Texture Feature Based Satellite Image Classification Using LNIP and Gabor filter

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Abstract : The objective of the image classification is to extract the patterns, tremendous information present in the image in form of classes .Satellite image classification process involves grouping the image pixel values into meaningful categories. Several satellite image classification methods and techniques are available but texture extraction plays an important and vital role for efficient classification. This system proposes a novel method for Satellite Imagery Classification .Local Neighborhood Intensity Pattern (LNIP) which considers the relative intensity difference between a particular pixel and the center pixel by considering its adjacent neighbors and generate a sign and a magnitude pattern. Gabor filters with different frequencies and orientations may be helpful for extracting useful features from an image. They have rich applications in image processing, especially in feature extraction for texture analysis and segmentation .Fuzzy c means algorithm classifying the images into different classes such as Barren Land,Agriculture,Forest,Water. Our proposed method is a combination of LNIP(Local neighborhood Intensity Pattern),Gabor filter for texture feature extraction and then image is classified using an unsupervised Fuzzy c-means(FCM) classification algorithm.

***IndexTerms*-** **Satellite Image Classification, Texture feature,LNIP, Gabor filter ,FCM**

I. INTRODUCTION

Satellite image classification is an effective technique to extract data from a number of satellite images. Satellite image classification is a process of grouping the pixels into relevant classes[1] .Satellite image classification can also be known as extracting knowledge from satellite images. Satellite image classification associate in the analysis of remote sensing images, spatial data mining, studying different vegetation category such as agriculture and foresters etc. and studying urban and to determine different land use in that area. The recent research work is on satellite image classification methods and techniques. It defines and provides details on different satellite image classification technique to analyze.

Image classification is contextual information in image. Contextual means it will mainly focus on relationship of nearby pixels. Image classification is an important and challenging task in various application domains like remote sensing, vehicle navigation, robot navigation, video surveillance and biomedical imaging remote sensing[2]. Image classification process includes different steps like different digital data, pre-processing, feature extraction, selection of training data, decision and classification, classification output, post-processing and accuracy assessment . The output of classified remotely sensed images will classify different areas from satellite image in form of land, vegetation, water bodies, rock etc[4] .

1.1 NEED OF SATELLITE IMAGE CLASSIFICATION

Satellite Images Classification are used for various purpose and useful for extracting valuable information[3].

- Spatial data mining
- Extract information for an application
- Thematic map creation
- Visual and digital satellite image interpretation
- Field surveys
- Effective decision making
- Disaster management

1.2 CLASSIFICATION ALGORITHM FOR SATELLITE IMAGE

There are basically two types of image classification techniques, those are mostly used in satellite image [5].

- Unsupervised Classification Algorithm.
- Supervised Classification Algorithm.

1.2.1 Unsupervised Classification Algorithm:

It is a technique, in which the outputs (groupings of pixels with common characteristics) are based on the software evaluation of the image without the user provides sample classes. The computer uses techniques to find that which pixels are related to the classes. The user can a provides desired a number of output classes. However, the user must have knowledge about the area being classified during the groupings of pixels with common characteristics provided by the computer ,have to relate the actual features of the ground[16] (such asdeveloped areas, coniferous forests, wetlands, etc.).

Eg: K-means and FCM(Fuzzy C Mean).

1.2.2 Supervised Classification Algorithm:

It is based on the concept that a user can select sample pixels in an image that represent the specific class and then the direct software is used, these training sites as references for the classification of all other pixels in the image. Training sites (also known as testing sets or input classes) are chosen based on the facts of the user. The user also sets the boundaries for how similar other pixels must be to set them together. Theuser also designates the number of classes in which the image is classified into. Many analysts use a combination of supervised and unsupervised classification procedure to develop concluded output analysis and classify maps.

Eg: Maximum likelihood, Minimum-distance classification,Mahalanobis distance classifier.

1.3 TEXTURE EXTRACTION METHODS

Texture plays an important role in many machine vision tasks such as surface inspection, scene classification, surface orientation and shape determination. Texture is characterized by the spatial distribution of gray levels in a neighborhood[12].

Based on Texture different regions of image is classified and that is known as Texture based Image classification.Various Texture Feature extraction method used for satellite image classification such as Local Binary Pattern,Local Ternary Pattern,Gabor filter,GLCM, Markov Random Field etc[6].

1.4 ISSUES OF CLASSICAL CLASSIFICATIONALGORITHMS

Classification algorithms of satellite images can be categorized into two main methods supervised and unsupervised algorithms . The use of supervised or unsupervised algorithms in the classification procedure depends on the analyst expert ́s information on the satellite image study area. Despite a large number of classification algorithms of satellite images, all algorithms have the drawback that prevents them from being reliable in the terms of classification correctness rate.These limitations are amplified when some classes have a high level of heterogeneity because it make complicate the combination of pixels with different characteristics that may belong to several classes (uncertain pixels) or when the images are changed with a Gaussian impulse-type noise (noisy pixels),cause the resulting image to have a lot of tiny areas (often a pixel) which are misclassified[18].

Clearly, the Unsupervised classification methods may not be appropriate for classification of images fraught with mixed pixels. This problem may be resolved either by ignoring or removing the mixed pixel from the classification process. This may be undesirable due to loss of class information hidden in these pixels[17].

II. LITERATURE REVIEW

Banerjee, Prithaj [7] proposed the new texture descriptor that is Local Neighbourhood Intensity Pattern which consider both sign as well asmagnitude for feature generation and hence it provide robustness to the illumination changes in the intensities of gray level of a pixel of an image and it shows better performance than local binary pattern.

Vignesh[8] proposed an novel approach for satellite Image Classification where Local binary pattern is used for texture extraction amd than classification is done using Fuzzy C Mean algorithm which shows better accuracy than other texture feature extraction method such as Gabor,LTP and GLCM.

Venkateswaran, K., N. Kasthuri, and R. A. Alaguraja[9] proposed a combination of two texture feature that is GLCM and wavelet to classify the image in several classes using supervised classification and the result obtained are better than exisiting method which consider only one feature descriptor for feature extraction.

Vignesh, T., and K. K. Thyagharajan[10]proposed a classification of water bodies from Land Use and Land Cover using Gabor Filter which extract the feature from satellite image and than classification is done using Fuzzy C Mean and result obtained are better than GLCM with SVM,GLCM with FCM and LTP.

Sharifah Sakinah Syed Ahmad[11]proposed a classification of Satellite Image using Fuzzy C Mean algorithm and the accuracy obtained is very high.

III.RESEARCH METHODOLOGY

3.1 Gabor Filter

Gabor filters are band pass filters which are used in image processing for feature extraction, texture analysis .Gabor filters to capture the global texture information from an input image.

A Gabor wavelet is a filter whose impulse response is defined by a sinusoidal wave multiplied by a Gaussian function[14]. In the 2-D spatial domain, a Gabor filter, including a real component and an imaginary term, can be represented as

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right) \quad (9)$$

Where

$$a' = a\cos\theta + b\sin\theta \quad (10)$$

and

$$b' = -b\sin\theta + a\cos\theta \quad (11)$$

In this equation, λ represents the wavelength of the sinusoidal factor, θ represents the orientation of the normal to the parallel stripes of a Gabor Function, Ψ is the phase offset, σ is the sigma/standard deviation of the Gaussian envelope and ɣ is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function.

`3.2 Local Neighborhood Intensity Pattern(LNIP)

Here we use a 3*3 window to calculate LNIP. It tends to explore the mutual information with respect to the adjacent neighbors[7]

- First,we calculate sign of relative difference between one of the eight neighbour of center pixel I_c with its adjacent neighbour.
- Then we calculate second binary pattern where sign of relative difference between center pixel I_c with it's neighbour is calculated.
- The structural change in two binary bit pattern can be computed using XOR operation

$$B_{(1,i)}(k) = Sign(\ S_i(k), I_i) \text{ where, } k = 1 \text{ to } M \quad (1)$$

$$B_{(2,i)}(k) = Sign(\ S_i(k), I_c) \text{ where, } k = 1 \text{ to } M \quad (2)$$

$$D_i = XOR(B_{1,i}, B_{2,i}) \quad (3)$$

- For two M bit patterns the total number of positions at which the respective bits may differ ranges from 0 to M. Here 1/2(M) is considered as threshold where, M = 4, if i odd number; M = 2, if i even where i=1,2,3,....,8 number .A binary bit for I_i.

$$B(I_i, I_c) = \begin{cases} 1, & if\ (D_i = 1) \geq (1/2)M \\ 0, & otherwise \end{cases} \quad (4)$$

$$LNIP_s(I_c) = \sum_{i=1}^{8} 2^{i-1} \times B(I_i, I_c) \quad (5)$$

- we consider the mean of absolute deviation(M_i) of adjacent neighbors to acquire the information of total deviation of these neighbors from a particular pixel I_i tocalculate the magnitude pattern.
- T_c is the threshold value which is calculated by taking the mean deviation of the neighbors(I_i) about the center pixel I_c.

$$M_i = \sum_{k=1}^{M} |\ S_i(k) - I_i\ | \quad (6)$$

$$T_c = \frac{1}{8} \sum_{i=1}^{8} |\ I_i - I_c\ | \quad (7)$$

- The final magnitude pattern is calculated as:

$$LNIP_M(I_c) = \sum_{i=1}^{8} 2^{i-1} \times M(I_i, I_c) \quad (8)$$

- Finally now two pattern LNIPs and $LNIP_M$ concatenated to form the combined histogram.Hist=Hist ^{LNIPs},Hist ^{LNIP}

Figure6:Working of Local Neighbourhood Intensity Pattern(LNIP)

3.3 Fuzzy C-Mean

Analysis allows data to belong more than one cluster at thesame time. Membership values are determined for each data, which represents the degree of belongingness of that data to each of the clusters[15] .

The FCM algorithm assigns pixels to each category using fuzzy memberships. Let X = ($x_1, x_2, x_3, \ldots, x_n$) in image with n pixels to be partitioned into 1 < c < n clusters, where x_i represents multispectral (features) data. The FCM algorithm is an iterative optimisation that minimises the objective function defined as follows:

$$J_m = \sum_{i=1}^{n} \sum_{j=1}^{c} \mu_{ij}^{m} \left\| \mathbf{x}_i - \mathbf{c}_j \right\|^2, 1 \leq m\infty, \quad (12)$$

Where μ_{ij} is the degree of membership of x_i the cluster j, $x_i$is the ith of d-dimensional measured data, c_j is the d-dimension center of the cluster, and |*| is any norm expressing the similarity between any measured data and the center.

3.3.1 Steps of Fuzzy C Mean

- Initialize the membership M=μ_{ij} ,M[0]
- Calculate the center vectors c(k)=[c_j] }with M(k) where k is the current iteration

$$\mu_{ij} = \frac{\sum_{i-1}^{n} m_{ij}^{p} \cdot x_i}{\sum_{i-1}^{n} m_{ij}^{p}} \quad (13)$$

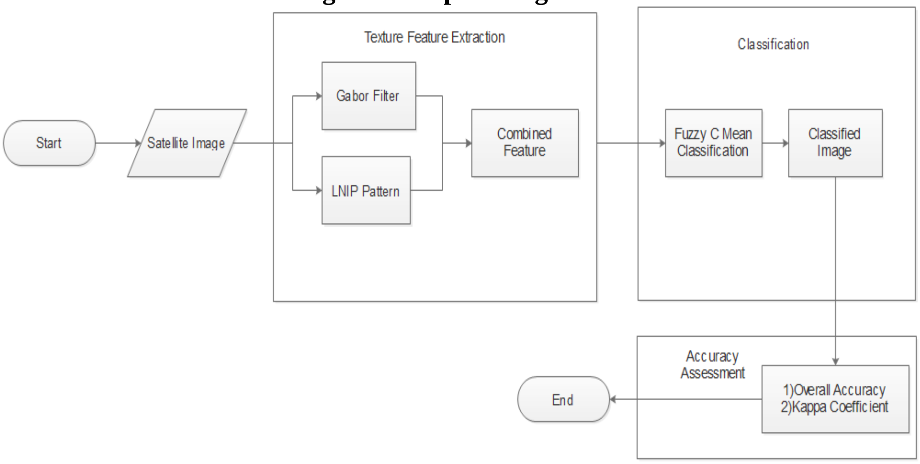
Update the membership function

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{\|\mathbf{x}_i - \mathbf{c}_j\|}{\|\mathbf{x}_i - \mathbf{c}_k\|} \right)^{\frac{2}{m-1}}}. \quad (14)$$

- If ||M(k+1)-M(k)||is lesser than a threshold value then it indicates that no more improvements in the clustering process can be done and hence stop;otherwise return to step 2.

IV.PROPOSED METHODOLOGY

Figure1- Proposed algorithm

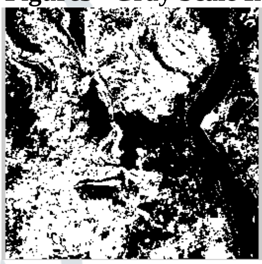


4.1 Steps of proposed method

- Input: Satellite Image is given as an Input.
- Resize the input image.
- Convert the resized image into gray scale image as LNIP and Gabor works only on gray scale image.

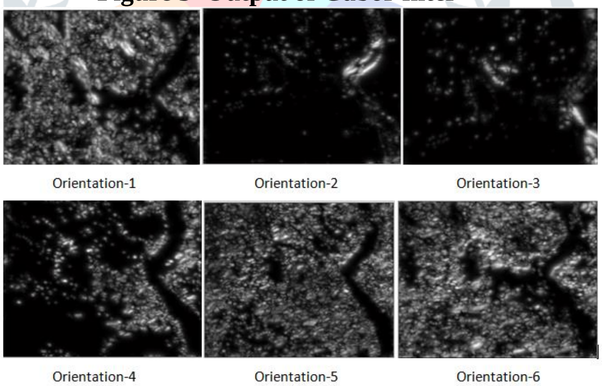
Figure2-Input Image

Figure3 –Gray Scale Image



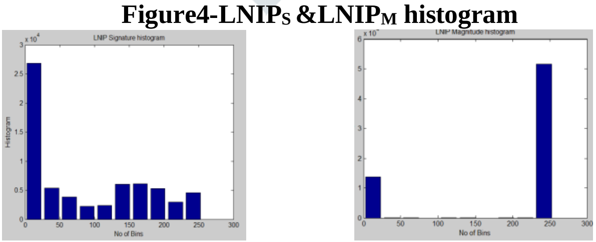
- Obtain the Global feature of Satellite Image Using Gabor Filter as explained in (3.1) for six different orientation.

Figure 3–Output of Gabor filter



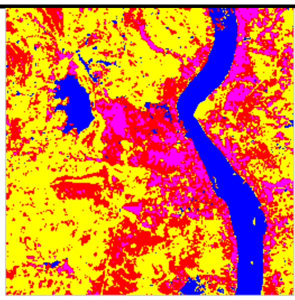
- Obtain the Local feature of Satellite Image Using LNIP as explained in (3.2).

Figure4-LNIP$_S$ &LNIP$_M$ histogram



- Combine the feature vector obtained in step 2 and 3
- The feature vector of an image obtained from step 4 is Classified using Fuzzy C Mean algorithm as explained in (3.3).
- Output: Classified Image is obtained.

Figure5-Output Classified Image



- Calculate accuracy assessment of the classified image such as accuracy,precision,recall,time complexity,kappa coefficient.

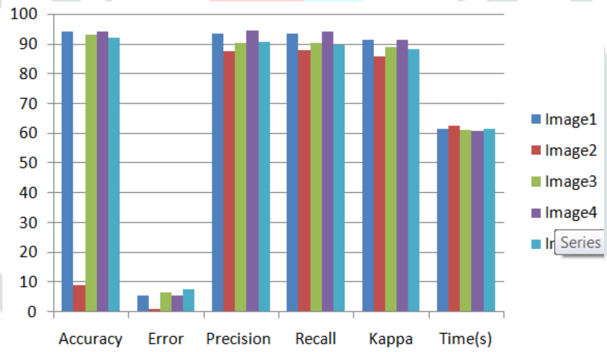
IV.RESULT & ANALYSIS

Table1-Result of 5 Satellite Classified Image

Image	Accuracy	Error	Precision	Recall	Kappa	Time(s)
Image1	94.5	5.5	93.86	93.76	91.74	61.614068
Image2	9	1	87.96	88.28	86.06	62.574693
Image3	93.5	6.5	90.46	90.46	89.34	61.338672
Image4	94.5	5.5	94.62	94.55	91.59	61.005376
Image5	92.5	7.5	91.05	89.88	88.37	61.770285

The Proposed work is checked for more than 20 image and result of 5 images are shown in table1 and the various value such as Accuracy,Precision and Recall are checked and the value obtained is very high while the error that is misclassified pixels value is very less.Moreover,the time complexity is also very less.The graph for the respected value are shown below which indicates that the proposed work is very efficient.

Figure6-Graphical representation of Results



V.CONCLUSION

In this research work,we have used LNIP for local feature extraction which will find out the pattern in pixels of local region and Gabor filter for the pattern in pixels at whole image and then will combine both the texture feature and that feature vector is given as data to FCM which will classify the image into four classes.The result obtained in this research work that is Accuracy,Precision and Recall are very high and hence our proposed work is very much efficient than the exisiting system.Furthermore,the time complexity is also less.Hence,our proposed research has shown good efficiency and can be considered for satellite image classification.

REFERENCES

[1] Mahmon, Nur Anis, Norsuzila Ya'Acob, and Azita Laily Yusof. "Differences of image classification techniques for land use and land cover classification." Signal Processing & Its Applications (CSPA), 2015 IEEE 11th International Colloquium on. IEEE, 2015**.**

[2] Ennouni, Assia, "A review on image mining." 2017 Intelligent Systems and Computer Vision (ISCV). IEEE, 2017.

[3] Abburu, Sunitha, and Suresh Babu Golla. "Satellite image classification methods and techniques: A review." International journal of computer applications 119.8 (2015).

[4]Pushpendra Singh Sisodia, Vivekanand Tiwari, Anil Kumar. "A Comparative Analysis of Remote Sensing Image Classification Techniques",2014 IEEE.

[5] Pooja Kamavisdar, SonamSaluja, and Sonu Agrawal, "A Survey on Image Classification Approaches and Techniques", International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, No. 1, 2013.

[6] Vijaya V. Chamundeeswari, Dharmendra Singh, and Kuldip Singh, "An Analysis of Texture Measures in PCA-Based Unsupervised Classification of SAR Images", IEEE Geoscience and Remote Sensing Letters, April 2009, Vol. 6, NO. 2, 214-218.

[7] Banerjee, Prithaj, "Local Neighborhood Intensity Pattern–A new texture feature descriptor for image retrieval". Expert Systems with Applications 113 (2018): 100-115**.**

[8] "Local binary pattern texture feature for satellite imagery classification", IEEE 2017 International conference on Science, Engineering and management Research.

[9] Venkateswaran, K., N. Kasthuri, and R. A. Alaguraja. "A Combined Detail Enhancing Algorithm and Texture Feature Extraction Method for Supervised Classification of Remote Sensing Images." Journal of the Indian Society of Remote Sensing (2018): 1-10.

[10] Vignesh, T., and K. K. Thyagharajan,"Water bodies identification from multispectral images using Gabor filter, FCM and canny edge detection methods." Information Communication and Embedded Systems (ICICES), 2017 International Conference on. IEEE, 2017

[11] Taufik, Afirah, Sharifah Sakinah Syed Ahmad, and Nor Fatin Emiliza Khairuddin. "Classification of Landsat 8 Satellite Data using Fuzzy c-means." Proceedings of the 2017 International Conference on Machine Learning and Soft Computing. ACM, 2017

[12] https://nptel.ac.in/courses/117106100/Module%209/Lecture%204/LECTURE%204.pdf

[13] https://gisgeography.com/image-classification-techniques-remote-sensing/

[14] Idrissa, Mahamadou, and Marc Acheroy. " Texture classification using Gabor filters." Pattern Recognition Letters"} 23.9 (2002): 1095-1102.

[15] Tian, Yu,"FCM texture image segmentation method based on the local binary pattern." ,Intelligent Control and Automation (WCICA), 2016 12th World Congress on. IEEE, 2016**.**

[16] Duda, Tanja, and Mort Canty "Unsupervised classification of satellite imagery: choosing a good algorithm." International Journal of Remote Sensing 23.11 (2002): 2193-2212.

[17] Pushpendra Singh Sisodia, Vivekanand Tiwari, Anil Kumar. "A Comparative Analysis of Remote Sensing Image Classification Techniques",2014 IEEE

[18] Yang, Ting, et al. \emph{"Combining multiple feature for texture image classification."} Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), 2017 10th International Congress on. IEEE, 2017.