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CERTAIN INVESTIGATIONS ON REMOTE SENSING BASED WAVELET COMPRESSION TECHNIQUES FOR CLASSIFICATION OF AGRICULTURAL LAND AREA

[1]R.KOUSALYADEVI, [2]J.SUGANTHI

[1]Research Scholar & Associate Professor, Department of Electronics and Communication Engineering, PERI Institute of Technology, Chennai, Tamil Nadu, INDIA

[2]Professor & Head, Department of Computer Science Engineering, Hindusthan College of Engineering and Technology, Coimbatore, Tamil Nadu, INDIA

E-mail: [1]kousalyadevi71@gmail.com, [2]sugi_jeyan@hotmail.com

ABSTRACT

Remote sensing data is highly useful for creating or updating base maps and detecting the major changes in land use and land cover. Usually there are lots of differences between Toposheet and RS images. Change in land use pattern can be analysed by RS images. Conversion of land cover into land use can be monitored by subsequent follow up of RS images and depending upon the land classes like forest, agriculture and desert, the updating may vary. This image contains huge volume of data. Instead of using the entire data for land use land cover mapping, the compressed images can also be used for mapping purposes. In this paper the Landsat5 agricultural image is compressed using discrete wavelet transform and the quality has been analysed using the parameters compression ratio, peak signal to noise ratio and digital number values. Using the digital number values the spectral signature graph is drawn. Finally Coif3 wavelet is selected for land use and land cover mapping of agricultural area based on high CR, PSNR and minimum cumulative error of the digital number values.

Keywords: *Compression Ratio (CR), Peak Signal to Noise Ratio (PSNR), Digital Number (DN), Image Classification, Error Matrix.*

1. INTRODUCTION

Land is a non-renewable resource base which supports all primary production system as well as the essential social environment in terms of shelter, communication, industries and other facilities [1]&[4]. For the preparation of LULC map, it is not necessary to have huge amount of data. It can also be prepared by using the compressed image based on the applications. Image compression plays a vital role in removing the redundancies in an image. While compressing the RS image, there must be a trade off between Compression Ratio (CR) and the image quality.

Remote sensing (RS) images contain huge amount of geographical information and reflect the complexity of geographical features and spatial structures [12]. It is useful for land use and land cover classification system. RS data is highly useful for creating or updating base maps and detecting the major changes in land use and land cover. The land use is used to identify the change in land cover pattern [5]&[6].

RS data is highly useful for creating or updating base maps and detecting the major changes in land use and land cover. Usually there are lots of differences between Toposheet and RS images. Especially in LULC, during harvesting period land cover will appear as land use and during autumn the trees will lose their leaves and appears as less dense forest, also the population construct houses in dry lake. Change in land use pattern can be analysed by RS images [8].

Till a few years back, a monochrome or panchromatic (PAN) image is taken for environmental monitoring and preparing the LULC maps. Since some of the information is lost in these images, there is a need for RGB colour images. These colour images are compressed using various compression techniques such as Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) & Short Time Fourier Transform (STFT) and the image quality is analysed using the parameters like CR and PSNR[7]&[2]. The drawbacks of the above techniques are blocking artifact, blurring and ringing artifacts [10]. To overcome these drawbacks, the wavelet transform

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is introduced. Previous works were carried out using only one wavelet and its performance was analysed. Sadashivappa and Anand (2008) have analysed the performance (CR and PSNR) for a large set of wavelets.

In remote sensing the minimum and maximum value of the pixel are important like CR and PSNR. Because these pixel values will specify the amount of deviation in the compressed image with the original image. Hence the quality of the compressed image has to be analysed based on CR, PSNR and DN values. By finding the minimum cumulative error of the DN values, a suitable wavelet for LULC mapping has been identified.

The accuracy assessment is a tool to measure accuracy of the compressed image. The accuracy of the compressed image must be calculated by classifying the compressed image and calculating the error from the error matrix.

2. METHODOLOGY

2.1 Study Area of Agriculture Image

The subset of the Landsat5 Thematic Mapper sensor satellite image of size 256 × 256 × 6 is taken from the raw image of size 8106 × 7064 × 6 using ERDAS software. It is an agriculture image of Kaveripakkam near Kancheepuram, Tamilnadu, India. The latitude and longitude of Kaveripakkam is 12.90545120 and 79.46195060. TM sensor is a cross track scanner deployed on Landsat that records seven bands of data from the visible through the thermal IR regions.

2.2 Wavelets

The various wavelets used for the compression are Haar, DaubechiesN (dbN), CoifletN (coifN), SymletN (symN), BiorthogonalN (biorN), Reverse biorthognalN (rbioN) and discrete Meyer wavelet (dmey), where N represents the number of coefficients which specify the number of vanishing moments and zero moments[9].

This research work is carried out in two methods. The first method is based on the minimum cumulative error of the DN values and the second one is evaluation by image classification and ground truth.

2.3 Software tools used

The softwares used for this research work are ERDAS Imagine and MATLAB.

2.4 Compressed Agriculture Image at Level 3

In this research, the agriculture images are taken from Kaveripakkam near Kancheepuram, Chennai. All the wavelets are applied over the image at decomposition levels 3 and threshold levels 5, 8, 10, 12, 15 and 20 and then the DNmin and DNmax values for each band of the compressed image are calculated. From the DN values of the original image and the compressed image, the cumulative error is calculated. The cumulative error is defined as the difference between sum of the DN values of each band of the original image and the sum of the DN values of each band of the compressed image. The wavelet which provides zero or minimum cumulative error is selected for compressing the RS image, the CR and PSNR is calculated for that wavelet[3]. The spectral signature graph is drawn by using the DN values.

Then the compressed image is classified using Maximum Likelihood classification for accuracy measurement in ERDAS. The training data called signatures are generated to define the class signatures. These signatures are labelled and colours are assigned to each class. By applying these signatures to the entire space, all the pixels in the original image are labelled. The same set of training data are used to classify the wavelet compressed image. Using these signatures the signature editor table and the error matrix are constructed. The error matrix specifies the error in the classification technique.

2.5 CoifletN Wavelet

It is similar to Daubechies wavelets. The Coiflet scaling functions have (N/3)-1 vanishing moments and its wavelet functions have N/3 vanishing moments whereas Daubechies have (N/2) - 1 vanishing moments. Mathematically,

$$B_k = (-1)^k C_{N-1-k} \tag{1}$$

In Equation 1, k is the coefficient index, B is a wavelet coefficient and C is a scaling function coefficient; N is the wavelet index.

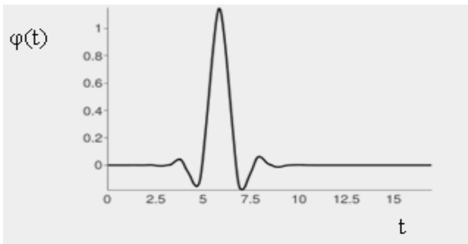

Figure 1: Coiflet3 Scaling Function Φ(T)

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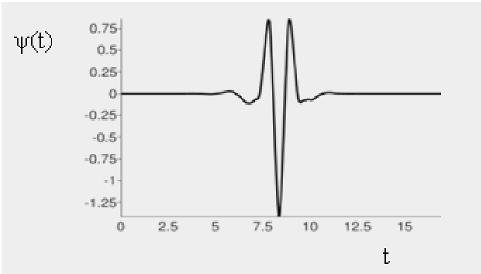

Figure 2 : Coiflet3 Wavelet Function Ψ(T)

The scaling function φ(t) and wavelet function ψ(t) of coiflet3 wavelet is shown in Figure 1 and Figure 2 respectively.

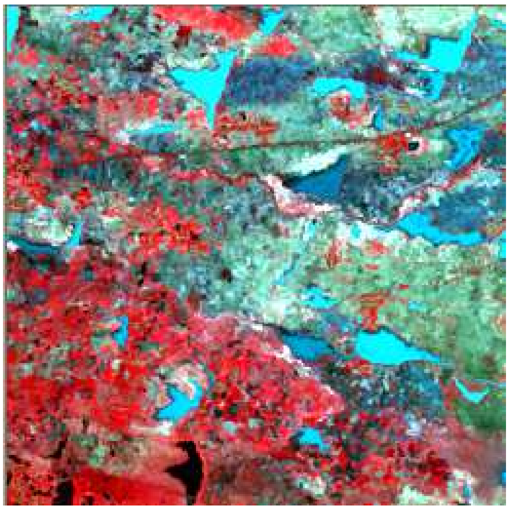

Figure 3 : Original Multispectral Band Agriculture Image Of Kaveripakkam

The original agriculture image of Kaveripakkam is shown in figure 3. All the wavelets are applied over the image and haar at threshold 5, 8 and 12, db3 at threshold 5, db4 at threshold 5 and 8, db7 at threshold 8, dmey at threshold 8, sym3 at threshold 5, coif2 at threshold 10, coif3 at threshold 5, coif4 at threshold 5 and 15 are selected.

At decomposition level 3, coif3 provided the cumulative error of value 2 compared to other wavelets and it is shown in Table1. The Table2 provides the CR and PSNR at level 3 compressed image. The compressed and classified images using coif3 wavelet is shown in Figure 4 and Figure 5 respectively. The error matrix and the signature editor are shown in Table 3 and 4. From the error matrix table it is found that 2 errors are occurred out of 1358 samples. The Figure 6, Figure 7 and Figure 8 shows the spectral signature graph, compression ratio and peak signal to noise ratio of the compressed image at level 3.

From the table 1, coif3 is selected because it has provided the cumulative error of value 2 compare with other wavelets. Table 2 provides the CR and PSNR of the coif3 compressed agriculture image at decomposition level 3. The PSNR is calculated using the equation 2 &3.

$$MSE = \frac{\sum_{M,L}[I_1(m,l) - I_2(m,l)]^2}{M \times L} \quad (2)$$

$$PSNR = 20 \log_{10}\left(\frac{255}{MSE}\right) \quad (3)$$

Then the compressed image is classified using supervised classification technique for accuracy assessment. The error matrix is a means of comparing two thematic maps. This describes the accuracy of the classified map with respect to the reference map The compressed and classified images are shown in Figure 4 and Figure 5. The error matrix is constructed by defining the signatures of each class. The error matrix and the signature editor are shown inTable 3 and Table 4 respectively. From the error matrix table, it is found that 14 errors occurred out of 1340 samples. The Figure 6, Figure 7 and Figure 8 shows the spectral signature graph, compression ratio and peak signal to noise ratio of the compressed image at decomposition level 3.

The ground truth data of agricultural image of Kaveripakkam is shown in figure 9. The entire operation of the image compression and image classification is explained in Figure 10.

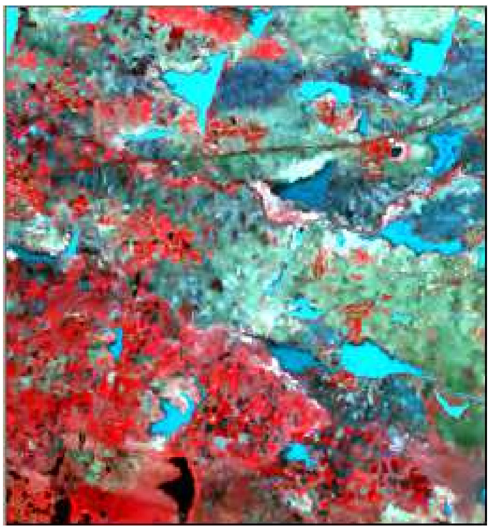

Figure 4 : Coif3-Level3-Threshold5 Compressed Agriculture Image Of Kaveripakkam

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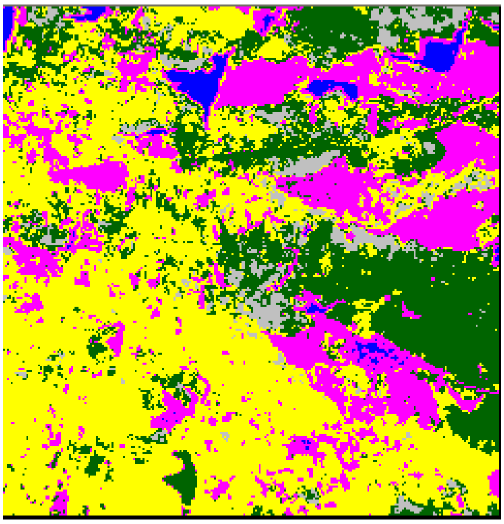

Figure 5 Coif3-Level3 - Threshold5 Classified Agriculture Image Of Kaveripakkam

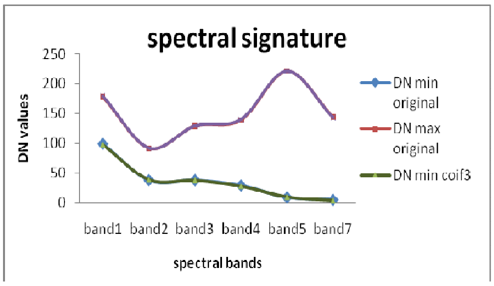

Figure 6 Spectral Signature Of Coif3-Level 3-Threshold 5 Compressed Agriculture Image Of Kaveripakkam

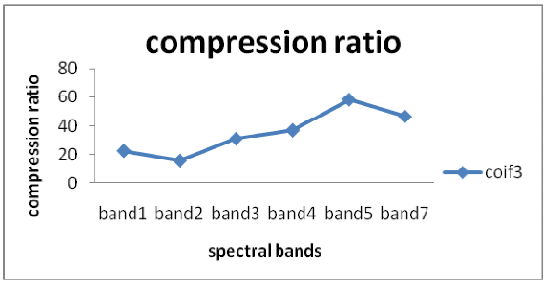

Figure 7 Compression Ratio Of Coif3- Level 3-Threshold 5 Compressed Agriculture Image Of Kaveripakkam

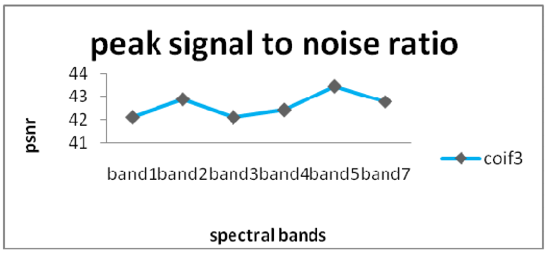

Figure 8 : Peak Signal To Noise Ratio Of Coif3- Level 3 -Threshold 5 Compressed Agriculture Image Of Kaveripakkam

Figure 9 : Ground Truth Data Of Agriculture Image Taken From Kaveripakkam

3. CONCLUSION

In this paper, Landsat5 remote sensing images are compressed using Discrete Wavelet Transform (DWT) and the performance is analysed using the parameters such as CR, PSNR, DNmin, and DNmax. The RS images are compressed at various decomposition and threshold levels. Based on the high PSNR, CR, DNmin and DNmax of the compressed images, a set of wavelets are chosen. The spectral signature graph is drawn using the Digital Number (DN) values.

Based on the above discussions, the suitable wavelet for compressing the multispectral band RS image is identified. It is observed that Coif 3 wavelet at decomposition level 3 is recommended for LULC map preparation of agricultural areas.

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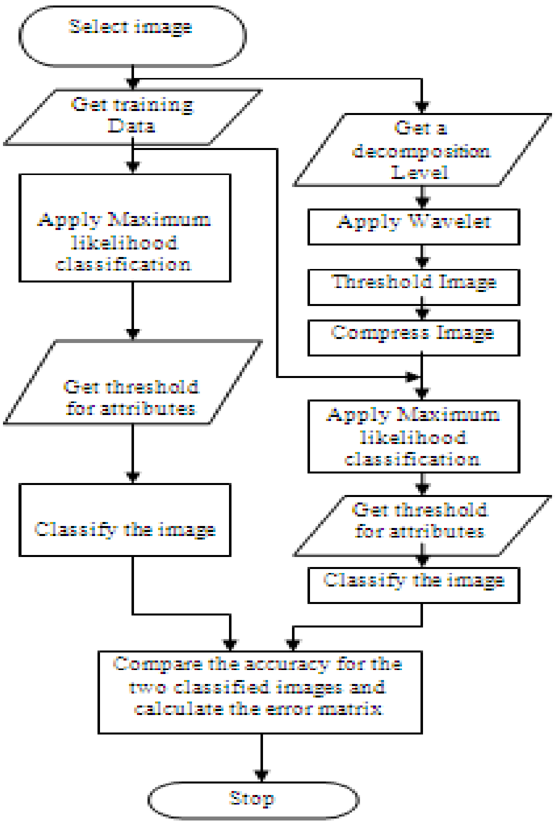

Figure 10 : Flow Chart Of The Above Technique

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Table 1 : Compressed Level 3 Agriculture Image Of Kaveripakkam

Compression at level 3 agriculture										
wavelet	**threshold**	**DN values**	**band1**	**band2**	**band3**	**band4**	**band5**	**band7**	**sum**	**cum error**
original		DNmin	99	38	38	29	9	5	218	
original		DNmax	178	92	129	139	221	144	903	
Haar	5	DNmin	99	38	39	26	10	4	216	2
Haar	5	DNmax	178	93	128	139	221	144	903	0
Haar	8	DNmin	98	38	38	29	13	5	221	-3
Haar	8	DNmax	178	93	128	139	221	144	903	0
Haar	12	DNmin	101	41	38	26	13	0	219	-1
Haar	12	DNmax	173	93	126	139	224	144	899	4
db3	5	DNmin	98	39	39	28	11	4	219	-1
db3	5	DNmax	178	94	130	137	221	141	901	2
db4	5	DNmin	98	39	39	28	11	2	217	1
db4	5	DNmax	176	92	126	141	219	142	896	7
db4	8	DNmin	100	40	37	27	13	0	217	1
db4	8	DNmax	174	90	122	141	219	141	887	16
db7	8	DNmin	99	41	37	26	14	0	217	1
db7	8	DNmax	175	92	128	142	221	142	900	3
dmey	5	DNmin	98	39	38	26	13	3	217	1
dmey	5	DNmax	176	95	128	139	221	146	905	-2
sym3	5	DNmin	98	39	39	28	11	4	219	-1
sym3	5	DNmax	178	94	130	137	221	141	901	2
coif2	10	DNmin	97	38	36	25	12	2	210	8
coif2	10	DNmax	177	93	126	140	223	144	903	0
coif3	**5**	**DNmin**	**98**	**39**	**38**	**28**	**10**	**4**	**217**	**1**
coif3	**5**	**DNmax**	**179**	**92**	**129**	**140**	**221**	**143**	**904**	**-1**
coif4	5	DNmin	98	39	38	26	11	3	215	3
coif4	5	DNmax	178	93	128	139	221	144	903	0
coif4	15	DNmin	100	41	38	24	8	0	211	7
coif4	15	DNmax	172	96	124	144	222	145	903	0

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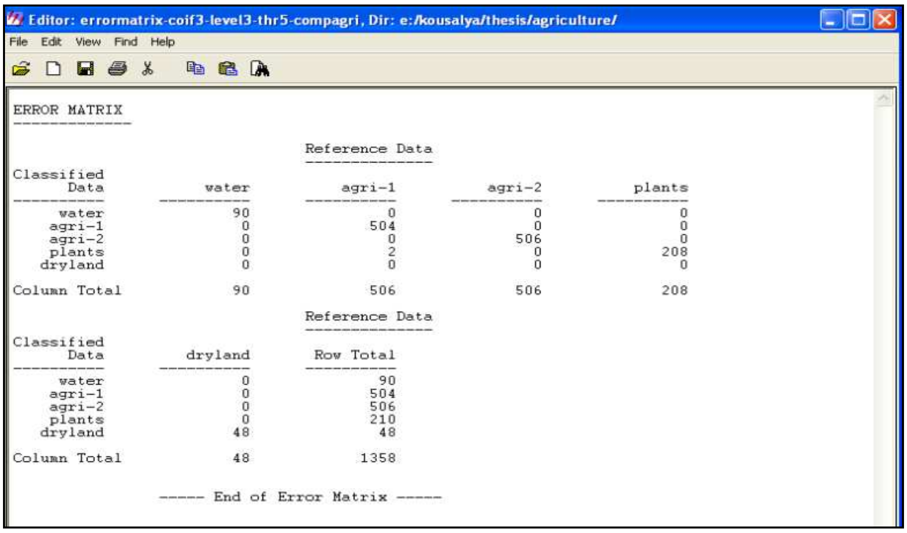
Table 2: Selected Wavelet At Compressed Level 3 Agriculture Image Of Kaveripakkam

Selected wavelet at level 3 agriculture										
parameters	**wavelet**	**threshold**	**band1**	**band2**	**band3**	**band4**	**band5**	**band7**	**sum**	**cum error**
DNmin	original		99	38	38	29	9	5	218	
DNmax	original		178	92	129	139	221	144	903	
DNmin	**coif3**	**5**	**98**	**39**	**38**	**28**	**10**	**4**	**217**	**1**
DNmax	**coif3**	**5**	**179**	**92**	**129**	**140**	**221**	**143**	**904**	**-1**
CR	coif3	5	20.54	14.62	28.58	34.42	56.2	42.75		
PSNR	coif3	5	42.18	43.18	42.1	42.27	42.99	42.35		

Table 3 : Error Matrix Of Coif 3–Level 3 –Threshold 5 -Compressed Agriculture Of Kaveripakkam


Editor: errormatrix-coif3-level3-thr5-compagri, Dir: e:/kousalya/thesis/agriculture/

File Edit View Find Help

ERROR MATRIX

Reference Data

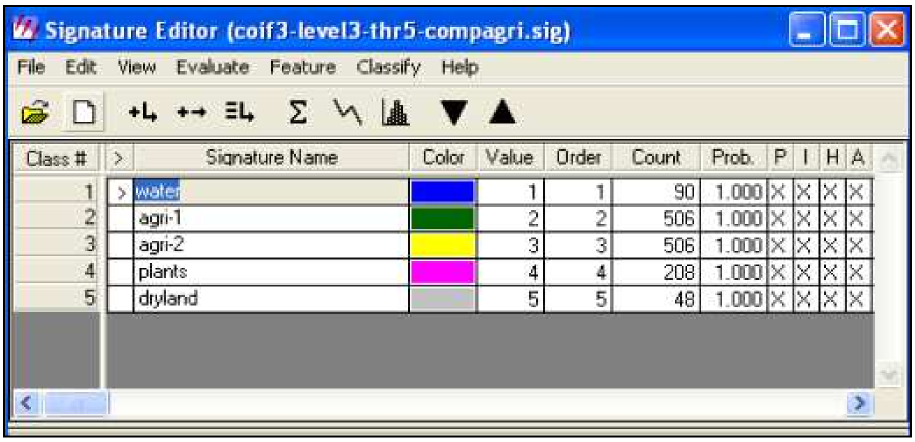
Classified Data	water	agri-1	agri-2	plants
water	90	0	0	0
agri-1	0	504	0	0
agri-2	0	0	506	0
plants	0	2	0	208
dryland	0	0	0	0
Column Total	90	506	506	208

Reference Data

Classified Data	dryland	Row Total
water	0	90
agri-1	0	504
agri-2	0	506
plants	0	210
dryland	48	48
Column Total	48	1358

----- End of Error Matrix -----

Table 4 : Signature Editor Of Coif 3-Level 3-Threshold 5-Compressed Agriculture Of Kaveripakkam


Signature Editor (coif3-level3-thr5-compagri.sig)

File Edit View Evaluate Feature Classify Help

Class #	>	Signature Name	Color	Value	Order	Count	Prob.	P	I	H	A
1	>	water		1	1	90	1.000	X	X	X	X
2		agri-1		2	2	506	1.000	X	X	X	X
3		agri-2		3	3	506	1.000	X	X	X	X
4		plants		4	4	208	1.000	X	X	X	X
5		dryland		5	5	48	1.000	X	X	X	X