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Classification of Remotely Sensed Images using Adaptive Neuro Fuzzy Inference System

[1]K. Uma Maheswari, [2]S. Rajesh
[1]Assistant Professor,
Department of Computer Science and Engineering,
University College of Engineering Ramanathapuram, Ramanathapuram, India.
[2]Professor, Department of Information Technology,
MepcoSchlenk Engineering College, Sivakasi, India.
[1]umamaheswari_kg@yahoo.co.in, [2]srajesh@mepcoeng.ac.in

Abstract: *The old-fashioned hard classification techniques are parametric in nature and they expect data to follow a Gaussian distribution, they have been found to be performing poorly on high resolution satellite images. The classes in these images tend to exhibit wide-ranging coinciding in spectral space. Digital image classification is the process of sorting all the pixels in an image into a finite number of individual classes. Decision making was performed in two stages: feature extraction using the Wavelet Packet Transforms (WPT) and the ANFIS trained with the back propagation gradient descent method in combination with the least squares method for classification .Decision tree algorithm based approach is analysed for the selection of a subset from the combination of Wavelet Packet Spatial Features and Wavelet Packet Co-occurrence (WPC) textural feature set, which are used to classify the multispectral images. Overall accuracy, sensitivity, specification are used to assess the accuracy of the classified data.*

Keywords: Wavelet packet transforms, Wavelet packet spatial, Wavelet packet co-occurance, Decision tree, adaptive neuro fuzzy inference system.

I. INTRODUCTION

The satellite image classification is an important activity for mining geospatial information for military and civil purposes like inaccessible areas. It is difficult to classify satellite images, since geographical information is imprecise in nature. During land cover mapping, a piece of land with sparse grass can be classified into either grassland or soil. There is not a well-specified criterion for distinguishing between the two cover-types. If hard classification algorithm is applied to the remotely sensed (texture based) data set, the classical approach creates discrete classes, and no intermediate situations are allowed. To classify and segment the different objects of a digital image texture is an important property, because texture of an image is expressed in terms of smoothness, coarseness, fineness, lineation, granularity and randomness. Wavelet Transform (WT) is an example of such a transform which does not lose the spatial localization of the signal frequencies (Mallat 1989).

One dimensional Discrete Wavelet Transform (DWT) based on Daubechies wavelet filter have been used in (Lindsay et al.1996) and the applications of octave band wavelet decomposition scheme for texture segmentation to remotely sensed images is discussed. A wavelet-based texture feature set is derived in (Fukuda and Hirosawa 1999). It consists of the energy of sub images obtained by the over complete wavelet decomposition of local areas in SAR images, where the down sampling between wavelet levels is omitted.

Murtagh and Starck (2008) describe a method for extracting wavelet and curvelet features for image classification, and applied it to aggregate mixture grading. Zhang et al. (2009) proposed a technique for fusion of multispectral and hyper spectral images to enhance the spatial resolution of the latter. In this paper, the advantages of wavelet packet transform are explored by incorporating it as a pre-processor for classification. In the proposed method, the features of the input patterns are first extracted and features subset selection is done using Decision tree method. DB2 wavelet packet filter is used for decomposition and ANFIS is used as the classifier.

II. STUDY AREA AND DATA USED

The multi temporal satellite sensor image used in this study is of Madurai city in Tamil Nadu, state of India and is shown in Fig. 1. In the state of Tamil Nadu Madurai is the second largest city. It is identified as one of the 12 heritage cities of India and is situated between longitude 78 04′ 47″ E to 78 11 ′23″ E and latitude 9 50′ 59″ N to 9 57 ′ 36″ N. The geography of Madurai is approximately 101 m above mean sea level. The land cover features of this study area include urban, vegetation, water body, waste land and hilly region. This image was captured by the IRS P6/LISS IV Satellite/Sensor which has a resolution of 5.8 m.

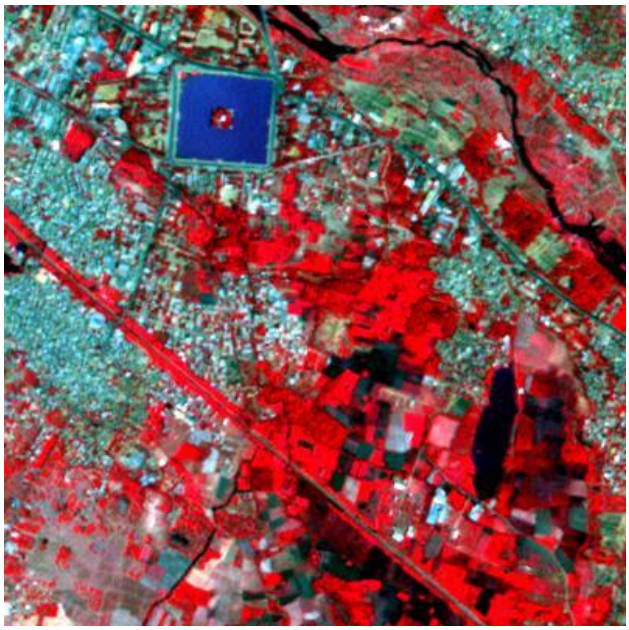

Figure 1: Madurai city

Adaptive Neuro Fuzzy Inference System

The adaptive network based fuzzy inference system is a useful neural network approach for the solution of function approximation problems. An ANFIS using hybrid learning method gives the mapping relation between the input and output data to determine the optimal distribution of membership functions. Both Fuzzy Logic (FL) and ANN are used in ANFIS architecture. Such framework makes the ANFIS exhibiting more organised and less reliant on expert knowledge. Basically, five layers are used to construct this inference system. Each ANFIS layer consists of several nodes described by the node function. The inputs of present layers are obtained from the nodes in the previous layers.

III. PROPOSED SYSTEM

The steps involved in the proposed system are presented as a flowchart Fig 2.

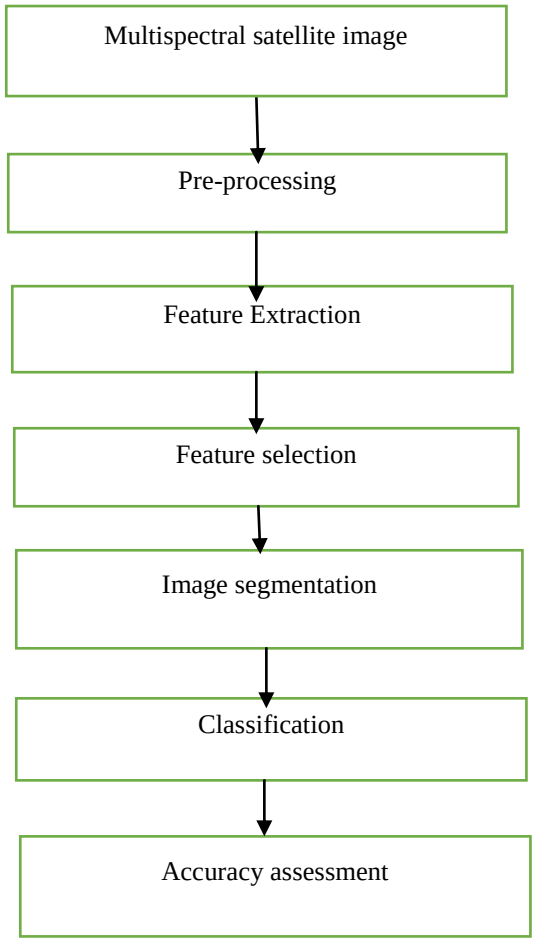

Figure 2: Steps involved in proposed System

Feature Vectors Extraction

In texture training, the known texture images are decomposed using discrete WPT. To create feature database, a set of WPSF, such as mean and standard deviation are calculated form original image and a set of WPC features such as contrast, energy, entropy, local homogeneity, cluster shade, cluster prominence and correlation, as suggested by (Haralick et al. 1973), are calculated from the co-occurrence matrix C (i,j) using the Eqs. (1)–(5).

$$\text{Mean}=\frac{1}{N^2}\sum_{i=1}^{N}\sum_{i=1}^{N}x_{i,j} \quad (1)$$

$$\text{Variance}=\frac{1}{N^2}\sum_{i=1}^{N}\sum_{i=1}^{N}(x_{i,j}-\dot{x})^2 \quad (2)$$

$$\text{Entropy}=-\sum_{i=1}^{N}\sum_{j=1}^{N}(C(i,j))\log(C(i,j)) \quad (3)$$

$$\text{Contrast}=\sum_{i,j=0}^{N}(i-j)^2C(i,j) \quad (4)$$

$$\text{Energy}=\sum_{i=1}^{N}\sum_{i=1}^{N}C(i,j)^2 \quad (5)$$

Feature Subset Selection

Decision tree based approach is used for the selection of a subset from the combination of textural feature

sets. The feature set X derived using the proposed wavelet based technique contains 13 features for each pixel of the image of size 512*512 pixels. The performance and complexity of the Decision tree based classification scheme were investigated. The average user processing time for classification of the Madurai image using 13 Features respectively.

ANFIS Based Classification

ANFIS is a multilayer feed-forward network that uses neural network learning algorithms and fuzzy logic to map an input space to an output space. Five layers are used to construct the inference system. Mamdani and Sugeno are two types of FIS. The most fundamental difference between Mamdani-type FIS and Sugeno-type FIS is the way the crisp output is generated from the fuzzy inputs. While Mamdani-type FIS uses the technique of defuzzification of a fuzzy output, Sugeno-type FIS uses weighted average to compute the crisp output. The sensitive power and interpretability of Mamdani output is lost in the Sugeno FIS since the consequents of the rules are not fuzzy. But Sugeno has better processing time since the weighted average replace the time consuming defuzzification process.

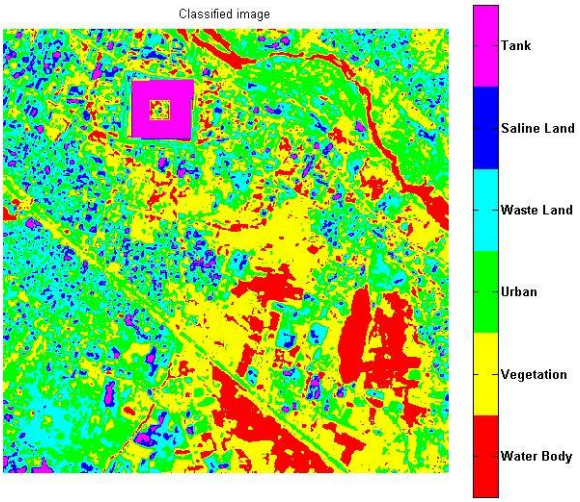

Figure 3: Classified image using AFIS

IV. RESULTS AND DISCUSSION

Accuracy Assessment

One of the most common means of expressing classification accuracy is analysis of confusion matrix. In error matrices compare, on a category by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification. Various accuracy indices such as overall accuracy, specification, sensitivity. Experimental study was carried out for the LISS IV Madurai image to extract the features for Classification. Inspiring results were obtained by applying the ANFIS classification algorithm to the data. The 500 pixels chosen for the experimental study comprises 151, 316, 68, 48, 9 and 3 pixels of urban, vegetation, water body, waste land, tank and saline land pixels, respectively.

	Recognition Schemes for ANFIS Based Land Cover/Land
sensitivity	95
specificity	95.0283
Accuracy	99.4859
Processing_Time	0.3719

V. CONCLUSION

The wavelet, decision tree and Adaptive neuro fuzzy inference system has been tested and evaluated for multispectral satellite image. Decision tree algorithms offer a fast approach to solving the features subset selection problem, where these features are used to train and classify patterns. We have demonstrated that the proposed methodology succeed in reducing the complexity of the feature set used by the classifier and also that such a classifier even using less features achieved recognition rates at the same level than reached by the traditional classifier.

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