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Urban Road Extraction High resolution remotely sensed imagery with Gabor texture and geometrical Features

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Abstract: Through the feature analysis of the frequency curve , The paper proposed a new method which integrated Gabor texture and geometrical features in the urban road Ction from high resolution remotely sensed imagery. in the experiment, the texture features in different frequencies and Different directions were obtained by a given bank of Gabor filters,andthen K-means clus Tering method is applied for imagery segmentation. The morphological methods were utilized to separate the road objects from Non-^oadobjects,<b 21>and the geometrical features were applied to take out the non-road. Then the extracted roads were regulated by mathematical morphology. The result showed this proposed method could effectively extract the urban road information from high resolution Remo Tely sensed imagery.

Keywords: Road extraction; Gabor filter; texture; Geometrical features; Mathematical morphology

Extract Road information from remote sensing images for vehicle navigation , Traffic Control , City Planning and other urban remote sensing applications withSignificance . current , Road Extraction algorithm overall can be divided into a base extraction algorithm for edge tracking and extraction based on region segmentation Law two categories . method based on edge tracking to Extract the edge of a feature from a remote sensing image , matches , Connect to get road information M . Such methods can obtain _ effect , but the High resolution remote sensing image that is affected by the noise is still difficult to obtain from the edge information Ideal results . method based on region segmentation through Road objects split , Elimination of non-road objects and trimming of road sections , to to road information [4-] . the effect of such methods is greatly affected by the road split volume . therefore , feature values for road segmentation and Segmentation the model becomes the focus of research on such methods .

In recent years , Ground features spectral analysis and frequency domain feature extraction start the receives increasing attention .. Wang Ke , Zhao OK &1, Huangqiu yanM through spectral analysis ,, respectively implement to river channel , Road Road green space coverage and extraction of farmland information . The references the above algorithm think want , proposed one kind of binding Gabor path to texture and geometric features Extract Method . This method is used to analyze the basis of road spectrum features on , uses the Gabor Filter group highlights the line and direction of the road feature , and take

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advantage of the K - Neans The method initially splits the road object , and then use morphological methods to segment objects that are connected to the road , Select the appropriate geometry feature to remove non-road features . experimental junction results show , This method works , easily from high-resolution remote sensing shadows the image extracts the urban trunk road network with distinct directional features .

1. combines Gabor Road extraction methods for textures and geometric features

1.1 Road Spectrum feature Analysis for a size of M x N Remote Sensing image , second dimension discrete fourier transform defined as

T M-1 N-1

F (u,)= mvel /(x,) e - End). (1) type , and y is the spatial coordinates of the image ; u and v is the space frequency component . assumption F(u ,,) with the real part of (u ,«,), imaginary part is

called Fourier transform amplitude spectrum , also called Spectrum . The spectrum of every, Point represents the _ periodic component, its location (u,) and amplitude I F(u ,) I The reflects the frequency of the periodic component, respectively , Direction , with and its share in the image . The bright lines in the spectrum correspond to the object structure or edge that is perpendicular to the image . visible , spectrum and pattern the cycle and direction of the rationale are closely related , is ok Gabor filter wave Group related parameters

important basis .diagram 1 (a) is a region of IK (10) OS panchromatic

Image , size for 256 pixels x 256 pixels , Space resolution is 1 N . diagram 1 (b) to diagram 1 (a) Spectrum . for quantitative analysis of the spectrum of roads features , with radial and angular sampling of the spectrum , to obtain its radial and angular Energy distribution curve .

diagram 2 (a) The is the angular energy distribution curve of the spectrum . curve Peak value 83 and 167 The direction is the side of the bright spectral line to . to analyze the energy of the peak direction , respectively to two peaks value direction overrides 5 range wedge Filter . from Diagram 2 (b) and diagram 2 (c) The filter result

shown in shows the , 167 in the direction Energy comes mainly from A path that is distributed along the 77 direction , 3 direction Energy comes mainly from along 173 Direction distribution of roads and buildings

Object . visible , Clear path for directional features , can learn about its distribution direction from the Spectrum's angular energy distribution curve , The can get most of its energy along this .

(b) directional wedge filter (c)"" directional wedge filtering

diagram 2 spectrum angular energy distribution curve and its peak direction wedge filtering

to analyze the energy distribution of the road in the direction of the bright spectral line , respectively along 83 and 167 direction of the spectrum to be radially sampled , to to radial energy distribution curves as shown 3 (A) and diagram 3 (b) theshow . can see , the Energy distribution of the road on the bright line is low frequency large , at high frequency , and with increasing frequency , Energy distribution volatility becomes smaller . based on a large number of experimental summaries , Find roadsThe energy of the contribution is mainly focused on the (0,0. 2 band . the also requiresto indicate. contributes to Peak energy "" due to many ground features distributed along the road , So although you can quantify the peak energy of frequency , But this frequency does not necessarily correspond to the periodic component of the roadabout .

1.2 Is based on the Gabor Clustering Segmentation of texture features

1.2.1 Gabor Filter Group

Gabor The expression for the function has several forms , in the text Kamarainen etc proposed Normalization Gabor Formula , its empty field expression is H (x,,,;/,(p)) =-^e-F [] x 'hydrate$y'2 ' +j2n/x'.

(2)

N yn

sharpness . Its frequency field expression is

H (u,v[[/, e) = e (y2 (u'-f) 2 +n2v'2) (3)

where , (u ',')=(Ucos ^ - vsin ^, usin + VCOs History). diagram 4 to Gabor The shape of the filter in the airspace and frequency domain like , show obvious bandpass features . in use Gabor filter makes a Gabor Filter Group in addition to determining Gabor Filter to itself 4 parameters outside , also needs to consider the : The secondary axis of the filter Extended angle 0, frequency m ,Highest frequency /_, Adjacent Frequency scale factor k overlap of adjacent frequency filters P/ and adjacent directional filters overlap P . , and so on . to guarantee Gaborfilter The response of the group can contact each other at the half peak amplitude of the spectrum , ,/ the and the ~ one value 0.5. The remaining parameters of the are reciprocal conversions , actually only needs to determine 屮 ,m,/ max and k .

According to the literature , - Dan k determines , to calculate the y :

(4)

Y n k- 1

and N can be based on the 0 determines :

N = Yin2 / / itan (0) N]. (5)

= k -/ Max , F = { 0 , ... ' Hunger -1} . (6)

where / is the first I The central frequency of the filter .

1.2.2 Gabor Filter group parameters OK

1) parameter p ok . p is the bright spectral line direction of the Spectrum set , to highlight the directional characteristics of the road . p value can be from corner Get the to the peak point of the energy distribution curve . on the one hand only select a width value greater than maximum value of amplitude ; on the other hand to the fetched peak value point amplitude check , to Determine this peak point is within a limited angle is maximum . because the spectrum is in the direction of a non-peak point. Road Less energy , So this part of the spectrum does not need a filter to overwrite .

2) parameter 0 ok . for filtered texture images

to highlight road information , should avoid the of the filter in the secondary axis direction extended angle is too large . 0 values should be based on remote sensing image resolution Rate and the width of the extraction path are set . based on a large number of experimental summaries / values 5 / 0] is preferable to . General , for resolution greater than 1 m Remote sensing image , 0 Take 20 effect better ; and for resolution below 1 m Remote sensing Image , If the path being extracted is narrower / a value 5 or10 , and if the path being fetched is wider / General take value 20 .

3) parameter hungry /_ and k OK . Jainpresenting a to determine m methods , Set image size N pixel x N pixels , N to 2 Integer power , then m value log2 (N/4) . other , because the energy that the road contributes is often concentrated in the (0,0.2] band ,,, this /max value 0. 2. for k values , text through a lot of experiments

Summary , believes that when the adjacent frequency is Gabor filter Interval 2 Times frequency can achieve better results , so k value 4.

1.2.3 based on Gabor Clustering segmentation of texture features

A series of different frequencies obtained by using the above parameters to solve the process rate , different direction Gabor Filter to experimental image to line filter , can get pixel-by-byte Gabor Texture features . to extract Road information from high resolution remote sensing images , takes the K -means The resulting clustering algorithm for Gabor texture Feature clustering , merging based on people's judgment , initially divided from remote sensing images Cut Road objects . K.-means algorithm one more effective cluster analysis

algorithm , whose basic idea is : through iterations , move eachThe center of a base category , until best clustering results on . K-means Algorithm needs to specify the number of clustering in advance c, based on experimental summary , considers C value 4 or 5 works better .

1.3geometric feature recognition

1.3.1 morphological segmentation

Artificial objects are a class of complex

features , Different terrain is possible use similar or even identical surface materials , This leads to image Other features such as buildings such as are easily broken into roads . other , from to cluster segmentation using texture features , separated paths in is somewhat expanded , so it's common in split results There is a large adhesion on the edge of the road . so , on objects Before the geometry feature is recognized , to use morphological opening operations cut different objects that are sticking together at the edge of the road .

The morphological opening is the use of structural elements to two-value images into The line first corrodes the expanded process . text for the road in its extension the direction of a narrow banded distribution of features , Select a linear structure element The morphological segmentation of the result of cluster segmentation . line-shaped elements in the same direction as road extension , size is based on the side of the road margin of adhesion different , general values 3,7.

1.3.2 geometric feature recognition

Morphological segmentation results often exist in both roads , also exists Building-oriented non-road features , pass to road geometry special recognition , Remove non-road features , To extract the path letter ,,. because urban roads are usually linearly intersecting mesh , full degree less , and buildings more approximate rectangles , Full size, because the this , Comprehensive selection area (Area) and full degree (fullness) = number as road recognition geometry features .

1) area A defines the number of pixels contained in a zone . area index is used to eliminate minor objects , Reduce subsequent actions for the amount of calculation .

2) full F =A * /A/. where , for area area , A* for zone minimum external rectangle area .

1.3.3 morphological processing

after morphological segmentation and geometric feature recognition , also requires can be finalized by morphological refinement and burr removal. get road centerline . the morphological refinement algorithm can be based on a hit hit without transformHMT(hit/miss Transform) to set semantic . with morphological refinement , to remove burrs , must also find all endpoints and intersections in a two-value image with all . Its search method to : Iterate through the pixels in a binary image , Place each pixel 8 The gray value of the neighboring pixels is subtracted by 22 and the absolute value , then add all the results , when and to 2 think this pixel is end point , when and to 6 , the pixel is considered a crossover . for after all endpoints and intersections , to further remove burrs . Its rationale is : Find each endpoint , and moving along a thin line 5 Pixel , if crossing points are encountered within 5 , is considered the end Point to Burr ,and remove this point .

2.Experimental results and analysis

2.1 experiment 1

Experiment 1 primarily verifies the correctness of the proposed algorithm . using the lift out algorithm pair diagram 1 (a) main road extraction , steps Results of the experiment as shown in the diagram 5 Show .

cluster split result

(b) geometric feature recognition results

from Diagram 5 can be seen in , diagram 5 (a) after morphological cut with geometric feature recognition , Nursery , bare earth and buildings have been picked except ,to get diagram 5 (b) Road Information

shown in ; and then through the shape State Refine and remove burrs , quick access to figure 5 (c) shows Road Centerline . Overlay Road centerline with original image , As shown in 5 (d) . can see , using the proposed algorithm pair diagram 1 (a) The backbone of the road network on the extraction , can get more reason the results you want to further verify the correctness of the proposed algorithm , the has A large number of experiments , Here are two representative sets of experimental results . Chart 6 (a) to a resolution of 0. 5 m , size is The Pixel x a Pixel GeoEye 4 Image ;diagram 7 (a) is a distinguished rate 2.5 m , size is The Pixel X The Pixel SPOT -5

Image . Experimental results and related parameter settings as shown in the diagram 6, 7

and table 1 are shown .

(a) original image

(b) Clustering split results

diagram 6 geoeye - L Image Path extraction process, you can see from the results of the experiment that , to propose algorithms for different sensors The Urban Roads on the high resolution remote sensing images of the type have the better Extract effect , This indicates that the proposed algorithm has a strong fit compliance .

2.2 experiment 2

Experiment 2 by using the proposed algorithm with different road segmentation algorithms Compare , proposed algorithm from visual and time-consuming aspectsto evaluate . experiment using original image grayscale features , text offer 9] algorithm and documentation 2 0] algorithm to diagram 1 (a) and diagram 7 (b) Road split . split results for different algorithms [diagram 8 and diagram 9 are shown .

(C) Is based on the traditional Gaboi • feature (d) algorithm

(a) based on grayscale features

you can see from visual effects , uses grayscale features only to access the Road image split , Road with bare soil , Building Objects mixed with grave , and accompanied by a lot of salt and pepper noise . use GLCM Texture Special Levy split , road breaks and edge adhesion more stringent heavy . use traditional Gabor texture feature split ,because of its uniformly cover all bands and orientations of the spectrum , so the road's mixed the point and edge adhesion are still more pronounced . and in the split resultof the proposed algorithm , not only the false points of the road , break and Edge adhesion now appears significantly less , and separated objects are complete and clearExplicit geometric features . This is more advantageous for subsequent geometric feature recognition and morphology post-learning processing, etc. .

4 the time consuming for the partitioning algorithm is the table 2 shows . can look at show , The proposes the algorithm to guarantee the segmentation quality while dividing the efficiency also has _ Set Advantage .

3. Conclusion

3.1 propose an algorithm to quantify road spectrum characteristics analysis , specifically designed the Gabor Filter group , And this is based on the road image GaborTexture feature Extraction and division slit , not only make the quality of road segmentation significantly better , and large greatly shortened split time . The experiment shows that , presents an algorithm to accurate extraction of urban roads on high-resolution remote sensing images , and the more obvious the line feature of the road , The better the extraction effect .

3.2 parameter 0 directly affect quality of road segmentation , If you can based on remote sensing image resolution and road width information automatically set 0 Best value , the _ raises the automation of the algorithm to The _ step Increase .

3.3 proposes that the algorithm has certain requirements for the applicable image , shadow The path on the image must be more straight . Road is more straight , Extract effect Better fruit ; bends , the more inappropriate the algorithm is with .

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