Color Image Segmentation for Satallite Images

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Abstract— **This paper introduces efficient and fast algorithms for unsupervised image segmentation, using low-level features such as color, applied on satellite images. With the increase in spatial resolution of satellite imagery, the image segmentation technique for generating and updating geographical information are becoming more and more important. The present paper describes a satellite image segmentation technique using M-band fuzzy c-Means features. In remotely-sensed multispectral imagery the variations in the reflectivity of surface materials across different spectral bands provide a fundamental mechanism for understanding the image features. Fuzzy methods in remote sensing have received growing interest for their importance in situations where the geographical phenomena are inherently fuzzy. The proposed approach is based on that first enhance multispectral image and then applying clustering technique, using La*b* color space and the vectors are used as inputs for the k-means or fuzzy c-means clustering methods, for a segmented image whose regions are distinct from each other according to color and texture characteristics.**

Keywords- Image segmentation; k-means; fuzzy c-means (FCM); La*b* color space.

Introduction

Satellite **i**mage segmentation has been a focused research area in the image processing, for the last few decades. Many papers has been published, mainly focused on gray scale images and less attention on color image segmentation, which convey much more information about the object or images. Image segmentation is typically used to locate objects and boundaries in images. Image segmentation is a process of partitioning image pixels based on selected image features. The pixels that belong to the same region must be spatially connected and have the similar image features. If the selected segmentation feature is color, an image segmentation process would separate pixels that have distinct color feature into different regions, and, simultaneously, group pixels that are spatially connected and have the similar color into the same region [10]. In color imagery, image pixels can be represented in a number of different color spaces e.g. RGB, HSV or LUV [5, 9, and 10].

The CIELAB color space, adopted as an international standard in the 1970's, provides perceptually uniform space, which means the Euclidean distance between two color points in the CIELAB color space corresponds to the perceptual difference between the two colors by the human vision system [1]. This property has made the CIELAB color space to be attractive and useful for color analysis, and the CIELAB color space has shown its superior performance in many color image applications ([2]-[4]). Based on these reports, the CIELAB color apace has been chosen for color clustering.

High-resolution images are useful for applications such as transportation network mapping, disaster preparedness, urban planning, precision farming, and telecommunications. On the other hand, low-resolution satellite images, with ground resolution greater than 10m, are useful for applications like environmental assessment, regional mapping, forestry management, widespread disaster assessment, and urban monitoring. It is often necessary to enhance multispectral radiance or reflectance data to create an image that is suitable for visual interpretation.

Clustering is an unsupervised, computationally efficient and simplest technique, which can be applied to multi dimensional data and the results are meaningful only if the homogenous non-textured color regions define the image data, in general ([5]-[17]). The pixel-based segmentation technique, consisting of Fuzzy C Means [6] and K-Means [14] considers only the spectral pattern to segment the image. These techniques are not sufficient to segment high-resolution satellite images due to the variability of spectral and structural information in such images.

This paper considers the segmentation problem of image regions based on two clustering methods: color feature similarity using fuzzy c-means or k-means. The rest of the paper is organized as follows: In section I, a brief description the clustering techniques presented. The section II describes the Image segmentation using kmeans (KM). The section III, Image segmentation using fuzzy C- means (FCM). The experimental results are given in section IV. Finally the conclusions are presented in section V.

I. CLUSTERING TECHNIQUE ON IMAGES

Clustering is considered to be the most important unsupervised learning problem. It deals with finding a structure in a collection of unlabeled data. Clustering is the process of organizing objects into groups whose members are similar in some way. A cluster is therefore a collection of objects which are "similar" between them and are "dissimilar" to the objects belonging to other clusters. The two basic clustering techniques are K-means (an exclusive clustering algorithm) and Fuzzy C-means (an overlapping clustering algorithm). ([5], [20] - [23]).

A. K-Means Algorithm

K-means algorithm was originally introduced by McQueen in 1967 [22]. It is a non-fuzzy clustering method whereby each pattern can only belong to one centre at any one time. The K-means algorithm is an iterative technique that is used to partition an image into K clusters.

Let $X = \{x_1, x_2 ... x_n\}$ represent a set of pixels of the given image, where n is the number of pixels. $V = \{v_1, v_2 ... v_k\}$ is the corresponding set of cluster centres, where k is the number of clusters. The aim of K-means algorithm is to minimize the objective function J(V), in this case a squared error function:

$$J(V) = \sum_{i=1}^{k} \sum_{j=1}^{k_t} \left\| x_{ij} - v_j \right\|^2 \qquad (1)$$

Where, $\left\| x_{ij} - v_j \right\|$ is the Euclidean distance between x_{ij} and v_j.k_i is the number of pixels in the cluster i.
The difference is typically based on pixel colour, intensity, texture, and location, or a weighted combination of these factors. In our study, we have considered pixel intensity.

The i^{th} cluster centre v_i can be calculated as:

$$v_i = \frac{1}{k_i} \sum_{j=1}^{k_t} x_{ij} \qquad (2)$$

for i = 1, ..., k.

The basic algorithm is:

i) Randomly select k cluster centres.

ii) Calculate the distance between all of the pixels in the image and each cluster centre.

iii) A pixel is assigned to a cluster based on the minimum distance.

iv) Recalculate the centre positions using equation (2).

v) Recalculate the distance between each pixel and each centre.

vi) If no pixel was reassigned, then stop, otherwise repeat step (iii).

This algorithm is guaranteed to converge, but it may not return the optimal solution. The quality of the solution depends on the initial set of clusters and the value of k.

B. Fuzzy C-means (FCM) Algorithm

Fuzzy clustering is one of the most widely used fuzzy approaches in image segmentation. The FCM algorithm was originally introduced by Bezdek in 1981 [23]. It is an iterative algorithm. FCM can be used to build clusters (segments) where the class membership of pixels can be interpreted as the degree of belongingness of the pixel to the clusters.

Let $X = \{x_1, x_2... x_n\}$ represent a set of pixels of the given image, where n is the number of pixels and $V = \{v_1, v_2... v_c\}$ is the corresponding set of fuzzy cluster centers, where c is the number of clusters. The main aim is to minimize the objective function J(U,V), which is a squared error clustering criterion defined as :

$$J(U,V) = \sum_{i=1}^{n} \sum_{j=1}^{c} \mu_{ij}{}^{m} \left\| x_i - v_j \right\|^2 \quad (3)$$

Where, $\left\| x_{ij} - v_j \right\|$ is the Euclidean distance between x_{ij} and v_j. μ_{ij} is the membership degree of pixel x_i to the cluster centre v_j and μ_{ij} has to satisfy the following conditions:

$$\mu_{ij} \in [0,1], , \forall i = 1,...n, \forall j = 1,...c \quad (4)$$

$$\sum_{j=1}^{c} \mu_{ij} = 1 , \quad \forall i = 1,...n \qquad (5)$$

$U = (\mu)_{ij_{n*c}}$ is a fuzzy partition matrix. Parameter m is called the "fuzziness index"; it is used to control the fuzziness of membership of each pixel. The value of m should be within the range $m \in [1, \infty]$. m is a weighting exponent that satisfies $m > 1$ and controls the degree of "fuzziness" in the resulting membership functions: As m approaches unity, the membership functions become more crisp, and approach binary functions. As m increases, the membership functions become increasingly fuzzy.

The FCM algorithm can be performed by the following steps:

i) Initialize the cluster centres $V = \{v_1, v_{2....,} v_c\}$, or initialize the membership matrix μ_{ij} with random value such that it satisfies conditions (4) and (5). Then calculate the cluster centres.

ii) Calculate the fuzzy membership μ_{ij} using:

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c} (\frac{d_{ij}}{d_{ik}})^{\frac{2}{m-1}}} \qquad (6)$$

Where, $d_{ij} = \|x_i - v_j\|, \forall i = 1... n, \forall j = 1,...,c$.

iii) Compute the fuzzy centres v_j using:

$$v_j = \frac{\sum_{i=1}^{n} (\mu_{ij})^m x_i}{\sum_{i=1}^{n} (\mu_{ij})^m} \qquad (7)$$

iv) Repeat step (ii) to (iii) until the minimum J value is achieved.

II. PROPOSED IMAGE SEGMENTATION TECHNIQUE

A. *K-MEANS(KM)*

- Read color image.
- Enhance the image
- Convert the image into La*b* color space.
- Segment the feature vector using K-Means Clustering.
- Label every pixel in the image using the Results from K-Means Clustering.
- Create segment image.

B. *Fuzzy C –means(FCM)*

- Read color image.
- Enhance the image
- Convert image into La*b* color space.
- Segment the feature vector using FCM.
- Assign the pixels to the clusters as follows:

  - A pixel *x* is assigned to cluster *i* such that the value of the membership function of *x* for *i* is maximum.

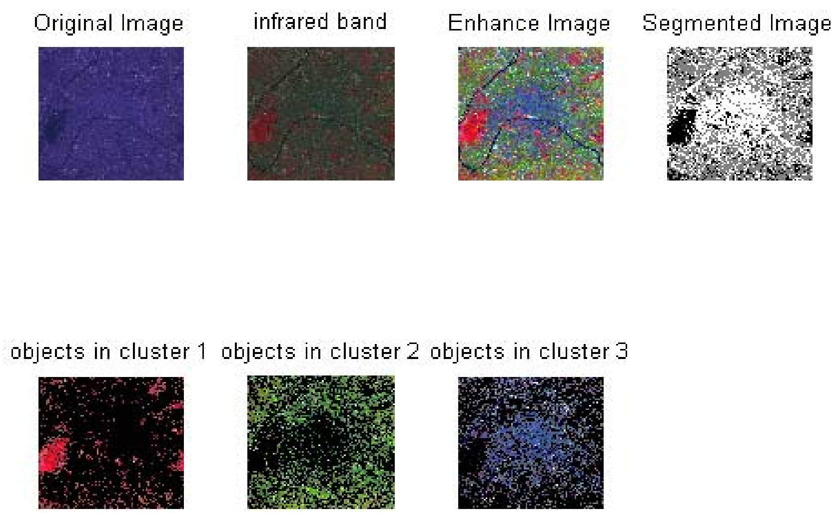
- Label every pixel in the image using the results from FCM.
- Create segment image.

III. EXPERIMENTAL RESULTS

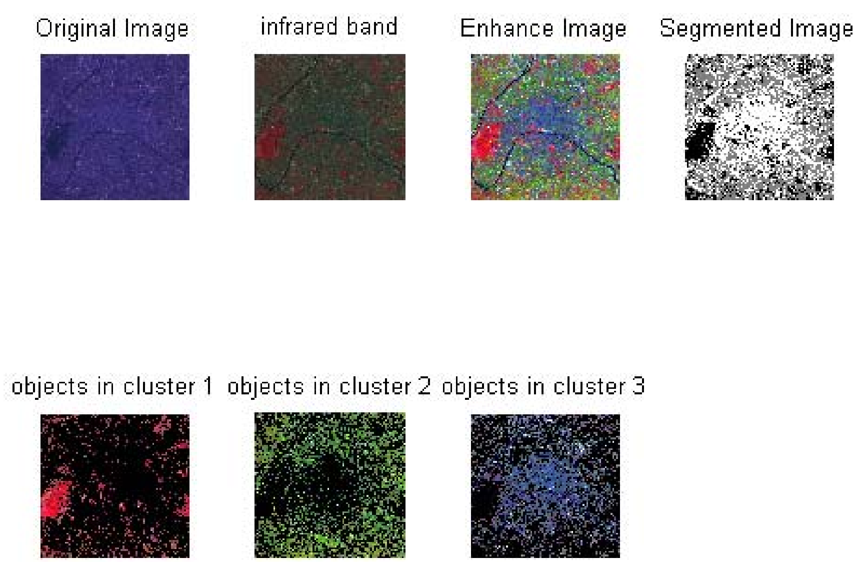
The algorithms are implemented on Matlab 7.3 (The Mathworks Inc.). The first test satellite images the LAN file, paris.lan, contains a 7-band 512x512 Landsat image (called test1). A 128-byte header is followed by the pixel values, which are band interleaved by line (BIL) in order of increasing band number. They are stored as unsigned 8-bit integers, in little-endian byte order [MATLAB 7.3]. The near infrared (NIR) band is important because of the high reflectance of chlorophyll in this part of the spectrum. It is even more useful when combined with visible red and green. To read multispectral bands from the LAN file using the MATLAB function multibandread. Here we are reading band through multibandread are infrared, red, green. To enchance multispectral image is to use a decorrelation stretch, which enhances color separation across highly correlated channels. Use MATLAB Functrion decorrstretch to perform the decorrelation. The surface features have become much more clearly visible. The spectral differences across the scene have been exaggerated. The green area is the Bois de Boulogne, a large park on the western edge of Paris. A property of color infrared composites is that they look red in areas with a high vegetation (chlorophyll) density, right red on the left edge, a large park (the Bois de Boulogne) located west of central Paris within a bend of the Seine River. The second satalite image downloaded from [25] of size 1024x1024 (called test2). To segment the multispectral images, the proposed algorithms K-Means and Fuzzy C-Means, have been implemented and tested on satellite images. The KM and FCM algorithms based on color segmentation, as described in section IV, have been tested on La*b* color space and the results are shown in fig. 2(a) and 2(b). The number of clusters were chosen, in such a manner, to segment the region of interest completely, for the image provided. The time taken to segment the satellite test image by different algorithms is given in Table 1. From the results, it can be conclude that the segmentation time (table 1.) for FCM method is more and the quality of the segmentation is much accurate than the KM method (fig.2a and 2b.), for the same test satallite image. This is in conformity with the results of [24].

TABLE1. Segmentation time of different algorithms on a test images:

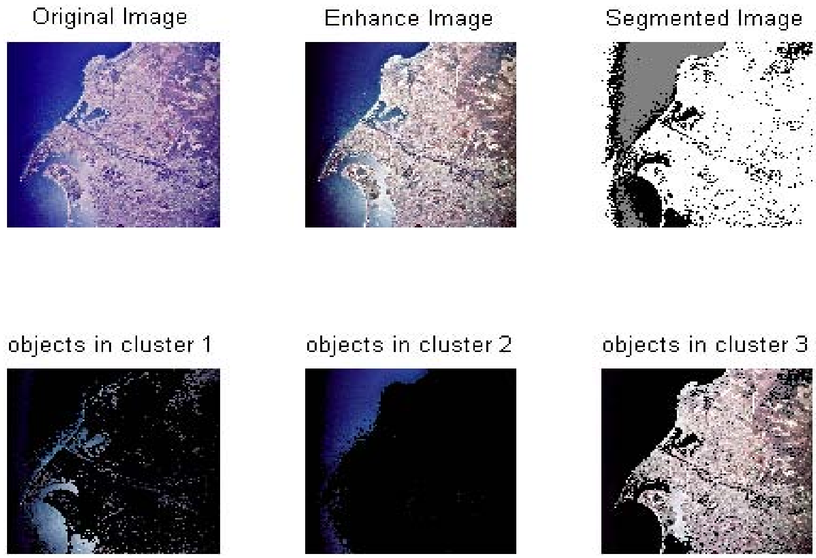
Algorithms	**Time in sec.**
K-Means test1	4.13
Fuzzy C-Means test1	5.65
K-Means test2	4.01
Fuzzy C-Means test2	5.30


Original Image
infrared band
Enhance Image
Segmented Image
objects in cluster 1
objects in cluster 2
objects in cluster 3

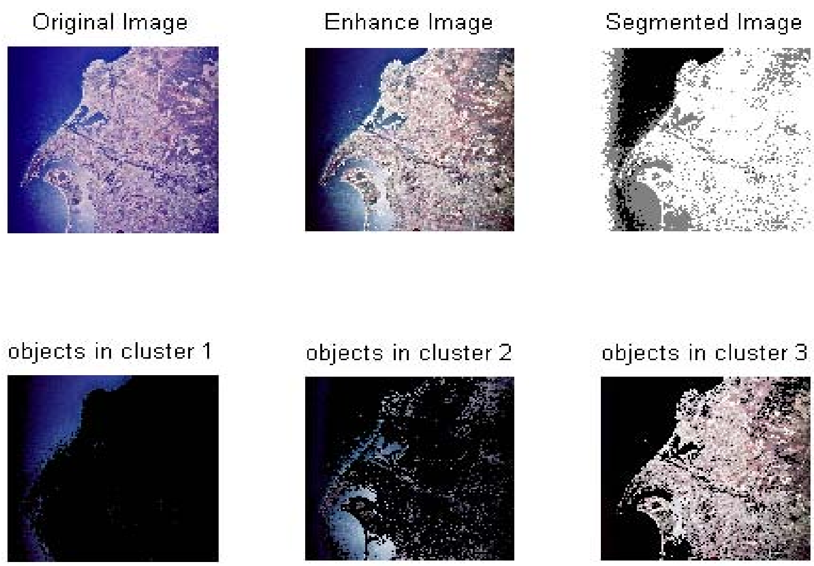
(a)


Original Image
infrared band
Enhance Image
Segmented Image
objects in cluster 1
objects in cluster 2
objects in cluster 3

(b)



(c)



(d)

Fig2. Color image segmentation using (a), (c) K-means and (b), (d) FCM.

IV. Conclusions

Algorithms for segmentation of satellite images using Fuzzy C-Means (FCM), K-Means (KM) as described in section II, have been implemented and tested on satellite image. Before doing image segmentation some low-resolution satellite images, it is often necessary to enhance multispectral image that is suitable for visual interpretation, for that we have used decorrelation stretch technique. So the surface features have become much more clearly visible from the figures we can see that. The experimental result is shown in fig 2. From the

Table.1 it seen that KM segmentation methods are fast as compared to FCM, but segmentation methods using FCM give better segmented images with finer details and accurate location.

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