ISODATA classification using Fuzzy Logic

K.Himabindu[1], T,Sarath[2]

[1]Associate Professor,
Dept. of MCA, SVCE,
himabindu.karamala@svcolleges.edu.in

[2] Assistant Professor,
Dept. of CSE, SISTK, Puttur,
sarathbalakrishna@gmail.com

Abstract*:*In current days remote sensing is mainly recent application in many sectors. Remote Sensing (RS) refers to the science of identification of earth surface facet and analysis of their geo-biophysical property via electromagnetic emission as a model for interaction. Spectral, spatial, temporal and polarization signatures are key features of the sensor/target, which make easy target bias. Earth surface data seen by the sensors in altered wavelengths (reflected, scattered and/or emitted) is radio metrically and geometrically right by extraction of spectral data. RS data is a synoptic read, pedestrian exposure with calibrate sensors to work out changes, observations at various resolutions, deals with a alternative for normal resources management as compare to standard methods. This remote sensing utilizes dissimilar images like multispectral, hyper spectral or ultra-spectral. The remote sensing image classification is being of the significant methods to sort image. In order to state we classify the ISODATA classification amid fuzzy logic. In this we experimenting fuzzy logic be affectionate of spatial, spectral texture methods in that dissimilar sub methods to be worn for image classification.

***Keywords*: Hyperspectral, Multispectral, Image processing, Remote sensing, Classifications, ISODATA, Fuzzy logic..**

(Article history: Received: 1st September 2020 and accepted 21st December 2020)

I. INTRODUCTION

The achievement of any GIS [10, 11] application depends on the excellence of the geographical data. GIS [15] means "Geographic Information System". In general, it distinct as computer assisted systems for the confine, storeroom, salvage, analysis and display of spatial/spectral data. This will collect the high-quality geographical data for input. To study this, we take a remote sensing.

Hyper spectral Remote Sensing

The hyper spectral remote sensing [1, 8, 2, 17] is an advanced tool to facilitate high spatial/spectral resolution data from a distance.The primarily powerful tools used in the field of remote sensing are hyper spectral imaging (HSI) and Multispectral Imaging (MSI). Since the mid 1950's a few airborne sensors have recoded spectral information [8] on the Earth surface in the wavelength region extending from 400 to 2500 nm. Starting from the early 1970's [9] a large number of space borne multispectral sensors have been launch on board the LANDSAT, SPOT and Indian Remote Sensing (IRS) series of satellites.

Hyper spectral image be keen on other spectral image which gathers information through the spectrum. Such as the human eye sees light in 3 bands (red, green, and blue), spectral imaging divides the spectrum into many more bands. This practice of dividing images into bands which is extended beyond the visible.

Engineers erect sensors and processing systems to afford such capability for application in agriculture, mineralogy, physics, and surveillance. Hyper spectral sensors appear at objects using infinite portion of the electromagnetic spectrum. Firm objects leave unique 'fingerprints' crosswise the electromagnetic spectrum. These 'fingerprints' are branded as spectral signatures and enable identification of the materials that make awake a scanned object. For example, a spectral signature pro oil helps mineralogists find new oil fields.

Hyper spectral imaging is part of a class of techniques commonly referred as spectral imaging or spectral analysis. Hyper spectral imaging is linked to multispectral imaging. The distinction between hyper and multi-spectral is usually supported an arbitrary "number of bands" or the character of measurement, counting on what's is apt to the aim.

Multispectral image deal through numerous images at discrete and somewhat narrow bands. Being "discrete and somewhat narrow" is what distinguishes multispectral within the visible from color photography. A multispectral sensor may have many bands covering the spectrum from the visible to the long wave infrared. Multispectral pictures don't turnout the "spectrum" of associate degree object. Land sat is an excellent example of multispectral imaging.

Hyper spectral deals with imaging slender spectral bands over a endless spectral range, and produce the spectra of all pixels in the scene. So a sensor with only 20 bands can also be hyper spectral once it covers the vary from 500 to 700 nm with 20 bands each 10 nm wide. (While a sensor with 20 discrete bands covering the VIS, NIR, SWIR, MWIR, and LWIR would be thought-about multispectral.)'Ultra spectral' could live keep for interferometer type imaging sensors with a awfully fine spectral resolution. These sensors a lot have (but not necessarily) a low spatial resolution of several pixels only, a control imposed by the high data rate.

In this we carry out the hyper spectral remote sensing classification, where image classification is a route of sorting pixels in to individual classes, based on pixel values. This classification is used to assign corresponding levels with deference to groups. This classification is generally used as extraction techniques in digital remote sensing. Most of the digital image analysis is awfully nice to have a good image to show a magnitude of colours contains various features of the underlying terrain, but it is useless if you don't know what the colours mean.

There are two key classification methods are Supervised Classification and Unsupervised Classification. The unsupervised classification is the identification of normal groups. The supervised classification is the process of sample the known identity to classify and unclassified pixels to one of several informational classes.

II. ISODATA

The ISODATA method is the scheme developed by Ball, Hall and others in the 1960s. The ISODATA method is which added partition of a cluster, and processing of fusion to the K-means method. The entity density of a cluster is controllable by performing division with fusion to the cluster generated from the K-means method. The entity in a cluster divides past [a detached building] and its cluster, and the space between clusters unites them with past close. The parameter that found out division and fusion beforehand determines. The procedure of the ISODATA technique is shown as follows.

1. Parameters, just like the quantity of the last clusters, a convergence situation of transcription, judgment conditions of a second cluster, branch condition of division and fusion, and finish conditions, are determined.

2. The initial cluster center of gravity is chosen.

3. Based on the convergence condition of Rearrangement, an individual is rearranged in the way of the K-means method.

4. It considers with a minute cluster that it is below threshold with the number of individuals of a cluster, and excepts from future clustering.

5. When it is more than the threshold that exists within fixed limits which the number of clusters centers on the number of the last clusters, and has the minimum of the gap among the cluster center of gravity and is below threshold with the most of distribution during a cluster, clustering regards it as convergence and ends process. When not connection, it progresses to the subsequent step.

6. If the quantity of clusters exceeds the mounted vary, when large, a cluster is split, and when little, it will unite. It divides, if the quantity of times of a replication is odd when there is the number of clusters within fixed limits, and if the quantity is even, it unites. If splitting up and union finish, it will arrive to 3 and processing will be repeated.

- Division of a cluster: If it is more than threshold with distribution of a cluster, carry out the cluster along with the 1st principal component for 2 minutes, and search for the new cluster center of gravity. Allocation of a cluster is re-calculated, and division is continued until it become under threshold.
- Fusion of a cluster: If it is below threshold with the minimum of the distance between the cluster centers of gravity, unite the cluster pair and search for the new cluster center of gravity. The distance between the cluster center of gravity is re-calculated, and fusion is sustained until the minimum becomes more than threshold.

Although the ISODATA methodology will regulate the amount of bound inside the bounds cluster, and the homogeneity of a cluster by division and fusion, international best nature cannot be warranted. Since the ISODATA technique has a lot of parameters than the K-means technique, adjustment of the parameter continues to be harder.

III. METHODOLOGY

Fuzzy logic

Traditional rule-based classification is predicated on strict binary rules, for example: objects meeting the principles for "tree" are classified as "tree," objects meeting the principles for "urban" are classified as "urban," and objects meeting neither rule remain unclassified. Fuzzy logic [20] is a vital part in ENVI Feature Extraction rule-based classification. Rather than classifying an object as absolutely "true" or "false" (as in binary rules), fuzzy logic uses a membership function to represent the degree than an object belongs to a feature type. Information extraction from remote sensing data is limited by noisy sensor measurements with limited spectral and spatial resolution, signal degradation from image pre-processing, and imprecise transitions between land-use classes. Most remote sensing pictures contain mixed pixels that belong to single or a lot of categories. Fuzzy logic helps alleviate this drawback by simulating uncertainty or partial info that's in keeping with human reasoning. The output of each fuzzy rule is a confidence map, where values represent the degree that an object belongs to the feature type defined by this rule. In classification, the entity is assign to the feature type that has the utmost assurance value. With rule-based classification, you can manage the measure of fuzzy logic of each order when you construct rules.

Fuzzy ISODATA

Fuzzy ISODATA (Iterative Self-Organizing Data Analysis Techniques Algorithm) is an interactive self-organizing data analysis technique for fuzzy cluster [19, 20]. Cluster use customary Fuzzy ISODATA mechanism as track, suppose classes' variety has been determined, and opt for a resourceful fuzzy cluster matrix, and calculate best fuzzy cluster matrix and best cluster center matrix by iterative operation, then classify the inspected object. The algorithm requires more stringent selection of original fuzzy cluster matrix. In appropriate selection would cause is to rtioniiterive process. There are limitations once customary fuzzy ISODATA was employed in the scene of rating of target object. The algorithm can only cluster object hooked on specificlaes, but can't discriminate whether classes meet the "meaningful distance". Based on this, reference sample system and investigation sample will be collected to cluster. Superior fuzzy ISODATA algorithm ladder area follows:

1) Establish the original characteristic indicators matrix U* that descript each attribute value of all inspected object and reference samples. U^*_{ij} is on behalf of the characteristic indicators j of object i.

2) Standardize the data of original characteristic indicators matrix U* by range method to get U, define

$$M_J = \max(u^*_{1j}, u^*_{2j}, \ldots\ldots\ldots, u^*_{nj})$$

$m_J = \min(u^*_{1j}, u^*_{2j}, \ldots\ldots\ldots, u^*_{nj})$ for column j of U^*, calculate *uij* using formula (1)

$$u_{ij} = \frac{u^*_{ij} - m_j}{M_j - m_j} \qquad (1)$$

3) Start iterative operation based on original cluster center matrix $V^{(o)}$ of reference sample system, l 0,1, 2

4) Calculate fuzzy classified matrix $R^{(l)}$ using formula (2), where c is on behalf of classes number. And based on Euclid distance

$$\|u_k - v_i\| = \left(\sum_{j=1}^{m} (u_{kj} - v_{ij})^2 \right)^{\frac{1}{2}}$$

$$r^{(l)}_{ik} = \left[\sum_{j=1}^{c} \left[\frac{\|u_k - v^{(l)}_i\|}{\|u_k - v^{(l)}_j\|} \right] \right] \qquad (2)$$

5) Modify cluster center matrix for $R^{(l)}$

$V^{(l+I)} = (v^{(l+I)}_1, v^{(l+I)}_2, \ldots.., v^{(l+I)}_c)^T$, where

$$V^{(l+I)}_i = \frac{\sum_{k=1}^{n} (r^{(l)}_{ij})^2 u_k}{\sum_{k=1}^{n} (r^{(l)}_{ij})^2} \qquad (3)$$

6) Repeat step 2, compare R(l) and R(l+I), for given precision e> 0, if , iterative opera- tion should be stopped and should and $R^{(l+i)}$ $V^{(l+I)}$ outputted. In opposite condition, l=l+1, repeat step 3.

7) Getfuzzy cluster based on optimal cluster center matrix discrimination principle--suppose the optimal cluster center matrix ,

$$V^* = (V^*_1, V^*_2, \ldots.., V^*_c), \forall\, u_k \in U \text{ if}$$

$$\|u_k - V^*_i\| = \min_{l \le j \le c}(\|u_k - V^*_j\|)$$

if object $u_k$should be classified to class i.

IV. STUDY AREA

Here input image fig. 1. is taken from the ENVI software default dataset. These areas result to find the unsupervised classification on ISODATA with no training sites in which we mainly used to find the different areas can be defined. By this we can get many bands and to smooth the areas then we will get the ISODATA classification image as shown in fig2. This image we will get in the ENVI zoom. By using the ISODATA classification image we will conduct the feature extraction to that image and select the band to that select scale level and merge level to find the refinement in thresholding advanced state is selected for that state it has spectral, spatial, texture state in that we have to choose the creating rules and in that we have select the add attribute to rule in that we can select each state have different methods. In the methods at texture we selected max band in spectral we selected range and in spatial area and we have to select the fuzzy tolerance and to set the function type may be s type or linear and to find the vector level to be levelled so that we have to smooth the level as the respected output will be the fuzzy ISODATA classification image as shown in fig3. The performance of the fuzzy ISODATA classification is as shown in TABLE II

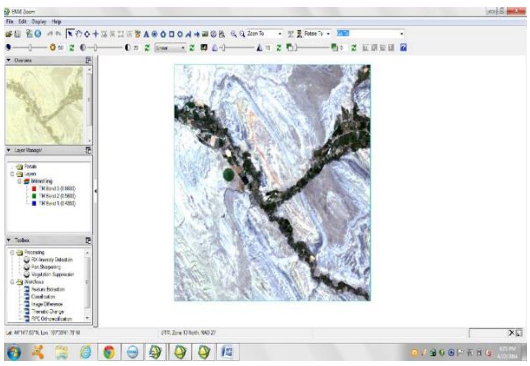

Fig. 1 Input Image

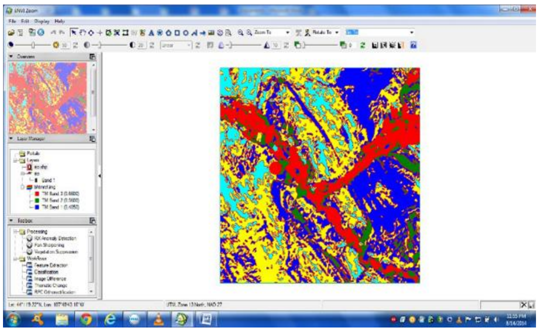

Fig. 2 ISODATA Image

TABLE.ISHOWS THE BANDWIDTHS OF ISODATA CLASSIFICATION

S. No.	No. of Bands	Value
1	Band 1	0.4850
2	Band 2	0.5600
3	Band 3	0.6600

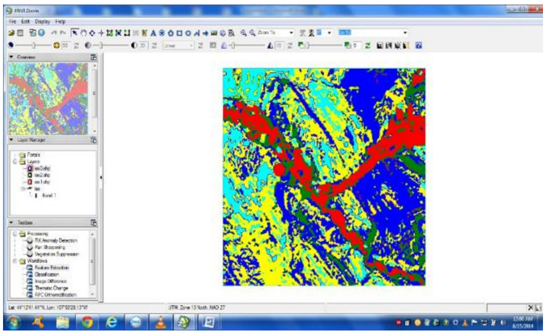

Fig. 3 Fuzzy ISODATA Image

V. PERFORMANCE

File Name: iso
Segment Scale Level: 60.0
Merge Level: 10.0
Refine: 1.00000 to 5.00000
Attributes Computed: Spatial
Spectral
Texture
Classification: Rule-Based
Rule Set:
#1 (1.000): If maxband_1 [1.1725, 4.8431], then object belongs to "iso1".
#2 (1.000): If tx_range [0.3265, 3.0080], then object belongs to "iso2".
#3 (1.000): If area [1287.9310, 2737671.0000], then object belongs to "iso3".
Export Options:
Feature Info:
iso1 Type: Polygon
iso2 Type: Polygon
iso3 Type: Polygon
Smoothing: Threshold of 1

TABLE II. PERFORMANCE OF THE FUZZY SUPPORT VECTOR MACHINE CLASSIFICATION

Feature Name	Feature Count	Total Area	Mean Area	Min Area	Max Area
Feature_1	407	56281050	138282.68	1800	19740150.00
Feature_2	245	98381250	401556.12	900	47958300.00
Feature_3	136	32809050	241243.01	1800	4333050.

VI. CONCLUSION

In this paper, the fuzzy logic by rule based classification for spatial, spectral, texture methods is classified for maxband, range, and area and for that feature count, total area, mean area, min area, max area can carry out all the stage in the rule based method which will show the feature extraction and state different methods of spectral, spatial, texture. In this we only conduct feature extraction on ISODATA but we can conduct on dissimilar methods of supervised classification and unsupervised classification.

VII. REFERENCES

[1] R. Ablin; C. Helen Sulochana (2013). A Survey of Hyper Spectral Classification in Remote Sensing.

[2] Michacl T. Eismann. (2012) A Textbook of Hyperspectral Remote Sensing. ISBN: 9780819487872, Volume: PM210

[3] Mariocaetano Image classification. ESA Advanced training course on Land Remote Sensing.

[4] Pegshippeet. Introduction to Hyperspectral Image Analysis.https://spacejournal.ohio.edu/pdf/shippert.pdf

[5] Sarath, T., Nagalakshmi, G., Jyothi, S.: A Study on Hyperspectral Remote Sensing Classification. International Journal of Computer Applications. doi: 0975-8887 (2015).

[6] Leng J, Li T, Bai G, et al. Cube-CNN-SVM: A Novel Hyperspectral Image Classification Method[C]// IEEE, International Conference on TOOLS with Artificial Intelligence. IEEE, 2017:1027-1034.

[7]Qingxitong; Bingzhang; Lanfenzheng (2004). Hyperspectral remote sensing technology and applications in china. European space agency special publication ESA SP.

[8] Eyalbendor; timmalthus; antonioplaza and Daniel schlapfer (2012). A report on Hyperspectral remote sensing.Airborne Measurements for Environmental Research (pp.413-456) DOI: 10.1002/9783527653218.ch8

[9] A tutorial on Introduction to remote sensing & Image processing.https://www.microimages.com/documentation/Tutorials/introrse.pdf

[10] Dr. pungatoyapatra. Remote sensing and geographical information system (GIS).https://www.dphu.org/uploads/attachements/books/books_2259_0.pdf

[11] David Landgrebe. Hyperspectral image data analysis. IEEE Signal Processing Magazine, 19(1):17– 28, 2002.

[12] Balasubramanian subbiah; seldevChristopher.c. (2012) Image classification through integrated K-means algorithm.International Journal of Computer Science Issues (IJCSI); Mahebourg Vol. 9, Iss. 2, 518-524.

[13] Pouja K amavisdar; sonam saluja; sonuagrawal (2013). A survey on image classification approaches and techniques.International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 1.

[14] Dr.nidaa f.hassan. Introduction to image processing.https://sisu.ut.ee/imageprocessing/book/1#:~:text=Image%20processing%20is%20a%20method,features%20associated%20with%20that%20image.

[15] Lecture on Applications of geographic information system (GIS) introductory.https://www.le.ac.uk/ar/arcgis/Downloads/Lecture_notes_1.pdf

[16] M. Govender, K. cheety and H. bulcoce. (2007) A review of hyperspectral remote sensing and its application in vegetation and water. vol. 3,no. 2.

[17] R.N.Sahou (2013). Hyperspectral remote sensing.Indian Agricultural Statistics
[18] Jensen, John R. (1996). Introductory Digital Image Processing (2nd Ed.). Chapter 8, thematic information extraction: Image classification. Upper saddle river, NJ: Prentice-Hall.
[19] J. C. Bezdek (1981) “Pattern Recognition with Fuzzy Objective Function Algorithms,” Plenum Press, New York.
[20] S. Chen, J. Chen and X. Wang, (2005) “The Fuzzy Set Theory and Its Application”, Science Press, Beijing, (in Chinese)
[21] Manibhushan; Nilanchal Patel; Gadadhar Sahoo & Anil Kumar Singh. (2013) Image Classification for Different Land Use and Land Covers Using Fuzzy Logic for the Improvement of Accuracies. Journal of Agricultural Science; Vol. 5, No. 3.
[22] C.F. Lin; S. D. Wang, (2002) “Fuzzy support vector machines,” IEEETransactions on Neural Networks, vol. 13, no. 2, March 2002.
[23] Dr. C. Venkateswaran; R. Vijaya; A. M. Saravanan. (2013) A fuzzy based approach to classify remotely sensed image. Vol 5 No 3 Jun-Jul 2013

AUTHOR PROFILE

First Author Dr. K.Himabindu,completed her Ph.D. in the area of SoftComputing from Sri Padmavati Mahila Visvavidyalayam (Women’s University), Tirupati. working as Associate Professor in Computer Science., Dept. of Computer Science, Sri Venkateswara College of Engineering, Tirupati. She has 11 years teaching experience. She presented many papers in National, , International Conferences and published papers in International Journals. She has a Patent regarding her research work. She is a member of IAENG. Her area of interest are Image Processing and Soft Computing.