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Speed Control of DC Motor using Neural Network Configuration

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Abstract - ***This paper introduces the concept of Artificial Neural Networks (ANN) in estimating and controlling the speed of separately excited DC motor. The Neural Network scheme consists of two parts: one is the neural estimator, which is used to estimate the motor speed and the other is the neural controller, which is used to generate a control signal for a converter. These two neural networks are trained by Levenberg-Marquardt back propagation algorithm. Standard three layer feed forward neural network with sigmoid activation functions in the input and hidden layers and purelin in the output layer is used. Simulation results are presented to demonstrate the effectiveness and advantage of control system of DC motor with ANNs in comparison with the conventional control scheme.***

Kewords -***Artificial neural networks(ANN), Learning of ANN, Structure of ANN, DC motor, control System.***

I. INTRODUCTION[1]

The development of high performance motor drives is very important in industrial applications. Generally, a high performance motor drive system must have good dynamic speed command tracking and load regulating response.

D.C motors have long been the primary means of electric traction. D.C motor is considered a SISO system having torque/speed characteristics compatible with most mechanical loads. This makes a D.C motor controllable over a wide range of speeds by proper adjustment of its terminal voltage. Recently, brushless D.C motors, induction motors, and synchronous motors have gained widespread use in electric traction. However, there is a persistent effort towards making them behave like dc motors through innovative design and control strategies. Hence dc motors are always a good proving ground for advanced control algorithm because the theory is extendable to other types of motors. Many practical control issues (motor control problems):

1) Variable and unpredictable inputs
2) Noise propagation along a series of unit processes
3) Unknown parameters
4) Changes in load dynamics

Under these conditions, the conventional constant gain feedback controller fails to maintain the performance of the system at acceptable levels. The incorporation of feed forward in artificial neural networks is important for several reasons the dynamical properties of the system, and in practice it may improve the performance. They are generally present in most non-linear dynamical system and can be used to implement specific structures.

Advantages of using ANNs:

1) Learning ability
2) Massive parallelism
3) Fast adaptation
4) Inherent approximation capability 5) High degree of tolerance Speed control techniques in separately excited dc motor:

1) Varying the armature voltage in the constant torque region.
2) In the constant power region, field flux should be reduced to achieve speed above the rated speed.

2. MATHEMATICAL MODEL OF DC MOTOR:

The separately excited DC motor is described by the following equations:

$$KF\omega p(t) = -Raia(t) - La[dia(t)/dt] + Vt(t) \quad \ldots\ldots\ldots\ldots(1)$$

$$KF\, ia(t) = J[d\omega p(t)/dt] + B\omega p(t) + TL(t) \quad \ldots\ldots\ldots\ldots(2)$$

where,

$\omega p(t)$ - rotor speed (rad/s)
$Vt(t)$ - terminal voltage (V)
$ia(t)$ - armature current (A)
$TL(t)$ - Load torque (Nm)
J - rotor inertia (Nm2)
KF - torque & back emf constant (NmA-1)

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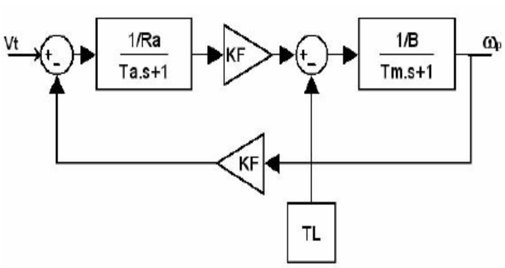
B - viscous friction coefficient (Nms)
Ra - armature resistance (Ω)
La - armature inductance (H)
From these equations mathematical model of the DC motor can be created when,
Ta -Time constant of motor armature circuit and

$$Ta=La/Ra \ (s)$$

Tm – Mechanical time constant of the motor

$$Tm=J/B \ (s)$$

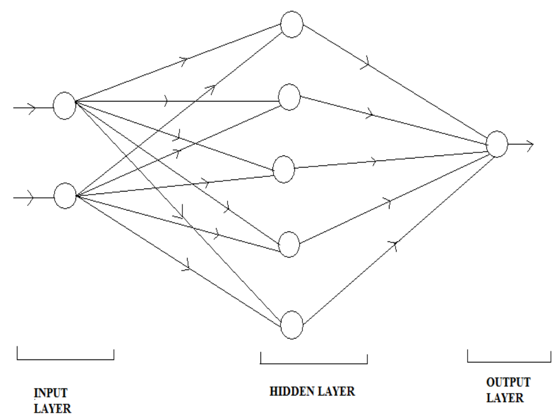


3. CONVENTIONAL DC DRIVES

Conventional direct current electric machines and alternating current induction and synchronous electric machines have traditionally been the three cornerstones serving daily electric motors needs from small household appliances to large industrial plants. Recent technological advances in computing power and motor drive systems have allowed an even further increase in application demands on electric motors. Through the years, even AC power system clearly winning out over DC system, DC motors still continued to be significant fraction in machinery purchased each year. There were several reasons for the continued popularity of DC motors. One was the DC power systems are still common in cars and trucks. Another application for DC motors was a situation in which wide variations in speed in needed. Most DC machines are like AC machines in that they have AC voltages and currents within them, DC machines have a DC output only because a mechanism exists that converts the internal AC voltages to DC voltages at their terminals.
The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and/or the field current will change the rotor speed. Today, adjustable frequency drives can provide precise speed control for AC motors, but they do so at the expense of power quality, as the solid-state switching devices in the drives produce a rich harmonic spectrum. The DC motor has no adverse effects on power quality.

3. THE CONTROL SYSTEM OF DC MOTOR USING ANN

A neural network is a generalized approach of making the learning algorithm and making a decision for accurate controlling operation in various applications. The approach of neural network basically works on the provided priories information and makes a suitable decision for a given testing input based on the provided training information. This approach is analogous to the human controlling approach where all the past observations are taken as the reference information and are used as a decision variable. To obtain such estimation in current DC motor controlling approach the current DC motor drives are to be improved using such a learning approach. In this paper a dual level neural network approach is designed for DC machine speed controlling. A dual level modeling provides a faster training and converging as compared to a single level neural modeling. For the realization of a dual level neural modeling, two-neuro architecture namely ANN-control and ANN-train is proposed.
The 2 models of the control system of DC motor using ANNs is built withANNtrain,and ANN control unit where the network are trained to emulate a function: ANN-train to estimate the speed, ANN-control to control terminal voltage.[1,2,3]



4. THE STRUCTURE AND LEARNING OF ANN

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 through links which either attenuate or amplify the signal. 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 [4]. 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

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sweeps .[6,7]

Network	ANN 1	ANN 2
Number of input	3	4
Number of output	1	1
Number of hidden layer	1	1
Number of hidden neurons	3	4
Number of training patterns	1215	1215

The ANN1 and ANN2 structure 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. Three inputs of ANN are reference speed ωr(k), terminal voltage Vt(k-1) and armature current ia(k-1). And output of ANN1 is an estimated speed ωp*(k). The ANN2 has four inputs: reference speed ωr(k), terminal voltage Vt(k-1), armature current ia(k-1) and an estimated speed ωp*(k) from ANN-1. The output of ANN is the control signal for converter Alpha.

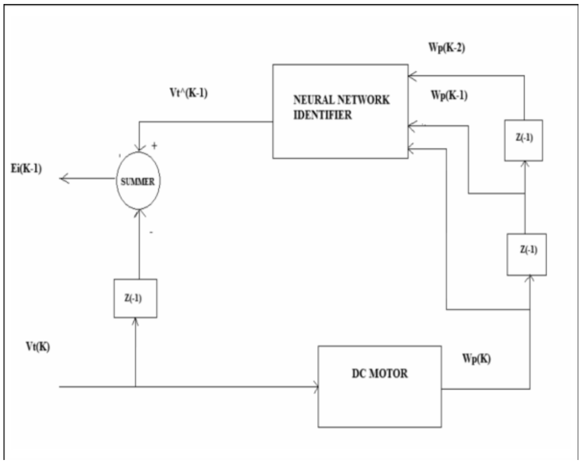
5.IDENTIFICATION OF DC MOTOR MODEL: [8,9]
The equation can be manipulated to the form;
Vt(k) = g[Wp(k+1), Wp(k), Wp(k-1)]

where the function g[.] is given by;

g[Wp(k+1), Wp(k), Wp(k-1)] = { Wp(k+1) - α Wp(k) - β Wp(k-1) - [sign (Wp(k))]
Wp 2(k) - [sign (Wp(k-1))] Wp 2(k-1) }/ ;

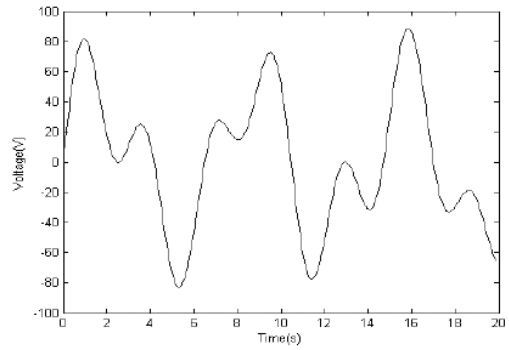
and is assumed to be unknown. An ANN is trained to emulate the unknown function **g[.]**.
However as **Wp(k+1)** cannot be readily available.

Structure of ANN identifier is as:

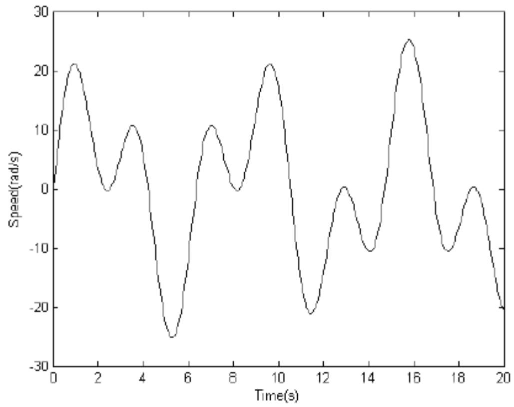


6. OUTPUT

Specifications of the motor used:- separately excited dc motor with name plate ratings of 1 hp, 220V, 550 rpm is used in all simulations. Following parameter values are associated with it.
J = 0.068 Kgm2
K = 3.475 Nm A-1
Ra = 7.56
La= 0.055 H
D = 0.03475 Nms
μ= 0.0039 Nms2 ; T = 40ms



Output curve for terminal voltage



Output curve for the rotor speeds

7. CONCLUSION
The DC motor has been successfully controlled using an ANN. Two ANNs are trained to emulate functions: estimating the speed of DC motor and controlling the DC motor, Therefore, ANN can replace speed sensors in the control system models. Using ANN, there is no need to calculate the parameters of the motor when designing the system control. It has shown an appreciable advantage of control system using ANNs above the conventional one, when parameter of the DC motor is variable during the operation of the motors. The satisfied ability of the system control with ANNs is much better than the conventional controller. ANN application can be used in adaptive controls for machines with complicated loads.

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REFERENCES

[1] Moleykutty, G. (2008). Speed Control of Separately Excited DC Motor. A*merican Journal of Applied Sciences 5* , 227-233.

[2] S.Weerasoorya and M.A Al-Sharkawi "Identification and control of a DC Motor using back-propagation neural networks" *IEEE transactions on Energy Conversion,* Vol.6, No.pp663-669, December 1991

[3] Neural Network Controller", *IEEE Control System Magazine,* pp.17- 20,1988.

[4] B. Kosko, *Neural Networks and Fuzzy Systems, Prentice*- Hall International Inc,1992

[5] E. Levin, R. Gewirtzman, and G.F. nbar, "*Neural Network Architecture for Adaptive System Modellinggand Control*", Neural Networks, No 4(2) pp185-191,1991.

[6] Parthasarathy, K., & Narendra, K.(March, 1990). Identification and Control of dynamical systems using neural networks. *IEEE Transactions on Neural Networks, volume-1* , 4-27.

[7] J. Santana, J. L. Naredo, F. Sandoval, I. Grout, and O. J. Argueta, *Simulation and construction of a peed control for a DC series motor*," Mechatronics, vol. 12, issues 9-10, Nov.- Dec. 2002, pp. 1145-1156

[8] Zilkova, J., Timko, J., & Girovsky, P. (2006). Nonlinear System Control Using Neural Networks.*Acta Polytechnica Hungarica, Vol.3; No.4* 85-94.

[9] Liu, Z., Zhuang, X., & Wang, S. (2003). Speed Control of a DC Motor using BP Neural Networks.*IEEE Transactions* , 832-835.

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