SATELLITE IMAGE CLASSIFICATION USING WAVELET TRANSFORM

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ABSTRACT

Classification of satellite data has received considerable attention during the past decades. One difficulty of texture analysis in the past was a lack of adequate tools to characterize different scales of textures effectively. Recent space-frequency analytical tools like the wavelet transform can effectively characterize the coupling of different scales in texture and help to overcome the difficulty. This presents a wavelet based texture classification technique that is applied to a MSS image of Madurai City, South India. The feature extraction stage of the technique uses wavelets (Coiflet, Daubechies and Symlet) to derive a texture feature vector and this vector is input to a kmeans classifier, an unsupervised classification procedure. Four indices (user’s accuracy, producer’s accuracy, overall accuracy and Kappa co-efficient) are used to assess the accuracy of the classified data. The experiment results show that the performance of the presented technique is better than the classical techniques.
Key words: Classification, texture, Wavelets, Accuracy assessment

1. INTRODUCTION

Texture is an important feature for the analysis of many types of images. It can be seen in all images of multispectral scanner images obtained from aircraft or satellite platforms. Texture classification [1] is the process by which features are extracted from a set of texture classes since features in remotely sensed data are often highly heterogeneous. The conventional automatic per-pixel classification procedures cannot always provide a good discrimination between the features. In order to obtain the features with good discriminatory power the texture measures can be used for classification. Most of the conventional approaches for texture feature extraction lead to make use of statistical techniques in which processing the texture image data requires large storage space and computational load to calculate the feature’s matrix content. The scalar features calculated from this matrix is not efficient to represent the characteristics of image content. Alternatively, space-frequency analysis has received a lot of attention which uses multi-resolution techniques such as wavelet transform.

This paper presents a method for Classification which uses wavelet based algorithm [4]. The texture features from the image is extracted by wavelet and thereby classified using kmeans algorithm. The algorithm has been developed by the Image Processing Software known as Interactive Data Language (IDL) [6].

2. STUDY AREA AND DATA USED

The selected area of this research is the Madurai City, Tamilnadu. Madurai is situated between the longitude $78^004'47''$ E to $78^011'23''$ E and the latitude $9^050'59''$ N to $9^057'36''$ N. The topography of Madurai is approximately 101 meters above the sea level. The present area of the city is 51.9 square kilometers. The percentage of urbanization is about 65%. Now due to economic advancement of the people of the city the rural hamlets in the districts are given an urban image by people.

Date of acquisition : 19th March, 2009
Satellite/SENSOR : IRS P6/ LISS III
Resolution : 23.50 meter
3. METHODOLOGY

In this study, we analyze several texture methods applied to the classification of remote sensing images with different types of landscapes. Figure 2 shows the steps of the methodology for the proposed wavelet based texture classification approach [4].

![Methodology Diagram]

Figure 2 Methodology for texture classification

4. TEXTURE FEATURE EXTRACTION

Transforming the input data into a set of useful details is called feature extraction. The goal of feature extraction is to obtain a set of measures that can be used to
discriminate different textures. The extraction of texture [2] features from remotely sensed imagery provides a source of data for identification or classification of spectrally heterogeneous landscape units. However, there is a wide range of texture analysis techniques that are used with different criteria for feature extraction. The basic assumption for most filtering approaches is that the energy distribution in the frequency domain identifies a texture.

5. TYPES OF WAVELETS

5.1 Daubechies wavelet

The Daubechies wavelets are family of orthogonal wavelets defining a discrete wavelet transform [2] and characterized by a maximal number of vanishing moments. Daubechies orthogonal wavelets D2-D20 (even index numbers only) are commonly used. Each wavelet has a number of zero moments or vanishing moments equal to half the number of coefficients. A vanishing moment limits the wavelet’s ability to represent polynomial behaviors or information in a signal.

For example, D2—with one moment easily encodes polynomials of one coefficient or constant signal components. D4-encodes polynomials with two coefficients or constant and linear signal components. D4 transform has four wavelet and scaling function coefficients.
Scaling coefficients = [0.4830 0.8365 0.2241 -0.1294]
Wavelet Coefficients = [-0.1294 -0.2241 0.8365 -0.4830]

5.2 Coiflet wavelet

Coiflet is a discrete wavelet designed by Ingrid Daubechies to be more symmetrical than the Daubechies wavelets whereas Daubechies wavelet have $N/2 - 1$ vanishing moments, coiflet scaling functions have $N/3 - 1$ zero moments and their wavelet functions have $N/3$. Both the scaling function (low pass filter) and the wavelet function (High pass filter) must be normalized by a factor $\frac{1}{2}$.

Scaling coefficients = [-0.0514 0.2389 0.6029 0.2721 -0.0514 -0.0111]
Wavelet Coefficients = [-0.0111 0.0514 0.2721 -0.6029 0.2389 0.0514]

![Image of Coiflet wavelet + K means Classifier Output](image)

5.3 Symlet Wavelet

Daubechies proposes modification of this wavelets that increases their symmetry while retaining great simplicity. Daubechies wavelets are very asymmetric because they are constructed by selecting minimum phase square root $Q(e^{-jw})[1]$. One can show that filters corresponding to a minimum phase square root have their energy optimally concentrated near the starting point of their support. Symlet filters of Daubechies are obtained by optimizing the choice of the square root $R(e^{-jw})$ of $Q(e^{-jw})$ to obtain linear
phase. The resulting wavelets [3] still have a minimum support [-P+1, P] with P vanishing moments but they are more symmetric.

Scaling coefficients = [0.2352  0.5706  0.3252  -0.0955  -0.0604  0.0249]
Wavelet Coefficients = [0.0249  0.0604  0.0955  -0.3252  0.5706  -0.2352]

6. ACCURACY ASSESSMENT

Another area that is continuing to receive increased attention by remote sensing specialists is that of classification accuracy assessment. Historically, the ability to produce digital land cover classifications far exceeded the ability to meaningfully quantify their accuracy. In fact, this problem sometimes precluded the application of automated land cover classification techniques even when their cost compared favorably with more traditional means of data collection. The lesson to be learned here is embodied in the expression” A classification is not complete until its accuracy is assessed”. Various accuracy indices [5] such as overall accuracy, producer accuracy, and user accuracy have been discussed in determining the accuracy of classification. Commonly, most of the researchers recommended the use of the kappa coefficient of agreement as the standard measure for accuracy.

Using the field visit data the classification rate can be computed and performance of classification algorithm can be analyzed. The error matrix for Coiflet wavelet is shown here in table1 and the accuracies obtained are also calculated and shown.
Table 1 Error matrix for Coiflet wavelet

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Vegetation</th>
<th>Waste land</th>
<th>Hilly</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>403</td>
<td>6</td>
<td>75</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Vegetation</td>
<td>1</td>
<td>251</td>
<td>40</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Waste land</td>
<td>18</td>
<td>3</td>
<td>77</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Hilly</td>
<td>10</td>
<td>2</td>
<td>7</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Water</td>
<td>18</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 2 Accuracy Assessment simulation

<table>
<thead>
<tr>
<th>S.No</th>
<th>Wavelets</th>
<th>User Accuracy</th>
<th>Producer Accuracy</th>
<th>Overall Accuracy</th>
<th>Kappa Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Daubechies</td>
<td>68.07</td>
<td>70.38</td>
<td>76.52</td>
<td>0.8254</td>
</tr>
<tr>
<td>2</td>
<td>Coiflet</td>
<td>69.45</td>
<td>71.18</td>
<td>78.40</td>
<td>0.8392</td>
</tr>
<tr>
<td>3</td>
<td>Symlet</td>
<td>66.10</td>
<td>65.19</td>
<td>71.55</td>
<td>0.7939</td>
</tr>
</tbody>
</table>

7. RESULTS AND DISCUSSION

To demonstrate the potential of wavelets in extracting features [1] for texture classification, we have applied the algorithm to remotely sensed data of Madurai City, South India. Also we have implemented the wavelets for comparative analysis. Figures 3-5 depict the classification results for the wavelet based method respectively. Table-1 summarizes the quantitative results obtained by comparing the reference map (through field visit) with the classification map yielded applying the proposed and traditional classification methods. Coiflet wavelet produced the Kappa coefficient of 0.8392 and accuracy of 78.40 (over all accuracy). This table proves Coiflet wavelet can be used to classify any satellite image.

8. CONCLUSION

This paper provides an efficient method of wavelet based feature extraction combined with K-means clustering for texture information extraction from multispectral space borne data. Further work is to compare these results with many more wavelets.

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REFERENCES


