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Reproduction of Remote Sensing Image Using Supervised Mode of Learning Using Artificial Neural Network

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ABSTRACT

Remote sensing is the science of gathering information from a location that is distant from the source. Image analysis is the technique of extracting and interpreting meaningful information from a remotely sensed image. The information from an image may be extracted with the help of computer software or be visually considered. Images like such can be acquired in the form of aerial photograph, a multispectral satellite image, Light Detection and Ranging data, a radar data or a thermal image. Remote sensing is a dynamic technical field of endeavor. This paper is based on the technique involved in mapping of Geographic Information System projects.

Indexing terms/Keywords

Light Detection and Ranging (LIDAR); Geographic Information System (GIS); Artificial Neural Network (ANN); Mean Square Error (MSE); Matrix Laboratory (MATLAB); Support Vector Machines (SVM).

Academic Discipline And Sub-Disciplines

Computer Science and Engineering.

SUBJECT CLASSIFICATION

Artficial Neural Networks, Remote Sensing and MATLAB.

TYPE (METHOD/APPROACH)

A novel algorithm has been applied to the digital data using supervised method of learning with the back propagation feed forward neural network. This implementation was done with the help of Matrix laboratory and its tools.

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1. INTRODUCTION

1.1. Sun Synchronous Orbit

A Sun-synchronous satellite is any satellite which is placed in a Sun-synchronous orbit. This orbit is one that places a satellite over a given location at the same mean solar time on successive orbits. This is accomplished by tuning the orbital altitude and inclination. The object is to have the same solar illumination angle at each approach with the same orbital motion. The consistency of Sun angle is attained by tuning the inclination to the altitude of the orbit such that the extra mass near the equator causes the orbital plane of the spacecraft to precess with the desired rate: the plane of the orbit is not fixed but rotates slowly about the Earth's axis. Sun-synchronous orbits have inclination angle of about 98°, an altitude of about 600-800 km and time period of about 96-100 minutes[1].

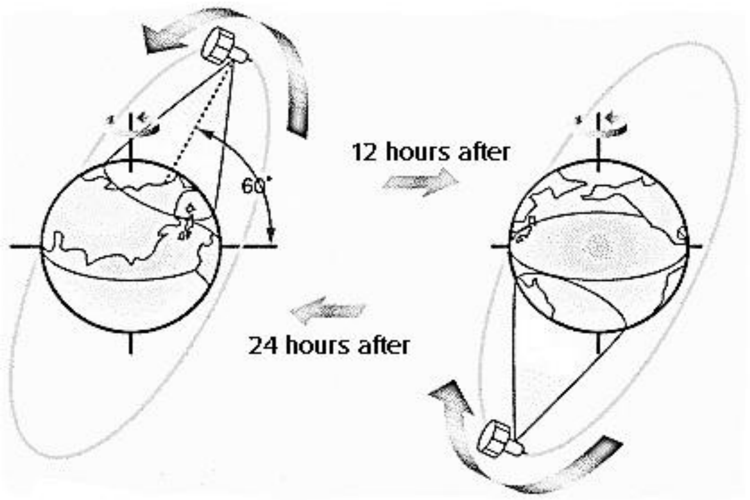

Figure 1: Sun-Synchronous Orbit (Monteverdi, 2013)

Sun-synchronous satellites go around the Earth 24x7. These acquire the aerial photographs of Earth’s field of view and stores the images in a database. These photographs are refreshed during each revolution of the satellite. These images can be retrieved and displayed as and when required.

1.2. Indian Remote Sensing Satellite

Indian Remote Sensing satellites (IRS) are a series of Earth Observation satellites, built, launched and maintained by Indian Space Research Organization. The IRS series provides many remote sensing services to India. Data from the IRS satellites is received and disseminated by several countries all over the world. The IRS system is the largest constellation of remote sensing satellites for civilian use in operation today in the world, with 12 operational satellites. It completed its 25 years of successful operations on March 17th, 2013 [9]. All these are placed in polar sun-synchronous orbit and provide data/images that have variation of information pertaining to spatial, spectral and temporal resolutions. The National Remote Sensing Centre (NRSC) at Hyderabad is the nodal agency for reception, archival, processing and distribution of remote sensing data in the country. Satellites like Cartosat-1, Cartosat-2 [8], Resourcesat-1, IRS - 1D, Oceansat-1 etc acquire and process data for NRSC.

1.3. Image Acquisition & Storage

Both satellite and surveillance databases are categorically huge and image processing needs to be real time. Satellite imagery is used in the fields of agriculture, forestry, mineral exploration, land-use mapping, weather forecast, mapping of water resources, environmental monitoring and 3D visualization. Real-time imaging with highest possible resolution is required for intelligence and military purposes [9].

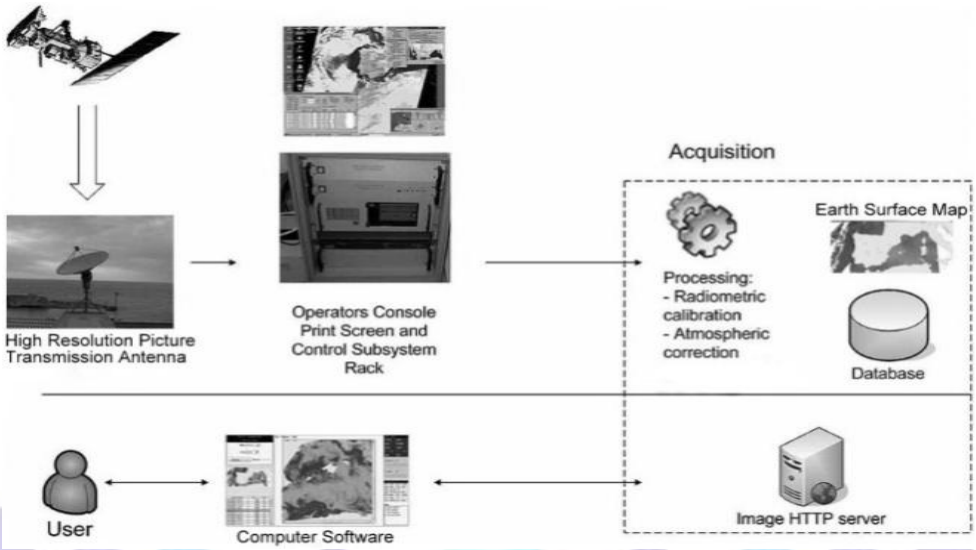

Figure 2: Image Acquisition and Storage (Òscar Chic, 2014)

1.4. Artificial Neural Networks

ANN is based on Biological Neuron Model that is a mathematical description of the properties of nerve cells. The artificial neuron is designed to mimic the first order characteristics of the biological neuron [5].

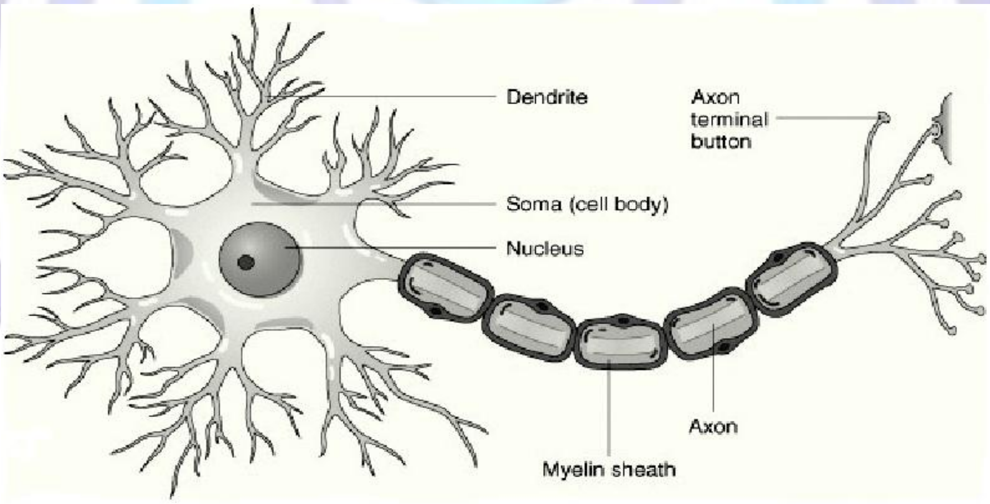

Figure 3: Biological Neuron (Boone, 2014)

When a set of inputs x is applied, then each input is multiplied by corresponding weight w. The weighted input is analogous to a synaptic strength in biological neuron. All the weighted inputs are then summed to determine the activation level of the neuron. Each input signal is multiplied by associated an weight, w_1, w_2,... w_n before it is applied to the summation block, labeled ∑. The summation block corresponds roughly to the biological cell body. It adds all the weighted inputs algebraically and produces an output called "*NET*" [10].

NET = **XW**

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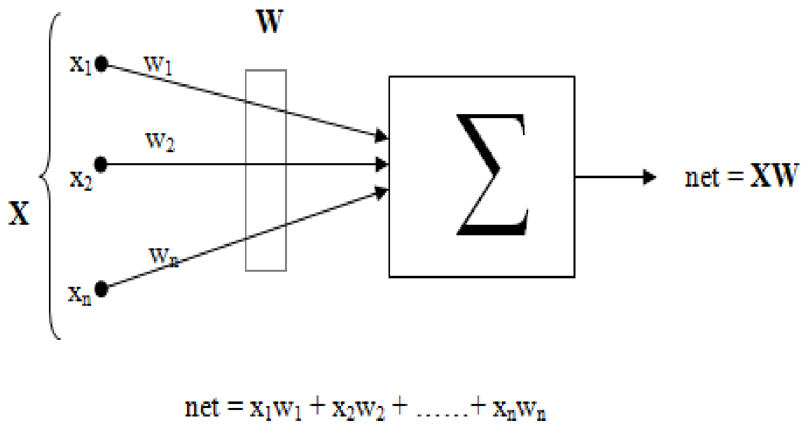

Figure 4: Model of Neuron (Wasserman,1989)

The NET signal is further processed by an activation function F which may be a simple linear function, to produce the neuron's output signal, OUT.

OUT = K (NET)

where K is a threshold function (a constant).

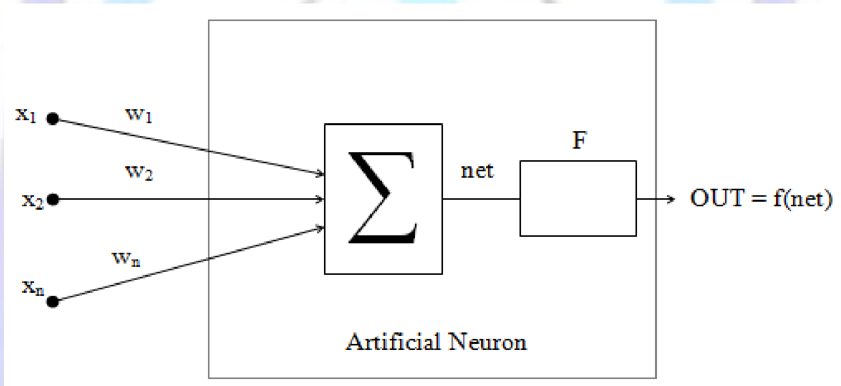

Figure 5: Artificial Neuron with Activation Function (Wasserman,1989)

1.5. Objective of Training

An artificial neural network is trained; so that application of a set of inputs vector produces the desired (or at least consistent) set of outputs. Each such input (or output) vector is referred as training pair. Training is accomplished, by sequentially applying input vectors and adjusting network weights according to a preordained subroutine. During training, the network weights gradually converge to the minimal error value. The error back propagation technique is used for training the neural network. When the input vector matched exactly with training pattern the exact output will be produced. In case the input vector does not match exactly with the training pattern, then its approximation matching with the training pattern will give the output using semi supervise mode of learning.

1.6. Back Propagation

Backward propagation of error is a commonly used systematic method for training multilayer artificial neural networks [6]. It has great mathematical foundation. Training process using the back-propagation requires the follow steps:

- Select training pair from the training set; apply the input vector to the network input.
- Calculate the output of the network.
- Calculate the error between the output of the network and the required output.
- Adjust the weights of the network such that the error is minimized.
- Repeat the above steps for each vector in the training set until the error for the entire set is admissibly low.

It is a supervised method of learning that is based on Delta rule. According to Delta rule for a neuron j whose activation function g(x), j's i^{th} weight w_{ji} is given as

Δw_{ij}=α (t_j-y_j) g'(h_j) x_i

Where:

α is learning rate (constant).
t_j is target output.

h_j is weighted sum inputs.

y_j is actual output.

x_i **is** i^{th} input.

Delta rule is further simplified as:
Δw_{ij}=α (t_j-y_j) x_i

The inputs/weights are applied either from the outside or from the previous layer of the network. These weights must be adjusted such that the error between the desired output and the actual output is reduced. In a way the neural network computes the slightest increase or decrease in the weights.

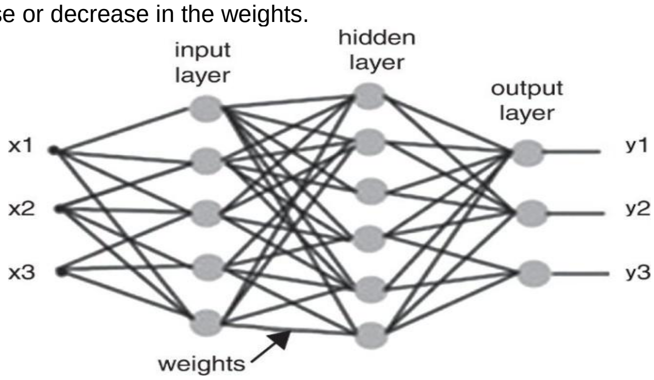

Figure 6: Back propagation Ann (Amirjan,Siadati,2013)

The main aim of the supervised learning algorithm is to find and apply a function that best maps a set of inputs to its accurate output [10].

1.7. Multilayer Network

A single neuron can perform certain simple pattern detection functions; the power of neural computation comes from connecting neurons into network. The networks that are large and have certain level of complexity generally offer greater computational skills. The networks have been constructed in every imaginable configuration by arranging the neurons in layers to mimic the layered structure of the certain portion of the brain.

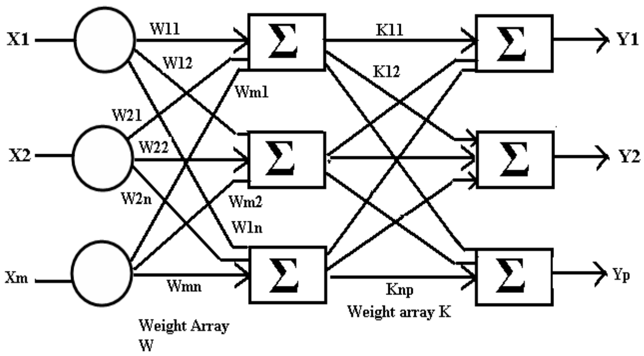

Figure 7: Multilayer network (Wasserman,1989)

The multilayer networks have been proven capabilities beyond those of a single layer, and in recent years, algorithms have been developed to train them. Multilayer networks may be formed by simply cascading a group of single layers; the output of one layer provides the input to the subsequent layer.

1.8. Training of ANN

A set of a digital data pertaining to different landmarks prepared by assigning different area codes according to different topographical features in the form of a binary input of 19 columns is fed to the ANN the target vector is ‘000001’ and similarly for all the target values are a assigned in sequential order and the training pairs are made; which are fed to the ANN one by one [2], [3].

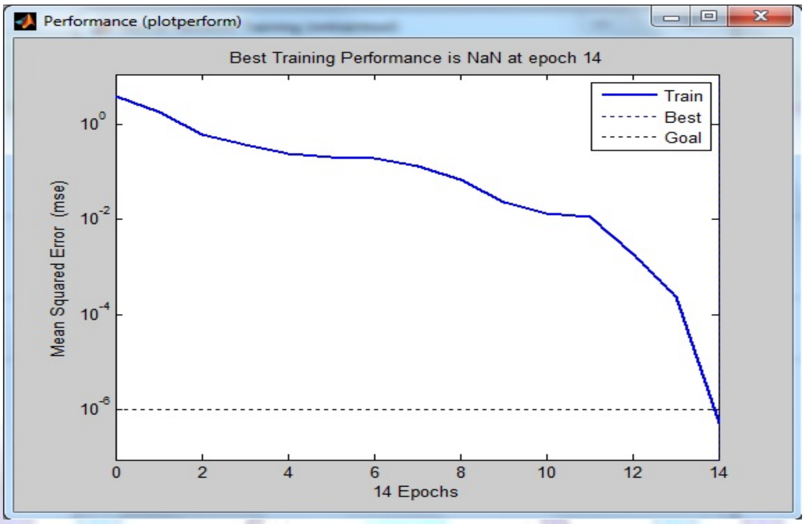

Figure 8: Training Performance

During training of ‘EBPANN’, each input vector of 19 values; is fed to ANN using MATLAB. These patterns were used to train 19-18-12-6 error back propagation neural network using MATLAB. It was implemented on Intel Core2 Duo processor with 3.0 GHz clock. The neural network was trained for 10^{-6} mean square error (MSE). The neural network was trained after 14 epochs in 2 minutes.

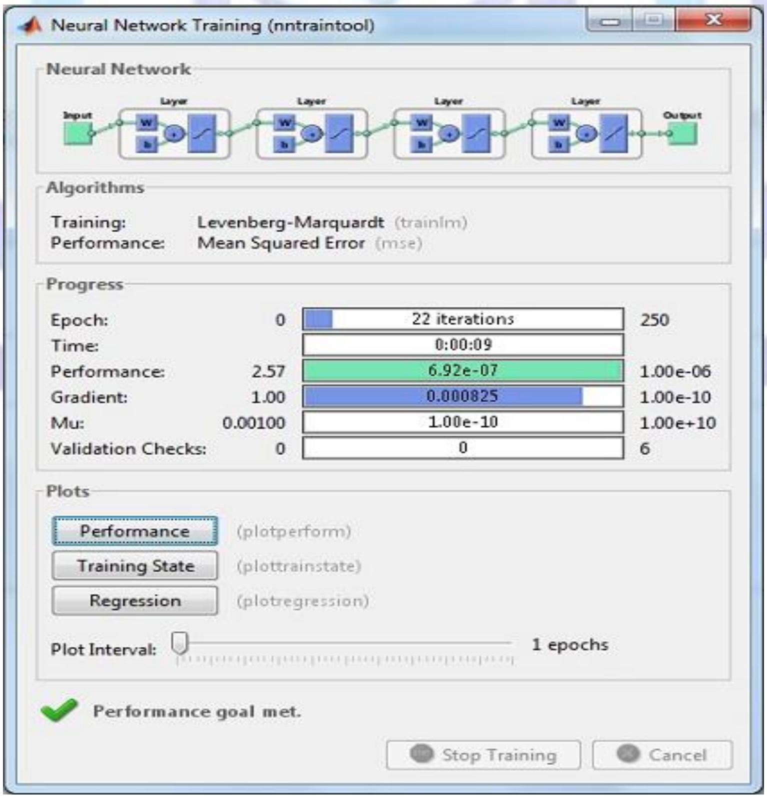

Figure 9: Training of an ANN

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Table 1. Training patterns used for training ANN

REGION	AC	M	PL	R	F	L	PP	D	C	MG	I	O/p
JAMMU & KASHMIR (u)	000001	0	11	0	11	1	00	0	1	1	1	000001
JAMMU & KASHMIR (l)	000010	0	11	0	00	0	00	1	1	1	1	000010
HIMACHAL PRADESH (u)	000011	0	11	0	00	1	01	1	1	1	1	000011
HIMACHAL PRADESH (l)	000100	0	11	0	00	0	01	1	1	1	1	000100
PUNJAB (u)	000101	1	00	0	01	0	10	1	1	1	1	000101
PUNJAB (l)	000110	1	00	0	11	0	01	1	1	1	1	000110
UTTRAKHAND (u)	000111	0	11	0	00	1	00	1	1	1	1	000111
UTTRAKHAND (l)	001000	0	00	0	00	1	01	1	1	1	1	001000
HARYANA (u)	001001	1	00	1	11	0	01	1	1	1	1	001001
HARYANA (l)	001010	1	00	1	11	0	10	1	1	1	1	001010
RAJASTHAN (u)	001011	1	00	1	11	1	00	0	1	1	1	001011
RAJASTHAN (l)	001100	0	11	0	01	1	01	0	1	1	1	001100
UTTAR PRADESH (u)	001101	1	00	0	11	1	10	1	1	1	1	001101
UTTAR PRADESH (l)	001110	1	01	0	01	0	10	1	1	1	1	001110
BIHAR	001111	1	00	0	01	1	10	1	1	1	1	001111
JHARKHAND	010000	0	01	0	00	1	10	1	1	1	1	010000
SIKKIM+WEST BENGAL (u)	010001	0	01	0	00	1	00	1	1	1	1	010001
WEST BENGAL (l)	010010	1	00	0	01	1	10	1	0	0	0	010010
NORTH EAST (u)	010011	0	00	0	00	1	00	1	1	1	1	010011
NORTH EAST (l)	010100	0	01	0	01	1	01	1	1	1	1	010100
CHHATTISGARH (u)	010101	0	01	0	00	1	01	1	1	1	1	010101
CHHATTISGARH (l)	010110	1	01	0	00	1	01	1	1	1	1	010110
MADHYA PRADESH (u)	010111	1	01	0	01	0	01	1	1	1	1	010111
MADHYA PRADESH (l)	011000	0	01	0	00	1	01	1	1	1	1	011000
GUJARAT (u)	011001	1	10	1	10	1	00	1	0	1	1	011001
GUJARAT (l)	011010	1	10	0	11	1	10	1	0	1	0	011010
MAHARASHTRA (u)	011011	0	01	0	11	1	10	1	1	1	0	011011
MAHARASHTRA (l)	011100	0	10	0	10	1	01	1	0	1	1	011100
ODISHA (u)	011101	1	01	0	00	0	10	1	0	1	1	011101
ODISHA (l)	011110	0	10	0	01	0	01	1	1	1	1	011110
ANDHRA PRADESH (u)	011111	0	01	0	00	0	10	1	1	1	1	011111
ANDHRA PRADESH (l)	100000	1	10	0	10	1	01	1	0	1	1	100000
KARNATAKA (u)	100001	0	01	0	00	0	01	1	1	1	1	100001
KARNATAKA (l)	100010	1	01	0	01	0	01	1	0	1	1	100010
KERALA (u)	100011	1	10	1	00	0	10	1	0	1	1	100011
KERALA (l)	100100	1	10	0	00	0	10	1	0	1	1	100100
TAMIL NADU (u)	100101	0	10	0	11	0	10	1	0	1	1	100101
TAMIL NADU (u)	100110	1	10	0	11	1	10	1	0	1	1	100110
LAKSHDWEEP	100111	1	11	1	00	1	00	1	0	1	0	100111
ANDAMAN & NICOBAR	101000	1	11	1	11	1	00	1	0	1	0	101000

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BRIDGE – RAM SETU	101001	1	11	1	10	1	00	1	0	1	0	101001
NILE RIVER	101010	0	01	0	10	0	00	0	0	0	1	101010
SUNDERBAN DELTA	101011	0	00	0	00	0	01	1	0	0	0	101011
HIMALAYAN RANGE	101100	0	11	0	00	0	00	1	1	1	1	101100
NORTHERN INDIA	101101	0	00	0	00	0	01	1	1	1	1	101101
SOUTHERN INDIA	101110	1	10	0	00	0	10	1	0	1	0	101110
EASTERN INDIA	101111	1	01	0	00	0	01	1	0	0	0	101111
WESTERN INDIA	110000	0	10	0	01	0	01	0	0	1	0	110000
CENTRAL INDIA	110001	1	01	0	01	0	10	1	1	1	1	110001
EARTH	110010	0	00	0	00	0	00	0	0	0	0	110010

Abbreviation used:

AC-Area Code PP-Population (u)-Upper (l)-Lower

M-Mountains D-Desert L-Lake

PL-Plains C-Coastal Region I-Island

R-Rivers MG-Mangrove F-Forest

2. CASE STUDIES

2.1. Case (1)

GUJ shows the input concerning to Gujarat landmark topology was given as a test pattern to ANN. The ANN has produced using testing algorithm calculating the output and mapped it accurately with the image of Gujarat.

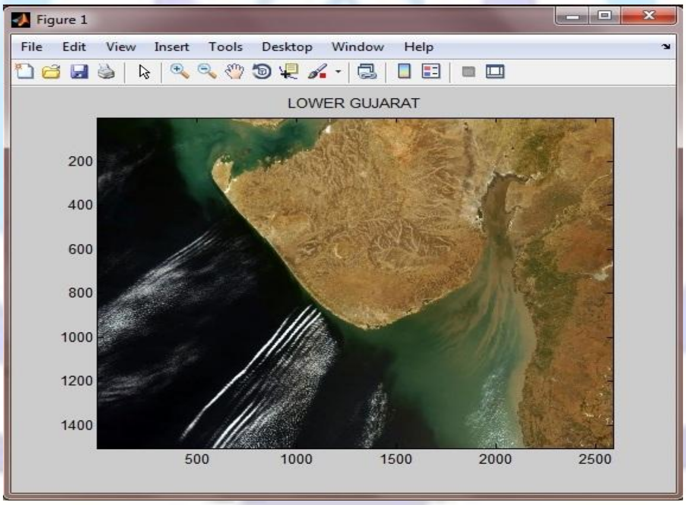

Figure 10: Aerial view of Gujarat

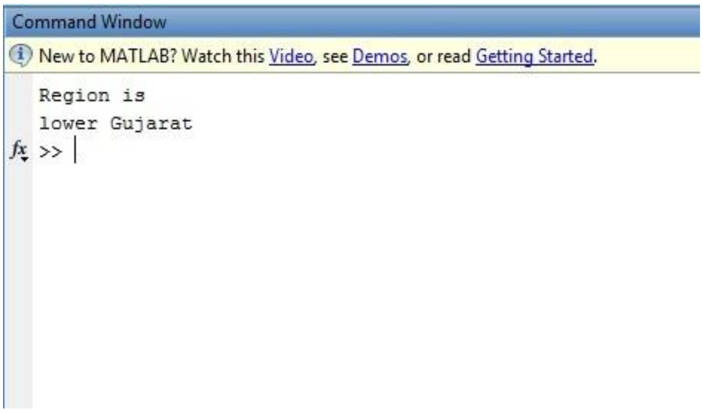

Figure 11: Result given by Algorithm

2.2. Case (2)

BDELTA shows the input concerning to Sunder ban landmark topology was given as a test pattern to ANN. The ANN has produced using testing algorithm calculating the output and mapped it accurately with the image of Sunder bans. The image and the result produced by ANN are exactly matching. Hence it is the case of accurate image reproduction.

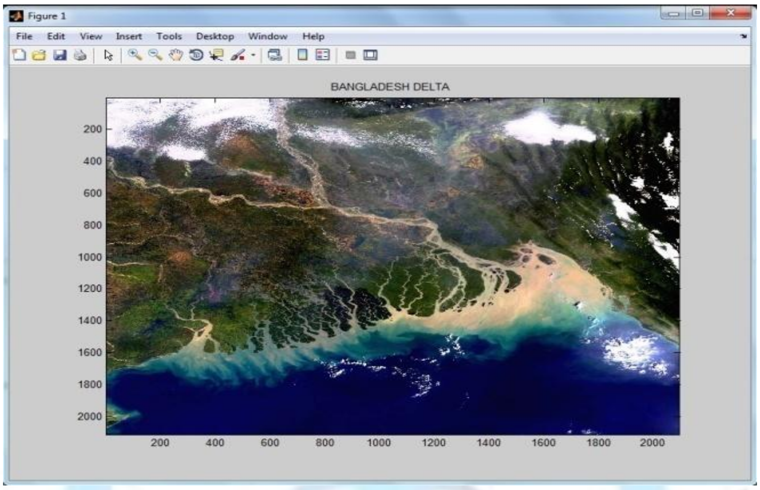

Figure 12: Aerial view of Ganga Delta

Figure 13: Result given by Algorithm

2.3. Case (3)

HIMR shows the input concerning to Himalayan Range landmark topology was given as a test pattern to ANN. The ANN has produced using testing algorithm calculating the output and mapped it accurately with the image of Himalayas.

Figure 14: Aerial view of the Himalayas

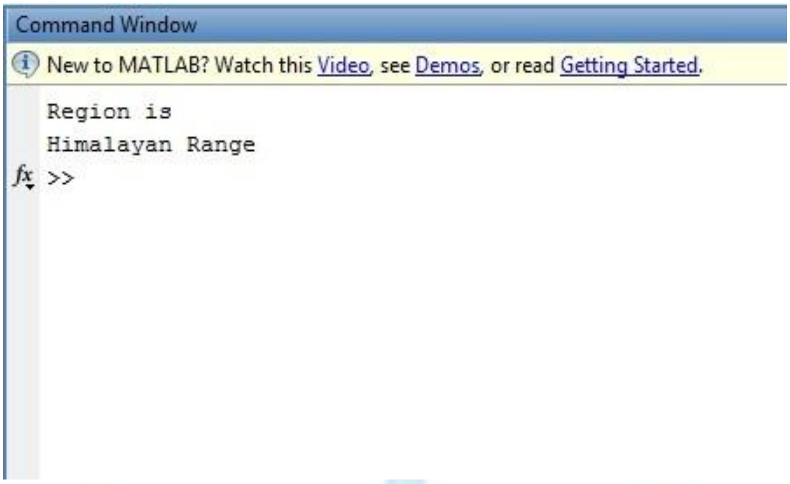

Figure 15: Result shown by algorithm

3. CONCLUSION

The technique used for image reproduction using ANN is very accurate method and the results produced are almost 100%. Wavelet and SVMs are equally strong techniques for classification and reproduction of satellite images. The results will be at par with what has been achieved using ANN.

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