

Application of Artificial Neural Network to Satellite Images Classification

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Abstract: Artificial neural networks (ANNs) have become a popular tool in the analysis of remotely sensed data. Remotely sensed images are major sources of data and information that are used in various fields such as environmental studies, forest management, and urban change detection etc. Although significant progress has been made in image classification based upon neural networks, a number of issues remain to be resolved. This paper reviews remotely sensed data analysis with neural networks. First, we present an overview of the main concepts underlying ANNs, including the main architectures and learning algorithms. Then, the main tasks that involve ANNs in remote sensing are described. The limitations and crucial issues relating to the application of the neural network approach are discussed. A brief review of the implementation of ANNs in some of the most popular image processing software packages is presented. Finally, we discuss the application perspectives of neural networks in remote sensing image analysis. Remotely sensed images are major sources of data and information that are used in various fields such as environmental studies, forest management, and urban change detection etc. So far many efforts have been performed to extract information from remotely sensed images and various methods have been developed in this field. One of the main approaches is quantitative analysis (digital interpretation). Among digital techniques, classification is a common and powerful information extraction method, which is used in remote sensing. There are two techniques that are used for classification in pattern recognition such as Supervised Classification and Unsupervised Classification. In supervised learning technique the network knows about the target and it has to change accordingly to get the desired output corresponding to the presented input sample data. Most of the previous work has already been done on supervised classification. In this study we are going to present the classification of satellite images using Unsupervised classification method of ANN.

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I. INTRODUCTION

Artificial Neural Networks are the computing models that are inspired by biological neural network and provide new directions to solve problems arising in natural tasks. In particular, it is hoped that neural network would extract the relevant features from the input data and perform a pattern recognition task by learning from examples without explicitly stating the rules for performing the task.

Currently most of the neural networks models are severely limited in their abilities to solve real world problems. For problems such as speech recognition, image processing, natural language processing and decision-making, it is not normally possible to see a direct mapping of the given problem on to a neural network model. These are natural tasks, which human beings are good at, but we still do not understand how we do them. Hence it is a challenging task to find suitable neural network models to address these problems.

Automatic recognition, description, classification and grouping of patterns are important problems in a

variety of engineering and scientific disciplines such as biology, psychology, medicine, marketing, computer vision, artificial intelligence and remote sensing. In the most pattern recognition problems, patterns have a dynamic nature and non-adaptive algorithms (instruction sets) will fail to give a realistic solution to the problem. So in these cases, adaptive algorithms are used and among them, neural networks have the greatest hit. For example, the defense applications very frequently need to record, detect, identify and classify images of objects or signals coming from various directions and from various sources- static or dynamic. There are many applications in remote sensing like deforestation, effects of natural and manmade disasters, migration in the path of river due to dynamic nature of earth plates where study of dynamic data is needed.

Artificial Neural Networks (ANN) can play a role in such applications because of their capability to model nonlinear processes and to identify unknown patterns and images based on their learning model, or to forecast certain outcomes by extrapolation. On the basis of properties like steepness of slopes, local relief

(the maximum local difference in elevation), cross sectional forms of valley and divides, and texture of the surface material etc. considerable foresight can be achieved regarding temporal changes in land patterns. The land pattern of landform differences is strongly related in the arrangement of such other features of the natural environment as climate, soils, and vegetations.

In the present work we wish to classify satellite images using ANN's pattern recognition and classification capabilities. The Unsupervised Classification approach uses self organizing feature map to classify the patterns. The Self-organizing feature maps (SOFM) transform the input of arbitrary dimension into a one or two dimensional discrete map subject to a topological (neighborhood preserving) constraint. The feature maps are computed using Kohonen unsupervised learning. The output of the SOFM can be used as input to a supervised classification neural network such as the MLP.

This network's key advantage is the clustering produced by the SOFM which reduces the input space into representative features using a self-organizing process. Hence the underlying structure of the input space is kept, while the dimensionality of the space is reduced.

II. ARTIFICIAL NEURAL NETWORK

The ANN is usually implemented using electronic components (digital or analog) and/or simulated on a digital computer. It employs massive interconnection of simple computing cells called 'neurons' or "processing elements (PE)". It resembles the brain in two ways :

- Knowledge is acquired by the network through learning process,
- Inter neuron connection strengths (synaptic weights) are

responsible for storing the knowledge.

The way the synaptic weights change is what makes the design of ANNs. An ANN works as follows:-

A neuron receives inputs from a large number of other neurons or from an external stimulus. Weighted sums of these inputs are fed into a nonlinear activation function. The output of this function is fanned out (distributed) to connections to other neurons. The topology of neuron connections defines the flow of information in the network. The way the weights are adjusted in the network constitutes the learning process. Thus the three essential components of an ANN computational system are- activation function, architecture, and, the learning law. Due to the differences in these three components, different ANN structures are explored for various applications and these structures differ in their computational complexities and requirements.

The main attributes of neural processing are its nonlinear and adaptive learning capability, which enables machines to recognize possible variations of a same object or pattern and/or to identify unknown functions and mappings based on a finite set of training data, which can be noisy with missing information. Based on this 'Training by example' property with strong support of statistical and optimization theories, neural networks are becoming one of the most powerful and appealing nonlinear and adaptive data analysis tools for a variety of signal processing applications[1].

III. SELF ORGANIZING FEATURE MAP

The Self Organizing Maps developed by Teuvo Kohonen in 80's has now become a well known tool, with established properties. A Self-Organizing Map(SOM) or self-organizing feature map (SOFM) is a type of artificial neural network that is trained using unsupervised learning to produce a low-dimensional (typically two-dimensional), discretized representation of the input space of the training samples, called a map. Self-organizing maps are different from other artificial neural networks in the sense that they use a neighborhood function to preserve the topological properties of the input space. The Self Organizing Feature Maps have been commonly used since their first description in wide variety of problems as classification, feature extraction, pattern recognition and other related application.

Self-organizing feature maps (SOFM) learn to classify input vectors according to how they are grouped in the input space. They differ from competitive layers in that neighboring neurons in the self-organizing map learn to recognize neighboring sections of the input space. Thus, self-organizing maps learn both the distribution (as do competitive layers) and topology of the input vectors they are trained on[5].

The neurons in the layer of an SOFM are arranged originally in physical positions according to a topology function. Distances between neurons are calculated from their positions with a distance function.

The Kohonen Self Organizing Feature Map can be defined as an Unsupervised Classification Algorithm from the artificial neural network paradigm.

IV. SOFM TO CLASSIFY THE SATELLITE IMAGES

In the present work self-organizing feature map network identifies a winning neuron using the same procedure as employed by a competitive layer. However, instead of updating only the winning neuron, all neurons within a certain neighborhood of the winning neuron are updated using the Kohonen rule.

The weights of the winning neuron (a row of the input weight matrix) are adjusted with the Kohonen learning rule. Supposing that the i th neuron wins, the elements of the i th row of the input weight matrix are adjusted as shown below.

$$iW_{1,1}(q) = iW_{1,1}(q-1) + \alpha(p(q) - iW_{1,1}(q-1))$$

The Kohonen rule allows the weights of a neuron to learn an input vector, and because of this it is useful in recognition applications. Thus, the neuron whose weight vector was closest to the input vector is updated to be even closer. The result is that the winning neuron is more likely to win the competition the next time a similar vector is presented and less likely to win when a very different input vector is presented. As more and more inputs are presented, each neuron in the layer closest to a group of input vectors soon adjusts its weight vector toward those input vectors. Eventually, if there are enough neurons, every cluster of similar input vectors will have a neuron that outputs 1 when a vector in the cluster is presented, while outputting a 0 at all other times. Thus, the competitive network learns to categorize the input vectors it sees.

Finding the negative distance between input vector p and the weight vectors and adding the biases b compute the net input. If all biases are zero, the maximum net input a neuron can have is 0. This occurs when the input vector p equals that neuron's weight vector. After this computation all neurons within a certain neighborhood $N_i^*(d)$ (2) of the winning neuron are updated using the Kohonen rule. Specifically, we adjust all such neurons as follows.

$$iW_{1,1}(q) = iW_{1,1}(q-1) + \alpha(p(q) - iW_{1,1}(q-1))$$

or

$$iw(q) = (1 - \alpha) iw(q - 1) + \alpha p(q)$$

Here the neighborhood $N_i^*(d)$ (2) contains the indices for all of the neurons that lie

Within a radius " d " of the winning neuron i^* (1).

$$N_i(d) = \{ j, d_{ij} \leq d \}$$

Thus, when a vector is presented the weights of the winning neuron and its close neighbors move toward. Consequently, after many presentations, neighboring neurons will have learned vectors similar to each other[6].

V. UNSUPERVISED CLASSIFICATION

Unsupervised Neural networks are one of the most fascinating topics in the neural network field. Such networks can learn to detect regularities and correlation in their input and adapt their future responses to that input accordingly. The neurons of competitive networks learn to recognize groups of similar input vectors. Self-organizing maps learn to recognize groups of similar input vectors in such a way that neurons physically near each other in the neuron layer respond to similar input vectors[7].

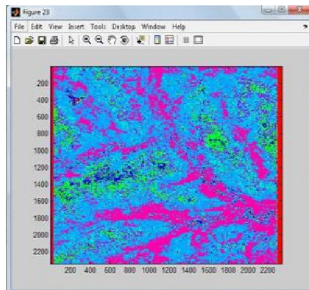
Learning vector quantization (LVQ) is a method for training competitive layers in a supervised manner. A competitive layer automatically learns to classify input vectors. However, the classes that the competitive layer finds are dependent only on the distance between input vectors. If two input vectors are very similar, the competitive layer probably will put them in the same class. There is no mechanism in a strictly competitive layer design to say whether or not any two input vectors are in the same class or different classes.

Self-organizing feature maps (SOFM) learn to classify input vectors according to how they are grouped in the input space. They differ from competitive layers in that neighboring neurons in the self-organizing map learn to recognize neighboring sections of the input space. Thus, self-organizing maps learn both the distribution (as do competitive layers) and topology of the input vectors they are trained on.

The neurons in the layer of an SOFM are arranged originally in physical positions according to a topology function. Distances between neurons are calculated from their positions with a distance function.

An unsupervised classification is experimented on a IRS/1D L3 Image of a Banasthali region. This image of size 2340*2511 consists of 3 bands 0.52 - 0.59 microns (B2), 0.62 - 0.68 microns (B3), 0.77 - 0.86 microns (B4) and 1.55 - 1.7 microns (B5). The aim of the classification is to distinguish between vegetation, fallow land, water body, grazing land, open scrub and salt affected area of the Image. Features are the characteristics of the image like statistical features (e.g. mean, minimum, maximum, variance, covariance, co relation, and std. deviation), band ratio and difference between to images of the same area (i.e. taken at difference of time span). Mean is used as the statistical feature. A Three-by-Eight Neural Network that consists of 24 nodes with hexagonal topology has been used in this work. There is no bias in the SOFM neural network. Weights initially are kept at the intermediate value of the minimum & maximum gray of the image pixels.

The following images (A) and (B) are the input and the classified images respectively using self organizing feature map



VI. CONCLUSION

In the present work the classifications for multispectral satellite images using self organizing feature map have been done. The classification difference taken over a period of time can be used for trend analysis using SOFM. Such techniques can indeed be applied for a variety of purposes such as deforestation, archeology, urban planning and development, damage assessment, defense intelligence, and environmental monitoring, weather forecasting etc. The work is executed using the Image Processing and

Neural Network toolboxes of MATLAB because of the definite advantage of flexibility and expandability.

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