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Contourlet Transform Based Feature Extraction and Classification of Multispectral Images

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Abstract: Classification of multispectral images in remote sensing has received attention during past decades. In this work, Contourlet based feature extraction and classification of multispectral satellite images are proposed. Wavelet transform is used to get detailed information with spectral and spatial characteristics of a pixel. But, it does not provide information about features in its directional components. To extract these features, Contourlet transform based laplacian pyramid followed by directional filter banks are used for feature extraction. Initially, the input multispectral image is decomposed into four subbands by the application of stationary wavelet transform. Then the GLCM features are extracted from LL subband. The remaining subbands are subjected to directional filterbank.. All the extracted features are applied principal component analysis for feature reduction. Then, the reduced feature sets are classified into urban, wasteland, vegetation, water body, hilly region using FCM classifier.

Key words: Wavelet based contourlet transform (WBCT) and Gray level co-occurrence matrix (GLCM) Feature extraction · Feature reduction (PCA) · Feature classification (Fuzzy C-mean classifier) · Accuracy assessment

INTRODUCTION

Multispectral image is one capture image data at specific frequency across the electromagnetic spectrum. It consists of data less than 30 bands. Remote sensing images are typically multispectral responses of various features it is hard to recognize directly the feature type by visual examination. Hence the remote sensing data has to be classified to understand the features that are present in the image. The extracted features are expected to contain the relevant information from the input data, so that the preferred task can be performed by using this reduced representation instead of the complete initial data [1]. Classification image are used for categorizing groupof all pixels in a digital image into several land cover classes. The classification accuracy depends on many factors such as image preprocessing, feature extraction, selection of suitable classification approaches and accuracy assessment [2]. Vast applications in related area in agricultural survey, environmental monitoring, surveillance, medical diagnosis. Different types of feature extraction methods are spectral, statistical and structural. The Statistical and structural approaches for the analysis of texture is elaborately discussed in [3]. Large class of natural textures can be modeled by wavelet packets [4]. The author [5] discussed about the unsupervised land cover classification based on sparse texture dictionary learning method.The method takes the distance that land cover in remote sensing data is best analyzed texture patches rather than localized pixels. The author [6] proposes the multiresolution analysis of images. It provides the information at various scales. But, it doesn't provide the information about it's directional components [7]. Wavelet transforms have advantages over traditional for denoting functions that have discontinuities and sharp peaks [8]. Wavelet packet and Wavelet frame transform were the superior methods used for feature extraction [9]. In order to extract directional components features, wavelet based contourlet transform is proposed in this work. The contourlet transform has a fast performance based on a Laplacian Pyramid decomposition followed by directional filter banks applied on LL subband of each band [10].

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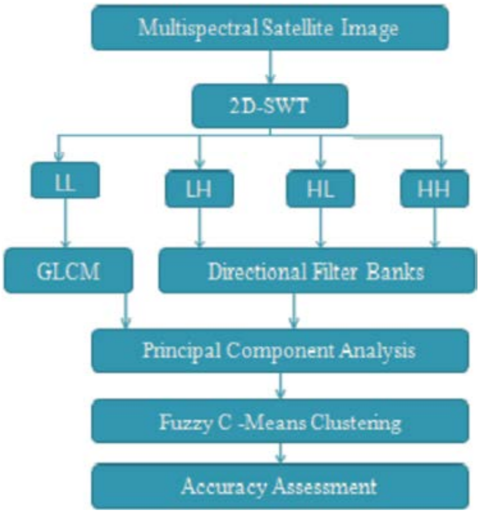


Fig. 1: Proposed Methodology

The rest of the paper describes about each section as follows. In section II, proposed method has been discussed. In section III, feature extraction has been briefed. In section IV, feature fusion is described. In Section V, VI feature extraction and classification is explained. In Section VII, Experimental results and data used for this work is explained are demonstrated. At last In section IX, Conclusion is given.

Proposed Methodology: In this work, the multispectral image is classified into different land cover classes. Initially, wavelet frame based contourlet transform is applied to the input image. After the application of this transform, the input image is divided into four different subbands such as LL, LH, HL and HH. The low frequency subband contains the approximation details. Whereas the remaining subbands having the high frequency details. The flow diagram for the proposed work is shown in Fig. 1.

Feature Extraction

Wavelet Frame Based Contourlet Transform: The wavelet transform is not finest in capturing the 2-D singularities of images, it can take the place of LP decomposition in the double filter bank structure to build the contourlet transform. It is a non-redundant image transform. In the *WBCT*, 2-dimensional stationary wavelet transform is applied on the red band input image by dividing in to four sub bands (LL, LH, HL and HH). From this the last three high frequency sub bands are further divided by the directional filter banks into eight sub images. High frequency sub bands are then segmented in to several directions. The Lemaire battle wavelet based contourlet transform is used for decomposition. The low pass band is applied to the GLCM to extract spatial features. The same process is applied to the remaining bands also.

GLCM: Gray level co-occurrence matrix (GLCM) based texture feature extraction has been considered It is a powerful method and still now has been used in many application of remote sensing for texture analysis. GLCM technique comes under the statistical method of texture analysis which describes texture as a set of statistical measures based on the spatial allocation of gray levels in the band of the remotely sensed imagery. The nine features namely, mean, standard deviation, energy, contrast, entrophy, homogeneity, correlation, dissimilarity and angular second moment are computed using this method.

Entropy $= \sum_{i,j=0}^{N-1} p(i,j)(-\ln p(i,j))$

Energy $= \sum_{i,j=0}^{N-1} P(i,j)2$

Mean $= \sum_{i,j=0}^{N-1} (i * p(i-j))2$

Contrast $= \sum_{i,j=0}^{N-1} (p(i-j) * (i-j)^2)$

Homogeneity $= \sum_{i,j=0}^{N-1} p(i,j)/1+(i-j)^2$

Correlation $= \sum_{i,j=0}^{N-1} \frac{(i-\mu)(j-\mu)p(i,j)}{\sigma_x \sigma_y}$

Dissimilarity $= \sum_{i,j=0}^{N-1} P_{i,j}|i-j|$

Angular second moment $= \sum_{i,j=0}^{N-1} p_{ij}2$

Standard deviation $= \sigma_i = \sqrt{\sigma_i^2} \quad \sigma_j = \sqrt{\sigma_j^2}$

Feature Reduction: The selection of a proper set of features is vital for any successful operation of a single or multiple classifier system. The main aim of feature reduction is the removal of noisy features. Also it can merge two or more features of different domains and reduce the annoyance of dimensionality problem.

Feature reduction is the method of minimizing the number of random variables under consideration and can be divided into feature selection and feature extraction. These methods to estimate absolute worth of features in a quantitative and accurate way have to be devised. In this work, PCA is used for feature reduction.It is one of the well-known methods that removes redundant information considerably with major information and improves the classification performance. The spatial and spectral features extracted from all the three bands are applied to PCA. The mean vector of the population is defined as

$$m_k = \frac{1}{M}\sum_{k=1}^{M} x_k$$

The covariance matrix of the population is defined as

$$c_x = E\left(x_k x_k^T\right) - m_x m_x^T$$

where, k=1, 2,. . . M

For the covariance matrix C_x n orthonormal eigen vectors are calculated. The output Eigen channels produced by the principal component transformation has a large dynamic range, particularly the first few layers which pack most of the information.

Classification: Feature classification is a basic task in the method of satellite image analysis which involves a process of classification of the various regions based on the extracted features. The output from the feature extraction stage is a set of images. These images characterize different spatial frequency features of the input image. Different land cover types in an image can be categorized using some image classification algorithms with textural features. When the reduced feature vector is used for classification, there is a feature in single class that resulted in spectral overlap with feature within other classes. Inorder to classify the pixels into correct land cover classes fuzzy mean classifier algorithm is used.

Fuzzy C-mean Classification: One of the most widely used classification is fuzzy clustering algorithms is the Fuzzy C-Means (FCM) Algorithm. Classification image are used for categorizing group of all pixels in a digital image into several land cover classes. Fuzzy clustering is a process of assigning different degrees of these membership levels to each pixel and then using them to assign data elements to one or more clusters.

The algorithm is carrying throughout iterative optimization to find out the good partition of clusters.

- First step to initialize center of cluster are selected C_i
- calculate the degree of membership with all feature vectors in all the cluster compute

$$u_{ij} = \frac{\left[\frac{1}{d^2(x_j, c_i)}\right]^{\frac{1}{(q-1)}}}{\sum_{k=1}^{c}\left[\frac{1}{d^2(x_j, c_k)}\right]^{\frac{1}{(q-1)}}}, \; i=1,2\ldots.c \text{ and } j=1,2\ldots M$$

- The new centroids based on the membership function is calculate by Ci

$$Ci = \frac{\sum_{j=1}^{M}(u_{ij})^q x_j}{\sum_{j=1}^{M}(u_{ij})^q}, \; I=1,2,\ldots$$

where, q is the fuzziness index and its value falls in the range of [1, ∞] and update the memberships, u_{ij} to $\hat{u}_{ij}$ according to step 2.

- If $\max_{ij} \| u_{ij} - \hat{u}_{ij} \| < \varepsilon$ stop, otherwise go to step 3.Where, ε is the positive threshold.

Accuracy Assessment: The methods of classification accuracy assessment that are commonly used to determine efficiency and accuracy of classified images. There ifferent types of accuracy indices such as overall accuracy, producer accuracy, user accuracy are used to determine classification accuracy by several processes. Usually most of the researchers suggested the use of the Kappa coefficient of verification as the standard evaluate for accuracy of classification in remote sensing.

RESULTS AND DISCUSSION

The multispectral image from LISS –III used in this work is of Madurai city in Tamilnadu taken by the Indian remote sensing satellite. In this image, there are 512x 512pixels. Fig. 2 shows the input image.

The input image is preprocessed by Gaussian filter.Then it will be subjected into 2D-SWT for decomposition. Then the directional filters will be applied to the high frequency subbands. The directional coefficients of red, green and blue bands are shown in Fig. 3.

The textural features are extracted from low frequency subband using GLCM. There are nine textural features are extracted which are tabulated in Table 1.

The directional features and textural features obtained from all the bands are applied to principal component analysis for features reduction. Then the reduced feature set is classified using Fuzzy C-means classifier and it is accuracy has been evaluated. The classified output is shown in Fig. 4.

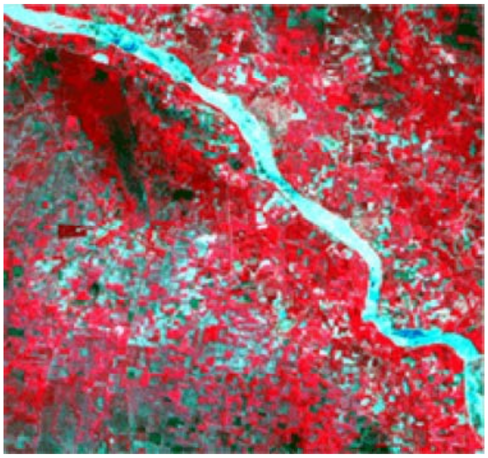


Fig. 2: Input image

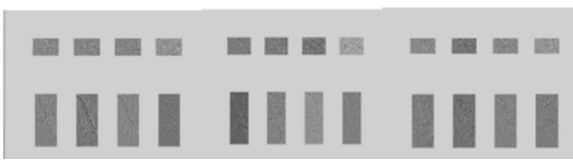


Fig. 3: Directional coefficients of red band

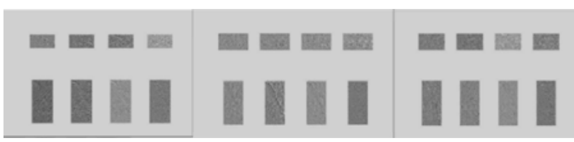


Fig. 3: Directional coefficients of green band

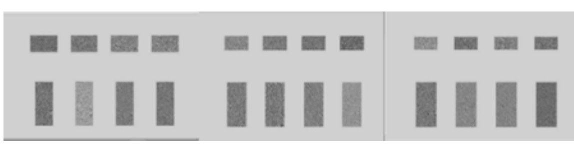


Fig. 3: Directional coefficients of blue band

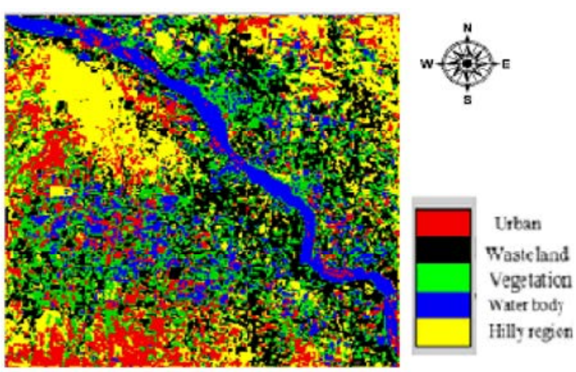


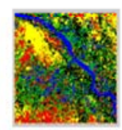
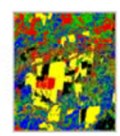
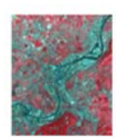
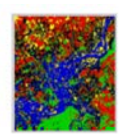
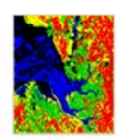
Fig. 4: Classified output

The proposed method has been applied to different satellite images. The corresponding classified output and it is accuracy is given in Table 2.

Table 1: GLCM Features

Features	Red band	Green band	Blue band
Contrast	0.7192	1.9290	1.5749
Correlation	0.6119	0.4949	0.4901
Energy	0.9455	0.8770	0.9003
Homogeneity	0.9860	0.9620	0.9689
Standard deviation	31786	30591	31003
Mean	4088	4088	4088
Entropy	0.2730	0	0.1161
Angular second moment	255	255	255

Table 2:

Satellite images name	Satellite images	Classified images	Accuracy%
IRS 16 Madurai image			92.45
Spot4			91.49
Spot1			89.19
spot12			86.07

CONCLUSION

This paper proposes a classification of multispectral images into various land use and land cover details. The proposed method explores the possible advantages of using and contourlet transform based wavelet GLCM.

Spectral and spatial features obtained from all the band is applied to principal component analysis for feature reduction. Then the reduced feature set is classified using Fuzzy C-means classifier. Finally, the accuracy is calculated. The experimental results show that the proposed work gives good result when compared to traditional methods.

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