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High Performance Modeling of Intelligent Pattern Recognition with Enhanced Fault-Tolerance in Real Time

Renukaradhya P.C[1], Shobha M[2]

Abstract

Designing an ANN which could recognize the learned patterns even if there is variation in applied test patterns from learned patterns. A mechanism has been developed which provided the recognition facility intelligently. Recognition of patterns can be broadly categorized into two classes. When precision of recognition is not defined, term name "Forced recognition" given to the process. When precision of recognition is properly defined termed "Custom recognition" given to process. Analysis of fault tolerant property of feed forward architecture will be given training with back propagation method. Under this, analysis of effect of initially selected random weights and what should be the nature of random weights so that to maximize the fault tolerance capability of system has done. Analysis can be done with two different distribution namely Gaussian distribution and Uniform distribution. Effect of faults at output is also a function of fault position in ANN system like Hidden layer weight, Output layer weights, with processing elements at hidden layer. Analysis capability of back propagation algorithm itself is to tolerate the fault by learning process. A development of test mechanism to check faulty system in coming future is ANN system in hardware world i.e. on the VLSI chip. Once the architecture implemented it is required a mechanism to check the functioning. Analysis of internal parameters of ANN is completely research work with behavior of internal parameters, which will provide all responsible factors behind success of an ANN.

Keywords

Artificial Neural Network, Patterns, Forced recognition, Custom recognition, Fault Tolerant.

Renukaradhya P C, Department of Computer Science & Engineering, Visvesvaraya Technological University, Shridevi Institute of Engineering & Technology, SCT, Tumkur, India.

Shobha M, Department of Computer Science & Engineering, Visvesvaraya Technological University, Shridevi Institute of Engineering & Technology, SCT, Tumkur, India.

1. Introduction

An Artificial Neural Network (ANN) also called Neural Network is an information-processing paradigm that is inspired by the way biological nervous systems, such as the brain process information [1]. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in parallel to solve specific problems. ANNs, like people, learn by example [2]. An ANN is configured for a specific application, such as pattern recognition, signal processing and data classification etc., through a learning process. Hence neural networks take a different approach to problem solving than that of conventional computers, which use an algorithmic approach i.e., they follow a set of instructions (program) in order to solve a problem. Conventional computers cannot solve the problem unless the specific steps they need to follow are known [3]. Whereas neural networks cannot be programmed to perform a specific task. They process information in a similar way the human brain does. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of neural networks as well. ANNs have been applied to an increasing number of real-world problems of considerable complexity. Most important advantage of ANN is in solving problems that are too complex for conventional technologies-problems that do not have an algorithmic solution or for which an algorithmic solution is too complex to be found [4]. In general, because of their abstraction from the biological brain, ANNs are well suited to problems that people are good at solving, but for which computers are not.
"Neural networks do not perform miracles. But if used sensibly they can produce some amazing results".

2. Pattern Recognition and Fault tolerance in neural networks

Pattern recognition is one of the applications of neural network. It is a field within the area of

machine learning [5], which aims to classify patterns [7] based on a priori knowledge or information extracted from the patterns. It can be defined as the act of taking in raw data and taking an action based on the category of that data.

2.1 Fundamental Principle Applied for Pattern Recognition

Degree of maximum correlation is taken as the deciding parameter for pattern recognition in our dissertation. If there is two set of values [X] & [W] and a function '*f* ' exists such that the given condition

$$\mathbf{f(\Sigma X_i * W_{ik}) > f(\Sigma Xj * W_{ik})}$$

Satisfies for a particular tuple $\{X_i, W_{ik}\}$ and any other tuple $\{Xj, W_{ik}\}$, where $X_i, X_j \in [X]$, $i \neq j$, then value of function *f* can be taken as Degree of correlation between 'X_i' & 'W_{ik}'.

3. Proposed Feed Forward Architecture

Working with three layer feed forward architecture [6] with input, hidden and output layer respectively [12]. Feed forward architecture is the most general and supports lot of applications, one among which is pattern recognition [8].

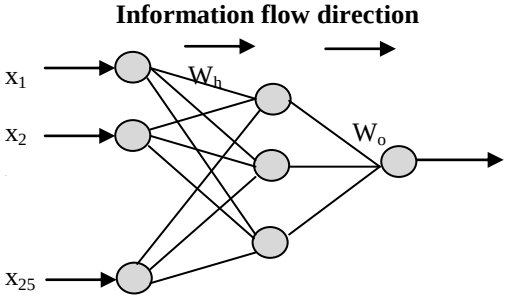

Fig. 1: Proposed feed forward ANN architecture

3.1 Operation flow

ANN also referred to as "parallel distributed processing system" [14]. This is because all the nodes at the same layer process operation at the same time and are independent of each other and the output from each node is distributed to all the nodes of the next layer [9]. The input nodes are passive since they just replicate the information whatever they possess and pass them to the hidden nodes. The hidden nodes are active, which extract the input features and maps them into other domain that is made availed to the outer layer. The outer node is active as well. So the hidden layer and the output layer do all the necessary computations. The links between the layers carry the signal [10] from one node to the next node with the aid of connection weights, which can amplify or diminish the signal strength. These weights are modifiable using learning algorithm to obtain the desired output.

3.2 Selection of Learning Algorithm

Supervised learning is required for pattern matching and Generalized Delta Rule (GDR) used in so called Error Back Propagation Algorithm (EBPA) is the most popular of the supervised learning techniques used to train a feed forward multi-layered artificial neural network The EBPA uses gradient descent to achieve training by error correction, where network weights are adjusted to minimize error based on a measure of the difference between desired and actual feed forward network output. Desired input/output behavior is given in the training set where the input & the target values {i, t} are predefined. As the name 'Error Back Propagation' itself suggests, the generated error signal at the network output is propagated backwards. The algorithm tries to minimize an error function, starting from the output layer towards the input layer, which is defined as the mean square of the generated error signal over the set of training data. It requires an error function to adjust the weights in a proper direction, as to provide the maximum co-relation with respect to the inputs, so that the network can converge towards a state that allows all the training patterns to be encoded, so this algorithm opted for training ANN.

3.3 Fault Tolerance Analysis

The ultimate goal of any technology is its physical implementation. Software simulation plays a very important role in the hierarchy of physical implementation process

3.3.1 Place of Faults Inside the System

Connection Weights: Fault tolerating capability [11] is maximum irrespective of position of faults in W_h because the output isn't directly linked and the distribution of work is very high at this layer, but in case if faults occur in W_o, the tolerance depends upon

where the fault occurs, since the distribution of work is very less.

There are two types of fault, viz., Open circuit type fault (0) and Short circuit type fault (1). Former type of faults (0) are much sensitive than latter type of faults (1) or to say in other words fault tolerance is more for short circuit type of faults because the activation function (Sigmoid) provides maximum output value for such type of input faults and for faults of type 0 it provides half of the maximum output obtained for faults of type 1.

Because the number of hidden layer links with respect to output layer links is maximum, probability of fault occurrence is maximum in these links only and also tolerating capability is maximum. This means this layer is less sensitive compared to the output layer towards affecting the response.

Processing Elements: If we know the most sensitive nodes where sensitivity is defined in terms of affect at the output, it's a good information about fault tolerance capability of that system. It's an achievement of our project to provide knowledge of sensitivity of nodes before the start of experiment. This information is obtained by all the random values selected as the output layer weights. The weight pattern at this layer remains same even after training irrespective of any kind of input patterns available. The hidden layer node having maximum random value at its output link will remain contain this maximum value & this node will become the most sensitive node after training. So if any fault happens at this node, affect at the output will be maximum. This is enough information to reduce the sensitivity w.r.t faults in maximally affecting case of nodes.

Solution: It has been proposed to create either a redundant node for a part of processing operation or provide a facility of global correction in terms of defining a node globally for a particular active node layer.

3.3.2 Place of Faults Outside the System

If any fault happens with the input itself, the same will be mapped onto by the hidden layer and because of the parallel distributed computation of ANN, maximum fault tolerance [13] capability defined at hidden layer and hence the input faults are less sensitive towards affecting the final response.

3.3.3 Selection of Random Weights

Very less work has been done like what should be the nature of random weights from the point of view of fault tolerant capability. By experience, it is found that if the random values are taken from the Gaussian distribution [mean→0, variance→1] tolerance capability is more as compared to if data taken from uniform distribution. This is because the variation among data values is large in Gaussian distribution as compared to uniform distribution. So if any faults happen at the low value weights, it can be more tolerable and the high value weights are much sensitive towards affecting the output. Where as if data are from uniform distribution, since the variation among values is very less, fault in any data poses nearly equal affect at the output and is more.

The criteria selected for recognition [15] of patterns is the principle of maximum correlation, which for a particular set of input and weights is achieved by delta rule. Two different approaches of recognition have been created namely forced recognition & custom specified recognition. In forced recognition where decision must be taken in favor of things which has been learned previously, using just maximum correlation method. Where as in the latter case a true correlation value set is compared with new set of correlation value. Decision is defined in terms of precision required in recognition. For very high precision, a small threshold is required, so precision can be changed by just adjusting the threshold value. Result of pattern recognition is very satisfactory.

Analysis of fault tolerance for a system is difficult task. All three possible places of fault inside the system, hidden layer weights W_h, outer layer weights W_o & combination of both has been experimented. Because W_o has more direct affect on output as compared to W_h, so sensitivity with respect to Wo is very high if any fault happen compared to W_h. But the probability of fault is high for W_h because there is more available space. Also if fault occurs in the input, the same will be mapped onto by the hidden layer and due to parallel-distributed processing of the system, maximum fault tolerance capability exhibited by the hidden layer and hence overall probability of tolerating faults is very high in multilayer feed forward systems.

Random value of W_o plays a very high role in defining the sensitivity of place with respect to faults. It is shown that probability to tolerate the fault can be defined for each & every place just by using the

analysis of random values of Wo. Several graphs have been used to analyze the system as well as to prove our some assumptions.

By experiencing in our project, it is found that if the data (initial random values) are taken from Gaussian distribution, tolerance capability is more as compared to if data taken from uniform distribution.

4. Graphical Analysis

The graphical analysis helps to analyze the internal mechanism of the system through which it is able to understand the things better what actually designed and developed, so that the analysis can lead to further improvement in system performance. The following graphs provide good analysis of the system's internal mechanism, once execution is successfully completed.

Random weights have been selected from Gaussian Distribution (GD) for first subplot, by which hidden layer weights forming a meshed pattern using random values can be identified. This represents the basic principle of maximum/ minimum correlation, since there is no pattern associated.

From the second subplot, a pattern is available which has highest value as well as the lowest one. Initially because of random nature, it is not able to draw any conclusion from this graph, but with experiment it has found that, this pattern playing a very important role in the fault analysis as well as pattern recognition.

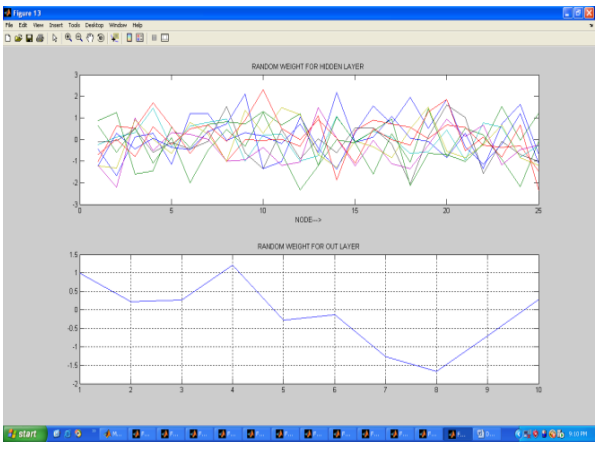

Fig 2: Random Weights between Input to Hidden layers and hidden to output layer

5. Conclusions

The criteria selected for recognition of patterns is the principle of maximum correlation, which for a particular set of input and weights is achieved by delta rule. Two different approaches of recognition have been created namely forced recognition & custom specified recognition.

Analysis of fault tolerance for a system is difficult task. All three possible places of fault inside the system, hidden layer weights W_h, outer layer weights W_o & combination of both has been experimented. Because W_o has more direct affect on output as compared to W_h, so sensitivity with respect to W_o is very high if any fault happen compared to W_h. By experiencing, it has found that if the data (initial random values) are taken from Gaussian distribution, tolerance capability is more when compared to the data taken from uniform distribution.

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Renukaradhya P C completed Master of Technology in Computer Science and Engineering at University BDT college of Engineering, Davanagere and completed his Bachelor of Engineering degree at Sri Siddhartha Institute of Technology at Tumkur. He worked as a Lecturer in Department of Computer Sceience and Engineering at HMS Institute of Technology, Tumkur. Presently he is working as a Senior Lecturer in Department of Computer Sceience and Engineering at Shridevi Institute of Engineering & Technology, Tumkur. His research interests are Artificial Neural Networks, Artificial Intelligence, Computer Graphics and Image processing.

Shobha M is Master of Engineering scholar in the Department of Computer Network & Engineering, at University Visveswaraya College of Engineering, Bangalore and done Bachelor of Engineering in computer science and engineering at University BDT college of Engineering, Davanagere. Presently she is working as a Senior Lecturer in Department of Computer Sceience and Engineering at Shridevi Institute of Engineering & Technology. Her research interest lies in Image processing and neural networks.