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Clustering of Remote Sensing Standard Datasets Using Kernelised Fuzzy C Means

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Abstract: Satellite imaging is being the most attractive source of information for the governmental agencies and the commercial companies in last decade. The quality of the images is very important especially for the military or the police forces to pick the valuable information from the details. Satellite images may have unwanted signals called as noise in addition to useful information for several reasons such as heat generated electrons, bad sensor, wrong ISO settings, vibration and clouds. There are several image enhancement algorithms to reduce the effects of noise over the image to see the details and gather meaningful information. Satellite images are acquired with remote sensing. Remote sensing is the science and art of obtaining information about an object or area through a device that is not in contact with the object or the area under investigation. Satellite Images referred as hyper spectral images are the most used images in remote sensing and are of more interest to find out the classification of objects in those images. The classification can give us the important factors like vegetation, buildings, roads and more. The classification can be done by using Image segmentation via various clustering algorithms where Clustering is the process of grouping a set of objects into classes of similar objects. In this work FCM based algorithms are investigated and a Kernel based FCM is proposed and compared with existing generalized FCM.

Keywords: Clustering, C-Means, Fuzzy C-means, Generalized Fuzzy C-Means, Kernel Fuzzy C-means, Remote Sensing.

1. INTRODUCTION

According to reference, the image segmentation approaches can be divided into four categories: Thresholding, clustering, edge detection and region extraction. In this paper, a clustering based method for image segmentation will be considered. Image data clustering is the process of assigning a label to each location represented by a pixel in the image. In non-fuzzy or hard clustering, data is divided into crisp clusters, where each data point belongs to exactly one cluster. In fuzzy clustering, the data points can belong to more than one cluster, and associated with each of the points are membership grades that indicate the degree to which the data points belong to the different clusters.

Fuzzy clustering belongs to the group of soft computing techniques (which include neural nets, fuzzy systems, and genetic algorithms).Fuzzy clustering has emerged as an important tool for discovering the structure of data. Among the fuzzy clustering methods, fuzzy c-means (FCM) algorithm is the most popular method used in image segmentation because it has robust characteristics for ambiguity and can retain much more information than hard segmentation methods. The Fuzzy C-Means (FCM) clustering algorithm was first introduced by Dunn and later was extended by Bezdek. The FCM algorithm reveals structure in data through a minimization of a quadratic objective function (performance index). A structure in data is represented in the form of a fuzzy partition matrix as well as a collection of “c” prototypes. Given the Euclidean distance, FCM favours spherical shapes of the clusters.
Kernel methods have been applied to fuzzy clustering and the Kernelized version is referred to as kernel-based fuzzy clustering. The essence of kernel-based methods involves performing an arbitrary non-linear mapping from the original d-dimensional feature space $\mathbf{R}^d$ to a space of higher dimensionality (kernel space), cf. The kernel space could possibly be of infinite dimensionality. The rationale for going to higher dimensions is that it may be possible to apply a linear classifier in the kernel space while the original problem in the feature space could be highly non-linear and not separable linearly.

2. EXISTING METHOD

Fuzzy c-means clustering technique has been popularly used for remote sensing image data classification. However as per the studies the classical fuzzy c-means clustering algorithm has been able to achieve less accuracy due to spatial relationship existence and multi class existence in remotely sensed images.

Remote sensing images contain large number of classes but the probability of a pixel belonging to some classes may be low. Traditional fuzzy c-means algorithm considers all classes simultaneously during clustering process. In this paper generalized fuzzy c-means has been applied in exploring k nearest neighbors approach out of c cluster centers. Spatial information has been also integrated with generalized fuzzy c-means technique.

The experimental results show that the generalized fuzzy c-means technique with spatial information yields better results than traditional fuzzy c-means technique. "The process of grouping a set of objects into classes of similar objects is called clustering".

GFCM is a method of clustering which allows k nearest neighbours approach out of c clusters. In spatial information it yields better results than FCM technique.

The proposed framework for remotely sensed data aim to:
1. Use fuzzy c-means to manage fuzziness in remote sensing data
2. Use generalized fuzzy c-means for multi class problem of remote sensing data
3. Integration of spatial information to improve clustering results

GFCM Algorithm steps:
1. Initialize U=[Uij] matrix, U(0)
2. At k-step calculated the centers vectors C^k=[Cj]

$$C_i = \frac{\sum_{i=1}^{N} U_{ij}\, X_i}{\sum_{i=1}^{N} U_{ij}^{m}}$$

3. Update $U^{(k)}$, $U^{(k+1)}$

$$U_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\|x_i - c_i\|}{\|x_i - c_k\|} \right)^{\frac{2}{m-1}}}$$

4. If $\| U^{(k+1)} - U^{(k)} \| < \epsilon$ then stop, otherwise return to step 2.

3. PROPOSED METHOD

Now a Days, Remote sensing is the science and art of obtaining information about an object or area through a device that is not in contact with the object or the area under investigation. Satellite Images referred as hyper spectral images are the most used images in remote sensing and are of more interest to find out the classification of objects in those images.

The classification can give us the important factors like vegetation, buildings, roads and more. The classification can be done by using Image segmentation via various clustering algorithms where Clustering is the process of grouping a set of objects into classes of similar objects. In this work FCM (Fuzzy C-Means) based algorithms are investigated and a Kernel based FCM is proposed compared with existing Generalised FCM.

Fuzzy clustering has emerged as an important tool for discovering the structure of data. Among the fuzzy clustering methods, fuzzy c-means (FCM) algorithm is the most popular method used in image segmentation because it has robust characteristics for ambiguity and can retain much more information than hard segmentation methods Kernel methods have been applied to fuzzy clustering and the Kernelized version is referred to as kernel-based fuzzy clustering. The essence of kernel-based methods involves performing an arbitrary non-linear mapping from the original d-dimensional feature space $\mathbf{R}^d$ to a space of higher dimensionality (kernel space). The kernel space could possibly be of infinite dimensionality. The rationale for going to higher dimensions is that it may be possible to apply a linear classifier in the kernel space while the original problem in the feature space could be highly non-linear and not separable linearly.

KFCM Algorithm:

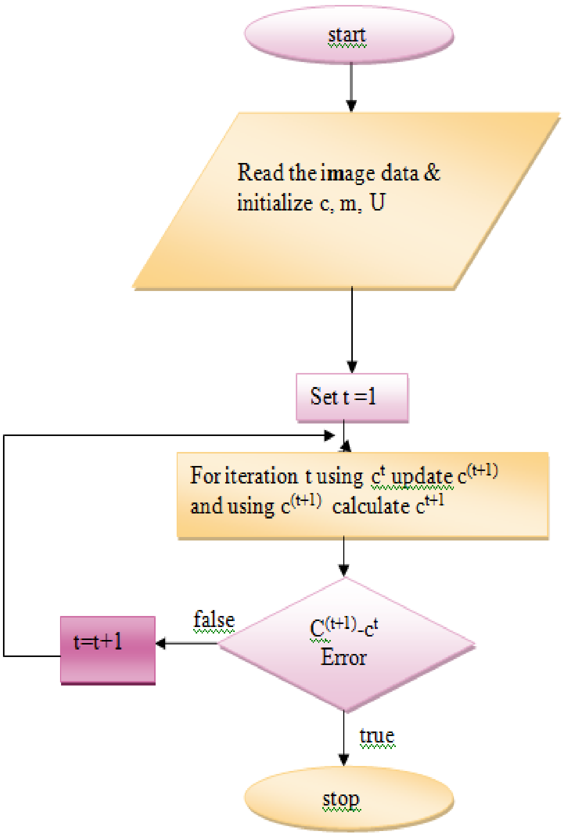

Fig 3.1: KFCM Algorithm steps

- Step 1: Fix c, t_{max}, m > 1 and ε > 0 for some positive constant;
- Step 2: Initialize the memberships u_{ik}^0;
- Step 3: For t =1,2,…, t_{max}, do:
  (a) Update all prototypes vi^t;
  (b) Update all memberships u_{ik}^t;
  (c) Compute E^t, if Et ≤ ε, stop; else t=t+1.

Implementation:
The block diagram of the proposed work is given as follows

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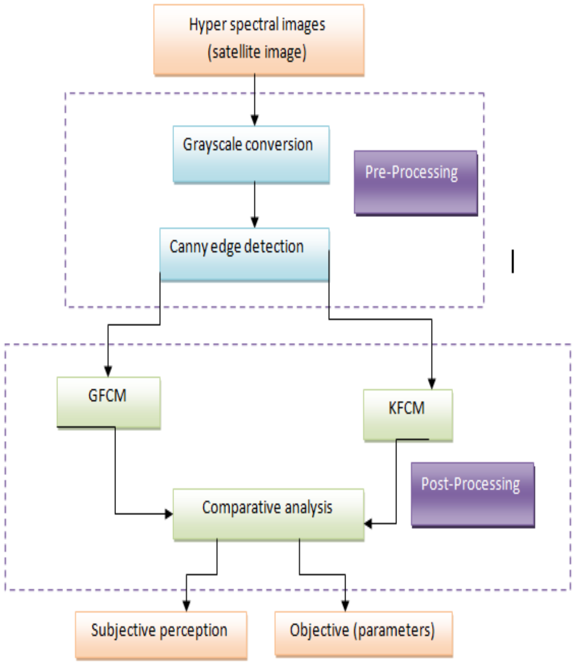

Fig 3.2: Block Diagram of Proposed Method

Hyperspectral images which process and collects the information from EM spectrum. The goal is obtain spectrum for each pixel in the image of scene with purpose of finding objects and identifying materials.

Grayscale conversion which converts the colour image into gray scale image. **Canny edge detector** is a popular method for detecting edges that begins by smoothing an image(used to reduce noise in an image)by convolving it with a Gaussian of given sigma value. It achieve less error rate while dividing the objects in an image.

GFCM is a method of clustering which allows k nearest neighbours approach out of c clusters. In spatial information it yields better results than FCM technique. **KFCM** is realized b substitution of a kernel induced distance metric of the original Euclidean distance and corresponding algorithms. In kernel space, the number of clusters is chosen automatically. The unsupervised algorithm combining FCM clustering in kernel space and GMM is present. Then item-by-item comparison of two or more comparable alternatives, processes is called **comparative analysis**. **Subjective perception** is a one person's opinion and **objective parameter** is not influenced by emotions and particular feelings

4. RESULTS

The below figure shows the original image which is hyper spectral image (satellite image, **Courtesy:** Google maps (Tamilnadu SETC Bus stop)).

The original image consists of various textures such as buildings (with different roof structures and colours), roads, trees, clay land, vehicles and much more unidentified objects. In order to achieve good and proper classification, image is subjected to both existing GFCM and proposed KFCM image segmentation methods

Fig 4.1. **Origin al Image**

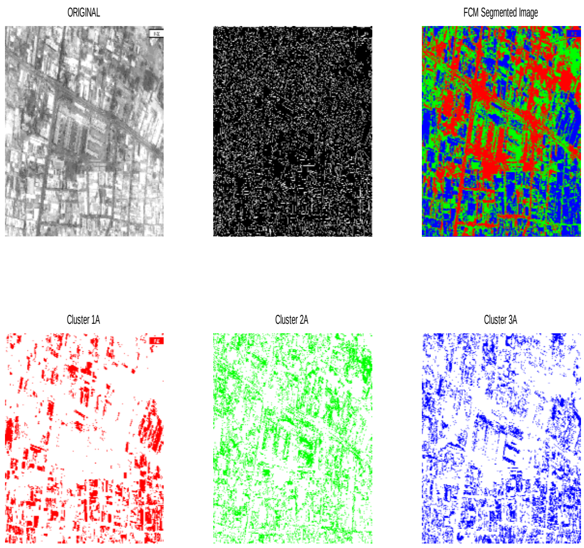

Fig 4.2. GFCM segmentation outputs and respective clusters

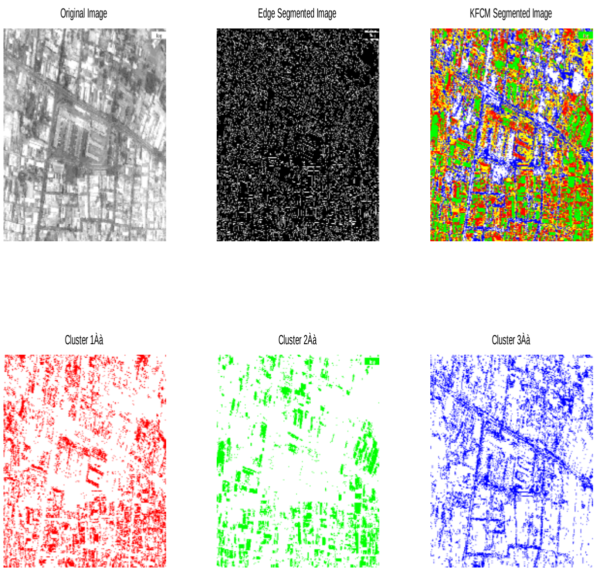

Fig 4. 3 KFCM segmentation outputs and respective Clusters

The Fig(s) 4. 2 and 4.3 show the six images each in one plot containing gray scale image of original image and Canny edge detected image which are useful for easy classification, classification images (GFCM and KFCM) and respective clusters of three results.

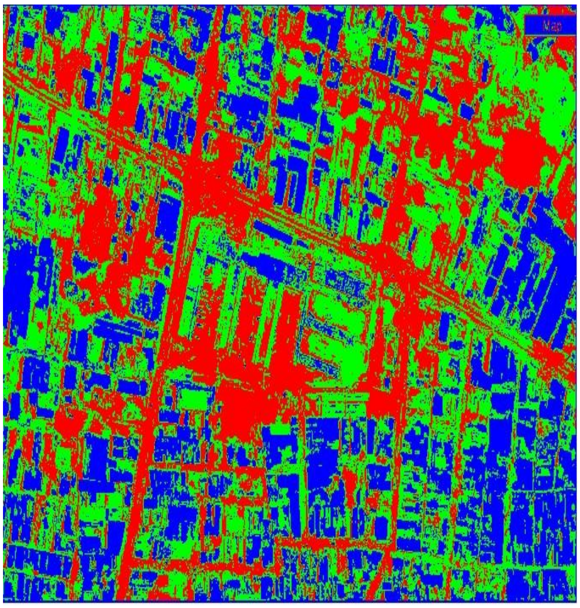

Fig 4. 4 GFCM segmentation output

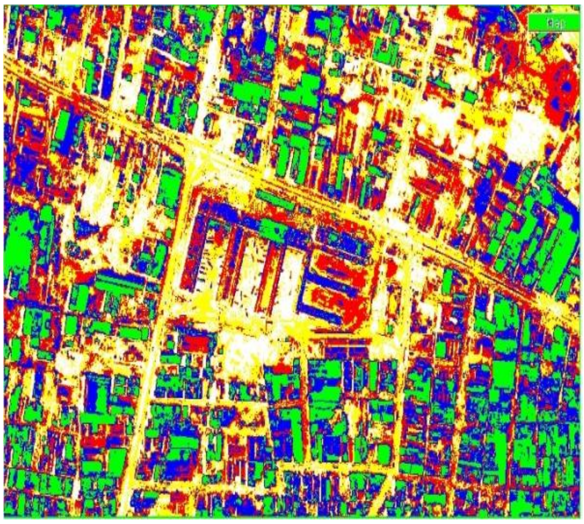

Fig 4. 5 KFCM segmentation output

The Fig(s) :4. 4 and 4.5 are taken out separately for good perception of the classification process. By observing two results one can easily be convinced that classification of textures in the original image are more in proposed method i.e. KFCM than existing method GFCM by the virtue of more colours.

The same can be proved by parametric analysis using the two basic parameters Mean and Standard deviation. Increase in Mean(Average) indicates the presence of more pixels because different colours & their intensities and Increase in Standard Deviation specifies that there is variation of intensity values, which gives rise to more classification on comparison of results of KFCM with GFCM.

Table: 1: Parametric Analysis of Classification methods.

Method/Parameter	**Mean**	**Standard Deviation**
GFCM	85	120.2082
KFCM	128.4297	127.4967

Table: 2: parameters

parameter	Existing image	Proposed image
Area	331680	329640
Perimeter	2332	2324
Circularity	0.7663	0.767
Std deviation	119.3481	120.6569
Sum of intensities	358.7090	369.7710

5. CONCLUSION AND FUTURE SCOPE

In this work Generic FCM and Kernel based FCM has been implemented on a hyper spectral image. The aim is to use Fuzzy Rules for the analysis of remote sensing image to manage fuzziness in it and hence it is achieved. The algorithm is formulated by introducing Canny edge detection method to achieve less error rate while dividing the objects in image and the Canny detection utilises Gaussian algorithm. Experimental results show that the proposed method is effective in terms of both subjective and objective analysis.

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