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Hybrid Clustering Algorithm and Feed-Forward Neural Network for Satellite Image Classification

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ABSTRACT: *This paper presents a hybrid clustering algorithm and feed-forward neural network classifier for land-cover mapping of trees, shade, building and road. It starts with the single step preprocessing procedure to make the image suitable for segmentation. The pre-processed image is segmented using the hybrid genetic-Artificial Bee Colony(ABC) algorithm that is developed by hybridizing the ABC and genetic algorithm to obtain the effective segmentation in satellite image and classified using feed-forward neural network classifier . Classification accuracy of hybrid algorithm is found better than well known KFCM, Moving KFCM.*

KEYWORDS : *Segmentation, classification, feature extraction, feed-forward neural network classifier, hybrid genetic ABC algorithm.*

I. INTRODUCTION

Satellite image classification includes mainly two steps segmentation and classification step. The main objective of image segmentation is to partition the image into parts of strong correlation with objects or areas of the real world image . Mainly, owing to its realistic significance, such as in the treatment of images attained from satellite prospection, the recognition of the types of objects comprises an important issue in pattern recognition [1]. Actually, image segmentation can be known as the practice of conveying a label to each pixel in an image, such that pixels with the similar label signify the same object, or its components. Based on segmentation methods, Segmentation algorithms can be categorized into dissimilar categories used such as the features thresholding [2], template matching [3], region based technique and clustering. Those methods have their own restrictions and benefits in terms of appropriateness, presentation and computational cost.At present , in the Literature, an extensive variety of satellite image categorization methods are: Cluster, Statistic, Bayesian Net, Artificial Neural Networks (ANN), etc [4]. By visual understanding of satellite imagery and aerial photography, now, operators can manually remove cartographic features, such as buildings, roads, and trees.

Semi-automatic algorithms also help the operator to develop the process. General categorization algorithms for low-resolution satellite imagery are excessively restricted to deal with complex high-resolution satellite information and need novel algorithms. Some authors have used categorization techniques for satellite images [5,6]. Based on computational intelligence diverse classifiers in the final direction, has been proposed [7]. Taking benefit of the improved mapping capabilities of neural networks, conventionally, neural network classifiers are proposed [8,9]. For building classifiers that are effortlessly interpretable by humans, Fuzzy theory presents an eye-catching framework, whereas at the same time modeling the inexactness come across in nature. Fuzzy classifiers are frequently consigned to as ‘‘soft’’ classifiers, as opposed to the non-fuzzy ‘‘hard’’ classifiers, with their applicability being of still larger significance under the survival of varied pixels.

II. REVIEW OF LITERATURE

In the image processing domain, Satellite image categorization is an extremely taxing task. In order to progress precision, researchers have applied different kinds of classification techniques. According to the database of skilled knowledge for a more focused satellite image classification, a hybrid biologically inspired method was adapted that was presented by Lavika Goel [10]. As a competent land cover classifier for satellite image, a hybrid FPAB/BBO based algorithm has been presented by Navdeep Kaur Johal *et al.* [11].A FPAB/BFO based algorithm for the categorization of satellite image has been presented by Parminder Singh *et al.* [12]. To choose the optimal and minimum set of fuzzy rules, the use of a genetic algorithm (GA) has been presented by O. Gordo *et al*. [13] and to categorize remotely sensed images using a fuzzy classifier.

A generalized multiple-kernel fuzzy C-means clustering (MKFCM) methodology for satellite image segmentation has been presented by M. Ganesh and V. Palanisamy [14]. Aissam Bekkari *et al*. [15] have progressed a methodology using a combination kernel that effortlessly combined multi-spectral features, Haralick consistency characteristics and Hybrid Median Filter, with dissimilar window sizes. The result demonstrated that the common use of spectral and texture data as one considerably enhanced the precision of satellite image categorization.This paper, proposes a significant satellite image classification technique using hybrid clustering algorithm and feed-forward neural network classifier. The proposed approach consists of three steps

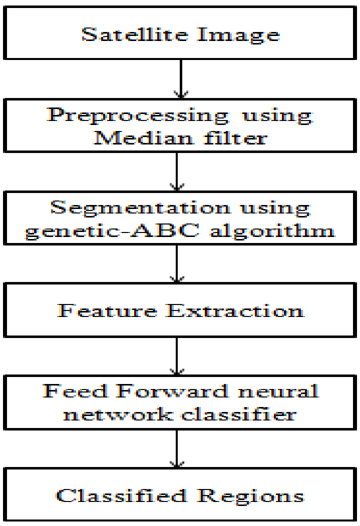
[1] Pre-processing
[2] Segmentation using genetic-ABC algorithm
[3] Classification using feed-forward neural network classifier.

Initially pre-processing is performed to make the image suitable for segmentation. In segmentation, the pre-processed image is segmented using hybrid genetic-ABC algorithm that is developed by hybridizing the ABC algorithm [16] and genetic algorithm to obtain the effective segmentation in satellite images. Then, feature is extracted and the classification of satellite image into four different labels (tree, shade, road and building) is done using feed-forward neural network classifier.

III. HYBRID CLUSTERING ALGORITHM AND FEED-FORWARD NEURAL NETWORK CLASSIFIER FOR SATELLITE IMAGE CLASSIFICATION

In remote sensing various techniques like Parallelepiped Classification, Minimum Distance to Mean Classification, Maximum Likelihood Classification etc. [17] are used satellite image classification. These techniques not only need high resolution image for processing, but also have limited accuracy in information retrieval and insensitive to different degrees of variances in the spectral response data. To provide a solution to the above problems, a new segmentation technique is introduced for image classification. Three major stages are involved in proposed methodology:

(1)Pre-processing
(2)Segmentation using genetic-ABC algorithm
(3)Classification using Feed-forward neural network
Classifier



*Fi*g(1).Flow Diagram of Proposed approach

3.1 Preprocessing

Satellite images cannot be given directly as the input for the proposed technique. Thus, it is indispensable to perform pre-processing on the input image, so that the image gets transformed to be relevant for the further processing. In proposed technique,

- A Nonlinear Median filter which is used to filter out the noise in the R, G and B layers for filtering noise. It is used because, under certain conditions, it preserves edges while removing noise.
  Image adjustment function is used and the range of pixel intensity in each of the R, G and B layers is made [0 - 255] by stretching if necessary.

3.2 Segmentation using Genetic-ABC Algorithm

ABC algorithm and Genetic algorithm are combined to obtain the effective segmentation of satellite images. Image segmentation process using hybrid algorithm as under:

Step (a): The satellite images are converted into gray images and then these gray images are segmented into six new segments using prposed algorithm.

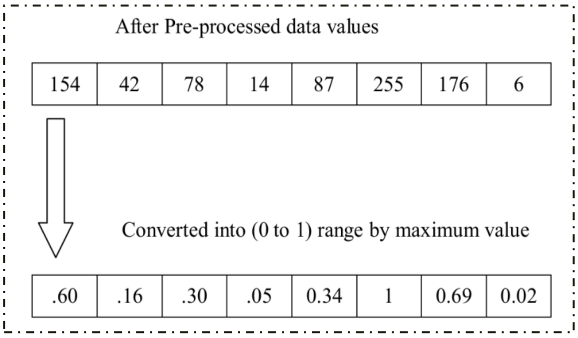
Step (b): The gray image is converted into HSL layer. From converted HSL images, the H layer image is segmented into six segments using Hybrid algorithm.

Step(c): From the above two steps , finally we have obtained thirty six new segments like as tree, shadow, building, road, etc.

The detailed explanation of proposed algorithm is given below.

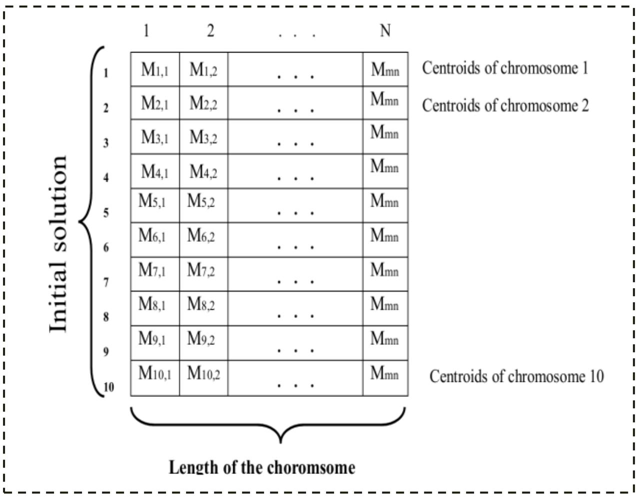
Step 1: Chromosome representation and Generation of an initial solution

In the initialization phase, we have generated the 'm' number of chromosome. Each element of the vectors representing a cluster centre is an integer that indicates the ranges between 0 to 1.



Fig(2): Chromosome representation process

In clustering process, the centroids should be defined based on the number of cluster. Most of algorithm uses random data points as an initial centroid for clustering. In this paper, a set of cluster centorid (solutions) is randomly generated (range between 0 to 1) to the hybridizing algorithm. Every chromosome (cluster centroid) in the initial population consists 'k' number of vectors where every vector is having a length of 'd' which is equal to the dimensions of data. For example, a chromosome encoding with N number of clusters and corresponding centroids for 10 chromosomes is given in Fig(3). Here, M is the centroid value.



Fig(3): Candidate solution encoding with N number of clusters and corresponding centroids for 10 chromosomes.

Step 2: Fitness Computation

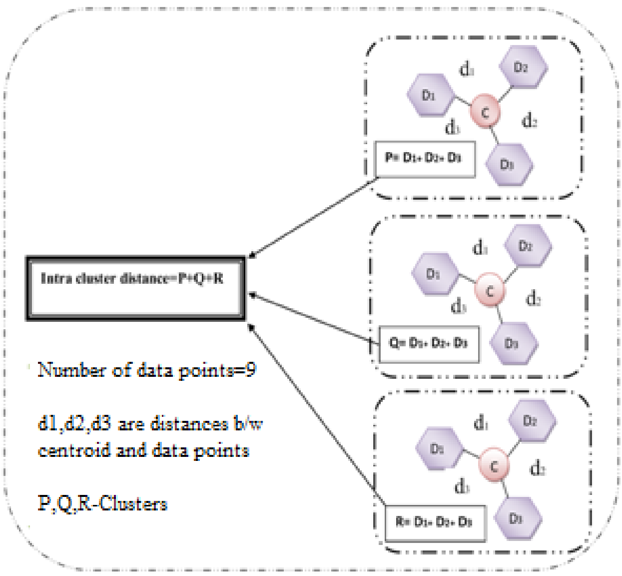
The fitness of each chromosome in the solution is evaluated with objective function presented by Eq(1). For every solution Y_i, the objective function should be computed to find the survival of the solution. The objective function of the clustering process taken for this paper is intra cluster distance that is computed by the following equation

$$J_1(Y) = \frac{1}{\sum_{i=1}^{N} \min\left\{\left\|X_i - X_j\right\|\right\}}; \; j = 1, 2, \ldots, k \quad ---- \quad (1)$$

Where, $\left\|X_i - X_j\right\|$ is a chosen distance measure between a data point X_i and the cluster centre X_j, 'N' and 'k' are the number of input data and the number of cluster centres, respectively. The finding of objective function of clustering process is illustrated in Fig(4).

Step 3: Employed bee phase

After initialization, in the employed bees' phase, each employed bee is sent to the food source in its memory and finds a neighboring food source. Here, 20% chromosomes are randomly generated for every new chromosome generation process. Subsequently, we have determined best fitness from the employed bee phase.



Fig(4): Example diagram of clustering process

Step 4: Onlooker bee phase

In the onlooker bees' phase, the onlookers receive the information of the food sources shared by employed bees. Then each chromosome has chosen a solution to exploit depending on a probability related to the nectar amount of the solution (fitness values of the solution). That is to say, there may be more than one onlooker bees choosing a same solution if the source has a higher fitness. The probability P_i is calculated according to Eq(2) as followed:

$$P_i = \left[\frac{0.25}{Max\ fitness}\right] * fit + 1 \qquad (2)$$

After solutions have been chosen, each onlooker bee finds a new solution in its neighbourhood following Eq(3),

$$x_{i,j} = x_j^{\min} + rand(0,1)(x_j^{\max} - x_j^{\min}) \qquad (3)$$

Step 5: Mutation

After onlooker bee phase, some selected chromosomes are considered for mutation. Mutation consists of changing the value of a random bit, which is randomly chosen in the chosen vector.

Step 6: Scout bee phase

In scout bees' phase, if the value of trials counter of a solution is greater than a parameter, known as 'limit', the solution is abandoned and the bee becomes a scout bee. A new food solution has produced randomly in the search space using Eq(3), as in the case of initialization phase. The employed, onlooker, mutation and scout bees' phases will recycle until the termination condition is met. The best food source which presents the best solution.

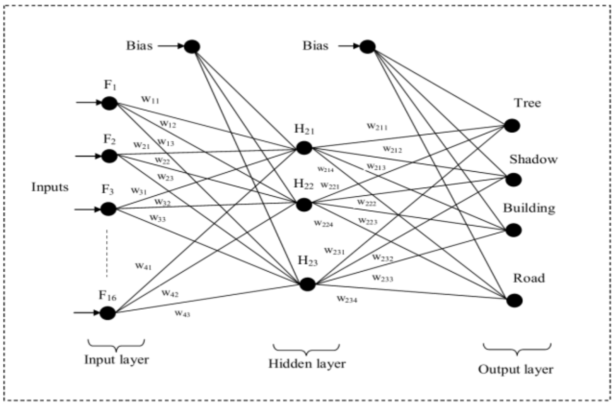
3.3 Feature Extraction

Feature extraction process for satellite image segmentation is discussed in this section. Four new segments like as road, building, tree and shadow are obtained from the 36 segments. First, HSL image is obtained from the median filtered training images. Then feature extraction step is formulated in the following steps.

- H, S and L layer obtained from HSL image
- T layer obtained from TSL image
- A and B layer obtained from LAB image
- U and V layer obtained UVL image
- Index of peak value in 256 bin histogram of each is noted.
- Mean pixel value in each of these layers is obtained.
- Values obtained in step 5 and 6 are used as features.

3.3 Classification using Neural Network

Classification step is to identify road, building, tree and shadow regions from original satellite image. 16 features have been used for the classification purpose. Here, feed forward neural network is used for classification purpose. The neural network model is depicted in Fig (5).



Fig(5): Neural network model for proposed approach

The proposed neural network model comprises three layers of nodes - an input layer, hidden layer and an output layer, as shown in Fig. 5. Each satellite image is represented by its features in separate columns of the pattern (input) matrix P. The weight matrix W is the connection matrix for the input layer to the output layer. The first step in simple network implementation is determination of number of output neurons. Before training a feed forward network, the weight and biases is initialized. Once the network weights and biases have been initialized, the network is ready for training. We used random numbers around zero to initialize weights and biases in the proposed neural network. The training process needs a set of proper inputs (for our approach we give 16 features) and targets as outputs (tree, shadow, building and road). During training, the weights and biases of the network are iteratively adjusted to minimize the network performance function. The default performance function for feed forward networks is mean square errors, the average square errors between the network outputs and the target output. Finally, the four different labels (tree, shade, road and building) of original satellite image are identified .

IV. SIMULATION RESULTS

The proposed approach of satellite image segmentation is experimented with the satellite image dataset and the result is evaluated with accuracy.

4.1 Experimental Setup and Dataset Description

Experimental results of proposed technique using different satellite images are experimented using MATLAB

7.12 with WINDOWS 7and 4GB RAM original satellite image (.lan format) have multispectral (R, G, B, NIR) bands and these images converted to TIFF format. This is done using Multispec32 which is a freeware multispectral image data analysis system. The
Fig(6), shows the input satellite image.

Fig.6 Input Satillite Image

4.2 Evaluation Metrics

The evaluation of proposed technique in different satellite images are carried out using the following metrics as suggested by below equation.

$$\text{Accuracy} = \frac{\text{number of true positives} + \text{number of true negatives}}{\text{number of true positives} + \text{false negatives} + \text{true negatives} + \text{false positives}}$$

4.3 Experimental Results

The proposed technique is designed for identify the four different labels (tree, shade, road and building) of satellite images. The obtained experimental results from the proposed technique are given in figure 7 (a)-(d).These figures shows the extracted regions (tree, shade, road and building) from the Input satellite images.

Fig.7(a) Building

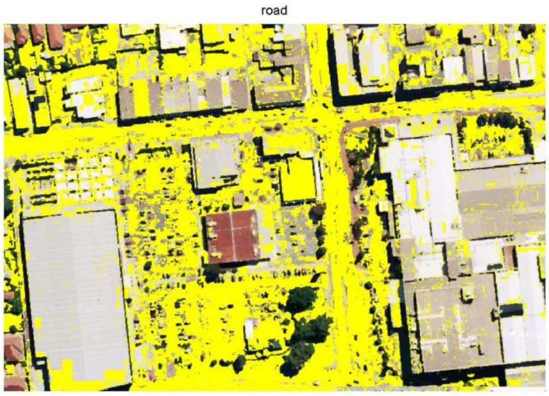


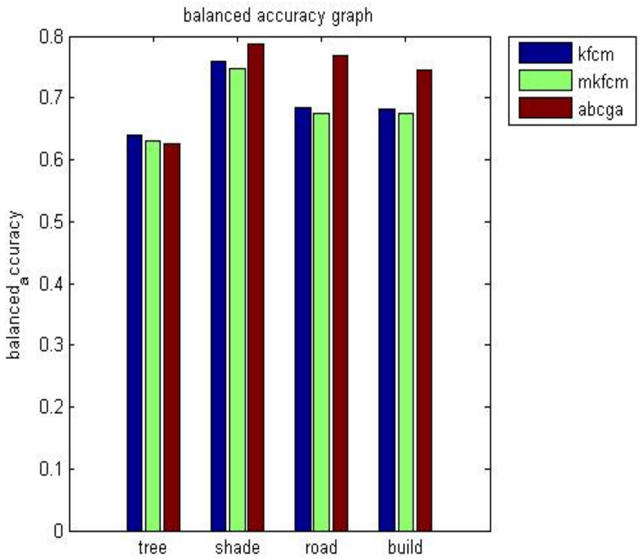
Fig.7(b) Road

Fig.**7(c)** Shade

Fig.7(d) Tree

4.4 Comparative Analysis

In this paper, the proposed algorithm results are compared with against Moving KFCM and KFCM algorithm. The performance of this is analyzed with parameter accuracy. The accuracy value is computed by dividing the total number of similar pixels identified as land use to the number of pixels in the tree, shade, building and road region. The detailed results obtained for proposed technique is drawn as graph shown in Fig((10). As shown in Fig(10) the proposed technique is achieved the maximum accuracy value of 74% for shade region which is high compared with the accuracy of MKFCM (67%), KFCM (68%) . It is giving better results for road, shade and build regions except tree. Hence, it is clear from result analysis that the proposed algorithm shows better results as compared with existing techniques.



Fig(10): Comparison graph of Accuracy

IV. CONCLUSION

In this paper, optimization algorithms for segmentation with the intention of improving the segmentation in satellite images using feed-forward neural network classifier is proposed. The overall steps involved in the proposed technique in three steps such as, i) Pre-processing, ii) segmentation using genetic-ABC algorithm, and iii) classification using feed-forward neural network classifier. Initially pre-processing is performed to make the image suitable for segmentation. In segmentation, the pre-processed image is segmented using hybrid genetic-ABC algorithm that is developed by hybridizing the ABC algorithm and genetic algorithm to obtain the effective segmentation in satellite images. Then, feature is extracted and the classification of satellite image into four different labels (tree, shade, road and building) is done using feed-forward neural network classifier. Finally, classification accuracy of the proposed algorithm in satellite image classification is calculated and the performance is compared with Moving KFCM and KFCM algorithm. **Practical implications: *Green area***: The detection of green areas could help scientist to study deforestation and changes in vegetation. ***Building area*:** This detection can be useful for urban development applications. ***Road area*:** This detection can be used in several industrial applications such as for auto recognition and for military purposes. It is important to provide military and other groups with accurate, up-to-date maps of the road networks in any region of the world. Overall, this work can be usefully to do the intelligent analysis to find the growth of every region as well as the awareness of building, and green.

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