Classification of Soil Textures Based on Law's Features Extracted from Preprocessing Images on Sequential and Random Windows

R. Shenbagavalli and Dr.K. Ramar

Abstract--- *Texture analysis has been used for recognizing synthetic and natural textures. Textures are one of the important features in computer vision for image classification and retrieval. An important approach to region description is to quantify its texture content. In this paper ,the Soil images has been analyzed using various image pre processing tasks such as Gray level thresholding, Low pass filter, Edge enhancement using Prewitt's Horizontal filtering and then Feature extraction using 3x3 Law's mask convolution.*

The features are constructed on preprocessed methods applied on the Soil texture image by considering different types of windows. These features offer a better classification rate. The experimental results on various Soil textures clearly demonstrate the efficiency of the proposed methods.

Keywords--- *Soil Texture, Proposed Methods, Experimental Results*

I. Introduction

THE principal approaches used in image processing to describe the texture of an image region are statistical, geometrical, structural, model-based and signal processing features. In which, the signal processing methods involve transforming original images using filters and calculating the energy of the transformed images[1]These are Law's masks ,Laines – Daubechies wavelets, Fourier transform, Gabor filters.In this paper ,we evaluate Law's feature extraction method to describe texture of Soil images using 3x3 mask convolution. This method is based on masks that aim to filter the images. From each mask, Five classical statistical parameters can be calculated.

A. Laws' Texture Measures

The texture energy measures developed by K. I. Laws have been used for many diverse applications.T hese measures are computed by first applying small convolution kernels to a digital image, and then performing a non-linear windowing operation. The 2-D convolution kernels typically used for texture discrimination are generated from the following set of one dimensional convolution kernels of length three and five: L3 = [1 2 1], E3 = [1 0 −1], S3 = [1 −2 1], L5 =[1 4 6 4 1], E5 = [1 −2 0 2 1], S5 = [−1 0 2 0 −1], W5 =[−1 2 0 −2 1], R5 =[1 −4 6 −4 1] These mnemonics stand for Level - average grey level, Edge - extract edge features, Spot - extract spots, Wave - extract wave features, and Ripple - extract ripples . All kernels except L5 and L3 are zero-sum. Convolution of texture with Laws' masks and calculation of energy statistics gives description features of a texture that can be used for texture discrimination[4].

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II. Soil Texture

Soil textures are classified by the fractions of each soil separate (sand, silt, and clay) present in a soil. Classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes, e.g. "sandy clay" or "silty clay." A fourth term, loam, is used to describe a roughly equal concentration of sand, silt, and clay, and lends to the naming of even more classifications, e.g. "clay loam" or "silt loam." Texture is important, because it affects the movement and availability of water and nutrients in the soil.[9]

The rate of water percolation is another way to describe the texture of soils. Soils percolate water at different rates. Soil should be watered only as much and as fast as the soil can absorb without runoff.[6] Sandy soil absorbs more than two inches of water per hour. It as very porous. Loam soils absorbs from 0.25 to 2 inches per hour. The soil is loose and porous but holds water quite well. Clay soil absorbs less than 0.25 inches of water per hour. Clay soil is dense with few air spaces between particles and holds water.

III. Methodology

The present paper computes statistical parameters derived from Law's 3x3 mask parameters on sequential window (SW) and random window (RW). The size P×Q of the

SW/RW is chosen based on the conditions $2 \leq P \leq M$ and $2 \leq Q \leq N$. Where P,Q are the window size and M,N are the image size .The starting position of the random window on the image is determined based on the equation (1).

$$Y(n+1) = ((a \times y(n)) + b) \% M \quad (1)$$

where a, and b are the deciding factors for the number of windows.

The RW may contain parts of the other window (overlapped) and the SW does not contain any overlapped windows (non overlapped). One of the features of preprocessing methods is to improve the image information content by suppressing the undesired distortions or enhancements. For this the present paper is applied on the following preprocessing methods called Gray level thresholding, Low pass filter,Edge enhancement using Prewitt's Horizontal filtering .

On the preprocessed images the statistical parameters of LAW'S mask are applied they are given by the equations (2)-(6). The entire process is given by the algorithm shown in Figure 1.

1. Mean $\mu = \frac{\Sigma N \text{ neighbouring pixels}}{N}$ (2)

2. ABSM $= \frac{\Sigma N \text{ abs(neighbouring pixels)}}{N}$ (3)

3. STD $\sigma = \sqrt{\frac{\Sigma N(\text{neighbouring pixels} - \mu)^2}{N}}$ (4)

4. Skewness $\gamma_1 = \frac{\mu_3}{\sqrt{\mu_2}\,(\mu_2)}$ (5)

where $\mu_i = E(X - \mu_i)^2$

5. Kurtosis $\gamma_2 = \frac{\mu_4}{\mu_2^2} - 3$ (6)

B. *Algorithm*

1. Read the texture (M×N)
2. Apply the required preprocessing method on the given texture Method
3. wcount = (size of the texture)/(size of the window)
4. IF Method = sequence
   i. i=1;j= 1 ;count = 1;
   ii. Read the window of P×Q from the pixel (i,j) size
   iii. From this window, calculate various Law's mask features

   If count>wcount

   Apply "classification "

   Else

   i=i×P, j=j×Q, count=count+1

   goto 2

   Else "method = random"

   i. Set the values of a, b and M, count=1
   ii. y(n+1)=((a*y(n))+b)%M
   iii. From the preprocessed image, read the window of size PxQ from the pixel y(n+1)

5. Read the window of P×Q from the pixel (i,j) size
6. From this window, calculate various Law's mask features
7. If count>wcount

   Apply "classification "

   Else

   Count = count +1

   Goto 2

Figure 1: Methodology for Soil Texture Classification System by Preprocessing Method

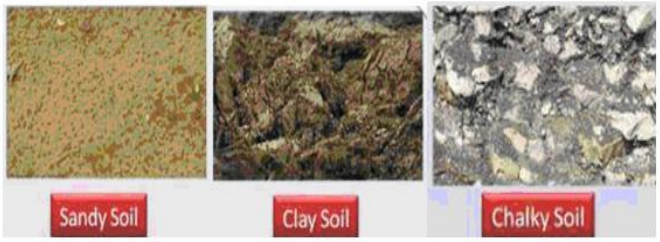

Figure 2: Input images Pictures of Soil - Depending on the Size of the Particles

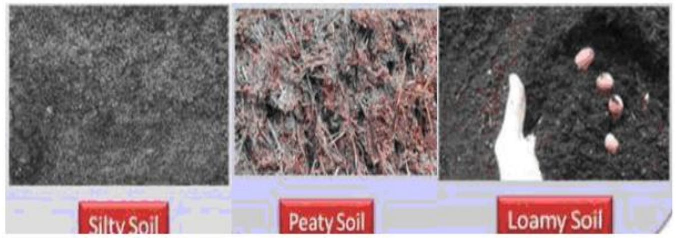

Table 1: Average Texture Classification Rates for RW and SW with Pre-processing

SEQUENCE

soil	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	91.19	94.261	94.96	88.114	87.3407
E3L3	100	92.25	93.679	94.24	91.317	88.3818
L3S3	100	95.84	93.455	96.2	94.849	95.3702
S3L3	100	95.35	93.693	95.67	94.305	95.035
E3E3	100	93	93.475	96.51	92.374	93.1004
E3S3	100	91.7	98.164	92.83	91.041	91.4853
S3E3	100	91.08	94.303	92.01	90.589	90.8137
S3S3	100	94.39	97.918	94.66	93.973	94.237

RANDOM

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	89.89	91.585	91.19	88.8	88.1926
E3L3	100	89.55	91.126	90.91	88.102	86.9398
L3S3	100	92.09	94.216	90.56	90.587	91.9254
S3L3	100	91.6	93.161	90.44	90.843	90.5566
E3E3	100	96.05	92.73	95	94.764	94.8856
E3S3	100	93.92	96.735	95.14	93.144	93.4267
S3E3	100	92.48	95.492	93.76	92.131	92.1887
S3S3	100	94.84	96.993	95.27	94.413	94.6964

IV. Results and Discussions

The experiments are conducted with 6 texture images of each size 128×128, collected from soil images [15] as shown in Figure 2. In the first method, a sequential window

(SW) of size 64×64 is considered. This divides the image into 4 parts and 5 Law's mask

Features are calculated by computing Mean, Abs mean, Standard deviation, Skewness and kurtosis. The average of these features of 4 parts over the set is computed and taken as training set. In the same way a training data is also created for random windows, and they are stored in the texture feature library.

The texture classification is implemented by considering the extracted texture feature from the sample X(loam soil) with the corresponding feature values of all the texture classes *v* stored in the feature library using the distance vector formula given by the equation (7)

$$D(v) = \sqrt{\sum_{j=0}^{N} [f_j(x) - f_j(v)]^2} \quad (7)$$

where N is the number of features in f, fj(x) represents the jth texture feature of the test sample x, while fj(*v*) represents the jth feature of the *v* th texture class in the library.

Table 2: Average Texture Classification Rates for SW with Preprocessing Techniques

MEAN

soil	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	93.184	90.0824	95.1735	92.1532	92.0632
E3L3	100	94.6232	91.0141	95.2389	89.6275	91.7376
L3S3	100	99.638	97.1926	96.9705	95.9866	94.3035
S3L3	100	96.8014	95.8292	96.0865	95.7763	92.2236
E3E3	100	99.9598	99.9256	99.9659	99.9478	99.963
E3S3	100	99.9964	99.9857	99.9885	99.9809	99.9722
S3E3	100	99.9803	99.9665	99.9754	99.9791	99.9592
S3S3	100	99.9965	99.995	99.9904	99.9902	99.9807
AVG	100	98.0225	96.74889	97.9237	96.6802	96.27538

A_MEAN

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	72.3852	94.2315	95.8198	48.7694	47.0352
E3L3	100	71.6249	94.7116	91.1854	66.3441	50.8608
L3S3	100	94.9813	91.0887	97.2033	83.3721	88.8915
S3L3	100	90.5432	93.9084	96.3699	91.888	87.6046
E3E3	100	94.3477	99.6907	97.7312	90.7896	92.5164
E3S3	100	97.3009	99.5139	98.4284	94.367	96.6442
S3E3	100	96.8581	99.9566	98.3529	95.276	95.9923
S3S3	100	98.3604	99.7655	98.9913	96.9021	98.0358
AVG	100	89.5502	96.60836	96.76028	83.46354	82.1976

STDD

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	67.9595	98.3936	86.902	25.6826	5.4809
E3L3	100	75.5455	99.9256	90.9541	70.3747	29.6358
L3S3	100	89.6587	74.9479	97.6649	96.7728	97.6948
S3L3	100	93.7717	75.3676	92.6556	84.4105	99.6278
E3E3	100	93.1294	99.7121	97.3064	88.5651	89.7351
E3S3	100	96.8977	99.1615	98.3172	93.36	95.8407
S3E3	100	96.4687	99.6261	98.4302	94.4637	95.0686
S3S3	100	98.0131	99.6328	98.8783	96.2224	97.5365
AVG	100	88.9305	93.3459	95.13859	81.23148	76.32753

SKEW

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	98.0722	96.719	97.4307	97.5123	97.0431
E3L3	100	99.0494	96.1808	97.9694	99.0274	98.5467
L3S3	100	99.9164	97.8064	97.8122	98.4629	97.9505
S3L3	100	98.4953	97.6895	97.8698	98.4839	97.5854
E3E3	100	98.7798	98.0427	99.9612	98.6862	99.0375
E3S3	100	98.4656	98.5798	99.3832	98.2913	98.4576
S3E3	100	98.7555	99.1891	99.5007	98.4867	98.6749
S3S3	100	99.1297	99.2733	99.2758	99.4612	99.0358
AVG	100	98.833	97.93508	98.65038	98.55149	98.29144

KURT

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	90.7079	87.6373	99.286	94.6071	98.1194
E3L3	100	99.1032	78.2112	91.4185	99.2352	94.2371
L3S3	100	98.4739	96.1237	95.9199	98.8773	99.7248
S3L3	100	98.7289	97.4332	98.3049	97.0086	98.3071
E3E3	100	64.8525	60.0471	92.8888	63.8484	71.1439
E3S3	100	38.4781	99.3883	52.4584	33.739	36.5852
S3E3	100	28.4451	68.8006	39.9018	23.2285	25.9178
S3S3	100	73.0008	96.9987	74.3411	71.1043	72.199
AVG	100	73.9738	85.58001	80.56493	72.70605	74.52929

Then the test texture is classified as *v* th texture, if the distance D(*v*) is minimum among all the texture classes available in the library. Based on the distance function the percentage of correct classification for RW and SW are calculated and are represented in table1.

The same is also applied for various preprocessed images and it is shown in table 2 and 3 for RW and SW respectively. Table 1 clearly indicates that on average RW and SW exhibits similar classification rate for the entire statistical measure. Table 2 and 3 clearly indicates the classification rate for the individual statistical measure. The mean and skew processing step has got an advantage, because it exhibits a higher classification rate than entire statistical measure methods for both SW and RW.

Table 3: Average Texture Classification Rates RW with Preprocessing Techniques

MEAN

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	93.19665	92.57743	97.21173	95.6606	85.03942
E3L3	100	96.8945	93.75475	97.63315	89.35482	86.60502
L3S3	100	95.77483	91.4605	93.22218	93.8192	94.11938
S3L3	100	95.09715	90.21095	93.12455	94.11338	93.5378
E3E3	100	99.9582	99.97633	99.99815	99.9541	99.9202
E3S3	100	99.99164	99.97077	99.98047	99.9598	99.94917
S3E3	100	99.97363	99.9588	99.9738	99.98834	99.9398
S3S3	100	99.9793	99.95598	99.9639	99.97778	99.98153
AVG	100	97.60824	95.98319	97.63849	96.6035	94.88654

A_MEAN

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	64.97355	95.1433	80.86828	51.44048	51.8525
E3L3	100	60.2276	91.73898	78.11823	48.9749	39.08775
L3S3	100	84.29135	99.0098	81.7003	74.13608	83.54163
S3L3	100	81.6503	94.8632	80.65303	77.07233	74.68188
E3E3	100	93.52713	99.99608	97.38073	89.96918	90.76698
E3S3	100	95.9064	99.51663	97.422	93.31525	94.92453
S3E3	100	96.31298	99.80863	98.00133	94.689	94.82433
S3S3	100	97.96098	99.86345	98.8019	96.7446	97.40068
AVG	100	84.35628	97.49251	89.11822	78.29273	78.38503

STDD

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	46.856	63.78255	53.21485	34.85283	31.6843
E3L3	100	44.09658	58.05383	50.37235	28.50678	12.26535
L3S3	100	77.91303	97.16343	61.21328	73.05775	86.62643
S3L3	100	80.53835	91.1433	61.70053	75.70113	74.34515
E3E3	100	91.70918	99.714	96.5342	87.33223	87.56488
E3S3	100	95.81148	99.55135	97.64593	92.72	94.47968
S3E3	100	95.47378	99.73615	97.41583	93.31933	93.8533
S3S3	100	97.48118	99.74153	98.55203	96.00028	96.70015
AVG	100	78.73494	88.61077	77.08112	72.68629	72.1899

SKEW

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	98.84578	97.34985	99.08945	98.9841	99.0386
E3L3	100	98.83633	97.31898	98.87658	99.06568	98.76228
L3S3	100	96.00208	91.9287	93.63505	95.209	94.77885
S3L3	100	95.09833	91.33128	93.36693	94.55123	94.29113
E3E3	100	99.8636	97.68363	99.12585	99.70205	99.55223
E3S3	100	98.33693	96.90298	97.49118	98.54778	98.6026
S3E3	100	97.81675	95.9488	96.85358	97.85408	97.85933
S3S3	100	98.39385	97.01828	97.85635	96.84783	98.34573
AVG	100	97.8992	95.68531	97.03687	97.59522	97.65384

KURT

	LOAMY	CLAY	SANDY	SILTY	PEATY	CHALKY
L3E3	100	93.89818	80.33958	92.04725	93.63273	92.96943
E3L3	100	90.83425	80.3878	92.32075	92.54668	92.70978
L3S3	100	83.4125	86.98598	81.16683	75.17805	75.73378
S3L3	100	77.114	85.67273	79.7244	74.71555	73.96575
E3E3	100	99.31753	49.77933	82.00915	95.62963	96.0384
E3S3	100	73.0289	93.39965	83.85773	68.4479	68.83613
S3E3	100	53.88223	84.22183	68.76095	52.22438	52.50745
S3S3	100	79.55783	94.37615	82.43235	79.20973	79.44353
AVG	100	81.38068	81.89538	82.78993	78.94808	69.09509

V. Conclusion

Various preprocessing methods applied on RW and SW. The RW on preprocessed methods exhibits same percentage of classification as in the case of normal SW method. Though preprocessing is a time consuming process, but the classification rate after preprocessing by mean and skew shows a better result. The preprocessing becomes an essential step when textures are collected from different places and backgrounds for this analysis, the loamy soil has been taken as a test image .Loamy soil is the mixture of clay, sandy and silty soil. From table1 and table2 data the average classification rate of clay, sandy and silty soil is approximated to loamy soil. But, the chalky and peaty soil rate has long difference from loamy soil. The best results were obtained with the TR_{E3E3} mask.

Reference

[1] Alaa Noori Mazher, Dr. Alyaa Hussain Ali, “Texture Analysis of Brodatz Images Using Statistical Methods”

[2] Evaluation of Texture Methods for Image Analysis Mona Sharma ,Markos Markou ,Sameer Singh

[3] Wavelet Based Features for Texture Classification P.S.Hiremath*, S.Shivashankar †,Dept. of P.G.Studies and Research in Computer Science,Gulbarga University,

[4] Texture segmentation: Co-occurrence matrix and Laws’ texture masks methods Guillaume Lemaˆıtre - Miroslav Rodojevi´c ,Heriot-Watt University, Universitat de Girona, Universit´e de Bourgogne

[5] IDL Tutorial Advanced Image Processing,Copyright © 2008 ITT Visual Information Solutions

[6] Role of Soil in Groundwater Protection By Carl F. Engle, Craig G. Cogger, and Robert G. Stevens

[7] Determining Composition of Grain Mixtures by Texture Classification Based on Feature Distributions.Timo Ojala, Matti Pietikäinen, and Jarkko Nisula Characteristics of Soil by Randy Scott, Consulting Rosarian Woodbridge.

[8] Loam From Wikipedia, the free encyclopedia

[9] Classification of Textures Based on Features Extracted from Preprocessing Images on Random Windows by B.V. Ramana Reddy, A. Suresh, M. Radhika Mani, and V. Vijaya Kumar