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Image Segmentation using High Resolution Multispectral Satellite Imagery implemented by FCM Clustering Techniques

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Abstract

Satellite Image segmentation has a most important role to play in the field of remote sensing imaging, for effectively detecting the Surface of the Earth. However more satellite image segmentation techniques are available. This paper work presents an image segmentation based on color feature with unsupervised FCM Algorithm, which yields better results. The entire work is divided into two stages, first one to enhance the color separation of satellite imagery using color transformation. Another step to process the regions is grouped into a set of FCM clustering algorithm. Finally, the performance of the proposed scheme is calculated visually and quantitatively. The results show that the proposed method can be used for segmentation and also enhances the future research with the image quality for imagery.

Keywords: *FCM, Remote Sensing, Cluster, Pixels, Imagery, Segmentation.*

1. Introduction

Satellite Image Segmentation is one of the most important problems in image pre-processing technique. It consists of constructing a symbolic representation of the imagery that divider an image into non-intersecting regions such that each region is homogeneous and the combination of no two adjacent regions is homogeneous and it can be used for the process of isolating objects of interest from the rest of the scene. In the literature survey, we can find various segmentation algorithms. Starting from the sixties, diverse algorithms have been arising persistently depending upon the applications involved.

Since the first Landsat (Multispectral Scanner System (MSS)) was launched in July 1972, which began the present period of land-living remote identifying from space, raw volumes of satellite image data have been collected. Many applications including environmental monitoring and assessment for use of Mapping, Agriculture, and renewable natural resources, recent advances in satellite imaging with significant contributions from Computer Science, electrical engineering have witnessed a revolutionary growth in satellite imaging. Groundbreaking improvements in engineering and computing technologies have made it possible to acquire multispectral high-resolution satellite images; to examine structural and practical information for computer aided study, assessment and intervention.

The high resolution satellite Imagery segmentation will be a major research for many image processing researchers. Since the applications are vivid the reasons are more obvious. In the high resolution multispectral Satellite imagery, aim is to separate different parts of the imagery in a way that improves image understanding and analysis process. Most remote sensing applications image analysis problems need a segmentation section in order an identify the objects or to detect the various boundaries of the imagery and convert it into regions, which are homogeneous according to a given condition, such as surface, color, etc.,[1,2], and assigning labels to every pixel such that pixels with the same label share certain visual characteristics and it's still reflected immature in the field of satellite image processing. The main cause for these vast variations is the image quality while capturing the image and increase in the size of the image and also difficulty in understanding the satellite images by various applications.

The total amount of visual pattern in the image is increased by an overwhelming methodology. These anxieties have increased the use of computers for assisting the processing and analysis of data. The segmentation process in satellite images is considered to be challenging because these images include many textured regions or different background and often subjected to the enlightenment changes or ground truth properties. All these force makes the urgent need in satellite image processing system for rapid and efficient image segmentation model that requires minimum involvement from user.

Existing solutions for segmentation of satellite images face three major drawbacks. It presentation degradation when supplied with large sized images, degradation of segmentation accuracy due to the quality of the acquired image and speed of segmentation is not meeting the standards of the modern equipment's. This paper considers the use to ERDAS Imagery of preprocessing segmentation techniques. Preprocessing performs operations on the input imagery to improve the imagery quality and FCM clustering algorithm is to increase the image quality by the segmentation process. It includes Color transformation, intensity correction, method and parameter selection, edge or boundary enhancement and de-noising [2]. Out of these, boundary enhancement, pixel correction and de-noising have more impact on segmented results.

This paper is planned as follows. Section-2 reviews the related works in image segmentation. Section-3 data set used in study area, Section-4 explains the proposed image segmentation method, Section-5 presents the experimental results and the work is concluded in Section-6.

2. Review of Literature

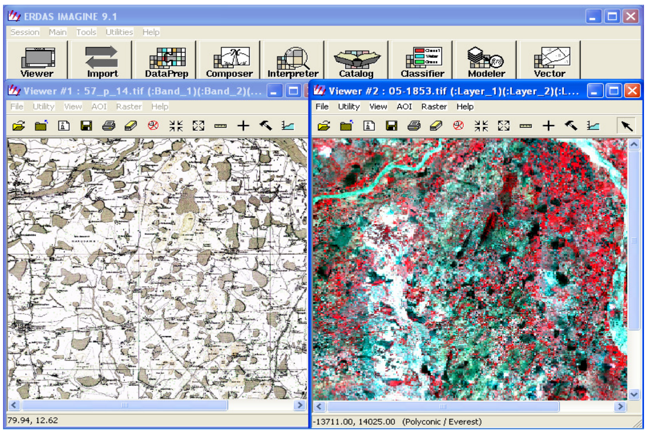
z.ulaikha et al. Have proposed to improve spatial FCM algorithm. The histogram based FCM is used to initial the input parameters for ISFCM because HFCM coverage more rapidly as it clustering the whole image.

Kannan et at. Have proposed a novel fuzzy clustering for intensity in homogeneities or weighted bias estimation and segmented of medical images of same pattern. The author has presented a centre knowledge method.

Pawlak have describe discrepant uncertainties inherent in satellite remote sensing imagery for geospatial features classification can be taken care of by use of soft computing technique effectively. For the purpose, rough sets, fuzzy set and rough-fuzzy tie-up, ant colony optimization biogeography based optimization and particle swarm optimization methods are compared.

3. Study Area and Dataset Used

Palar is a south Indian river, originating from the Nandidurg hills of Karnataka, it flows through the states of Karnataka (93 km), Andhra Pradesh (33 km) and Tamil Nadu (222 km) before finally draining into the Bay of Bengal at Vayalur. This river is divided in to 8 sub basins. This mostly covers Thiruvannamalai and Kanchipuram districts an area of about 939.91km2 of which about 92.43% of the total area.



(a) TopoSheet *(b) Satellite Image*

Fig. 1 Study Area

The Kiliar Sub Basin area around the Palar Basin is located at Latitude (12°41'9"N and 12°22'32"N) and Longitude (79°53'26"E and 79°25'10"E). Studied images of Kiliyar Sub basin is a Pan and Liss III merged data panchromatic stereo pair of 5.86m pixel size and proper radiometric quality, a base to height ratio equal to taken on March-2013. Figure 1(b) Viewer#1 shows the Study area Satellite Terrain data IRS-P6 Liss-III and Figure 2(a) Viewer#2 shows the Georeferenced data (Toposheet) the above data are collected from Remote Sensing Institute, Taramani, Chennai.

Table 1: Methodological Specification of IRS P6 Liss III Imagery

Image Type	Pan and Liss III Merged Data
File Format	Geo TIFF
Projection Type	UTM
Spheroid Name	WGS 84
Datum Name	WGS84
UTM Zone	1
North or South	North

ERAS Image software is used to segment the exact area (AOI) by using the FCM Algorithm. The current imagery type and file format details are shown in Table-1, which also presents the main characteristics of the acquired images.

4. Image Segmentation Method

Segmentation is a way to dividing raster image into segments based on pixel values and positions. Pixels that are spatially connected and have similar values are clustered in a single segment. In ERDAS IMAGINE Image Segmentation performs edge detection on the raster image. It executes segmentations on that raster image using edges found in the edge detection phase as boundaries of sections.

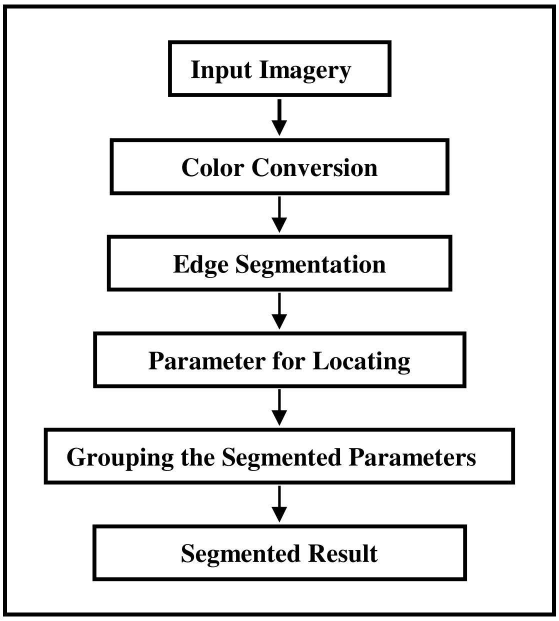


Fig. 2 Methodology Diagram for image segmentation

4.1 Color Conversion

Most remote sensing systems create arrays of numbers representing an area on the surface of the Earth. The entire array is called an image or scene, and the individual numbers are called pixels (picture elements) such as water body, wetland, forest area etc., the value of the pixel represents a measured quantity such as light intensity over a given range of wavelengths. However, it could also represent a higher-level product such as topography or chlorophyll concentration or almost anything. Some active systems also provide the phase of the reflected radiation so each pixel will contain a complex number. Typical array sizes with optimum pixels and system with multiple channels may require megabytes of storage per scene. Moreover, a satellite can collect 50 of these frames on a single pass so the data sets can be enormous.

There are several established color models used in computer graphics, but the most common are the Gray Scale model, RGB (Red-Green-Blue) model, HIS (Hue, Saturation, Intensity) model and CMYK (Cyan-Magenta-Yellow-Black) model, for Remote Sensing Technology used in digital image processing by Gonzalez and Woods (2008) has presented a detailed explanation.

RGB and L Color Transformation: When Red, Green and Blue light are combined it forms white. As a result to reduce the computational complexity the geo referenced data that exists in RGB color model is converted into a gray scale image. The range of gray scale image from black to white values can be calculated by the equation. Where L is Luminance, R is RED, G is Green and B is Blue.

$$X= L+ (0.2989*R) + (0.5870*G) + (0.1140*B)$$

RGB is a color space originated from CRT (or similar) display applications, when it was convenient to describe color as a combination of three colored rays (red, green and blue).

4.2 Edge segmentation

ERDAS imaging Segmentation process involves several steps. The major step is to input image conversion to particular feature space, which depends on the clustering techniques, uses two types.

- Primary step involves the conversion of the input image into L=RGB color value attributes using fuzzy c-means clustering method.
- Secondary step involves the image conversion to feature space with the selected fuzzy c-means clustering method.

The above method paving the way for next segmentation process (input image conversion to feature space of clustering Method).

Image Smoothing: The edge detection for the given imagery will be done smoothen the image using specific iteration. The specific iteration will be selected for the each image is the tool. If the imagery is noisy, the smoothing process will be applied of the noisy pixel in the process of edge detection.

Threshold: The specific threshold is used in the edge detection by considering the pixel. The specific threshold will be given in tool. The pixels value and the neighboring pixels is bigger means, the pixel value selected for comparison will be considered as a candidate for edge pixel. The threshold specified in the tool will depend on the value differences of neighboring pixels along the edges.

Minimal Length: In edge detection process specific the minimum acceptable length of the edge. The acceptable length will be measured from the adjacent point of the imagery and if it is less than the acceptable length the segment method will be dropped.

4.3 Parameter for locating

In this selection is set to be additional parameters used in edge detection process. There are minimal value difference and variance factor.

- The minimum value is used for neighboring segment between minimal differences.

- The variation factors specify the important role that shows variation in pixel value with in the same segment. This segmented result plays in defining whether expand the segment or not.

Area of interest parameter (AOI) is to use the specify the selected areas of the image to perform the Segmentation process.

4.4 FCM Algorithm

The main aim of a clustering technique is to divide a set of objects into a cluster, which signifies subsets or a cluster [3]. The cluster divided in to two properties; there are homogeneity inside clusters and heterogeneity between clusters.

- The raw data, belonging to a single cluster, should be as similar as possible, called Homogeneity inside clusters.

- The raw data, which belongs to different clusters, should be as different as possible, called Heterogeneity between the clusters.

Algorithm-1 Cluster Centers Initializations

Required X: dataset, C: no. of Clusters
Procedure ordering-split(X,c)
Compute m for each k $k \in \{1,.......,n\}$
Apply to m the ordering function σ
for i=0 to c do
$$\ell_i \leftarrow i * \lfloor n/c \rfloor$$
end for
for i=1 to c do
$$S_i \leftarrow \{\ell_{i-1}+1,.......,\ell_i\}$$
$$C_i \leftarrow \sigma^{-1}(S_i)$$
$$V_i \leftarrow \frac{1}{|C_i|}\sum_{j \in c_i} X_j$$
end for
return V
End procedure

Fig. 3 Cluster Centers Initialization

In hard or unsupervised clustering, data is divided into distinct clusters, where each data element belongs to exactly one cluster. In fuzzy clustering, data elements can belong to more than one cluster by using Algorithm-1, and associated with each element is a set of membership levels. These indicate the strength of the association between that data element and a particular cluster. Fuzzy clustering is a process of assigning these membership levels, and then using them to assign data elements to one or more clusters.

The most significant part of this segmentation method is grant of feature value. In the grant of feature value is based on simple idea, that neighboring pixels have approximately same values of lightness and chroma. Then an actual image, noise is corrupting the imagery data or imagery commonly contains of textured segments.

Basic segmentation methods based on fuzzy c-means clustering algorithm are working as follows

Algorithm Fuzzy C-Means(FCM)

Procedure Segmentation(Image I, No.of Clusters c, No.of bins q)
Pre-processing the image I
Initialize cluster center v using the ordering-split procedure.
repeat
Update partition matrix U
Update prototypes matrix V
Until is a matrix norm.
Regularize the partition U
Return(U,V)
End procedure

Fig. 4 FCM Algorithm

The FCM algorithm allots pixels to each class by using fuzzy memberships. Let X=(x_1, x_2,……,x_N) denotes an image with N pixels to be segregated into c clusters, where xi represents multispectral imagery(features) data. The algorithm is an iterative optimization that minimizes the cost function defined as follows:

$$J = \sum_{j=1}^{N}\sum_{i=1}^{c} u_{ij}^{m} \left\| x_j - v_i \right\|^2$$

where u_{ij} represents the membership of pixel x_j in the i_{th} cluster, v_i is the i^{th} cluster center, $\|.\|$ is a norm metric, and m is a constant. The parameter m controls the fuzziness of the resulting partition is used in this study.

Step1: Choose a number of clusters in a given image.
Step2: Assign randomly to each point coefficients for being in a cluster.
Step3: Repeat until convergence criterion is met.
Step4: Compute the center of each cluster.
Step5: For each point, compute its coefficients of being in the cluster.

The first measures of evaluation of segmentation were subjective, and the ever growing interest in this topic leaded to numerous metrics allowing proper evaluation. In

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order to objectively measure the quality of the segmentations produced, evaluation measures are considered in this paper.

5. Experimental Results

The satellite images retrieved from various places have been tested in our study area by using ERDAS IMAGING software. The results are summarized below.

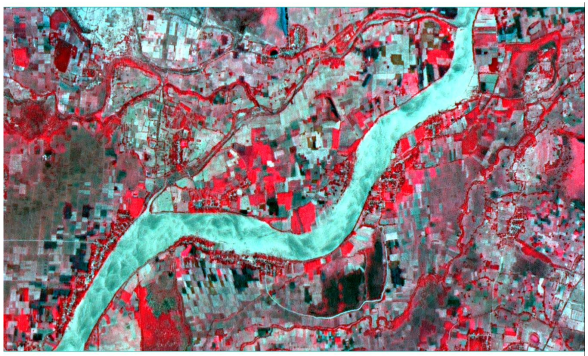
The figure1 gathered from the satellite is given an input to the FCM algorithm where the image undergoes various transformations. Forest, Wetland, Water Body, and River areas are the four different regions selected from the satellite imagery using AOI tools.

The following figure 5 (a) Forest, figure 5 (b) Wetland, figure 5 (c) Water Body, figure 5 (d) River are the preferred regions.

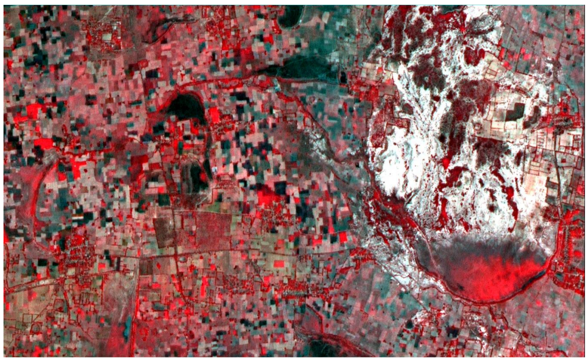
The satellite imagery does not reveal the clear picture of the selected regions and so the above four figures (a), (b), (c), (d) are distinguished from figure1 to make the image more visible.

(a) Wetland original image

(b) Water Body original image



(c) River Basin original image

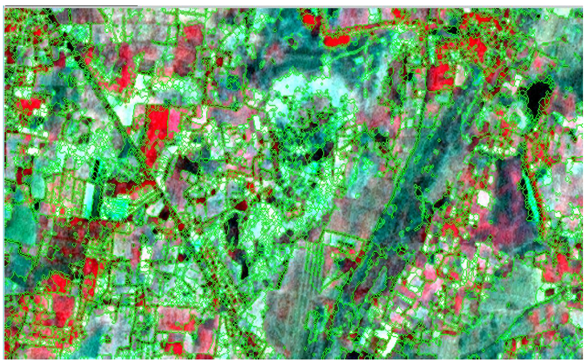


(d) Forest original image

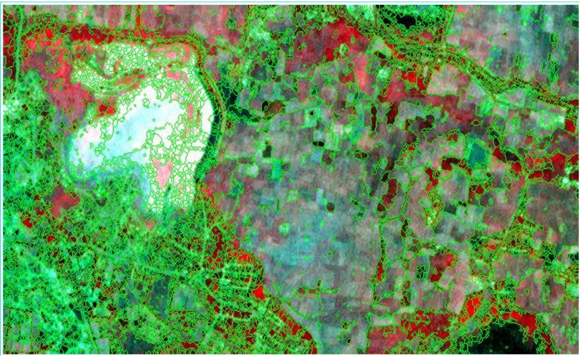
Fig. 5 Selected Images from figure1

The FCM Algorithm takes as input the above images and segments the images according to the regions with minimum distance.

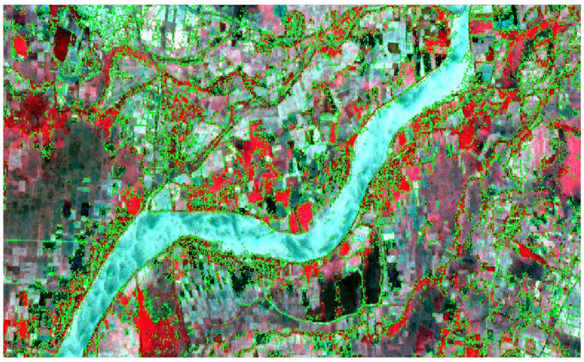
The following images when passed through the FCM algorithm using ERDAS IMAGING software, get transformed in to the following images as figure 6(a), figure 6(b), figure 6(c), and figure 6(d) respectively. The places that are recognized from the scalable imagery using the FCM method generate the segmented results of the selected regions.



(a) Wetland original image



(b) Water Body original image



(c) River Basin original image

(d) Forest original image

Fig. 6 Segmented Images Target Region

6. Conclusion

FCM clustering is a hard and an unsupervised clustering technique which will be applied to image segments to clusters with spectral properties. FCM use the distance between pixels and cluster centers in the spectral domain to compute the membership function. Image pixels are highly correlated, and this spatial information is an important characteristic that can be used to aid their classification. However, the spatia67l relationship between pixels are rarely to make practical and effective use of FCM.

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