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More Accurate and Fast Fault Identification on Power Networks using Artificial Neural Networks

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Abstract: ***This paper is mainly on illustrating the inherent potential of artificial intelligence(AI) tools and techniques to accurately predict and detect faults at an early stage in power systems. An AI mainly monitors and predicts locus 'n' nature of faults at an early stage on particular sections of power systems which increase the reliability and quality of the power system. The detector for this early warning fault detection device only requires external measurements taken from the input and output nodes of the power system. The AI detection system is capable of rapidly predicting a malfunction within the system. Artificial neural networks (ANNs) are being used at the core of the fault detection. Furthermore, comments on an evolutionary technique as the optimization strategy for ANNs are included in this work.***

Index Terms— ***Fault detection, fault identification, fault classification, artificial neural networks, power system networks, power quality, power reliability.***

I. INTRODUCTION

In the past several decades, there has been a rapid growth in the power grid all over the world which eventually led to the installation of a huge number of new transmission and distribution lines. Moreover, the introduction of new marketing concepts such as deregulation has increased the need for reliable and uninterrupted supply of electric power to the end users who are very sensitive to power outages.

Any abnormal flow of current in power systems components is called a fault in the power system. These faults cannot be completely avoided since a portion of these faults also occur due to natural reasons which are way beyond the control of mankind. Hence, it is very important to have a well coordinated protection system that detects any kind of abnormal flow of current in the power system, identifies the type of fault and then accurately locates the position of the fault in the power system.

The faults are usually taken care of by devices that detect the occurrence of a fault and eventually isolate the faulted section from the rest of the power system. Hence some of the important challenges for the incessant supply of power are detection, classification of faults. Faults can be of various types namely transient, persistent, symmetric or asymmetric faults and the fault detection process for each of these faults is distinctly unique in the sense, there is no one universal fault location technique for all these kinds of faults.

The High Voltage Transmission Lines (that transmit the power generated at the generating plant to the high voltage substations) are more prone to the occurrence of a fault than the local distribution lines (that transmit the power from the substation to the commercial and residential customers) because there is no insulation around the transmission line cables unlike the distribution lines.

The reason for the occurrence of a fault on a transmission line can be due to several reasons such as a momentary tree contact, a bird or an animal contact or due to other natural reasons such as thunderstorms or lightning. Most of the research done in the field of protective relaying of power systems concentrates on transmission line fault protection due to the fact that transmission lines are relatively very long and can run through various geographical terrain and hence it can take anything from a few minutes to several hours to physically check the line for faults.

The automatic location of faults can greatly enhance the systems reliability because the faster we restore power, the more money and valuable time we save. Hence many utilities are implementing fault locating devices in their power quality monitoring systems that are equipped with Global Information Systems for easy location of these faults. Fault location techniques can be broadly classified into the following categories

- Impedance measurement based methods
- Travelling-wave phenomenon based methods
- High-frequency components of currents and voltages generated by faults based methods
- Intelligence based method

From quite a few years, intelligent based methods are being used in the process of fault detection and location. Three major artificial intelligence based techniques that have been widely used in the power and automation industry are:

- Expert System Techniques
- Artificial Neural Networks
- Fuzzy Logic Systems

Among these available techniques, Artificial Neural Networks (ANN) has been used extensively in this project for fault location on electric power transmission lines. These ANN based methods do not require a knowledge base for the location of faults unlike the other artificial intelligence based methods.

II. FAULTS

In an electric power system, a fault is any abnormal flow of electric current. Example, a short circuit is the fault in which current flow bypasses the normal load.

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Open-circuit fault occurs if the circuit is interrupted by some failure. In three-phase systems, a fault can involve one or more phases and a ground, or also may occur only between phases. In "ground fault", the current flows into earth. The likely to happen in future, short circuit current of a fault can be calculated. In power systems, the protective devices will detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure.

In a polyphase system, a fault may affect all phases equally which is a "symmetrical fault". When only some phases are affected, the resulting "asymmetrical fault" becomes more complicated to analyze due to the simplifying assumption of equal current magnitude in all phases has being no longer applicable. Analysis of such type of fault is more often simplified by using methods such as symmetrical components.

A. Transient fault

A transient fault is a fault that is no longer present if power is disconnected for a short time. Most of the faults in overhead power lines are transient. On occurrence of a fault power system protection operates to isolate area of the fault. The transient fault will then be cleared and the power line can return to service.

Some examples of transient faults include:

- Momentary Tree Contact
- Bird or Other Animal Contact
- Lightning Strike
- Conductor Clash

In electricity transmission and distribution systems an automatic re-close function is commonly used on overhead lines to attempt to restore power in the event of a transient fault. This auto re-close functionality is not as common on underground systems as faults there are distinctively of a persistent behavior. Transient faults can cause damage both at the location of the original fault or elsewhere in the network as fault current is generated.

B. Persistent fault

A persistent fault does not disappear when power is disconnected. Faults in underground power cables are most often persistent due to mechanical damage to the cable, but are sometimes transient in nature due to lightning.

C. Symmetric fault

A symmetric or balanced fault affects each of the three phases equally. In the transmission line faults, just roughly 5% are symmetric. Which upon comparison with asymmetric fault, three phases are not affected equally. In practical, most faults in power systems are mostly unbalanced.

Keeping this in mind, symmetric faults can be somewhat of an abstraction; however, as asymmetric faults are difficult to analyze, analysis of asymmetric faults is built up from a thorough understanding of symmetric faults.

D. Asymmetric fault

An asymmetric or unbalanced fault does not affect each of the three phases equally. Few Common asymmetric faults and their causes are:

- Line-to-line - a short circuit between lines, caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator.
- Line-to-ground - a short circuit between one line and ground, very often caused by physical contact, for example due to lightning or other storm damage.
- Line to line-to-ground - two lines come into contact with the ground (and each other), also commonly due to storm damage.

The different types of faults that could occur on three phase A.C. system are:

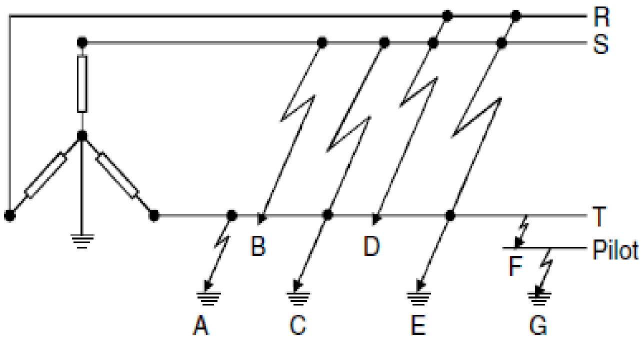

Fig: 1

Where there represents the following faults:
(A) Phase-to-earth fault
(B) Phase-to-phase fault
(C) Phase-to-phase-to-earth fault
(D) Three phase fault
(E) Three phase-to-earth fault
(F) Phase-to-pilot fault *
(G) Pilot-to-earth fault *

* In underground mining applications only

It will be noted that for a phase-to-phase fault, currents will be huge, because the fault current is only limited by the inherent (natural) series impedance of the power system up to the point of faulty (refer Ohms law). By pattern, this existing series impedance in a power system is purposely chosen to be as low as possible in order to get maximum power transfer to the consumer and limit unnecessary losses in the network itself in the interests of efficiency.

On the other hand, the magnitude of earth faults currents will be determined by the manner in which the system neutral is earthed. Solid neutral earthing means high earth fault currents as this is only limited by the inherent earth fault (zero sequence) impedance of the system.

It is worth noting at this juncture that it is possible to control the level of earth fault current that can flow by the judicious choice of earthing arrangements for the neutral. In other words, by the use of Resistance or Impedance in the neutral of the system, earth fault currents are engineered to be at whatever level it is desired and are therefore easily controllable. This cannot be achieved for the phase faults.

The fault in electrical transmission line which gives rise to symmetrical fault current is called symmetric fault. e.g. L-L-L-G fault.

The fault in transmission line which gives rise to unsymmetrical fault current is called unsymmetrical fault. e.g. L-L , L-G , L-G fault

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To solve unsymmetrical faults, fault current can be represented by sum of the sequences those are: zero phase sequence, +ve phase sequence, -ve phase sequence.

- L-G faults------------75-80 %
- L-L faults---------------5-7 %
- L-L-G faults---------10-12 %
- L-L-L-G faults------- 8-10 %

L-L faults have less number of occurrences because the distance between the two lines is adequate.

III. DIFFERENT ARTIFICIAL INTELLIGENCE TECHNIQUES

There is a need for the measuring algorithms that have the ability to adapt dynamically to the system operating conditions such as changes in the system configuration, source impedance and fault resistances. The trend since 90's, intelligent techniques are under investigation to increase the reliability, speed and also the accuracy of existing digital relays based on Artificial Neural Network (ANN), Fuzzy Logic (FL), Fuzzy-Neuron, Expert systems and Fuzzy Logic-Wavelet based systems.

ARTIFICIAL NEURAL NETWORK (ANN)

The accuracy of electromechanical, static or microprocessor based distance relay is affected by different fault conditions and network configuration changes.

So ANN techniques are under investigation over the past 20 years, which can easily adapt dynamically to the system operating conditions at high speed. The ability of an ANN to learn by training any complex input/output mapping and recognize the noisy patterns (those with desired segments missing and/or undesired segments added) gives them the powerful property of pattern recognition and classification (Haykin, 1994).

ANNs can solve the overreach and the under reach problems which are very common in the conventional distance relay design. ANN utilizes samples of currents and voltages directly as inputs without computation of phasors and related symmetrical components. Various kinds of neural network such as multi-layer perceptron (MLP), recurrent, radial basis function (RBF), probabilistic neural network and other techniques are being applied for the fault classification and also the fault location.

These can be designed by various training algorithms like back propagation, orthogonal least square, etc... The use of ANNs can extend the first zone of distance relays and enhance system security.

For selecting the appropriate network configurations, basic performance criteria are the fault tolerance, minimal response time and generalization ability. Artificial Neural Network approach has been utilized to improve some of the standard functions used in protection of transmission lines.

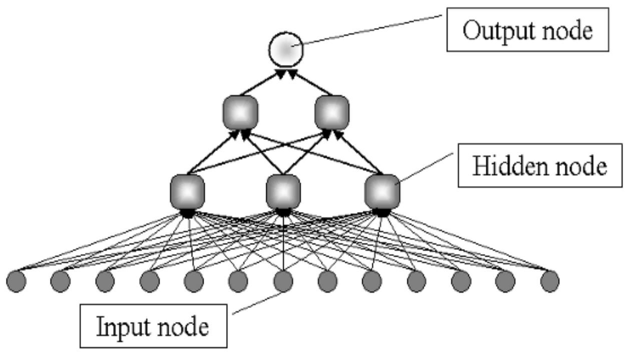

Fig: 2

They have been related to the fault detection and classification, distance protection improvements in fault distance computation, protection of series compensated lines, adaptive distance protection and adaptive reclosing.

To make the ANN responsive to time varying voltage and current waveforms different types of recurrent networks we reconsidered that allow hidden units of network to see their own previous outputs, so that the subsequent behavior can be shaped by previous result. Such an Elman recurrent network designed to act as the fault direction detection module of a transmission line is proposed by Sanaye al., (1999). Inside these Artificial Neural Networks the operations that take place are not clearly defined and hence they are not considered as highly reliable. Further development is the concept of supervised clustering to reduce the number of iterations in the learning process of multi layer feed forward networks (Kezunovic et al., 1995). A neural network simulator is developed by Venkateshan et al., (2001).

To identify the optimum ANN structure required for training the data and to implement the ANN also in hardware. Still the problem relating Artificial Neural Network's is that no exact rule exists for the choice to the number of hidden layers and neurons per each hidden layer. Hence, it is clearly uncertain whether the ANN based relay gives the most conducive output, to maintain integrity of the boundaries of relay characteristics. A high speed distance relaying scheme based on radial basis function neural network (RBFNN) is proposed by Pradhan al., (2001), due to its significant capability to distinguish faults with data falling outside the training pattern.

A sequential procedure is presented by Dash et al., (2001), for distance protection using a minimal radial basis function neural network (MRBFNN), to determine the optimum number of neurons in the hidden layer without resorting to trial and the error. The use of separate ANNs, for faults involving earth and not involving earth has proved to be convenient way of classification of transmission faults based on RBF neural networks by Mahanty et al., (2004). For simple and reduced architecture and better learning capability a modular neural network, is proposed by Lahiri et al., (2005), Pradhan et al., (2001) to discriminate the direction of faults for transmission line protection.

Such a network also considers the corresponding phase/ground voltage and current information as input and thereby the redundant inputs in conventional approaches are eliminated.

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The existing ANN based solutions easily converge on local minima whenever input patterns with large dimensionality are present and when designed for specific applications those are prohibitively expensive or infeasible for real time implementations. It is observed that the ANN based distance relays need much larger training sets and hence the training of these networks is time consuming and further research work shall produce a hardware realization with proper modification in the learning methodology and preprocessing of input data that would improve the learning rate of performance, efficiency and the reliability many folds. Presently research efforts are in the direction of evolutionary computational techniques such as genetic algorithms (GA) for determining the neural network weights and thereby avoid training of ANN.

IV. ARTIFICIAL NEURAL NETWORK (ANN)

A. What is Neural Net?

- A neural net is an artificial representation of the human brain that tries to simulate its learning process. An artificial neural network (ANN) is often called a "Neural Network" or simply Neural Net (NN).
- Traditionally, word neural network is related to a chain of biological neurons in the nervous system that process and transmit information.
- Artificial neural network is a chained group of artificial neurons that uses a mathematical model or computational model for information processing based on a connectionist approach to computation.
- The artificial neural networks comprise of inter joined artificial neurons which may share some properties of biological neural networks.
- Artificial Neural network is a group of interconnections of simple processing elements (neurons) which can exhibit complex global behavior, determined by the connections between the processing elements and element parameters.
- Artificial neural network is suitable for system that changes its structure based on through the network.

The simplest definition of a neural network, more properly referred to as an 'artificial' neural network (ANN), is provided by the inventor of one of the first neuron-computers, Dr. Robert Hecht-Nielsen. He defines a neural network as, "use of computing system which is made up of a number of simple and greatly interconnected computing elements, which compute information by their static state response to external inputs.

B. Why Neural Network?

- The conventional computers are good for - fast arithmetic and do what programmer programs, ask them to do.
- The convention computers are not that good for - interacting with noisy data or data from the environment, massive parallelism, tolerance, and adapting to circumstances.
- The neural network systems help where we cannot formulate an algorithmic solution or where we can get lots of examples of the behavior we require.
- Neural Networks follow different paradigm for computing. The von Neumann machines are based on the processing/memory abstraction of human information processing.
- The neural networks depend on the parallel structures of biological brains.
- Neural networks are a form of multiprocessor system with

→ simple processing elements ,
→ a high degree of interconnection,
→ simple scalar messages, and
→ Adaptive interaction between elements.

C. Biological Neuron Model:

The human brain consists of more than a billion of neural cells that process information received. Each and every neural cell works like a simple processor. The huge communication between all cells and their parallel processing only makes the brain's abilities possible. Neural Networks are considered to be a prominent component of futuristic Artificial Intelligence.

Presently the name Neural networks is synonymous with Artificial Neural Networks (ANNs) whose working concept is similar to that of Human Nervous System, and hence the name.

Generally in Human body, Neural Networks are building blocks of the Nervous System which controls and coordinates the different human activities. Neural network consists of a group of neurons (nerve cells) interconnected with each other to carry out a specific operation. Each and every neuron is constituted by a cell body call Cyton and a fiber called Axon. The neurons are interconnected by the fibrous structures called dendrites by the help of special gapped connections called synapses. The electric impulses (called Action Potentials) are used to transmit information from neuron to neuron throughout the network.

Artificial Neurons are similar to their biological counter parts. The input joining of the artificial neurons are summed up to determine the strength of its output, finally its result of the sum being fed into an activation operation, the most frequently being the Sigmoid Activation which gives output varying between 0 (for low input values) and 1 (for high input values).

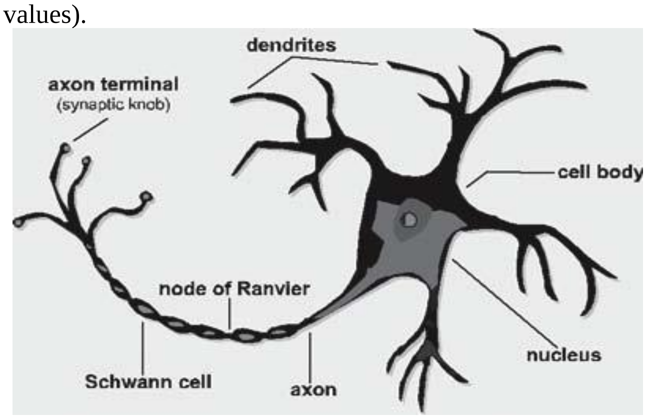

Fig: 8

Later the result of this function is passed as an input to other neurons through more connections, each of which are weighted and these weights determine the behavior of the network.

→ Dendrite receives the activation signal from other neurons.

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→ Soma performs operations on the incoming activations and converts them into output activations.
→ Axons behave like transmission lines to send activation to other neurons.
→ Synapses the junctions allow signal transmission between the axons and dendrites.
→ Procedure of transmission is through diffusion of chemicals called as neuro-transmitters.
→ A human brain contains about 10^11 neurons.
→ Each neuron has inputs (synapses connected to dendrites) and an output (axon ending in synapses).
→ One neuron generates input for 10^3…… 10^4 other neurons.
→ Each neuron receives data from 10^3…… 10^4 neurons.
→ Synapses connect each and every neuron to one another.
→ Signal is transmitted through releasing chemicals (neurotransmitters) from a sender neuron causing an electric potential in the receiving cell, etc.

An Artificial Neural Network (ANN) is basically an information processing system composed of a large number of interconnected processing elements (neurons) working in an integrated manner to solve particular problems. ANN is designed for particular applications, like pattern determination or data classification, through the understanding process.
An Artificial Neural Network (ANN) can be described as a set of elementary neurons that are usually connected in biologically inspired architectures and organized in several layers. The structure of a feed-forward ANN, also called as the perceptron is shown in Fig below.

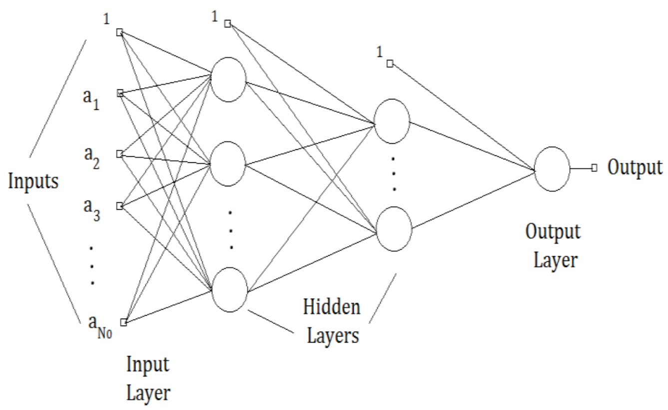

Fig: 9

There are Ni numbers of neurons in each ith layer and the inputs to these neurons are connected to the previous layer neurons. The input layer is fed with the excitation signals. Simply put, an elementary neuron is like a processor that produces an output by performing a simple non-linear operation on its inputs.
Neural networks are typically organized in layers. Layers are made up of a number of interconnected 'nodes' which contain an 'activation function'. Patterns are presented to the network via the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to an 'output layer' where the answer is output as shown above.

A weight is attached to each and every neuron and training an ANN is the process of adjusting different weights tailored to the training set. An Artificial Neural Network learns to produce a response based on the inputs given by adjusting the node weights. Hence we need a set of data referred to as the training data set, which is used to train the neural network.
In Fig above, a1, a2 ¡K aN0 is the set of inputs to the ANN. Due to their outstanding pattern recognition abilities ANNs are used for several purposes in a wide variety of fields including signal processing, computers and decision making. Some important notes on artificial neural networks are:
→Either signal features extracted using certain measuring algorithms or even unprocessed samples of the input signals are fed into the ANN.
→ The most recent along with a few older samples of the signals are fed into the ANN.
→ The output provided by the neural network corresponds to the concerned decision which might be the type of fault, existence of a fault or the location of a fault.
→ The most important factor that affects the functionality of the ANN is the training pattern that is employed for the same.
→ Pre-processing and post-processing techniques may be employed as well to enhance the learning process and reduce the training time of the ANN.

One of the biggest drawbacks of applications that make use of artificial neural networks is that no well-defined guide exists to help us choose the ideal number of hidden layers to be used and the number of neurons per each hidden layer. From a different perspective, it is advantageous considering the ability to generalize.
A vital feature of ANN is its dedication to parallel computing. Hence it can produce a correct output corresponding to any input even if the concerned input was not fed into the ANN during the training process. Another challenge in the ANN based application development was to synthesize the algorithm for the adaptive learning process. The back error-propagation algorithm is the basic algorithm in which the neuron weights are adjusted in consecutive steps to minimize the error between the actual and the desired outputs. This process is known as supervised learning.

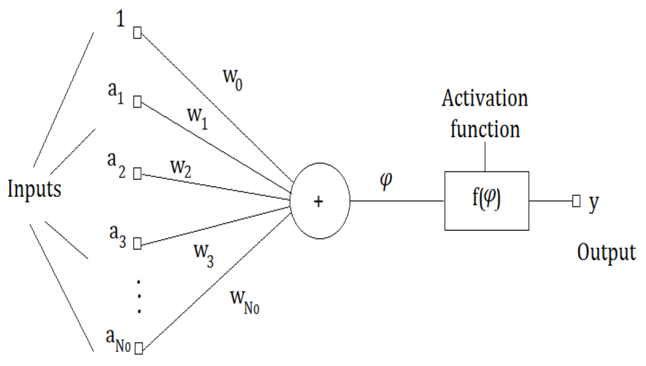

Fig: 10

→ A set of input connections brings in activations from other neurons.

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→ A processing unit sums the inputs, and then applies a non-linear activation function (i.e. squashing / transfer / threshold function).
→ An output line sends the result to other neurons. In other words,
→ Input to a neuron is received in the form of signals.
→ The signals build up in the cell.
→ Finally the cell discharges (cell fires) through the output .
→ The cell can begin to building up signals again.

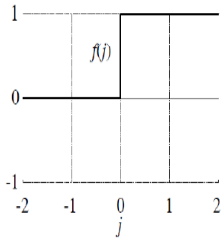
The output of the neuron is given by
y= f (φ) = f$\left(\sum_{i=0}^{N0}(W_i a_i)\right)$
Where: w0a0 is the threshold value (polarization), f (∅) is the neuron activation function,
∅ is summation output signal; y is the output of neuron.

$$\varphi = W^T A$$

Where: $W=[w_0,w_1 \ldots w_{k0}]$, $A=[a_0,a_1 \ldots a_{N0}]^T$
An activation function decides how powerful the output from the neuron should be, based on the sum of its inputs. Depending upon the application's requirements, the most appropriate activation function is chosen.
The activation function f (∅) can be in different forms a few of which are described below:

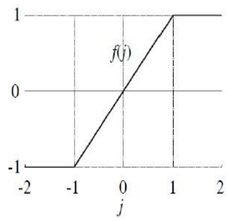
- Step function

$$f(\varphi)=\begin{cases}1 & \text{if } \varphi \geq 0\\ 0 & \text{if } \varphi < 0\end{cases}$$



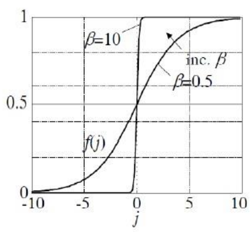
- Piece wise linear function

$$f(\varphi)=\begin{cases}1 & \text{if } \varphi > 1\\ -1 & \text{if } \varphi < -1\\ \varphi & \text{if } |\varphi| < 1\end{cases}$$



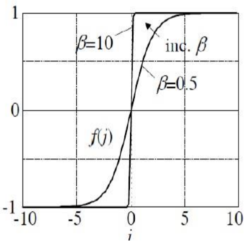
- Sigmoid unipolar function

$$f(\varphi)=\frac{1}{1+e^{-\beta\varphi}}$$



- Sigmoid bipolar function

$$f(\varphi)=\tanh(\beta\varphi)=\frac{1-e^{-2\beta\varphi}}{1+e^{-2\beta\varphi}}$$



Based on the way the neurons are interconnected in a model, neural networks can be broadly classified into two types namely feed forward and feedback networks. As the name suggests, feedback networks unlike feed forward networks have a feedback connection fed back into the network along with the inputs. Due to their simplicity and the existence of a well-defined learning algorithm, only feed forward networks are generally used.

D. Feed forward networks:

Feed forward networks are the simplest neural networks where there is no feedback connection involved in the network and hence the information travel is unidirectional. A feed forward network with N0 input and KR output signals is shown in Fig. The computation process in the ith layer can be described by the following equation

$$\mathbf{P}^{(i)} = f^{(i)}(\mathbf{W}^{(i)}\mathbf{g}^{(i-1)})$$

Where $\mathbf{P}^{(i)} = [P_1^{(i)}\ P_2^{(i)} \ldots P_{Ni}^{(i)}]^T$ is the signal vector at the output of the i^{th} layer

Where:

Is the weighing matrix between the $(i-1)^{th}$ and the i^{th} layer

$$g^{(i-1)} = \begin{cases} A & \text{for } i=1\\ \begin{bmatrix}1\\ p^{(i-1)}\end{bmatrix} & \text{for } i=2,3\ldots,R\end{cases}$$

A is the vector containing the input signals, f(i)(.) is the activation function of the neurons in the ith layer and R is the number of processing layers. All the neurons in a particular layer are assumed to be similar in all aspects and the number of hidden layers can be more than one and is usually determined by the purpose of the neural network. The output of the processed neural network is represented by the output vector:

$$y = p^{(R)} = [\ y_1\ y_2 \ldots y_{NR}\ ]^T$$

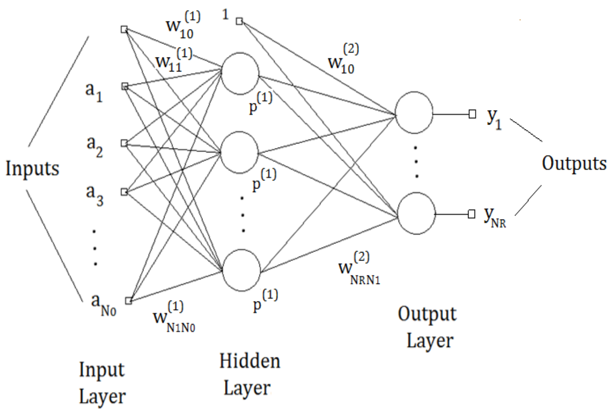


Fig: 15

E. Training of neuron

The basic concept behind the successful application of neural networks in any field is to determine the weights to achieve the desired target and this process is called learning or training. The two different learning mechanisms usually employed are supervised and unsupervised learning. In the case of supervised learning the network weights are modified with the prime objective of minimization of the error between a given set of inputs and their corresponding target values.

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Hence we know the training data set which is a set of inputs and the corresponding targets the neural network should output ideally. This is called supervised learning because both the inputs and the expected target values are known prior to the training of ANN.
On the other hand, in the case of unsupervised learning, we are unaware of the relationship between the inputs and the target values. We train the neural network with a training data set in which only the input values are known. Hence it is very important to choose the right set of examples for efficient training. These examples are usually chosen using some sort of a similarity principle. The most commonly used unsupervised learning algorithms are the Self-Organizing Map (SOM) and the Adaptive Resonance Theory (ART). The learning strategy employed depends on the structure of the neural network. Feed forward networks are trained using the supervised learning strategy. The supervised learning strategy for a feed forward neural network has been shown in the Fig
The set of input-output pairs that are used to train the neural network are obtained prior to the training process either by using physical measurements or by performing some kind of simulations. Fig shows that the teacher teaches the neural network to modify its weights according to the error 'e' between the outputs and the targets. The weights of the neural network are then modified iteratively according to equation. The general idea behind supervised learning and the mathematics involved has been adopted from.

$$W_{ji}(n+1) = w_{ji}(n) + \Delta w_{ji}(n)$$

F. Advantages and Disadvantages of ANN

Artificial neural networks are algorithms that can be used to perform nonlinear statistical modeling and provide a new alternative to logistic regression, the most commonly used method for developing predictive models for dichotomous outcomes in medicine.

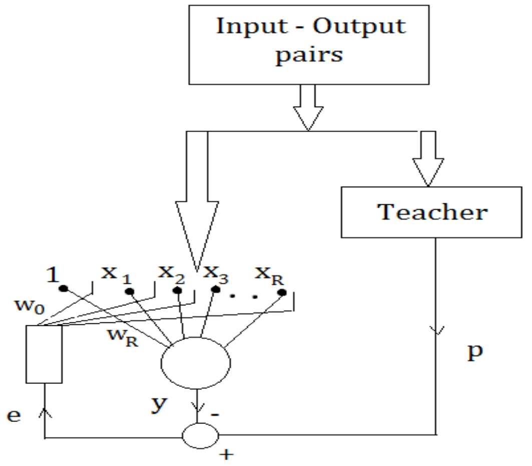

Fig: 16

Advantages:
Neural networks offer a wide number of advantages those include:

→ Requiring less formal statistical training,
→ Ability to implicitly detect complex nonlinear relationships between dependent and independent variables,
→ Ability to detect all possible interactions between the predicting variables and
→ The availability of multiple training algorithms.

Neural networks are quite simple to implement (you do not need a good linear algebra solver as for examples for SVNs). Neural networks generally exhibit patterns similar to those exhibited by humans.
The ANN's are used in many important engineering and scientific applications, some of which are: signal improvement, noise reduction, design classification, system determination, prediction and control. Also they are used in many of the commercial products, like modems, processing of image and recognition of systems, recognition of speech, and medical instrumentation, etc.,
Its structure is hugely organized in parallel. The process of information takes place in the iteration of a great amount of processing neurons; each neuron sends exciting signals to other nodes in the network. Differing from other classic Artificial Intelligence methods where the information processing can be considered sequential – this is step by step even when there is not a predetermined order in the Artificial Neural Networks this process is particularly in parallel, which is also the origin of its flexibility. Because the calculations are divided in most of the nodes, if any of them gets deviated from the expected behavior it does not affect the behavior of the net-work.
Its ability to learn and generalize the ANN has the capability to acquire knowledge from its surroundings by the adaptation of its inside parameters, which is developed as a response to the presence of an external stimulus. The network learns from the examples which are given to it and this generalizes knowledge of them. The generalization can be interpreted as the property of artificial neural networks to produce an adequate response to unknown stimulus which are related to the acquired knowledge.
Self – organization, this property allows the ANN to distribute the knowledge in the entire network design, no element is present with specific stored information.

G. Disadvantages:

→Disadvantages include its "black box" nature, greater computational burden, proneness to over fitting, and the empirical nature of model development.
→The VC dimension of neural networks is not very clear. This is important when we want to consider how good a solution might be.
→Neural networks cannot be with held. If we add data afterwards, it becomes almost impossible to add to an existing network.
→Handling data in neural networks is a very complicated topic.

H. Data Pre-Processing

In this project we are considering 300 kms transmission line to simulate the fault through artificial neural network. Here there are set of six inputs each (3 are phase voltages and 3 are phase currents) to all the neural networks in this paper. We have seen that care is taken each time that the denominator of each of the inputs is non-zero. If it is 0, then the value of n is incremented by one then the next sample is considered for the entire process.

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The main advantage of performing this scaling is to reduce the training computation time. The table below shows the voltage and current values that are scaled with respect to their pre-fault values and used as a part of the training set. Here, Vr, Vy and Vb are the post fault voltage and Vr(pf), Vy(pf) and Vb(pf) are the corresponding pre-fault values. The given table gives values for various types of faults and no fault case. Here in this work, simulation was done on a 300 km long transmission line at a distance of 100 km from the terminal.
From this data neuron was trained through several iterations and results were obtained(Table 1).

V. CONCLUSION

The study of artificial neural networks as an alternative technique to detect and classify the faults on the transmission lines proved competitive with respect to accuracy. This method uses the phase voltage and phase currents (with respect to their pre-fault values) as its input. Different types of faults namely: single line to ground, line to line, double line to ground and three phase faults have been taken and work has been carried out separately on each of these faults using ANNs.
Neural network developed in this project was done by using back propagation. A fault detector for the transmission system for the detection of faults was developed by using the software $C^{\#}$
The obtained results proved that satisfactory performance has been achieved by the proposed Neural Networks in general. Moreover, it depends upon the application of Neural Network, size of the training data, number of hidden layers and number of neurons per hidden layer keeps on varying. The best performance can be achieved by proper selection of ANN configuration (like: number of hidden layers are very important)
To train and analyze the performance of neural networks the $C^{\#}$ software has been extensively used. Some of the important conclusions that have been obtained from this work are:

- Neural networks are indeed attractive and reliable for fault detection on transmission lines, more so, in the wake of rapidly growing complexity of modern power transmission system.
- It is important and essential to analyze and investigate the advantages of neural network design you are selecting and learning of algorithm before actually choosing it for application, as there should be a balance between the training characteristics and the performance factor of any neural networks

Thus from this project we can say that use of artificial intelligence for the complicated Indian transmission system increases its reliability. AI such as ANN can be used, keeping the aspect of increasing growth in power demand.

TABLE 1

Vr/Vr	Vy/Vy	Vb/Vb	Ir/Ir	Iy/Iy	Ib/Ib	Faults
0.6204	0.971	1.0425	1.684	0.5056	0.8775	R-G
0.6573	0.735	0.8289	0.4024	27.6875	1.7453	Y- G
1.258	0.914	0.7924	1.4994	-1.5179	-4.7497	B- G
-0.1882	0.604	1.0001	4.9014	20.6762	0.9994	R- Y
1	0.551	0.3276	1	33.8158	-7.1187	Y-B
1.1586	1	0.9208	-1.6037	1.0025	-2.2493	B-R
-0.1276	0.584	0.9042	2.9694	30.4194	1.4733	R-Y-G
0.9359	0.514	0.3833	0.9257	35.3006	-6.7506	Y-B-G
0.9864	0.914	0.835	0.6229	-1.2876	-5.0284	B- R-G
0.3135	0.437	0.4991	1.8649	35.9958	-6.5793	R-Y-B
1	1	1.0001	1	1.0007	0.9998	No Fault

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