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Spatial clustering method for satellite image segmentation

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Abstract: *spatial clustering method can be used for the analysis of satellite image to get the meaningful information with the help of fuzzy local information c-means algorithm using image segmentation technique. In previous clustering based image segmentation method may lose the important image details due to the noise present in the satellite image. The effects of noise are avoided by the spatial relationship among pixels, but it often generates boundary zones for the mix of pixel around the edges .To overcome these problem (FELICM) reduces the edge degradation by introducing the weights of pixel within the local neighboring windows. Canny edge detection used for the extraction of edges, during that detection multi-Otsu threshold can be used to obtain two adaptive thresholds. Local neighbors and window center are separated by edge with respect to different weights are set to the windows. Until the final clustering result may be obtained in a efficient manner the pixel of the different local neighbor window periodically iterated. Without any filter preprocessing steps FELICM method can directly applied to the satellite image to get the valuable information when compared to the remote sensing image of a experimental results and not only solves the problem of isolation of samples and random distribution of pixels inside the region but it also produce the high edge accuracies.*

Index terms: *spatial clustering, image segmentation, canny edge detection, local information, multi-Otsu threshold.*

I. Introduction

Isolation of object or samples, and ignores the spatial relationship with respect to the pixel image clustering is an effective method for image segmentation.

Usually noise are present in that image, before clustering some smooth filters[1]-[3]are used to reduce the noise, and some other researcher to decrease the difference among the pixel[4],[5] in a region to use the texture description or spectral reduction as per the color clustering and color learning algorithm. The preprocessing steps of image clustering may lose some important image details and also it depends upon some important parameter like mean shift, and robustness of clustering.

Number of algorithm[6]-[9] have proposed for clustering based image segmentation to make clustering are more robust such as bias corrected fuzzy c-means (FCM) (BCFCM) which can deal with the original image. The spectral features of pixel and mean filtered neighbors and the parameter of controls the effect of neighbors to determine the label of pixel in BCFCM method and also introduce the partial membership function for classifying the object or samples to different number of cluster present in that image using fuzzy factor. The combined results of support vector machine(SVM) and clustering using majority voting[6] are used to determine the homogeneous region in the hyper spectral (spectral –spatial) images and also ISODATA algorithm and Gaussian mixture resolving techniques used for the image clustering.[7] presented the new adaptive clustering algorithm is capable of utilizing local contextual information to impose the local spatial continuity that exploiting the inter-pixel correlation inherent in most of the real –world images. The proposed of Dulyakarn and Rangsanseri [8] spatial information with FCM improved the segmentation performance when compared to the remote sensing image results. FLICM can overcome the disadvantages of fuzzy c- means algorithm [10] and at the same enhance the clustering performance using the spectral and spatial information with the help of fuzzy factor, and it also noise insensitive method. In this method label of one pixel is related to label of its spatial neighbors, and the edges of each region will be dislocated due to the incorrect cluster of labels assigned to pixel. Therefore fuzzy c-means (FCM) with edge and local information (FELICM) reduces the edge degradation by introducing the weights of pixel within the local neighboring windows and also produce the high edge accuracies when compared to the FLICM. The implementation of spatial image clustering will be introduced in the section II. Experimental results and discussion will be addressed in the section III. Finally the conclusion and future enhancement work will be drawn.

II. Implementation Of Spatial Image Clustering Segmentation

The methodology of image clustering procedure is explained in fig 1.using the principle component analysis (PCA) the gray image can be obtained from the original satellite image. From the gray image the noise is removed by using the Gaussian filter and the canny edge detection [11] can be used to extract the edges with the help of two adaptive threshold (high and low) using multi-Otsu threshold techniques [12]. Using the estimation of edges and lines from the grey image different number of weights are set to the local neighboring (next or near to) windows. After that process depending upon the spectral information from the (PCA) and spatial information from the local neighboring windows the FLICM uses the clustering property to clustered the satellite image in a pixel-by-pixel manner. Finally the effective clustering based segmented image can be obtained from the edge pixel processing on the clustered image.

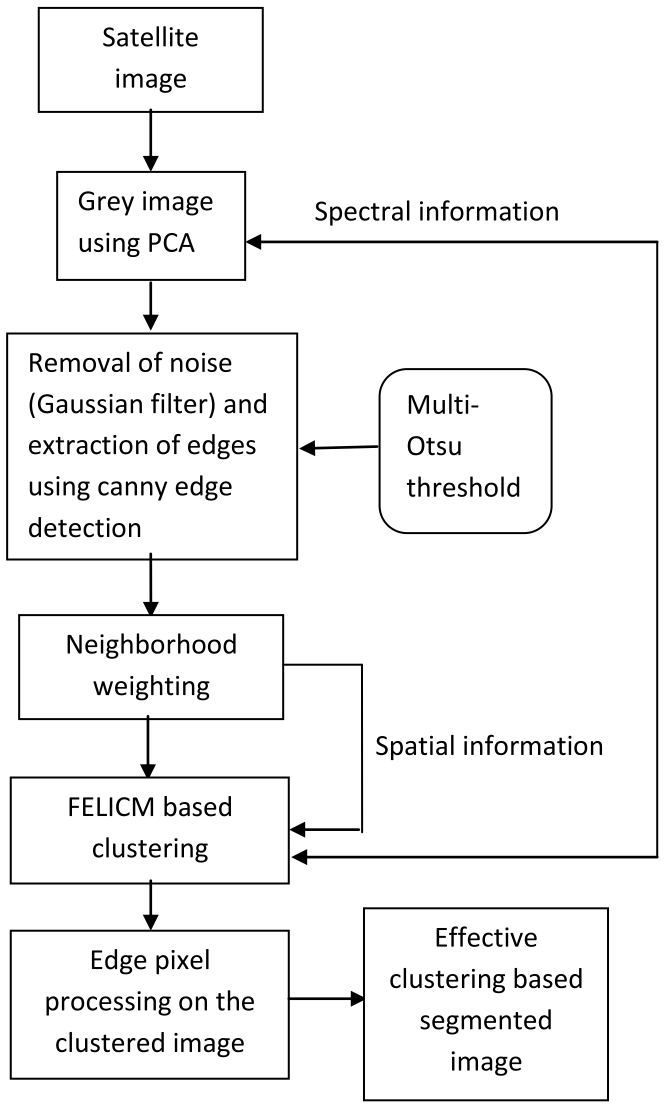


Fig 1. Architecture of spatial clustering method

A. Principle component analysis (PCA)

Principle component analysis is mathematical procedures that use the orthogonal transformation to convert the set of observation of possible correlated variables into set of linearity uncorrelated variables. Using this method the grey image can be obtained from the RGB color satellite image then lot of edge can be extracted from the grey image by adjusting the two threshold (high and low) canny edge detection algorithm.

B.Canny edge extraction procedure

Canny edge detection plays a important role in the field image processing to determine the edges from the grey images. Enhancement of edges can be used to identify the edges and threshold value based on their

pixel value having the significant change in local intensity and it also estimate the location of object in an image to extract their shape,size,image sharpening etc. It is mainly depends upon low error rate, localization and responses because of canny edge detector is optimal edge detector.
The basic steps of canny edge detection as follows.

1) Reduction of noise.

Before extracting the edges the noise is filtered out by the Gaussian filter and also improve edge detector performance with respect to noise. Removal of noise before clustering mainly based on two factors such as choosing the width of the image and identification of edges by taking the gradient of the image(the grey image is convolved with 5×5 Gaussian filter with standard deviation σ=0.4).

2) Finding the intensity of gradient image

To determine the edges in an image the canny operator uses the four types of filter to detect the horizontal, vertical, diagonal edges in the blurred image.

3) Non maximum suppression

After the estimation of image gradients to determine if the gradient magnitude assumes a local maximum intensity in the gradient direction. In many implementations, the algorithm categorizes the continuous gradient directions into a small set of discrete directions, and then moves a 3x3 filter over the output of the previous step (that is, the edge strength and gradient directions). At every pixel, it suppresses the edge strength of the center pixel (by setting its value to 0) if its magnitude is not greater than the magnitude of the two neighbors in the gradient direction.

4) Tracing the edges through the image and hysteresis thresholding

Thresholding with hysteresis requires two thresholds (high and low) can be obtained by multi-Otsu threshold technique.. The multi-Otsu threshold can be used to find the threshold with the help of gradient histogram and the optimum threshold is calculated by separating the gradients into three types. In this way two adaptive thresholds for edge detection can be obtained. After the non maximum suppression thin edge map with edges of one pixel width can be obtained. A 5×5window is used to scan the edge map, if the center pixel of the window is a candidate edge pixel; the gradient of this pixel is set to

$$Ti = \frac{\sum_{j=1}^{n} Tj}{n} \qquad (1)$$

Where and n are the gradient of candidate edge pixel j and the number of candidate edge pixel respectively, within the window. And the histogram is created by recording the gradient of edge pixel and the statistical mean is

$$u = \frac{\sum_{i=1}^{l} si}{l} \qquad (2)$$

Where si represents the count value of cell i who is greater than in the histogram and l is the number of cells whose count value is greater than zero. Therefore the count values are lower than u are combined with their nearest cells to reduce the number of cells. The two thresholds are calculated with respect to the histogram using multi-Otsu method and it is also the optimum threshold for the canny edge detection operator.

Since the two adaptive thresholds are obtain more edges and correct the boundaries of object which are present in the image. The canny operator does not estimate the accurate boundaries but it also gets the edges with respect to the sets of weights in the local neighbor window and the edges inside the same re will be eliminated after clustering.

C. *neighborhood weight implementation*

We make a neighborhood processing implementation by using the straight line can be used to cut the pixel window diagonally into two edges of region, and if the two different regions can be used to finding the most useful spatial neighbors are present in the different region of an image. The weights are set for only at the pixel which is present in the different region not for the same region of image.
The weight set for the pixel of local neighbors is implemented by following methods.

1. The pixel which is present in the n×n neighbor window it is mainly affected by the center of the pixel pi that is size of the s1i spatial neighbor window is less than that of the center pixel window size pi.
2. Get an m×m spatial neighbor window s2i from the same center of the spatial neighbor window s1i, where m=2×n+1.
3. With the help of s2i window and set the total number of t which can be used to count the number of neighbors pixel which are not separated from the center pixel pi. Suppose if t is more than n2, the weight of the pixel pj within the window s1i is set as

$$wij = \begin{cases} 0.33, if pi, pj \text{ are seperated by edge} \\ 1, otherwise \end{cases}$$

The weight of the pixel pj is should be set as zero then if pi and pj are separated by edges. Here the weight set as 0.33 as weakening the possible errors in edge detection.
5. Suppose if t is less then n2 the weight of the pixel pj within the window s1i is wij=1.
The above calculation of neighborhood weighting should be existing in the following three cases.

Case1.if the weight of the pixel should be always 1 in s1i even if there is no edges are present within the window s1i.
Case2. Regarding with the step 4 in above section as the neighbor pixel are separated by edges and if the two pixel belongs to the different region, since the weight of the neighbor pixel pj set as 0.33 as the result of the center pixel pi can also be reduced.
Case3. If there is any edge exist in window s1i and the total number of t in the windows s2i is less than n2. This case may be occurred by the noise and edge error, and the weight of the pixel in window s1i as set as one. Since the effect of errors can be corrected by the spatial neighborhood.

D.FELICM based clustering

It is the iterative clustering method then the objective function of the FELICM can be expressed for an image of N pixel p={p1,p2,p3…pN} such as,

$$J = \sum_{i=1}^{N} \sum_{K=1}^{C} [Qki + Gki] \qquad (3)$$

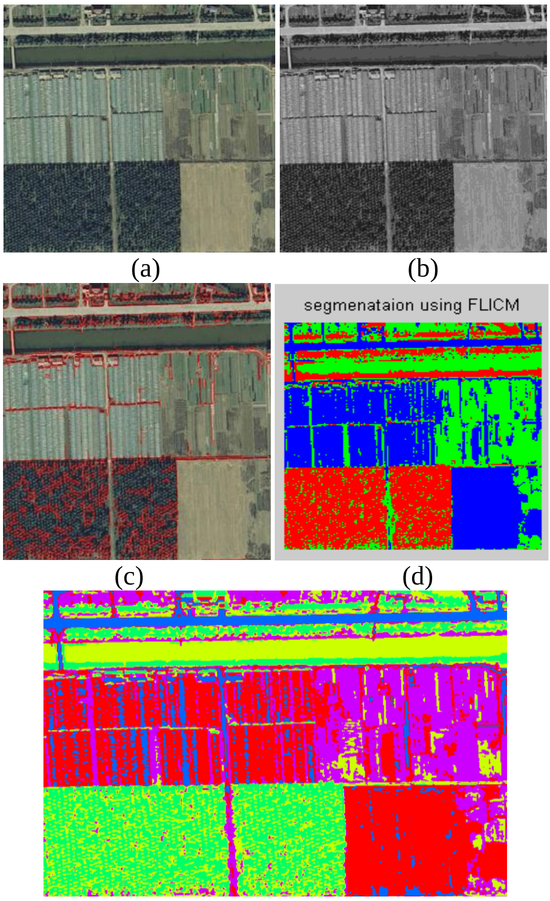
Where, N is the representation of number of pixel and c is the number of cluster and Qki is the distance between the pixel pi,and the center of cluster k can be defined as

$$Qki = u_{ki}^{m} \|pi - vk\|2 \qquad (4)$$

Where m is the exponent weighting factor, uki is the membership degree of pixel pi to the cluster k, and vk is the prototype center cluster k.
The distance Gki is the spatial neighbors of the pixel pi, and the center of the cluster k is used to control the impact of noise and it can be defined as

$$Gki = \sum_{\substack{j \in s1i \\ i \neq j}} \frac{1}{dij+1} [wij\,(1 - ukj)]^{m} \|pj - vk\|^{2} \qquad (5)$$

Where pixel pj is belongs to the window s1i whose center is pixel pi, pj is the spatial Euclidean distance between pi, pj and wij is the weight of the pixel pj in the window s1i.
In this FELICM method different weights are assigned to all the pixel in the satellite image and the edges of region can be obtained by using the weighted windows. From using the above description the distance between the Gki of the spatial neighbors of the pixel pi, and the center of the cluster k can be obtained without any parameter. It can be changed automatically with respect to the spectral features of pixel in the spatial window and fuzzy membership of pixel to the cluster. The fuzzy membership can be used to improve the accuracy of clustering and also preserve the satellite image details. Finally the clustering result can be achieved efficiently based on the FELICM procedures and the canny operator can be assigned at the nearest adjacent region to detect the edges of the entire pixel in the image.



(a) (b) (c) (d) (e)

Fig.2 Experiment Of Satellite Image (a) satellite image (b) grey image (c) canny edge detection (d) results of FLICM (e) result of FELICM.

III. Experimental Results and Discussion.

If the satellite image is taken out from the rural area which is located in the eastern of china at Chongming Island and the size of the satellite image is 487×487 matrix of pixel and the format of image is Tiff.. This satellite image contains several types of agricultural land, small building and rivers. Using the artificial segmentation the reference data as collected from the satellite image. Maintain the balance between clustering efficiency and effect of neighboring window size at the range 11×11 matrix with the help of LUV color space can be used.

Fig. 2(c) shows the result of FLICM method in this figure more number of isolated region reduced efficiently in a visualized manner, but even also some errors are occurred at the edges which are present in the satellite image. For example agricultural land and planted forest which are located in different region in the image in a clear format but even also some errors are present at the bottom part of the image. But FLICM algorithm shows better edge accuracy performance when compared to the FLICM method then the edges are estimated by using canny edge detection operator and determine the pixel are separated in local spatial windows region and also edges of object is distributed within the region or isolated region.

A.Quantative evaluation based on edge accuracies and regional accuracies

The quantities evaluation method mainly based on the edge accuracies and regional accuracies in the clustering based image segmentation technique. Usually the reference data may not be available for the complex satellite images because the object or samples have the same features and it cannot be separated in an efficient level, therefore to use the artificial segmentation technique to obtain the reference data about the satellite image to increase the clustering rate to evaluate their performance.

1) Determination of regional accuracy

Now, applying the regional accuracy can be expressed as

$$RA = \frac{\sum_{i=1}^{n} max\{Aik\}}{N} k \in [1, c] \qquad (6)$$

Where N is the overall number of pixel in the image, n is the number of object in the reference data and Aik is the number of pixel of cluster k in object i, and max {.}Used to obtain maximum number of pixel of all the cluster in the object.

Algorithm	FCM	Mean Shift	FLICM	FELICM
accuracy	68.4%	78.0%	82.7%	82.6%

Tabular column shows regional accuracy for different fuzzy c-means method based on the reference data.

This tabular column shows the regional accuracy percentage for different types of fuzzy c-means method with respect to the satellite image comparatively. In this method mean shift produces greater accuracy compared to the fuzzy c-means (FCM) method and mean shift has less regional accuracy when compared to (FLICM) method similar to that of FELICM also. But the FELICM method highly concentrates for the determination of edges to the object which is present in the satellite image comparing to the regional part.

2) Determination of edge accuracy with respect to FELICM

The edge accuracy can be defined as the accuracy of pixel can be around the edges in the image to calculate the edge accuracy performance by using the equation can be expressed a

$$EA = \sum_{i=1}^{n} \frac{A\prime ik}{N\prime} k = \underset{K\in[1.C]}{argmax}\{Aik\} \quad (7)$$

The following diagram shows edge accuracies result with respect to FLICM vs FELICM corresponding to the satellite image.

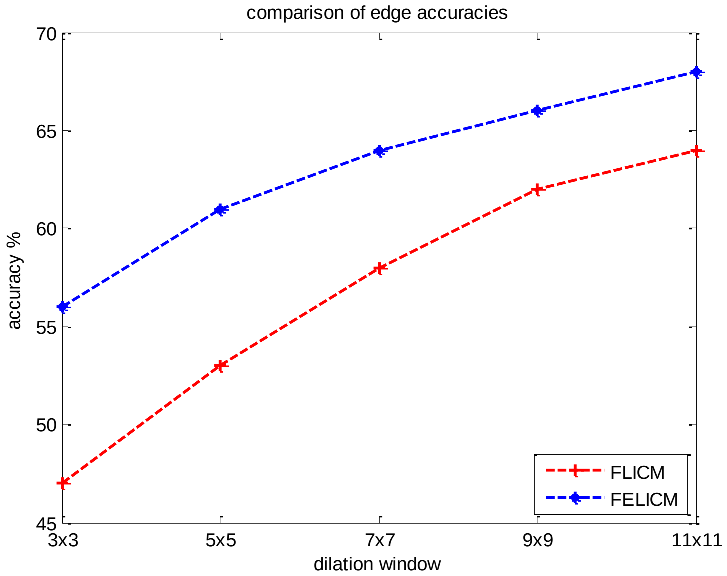


Fig 3.comparison of edge accuracies.

Usually edge accuracies result of the small dilation window is slightly lower than that of large dilation window that means the accuracies of pixel edge are more accurate in within the region compared to the nearest edges. Due to that reason FELICM produce more edge accuracy increased at the rate of 2% to8% within in a small number of iteration such as 17 can be needed compared to the iterated result of 19 for FLICM and also reduces time consumption process with respect to the iteration timing of FLICM method.

IV. Conclusion

In clustering based satellite image segmentation the FLICM uses the local information to guarantee the noise insensitivities, but it often produce the boundary zones due to the mix of pixel near the edges of different region. To overcome the drawback or compensate the clustering edge accuracies of FLICM fuzzy edge with local information c-means (FELICM) produce more accurate result. Since the FELICM method effectively solves the problem of isolation or samples or object and random distribution of pixel inside the region and also obtains the high edge accuracies. Therefore performance of the satellite image segmentation should be evaluated in terms of clustering efficiency and sensitivity.

FUTURE WORK

Usually Gaussian filters are only used to remove the noise in all the fuzzy c-means method, while using the Laplace transform with combination of neural network and fuzzy c-means produce highly reduced noise with effective clustering.

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