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A Proficient Segmentation of Remote Sensing Images using Modified Kernel Fuzzy C-Means Algorithm

V. Mageshwari
Department of Computer Science
Periyar University
Salem, Tamil Nadu, India
maheejasmine2290@gmail.com

I. Laurence Aroquiaraj
Department of Computer Science
Periyar University
Salem, Tamil Nadu, India
laurence.raj@gmail.com

T. Dharani
Department of Computer Science
Periyar University
Salem, Tamil Nadu, India
dharanimca28@gmail.com

***Abstract*- Images are imitations of factual world substances. Processing it to get better visualization is called as image processing. With the increasing availability and decreasing cost of satellite imagery, the Remote sensing image enhancement, segmentation and classification has become the most important research issue in field of Remote sensing. In this proposed work, Land sat 7 Remote Sensing images are considered. Initially the enhancement of satellite image is done using image enhancement techniques. Then the segmentation of satellite images has been done using Expectation Maximization(EM), Kernel-Means(K-Means), Kernel Fuzzy C-Means(KFCM) and Modified Kernel Fuzzy C-Means (MKFCM) algorithms. Results are obtained for different Land sat 7 Remote Sensing images. Finally quality measures such as mean square error, average difference, normalized cross correlation and error measurements like Peak signal to noise ratio, Normalized absolute error are calculated.**

Keywords- Image Enhancement, EM, K-Means, KFCM, MKFCM Algorithm**.**

I. INTRODUCTION

Images are replications of real world objects [3]. Processing those copies to get betterment of an image is called as image processing. Image Processing is a tactic which is used in improvising the quality and clarity of the image to get an enhanced retrieval of information [2]. Image can be represented in the area of digital processing, which can be said as another reproduction of an object. A grayscale image is one which has merely the intensity value. Its value usually ranges from 0 to 1. Zero signifies black and 1 signifies white. A gray image has a value which ranges between these two.

Image Enhancement is the process of improving the quality of a digitally stored image [3]. Itstechnique is used to process an image so that outcome is more suitable than original image for definite application. To increase or decrease contrast or to make an image darker or lighter image enhancement method is needed [1].Image segmentation is the process of portioning a digital image into multiple segments or sets of pixels which is also known as super pixels passing on a label to every pixel in an image such that pixel with the same label distribute certain visual qualities [2]. It can also be said as a separation of an image into meaningful structures. Segmentation divides an image into distinct regions having each pixel with similar attributes [4].

II. LITERATURE SURVEY

Mrs.D.Manju et al.,[15] proposed multiple kernel fuzzy c-means (MKFCM) algorithm and adaptive level set method for image segmentation can be used to detect brain tumor. MKFCM combines different information of image pixels in the kernel space by using different kernel functions. Edge indicator function was redefined in MKFCM, which is used for segmentation. Level set methods are used for contour evaluation and shape recovery. The result of MKFCM segmentation was used to obtain the initial contour of level set method. This proposed algorithm can be implemented on the brain MRI images to detect tumors.

Long Chen et al.,[17] introduced a generalized multiple-kernel fuzzy C-means (MKFCM) methodology as a framework for image-segmentation problems. In the framework, aside from the fact that the composite kernels are used in the kernel FCM (KFCM), a linear combination of multiple kernels is proposed and the updating rules for the linear coefficients of the composite kernel are derived as well. The proposed MKFCM algorithm provides us a new flexible vehicle to fuse different pixel information in image-segmentation problems. That is, different pixel information represented by different kernels is combined in the kernel space to produce a new kernel. It is shown that two successful enhanced KFCM-based image-segmentation algorithms are special cases of MKFCM. Several new segmentation algorithms are also derived from the proposed

MKFCM framework. Simulations on the segmentation of synthetic and medical images demonstrate the flexibility and advantages of MKFCM-based approaches.

III. Methodology

Image Processing is an approach of doing incredible in a systematic way in order to acquire premium output. Images are the diverse sources for information reclamation [4]. The following figure shows the process.

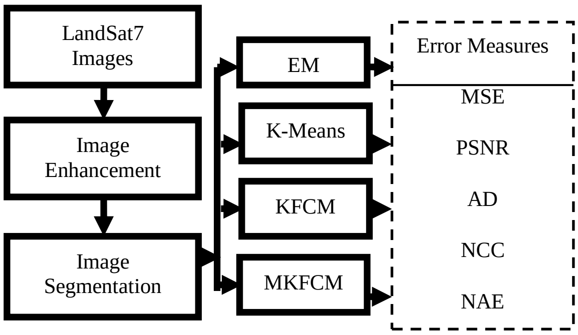

Figure 1: System Architecture

IV. Image Enhancement

Main objective of Image enhancement is to process an image so that outcome is more suitable than original image for definite application [3]. Digital image enhancement techniques offer a multitude of choices for developing the visual quality of images [1]. Suitable choice of such techniques is significantly influenced by the imaging task at hand and viewing conditions.

Spatial Domain Methods: Spatial domain techniques are executed to the image plane itself and they are based on straight manipulation of pixels in an image [14]. The operation can be formulated as

$$g(x,y) = T[f(x,y)] \quad (1)$$

where g is the output, f is the input image and T is an operation on f defined over some neighborhood of (x,y).

*Frequency Domain Methods:*These methods enhance an image f(x,y) by convoluting the image with a linear, position invariant operator [14]. The 2D convolution is performed in frequency domain with DFT.

V. Image Sgmentation

The goal of image segmentation is to make things easier and/or modify the representation of an image into groups of pixels something that is more meaningful and easier to analyze the related image regions, i.e., regions corresponding to individual surfaces, locate objects, or natural parts of objects, boundaries, lines, and curves [11]. Image segmentation is the process of portioning a digital image into multiple segments or sets of pixels is also known as super pixels passing on a label to every pixel in an image such that pixel with the same label distribute certain visual qualities [2]. Some popular approaches are used in segmentation: threshold techniques, edge based methods, region based techniques, pixel-based methods, model-based methods, and connectivity-preserving relaxation methods [4].

A. EM Algorithm

An expectation–maximization (EM) algorithm is an iterative method for finding maximum likelihood or maximum a posteriori (MAP) estimates of parameters in statistical models, where the model depends on unobserved latent variables[5]. The EM iteration alternates between performing an expectation (E) step, which creates a function for the expectation of the log-likelihood evaluated using the current estimate for the parameters, and amaximization (M) step, which computes parameters maximizing the expected log-likelihood found on the E step[8]. These parameter-estimates are then used to determine the distribution of the latent variables in the next E step.

EM algorithm aims to maximize the likelihood of the mixture density given by the data, i.e.

$$p(D|\theta) = \prod_{i=1}^{N} \sum_{j=1}^{k} P_j \cdot g_j(x_i|\mu_j, \Sigma_j) \tag{2}$$

where, $g_j(.)$ - is the normal density with the mean μ_j and Σ_j. P_j is the prior probability of the class *j*.

B. K-Means Clustering Algorithm

The K-means clustering is a method of vector quantization, originally from signal processing, that is popular for cluster analysis in data mining[9]. The K-means clustering aims to partitionn observations into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster[10]. This results in a partitioning of the data space into Voronoi cells.

The k-means algorithm estimates the unknown cluster centers (means) $M = \{\mu_1, \dots, \mu_k\}$ based on the data $D = \{x_1, \dots, x_N\}$. It aims to minimize

$$J(M) = \sum_{i=1}^{N} \| x_i - \mu_i \|^2 \tag{3}$$

where μ_i is the closest cluster center to x_i.

C. Kernel Fuzzy C-Means Algorithm

In image clustering, the most commonly used feature is the gray-level value, or intensity of image pixel[10]. Where high membership values are assigned to pixels whose intensities are close to the centroid of its particular class, and low membership values are assigned when the point is far from the centroid. Kernel function is that the inner product be implicitly computed in F without explicitly using or even knowing the mapping ф. So, kernels allow computing inner product in spaces, where one could otherwise not practically perform any computations[13]. Kernel Fuzzy C-Means define a nonlinear map as ф: x→ ф (x) belong to F, where x(F), x-denotes the data spaces. F-Transformed feature space with higher even infinite dimension. The function of KFCM is,

$$J_m(U,V) = 2\sum_{i=1}^{c} \sum_{k=1}^{n} \mu_{ik}^{m} (1 - K(x_k, V_i)) \tag{4}$$

D. Modified Kernel Fuzzy C-Means Algorithm

Although KFCM can be directly applied to image segmentation, like FCM, we propose to modify algorithm by taking into account the image topology. For the Enhanced KFCM we propose:

1. To take into account the image topology, the statistical parameters of a window around the pixel are considered.
   For an image y, of size (N×M), and a sliding window of size (p×p), the four features extracted from the window centered at pixel (n,r) are given by the following equations:

$$M_e = \frac{1}{MN} \sum_{i=-\frac{p-1}{2}}^{\frac{p-1}{2}} \sum_{j=-\frac{p-1}{2}}^{\frac{p-1}{2}} y(n+i, r+j) \tag{5}$$

$$V = \frac{1}{MN} \sum_{i=-\frac{p-1}{2}}^{\frac{p-1}{2}} \sum_{j=-\frac{p-1}{2}}^{\frac{p-1}{2}} (y(n+i, r+j) - Me)^2 \tag{6}$$

$$S_k = \frac{1}{MN} \sum_{i=-\frac{p-1}{2}}^{\frac{p-1}{2}} \sum_{j=-\frac{p-1}{2}}^{\frac{p-1}{2}} (y(n+i), r+j) - Me)^3 \tag{7}$$

$$K_u = \frac{1}{MN} \sum_{i=-\frac{p-1}{2}}^{\frac{p-1}{2}} \sum_{j=-\frac{p-1}{2}}^{\frac{p-1}{2}} (y(n+i, r+j) - Me)^4 \tag{8}$$

Where M_e, V, S_k and K_u are mean, variance, the skeweness, and the kurtosis respectively.

Enhanced Objective Function is

$$J_m(U,V) = 2\sum_{i=1}^{c} \sum_{k=1}^{n} \mu_{ik}^{m} \left(1 - K(x_k, V_i)\right) + M_e + V + S_k + K_u \tag{9}$$

VI. TESTING AND IMPLEMENTATION

Testing is a process of checking whether the developed system is working according to the original objective and requirements. Testing is a set of activities that can be planned in advance and conducted systematically. It is vital to the success of the system. Testing is like processes where inputs are received and outputs are produced. In the proposed work the testing is done by finding the Mean Square Value, Peak Signal to Noise Ratio, Normalized Cross Correlation, Average Difference and Normalized Absolute Error.

A. Implementation

Implementation is carrying out, execution, or practice of a plan, a method, or any design for doing something. Implementation is action that must follow any preliminary thinking in order for something to actually happen. In this proposed work the implementation is carried out using Expectation Maximization Algorithm, Kernel-Means Algorithm, Kernel Fuzzy C-Means Algorithm and Modified Kernel Fuzzy C-Means Algorithm.

VII. DATA SET DESCRIPTION

In this study we segment different LandSat7 remote sensing images. Among those the LandSat7 Image1 is a real sample image data of America. The experimental results are discussed for Expectation Maximization Algorithm, Kernel Means Algorithm, Kernel Fuzzy C-Means Algorithm and Modified Kernel Fuzzy C-Means Algorithm. For this work the system has used the specification of i3 processor and 3GHZ, disk space on windows 7 system. The result may be varying by the system specification and the goal is to segment the image.

VIII. EVALUATION MEASURES

Image Quality Assessment (IQA) is a necessary characteristic for evaluating the image quality. Widely popular IQA techniques such as Mean Square Error(MSE), Peak Signal to Noise Ratio(PSNR), Normalized Absolute Error(NAE), Normalized Cross Correlation(NK) and Average Difference(AD) are considered to evaluate the quality of proposed methodology.

A. Mean Squared Error (MSE)

MSE measures the average of the square of the "error." The error is the total by which the estimator differs from the quantity to be estimated[12]. The difference occurs because of arbitrariness or because the estimator doesn't account for information that could produce a more accurate estimate.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j) - y(i,j))^2 \tag{10}$$

Where x(i, j) represents the original (reference) image and y(i, j) represents the Segmented image (modified) image and i and j are the pixel position of the M×N image. MSE is zero when x(i, j) = y(i, j) .

B. Peak Signal –to-Noise Ratio(PSNR)

PSNR is the evaluation standard of the reconstructed image quality, and is important feature. PSNR is defined as follow

$$PSNR = 10log\frac{255^2}{MSE} \tag{11}$$

where255 is maximum possible value that can be attained by the image signal. Ideally it is infinite. Practically it is in the range of 25 to 40 dB.

C. Normalized Absolute Error (NAE)

Normalization is the process of separating statistical error in repeated measured data. Normalization is sometimes based on a property. NAE is defined as

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i.j) - y(i,j)|}{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i.j)|} \tag{12}$$

D. Normalized Cross-Correlation (NK)

The closeness between two digital images can also be quantified in terms of correlation function. Normalized Cross-Correlation (NK) measures the similarity between two images and is given by the following equation,

$$NK = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j) \times y(i,j))}{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j))^2} \quad (13)$$

E. Average Difference (AD)

The difference is visual properties that make an object distinguishable from other objects and the background. AD is given by,

$$AD = \sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k})/MN \quad (14)$$

IX. RESULT

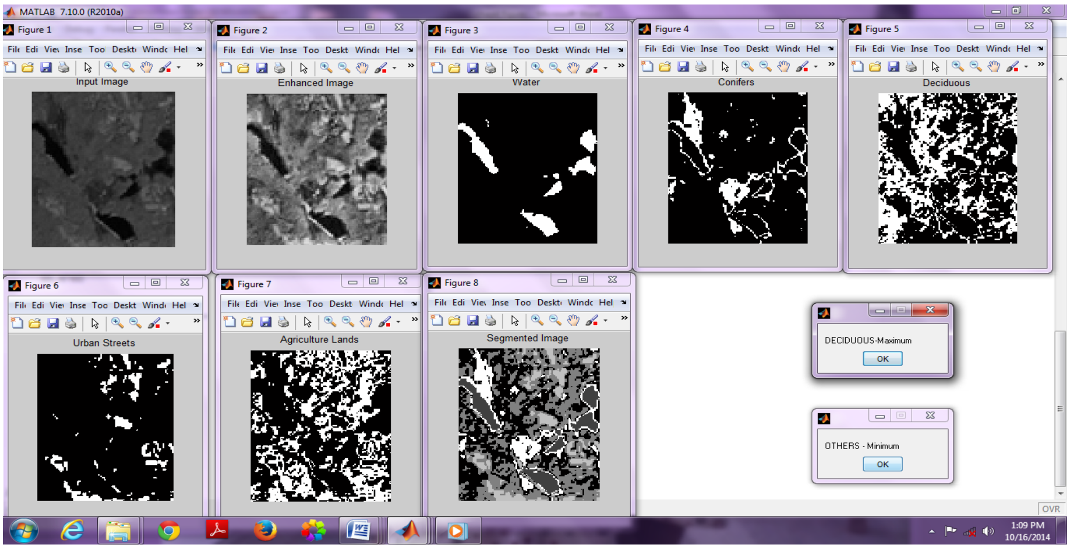

Figure 2: Result of MKFCM (Landsat7 Image-1)

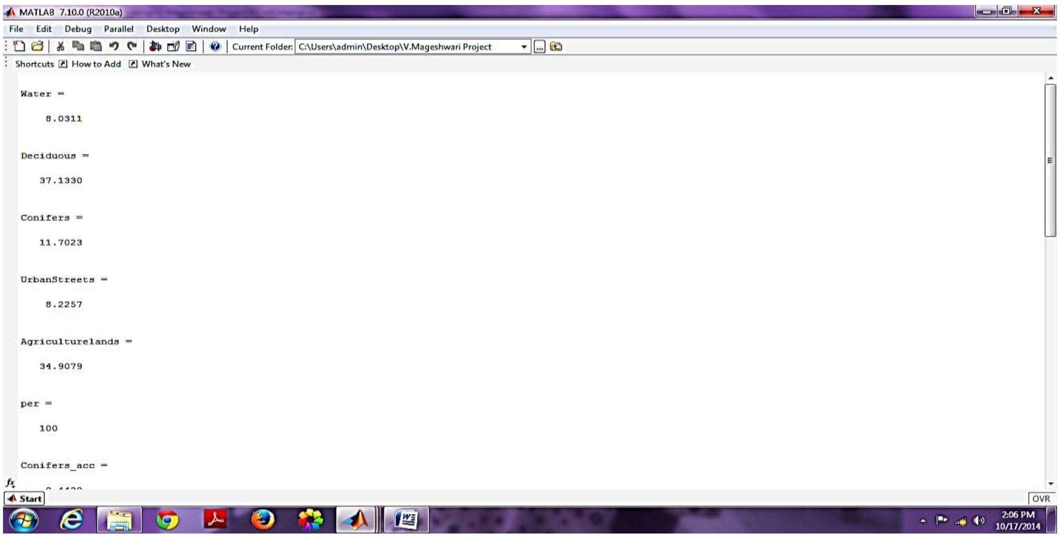

Figure 3: Classified Regions in MKFCM (LandSat7 Image-1)

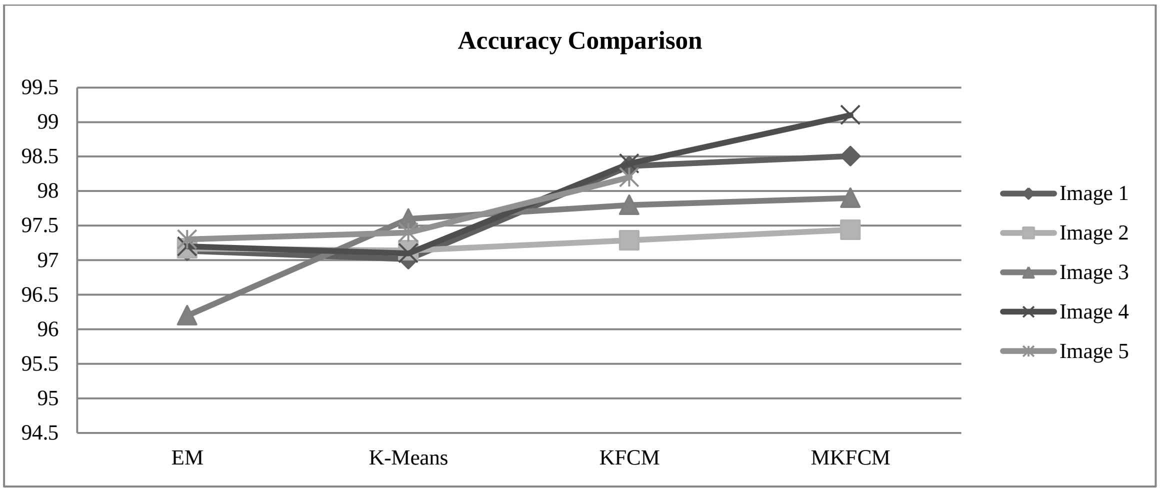

Figure 4 : Segmentation Ratio Accuracy between EM, K_Means, KFCM and MKFCM

Table1. (Result of LandSat7 Image Segmentation Ratio)

Performance Measure	Image1				Image2			
	EM	K_Means	KFCM	MKFCM	EM	K_Means	KFCM	MKFCM
MSE	4.2389	4.2341	4.2869	3.3587	5.8623	5.8643	5.8599	1.6123
PSNR	35.5857	35.5955	35.4879	37.6074	32.7695	32.7665	32.7730	43.9817
NCC	0.9794	0.9699	0.9742	1.0297	3.0865	4.0139	0.2362	1.2205
AD	17.9683	17.9280	18.3778	11.2809	34.3660	34.3902	34.3382	22.5996
NAE	4.2389	4.2341	4.2869	3.3587	5.8623	5.8643	5.8599	1.6123

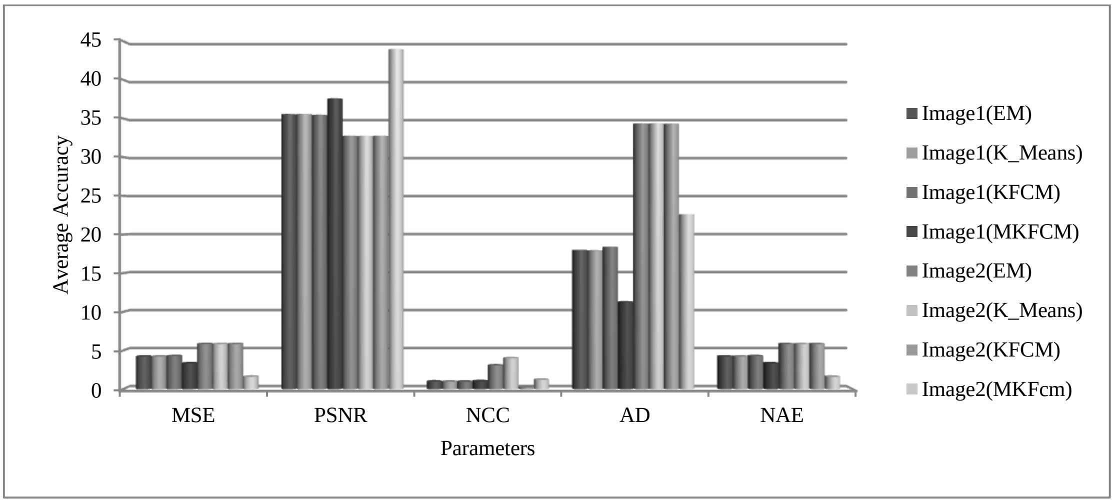

Figure 5: Comparison Chart

X. Conclusion

In this proposed work, five LandSat7 remote sensing images are taken as input image. Image segmentation based on Expectation Maximization, Kernel Means, Kernel Fuzzy C-Means and Modified Kernel Fuzzy C-Means has been done. In the first image water, conifers, deciduous, urban street and agriculture land regions are segmented using the above mentioned algorithms. For rest of the images also the same process has been carried out.For the analysis of image, Quality Performance Parameters such as Mean Square Error, Peak Signal to Noise Ratio, Normalized Cross Correlation, Average Difference, and Normalized Absolute Error are considered.The experimental result shows that the proposed MKFCM segmentation method exhibits higher efficiency than the EM, K-Means and KFCM algorithms.

XI. FUTURE WORK

In the future, work can be focused on proposing enhanced algorithms which can further reduce the mis-segmentation ratio, error ratio and increase the efficiency of segmentation of regions in Remote Sensing Images.

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