Artificial Neural Network

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Abstract : **Neural networks, as used in artificial intelligence, have traditionally been viewed as simplified models of neural processing in the brain, even though the relation between this model and brain biological architecture is debated. Historically, computers evolved from the von Neumann architecture, which is based on sequential processing and execution of explicit instructions. On the other hand, the origins of neural networks are based on efforts to model information processing in biological systems, which may rely largely on parallel processing as well as implicit instructions based on recognition of patterns of 'sensory' input from external sources. In other words, at its very heart a neural network is a complex statistical processor (as opposed to being tasked to sequentially process and execute) An artificial neural network (ANN), also called a simulated neural network (SNN) or commonly just neural network (NN) is an interconnected group of artificial neurons that uses a mathematical or computational model for information processing based on a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network.**

Key terms: **consisted, suggestions, spanning, entire.**

1. INTRODUCTION

This seminar is about the artificial neural network application in processing industry. An artificial neural network as a computing system is made up of a number of simple and highly interconnected processing elements, which processes information by its dynamic state response to external inputs. In recent times study of ANN models have gained rapid and increasing importance because of their potential to offer solutions to some of the problems in the area of computer

science and artificial intelligence. Instead of performing a program of instructions sequentially, neural network models explore many competing hypothesis simultaneously using parallel nets composed of many computational elements. No assumptions will be made because no functional relationship will be established. Computational elements in neural networks are non linear models and also faster. Hence the result comes out through non linearity due to which the result is very accurate than other methods. The details of deferent neural networks and their learning algorithm are presented its clearly illustrator how multi layer neural network identifies the system using forward and inverse modeling approach and generates control signal. The method presented here are directed inverse, direct adaptive, internal model and direct model reference control based ANN techniques.

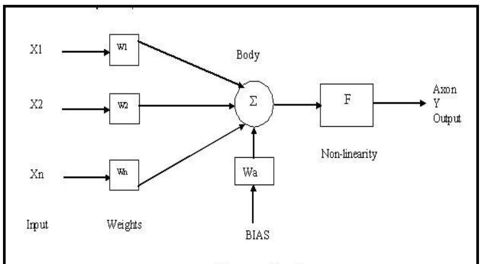
2. NEURAL NETWORKS

Artificial neural networks have emerged from the studies of how brain performs. The human brain consists of many million of individual processing elements, called neurons that are highly interconnected.

Information from the outputs of the neurons, in the form of electric pulses is received by the cells at connections called synapses. The synapses connect to the cell inputs, or dendrites and the single output pf the neuron appears at the axon. An electric pulse is sent down the axon when the total input stimuli fro all of the dendrites exceed a certain threshold.

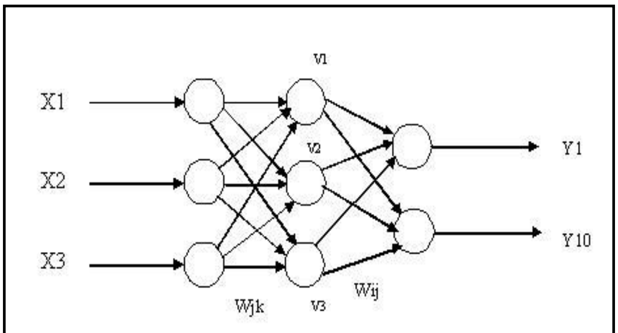
Artificial neural networks are made up of simplified individual models of the biological neuron that are connected together to form a network. Information is stored in the network in the form of weights or different connections strengths associated with synapses in the artificial neuron models.

Many different types of neural networks are available and multi layer neural networks are the most popular which are extremely successful in pattern reorganization problems. An artificial neuron model is shown below. Each neuron input is weighted by W. changing the weights of an element will alter the behavior of the whole network.,



A Neuron Model

Multi layer networks consists of an input layer, a hidden layer are made up of no. of nodes. Data flows through the network in one direction only, from input to output; hence this type of network is called a feed-forwarded network. A two-layered network is shown below.



A Two Layered Network

2.1 NEURAL NETWORKS IN PROCESS CONTROL

Artificial neural networks are implemented as software packages in computers and being used to incorporate of artificial intelligence in control system. ANN is basically mathematical tools which are being designed to employ principles similar to neurons networks of biological system. ANN is able to emulate the information processing capabilities of biological neural system. ANN has overcome many of the difficulties that t conventional adaptive control systems suffer while dealing with non linear behavior of process.

2.2 PROCEDURES FOR ANN SYSTEM ENGINEERING

In realistic application the design of ANN system is complex, usually iterative and interactive task. Although it is impossible to provide an all inclusive algorithmic procedure, the following highly interrelated, skeletal steps reflect typical efforts and concerns. The plethora of possible ANN design parameters include:

- The interconnection strategy/network topology/network structure.
- Unit characteristics (may vary within the network and within subdivisions within the network such as layers).
- Training procedures.
- Training and test sets.
- Input/output representation and pre- and post-processing.

2.3 FEATURES OF ANN

- Their ability to represent nonlinear relations makes them well suited for non linear modeling in control systems.
- Adaptation and learning in uncertain system through off line and on line weight adaptation
- Parallel processing architecture allows fast processing for large-scale dynamic system.
- Neural network can handle large number of inputs and can have many outputs.

Neural network architecture have learning algorithm associated with them. The most popular network architecture used for control purpose is multi layered neural network [MLNN] with error propagation [EBP] algorithm.

3. LEARNING TECHNIQUES

Learning rules are algorithm for slowly alerting the connections weighs to achieve a desirable goal such a minimization of an error function. The generalized step for any neural network leaning algorithm is follows are the commonly used learning algorithm for neural networks.

- Multi layer neural net (MLNN)
- Error back propagation (EBB)
- Radial basis functions (RBF
- Reinforcement learning
- Temporal deference learning
- Adaptive resonance theory (ART)
- Genetic algorithm

Selection of a particular learning algorithm depends on the network and network topology. As MLNN with EBP is most extensively used and widely accepted network for process application, namely for identification and control of the process.

3.1 MLNN IN SYSTEM IDENTIFICATION:

There has been an"explosion" of neural network application in the areas of process control engineering in the last few years.since it become very difficult to obtain the model of complex non-linear system due its unknown dynamics and a noise

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environment.it necessitates the requirement for a non classic technique which has the ability to model the physical process accurately. since nonlinear governing relationships can be handled very contendly by neutral network, these networks offer a cost effective solution to modeling of time varying chemical process.

Using ANN carries out the modeling of the process by using ANN by any one of the following two ways

- Forward modeling
- Direct inverse modeling

3.2 FORWARD MODELING

The basic configuration used for non-linear system modeling and identification using neural network. The number of input nodes specifies the dimensions of the network input. In system identification context, the assignment of network input and output to network input vector.

3.3 DIRECT INVERSE MODELING:

This approach employs a generalized model suggested by Psaltis et al.to learn the inverse dynamic model of the plant as a feed forward controller. Here, during the training stage, the control input are chosen randomly within there working range. And the corresponding plant output values are stored, as a training of the controller cannot guarantee the inclusion of all possible situations that may occur in future. Thus ,the developed model has take of robustness

The design of the identification experiment used to guarantee data for training the neural network models is crucial, particularly, in-linear problem. The training data must contain process input-output information over the entire operating range. In such experiment, the types of manipulated variables used are very important.

The traditional pseudo binary sequence (PRBS) is inadequate because the training data set contains most of its steady state information at only two levels, allowing only to fit linear model in over to overcome the problem with binary signal and to provide data points throughout the range of manipulated variables.The PRBS must be a multilevel sequence.This kind of modeling of the process play a vital role in ANN based direct inverse control configuration.

4. ANN BASED CONTROL CONFIGURATION:

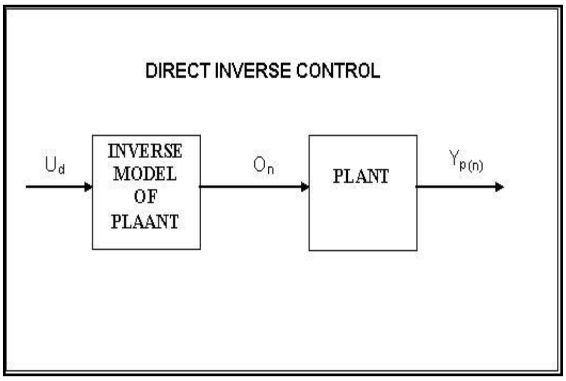
- Direct inverse control
- Direct adaptive control
- Indirect adaptive control
- Internal model control
- Model reference adaptive control

4.1 DIRECT INVERSE CONTROL

This control configuration used the inverse planet model.Fro the direct inverse control. The network is required to be trained offline to learn the inverse dynamics of the plant. The networks are usually trained using the output errors of the networks and not that of the plant. The output error of the networks is defined.

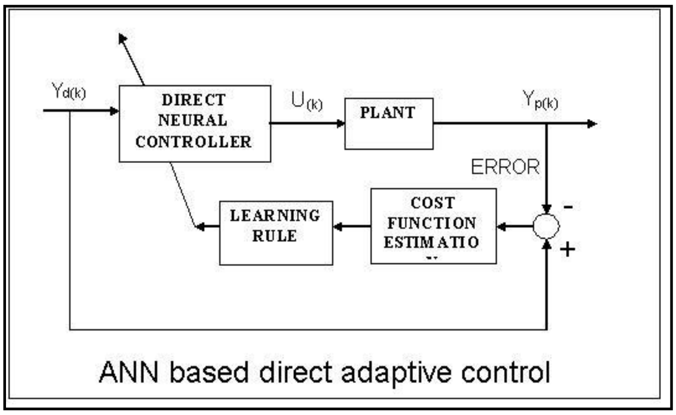
$$En=1/2(ud-on)^2$$

Where En is the networks output error ud is the actual controls signal required to get desired process output and on is the networks output. When the networks is to be trained as a controller. The output errors of the networks are unknown. Once the network is trained using direct inverse modeling learns the inverse system model. It is directly placed in series with the plant to be controlled and the configuration shown in figure. Since inverse model of the plant is in off line trained model, it tacks robustness.



4.2 DIRECT ADAPTIVE CONTROL (DAC)

In the direct adaptive control. The network is trained on line. And the weights of connections are updated during each sampling interval. In this case' the cost function is the plant output error rather than the networks output error. The configuration of DAC is shown in figure.

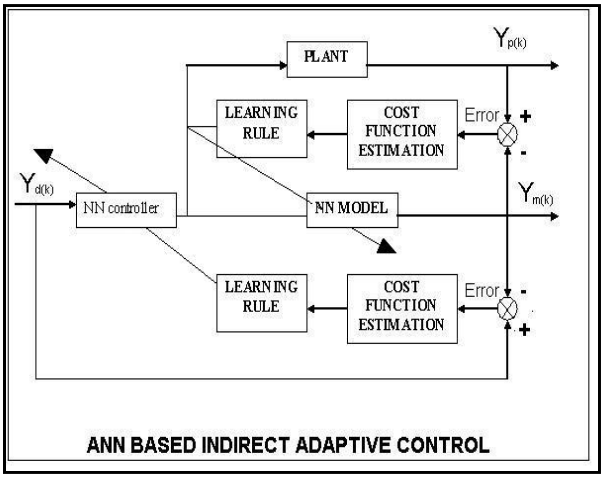


ANN based direct adaptive control

The limitation of using this configuration is that one must have the some knowledge about the plant dynamics i.e. Jacobin matrix of the plant. To solve the problems; initially, Psaltis D.et al proposed a technique for determining the partial derivatives of the plant at its operating point Xianzhang et al and Yao Zhang et al presented a simple approach, in which by using the sign of the plant Jacobin. The modifications of the weights are carried out.

4.3 INDIRECT ADAPTIVE CONTROL

Narendra K S et al. Presented an indirect adaptive control strategy. In this approach, two neutral networks for controller purpose and another for plant modeling and is called plant emulator decides the performance of the controller. The configuration of indirect adaptive control scheme becomes as shown FIG.3.



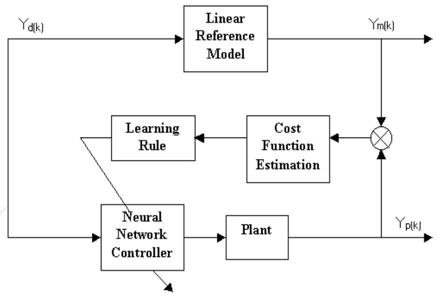
ANN BASED INDIRECT ADAPTIVE CONTROL

In direct learning the neutral controller, it is well known that the partial derivatives of the controlled plant output with respect to the plant input (plant Jacobin) is required . One method to over come this problem is the use NN to identify the plant, and to calculate its Jacobin. Since the plant emilator learning converges before the neutral controllers learning begins, an effective neutral control system is achieved.

4.4 INTERNAL MODEL CONTROL (IMC)

The IMC uses two neutral networks for implementation . I n this configrurations,one neutral networks is placed in parallel with the plant and other neutral network in series the plant. The structure of nonlinear IMC is shown in FIG.4.

The IMC provides a direct method for the designof nonlinear feedback controllers. If a good model of the plant is savable, the close loop system gives an exact set point tracking despite immeasurable disturbance acting on the plant.



ANN based reference model adaptive control

For the development of NN based IMC, the following two steps are required:

- Plant identification
- Plant inverse model

Plant identification is carried out using the forward modeling techniques. Once the network is trained, it represents the perfect dynamics of the plant the error signal used to adjust the networks weights is the difference between the plant output and the model output.

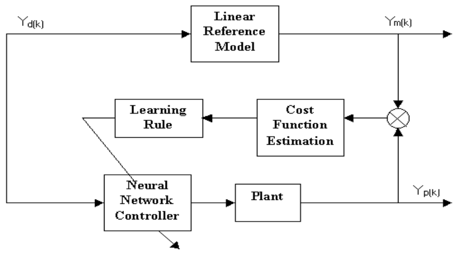
The neutral networks used to represent the inverse of the plant (NCC) is trained using the plant itself. The error signal used to train the plant inverse model is the difference between the desired plant and model outputs.

4.5 DIRECT NEURAL NETWORK MODEL REFERENCE ADAPTIVE CONTROL:

The neural network approximates a wide variety of nonlinear control laws by adjusting the weights in training to achieve the desired approximate accuracy. One possible MRAC structure based on neural network is shown

In this configuration, control systems attempted to make the plant output $Y_P(t)$ to follow the reference model output asymptotically. The error signal

Used to train the neural network controller is the difference between the model and the plant outputs, principally; this network works like the direct adaptive neural control system.



ANN based reference model adaptive control

6. CONCLUSION

This paper presents the state of ANN in process control applications. The ability of MLNN to model arbitrary non linear process is used for the Identification and control of a complex process. Since the unknown Complex systems are online modeled. And are controlled by the Input/output dependent neural networks, the control mechanisms are robust for varying system parameters. It is found that the MLNN with EBP training algorithm are best Suited for identification and control since the learning is of supervised nature And can handle the nonlinearity present in the plants with only input/output Information. However, there are difficulties in implementing MLNN with EBP. Like selection of learning rate, momentum factor, selection of network size etc

Thus it becomes very much essential to have some concrete guard Lines for selecting the network. Further, there is lot of scope in developing Different effective configurations based on ANN for identification and control of the complex process.

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