thereby convert the original image into a standard image. In order to facilitate the image processing, the min-max standardized linear transformation is performed on the original Dem image, so that each pixel value of the image is mapped between 0-1. The conversion function is as follows:

$$x^* = \frac{x - \min(x)}{\max(x) - \min(x)} \tag{1}$$

$x$ is the pixel value of a certain pixel of the original Dem image, $\min(x)$ and $\max(x)$ are the minimum pixel value and maximum pixel value in the Dem image, respectively, and $x^*$ is the pixel values of the corresponding pixels after the image is normalized.

### *3.3. Image Denoising*

The Dem image will be affected by the imaging equipment and the external environment during the acquisition process to generate noise, which will directly affect the subsequent work. This article uses median filtering method to denoise Dem images. The median filtering method is as follows:

$$g(x, y) = med\{f(x-k, y-l), (k, l \in W)\} \tag{2}$$

Among them, $f(x, y)$ is the original image, $g(x, y)$ is the image after denoising processing, and $W$ is the two-dimensional template. The denoising process can filter out abnormal pixels in the image, and eliminate the influence of abnormal pixels on the result of valley recognition.

## 4. Valley segmentation in Dem image

### *4.1. Rough river recognition*

Rough recognition of rivers based on regional growth algorithm. The key steps of the region growth algorithm are: select seed points; determine the growth threshold; formulate the growth termination criteria. The first is to determine the seed point. Rough river recognition does not require high precision in selecting the seed point. You only need to clarify the approximate range of the seed point and manually select the seed point. The experimental Dem picture is a part of the Nu River basin, located between 26°59'59.5"~28°0'0.5" north latitude and 97°59'59.5"~99°0'0.5" east longitude. The picture size is 3601 x 3601.Seed points can be selected at the trunk, ridges, ditch mouths and the area between the mouths of the two valleys. Through experimentation, the identification effect of selecting seed points between two valleys and mouths is the best. The test results are shown in Figure 2. The left image is the recognition effect of seed points selected between two valleys and mouths, and the right image is the recognition effect of seed points selected on the ridge. Then the iterative threshold method [10] is used to determine the growth threshold:①Set the initial threshold $threshold_{\text{original}} = \frac{P_{\max} + P_{\min}}{2}$, where $P_{\max}$ is the maximum pixel value in the Dem image, and $P_{\min}$ is the minimum pixel value in the Dem image;② Divide the Dem image into two parts, foreground and background, according to the initial threshold, and find the average pixel values $\overline{P}_{front}$ and $\overline{P}_{back}$ of the foreground and background respectively;③ Iteratively find a new threshold $threshold = \frac{\overline{P}_{front} + \overline{P}_{back}}{2}$ until the threshold no longer changes. The threshold $threshold = 0.02$ is obtained according to the iterative threshold method. Finally, the criterion of growth termination is determined by the threshold: $|P - P_{seed}| \le threshold$.Where $P_{seed}$ is the pixel value of the seed point, and $P$ is the pixel value of the adjacent point to be measured. If the criterion is met, the growth is continued, otherwise, the growth is terminated and the river identification result is output. The rough river recognition result is shown in Figure 2 on the left.

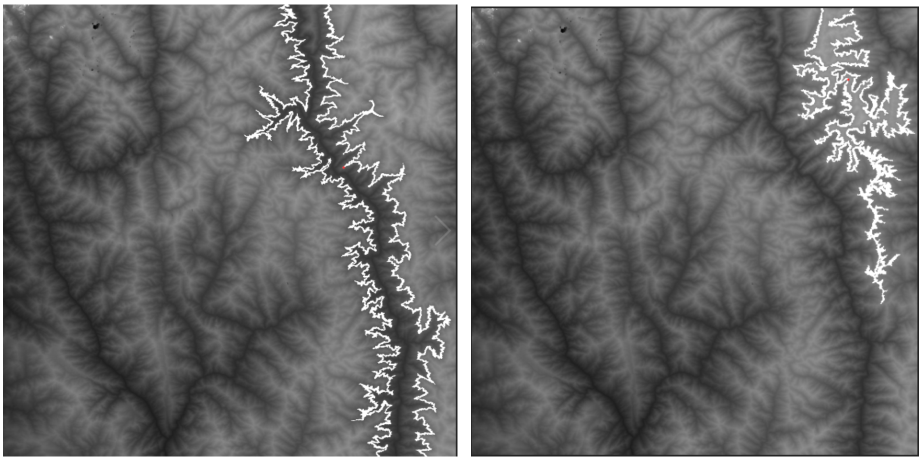

Fig.2 River recognition results under different seed points selected

### *4.2. Valley recognition and cutting*

Based on the rough identification of rivers, the valleys are identified and cut again based on the improved regional growth algorithm. Take the valley on the right side of the main river as an example. First, select a point $O(x, y)$ from the outline of the river roughly identified as the starting point, and move in the four directions up, down, left, and right in turn. When it encounters the trunk of the river or the identified outline, it stops moving, as shown in Figure 3.The end coordinates of the four points are set to $A(b_1,a_1)$、$B(b_3,a_3)$、$C(b_2,a_2)$、$D(b_4,a_4)$.A, B, C, and D can be used to initially construct the circumscribed rectangle of the valley. Since each valley has a different shape, it is necessary to set different length and width expansion parameters for the valley. The final circumscribed rectangle constructed is shown in Figure 4. Let c2, c1, c4, and c3 be the extended parameters of the upper, lower, left, and right of the initial test external matrix, respectively. The coordinates of the four points of the final circumscribed matrix are calculated:

$$\begin{cases} P1_x = b_4 - c4 \\ P1_y = (b_2 - b_1)*(b_2 - b_4)/(a_2 - a_1) + a_2 + \mathrm{c}1 \end{cases} \begin{cases} P2_x = b_4 - c4 \\ P2_y = (b_2 - b_1)*(b_1 - b_4)/(a_2 - a_1) + a_1 - \mathrm{c}2 \end{cases}$$

$$\begin{cases} P3_x = b_3 \\ P4_y = (b_2 - b_1)*(b_2 - b_3)/(a_2 - a_1) + a_2 + \mathrm{c}1 \end{cases} \begin{cases} P4_x = b_3 \\ P4_y = (b_2 - b_1)*(b_1 - b_3)/(a_2 - a_1) + a_1 - \mathrm{c}2 \end{cases}.$$

Finally, the four vertices $(P1_x, P1_y),(P2_x, P2_y),(P3_x, P3_y),(P4_x, P4_y)$ of the circumscribed rectangle of each valley are saved in the excel table, and the coordinates of the vertices of the circumscribed rectangle are read through matlab, and all valleys are divided.

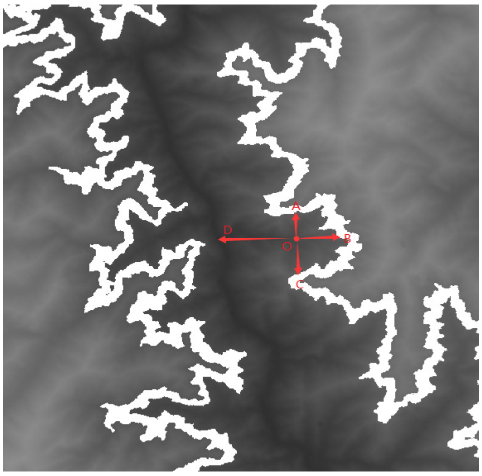


Fig.3 Starting point movement direction

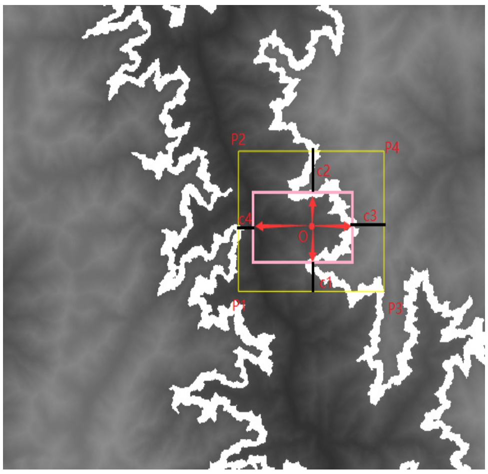


Fig.4 Final external matrix

## 5. Valley segmentation in remote sensing images

In the process of satellite remote sensing imaging, it will be affected by the internal factors of the sensor structure, the change of the sensor's azimuth, and the rotation of the earth. The captured remote sensing images will produce certain geometric distortion, so the remote sensing images need to be aligned and corrected. This article uses projection transformation to process remote sensing images. Projection transformation can correct the remote sensing image for true north, and after segmentation and processing according to latitude and longitude, it is convenient for one-to-one correspondence with the Dem image. The projection transformation is a linear transformation of the aligned three-dimensional vector, the linear transformation is as follows:

$$\begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} \tag{3}$$

Assuming that the pixel coordinates in the original image are $(x, y)$, and the coordinates after the projection transformation become $(x', y')$, the projection transformation can be written as:

$$\begin{cases} x' = \dfrac{x_1'}{x_3'} = \dfrac{h_{11}x + h_{12}y + h_{13}}{h_{31}x + h_{32}y + h_{33}} \\ y' = \dfrac{x_2'}{x_3'} = \dfrac{h_{21}x + h_{22}y + h_{23}}{h_{31}x + h_{32}y + h_{33}} \end{cases} \tag{4}$$

The left image of Figure 5 shows the fourth band of the original remote sensing image, the image size is 7486 x 9151. The middle image is the remote sensing image after projection transformation and latitude and longitude segmentation. The image size is 4338 x 6888. The picture on the right is the processed remote sensing image corresponding to the Dem image. The geographic range is 26°59'59.5"~28°0'0.5" north latitude and 97°59'59.5"~99°0'0.5" east longitude. The image size is 3601 x 3601.

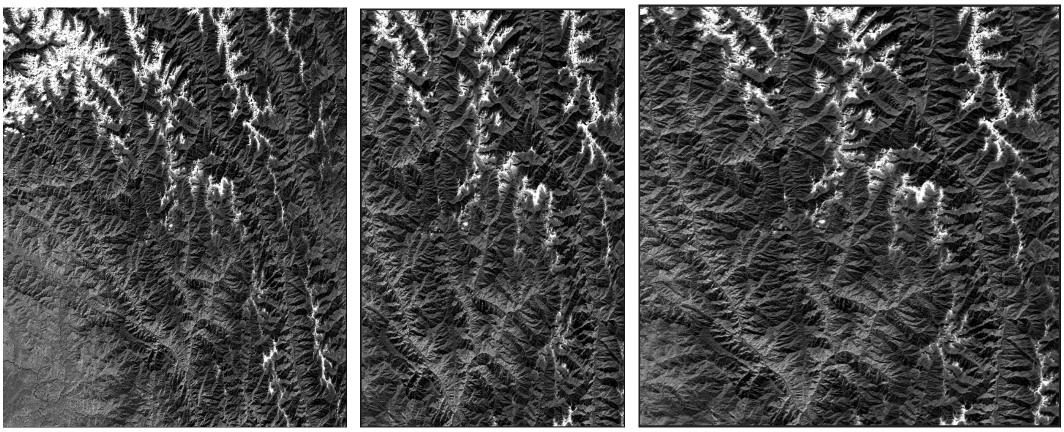

Fig.5 Remote sensing image fourth band

Since the geographic range and image size of the processed remote sensing image correspond to the Dem image, the four bands of the remote sensing image can be segmented by reading the coordinates of the four vertices of the circumscribed rectangle of each valley of the Dem image. The segmentation results of the final Dem and the valleys in the remote sensing image are obtained. The segmentation result of one of the valleys is shown in Figure 6, and the image size is 397 x 190.

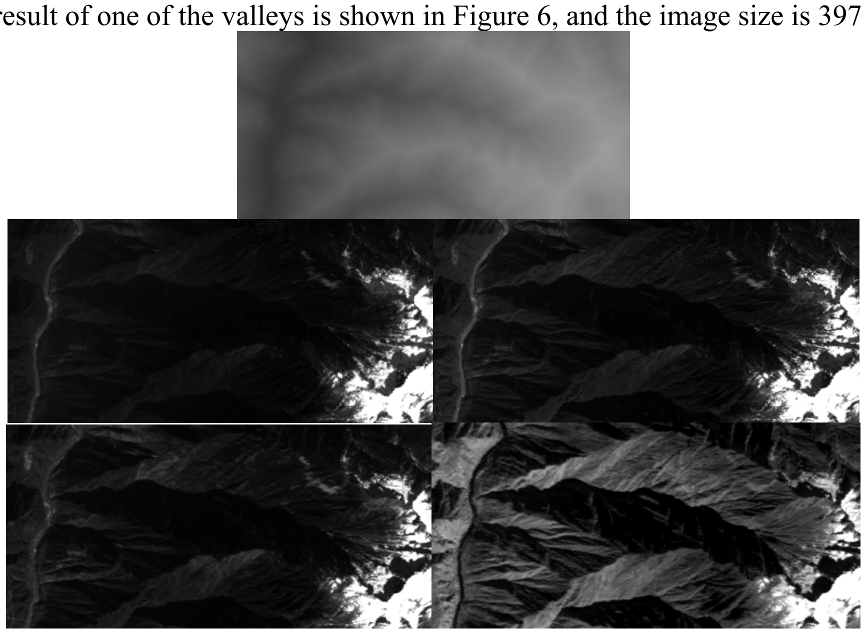

Fig.6 Segmentation results (from top to bottom, from left to right are Dem images and bands 1-4 of remote sensing images)

## 6. Conclusion

This paper uses the region growing algorithm to study the segmentation of Dem and remote sensing images. This method combines the morphology and feature research of valleys with regional growth algorithms to facilitate manual selection of seed points and automatic threshold determination, and can effectively avoid errors caused by manual thresholds. Experiments show that this method can effectively and accurately segment Dem and valleys in remote sensing images. However, due to the variety of different valley forms, the determination of the circumscribed rectangle still requires manual adjustment. Therefore, how to automatically segment the valley according to the shape of the valley is the next research direction.

## References

[1] Adams R, Bischof L. Seeded region growing[J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 1997, 18: 1065−1071.
[2] Li Jianfei, Wen Zhiqiang, Hu Yongxiang, Deng Liu Zhaolu. Road extraction from remote sensing images based on improved regional growth[J]. Computer Engineering and Applications, 2016, 52(02): 209-213+238.
[3] Yu Jie, Yu Feng, Zhang Jing, Liu Zhenyu. Road extraction from high-resolution remote sensing images combining regional growth and road primitives[J]. Journal of Wuhan University (Information Science Edition), 2013, 38(07): 761 -764+754+887.
[4] Yan Dongyang, Ming Dongping. Remote sensing image object-oriented segmentation method based on automatic multiple sub-region growth[J]. Journal of Engineering Science, 2017, 39(11): 1735-1742.
[5] Su Tengfei, Zhang Shengwei, Li Hongyu. High-resolution remote sensing image segmentation algorithm based on texture features and regional growth[J]. Remote Sensing for Land and Resources, 2017, 29(02): 72-81.
[6] Xu Ling, Hou Xiaofeng. Remote sensing image river extraction based on regional growth [J]. Surveying and Spatial Geographic Information, 2015, 38(03): 198-200.
[7] Sun Xianchen, Wang Baoyun, Liu Kunxiang, Peng Juan, Kong Yan, Zhang Zhuhong. Analysis of impact factors of debris flow disasters in Yunnan Province[J/OL]. People's Yangtze River:1-10[2020-09-01].http://kns .cnki.net/kcms/detail/42.1202.TV.20200623.0857.002.html.
[8] Zhang Zhuhong,Wang Baoyun,Sun Yumei,Li Caidong,Sun Xianchen,Zhang Lingli.High score No.1 remote sensing image river extraction combining stroke width transformation and geometric feature set[J].Remote Sensing for Land and Resources,2020,32(02):54-62.
[9] Sun Yumei,Wang Baoyun,Zhang Zhuhong,Han Wenke,Sun Xianchen,Zhang Lingli.A method for extracting small rivers from TM images based on search for structurally similar regions[J].Remote Sensing for Land and Resources,2020,32(02):63-72.
[10] Zhang Hong, Gao Wei. Threshold segmentation algorithm based on local spatial information [J]. Computer and Digital Engineering, 2018, 46(02): 251-255+325.
[11] Sun Xianchen,Wang Baoyun,Peng Juan,Liu Kunxiang,Yang Sui,Jin Zhu.Analysis of the laws of debris flow disasters and water system distribution in various cities in Yunnan Province[J].Computer Knowledge and Technology,2020,16(15):16-18.
[12] Kong Yan, Wang Baoyun, Yang Kun, Wei Bao, Zheng Lu, Zhang Zhuhong. Analysis of the temporal and spatial distribution of debris flow disasters in Yunnan Province and the characteristics of disasters in typical regions[J]. Journal of Yunnan Normal University (Natural Science Edition), 2018, 38 (06):55-63.