Analysis of Remote Sensed Data using Hybrid Intelligence System: a Case Study of Bhopal Region

Hari Kr. Singh
Deptt. Of ECE
I.E.T,M.J.P.R.U
Bareilly,(U.P) INDIA

Prashant Kr. Maurya
Deptt. Of ECE
I.E.T,M.J.P.R.U
Bareilly,(U.P) INDIA

Khushboo Singh
Deptt. Of ECE
I.E.T,M.J.P.R.U
Bareilly,(U.P) INDIA

Pooja Singh
Deptt. Of ECE
RBMI,
Bareilly, (U.P) INDIA

ABSTRACT
In this paper we are presenting the Estimation of Agricultural land in India using Neuro –Fuzzy approach in Digital image processing. Digital image processing processing refers to the manipulation of an image by means of a processor. The advantage of combining neural networks with fuzzy logic is that, it is better in noisy environment and it has fault tolerance capability better than individual approach, so we are working for a better result using this approach in image processing. Every intelligent technique has particular computational properties (e.g. ability to learn, explanation of decisions) that make them suited for particular problems and not for others. For example, while neural networks are good at recognizing patterns, they are not good at explaining how they reach their decisions. Fuzzy logic systems, which can reason with imprecise information, are good at explaining their decisions but they cannot automatically acquire the rules they use to make those decisions. Hybrid systems are also important when considering the varied nature of application domains. Many complex domains have many different component problems, each of which may require different types of processing. Fuzzy logic provides an inference mechanism under cognitive uncertainty, computational neural networks offer exciting advantages, such as learning, adaptation, fault-tolerance, parallelism and generalization.

Keywords

Fuzzy logic, Remote sensing, Artificial Neural Network, Hybrid systems, Multi spectral image, Fault tolerance system, Neuro-fuzzy system

1.INTRODUCTION
In the present scenario of the world, the information technology plays a major role in the world economics; if we get the information about the resources of a region well in time then we can plan and manage the resources of that region in a better way, for the economically and environmentally sustainable development land cover.

Satellites play a major role to provide the timely and cost effective information about the resources of any area. With the increased availability and improved quality of multi-spatial and multi-temporal remote sensing data as well as new analytical techniques, it is now possible to monitor land cover/ land-use changes and urban sprawl in a timely and cost-effective way.

The techniques we have used here are well known for the classification of the multi spectral images worldwide, they are: Fuzzy C-Mean clustering and ANN. Then we have used the technique of NEURO-FUZZY. As it is the combination of ANN and FCM, it gives better results than that of ANN and FCM taken individually. It is found that these techniques are fast and efficient algorithms for image analysis.

Satellite Data Image that we have received from the National Remote Sensing Agency (Space Department, Government of India); Integrating Spectral, Temporal and Spatial Features of the Objects in the area of satellite image processing. Here the multi-spectral remote sensing data is used to find the spectral signature of different objects of city which we have already mentioned for the land cover classification, how the use of land changes according to time and also performed the temporal analysis to analyse the impact of climate over the surface.

During the study following objectives were achieved:

- General analysis of the different bands data of the multi spectral images.
- Determination of fuzzy mean and fuzzy covariance of FCM for classified objects from the ground survey data.
- Creation of the False Color Composite image for the classified objects such as (vegetation, structures,roads, free land and water) using intelligence methods and FCM.
- Calculation of transformed image using ANN**.**
- Calculation of comparative chart for different algorithms of ANN & NEURO FUZZY.

2. REMOTE SENSING
Remote sensing is a technology used for obtaining information about a target through the analysis of data acquired from the target at a distance. It is composed of three parts, the targets - objects or phenomena in an area; the data acquisition through certain instruments; and the data analysis - again by some devices. This definition is so broad that the vision system of human eyes, sonar sounding of the sea floor, ultrasound and x-rays used in medical sciences, laser probing of atmospheric particles, and are all included. The target can be as big as the earth, the moon and other planets, or as small as biological cells that can only be seen through microscopes.
Remote Sensing consists of the following elements: electro-magnetic energy, target (s), spectral response, sensors, platforms, and data/image. It involves the following:
(a) Data Acquisition
(b) Data Processing/Analysis
(c) Data Fusion
(d) Data Interpretation
(e) Data Utilization
A diagrammatic illustration of the remote sensing process is as given below.

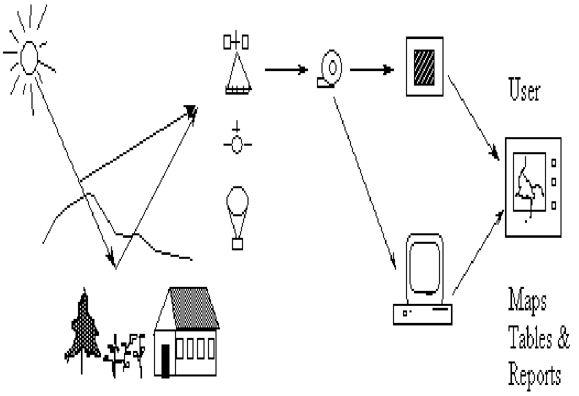


Figure1 Flows of Energy and Information in Remote Sensing

Remote sensing data acquisition can be conducted on such platforms as aircraft, satellites, balloons, rockets, space shuttles, etc. Inside or on-board these platforms, we use sensors to collect data. Sensors include aerial photographic cameras and non-photographic instruments, such as radiometers, electro-optical scanners, radar systems, etc. Electro-magnetic energy is reflected, transmitted or emitted by the target and recorded by the sensor. Because energy travels through the medium of the earth's atmosphere, it is modified such that the signal between the target and the sensor will differ, **(CHAVEZ, P. S., Jr. 1988)**
Once image data are acquired, we need methods for interpreting and analyzing images. By knowing "what" information we expect to derive from remote sensing, we will examine methods that can be used to obtain the desirable information.

3. INDIAN REMOTE SENSING (IRS) PROGRAM

Remote sensing is an important part of the Indian Space Program and the Department of Space (DOS), Government of India, is the nodal agency for the realization of the National Natural Resources Management System (NNRMS), the National Resources Information System (NRIS) and the Integrated Mission for Sustainable Development (IMSD), besides several other national level application projects like Crop Acreage and Production Estimation (CAPE), National Drinking Water Mission and Wasteland Mapping etc., In close collaboration with the user agencies. As a part of this program, DOS has acquired the capability to design, develop and operate state-of-art multi-sensor satellite based systems comprising of space, ground and application segments to meet domestic and international requirements. The department also successfully operationalized the launch vehicle program for the remote sensing satellites.

3.1INDIAN REMOTE SENSING SATELLITES

The following satellite missions are the important milestones, which have been crossed, in the realization of indigenous end-to-end remote sensing capabilities. Bhaskara 1 and 2.These were experimental remote sensing satellites launched in June 1979 and November 1981 respectively. Their payload consisted of TV cameras and radiometers. These satellites provided hands-on experience in achieving the goal of the Indian Space Program.

IRS-1A and 1B: These two satellites, launched in March 1988 and August 1991 respectively, were the first generation, operational remote sensing satellites. The two identical satellites carried Linear Imaging and Self Scanning sensors (LISS-1 and LISS-II (2)) for providing data in four spectral bands with a resolution of 72.5m and 36.25m respectively with a repetivity of 22 days. These two satellites, during a period of more than a decade of operations, provided vital data for several national level projects. IRS-P2:This satellite was launched in October 1994 using the indigenously developed Polar Satellite Launch Vehicle (PSLV-D2). IRS-P2 carried a modified LISS camera.

IRS-1C and IRS-1D: These two satellites, launched in December 1995 and September 1997 respectively, are the second generation, operational remote sensing satellite missions with improved sensor and coverage characteristics.

The three sensors on-board the satellites are:

***** A PAN sensor with a spatial resolution of 5.8m (at nadir) in a single band in the visible region, with a swath of 70 Km (at nadir) and across track steerability of +/- 26 degrees.

***** A LISS-III multi-spectral sensor with a spatial Resolution of 23.5m, operating in the visible, near Infra-red bands and 70.5m resolution in the shortwave Infra-red band, with a swath of 141Km.

***** A Wide Field Sensor (WiFS) sensor with a spatial resolution of 188m, two spectral bands in the visible and near infra-red regions, with a swath of 810 Km. These two satellites are providing data that can be used for resource mapping up to 1:25,000 scales. Several applications have exploited the improved Capabilities of these two missions.

IRS-P3: This satellite was launched in April 1996 by the PSLV-D3. The payload consists of two imaging sensors and one non-imaging sensor.

OCEANSAT-1 (IRS-P4): This satellite, the eighth one in the IRS program, was launched in May 1999. The payload consists of an Ocean Color Monitor (OCM) operating in eight spectral in the visible and infra-red region and a Multi-frequency Scanning Microwave Radiometer (MSMR), operating in four frequencies namely 6.60, 10.61, 18 and 21 GHz. These sensors are providing data for measuring the physical and biological parameters of oceans.

CARTOSAT-1 (IRS-P5): This satellite has Two PAN sensors with 2.5m resolution and fore-aft stereo capability. The payload is designed to cater to applications in cartography, terrain modeling, cadastral mapping etc.

OCEANSAT-2: This satellite mission is conceived to provide continuity of services to the Oceansat-1 data users. This satellite has enhanced capabilities. It carries an Ocean Color Monitor (OCM) and Wind Scatterometer. Monitoring, paddy crop acreage and yield estimation, Flood inundation mapping, ship routing and snow mapping.

RESOURCESET-1 (IRS P6) AND ITS SENSORS

The main objectives of IRS-P6 mission are: To provide continued remote sensing data services on an operational basis for integrated land and water resources management at micro level with enhanced multi-spectral and spatial coverage with stereo imaging capability. To further carry out studies in advanced areas of user applications like improved crop discrimination, crop yield, crop stress, pest/disease surveillance, disaster management and urban management.

Specification:IRS-P6 is a three axes body-stabilized spacecraft launched by PSLV-C5 into a Sun Synchronous Orbit at an altitude 817 Km. descending node and Repetevity341 orbits / cycle (24 days).The spacecraft is designed for a nominal mission life of five years. IRS-P6 carries three optical cameras as payload.

3.2Sensors of RESOURCESET-1 (IRS p6)

Linear Imaging Self Scanning Sensor (LISS-IV) Camera: LISS-IV is a high-resolution multi-spectral camera operating in three spectral bands 0.52 to 0.59 m (Green (band 2)), 0.62 to 0.68 m (Red (Band 3)) and 0.76 to 0.86 m (NIR (Band 4)). LISSIV provides a ground resolution of 5.8 m (at Nadir) and can be operated in either of the two modes. In the multi-spectral mode (Mx), a swath of 23.9 Km (selectable out of 70 Km total swath) is covered in three bands, while in mono mode (Mono), the full Swath of 70 Km can be covered in any one single band, which is selectable by ground command (nominal is B3 – Red band). The LISS-IV camera can be tilted up to ± 26° in the across track direction thereby providing a revisit period of 5 days.

3.2.1LINEAR IMAGING SELF SCANNING SENSOR (LISS-III) CAMERA: The LISS-III camera is identical to the LISS-III flown in IRS-1C/1D spacecraft except that the spatial resolution of SWIR band (B5) is also 23.5 m (same as that of B2, B3, and B4). LISS-III covers a swath of 141 Km in all the 4 bands.

3.2.2Advanced Wide Field Sensor (AWiFS): AWiFS camera is an improved version compared to the WiFS camera flown in IRS-1C/1D. AWiFS operates in four spectral bands identical to LISS-III, providing a spatial resolution of 56 m and covering a swath of 740 Km. To cover this wide swath, the AWiFS camera is split into two separate electro optic modules, AWiFS-A and AWiFS-B. The IRS-P6 spacecraft mainframe is configured with several new features and enhanced capabilities to support the Payload operations.

4. ARTIFICIAL NEURAL NETWORK

Artificial Neural Networks commonly referred to as 'Neural Networks' is a new branch of AI, that enabled a crude simulation of the structure of human brain electronically or in software. The inherent properties of human brain enable it to analyze complex patterns consisting of a number of elements, those individually reveal little of the total pattern, yet collectively represent easily recognizable objects. The concepts of Neural Networks have been motivated right from its inception, by the recognition that the human brain computes in an entirely different way from the conventional digital computers. The brain modeling techniques opens a new era of Computer System that learns, from experience and uses its experiential knowledge next time. This biologically inspired method is being touted as the wave of the future in computing, relieving the programmer from the cubicle of traditional algorithmic problem solving. Inherent non-linearity property of Neural Networks makes it particularly suitable in many signal-processing applications like sound, image processing etc. **(Haykin, S. 1994)**

ANN is a mathematical model or computational model that tries to simulate the structure and/or functional aspects of biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In more practical terms neural networks are non-linear statistical data modelling tools.

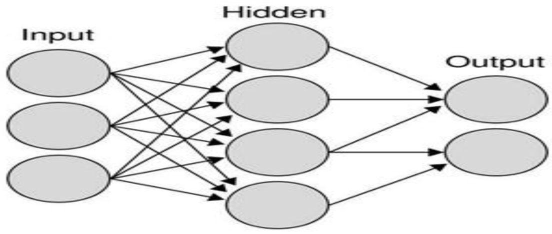


Figure 2 Neural Network Model

5. FUZZY LOGIC

The concept of Fuzzy Logic (FL) was conceived by LotfiZadeh, a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. This approach to set theory was not applied to control systems until the 70's due to insufficient small-computer capability prior to that time. Professor Zadeh reasoned that people do not require precise, numerical information input, and yet they are capable of highly adaptive control. If feedback controllers could be programmed to accept noisy, imprecise input, they would be much more effective and perhaps easier to implement. FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster. **(Kasabov, N.K. 1996)**

6. NEURO-FUZZY LOGIC

In the field of artificial intelligence, neuro-fuzzy refers to combinations of artificial neural networks and fuzzy logic. Neuro-fuzzy hybridization results in a hybrid intelligent system that synergizes these two techniques by combining the human-like reasoning style of fuzzy systems with the learning and connectionist structure of neural networks. Neuro-fuzzy hybridization is widely termed as Fuzzy Neural Network (FNN) or Neuro-Fuzzy System (NFS) in the literature. Neuro-fuzzy system (the more popular term is used henceforth) incorporates the human-like reasoning style of fuzzy systems through the use of fuzzy sets and a linguistic model consisting of a set of IF-THEN fuzzy rules. The main strength of neuro-fuzzy systems is that they are universal approximators with the ability to solicit interpretable IF-THEN rules. The strength of neuro-fuzzy systems involves two contradictory requirements in fuzzy modeling: interpretability versus accuracy. In practice, one of the two properties prevails. Although generally assumed to be the realization of a fuzzy system through connectionist networks, this term is also used to describe some other configurations including fuzzy logic based tuning of neural network training networks**. (Yang, C.-C., S.O. Prasher, R. Lacroix, S. Sreekanth, A. Madani and L. Masse. 1997a)**

NEURO FUZZY SYSTEMS

Neural networks can learn from data, but cannot be interpreted - they are black boxes to the user. Fuzzy Systems consist of interpretable linguistic rules, but they cannot learn from data. The learning algorithms can learn both fuzzy sets, and fuzzy rules, and can also use prior knowledge.we usually use the term neuro-fuzzy system for approaches which display the following properties:

- A neuro-fuzzy system is based on a fuzzy system which is trained by a learning algorithm derived from neural network theory.
- A neuro-fuzzy system can be viewed as a 3-layer feedforward neural network. The first layer represents input variables, the middle (hidden) layer represents fuzzy rules and the third layer represents output variables. Fuzzy sets are encoded as (fuzzy) connection weights. It is not necessary to represent a fuzzy system like this to apply a learning algorithm to it.
- A neuro-fuzzy system can be always interpreted as a system of fuzzy rules. It is also possible to create the system out of training data from scratch, as it is possible to initialize it by prior knowledge in form of fuzzy rules.
- The learning procedure of a neuro-fuzzy system takes the semantical properties of the underlying fuzzy system into account. This results in constraints on the possible modifications applicable to the system parameters.
- A neuro-fuzzy system approximates an N-dimensional (unknown) function that is partially defined by the training data. The fuzzy rules encoded within the system represent vague samples, and can be viewed as prototypes of the training data.
- The Neuro-Fuzzy system is able to deal with multiple parameter input and multiple class output problems.:

7.ANALYSIS OF THE MULTI SPECTRAL IMAGE USING ANN

Step 1Assembling the Training Data: We have received the image of the Bhopal region and by using the Data Cursor tool in the MATLAB we have obtained the R-G-B components of the pixels which best represent the different features of the image like the River & Water Bodies, the Concrete Structures, the Roads and the Vegetation and created the table:

Features	R	G	B
River & Water Bodies	120	059	056
	128	049	052
	131	051	060
	136	081	076
	142	052	058
Concrete Structures	151	104	096
	172	093	088
	181	059	074
	186	074	088
	197	098	104
Roads	154	049	064
	163	052	068
	169	096	087
	172	074	089
	178	062	073
Vegetations	224	086	101
	229	119	130
	230	096	105
	234	082	095
	240	104	114

Figure2 : Showing assembling the training data

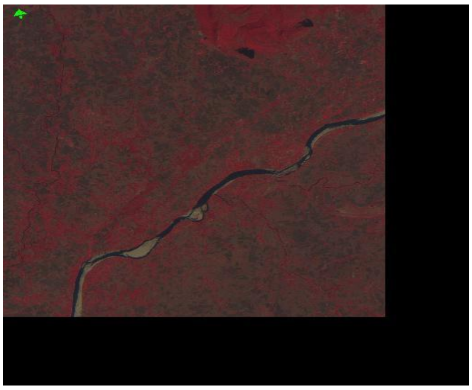


Figure 3 Original image of Bhopal(IRSA)

Thus we obtained R-G-B values of almost 100 pixels and these values may be moulded to form a 3X100 matrix as in figure.

R:	120 128 131 136 142 151 172 181 186 197 154 163 169 172....
G:	059 049 051 081 052 104 093 059 074 098 049 052 096 074....
B:	056 052 060 076 058 096 088 074 088 104 064 068 087 089....

Figure4 the Matrix of Input Pixels

Step 2 Create the Network Object: Now we define the network and specify its features like no. of neurons, rangee of the values of the input neurons, no. of layers etc. and specify the input and target matrices. In target matrix, there is a particular colour for the particular feature to generate the FCC

R: 0.0 0.0 0.0 0.0 0.6 0.6 0.6 0.6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0….
G: 0.7 0.7 0.7 0.7 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0….
B: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.8 0.8 0.8 0.8 0.0 0.0 0.0 0.0….

Figure5 the Matrix of Target FCC

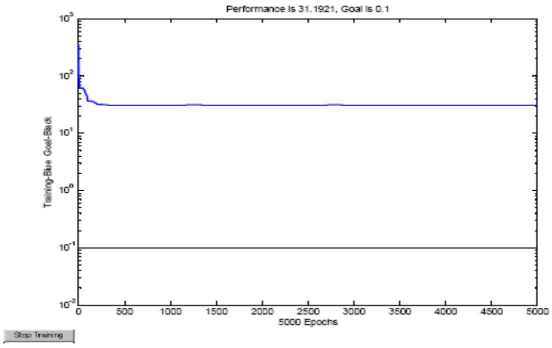


Figure6 training of network

Now starts the training of the network and the weights are assigned automatically. Since, the input and output are already defined; the weights for each input-output pair can be developed. Thus, the step 2 makes it to meet the requirement of the mapping relationship between the input and the target.

Step 3Simulate the Network Response for Whole the Image: Now, the function representing the relation between the input and the target, we are ready to generate a resulting matrix corresponding to the final FCC of the given image.

But, before we simulate the image with the help of given network of neurons, we are to convert the 3-dimensional matrix of dimensions '512 X 512 X 3' corresponding to the multi spectral image into a 3-dimensional matrix of dimensions '3 X 512X512' i.e. '3 X 262144' .

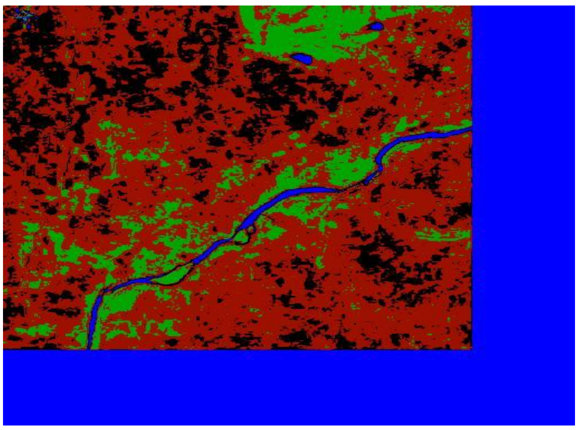


Figure7 FCC Image of the Multi Spectral image

ANALYSIS OF THE MULTI SPECTRAL IMAGE USING FCM

Step 1: In the very first step we receive the multispectral image and convert it into the double image to apply the FCM algorithm on the image.

Step 2: After we have got the double image, we apply the nir, red and green band images algorithm of the FCM on the multi spectral image and analyze the averaged component of this multi spectral image.

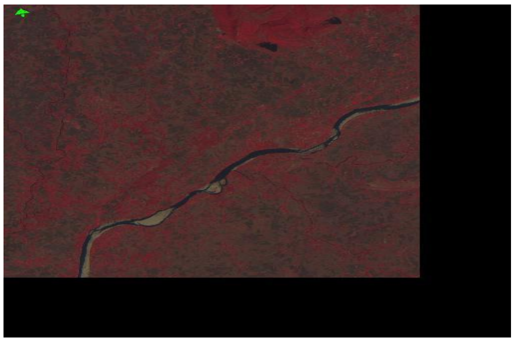
Step 3: Now as we have obtained the arrange data in a matrix component of the multi spectral image, using "reshape" function.

Step 4: After getting the images of the different bands and reshape the image now our aim is to find out the cluster values of FCM of the given image

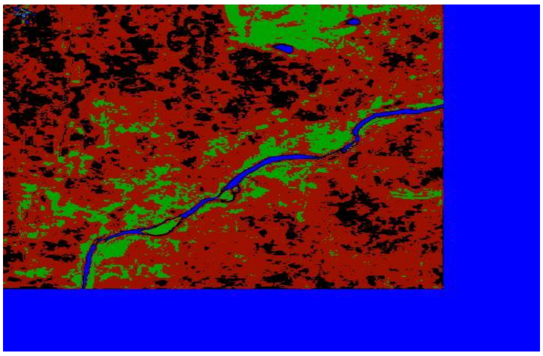
[CTR,CLASS]=FCM(DATA,4);

By using the MATLAB we got the cluster values of each pixel and finally we got the image. The values of cluster of FCM are in the range of 0 to +1. Now we calculate the reshape of class data using reshape function.

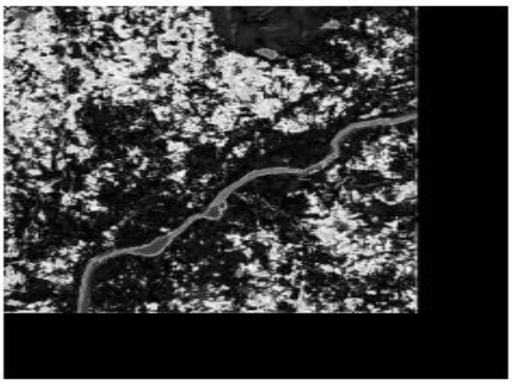
Figure 8: Images of Bhopal using different algorithms



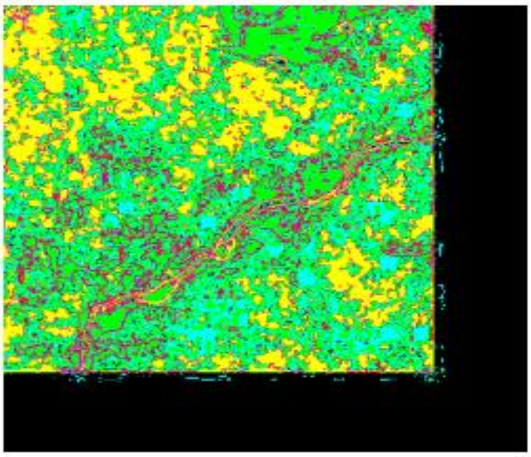
Original Image



Ann Fcc Image



Fcm Image



Neuro Fuzzy Fcc

Step 5: Next aim after getting the FCM image was to get the classified images of the region, in order to get the these images we performed the ground survey at various places of the city and taken the proper longitude and latitude values of the survey region from Google earth, and with the help of that we identified the survey locations into the multi spectral images. By the help of the ground survey I found the specific range of the FCM for each object.

- For the vegetation, I found the FCM vales are in between 0 & 1, the concentration of the vegetation is in the range of the 0.01 to 0.1:
  (fcm(m,n)<0.1) & (fcm(m,n)>=0.01)

- For the dense structures, I found the FCM vales are in the range of between 0.1 to 0.2:
  (fcm(m,n)<=0.2) & (fcm(m,n)>=0.1)

- For the roads, I found the FCM vales are in the range of between 1 & 0:
  (fcm(m,n)<1.0) &fcm(m,n)>=0.5)|((nir(m,n)<0.79) & (nir(m,n)>0.7))

- For the water, I found the FCM vales are in the range of between 1 & 0:
  (fcm(m,n)<0.225) & (fcm(m,n)>0.2)

- For the weak structure, I found the FCM vales are in the range of between 1 & 0:
  (fcm(m,n)<0.5) & (fcm(m,n)>=0.225)

- For the land, I found the FCM vales are in the range of between 1 & 0:
  (fcm(m,n)<0.01)

Table2 Comparison chart

AREA COVERED	**FCM**	**% RESULT**	**NEURO FUZZY**	**% RESULT**
TOTAL AREA	388.0800	100	388.0800	100
VEGETATION	261.4612	67.3730	317.9528	81.9297
RIVER&WATER BODIES	70.6794	18.2126	115.1018	29.6593
ROADS	113.3572	29.2098	83.4438	21.5017
DENSE STRUCTURES	226.9586	58.4824	138.5560	35.7029
WEAK STRUCTURES	52.2830	13.4722	25.3726	6.5380
FREE LAND	6.9982	1.8033	84.2996	21.7222

8. CONCLUSION

If we examine the results obtained from the three algorithms applied on the multispectral image, it is found that there are different pixels obtained by different algorithms. The ANN method has all the very good results for all the six features presented here in the multispectral image and almost all the pixels are trained in this case. The FCM algorithm has better result in most of the cases than ANN. We have worked here on NEURO FUZZY method and can conclude here that it is not giving as better result as expected because it is possible that we have not trained the pixels upto that much level as needed by NEURO FUZZY to give the best results. If we train the pixels in a very efficient way then it must be possible to get the more accurate results as expected. All these classification errors can be reduced by using the more higher resolution devices and hyper spectral images from the satellites, such satellites may be launched by the Indian government in coming years.

9.REFERENCES

[1] CHAVEZ, P. S., Jr. 1988, An Improved Dark Object Subtraction Technique for Atmospheric Scattering Corrections of Multi Spectral data. Remote Sensing of Environment, 24, 459 – 479.

[2] DEFRIES, R., HANSEN, M. and TOWNSHEND, J., 1995, Global discrimination of land cover types from metrics derived from the AVHRR Pathfinder data. Remote Sensing of Environment, 54, 209-222.

[3] Haykin, S. 1994. Neural Networks: A Comprehensive Foundation. New York, NY: Macmillan College Publishing Company, Inc.

[4] Kasabov, N.K. 1996. Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering Cambridge, MA: The MIT Press.

[5] Yang, C.-C., S.O. Prasher, R. Lacroix, S. Sreekanth, A. Madani and L. Masse. 1997a. Artificial neural network model for subsurface-drained farmlands. Journal of Irrigation and Drainage Engineering 123: 285-292.

[6] MathWorks. 1997a. MATLAB Image Processing Toolbox User's Guide. The MathWorks, Inc.

[7] MathWorks. 1997b. MATLAB Neural Network Toolbox User's Guide. Natick, MA: The MathWorks, Inc.

[8] MathWorks. 1997c. Using MATLAB. Natick, MA: The MathWorks, Inc.