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Performance Analysis of Segmentation of Hyperspectral Images Based on Color Image Segmentation

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Abstract

Image segmentation is a fundamental approach in the field of image processing and based on user's application .This paper propose an original and simple segmentation strategy based on the EM approach that resolves many informatics problems about hyperspectral images which are observed by airborne sensors. In a first step, to simplify the input color textured image into a color image without texture. The final segmentation is simply achieved by a spatially color segmentation using feature vector with the set of color values contained around the pixel to be classified with some mathematical equations. The spatial constraint allows taking into account the inherent spatial relationships of any image and its color. This approach provides effective PSNR for the segmented image. These results have the better performance as the segmented images are compared with Watershed & Region Growing Algorithm and provide effective segmentation for the Spectral Images & Medical Images.

1. Introduction

Images contains many information in it, some of part of an image is important for research and application. Image processing is an essential process to separate those important from the image. For image segmentation there are various existing algorithms [1]. Among which the widely used one is *k* means clustering algorithm. The k means clustering algorithm has disadvantage that it takes number of cluster as an input parameter whose inappropriate choice may yield poor results [3]. The quality of the segmentation depends a lot on image. Solar radiation spectrum which are reflected by Earth's surface are measured by Airborne and satellite hyper spectral sensors. For identification of elements on the surface of earth like minerals, farming land , water sources and environment etc., these spectrum might use and are often unique. This data is often in range of hundreds of megabytes so it requires considerable time and computing resources. For a particular application relevant information should be extracted from the huge amount of data. An algorithm which is based on basic color approach that can help to segment the required information. Solar radiation spectrum which are reflected by Earth's surface are measured by Airborne and satellite hyper spectral sensors. For identification of elements on the surface of earth like minerals, farming land, water sources and environment etc., these spectrum might use and are often unique. This data is often in range of hundreds of megabytes so it requires considerable time and computing resources. For a particular application relevant information should be extracted from the huge amount of data [2].

2. Segmentation Based on EM algorithm

2.1 Parameters Estimation

The EM (expectation-maximization) algorithm is an iterative approach to compute maximum-likelihood estimates when the observations are incomplete. In the mixture density estimation, the information that indicates the component from which the observable sample originates is unobservable. The E step computes an expectation of the likelihood by including the latent variables as if they were observed, and a maximization (M) step, which computes the maximum likelihood estimates of the parameters by maximizing the expected likelihood found on the last E step. The parameters found on the M step are then used to begin another E step, and the process is repeated until convergence [4].

The EM algorithm is very used for the research of the parameter achieving the maximum likelihood. The criteria of stop of the algorithm, is either a maximum number of iterations to limit the time of calculation, either a lower mistake. It is put easily in application because it leans on the calculation of the complete data. The EM algorithm is very similar in setup to the K-Means algorithm. Similarly, the first step of algorithm is to choose the input partitions. For the case, the same initial partitions used in this color segmentation with K-Means were used in order to compare of results more meaningful. Here, RGB color was again chosen as the comparison parameter. The EM cycle begins with an expectation step which is defined by the following equation:

$$E[z_{ij}] = \frac{p\left(x = x_i \mid \mu = \mu_j\right)}{\sum_{n=1}^{k} p\left(x = x_i \mid \mu = \mu_n\right)} = \frac{e^{-\frac{1}{2\sigma^2}\left(x_i - \mu_j\right)^2}}{\sum_{n=1}^{k} e^{-\frac{1}{2\sigma^2}\left(x_i - \mu_n\right)^2}} \tag{1}$$

The aforementioned equation states that the expectations or weight for pixel z with respect to partition j equals the probability that x is pixel x_i given that μ is partition μ_i divided by the sum over all partitions k of the same previously described probability. It leads to the lower expression for the weights. The sigma squared seen in the second expression represents the covariance of the pixel data. Once the E step has been performed and every pixel has a weight or expectation for each partition, the M step or maximization step begins. This step is defined by the following equation:

$$\mu_j \leftarrow \frac{1}{m} \sum_{i=1}^{m} E[z_{ij}] x_i \tag{2}$$

This equation states that the partition value j is changed to the weighted average of the pixel values where the weights are the weights from the E step for this particular partition. This EM cycle is repeated for each new set of partitions until, as in the K-Means algorithm, the partition values no longer change by a significant amount. Performances of different filters are tested for different types of noise models by calculating the MSE and PSNR. The values are calculated by the following expressions.

MSE is given by:

$$\text{MSE} = \sum_{x=1}^{M}\sum_{y=1}^{N}\left(f\,(x,y) - \hat{f}\,(x,y)\right)^2 \tag{3}$$

where M and N are total number of pixels, f and $\hat{f}$ are the original and segmented image respectively.

$$\text{PSNR} = 20\,log_{10}\left(256\right)/\ \text{MSE} \tag{4}$$

where MSE represents the mean square error of the estimation. The size of the image taken is 256X256 pixels. Steps of Algorithm are shown below.

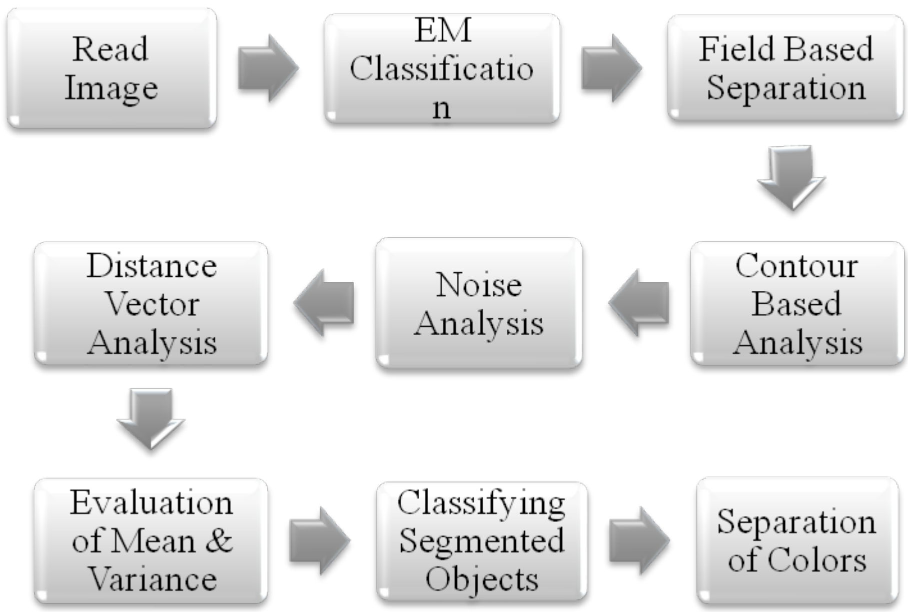
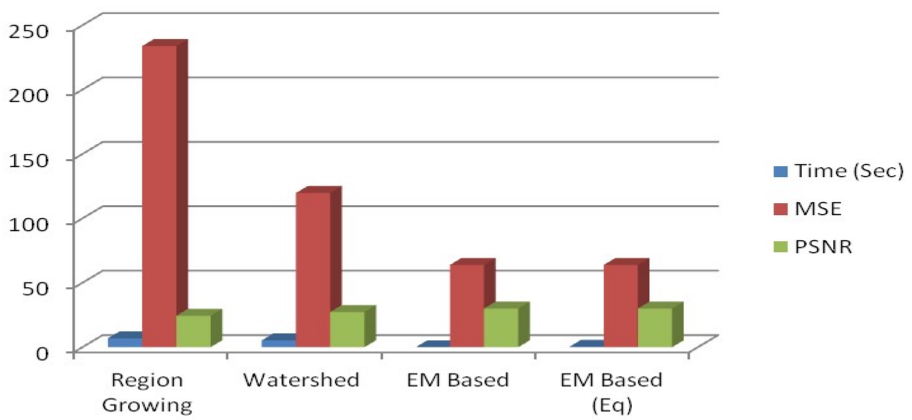


Fig. 1. Steps of the Proposed Algorithm

Table 3. Results of Hyperspectral Image

Approach → Parameters ↓	Region Growing	Watershed	EM Based	EM Based (Eq)
Time (Sec)	6.9436	5.3452	0.0524*	0.4
MSE	233.8495	119.8061	63.9143	63.9143
PSNR	24.4414	27.346	30.0748	30.0748

* Indicates A single Color Expectation Analysis



3. Experimental Results & Conclusion

We applied the proposed EM algorithm on a hyper spectral image of a geographical area and some parameters are compared with the conventional Watershed algorithm and Region Growing method which is given in the table. Original hyperspectral image is in figure 2 and some results of watershed are shown in figure 3 and 4 then results from Region growing are also shown in figure 5 and figure 6 and the results from the EM algorithm are shown in next two figures .

Fig. 2. Original hyperspectral image of a geographical area

Some results of Watershed Algorithm

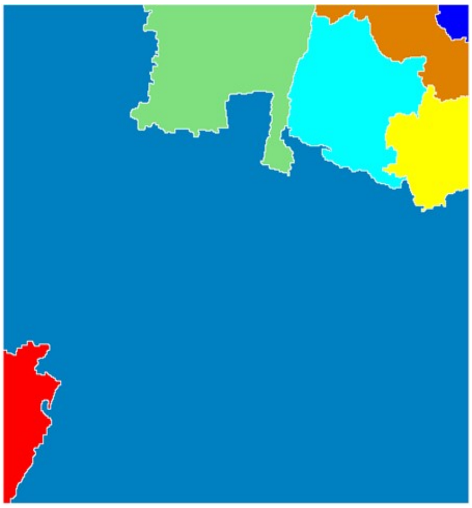


Fig. 3. Colored watershed label matrix (Lrgb)

Fig. 4. Markers and object boundaries superimposed on original image (I4)

In figure 7 Blue color is segmented from the original image which is the desired information and in the figure 8 Green color is segmented. The technique employs a feature-based, inter-region dissimilarity relation between the adjacent regions of the images under consideration. Finally, the regions are grouped to achieve the desired segmented outputs. The grouping strategy however, is dependent on the chosen inter-region dissimilarity relation and the comparative result among the technique used on the same images based on the parameters e.g. PSNR, MSE and time elapsed are shown in the form of table. That shows the proposed EM based Algorithm approach has a better result than region Growing and Watershed algorithm.

Results of Region Growing Approach on Hyper spectral image of Geographical area:

Fig. 5. Image labeled by cluster index

Fig. 6. Objects in cluster 1

Results of EM Algorithm:

Original Image Color Segmented Image

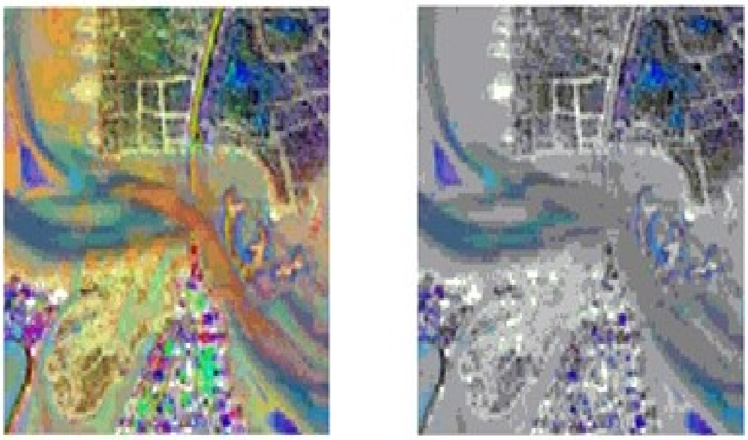


Fig. 7. Blue color segmented

Original Image Color Segmented Image

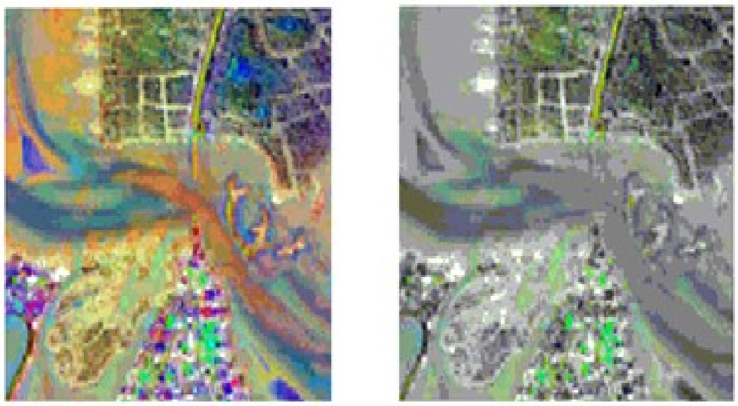


Fig. 8. Green color segmented

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