A Fuzzy Based Approach to Classify Remotely Sensed Images

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Abstract

Classification of Images is one of the challenging tasks in image analysis. Image classification is used in many fields such as Remote sensing, medical diagnosis, robotics, etc. Classification is to identify homogeneous groups of data points in a given dataset and assigning it to a class. In this paper classes of image objects are to be classified as region or area of interest for the land use/land cover types. Different classification techniques available categorize all pixels in a Multispectral image. An attempt had been made to analyse the performance of supervised classification and unsupervised classification methods for RSI images using Fuzzy. Experimental study revealed that the proposed supervised classification approach provides consistently better result than unsupervised classification.

Keywords: Image classification, Fuzzy, Supervised, Unsupervised, RSI

1. Introduction

Image classification is one of the most crucial part in image analysis. It includes two basic approaches: supervised and unsupervised. In both types the process can be viewed as one which determines the set to which each pixel belongs to. In case of supervised classification the sets are known in prior, whereas in case of unsupervised classification the sets are unknown. Most of the researches in classification are carried out as a supervised one. In the supervised techniques a model had constructed based on the priory known instances and will identify new objects. A bottleneck in supervised classification is they concentrate less on uncertain attributes as the training set includes only certain instances. Also, the training dataset generated are useful only when the images are simultaneous, or for the images selected under the same condition with same classes [1]. On the other hand, in [2] author suggests that the significant problem with that of unsupervised classification is that classes formed may not be an appropriate one or informative or useful classes.

In essence, classification may be viewed as a process of grouping pixels into a set of classes based on their relative similarities with regard to certain properties[2].There are many approaches and methods for classification and the most commonly used approaches involves statistical modelling like maximum likelihood classification, neural networks based approaches and support vector machines. Fuzzy analysis is applied in different areas such as data analysis, pattern recognition and image segmentation[3]. Different fuzzy supervised and unsupervised methodologies are available for classification [4][5]. Application of fuzzy in supervised classification and unsupervised classification and analysing their performance was the main objective of this paper.

The rest of the paper is organized as follows: Section II reviews the overview of fuzzy. Section III gives the description of the problem. Section IV gives the Experiments and Results. Section V gives conclusion.

2. About Fuzzy

Fuzzy set was introduced by Zadeh in 1965, where the fuzzy set is a set whose elements have different degrees of membership. The membership value assigned to each element in the set can be between 0 to 1, where 0 represents absolutely no membership and 1 represents complete or full membership. Therefore the degree of membership of an element depends on class properties. The degree of an element's membership in a fuzzy set can be defined by a mathematical function which is called membership function.

Though fuzzy is relatively young, it is applied in a wide area of applications such as pattern recognition and classification, process control, management and decision making [5].A main advantage in fuzzy classification is its ability to express each element's membership in more than just one class with different degrees of membership values. Also, it allows the natural description of the problems, in linguistic terms, rather than in terms of relationship between precise numerical values.

A fuzzy set is a set of ordered pairs which is given as follows:

$$A=((x,\mu_A(x)) : x \epsilon X, \quad (1)$$

Where X is a universal set and

$\mu_A(x)$ is the membership grade of x in A ($0 \leq \mu_A(x) \leq 1$)

A membership function $\mu_A(x)$ is characterized by:

$\mu_A(x)$: $X \rightarrow (0, 1)$ where X is the universe of discourse and x is a real number describing an object and each element of X is mapped to a value between 0 and 1.

A fuzzy approach classifies the regions well and there is better representation of uncertainty. Also, the representation of problems in linguistic terms rather than in terms of precise numerical values makes the usage of fuzzy in image classification.

3. Problem Description

The problem is to analyze the performance of the fuzzy supervised and fuzzy unsupervised classification in multispectral images. Fuzzy can be applied in both supervised classification and unsupervised classification.

3.1. Supervised classification

The supervised classification is used when there is prior information about the classes present in the image to be classified. Thus it needs a training data set for the classification.

Fuzzy is used to generate the training data set in supervised classification i.e., the training data set is generated using the unsupervised classification methods like Maximum Likelihood or Minim distance or by computing a fuzzy matrix, which holds the membership grade of each training site. The membership grade is computed by using the fuzzy membership functions like Gaussian distribution function, sigmoid curve and so on [4]

Basically, three steps are required for any supervised classification method which includes:

1. Identify training sites: Pixels of known class membership are characterised i.e., Selecting homogeneous areas in the image
2. Create signatures: Created signatures are used to match the unclassified pixels to that of the known training class signatures
3. Classify the image: Image can be classified using either hard classification(i.e., each pixel is assigned to exactly one of the training class) or using soft classification(i.e., each pixel is assigned a value which represents its “membership” grade with each of the training class)

The result of each classification method includes an ‘unknown’ or ‘unclassified’ pixels remaining (i.e., the pixels that are not assigned to any of the training classes). The unclassified pixels can be viewed in black dots in the result. Supervised fuzzy classification algorithms available are fuzzy Nearest Neighbour (FNN),Multi-Layer perceptron using Back propagation(BP) algorithm etc. FCM is also used in supervised classifications ,Where it is used in supervised classification in order to generate the training set.

3.2. Unsupervised classification

The unsupervised classification is used when there is no prior information about the classes present in the image used for classification. Thus it is completely an automatic process of classification and does not need any labelled data set as training data [4]. In case of unsupervised classification, most of the available methods initially select desired number of cluster centres and a threshold values. The clusters will be refined after each iteration. The iteration stops when the maximum number of iteration specified by the user is reached. Once the clusters are formed, each of the clusters is assigned to one of the appropriate classes. This type of classification will simply group pixels to a class that are similar and the derived class may not be a class of interest.

There are many fuzzy based algorithms available for unsupervised classification such as PCA)Principal Component Analysis,fuzzy c-means, fuzzy Gustafson-Kessel algorithm, fuzzy c-shells and genetic algorithm and so on [7]. But the most popularly used fuzzy based unsupervised classification is Fuzzy c-means [8].

4. Experiments and Results

Experiment in carried out in MATlab 7.1with the RSI image. An IRS LISS Image is used as a test image for classification. The image contains about 10MB of raw pixels information in 3 visible spectral bands. The image contains both rural and urban features of a small town in Tamil Nadu, India. The image has varied features that are present on the surface of the earth and they give out various levels of spectral reflectance as measured by the sensors.

4.1. Accuracy assessment

Accuracy assessment is necessary to know how well a classification procedure is performing. An error matrix and some accuracy measures are used in accuracy assessment. To represent classification accuracy of remotely sensed data, many researchers recommended an error matrix[9].An error matrix is a square array consisting numbers in rows and columns, where row indicates the classified data obtained from the remotely sensed data and column represents the reference data or the training data. The cells in an error matrix contain a count of pixels based on the information derived from the pixels of classified data and the reference data. An error matrix describes accuracy along with the inclusion (commission) and exclusion (omission) of errors present in the classification. Accuracy measure can be either producer’s accuracy or user’s accuracy. The proportion of correctly classified pixels i.e., the number of pixels on the diagonal of a cell to the total number of pixels in that column, obtained from the reference data, expressed as a percentage provides a measure of

classification accuracy of the column which is called “producer’s accuracy” or omission error. On the other hand, the proportion of correctly classified pixels i.e., the number of pixels on the diagonal to the total number of pixels in that row, obtained from the classified data, expressed as a percentage provides a measure of classification accuracy of the row, which is called “user’s accuracy” or commission error. The average accuracy is calculated as the sum of accuracy pixels in column accuracy divided by the number of classes in the training set. The overall accuracy is calculated as the total number of correctly classified pixels (numbers in diagonals) divided by the total number of test pixels.

Table 1 presents the error matrix generated from the supervised classification and unsupervised classification of a small area from IRS LISS image data.The classification uses only three categories as Road(R),Water(W) and vegetation(V).

Table 1. Error matrices for Supervised and Unsupervised approach

supervised Approach

		Reference Data R	V	W
classified Data	R	70	8	4
	V	10	118	13
	W	8	7	94

Overall Accuracy= 282/332=85%

Unsupervised approach

		Reference Data R	V	W
classified Data	R	63	13	6
	V	15	113	13
	W	10	9	90

Overall Accuracy= 266/332=80%

In addition, statistical measures such as the Kappa coefficient of Agreement, Kappa variance and Kappa standard normal deviate can be used in the accuracy of classification. Kappa coefficient is a more comprehensive measure used in the accuracy of a classification.For an error matrix with rows r and columns c, $\hat{K}$ is given below:

$$\hat{K} = \frac{N A - B}{N^2 - B} \qquad (2)$$

Where, A is the sum of diagonal elements(r),which is the numerator in the overall accuracy computation,

B is the sum of row total X column total, and

N is the number of pixels in the error matrix.

Table 2: A comparison of the accuracy measures for the supervised and unsupervised classification

classification Algorithm	Overall Accuracy	Kappa coefficient
supervised	85%	77%
Unsupervised	80%	70%

Table 2. Shows the overall accuracy measure comparison with the kappa coefficient for the supervised and unsupervised classification approach. Kappa coefficient gives the advantage to compare two classifications and helps to determine the accuracy level between the two classifications. This helps to improve the classification by separating misclassifications of pixels [15].

5. Conclusion

Here, an attempt has been made to compare the performance of fuzzy supervised and unsupervised classification. Fuzzy logic theory provides major advantage in classification, which allows the natural description of the problem, in terms of linguistic rather than in terms of relationships between precise numerical values. The fuzzy set theory offers powerful gadget for supervised and unsupervised classification. The accuracy assessment shows slower performance of the unsupervised classification when compared to the supervised fuzzy classification. This is because that the unsupervised classification procedure does not need any labelled data set as a training data whereas the supervised classification procedure shows a better performance as it have a labelled data set as training data set priory. The Fuzzy set theory can be used as a powerful tool in designing efficient models to process multispectral images.

References

[1] Gustavo Camps-Valls, tatyana V.Bandos, and Dengyong Zhou – semi-supervised Graph-based Hyperspectral Image Classification,IEEE Transactions on Geoscience and Remote sensing,Vol XX,No.y, Month z 2007

[2] Foody,G.M. – Classification and Fuzzy sets, Geoinformatics-Vol.II

[3] B.Sowmya and B.SheelaRani-Land cover classification using reformed fuzzy c-means,sadhana Vol.36,oart 2,April 2011,pp.153-165

[4] Gabriela Droj-The applicability of fuzzy theory in Remote Sensing Image classification, Studia Univ.Babes-Bolyai,Informatica,Volume LII,Number 1,2007

[5] I.Nedeljkovic-Image classification based on fuzzy Logic,commission VI,WG VI/1-3

[6] Benz, U.; Hofmann, P.; Willhauck, G.; Lingenfelder, I.; Heynen, M. - Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information, Journal of Photogrammetry & Remote Sensing, 2004)

[7] James C.Bezdek,Robert Ehrlich,,William Full-FCM:The Fuzzy c-means clustering algorithm,Computers & Geosciences Vol.10,No.2-3,pp,191-203,1984.

[8] Russell G.Congalton-A Review of Assessing the Accuracy of Classification of Remotely Sensed Data,Remote Sens,Environ.37:35-46(1991)

[9] S.H. Chavoshi, A. Amiri, J. Amini- Supervised classification in high resolution images (Quikbird) using Neural network, Fuzzy sets and Minimum distance

[10] Orlando J.Tobias-Image segmentation by Histogram thresholding using Fuzzy Sets,IEEE Transactions on Image Processing,Vol.11,No.12,December 2002.

[11] Zhenghao shi,Yuyan Chao,Lifeng He,Tsuyoshi Nakamura, and Hidenori Itoh-Rough set Based FCM Algorithm for Image Segmentation,International Jounal of Computational Science 1992-6669(print,Vol.1.No.1,58-68,2007.

[12] Satish Kumar,G.saravana,R.Rout,Ankur pandit,Snehmani-Fuzzy based sub-pixel classification of satellite Imagery,IJCST Vol.3.Issue 1,Jan-Mar 2012.

[13] Somying Promcharoen and Yuttapong Rangsanseri, Suwit Ongsomwang and Jirawan Jaruppat- Supervised Classification of Multispectral Satellite Images using Fuzzy LogicandNeural Network.

[14] Gary M.Senseman-Accuracy Assessment of the Descrete Classification of Remotely-Sensed Digital Data by Landcover Mapping,USACERL Technical Report,April 1995.

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