International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-2, Issue-1, January 2016
ISSN: 2395-3470
www.ijseas.com

A Survey on Remote Sensing Image Segmentation

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Abstract

Remote Sensing image segmentation is based on region growing/merging, simulated annealing, boundary detection, probability based image segmentation, probability based image segmentation, fractal net evolution approach and more. In this paper various segmentation methods used in remote sensing images are reviewed.

Keywords: Segmentation ,scale, Fuzzy ,Texture
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1. Introduction

Image segmentation in general is defined as a process of partitioning an image into homogenous groups such that each region is homogenous but the union of no two adjacent regions is homogenous. Image segmentation has been interpreted differently for different applications. For example, in machine vision applications, it is viewed as a bridge between low level and high level vision subsystems, in medical imaging as a tool to delineate anatomical structure.

Segmentation is based on different criteria. One of the criterion is the scale parameter, which is an abstract value to determine the maximum possible change of difference caused by combining different objects. It is dependent on the size of the object. Small scale number and large scale number results in small objects and large objects respectively, refers to multiresolution image segmentation. The second criteria is the color which is actually the pixel value. The next criteria is the shape which includes smoothness , which describes the similarity between image object borders and a perfect square and compactness, which describes the closeness of pixels clustered in an object by comparing it to a circle . The last criteria is the neighborhood function, which compares image object grown with adjacent pixels.

Classification of image object is based on fuzzy system and nearest neighbor. Membership functions based on fuzzy logic is used to determine if an object is belonging to a class or not. The classification method used in nearest neighbor is that in which individual image objects are marked as training areas of a class and rest of the scene is classified accordingly.

Texture and non-texture images are contained in the imagery which are used in the image segmentation method. Texture images proposes a large number of methods. These method defines two issues: The texture model defines the region similarity and a method for segmentation. A successful segmentation method should depend on both accurate texture model and effective segmentation strategy.

The rest of this paper is organized as follows: In Section II, we introduce different segmentation techniques used in remote sensing images. In section III contains conclusion about techniques used in various segmentation method.

II. Literature Review

The main step in object-oriented classification is image segmentation which divides an image into non overlapping regions in which each region is as homogeneous and neighboring ones are different as possible.

In remote sensing data, object based analysis methods receives more and more attention. It uses regions or segments as basic units which has a number of advantages such as reduced spectral variability and more spatial and contextual information such as shape and topological relationships.

Geographic object based image analysis (GEOBIA) [1] has received tremendous attention in analyzing remote sensing images. GEOBIA is based upon two major concepts a) dividing images b) allowing for multiple scales when organizing and utilizing the segmented objects.

[2] Reviewed various segmentation techniques .Measurement space guided clustering involves separating images based on histogram peaks to define classes in the image. This type of segmentation is most likely to avoid errors through poor region merges. It doesn't provide spatially contiguous regions and which may result in salt and pepper effect. Single linkage algorithms involving individual pixel linkage to create regions. Hybrid linkage avoids this problem through using neighborhood characteristic. In centroid based algorithm region means are recomputed as regions are merged. Texture can be thought of as the spatial patterns in an image.

Remote sensing radiometers which produce multispectral images provide much enhanced capabilities of characterizing ground objects. Both spectral and texture information are expected to use in the remote sensing segmentation techniques. Automatic segmentation using region based method and feature distribution [3] consists of three steps 1) Hierarchical splitting 2) agglomerative merging 3) Pixel-wise refining .This method doesn't require a priori knowledge. According to their features such as texture, intensity etc. different regions are separated. Then the merging method merges the similar adjacent sub regions until a stopping criterion is satisfied. Pixel wise refinement is used to improve localization of the region boundaries. In order to describe the region features, we use feature distribution. The n-dimensional discrete histogram is used as the feature descriptor. For a region i,the feature can be described as

$$H_i(x)=F(x)/N_i \quad \sum H_i(x)=1$$

Where $H_i(x)$ is the histogram function, x feature vector (x) is the pixel number of the vector x and x_i is the total pixel number of the region. To measure the similarity of two histograms H_i and H_j:

$$P_{ij}=cov(Hi,Hj)/\sigma_i\sigma_j P_{ij}<1$$

Where $cov(H_i,H_j)$ is the covariance of the two histogram σi and σj are the mean square deviation. The result of the correlation coefficient is high values, which indicate high similarity of the two feature distribution .The last problem is to integrate multiple features of the different regions. To measure the similarity $sim_{ij}(f_t,f_i,f_c)$ of two regions i and j, we use an aggregate function

$$Sim_{ij}(f_t,fi,f_c)=c_t p_t+c_i p_i+c_c p_c$$

Where f_t,f_i,f_c represent the three different types of features, which are described as the histograms: p_t,p_i,p_c are respectively similarity measures of texture, intensity and color features.

Texture is very difficult to characterize. A multiscale texture analysis procedure for improved forest stand classification [4] utilized two different approaches: local variance and second order statistics. Local image variance is a measure of deviation from the mean within the processing neighborhood. This procedure results in a dataset which contains the variance values for all spectral bands. The maximum size of the processing window was set using range values. The next approach is the second order statistics. This method uses three second order texture measures: angular second moment, entropy and contrast. Angular second moment measures homogeneity. Entropy is a measure of the amount of the order and repeatability and contrast is the measure of the degree of spread of the values in the matrix.

Watershed method is one of the traditional segmentation method. It is a mathematical approach. First image is converted to its gradient format. Then image is seen as the topographical surface where grey values are deemed as the elevation of the surface at that location.Then, flooding process starts in which water effuses out of the minimum grey value. When flooding across two minimum converges then a dam is built to identify the boundary across them. This method is essentially an edge based technique. The original watershed algorithm was susceptible to over segmentation so a modified marker-controlled based watershed algorithm. Watershed algorithm produces over-segmentation because of noise or textured patterns. The application of watershed algorithm on remote sensing imageries requires only low computational cost.

Zhang Huiganget al. proposes a segmentation algorithm that requires graph laplacian energy as a generic measure. To capture the internal geometric analysis, we apply local self-similarity feature in an image. After calculating the image gradient, divide the image into small connected regions using watershed algorithm. Then transforms the input image into a region adjacency graph. The next step is to create hierarchical tree description which merges neighboring regions from bottom up. In each merging iteration, the newly merged regions are the parent nodes and continues until there is only one region left.

A novel texture preceded segmentation algorithm for high resolution imagery [5] uses a texture preceded algorithm for segmentation .Fast node merging can be achieved by region adjacency graph depending on a global optimum. The similarity between nodes in the graph is established by a combined distance, composed of texture, spectral and shape features. Then the final segmentation can be obtained iteratively by fast merging. This algorithm can also detect the real object boundaries.

The cues of contour and texture differences are exploited simultaneously because natural images contain both textured and untextured regions. Contour and texture analysis for image segmentation [6] uses algorithm which partitions grayscale images into disjoint regions of coherent brightness and texture. Contours are treated in the intervening contour framework, while texture is analyzed during textons.

In [7] we use local spectral histogram representation, which consists of histograms of filter responses in a local window. This representation provides an effective feature to capture both spectral and texture information. However, as a form of texture descriptors, local spectral histograms also suffer from the problems of high dimensionality and boundary localization. The computation leading to a spectral histogram involves commonly used spatial/frequency filters, and thus our definition does not invoke perceptual attributes.

Image segmentation using local spectral histograms and linear regression [8] uses a form of texture descriptors. A local spectral histograms also suffer from the problems of high dimensionality and boundary localization. To address these problems, we employ a recently proposed segmentation method, which formulates segmentation as multivariate linear regression. This method works across different bands in a computationally efficient way and accurately localizes boundaries

With remote sensing images, segmentation is inextricably linked to the scale issue. Conceptually, scale is a “window of perception” [9]. It is well known that meaningful structures and objects exist over a certain range of scales. In image processing, a scale usually refers to the size of the operators or measurement probes used to extract information from image data. Improper scales can lead to over segmentation, where segments correspond to portions of regions, or under segmentation, where one segment contains multiple land-cover classes.

MengjieZhang[11] performed segmentation using neural networks. Neural networks using image features as the input vectors. In this method the features of the object which have to be segmented is first identified by manual analysis of object samples. Programs are created according to this .Then it will be used in a neural network classifier. There are different types of neural networks like multi-layer feed-forward networks, ART (Adaptive Resonance Theory) net- works, SOM (Self-Organizing Maps) and recurrent networks. The number of output node is equal to the number of small objects present in the large pictures. As the number of hidden layers increases results in high error rare in the testing data but accuracy increases in the case of training data.

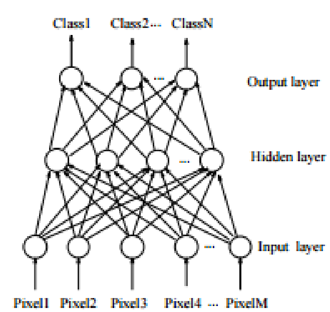

Fig 1.Neural network illustration

III. Conclusion

Different segmentation techniques are explained in this paper. In order to regain the contents of the paper it is necessary to summarize all these techniques.

The main criteria of segmentation are linked to scale parameter. Scale refers to the size of the window. The performance of the method decreases when selecting large segment number for dealing with complex images. Watershed algorithm has some disadvantages like over segmentation but it requires on low computational cost. In the case of segmentation using neural network, the speed of the segmentation is fair but it requires long time for training sample objects. The segmentation algorithm which uses combined features requires local spectra histograms for combining the features. Local spectra histograms have some problems such as boundary localization and high dimensionality.

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