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Satellite Image Classification Using Fuzzy Logic

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Abstract— The intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes, or "themes". In this paper, fuzzy inference system is developed for classifying the satellite image of (472x546x7 pixel).The input image from the satellite was in form of 7 bands which were then reduced to 3 bands.

Index Terms— classification, fuzzy logic,if-then rules, land cover, remote sensing.

I. INTRODUCTION

Vision is the most advanced of our senses so images play an important role in human perception. Pictures or images received by human are in pictorial form. In the present context, the analysis of pictures that employ an overhead perspective, including the radiation not visible to human eye are considered. Thus our discussion will be focusing on analysis of remotely sensed images[5] These images are represented in digital form. An image may be defined as a two dimensional function, *f* (x, y), where x and y are spatial co-ordinates, and the amplitude of *f*at any pair of co-ordinates (x, y) is called intensity or gray level of monochrome images at that point. Such an image is continuous image. Converting such an image to digital form requires that the coordinates, as well as the amplitude, be digitized.Digital image is composed of finite number of elements, each of which has a particular location and values. These elements are referred to as picture elements, image elements, pel and pixels. Pixel is the term used most widely to denote the elements of a digital image. Image classification[7][10] is formally defined as the process whereby a received pattern/signal is assigned to one of a prescribed number of classes. The overall objective of image classification procedures is to automatically categorize all pixels in an image into land cover classes or themes. Normally multi-spectral data are used to perform the classification and indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorize spectral pattern refers to the set of radiance measurements obtained in the various wavelength bands for each pixel.

In this we will classify the image using technique called *fuzzy theory*. Fuzzy theory evolves the concept of membership function and membership grade to the objects which are vague in nature. A neural network should be trained before it can be put to use.

Training involves feeding the neural network with training samples and allowing it to learn by adjusting weights of synapses and various other parameters. Neural networks can be broadly classified into two categories based on the type of learning.

II. CLASSIFICATION OF NEURAL NETWORKS BASED ON TYPES OF LEARNING

A. *Supervised*

The supervised classification methods are based on user-defined classes and corresponding representative sample sets. The sample sets are specified by training raster data sets, which must be created, prior to entering the process. In supervised classification, spectral signatures are developed from specified locations in the image. These specified locations are given the generic name *training sites* and are defined by the user. The training data consists of pairs of input objects and desired output. Supervised classification requires the analyst to select training areas where he/she knows what is on the ground and then digitize a polygon within that area. The computer then creates mean spectral signature. Thus, in a supervised classification we are first identifying the information classes which are then used to determine the spectral classes which represent them. Similarly all the pixels are analyzed by the analyst and corresponding spectral signature are created. The Result is Information--in this case a Land Cover map. Common Supervised classifiers:

a. Parallelepiped
b. Minimum distance to mean Maximum likelihood.

B. *Unsupervised*

Rather than defining training sets and carving out pieces of n-dimensional space, we define no classes beforehand and instead use statistical approaches to divide the n-dimensional space into clusters with the best separation using clustering algorithms. After that, we assign class names to those clusters. It is distinguished from supervised learning by the fact that there is no a priori output. The analyst requests the computer to examine the image and extract a number of spectrally distinct clusters. The result of unsupervised classification is not yet informative until the analyst determines the ground cover for each of the clusters.

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Common Unsupervised classification Methods are -

a. Simple One-Pass Clustering
b. K Means
c. Fuzzy
d. Minimum Distribution Angle
e. Adaptive Resonance

In the following sections fuzzy logic and fuzzy inference system are discussed. Thus, using this in classification of the mixed pixels of the image to specific degree in fuzzy logic manner.

III. FUZZY LOGIC

Over the past few decades, fuzzy logic[2][3] has been used in a wide range of problem domains. Although the fuzzy logic is relatively young theory, the areas of applications are very wide: process control, management and decision making, operations research, economies and, for this paper the most important, pattern recognition and classification. The natural description of problems, in linguistic terms, rather than in terms of relationships between precise numerical values is the major advantage of this theory.

A. Fuzzy Sets

Fuzzy logic starts with the concept of a fuzzy set. A fuzzy set is a set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership. Reasoning in fuzzy logic is just a matter of generalizing the familiar yes-no (Boolean) logic. If you give true the numerical value of 1 and false the numerical value of 0, this value indicates that fuzzy logic also permits in-between values like 0.2 and 0.7453.

B. MATLAB's Fuzzy Logic Tool Box

In the lack of precise mathematical model which will describe behaviour of the system, Fuzzy Logic Tool box is a good "weapon" to solve the problem: it allows using logic if-then rules to describe the system's behaviour. This Toolbox is a compilation of functions built on the MATLAB numeric computing environment and provides tools for creating and editing fuzzy inference systems within the framework of MATLAB. The toolbox provides three categories of tools:

- Ä command line functions.
- Ä graphical interactive tools.
- Simulink blocks and examples.

Fuzzy Logic Toolbox allows building the two types of system:

a) Fuzzy Inference System (FIS) and
b) *Adaptive Neuro -Fuzzy Inference System (ANFIS).*

IV. FUZZY INTERFERENCE SYSTEM

Fuzzy inference [8] is the process of formulating the mapping from a given input to an output using fuzzy logic. The process of fuzzy inference involves: membership functions, fuzzy logic operators and if-then rules. There are two types of fuzzy inference systems that can be implemented in the Fuzzy Logic Toolbox:

a) *Sugeno-type*.
b) *Mamdani-type*.

Mamdani's fuzzy inference method is the most commonly seen fuzzy methodology and it expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification. Sugeno-type systems can be used to model any inference system in which the output membership functions are either linear or constant.

A. If-Then Else

Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logics.

If x is A Then y is B where x and y are fuzzy variables and A and B are fuzzy values. The if-part of the rule "x is A" is called the antecedent or premise, while the then-part of the rule "y is B" is called the *consequent* or *conclusion*. Statements in the antecedent (or consequent) parts of the rules may well involve fuzzy logical connectives such as '*AND*' and '*OR*'. In the if-then rule, the word "is" gets used in two entirely different ways depending on whether it appears in the antecedent or the consequent part.

V. IMAGE DESCRIPTION AND ALGORITHM FOLLOWED

The input image from the satellite was in form of 7 bands which were then reduced to following 3 bands :

- Red
- Green
- Near infrared Region

Using Fuzzy toolbox image is classified into 5 sets called membership functions. These membership functions are as given below:

- Vegetation
- Rocky
- Urban
- Water bodies
- Open land

The aim of this method is to classify the mixed pixel to specific category with the help of the fuzzy logic. On MATLAB workspace, following instructions is given:

❖ **STEP-1**

To read and display image.

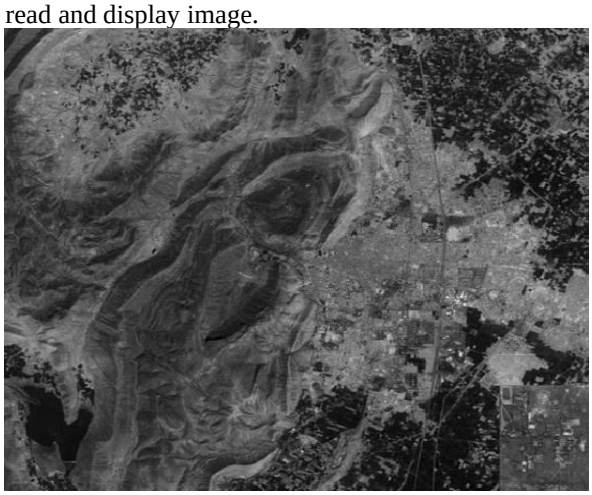

FIG. 1 Shows a satellite image of any heavenly body.

❖ **STEP-2**

Extracting image[1][4] in red, green and nir band respectively and then concatenating the image of 3 bands into 1band

Red Band Image

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FIG. 2 Represents seperation of red band pixels in the image.

Green Band Image

FIG. 3 Represents seperation of green band pixels in the image.

NIR Band Image

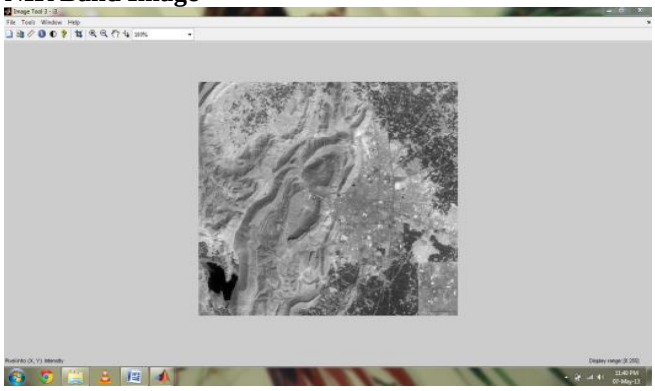

FIG. 4 Represents seperation of NIR band pixels in the image.

Concatenated Image

FIG. 5

❖ **STEP-3**

From the training set, minimum and maximum values of all the three bands are taken and applied to FIS EDITOR[8]

MEMBERSHIP FUNCTION EDITOR :

Here by default there are three membership function mf1, mf2, and mf3 so there have to make ADD MFs and enter the number of member ship function to be added. Now name these membership functions in the column *Name*; add minimum, average and maximum values of each membership function from training sets to column *Paramus* (both on the right side window), change range and display range from [0 1] to [0 255] on left side window. The range here is from 0-255 because we have the DN numbers of 8-bit image.

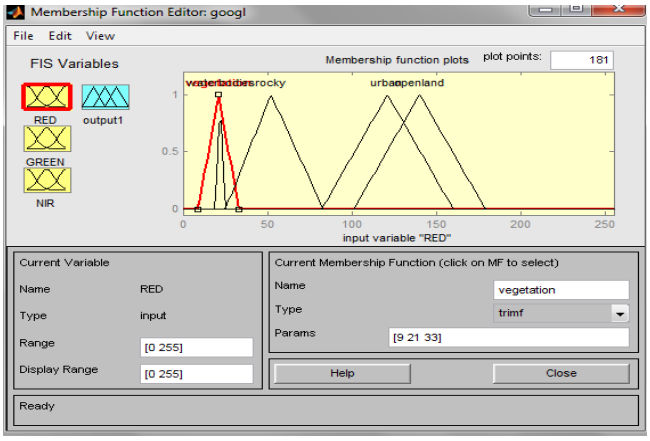

FIG. 6 Membership Function of Red Band Image

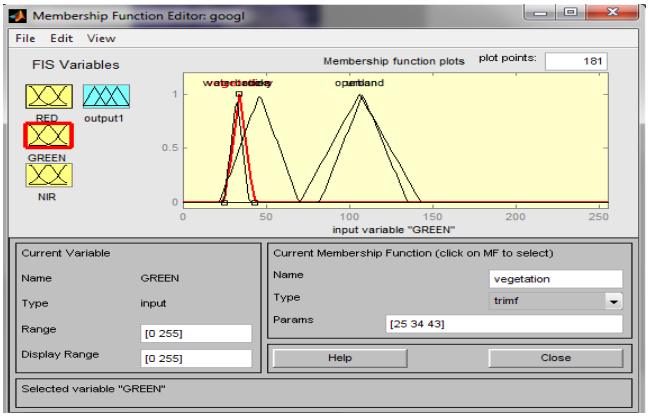

FIG. 7 Membership Function of Green Band Image

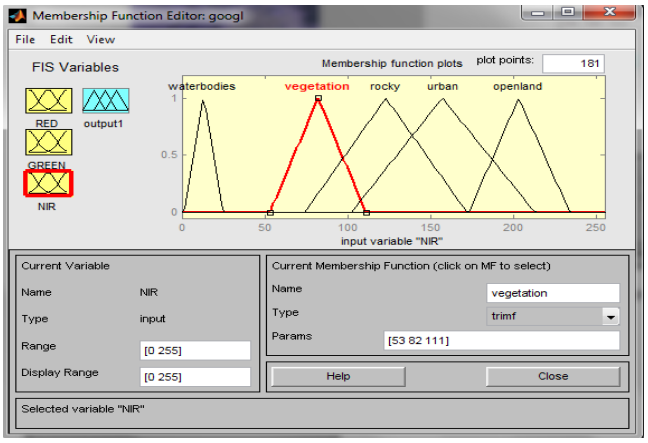

FIG. 8 Membership Function of NIR Band Image

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RULE EDITOR[9]: Now it`s the time to define the rules in rule editor. Based on the descriptions of the input (red, green and nir)& output variables the rules are constructed in the rule editor. As we define the rule that: *IF (red is mf1)* and (*green is mf1)* and *(nir mf1)* then class is mf1. The rules here are entered in the verbose format. The inputs are connected with and function. Basic if-then rules are used.
At this point , fuzzy inference systems has been completely defined in that variables, membership functions are the rules necessary to calculate classes are in place.

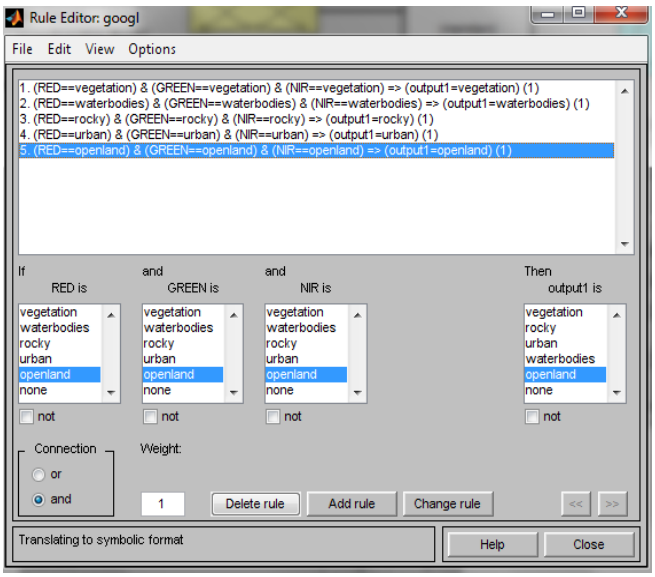

FIG. 9 Depiction of rules as implemented in MATLAB.

The final and classified image [4] is obtained which is given below

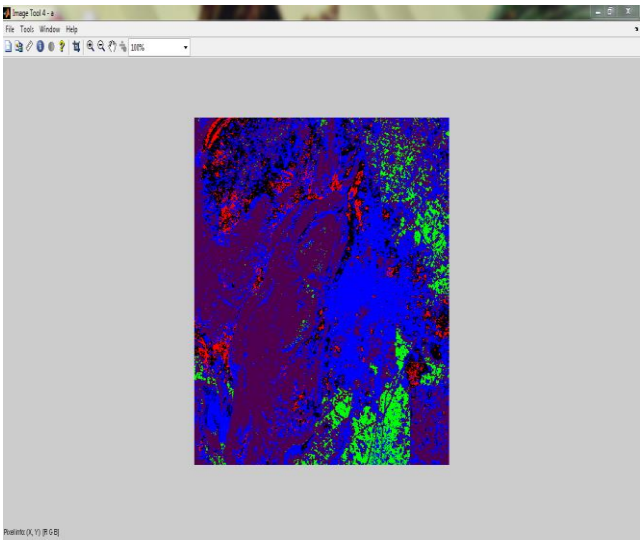

FIG. 10 Final Ouput as obtained is shown in this diagram

- Vegetation-[0 ,255,0] represented by color green
- Rocky –[80 0 80] represented by color purple
- Urban-[0 0 255] represented by color blue
- Waterbodies-[0 0 0] represented by black color.
- Openland-[255 0 0] represented by red color.

VI. CONCLUSION

The satellite image was classified easily using the concept of fuzzy logic. The mixed pixel is classified to a specific category with the help of the fuzzy logic.

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