CHAPTER 1

Introduction and Literature Review
1. INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Human intelligence in general sense is referred to knowledge or sometimes to fast thinking. A person can be fast yet stupid; and yet one can know a lot of facts, but be incapable of putting things together in a creative fashion. Therefore a satisfactory interpretation would be; “if the actions of a person are appropriate to each situation then he may be said intelligent”. Human intelligence is very powerful and it is very difficult to include the aspects of intelligence in a man made machine, yet some attempts were made and a field of study known as artificial intelligence emerged. Fundamental issues of artificial intelligence involve knowledge representation, search, perception and inference. This is basically computer scientific approach to machine intelligence. Parallel to this there is another approach to machine intelligence in which human brain is viewed as a dynamical system. This approach is based on the principles of adaptive systems and these principles are generally referred as machine-intelligence principles. Artificial neural network and fuzzy systems fall in the class of “machine-intelligent” adaptive systems.

Artificial neural network and fuzzy systems estimate functions relating input-output; and both are trainable dynamical system. These are model free estimator and learn from experience. Neural and fuzzy systems encode sampled information in a parallel-distributed numerical framework. These can be implemented in digital or analog VLSI circuitry or in optical computing media. Neural networks recognize pattern without definition. Recognition without definition characterizes their much intelligent behaviour and enables them to generalize like human brain. Fuzzy systems store banks of fuzzy associations or common sense rules. They may use linguist or numeric samples. An expert may provide linguistic association or a fuzzy system may
adaptively infer and modify its fuzzy association from the numerical samples. The later case and neural computing are almost similar in nature. The neural and fuzzy systems individually or in combination form an adaptive system with sensory and cognitive components.

Protection of lines and equipment in the power system is most urgent not only from the view point of minimizing damage to the system itself, but to provide continuous and reliable supply to the consumers as well. An effective protective system may alarm the alert state of the system to initiate preventive control to restore the security level. If the system enters in emergency state then the protective system supports the emergency control actions i.e., disconnection of faulted section and load shedding etc. There are various conventional methods of protecting power system. These methods involve current and voltage measurement; ratio of voltages and currents; current difference; phase comparisons and direction comparison. In the modern power system, stability requires early control measures, therefore the speed and accuracy of protective scheme is very important. Digital and microprocessor based relaying were attempted to meet the speed requirement. But these approaches are not able to adapt dynamically the changes in system operating conditions at the same time these are unable to deal with the vague information of voltage and current signals. Adaptive protection (intelligent protection) would be a solution in these situations. In almost all the protective techniques, system state is identified with the patterns of voltage and current signals. Therefore adaptive protection of power system is essentially a problem of pattern recognition.

In this thesis an attempt has been made to apply the dynamical system approach of machine intelligence to power system problems. Application of artificial neural network for fault detection and some other application are suggested. ANN- like model Adaptive Network Fuzzy Inference System (ANFIS) is also tried for some applications to show the similarity with neural computing.
1.2 Review of Literature

Inception of neural network concept took place in 1943 when Warren McCulloch and Walter Pitts proposed a model of computing element called McCulloch Pitts neuron. In 1949 Donald Hebb proposed learning scheme for connection weights based on pre- and post-synaptic values of variable. In 1958 Rosenblatt proposed perceptron rule. After these developments, LMS algorithm, an important training rule of adaptive elements, which was published in the year 1960 by Widrow and his students, gained much popularity. In 1970, Grossberg developed Adaptive Resonance Theory. In 1980, Hopfield and others introduced outer product rules for training a class of recurrent networks, which are now called Hopfield model. Parallel to these developments Widrow and his students devised Madaline-I rule and applied this to speech and pattern recognition, weather forecasting and adaptive controls. After this, their work switched to adaptive signal processing. Till these developments in neural networks research, attempt to develop learning rule for network with multiple adaptive layer were unsuccessful.

The first major extension of feedforward neural network took place in 1971, when Werbos developed backpropagation learning algorithms. Unfortunately his work remained unnoticed. In 1985-86 Rumelhart, Hinton and Williams rediscovered this technique. The elements used by Rumelhart in the backpropagation network differ from Madaline architectures. Madaline structure uses hard limiting quantizer, while the elements in the backpropagation network use only differentiable nonlinearities [1].

After the development of BP algorithm research in neural network gained momentum and opened the possibility of their application to many diverse fields. Power System is one such area where processing of voltage and current is needed. A. K. Gosh et. al. classified power system disturbances with ANN approach [2]. Jiansheng Huang et. al. applied neural fuzzy techniques for assessment of power quality disturbances. An expert system using two stage artificial neural network for real time control of capacitor in distribution...
system is proposed by N. Iwan Santoso et. al. [4]. A. U. Narendranath et. al. explore the application of ANN for voltage stability assessment [5]. Off-line simulation and on-line calculation of demand & energy losses has been done by T. S. Sidhu et. al. [6]. To achieve multilayer feedforward neural network has been used by them.

ANN application in power system is not limited to areas discussed above. With the inception of multilayer training rules and many new architectures the signal processing capability of ANN has increased many folds. Therefore it is proving more useful in protection as compared to other areas of power system. High impedance fault detection in distribution feeder is always difficult. This can be detected with ANN approach [7]. N. Kandil et. al. proposed identification of fault in AC-DC system with feedforward network. In this the faults have been detected with rms and instantaneous values of voltage signals [8]. Automated fault disturbance and detection is reported in [9]. Use of multilayer feedforward network is shown for direction discrimination by T. S. Sidhu et. al. [10]. Fault direction discrimination is attempted with feedback network by M. Sanaye-Pasand et. al. [11]. Fault generated high frequency noise signals have been used with preprocessing to detect the faulty phase [12]. In this presentation Z. Q. Bo et. al. have used three layered network with 18 inputs, 12 hidden units and 3 outputs. Application in the area of distance protection can be found in [13-17]. Ramchandran et. al. [16] have given the hardware implementation of Digital Artificial Neural Network (DIANNEN) based on simulation results. ANN relays to implement differential relay and other relays to protect power apparatus are addressed in [18-21].

Theory of fuzzy set is also another development in search of processing vague information. This theory was proposed by Dr. Lotfi Zadeh in 1965 in his work “Fuzzy Sets” [22]. Since 1965 this subject has been the focus of many researchers and engineers. The fuzzy applications have received much attention in the control problems. Takagi and Sugeno have applied fuzzy identification technique to modeling and control [23]. Mamdani and others
have addressed control problem with the application of fuzzy techniques [24-26]. Jyh-Shing Roger Jang developed adaptive network based fuzzy inference system and shown its application for time series prediction [27]. Attempt to train the neural network with fuzzy input-output is shown in [28]. These developments have attracted power engineers also to attempt neuro-fuzzy approaches to address power system protection problems. Some of these attempts are available in [29-30].

Review of literature as above clearly suggests that power scientists are keen to explore all the possibility of intelligent techniques such as ANN and fuzzy to be applied for protection needs.

1.3 Purpose and Objective of Study

This study is devoted to explore the possible application of connectionist model of distributed processing for power system protection. Artificial neural network and ANN-like model of fuzzy inference system have been used to extract the information in voltage and current signals. Most of the discussed applications are limited to feedforward network. In this study feedback networks are also suggested for their suitability in protection application.

1.4 Scope of Investigation

Scope of investigation is to obtain distinction among various waveforms, to filter out some waveforms and extract feature of signal to reveal status of system under consideration. These investigations have been done on two bus 300 km power transmission line fed from both the ends and 100 km line connected to three phase transformer with nonlinear magnetizing characteristic. Software simulations of these models of power system and connectionist model of intelligent techniques have been done and possibility of their applications is suggested.
1.5 Conceptualization

Instantaneous values of voltage and current have been preferred than rms values. The voltage and current generated by simulation are sampled at frequencies suitable for particular application. These samples have been generated under various conditions of power system to include generalization. Patterns have been formed with these samples by preparing sliding data window. For some cases patterns have been formed with preprocessing and feature extraction of the samples. Following the similar procedure, target for each pattern is formed. These input-output sets are presented to ANN in sequence or simultaneously. Mean square of error between target and actual output has been used to assess the performance of neural network. Trained network for each application has been tested with patterns made from samples which are not included in training phase.

********