ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 9(45), DOI: 10.17485/ijst/2016/v9i45/97437, December 2016* ISSN (Online) : 0974-5645

Satellite Image Classification using Back Propagation Neural Network

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Abstract

Objectives: The objective of proposed method is to improve the accuracy and performance of an image. To apply the segmentation on satellite image using a median filter and the Scale Invariant Feature Transformation algorithm for feature extraction from an image. And to implement the Back Propagation Neural Network algorithm so as to reduce the mean square error rate, false acceptance and rejection rate and to improve the accuracy of an image. **Methods/Statistical Analysis:** The single step pre-processing of an image is done to make it suitable for segmentation. For segmentation, median filter is used and the Scale Invariant Feature Transformation (SIFT) algorithm is used for feature extraction. When features from the image are generated then the image is optimized using a Genetic Algorithm. After image optimization Back Propagation Neural Network is used to classify the image based on different parameters. Our proposed technique is a Genetic Algorithm for an image optimization and Back Propagation Neural Network (BPNN) for classification of the satellite image. **Findings:** The image feature extraction using Scale Invariant Feature Transformation (SIFT) method results in better feature extraction as it gives both the key distribution points saved in database and image. The mean square error using GA-BPNN is less than existing technique ABC-FCM which gives better performance. GA-BPNN technique gives more accuracy which is approximately 99.91 as compared to other methods. **Application/Improvements:** The proposed technique has been tested with the images of different resolution and the results obtained by BPNN are proven to be better than the ABC-FCM. The proposed method can be used for different types of images and also for medical images.

Keywords: Back Propagation Neural Network, Genetic Algorithm, Image Classification, Optimization, Segmentation

1. Introduction

Image classification is the most important research area and application part in Artificial Neural Networks[1]. Classification helps in making various decisions regarding human activities. Classification problem happens when need arises to assign an object into already defined groups or classes on the basis of known attributes. Image segmentation is an important part in image analysis. A neural network has emerged as an important tool for classification. Recent research in this area of neural network classification has established that classification using neural networks is better than traditional approaches used for classification. The classification leads to a partition compound of homogeneous regions (the classes) with regular boundaries (with minimal length).

We propose a Genetic Algorithm for image optimization and BPNN for classification of a satellite image. The performance of proposed hybrid algorithm (GA-BPNN) is compared with the hybrid algorithm Artificial Bee Colony and Fuzzy c-mean (ABC-FCM). In[2] explains color image segmentation using Fuzzy C-Means (FCM), Possibilistic Fuzzy C-Means (PFCM) and Competitive Neural Network (CNN). In[3] presents color image segmentation using Support Vector Machine (SVM). In[4] used the hybrid technique for classification problems with noises using Kernel Fuzzy C-Means Clustering based Fuzzy Support Vector Machine algorithm (KFCMFSVM). In[5] deals with segmentation and classification of remote-sensing images using K-means and Back propagation NN. In[6] uses Entropy-based Fuzzy Clustering (EFC) and FCM and the performance in form of quality and time of these algorithms are compared on different dataset like WINES, IRIS, OLITOS, psychosis.

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In[7] has done classification of satellite images into different objects using K-means clustering. In[8] uses Cluster Repulsion based KFCM and SVM to classify objects of satellite images. In[9] deal with image segmentation based on color features using unsupervised FCM.

First Section explains image classification along with proposed work, Section 2 describes the clustering techniques, Section 3 defines image segmentation, Section 4 defines feature extraction, Section 5 discusses various soft computing techniques, Section 6 discuss about classification, Section 7 defines the methodology, Section 8 yields results, Section 9 discuss results, Section 10 conclude the results.

2. Clustering Techniques

Clustering is not a supervised learning process as classification. It is an unsupervised learning process. Clustering is the process of grouping large objects in a single class of similar objects. Objects are similar in one cluster but are dissimilar to the objects of other clusters. Clusters can be of different shape, size, density. Different type of clustering is there. One is hard clustering[1] and another is fuzzy clustering. In hard clustering an object might belong to a certain cluster or not. In this data is partitioned into number of mutually exclusive subsets. Clustering is to partition data points into various homogeneous classes or clusters[1] so that similar items are in same class and dissimilar items in other class. In clustering large number of items are converted into a small number of clusters.

2.1 Fuzzy Clustering

In non-fuzzy or hard clustering, data is divided into different clusters, each data point belongs to only one cluster. In fuzzy clustering, the data points can belong to several clusters[1]. Fuzzy clustering uses membership levels and based on these levels assign data elements to clusters. In fuzzy clustering boundary objects between several classes may or may not fully belong to one of the classes but they have partial membership means membership lies between 0 to 1. Partitioned data after clustering is more meaningful and gives internal structure of data. There are various fuzzy clustering algorithms. Various areas of applications include data analysis, pattern recognition and image segmentation. Fuzzy clustering is a part of soft computing techniques (which include neural networks, fuzzy systems and Genetic Algorithms)[1].

2.2 Fuzzy C-Means

Fuzzy C-Mean clustering algorithm is most salient of the fuzzy clustering algorithms[1]. The Fuzzy C means algorithm is an improvement over Hard C-Means clustering algorithm. In this a membership value is assigned to each data point corresponding to each cluster centroid on the basis of distance between the cluster center and the data point. The FCM algorithm receives the data in the form of matrix as n×m where n and m represents the number of data and number of parameters respectively and c is the number of clusters[2], U is the assumption partition matrix, E is the convergence value. The assumption partition matrix has n number of columns and c number of rows contains values from 0 to 1. The summation value of every column has to be 1. Firstly calculate the cluster centers. This is a matrix v of dimension c rows with m columns. Then calculate the distance matrix D which is called as Eucledian distance between every data point and centroid.

3. Image Segmentation

To extract information from an image is called as Image Analysis. Image segmentation is the initial step in most automated applications like pattern recognition and scene analysis problems[2].

Segmentation plays a vital role in any automated image recognition system to extract features[2]. Segmentation of an image means classification of each image pixel to any one of the image parts[2]. Many algorithms have been developed for segmenting gray scale images. Given a satellite image, we want to make a classification, i.e. to assign a label to each pixel. Image segmentation divides a digital image into multiple regions or clusters, where each specific region is made up of number of pixels. Image segmentation is widely used for locating objects of various interests and boundaries like lines, curves edges in an image[3]. The result of image segmentation is set of edge or key points that cover the entire image.

For image segmentation we use median filters to get clear and noise free image[3]. It is used to remove noise from image. Reduction of noise[4] is a pre-processing step so as to improve results for later processing of an image like for edge detection or key point. Median filter technique is often used in digital image processing area because it

does not affect edges while removing noise from image[5]. Edge preservation is also important at the same time while removing noise[6]. Its performance is not very good than Gaussian filter[7] for high level noise but for impulsive noise median filtering is effective.

4. Feature Extraction

SIFT is used to extract features from a set of an image[7]. It can robustly extract features from image in any type of image. Various key points are extracted from set of images taken in dataset and stored in a database.

An object is perceived in a new dataset image by comparing each feature individually from the new image to this database and based on Euclidean distance, it finds candidate of their feature vector[8]. The keypoints subset are matched with the object and its location, scale and orientation in the new image are identified and matches are filtered out. Clusters are determined using hash table each cluster of 3 or more features that match with an object is further verified and outliers are then discarded[9]. Finally the probability is calculated for correct and false matches. Objects that match and pass the entire verification test are taken as correct with high accuracy[10].

5. Soft Computing Techniques

5.1 Artificial Neural Network

ANN is a programming paradigm which is like shape of the brain and it is used in artificial intelligence problems from simple pattern recognition tasks to various different tasks. Artificial Neural Networks are analyzed to have capability to perform well for classification problems in many different areas. ANNs accepts fixed number of input signals and produces fixed output[11]. When a neural network is used for modeling the dataset, the main challenge is finding of different weights and bias values that generates the output which matches with existing data.

Neural networks are collection of elements. The process of reading hidden information is called training network. We train a neural network by adjusting the values means weights between elements. It is used in various areas including pattern recognition and pattern classification, optimization and speech recognition[12]. In this learning scheme, self-organizing map is used to find exact value[13]. Some input value is given to input layer and weights are assigned to input data and then activation functions compare the weights with target and these functions check for error and back propagate it and again adjust the weights until output is received.

5.2 Genetic Algorithm

Genetic Algorithm is an optimization technique which generates useful optimised solution to the problem[14] Genetic Algorithms belongs to a class of optimization algorithms which generate optimized solutions for problems using various GA operators or techniques named selection or initialization, crossover, mutation fitness function which include fitness value for each gene, for total genes and classification error.

Genetic Algorithms are used to overcome NP hard problems which are time consuming so Genetic Algorithm improves resolution and gives best fitness value. It assumes population size and fit value search which is in binary form to give best solution. These are used in number of applications. In this first evaluate the fitness value of individual in population. Then create new population using crossover or mutation operator. Then discard and use new population.

6. Classification

Classification is the most important research area and application part in Artificial Neural Networks[14]. Classification helps in making various decisions regarding human activities. Classification problem happens when need arises to assign an object into an already defined groups or classes on the basis of known attributes.

A neural network is emerged as an important tool for classification[14]. Recent research in this area of neural network classification has established that classification using neural networks is better than traditional approaches used for classification. The classification leads to a partition compound of homogeneous regions (the classes) with regular boundaries (with minimal length).

6.1 Feed Forward Neural Network Approach

The Multilayer layer feed forward neural network performs operation in two modes i.e., training and prediction[15–19].The training of the MLF neural network and for the prediction of MLF neural network there

is need of two data sets, training data set and testing data set for the prediction of accuracy. The training of feed forward neural network is mainly done using back propagation algorithm[15].

6.2 Back Propagation Neural Network

The back Propagation Neural Network used is capable of perform the pre processing of the training data[15]. As the data doesn't have the uniform representation so the neural network doesn't applied to the unprocessed data. For Training purpose, winner value has highest value. The randomly obtained initial synaptic weight of the neural network covers a range between -0.5 and 0.5. Best method of testing a neural network is to test a software application if all the coverage conditions are satisfied.

It iteratively learns a set of weights for prediction of class label tuples. The predicted output is compared with target value to check the error. This algorithm is type of supervised learning and used in feed forward neural network to train the network.

6.3 Algorithm

Proposed Pseudo code for BPNN
Input: Training set = Ga_features, target, hidden neurons, Iterationsmax, weights, bias.
Output: Network.

```
start
network initialize net1
threshold ≤ T
[ro,co] = size (Ga_features)
for  i = 1:ro
training_set = cat(1,1:50);
end
for j = 1:co
target (j) = j;
end
training_set = double(training_set);
for( i > 1, i ≤ T_max, i++)
do
net1 = newff (training_set,target,10);
net1.trainParam.epochs =100;
net = train (net1,training_set,target);
while
backpropagateerro r(net1,net,Network);
end
end
```

7. Proposed Methodology

Proposed methodology flow chart is shown in Figure 1.

In our methodology, the proposed algorithm classify different images based on different parameters. First we upload a satellite image and convert it into a gray scale image to fit the image for pre-processing. We have taken an image of giff. extension. Then apply an edge detection technique to segment the image from the original image. For segmentation we use median filter as a preprocessing step to remove noise from image. Median filter technique is often used in digital image processing area because it does not affect edges while removing noise from image. After this, clustering is done to find the number of clusters in an image. For clustering fuzzy C-mean clustering algorithm is applied to divide an image into clusters (k) and then find the centroid based on clusters. The distance of other objects is found from that centroid. Objects are grouped based on minimum distance, if any object left then again find the centroid and group them otherwise apply SIFT algorithm to extract features from an image. After clustering, features are extracted from the image. These features are key points or data points in an image. SIFT can robustly extract features from image in any type of image. Various key points are extracted from set of images taken in dataset and stored in a database. An object is perceived in a new dataset image by comparing each feature individually from the new image to this database and based on Euclidean distance, it finds candidate of their feature. If all the features have been generated then find down samples for the image otherwise go to SIFT algorithm. After this if down samples have been found then go to SIFT features, if not then again apply SIFT algorithm. The next step is image optimization. Image optimization is done through Genetic Algorithm (GA). GA generates useful optimized solution to the problem. Genetic Algorithms belong to a class of optimization algorithms which generate optimized solutions for problems using various GA operators or techniques named selection or initialization, crossover, mutation fitness function which include fitness value for each gene, for total genes and classification error. After image optimization, Back Propagation Neural Network classifier is used to classify an image and evaluate various parameters to evaluate the performance of training network. At the testing stage image is tested using BPNN to find the accuracy, Mean Square Error (MSE), false acceptance and rejection rate.

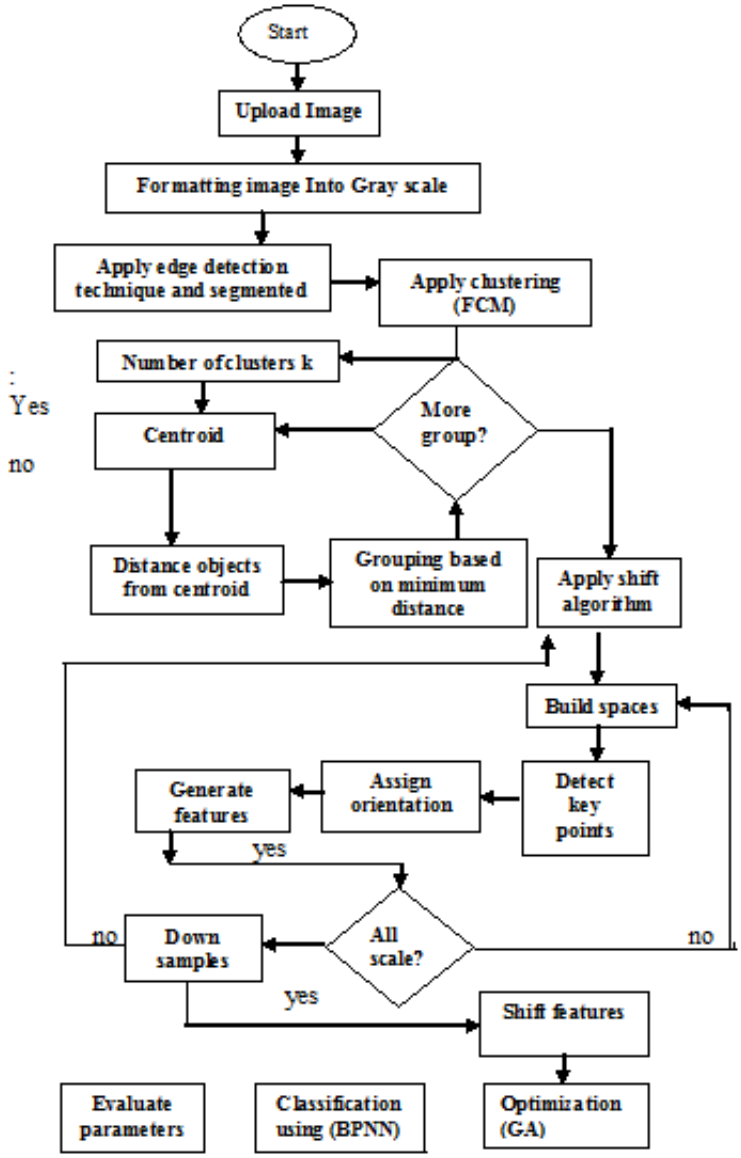


Figure 1. Proposed methodology.

Our proposed methodology has more accuracy and less Mean Square Error rate.

8. Results

In this section results of our proposed technique GA-BPNN are compared with existing optimization and segmentation technique ABC-FCM. The performance is compared as external and internal metrics. External is accuracy found and internal is Mean Square Error (MSE). For proposed technique we find performance parameters as Mean Square Error (MSE), False acceptance rate, False rejection rate, Accuracy. Results are shown in Tables 1 and 2.

9. Discussions

The clustering and classification techniques FCM and BPNN are applied on images of different rocks. The results obtained by both the methods are different BPNN gives a better quality of the image and it has less Mean Square Error. Table 1 represents the comparison of ABC-FCM with our proposed technique GA-BPNN in which the Mean Square Error and accuracy of ABC-

Table 1. Performance comparison of ABC-FCM and GA-BPNN

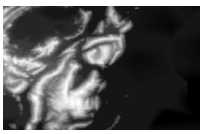
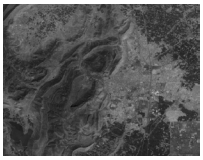
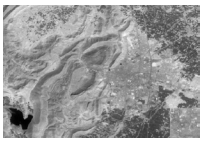
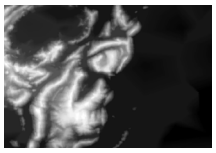
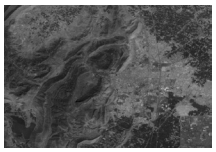
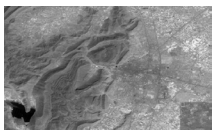
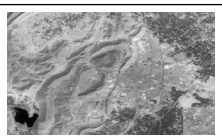
Image	Image no	Performance of ABC-FCM		Performance of GA-BPNN	
		MSE	Accuracy	MSE	Accuracy
	1(1)	239.985	75.8194	.48123	99.1042
	1(2)	239.985	75.6339	.48123	99.0813
	1(3)	239.985	75.862	.48123	99.5698
	1(4)	239.985	75.3859	.48123	99.6417

Table 2. Performance parameters using GA-BPNN

IMAGE	Image no.	MSE	Accuracy	False acceptance rate(FAR)	False rejection rate(FRR)
	1(1)	.48123	99.1042	0.0080116	0.0009464
	1(2)	.48123	99.0813	0.008241	0.0009459
	1(3)	.48123	99.5698	0.003346	0.0009557
	1(4)	.48123	99.6417	0.002625	0.009572

FCM and GA-BPNN is compared. We have taken four satellite images of different rocks and classify these images based on MSE and Accuracy. In Table 2, various performance parameters are evaluated using GA-BPNN. Various parameters are Mean Square Error (MSE), False Acceptance Rate (FAR), False Rejection Rate (FRR), Accuracy. Four images are evaluated on the basis of these parameters. From the table we can see that MSE and Accuracy using GA-BPNN technique yields better result. MSE is comparatively very less of GA-BPNN which means it gives better classification of images. Accuracy of GA-BPNN is very high 99.9% which is very much good. From both the hybrid techniques GA-BPNN is found to be good on the basis of MSE and Accuracy. In Figure 2, shaded region gives the performance of GA-BPNN and gives an average MSE, FAR, FRR and accuracy. In Figure

3, shaded region gives the performance comparison of both ABC-FCM and GA-BPNN on the basis of Accuracy and MSE.

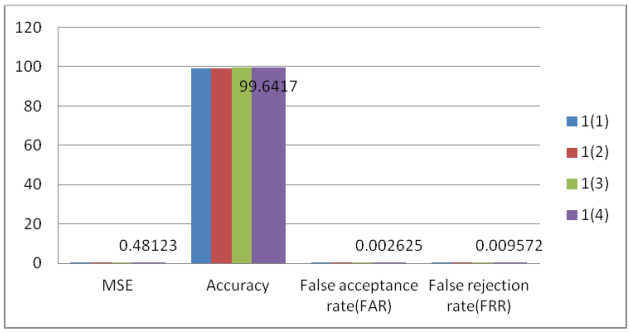


Figure 2. Performance of GA-BPN.

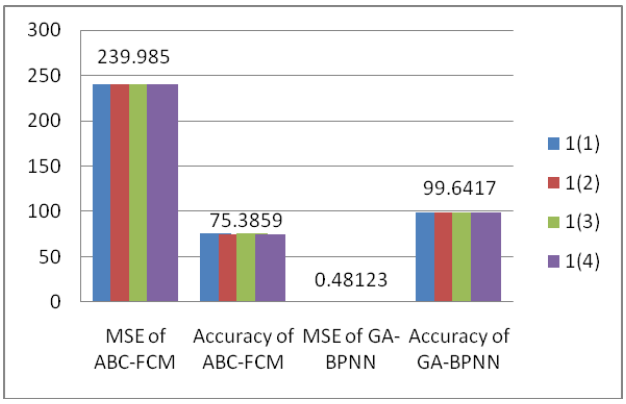


Figure 3. Comparison of ABC-FCM and GA-BPNN.

10. Conclusion

We use FCM for clustering various objects of satellite images of different rocks. Back Propagation Neural Network gives better accuracy and has a minimum Mean Square Error. The following points are worth considering:

- The image feature extraction using Scale-Invariant Feature Transformation (SIFT) method results in better feature extraction as it gives both the key distribution points saved in database and image.
- The Mean Square Error using GA-BPNN is less than existing technique ABC-FCM which gives better performance.
- GA-BPNN technique gives more accuracy which is approximately 99.91 as compared to other methods.

In future work, K-mean clustering can be used to divide the data into the cluster form. The hybrid approach (ICA+firefly) can be used to reduce the false acceptance, false rejection and Mean Square Error rate.

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