NEURAL NETWORKS IN MOTOR CONTROL

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ABSTRACT

This paper propose the basic types of the artificial neural networks(ANN) and their eventual aplications in the motor control. The first part of the document is the introduction into neural networks. The next part describes the basic types of the artificial neural networks, theirs advantage, disadvantage and methods of learning. The last part contains the eventual posibility of the aplication ANN in motor control.

1 INTRODUCTION

A neural network is an interconnected group of neurons fig.1. The prime examples is biological neural networks, especially the human brain. An artificial neural network is a mathematical or computational model for information processing based on a connectionist approach to computation. There is no precise agreed definition amongst researchers as to what a neural network is, but most would agree that it involves a network of relatively simple processing elements, where the global behaviour is determined by the connections between the processing elements and element parameters. The original inspiration for the technique was from examination of bioelectrical networks in the brain formed by neurons and their synapses. In a neural network model, simple nodes (or "neurons", or "units") are connected together to form a network of nodes — hence the term "neural network".

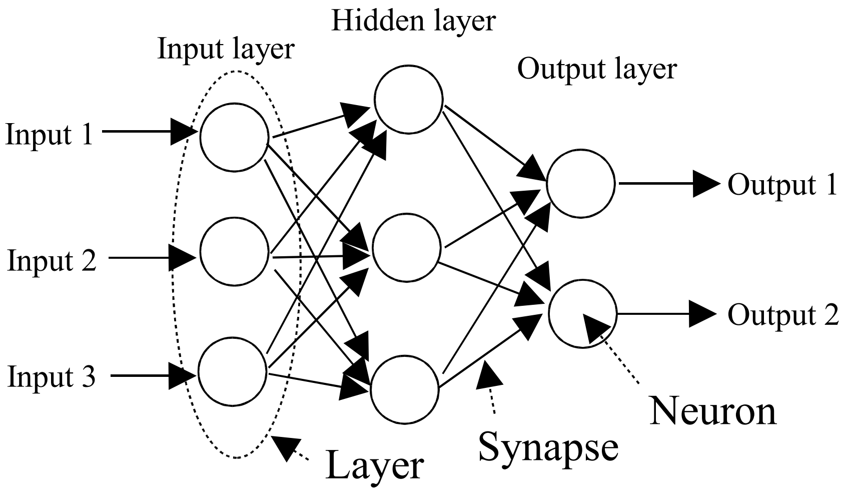

Fig. 1: *Neural network (Multilayerperceptron)*

The artificial neuron (also called "node") is the basic unit of an artificial neural network, simulating a biological neuron. It receives one or more inputs, sums these, and produces an output after passing the sum through a (usually) non-linear function known as an activation or transfer function. The tipical form of this function is a sigmoid, but also too another non-linear function or a step function.

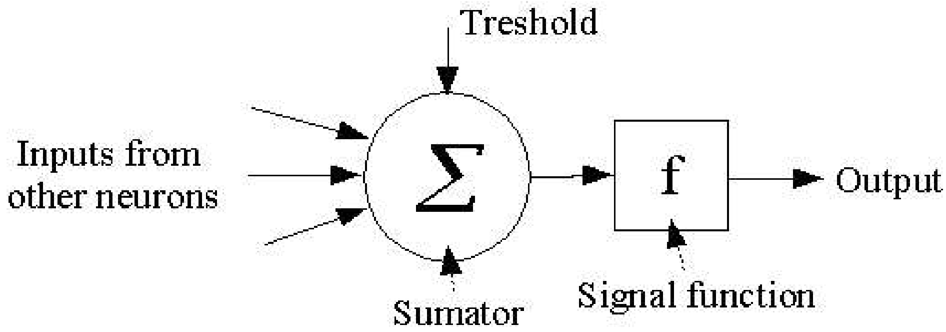

Fig. 2: *Scheme of the Artificial neuron*

Typical equation of the artificial neuron is: $output = f * (\sum inputs - treshold)$ (0)

where f is activation function (sigmoid) $f(x) = \frac{1}{1+e^{-x}}$ (1)

2 TYPES OF NEURAL NETWORKS

The artificial neural networks have many variant. Any variant are eficient for the different aplications. The basic clafication sort of two types: The feedforward networks propagate data linearly from input to output and he recurrent neworks (Rns) with by-directional data flow.

2.1 MULTILAYER PERCEPTRON

Multilayer perceptron is class of networks consists of multiple layers of artificial neurons, usually connected in a feedforward way. Each neuron in layer has directed connections to the neuron of the following layer. Especialy in non-linear applications the neurons of these networks apply a sigmoid function as an signal function.

Learning methods: gradient methods, genetic algorithms or combination of the methods

Usage: function approximation, classification, time series prediction

Advantages: high accuracy, solving non-linear problems, prediction

Disadvatages: slow process learning, number of neurons in hidden layers

2.2 KOHONEN SELF ORGANISATION MAP (SOM)

This network has typically three layers, first input layer, second Kohonen layer and third Grosberg layer. Input layer conveys the signal to neurons at Kohonen layer. Kohonen layer work on principle “winner take all”. The winner is neuron, that have greatest count of input signals increased by weights. Winner increases its weights and decreases weights of the surrounding neurons(self-learning).The Grosberg layer realize the output value based on output of Kohonen layer. All neurons of the Kohonen layer are interconnected, therefore SOM come under recurrent networks.

Learning methods: selforganise structure, it has not use of the supervision.

Usage: function approximation, classification

Advantages: easy structure, quick algorithm, learn himself

Disadvatages: It isnt accurate as multilayer perceptron.

2.3 HOPFIELD MODEL

This neural network have only one layer. The all neurons in this layer are interconnected and have one input and one output. This network is advisable to memorize of the patterns. A problems with this networks are number of memorized patters (depend on number of neurons) , stability and time of evocation of output (This is recurrent network and the output must wait for stabilization of internal state)

Learning methods: selforganise structure, it has not use of the supervision.

Usage: Only for pattern recognition

Advantages: easy structure, quick algorithm, learn himself

Disadvatages: number of the memored examples

3 POSIBILITY OF THE APLICATION ANN IN MOTOR CONTROL

In real life aplication of the motor control are usage of the neural networks efficient for solve folowing problems:

3.1 FUNCTION APPROXIMATION (REGRESSION ANALYSIS)

This feature is very good usefull in non-linear regulation systems, where can not realize matematical model or design of matematical model is very difficult. In real aplications we know three types. The first type is a common learning. The learning stage is presented in figure 3. After learning realize neural network regulator.

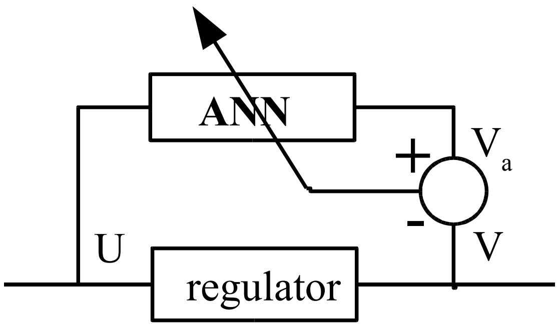

Fig. 3: *Learning stage of the common learning*

The second type is a inverse learning. The learning stage is presented in figure 4. After learning realize neural network inverse model of the system but this method is not realize for all non-linear systems.

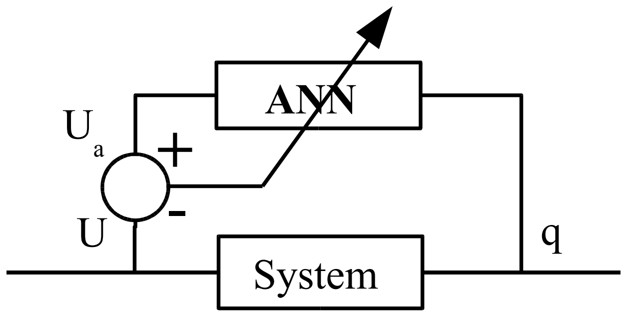

Fig. 4: *Learning stage of the inverse learning*

The last type is the learning network with control deviation presented in figure 5.. Neural net is learning on-line at control of the system. The system has classic PID regulátor and the neural network realize the non-linear corrector of the PID regulator gain.

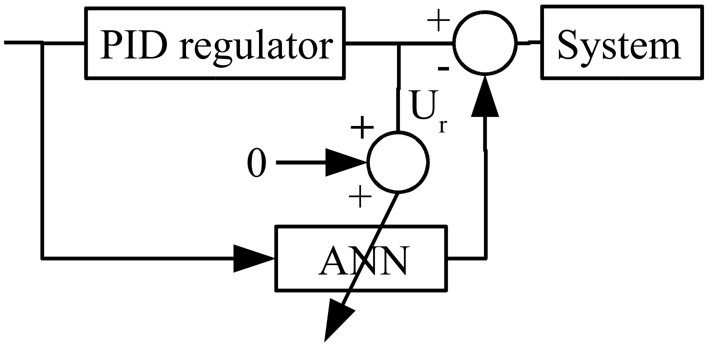

Fig. 5: *System regulation with adaptive control of deviation*

3.2 TIME SERIES PREDICTION

Neural network can solve problem of the singnals prediction. The learning process is presented in figure 6. At the learning is the signal on the input the neural netwok delayed about time Z^{-1}. After learning the net predicate output about time Z^{-1}

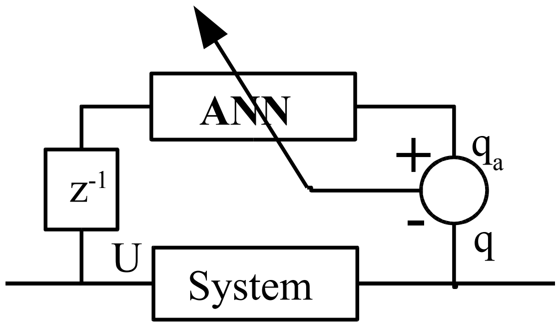

Fig. 6: *Learning process of the network for time prediction*

3.3 CLASSIFICATION

Typicall usage of the classification is in detect motor mode fault states. Neural net analizing input signals (speed, vibration, acceleration, currents) and classify actual state. When sum of the signals signify mode fault, the neural netwok make the control intervention or give signal to controller. Next usage is too update parameters of the PID controllers in different states.

4 CONCLUSION

The aplications of the neural networks in motor control have without question of the great future. Neural nets can solve problems, where classic mathematic is at a loss. The power of the today's microcontrolers is sufficient for their aplications and it will still to accrue. The algorithms for theirs create is very easy, but the problems staying with algorithms for create theirs structures and seting internal parameters.

5 ACKNOWLEDGEMENTS

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