Identification Of The Control Objects Using Artification Neural Networks

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Abstract — **This paper introduces the new ability of Artificial Neural Networks (ANNs) in defining the mathematical modern of the complicated control objects, in the context of missing the data base as well as performance function. The used Neural Networks is the Adaptive Neural Networks in which the activation function is the liner form - purelin, the late input; the Three layers feed-forward neural network with sigmoid activation functions in the input; and the Multi-input Adaptive Neural Networks with the hidden layers and purelin in the output layer. The training algorithm is Levenberg-Marquartd back propagation one. The result shows the advanced ability of the ANNs in defining of the mathematical model of non-liner control objects, especially the adaptive networks**.

Keywords:DC motor, artifical neural networks, control system, control objects.

I. INTRODUCTION

Nowadays, the field of electrical power system control in general, and motor control in particular have been researching broadly. And new technologies are applied to these in order to design the complicated technologies system. One of these new technologies is Artificial Neural Networks (ANNs) which base on the operating principal of human being nerve neural.

In the practical at present, many complicated technological systems are being applied in the industry. However, there are many difficulties we get stuck with when defining the system mathematical modern or establishing the control system using the traditional methods with its non-liner nature.

In order to solve this problem, many researchers have introduced the Artificial Neural Networks (ANNs) in defining the mathematical model of the non-liner control objects. The reasons of this application are because of the training ability together with the special adaptive ability. So the Artificial Neural Networks (ANNs) are applied to modernize the complicated non-liner control objects such as complicated technological systems in the industry.

There are a number of articles that use ANNs applications to identify the mathematical DC motor model. And then this model is applied to control the motor speed [1]. They also uses inverting forward ANN with two input parameter to controlling adaptive DC motor [4]. In [1], the authors mention the separately excited DC motor by using the ANNs in the adaptive control system. This Neural Network is trained approximately the performance with fixed coefficient. The input data are the speed, voltage, torque created by discretions the DC motor parameters. So this method is applied only to the control objectives with the performance functions known in advance

ANNs are applied broadly because of the following special qualities:

1. All the ANN signals are transmitted in one direction, the same as in automatically control system.
2. The ability of ANNs to learn the sample.
3. The ability to creating the parallel signals in Analog as well as in the discrete system.
4. The adaptive ability.

With the special qualities mentioned above, ANNs can be trained to display the nonlinear relationships that the conventional tools could not implemented. It also is applied to control complicated electro- mechanic system such as DC motor and synchronous machines [5].

To train ANNs, we have to determine the input and output parameters first, and then design the ANNs net by optimizing the number of hidden layers, the number of neural of each layer as well as the input/output number and the transfer function. The following is to find the ANNs net learning algorithm.

ANNs are trained relying on two basic principal: supervisor and unsupervisor. According to supervisor, ANNs learn the input/ output parameter (targets) before being used in the control system.

In this paper, the author would like to present the new ANNs application in the new method of defining the mathematical model of non-liner control objects in the context of missing the data base as well as performance function by the difference Neural Networks. To illustrate this issue, the authors simulate the process of defining the separately excited DC motor model with the parameter such as the speed, voltage, load torque.

II. THE TYPE OF NEURAL NETWORKS

In the papers, authors used the different type of neural networks for identification of control objects, but only some types approach for the decision of this problem: an adaptive network with activation function purelin, the standard three layers feed-forward neural network with sigmoid activation functions, an adaptive network with sigmoid activation function. In order to train exactly, the control object is represented as the multi-input system. The data base used to train the Network is the pattern data and is created by difference working regulations of the control object. The more the amount of patterns data, the more exact model of the control object described.

The topology of identification of non-linear control object is shown in figure1. It bases on the input data base u(k) and the reality output data y(t). There data base is achieved by experiment and being called training pattern. The ANN describe a relationship between the input and output data. The input matrix is used as input for the control object and for ANN model, and an error between the output of the control object and the ANN model is used to correct the parameters of ANN.

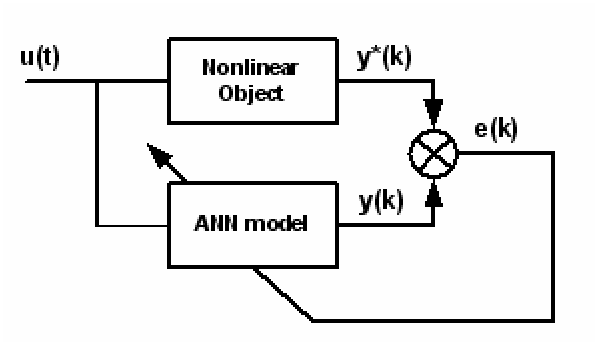

Figure1. Conventional model of control system DC motors

D. *The structure and the process of learning ANNs.*

ANNs have been found to be effective systems for learning discriminates for patterns from a body of examples [5]. Activation signals of nodes in one layer are transmitted to the next layer are through links which either attenuate or amplify the signal.

An ANNs are trained to emulate a function by presenting it with a representative set of input/output functional patterns. The back-propagation training technique adjusts the weights in all connecting links and thresholds in the nodes so that the difference between the actual output and target output are minimized for all given training patterns [1].

In designing and training an ANN to emulate a function, the only fixed parameters are the number of inputs and outputs to the ANN, which are based on the input/output variables of the function. It is also widely accepted that maximum of two hidden layers are sufficient to learn any arbitrary nonlinearity. However, the number of hidden neurons and the values of learning parameters, which are equally critical for satisfactory learning, are not supported by such well established selection criteria. The choice is usually based on experience. The ultimate objective is to find a combination of parameters which gives a total error of required tolerance a reasonable number of training sweeps [1,2,3].

The structure of an adaptive neural network with linear activation function is shown in Figure2. It consists of an input, output , and TDL, which have a delay function.

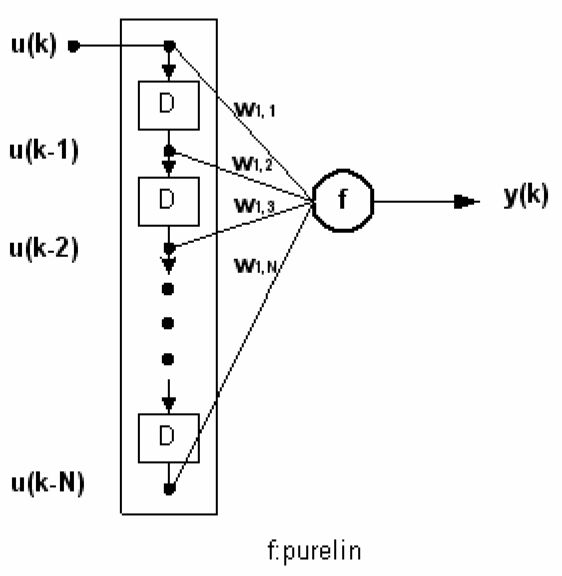

Figure 2. Structure of linear adaptive ANN

The structure of a feed – forward ANN is shown in Figure3. It consists of an input layer, output layer and one hidden layer. The input and hidden layers are tansig-sigmoid activation functions, while the output layer is a linear function.

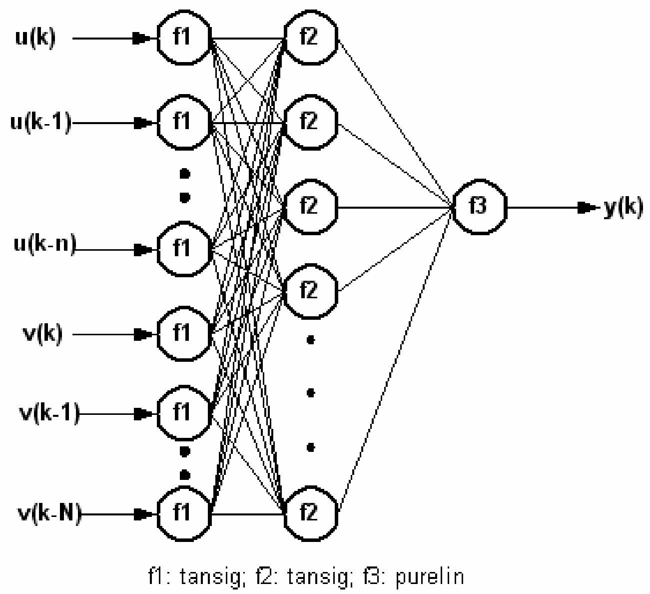

Figure 3 . Structure of feed-forward ANN

The structure of an adaptive neural network with sigmoid activation function is shown in Figure4. It consists of an input, output , and TDL, which have a delay function. This network have two inputs- matrixes and their delay values.

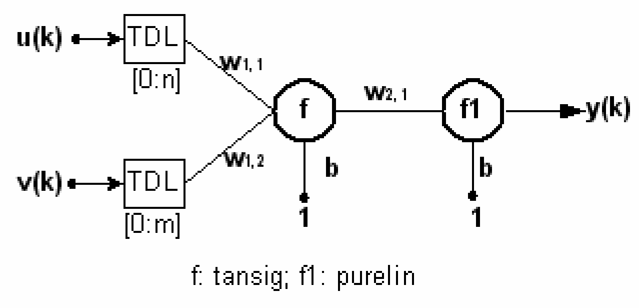

Figure 4. Structure of ANN2

All three ANNs are training by training by Levenberg-Marquardt back-propagation algorithm.

III. SIMULATION

To simulate the identification of control objects The DC motor is used in models has the follows parameter 5HP, 240V, 1750 RPM, field 150V. The load torque of DC motor is a fan ($m \approx \frac{1}{\omega^2}$)

$J=0.02215\ Nm^2$

$KF=1.976\ NmA^{-1}$

$B=0.002953\ Nms$

$R_a=11,2\ \Omega$

$L_a=0.1215\ H$

a. The creating of data base:

In simulink – Matlab we create model of DC motor, and simulate the motor in different modes: starting, regulation of speed. Result of simulation is presents in figure 5,6,7. The load torque of DC motor has the form similar to the form of speed.

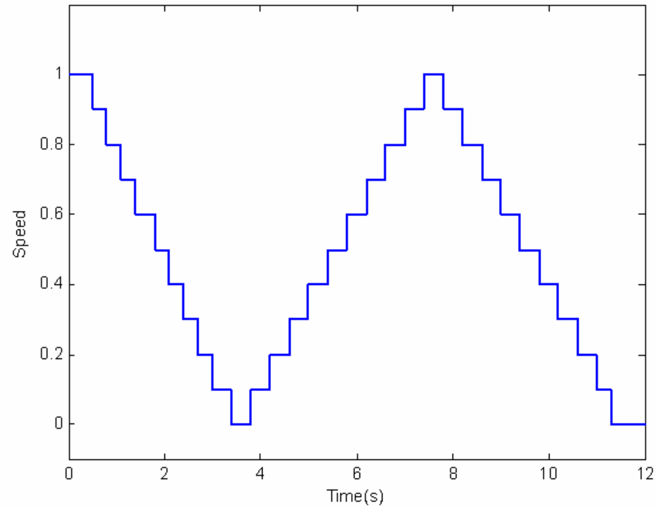

Figure5. The Reference speed DC motor

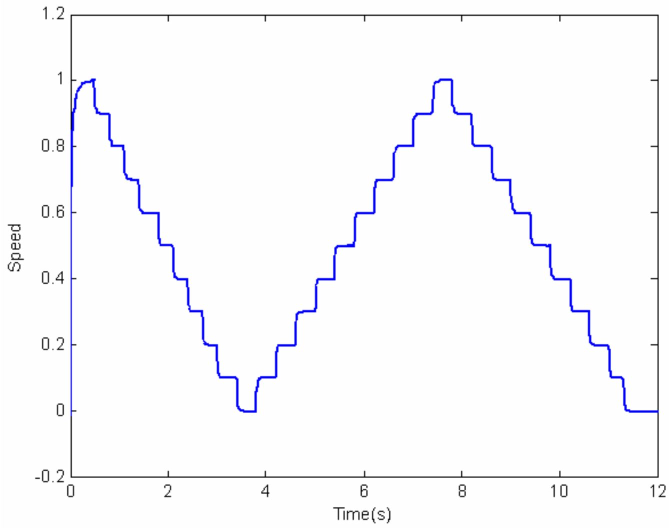

Figure 6. The target speed DC motor

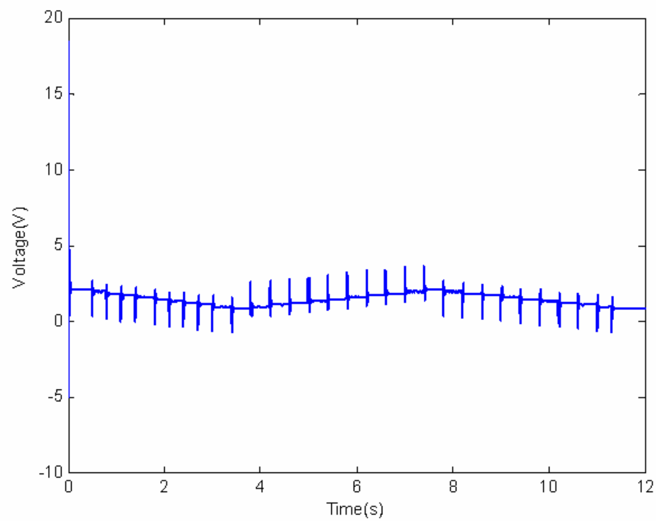

Figure 7. The terminal voltage of DC motor

b. The training ANNs

The training program three ANN are written in the Neural Network of Matlab program under m-file and it uses the Levenberg – Marquardt back propagation. There is no any reference that mention to the optimal number of neural in each layer, so collecting the neural networks becomes more complicated.

For the adaptive neural network with linear activation function (ANN1) input data is terminal voltage u(k),and output ANN is the speed y(k).

$$y(k)=f\{u(k),u(k-1),\ldots u(k-5)\} \qquad (1)$$

For the feed-forward ANN (ANN2) input data is terminal voltage u(k), reference speed W(k), and load torque m(k),and output ANN is the speed y(k).

$$y(k)=f\{u(k),u(k-1),W(k),m(k-1)\} \qquad (2)$$

For the adaptive neural network with sigmoid – tansig activation function (ANN3) input data is terminal voltage u(k), load torque m(k), and output ANN is the speed y(k).

$$y(k)=f\{u(k),u(k-1)..u(k-4),m(k-1),m(k-2)\} \qquad (3)$$

In order to choose the optimal number of neural, the neural network is trained by m-file program, reducing the number of neural in ANNs hidden layer until the learning error can be accepted.

The ANNs and the training effort are briefly described by the following statistics.

Table 1

Network	ANN1	ANN2	ANN3
Number of input	5	7	2
Number of output	1	1	1
Number of hidden layer	0	1	1
Number of hidden neurons		14	4
Number of training patterns	28000	28000	28000
TDL	0:5	-	0:5,0:2
Number of training sweeps	500	5000	2000
Learning error	1e-5	1e-7	1e-8

To compare the quality of two control systems we investigate different an operating mode of the DC motor:

The starting of DC motor and regulation of DC motor speed for three ANN are shown in Figure , 8,9,10. The results show that both models operate successfully and the control quality is same for two models.

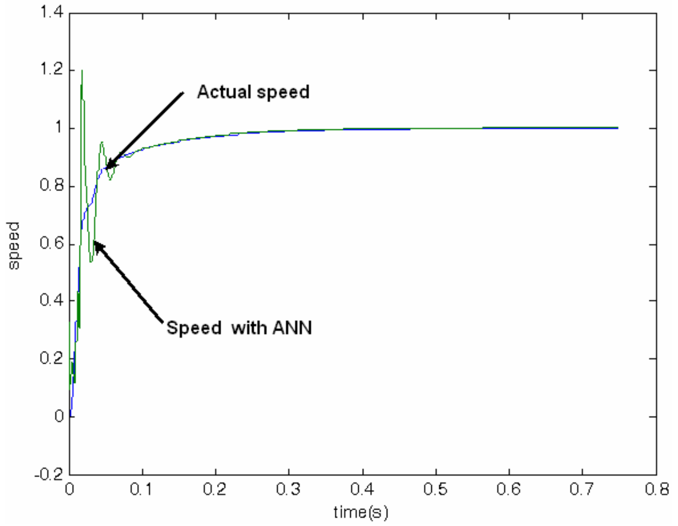

Figure 8 . Starting the DC motor with ANN1

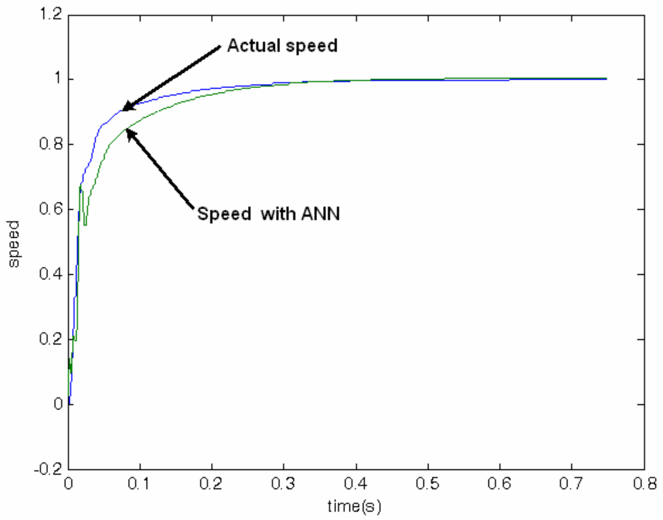

Figure 9 . Starting the DC motor with ANN2

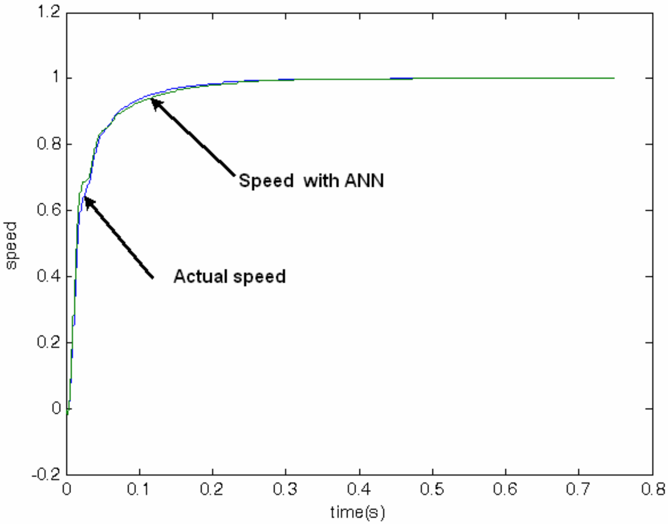

Figure 10 . Starting the DC motor with ANN3

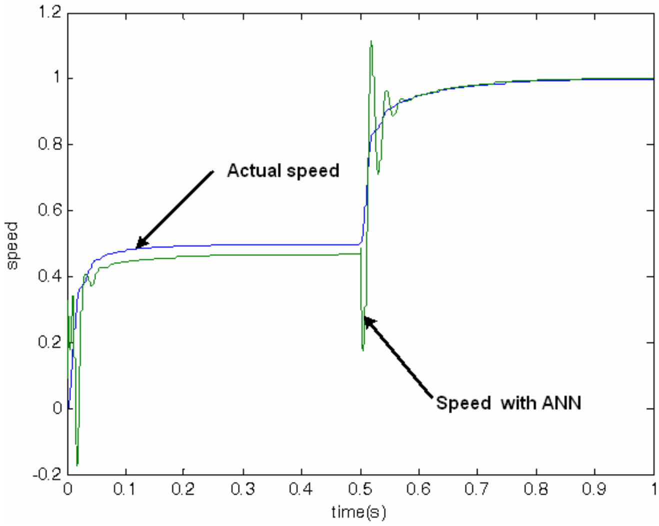

Figure11. Regulation of DC motor speed with ANN1

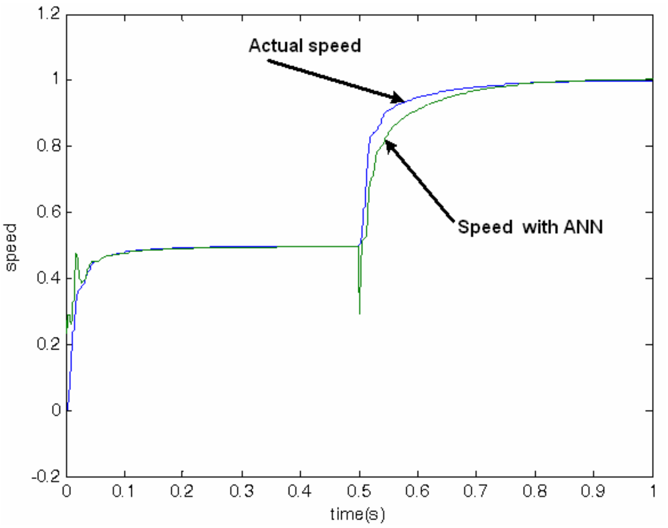

Figure12. Regulation of DC motor speed

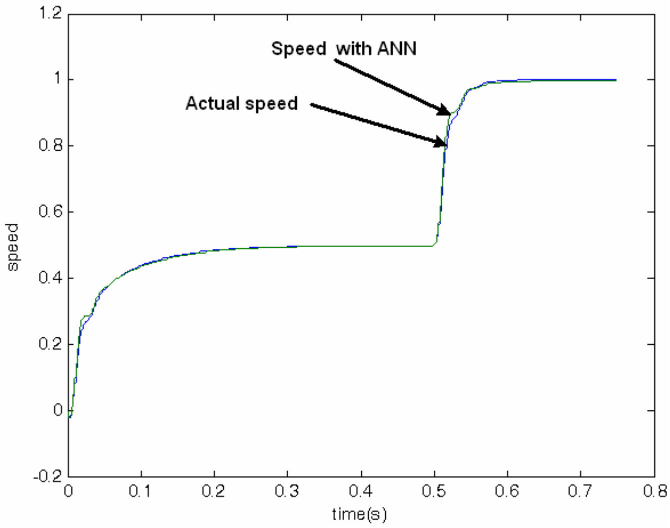

Figure13. Regulation of DC motor speed

V. CONCLUSION

Since its linear activation function, this network is very difficult to express the nonlinear relationship. As a consequence, its satisfying ability is not sufficient.

The result with feed-forward neural network is much better because it uses sigmoid - tansig, which makes it easier to express the nonlinear relationship.

The using an adaptive neural network with sigmoid – tansig activation function has the best satisfying ability because it use Moreover, we can use it in the adaptive control systems. However, in order to gain exact repeat in ANN, the control objects have to create suitable training patterns which can sufficiently express all the working regulations of the control objects. In this case the DC motor has been successfully controlled using an ANN. Using ANN, we don't have to calculate the parameters of the motor when designing the system control.

- In this paper it is shown an appreciable advantage of model using ANNs. In this paper, the author would like to present the new ANNs application in the new method of defining the mathematical model of non-liner control objects in the context of missing the data base as well as performance function by the difference Neural Networks
- ANN application can be used in adaptive controlling in the control system machine with complicated load.
- Nowadays, in order to implement the control systems DC motor on actual hardware, DSP is being used.

VI. REFERENCE

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