Teaching Neural Networks on the World Wide Web

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Abstract

An implementation of artificial neural networks is proposed to be added to the "Mind and Machine" web page for teaching neural networks on the World Wide Web. An unsupervised network will be designed that uses Principal Component Analysis to develop pattern recognition capabilities. An attempt will be made to write the code in High Performance Fortran as well as C in order to exploit the potential of using parallelism in neural nets. The current hypertext homepage for "Mind and Machine" is accessible at: *http://altair.syr.edu:2024/MM.*

1 Introduction

An artificial neural network (ANN) is a machine or algorithm modeled after the design and function of the brain. A network of many simple processors (*nodes*) are linked together in layers. There are input and output layers, each containing any number of nodes. There can also be hidden layers separating the input from the output and they also hold an arbitrary number of nodes. Each node contains some small amount of data and each link has a weight associated with it. (see Fig 1)

The network is trained in such a way that the weights will be manipulated until the ANN can generalize the input to produce the correct or most correct output. This training can be done using either supervised or unsupervised learning. An ANN undergoes supervised learning when the training pattern has both the input vectors and the corresponding output vectors available. In a manner of speaking, there is a "teacher" to guide the net to the correct output. Unsupervised learning doesn't have a teacher, rather it incorporates local information and internal rules to associate the different inputs with the different outputs.

A growing part of the study of artificial intelligence, neural networks are thought to be a link to true biological machines. The attraction of ANN comes from the need for a processor which has the functionality of the brain and the switching speed of a

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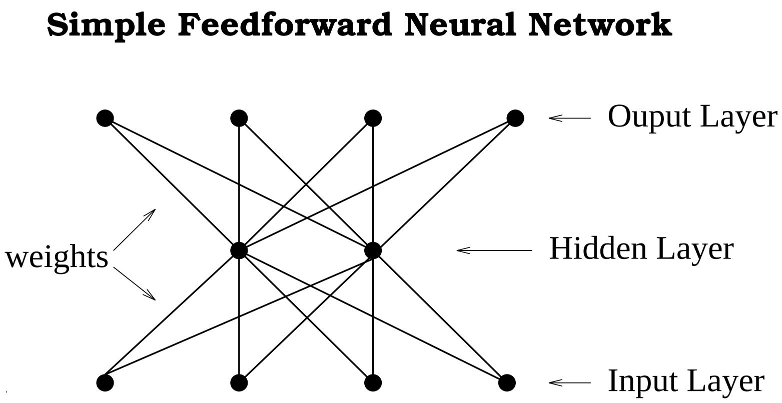

Fig. 1. *Example of an artificial neural network*

computer. They have many high performance applications such as the pronunciation of written English, handwritten character recognition, even autonomous land vehicles which can drive independent of human control [3].

A need for non-science majors to familiarize themselves with the fundamentals of neural networks led to the creation of a World Wide Web site called "Mind and Machine". The purpose of this page was to introduce students the basics of neural networks and artificial intelligence using tutorials and interactive simulations. The Syracuse University Physics department is responsible for the maintenance of this site [1].

2 Training

Efficient neural net output is dependent upon an effective algorithm for determining the values of the weights. The Hebb rule, or Hebbian learning, is the basis in many ANN applications for calculating the weights:

$$\Delta w_{ij} \propto O_j * \epsilon_i \tag{1}$$

where O is the output node and ϵ is the input pattern.

One of the unsupervised learning methods well suited to pattern recognition using Hebbian learning is Principal Component Analysis (PCA) [3]. PCA (also known as the Karhunen-Loeve transform) follows the idea that repetitious exposure to information can lead to "knowledge". An unsupervised ANN will determine its outputs by measuring the similarities of the inputs against patterns it has seen in the past. The goal of PCA is to find the greatest area of variance in the N dimensional data and find some group of orthogonal vectors which account for that space. The actual data is then projected onto the new orthogonal subspace of dimension M. When M is smaller than N the amount of data is reduced while retaining most of the pertinent information.

We can define the relationship between the input patterns by the correlation matrix C with components

$$C_{ij} \equiv < \epsilon_i \epsilon_j > \tag{2}$$

where $< ... >$ is the average over all the input patterns. This symmetry matrix has eigenvectors which are orthogonal and real. The eigenvectors are then placed in decreasing order according to their associated eigenvalues in such a way that the eigenvector with the largest eigenvalue is equal to the 1^{st} Principal component, the eigenvector with the second largest eigenvalue is equal to the 2^{nd} Principal component, etc. In Figure 2 the graph of the initial input patterns is shown. The axis has been rotated in such a way that the first principal component points in the main direction of the input. The second component would then be taken along the next orthogonal line with the greatest amount of variance, and so on [4].

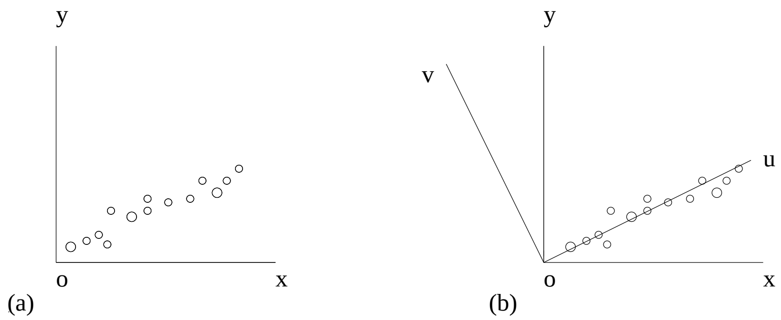

FIG. 2. *Principal Component extraction: (a) The initial graph (x,y) displays the input, (b) The new graph (u,v), is (x,y) rotated in the direction of the greatest input variance, the First Principal Component.*

3 Parallelization

While the computer is a million times faster in computation, the brain is a billion times faster in tasks such as vision, motor skills, and analyzing noisy data [2]. What is needed is a device that can combine the attributes of both mind and machine. Neural nets have a parallel, interconnective architecture which is advantageous in parallel computing. Using High Performance Fortran (HPF) may underscore the parallel nature of this network and improve upon the applications of ANNs in technology.

4 Proposed Work

The purpose of this project is to introduce nonscience majors to the idea and of Unsupervised Neural Networks. Simultaneous research will be done to test the capabilities of programming neural networks in a new parallel language.
The tasks at hand are:

- Write an unsupervised artificial neural net based on PCA in C that handles pattern recognition.
- Write a parallel implementation of the program using High Performance Fortran.
- Incorporate the ANN code into the "Mind and Machine" web site.

References

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