A Review on Speed Control of DC Motor using Non Linear Autoregressive Moving Average Controller

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Abstract: The development of technologies affects the demands of industries at the present time. Thus, automatic control has played a vital role in the advancement of engineering and science. In today's industries, control of DC motors is a common practice. Therefore, implementation of DC motor controller is required. There are many types of controller that can be used to implement the elegant and effective output. One of them is by using a NARMA L2 controller. The NARMA L2 controller is first trained to cancel both non-linearity and dynamics of the system and then it is reconfigured to become a controller. This paper focuses on implementing NARMA L2 controller to control speed of a dc motor. It has been found that both PI and Hysteresis current controller can be eliminated by using NARMA L2 controller.

Keywords- DC motor, NARMA L2 Controller.

I. INTRODUCTION

The DC motors are used in various applications such as defence, industries, Robotics etc. DC drives because of their simplicity, ease of application, reliability and favourable cost have long been a backbone of industrial application. DC drives are less complex with a single power conversion from AC to DC. DC drives are normally less expensive for most horse power ratings. DC motors have long tradition of use as adjustable speed machine and wide range of options have evolve for this purpose.

Almost every industry and household has used motor in their equipment or appliances. The motors that are often used by the computers have also become an essential part of many motion control systems. Traditionally rheostatic armature control method was widely used but the controllability and cheapness of static power converters made a major change in the performance of electrical drives .In recent years neural network controllers are effectively introduced to improve the performance of non linear system. The application of NNC is very promising in system identification and control due to learning ability, fast adaption and high degree of tolerance .Many advanced method have been develop to obtain the response of the system close to the desired response. One of these methods is based on Artificial Neural Network (ANN) that is termed as Non Linear Autoregressive Moving Average (NARMA) L2 controller .

Speed Control of Separately Excited DC Motor:

The speed of separately excited dc motor can be varied from zero to rated speed by varying armature voltage.

Speed control of dc motor using NARMA L2 controller:

NARMA L2 Controller:

The learning ability, self adapting and fast response feature of artificial neural network (ANN) make the NARMA L2 controller well suited for many electrical power applications like speed control of dc motor. In learning process a neural network adjusts its structure such that it will be able to follow the supervisor .The learning is repeated until the controller follow the desired output .The working of NARMA L2 controller can be divided in two steps:

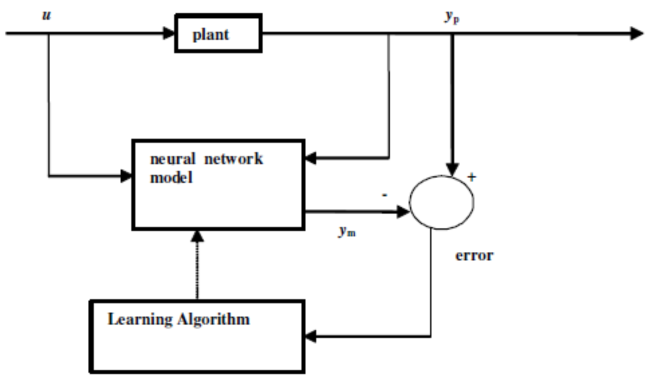
(a) System Identification Stage
(b) Controller Design Stage

(a) System Identification Stage:

A NARMA L2 controller, a multilayer neural network is applied in the identification and control of dynamic system .In system identification stage a neural network model of plant to be controlled is developed .The schematic diagram of system identification stage of NARMA L2 controller is as shown in below fig(1).In the system identification stage a neural network plant model must be developed before the controller is used

.The plant model is used to predict the future plant output .The plant model has only one hidden layer.

As with model predictive control, the first step in using feedback linearization (or NARMA-L2) control is to identify the system to be controlled.A neural network is trained to represent the forward dynamics of the system. The first step is to choose a model structure to use. One standard model that is used to represent general discrete-time nonlinear systems is the nonlinear autoregressive-moving average (NARMA) model.



Fig(1): System Identification Stage

y (k+d) = N[y(k),y(k-1),...,y(k-n+1),u(k),u(k-1),..,u(k-n+1)]

Where, $u(k)$ is the system input, and $y(k)$ is the system output. For the identification phase, you could train a neural network to approximate the nonlinear function N. This is the identification procedure used for the NN Predictive Controller.
If to make the system output to follow some reference trajectory then,

$$y(k + d) = y_r(k + d)$$

The next step is to develop a nonlinear controller of the form:
u (k) = G[y(k),y(k-1),..,y(k-n+1),y_r(k+d),u(k-1),..,u(k-m+1)]

The problem with using this controller is that if we want to train a neural network to create the function G to minimize mean square error, we need to use dynamic back propagation. This can be quite slow. One solution is to use approximate models to represent the system. The controller used in this section is based on the NARMA-L2 approximate model:

y (k+d) = f [y(k),y(k-1),...,y(k-n+1),u(k-1),..,u(k-m+1)] +g[y(k),y(k-1),...,y(k-n+1),u(k),u(k-1),..,u(k-n+1)].u(k)

This model is in companion form, where the next controller input $u(k\ )$ is not contained inside the nonlinearity. The advantage of this form is that it can be solved for the control input that causes the system output to follow the reference $y(k + d) = y_r(k + d)$. The resulting controller would have the form:

$$u(k) = \frac{y_r(k+d) - f[y(k), y(k-1), \ldots, y(k-n+1), u(k-1), \ldots, u(k-n+1)]}{g[y(k), y(k-1), \ldots, y(k-n+1), u(k-1), \ldots, u(k-n+1)]}$$

(b) Controller Design Stage:

In the controller design stage , a neural network plant model is used to train the controller .The central idea of this type of control is to transform nonlinear system dynamics by cancelling the non linearities.

Using the NARMA-L2 model, we can obtain the controller as:

$$u(k+1) = \frac{y_r(k+d) - f[y(k), \ldots, y(k-n+1), u(k), \ldots, u(k-n+1)]}{g[y(k), \ldots, y(k-n+1), u(k), \ldots, u(k-n+1)]}$$

which is realizable for $d \geq 2$. The following figure is a block diagram of the NARMA-L2 controller.

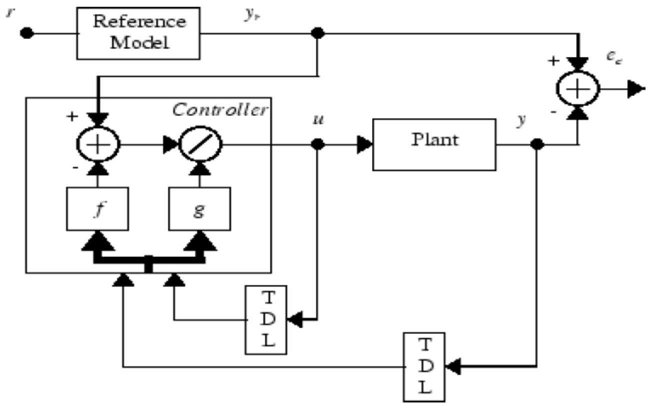
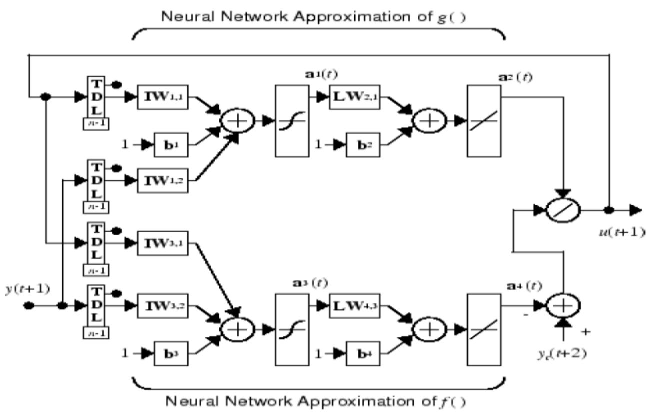


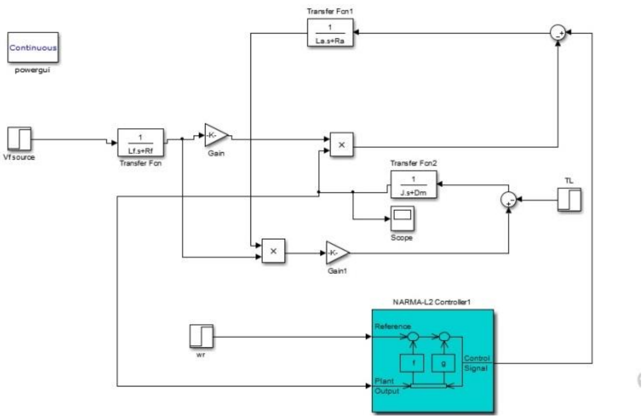
Fig (2): Block diagram of NARMA L2 Controller

This controller can be implemented with the NARMA-L2 plant model, as shown in the following figure:



Simulink Model of NARMA L2 controlled separately excited dc motor:

The simulink model of NARMA L2 controlled speed control of dc motor is as shown in fig (3).A simulink based PI controller can be used to generate the training data for NARMA L2 controller .The inputs to the NARMA controller are reference speed and actual speed of the motor and output is the required armature voltage to the dc motor .



Fig(3) Simulink model of speed control of dc motor using NARMA L2 controller

CONCLUSION

Speed control system using NARMA L 2 controller has been successfully studied to control the speed of separately excited dc motor .NARMA L2 controller is able to regulate the speed of motor well above rated speed .This controller gives very accurate and fast speed control of dc motor which is very essential requirement for dc drives .Also NARMA L2 controller eliminates both hysteresis current controller and PI controller for speed control application.

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