

# Reproduction of Remote Sensed Images Using Artificial Neural Network

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**Abstract:** Remote sensed images are reproduced using Artificial Neural Network. Elements of ANN perform similar to the functions of biological neuron. Once ANN learns it never forgets. Special feature of ANN is its capability of extracting correct result even from partially corrupt input. Different topologies of the earth surface are assigned with a digital code which is used as input to ANN and the location of image taken by satellite is used as target to train the ANN. Using the algorithm the trained ANN is used to reproduce the results.

**Keywords:** GIS: Geographic Information System, LIDAR: light detection and ranging, ANN: Artificial Neural Network, MSE: Mean Square Error, MATLAB: Matrix Laboratory, SVM: Support Vector Machines.

## 1. Introduction

**Data Clustering:** Clustering is the task of grouping a set of objects in such a way that objects in the same group are more similar to each other than to those in other groups (clusters). It is a main task of explorative data mining process, and a common technique for statistical data analysis used in many fields, including machine learning, image analysis, information retrieval, and bioinformatics. Popular notions of clusters include groups with low distances among the cluster members, dense area data space or particular statistical distributions. Clustering can therefore be summarized as a multi-objective optimization problem. This appropriate clustering algorithm and parameter settings depend on the individual data set and intended use of the results. There are fine distinctions possibilities:

- Strict partitioning clustering
- Strict partitioning clustering with the outliers
- Overlapping clustering
- Hierarchical clustering that belong to a child cluster also belong to the parent cluster
- Subspace clustering

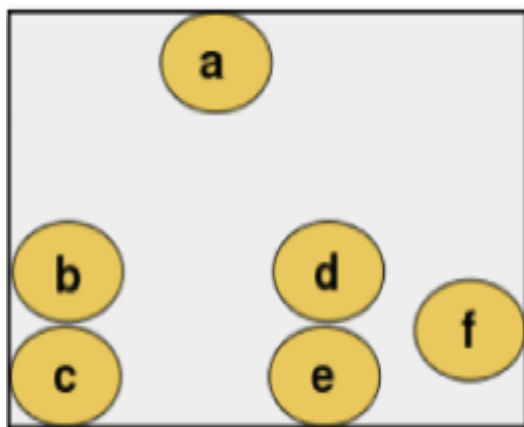


Figure 1: Raw Data

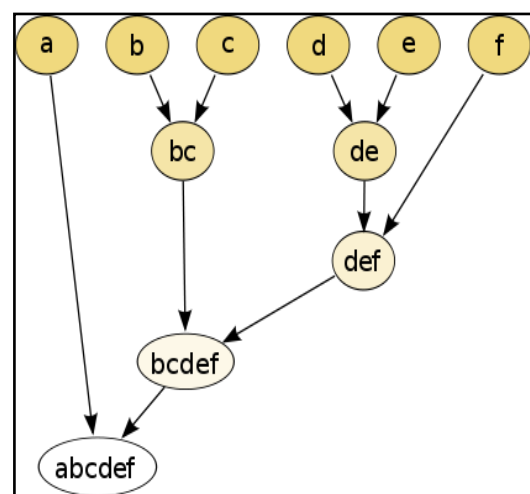


Figure 2: Dendrogram

**Hierarchical Clustering** is a method of cluster analysis which seeks to build a hierarchy for the clusters. Strategies for hierarchical clustering generally fall into two types:

- **Agglomerative:** This is a "bottom up" approach: each observation starts in its own cluster, and pairs of clusters are merged as one moves up the hierarchy.
- **Divisive:** This is a "top down" approach: all observations start in one cluster, and splits are performed recursively as one moves down the hierarchy.

The results of hierarchical clustering are normally presented in a dendrogram.

## Image Segmentation

Clustering may be used to divide a digital image into distinct regions for border detection or object recognition

## Remote Sensing with Active Learning

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object. In modern usage, the term refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. electromagnetic radiation emitted from aircraft or satellites).

The object or phenomenon of interest (the state) may not be directly measured, there exists some other type of variable that can be detected and measured (the observation), which can be related to the object of interest through the use of a data-derived computer model. The quality of remote sensing data consists of its spatial, spectral, radiometric and temporal resolution.

**Spatial Resolution:** The size of a pixel that is recorded in a raster image – typically pixels may correspond to square areas ranging in size length from 1 to 1,000 meters (3.3 to 3,300 ft).

**Spectral Resolution:** The wavelength width of the different frequency bands recorded – usually, that relates to the number of frequency bands recorded by the platform. Current Landsat collection for the seven bands includes several in the infra-red spectrum, which range from a spectral resolution of 0.07 to 2.1  $\mu$ m. The Hyperion sensor for Earth Observing-1 resolves 220 bands from 0.4 to 2.5  $\mu$ m, with a spectral resolution of about 0.10 to 0.11  $\mu$ m per band.

**Radiometric Resolution:** The number of different intensities of radiation the sensor is able to distinguish. Typically, it ranges from 8 to 14 bits, corresponds to 256 levels of the gray scale and up to 16,384 intensities or "shades" of color, in every band. It also depends on the instrument noise.

**Temporal Resolution:** The frequency of flyovers by the satellite or for the plane, and is only relevant in time-series studies or those requiring an averaged or mosaic image as in deforestation monitoring system. This was first used by the intelligence community where repeated coverage revealed changes in infrastructure, the deployment of some units or the modification/introduction of several equipment. Cloud cover over a given area or object makes it necessary to repeat the collection of said location.

## 2. Satellite Remote Sensing

Satellites remote sensing is equipped with sensors looking down to earth; they are the eyes in the sky constantly observing the earth as they go round in predictable orbits. In satellite remote sensing process of the earth, the sensors are looking through a layer of atmosphere separating the sensors from the Earth's surface being observed.

## 3. Sun Synchronous Orbit

A sun synchronous orbit is a geocentric orbit which combines altitude and inclination in such a way that an object on that orbit will appear to orbit in the same position, as from the perspective of the Sun, during its orbit around the Earth. More technically, it is an orbit arranged in such a way that it processes once a year.

## Sun-synchronous Orbit

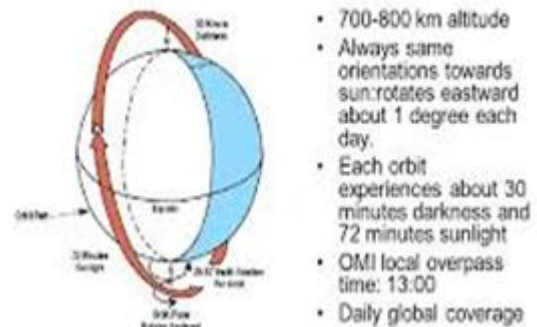


Figure 3: Sun-Synchronous Orbit

The surface illumination angle will be nearly the same every time that the satellite is overhead. This consistent lighting is a useful characteristic for satellite that image the Earth's surface in visible or infrared wavelengths (e.g. weather and spy satellites) and for other remote sensing satellites (e.g. those carrying ocean and atmospheric remote sensing. Instruments that require sunlight). Typical sun-synchronous orbits are of about 600–800 km in altitude, with periods in the 96–100 minute and inclinations of around 98° (i.e. slightly retrograde compared to the direction of Earth's rotation: 0° represents an equatorial orbit and 90° represents a polar orbit).

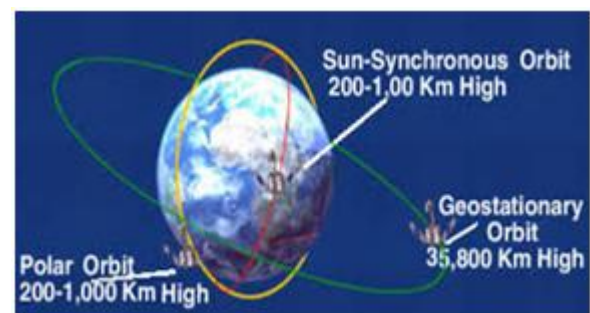


Figure 4: Orientation of sun synchronous orbit

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.

## 4. Image Acquisition and Storage

In many areas of commerce, government, academia, hospitals, and homes, large collections of digital images are being created. However, in order to make use of it, the data should be organized for efficient searching and retrieval. An image retrieval system is a computer system for browsing, searching and retrieving images from a large database of digital images. Due to diversity in content and increase in the size of the image collections, annotation became both ambiguous and laborious. With this, the focus shifted to Content Based Image Retrieval (CBIR), in which images are indexed according to their visual content. Sing 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.

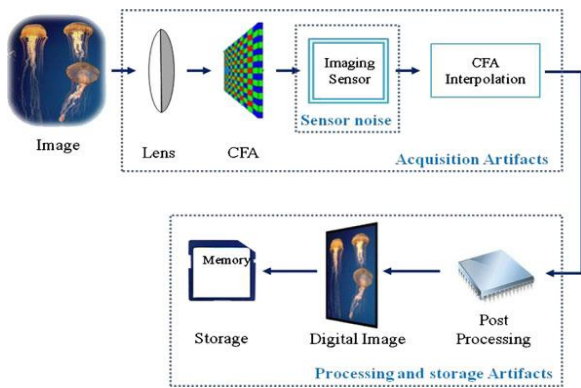


Figure 5: Image Acquisition and Storage

## 5. Artificial Neural Network

ANN is based on Biological Neuron Model that is a mathematical description of the pro cells. The artificial neuron is designed to mimic the parties of nerve cells. The artificial neuron is first order characteristics of the biological neuron. In machine learning and cognitive science, **artificial neural networks** (ANNs) are a family of statistical learning models inspired by biological neural network (the central nervous system of animals, in particular the brain) and are used to estimate or approximate functions that can depend on a large number of inputs and are generally unknown. Artificial neural networks are generally presented as systems of interconnected "neurons" which send messages to each other. The connections have numeric weights that can be tuned based on experience, making neural nets adaptive to inputs and capable of learning.

For example, a neural network for handwriting recognition is defined by a set of input neurons which may be activated by the pixels of an input image. After being weighted and transformed by a function (determined by the network's designer), the activations of these neurons are then passed on to other neurons. This process is repeated until finally, an output neuron is activated. This determines which character was read.

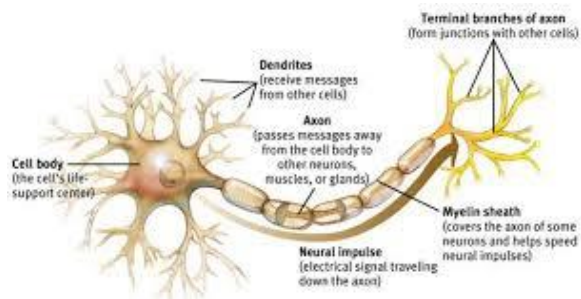


Figure 6: Biological Neuron

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 a weight,  $w_1, w_2, \dots, w_n$  before it is applied to the summation block, labeled  $\Sigma$ . The summation block corresponds roughly to the biological cell body. It adds all the weighted inputs algebraically and produces an output called "NET".

$$NET = XW$$

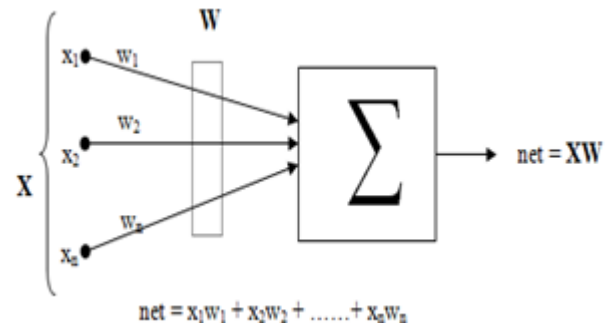


Figure 7: Model of Neuron

## 6. Activation Function

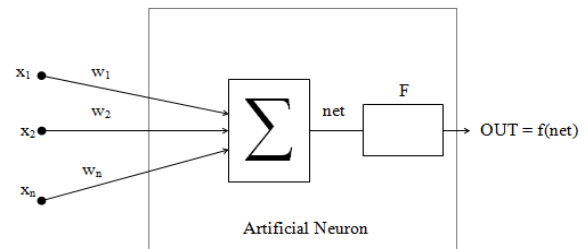


Figure 8: Artificial Neuron with Activation Function

The net signal is usually further processed by an activation function 'F' to produce the neuron's output signal, OUT [1]. This may be a simple linear function.

OUT = K (net) ; Where K is a constant i.e. threshold function

OUT = 1 if net > T

OUT = 0 otherwise

T is a constant threshold, or a function that more explicitly reproduces the non-linear transfer characteristic of the biological neuron and permits more general network functions. In figure 6, the block labeled F accepts the net output and produces the OUT labeled signal. If the processing block F compacts the range of net, so that OUT never exceeds some low limits regardless of the value of net, F is called a squashing function.

The squashing function is often chosen to be the logistic function or "sigmoid" (meaning S-shaped). This function is expressed mathematically as

$$F(x) = \frac{1}{1 + e^{-x}}$$

Thus

$$OUT = \frac{1}{1 + e^{-net}}$$



## 7. Back Propagation ANN

Backward propagation of error is a commonly used systematic method for training multilayer artificial neural networks. It is a supervised method of learning that is based on Delta rule. According to Delta rule for a neuron  $j$  whose activation function  $g(x)$ , joss  $i^{th}$  weight  $w_{ji}$  is given as

$$\Delta w_{ij} = \alpha (t_j - y_j) g'(h_j) x_i$$

Where:

$\alpha$  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:

$$\Delta w_{ij} = \alpha (t_j - y_j) x_i$$

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.

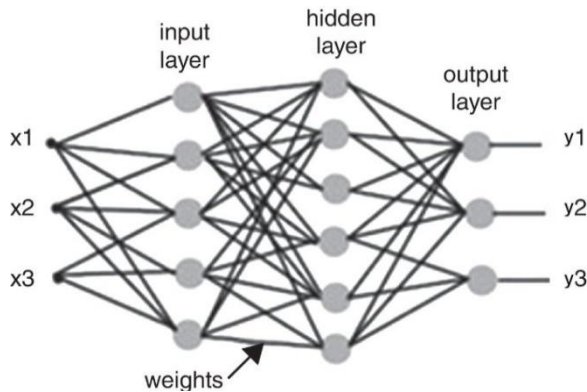


Figure 9: Back propagation Ann

The goal of any supervised learning algorithm is to find a function that best maps a set of inputs to its correct output.

### Active learning

It is a form of supervised machine learning in which a learning algorithm is able to interactively query the user (or some other information source) to obtain the desired outputs at new data points. In statistics literature it is sometimes also called optimal experimental design.

There are situations in which unlabeled data is abundant but manually labeling it is expensive. In such a scenario, learning algorithms can actively query the user/teacher for labels. This type of iterative supervised

### Semi-supervised Image Classification by Hierarchical Clustering

All current active learning strategies rely on a model that is optimized iteratively through supervision. These principles can be difficultly casted into image classification of a hierarchical clustering of the data, where the aim is to find a reasonable level of image partitioning representing the classes in each cluster. In this type of classification, each cluster can be attributed to a single class without over segmenting. The applied algorithm may provide efficient

image classification and yield a confidence map that may be very useful in many Earth observation applications. Learning is called active learning.

## 8. Training of Ann

A set of a digital data pertaining to different Landmarks by assigning different area codes according to different topographical features in the form of a binary input of 19 columns are used as training pattern. The desired output of the neural network was compared with the target output pattern of 20-25 columns.

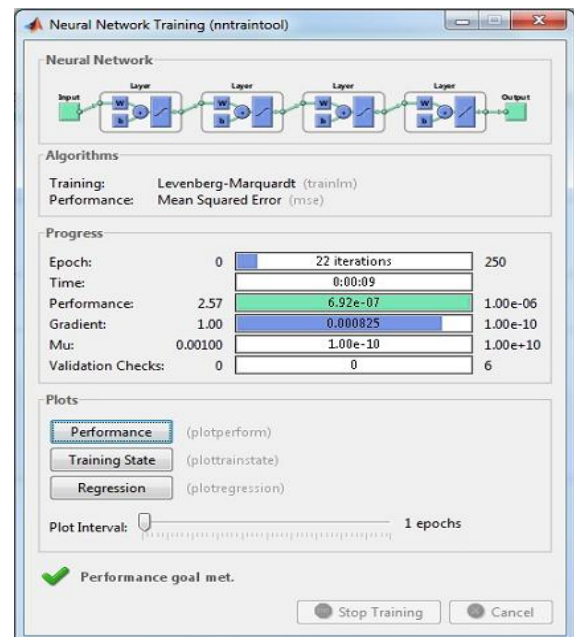


Figure 10: Training of an ANN

These patterns were used to train 19-18-12-6 error back propagation neural network using MATLAB.

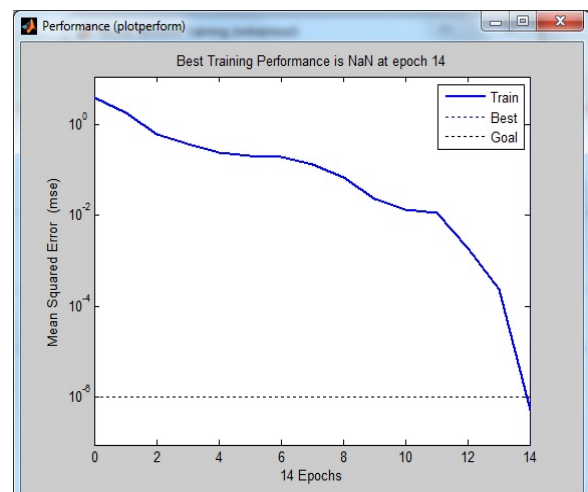


Figure 11: Training Performance

. 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.

## 9. Algorithm for Classification

**Step 1:** Acquire a digital input pattern related to different topographic location of India and some of earth's landmark in the matrix form.

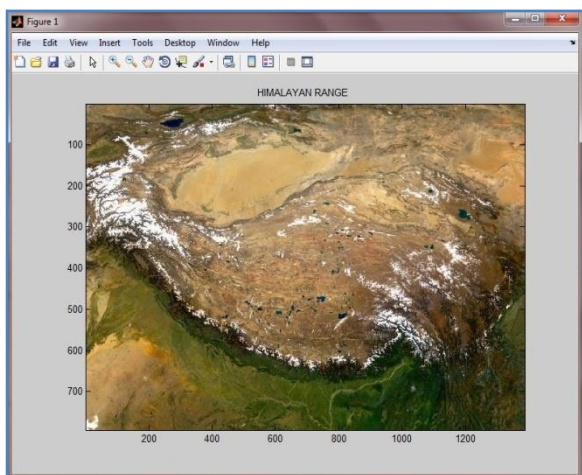
**Step 2:** Arrange all the digital input data pertaining to different landmarks in a particular pattern in which 1-19 columns represent input data whereas 20-25 represent a target output of the matrix.

**Step 3:** During the training of Error Back Propagation Artificial Neural Network (EBP ANN), the input patterns were fed to the four layered network that is one input, one output and two hidden layered network as training set to train the EBP ANN using MATLAB.

Case-1: Himalayan Range:



Mat lab Command window result

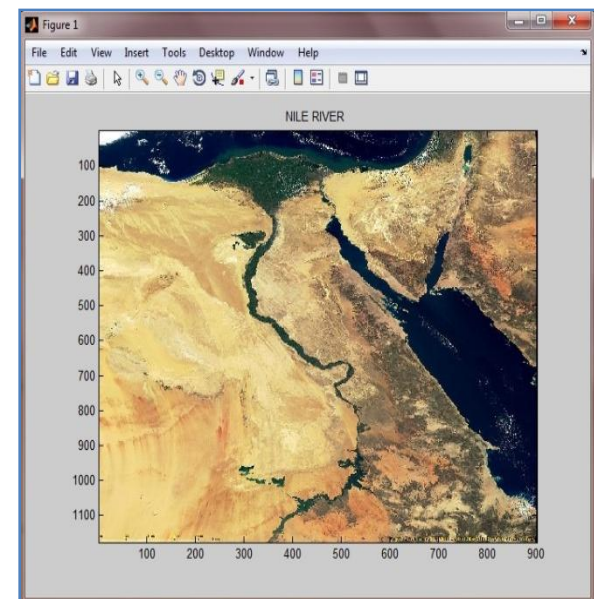


HIMR shows the input concerning to Himalayan Range landmark topology was given as a test pattern to ANN. The ANN has produced using testing algorithm calculating the output and mapped it accurately with the image of Himalayas.

Case 2 Nile River



Mat lab Command window result



NIL shows the input concerning to Nile River 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 Nile.

## 10. 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 I have achieved using ANN.

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### Author Profile



The author **AARSI SAINI** has received the Bachelor of Technology degree from Kurukshetra University in 2012. Has certification in CNN and Embedded System. Has done 8086 projects that are EVM and RADAR.