Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 5, July, 2021: 3945-3949

Research Article

A Review on Application of Adaptive Fuzzy Technique in a nonlinear system

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Abstract

The key conception of the paper is to study the responses of a nonlinear system when it is being controlled with an adaptive controller. The system considered is a two mass drive system that is customized out of an engine in which motor will be accompanied with a load shaft. The adaptive controller used here provides better accuracy and robustness for a system. The ANFIS controller alters various specifications in a fuzzy system by bringing the learning procedures into effect by employing input- output training data. The representation of ANFIS controller is explicated in detail and the considered system speed is contemplated using the ANFIS controller.

Keywords: *ANFIS Controller, Two mass drive system*

Introduction

The obligation for absolute operation in industrial electrical drives have been escalating with time in the current world. The key intent of industrial electrical drive system is to lower the delay with respect to time during the process and to execute the course of speed as well as position and at the same time the system should be vigorous to the variations of parameters. The considered system is a two mass drive system where the complication arises due to less resonant frequency across the load shaft located between the motor and load. The considered system will be applicable in industries like textiles, rolling mills, paper machinery conveyors etc.., i.e. where ever the electrical drives are being applied. The springy establishment between electrical drives builds active oscillations of the drive state variables. Therefore it embellishes problems to standardize shaft's position and speed which results in loss of stability. The estimation of system's state variables is done to provide a stable two mass system. This estimation process was implemented using neural network estimator. Fig.1 is a two mass system where wm defines motor speed and wi defines load speed; Tm defines motor torque and Tl defines load torque.

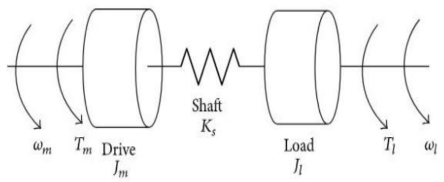

Fig 1. Two Mass Drive System

KS is the finite stiffness of the shaft; Jm defines motor inertia and Jl defines load inertia.

MATHEMATICAL MODELLING

The system has been designed by considering Fig 1. The system's state equation will be

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$$\frac{d}{dt}\begin{bmatrix}\partial 1(t)\\ \partial 2(t)\\ \partial 3(t)\end{bmatrix}=\begin{bmatrix}0 & 0 & \frac{-1}{C1}\\ 0 & 0 & \frac{-1}{C2}\\ \frac{1}{Cc} & \frac{-1}{Cc} & 0\end{bmatrix}\begin{bmatrix}\partial 1(t)\\ \partial 2(t)\\ \tau s(t)\end{bmatrix}+\begin{bmatrix}\frac{1}{C1}\\ 0\\ 0\end{bmatrix}[\tau e]+\begin{bmatrix}0\\ \frac{-1}{C2}\\ 0\end{bmatrix}[\tau L]$$

C1 and C2 defines time constants of the motor and load; Tc defines stiffness time constant, $\partial 1$ motor speed, $\partial 2$ load speed, τe, τs and τL defines motor , shaft and disturbance torques

In the construed system, the system parameters are reflected as constant: C1 =74 ms, C2 =74 ms, and Cc =5.6ms. Damping losses are deserted deprived of significantly disturbing the preceding simulation analysis, since under normal conditions these are contemplated to be relatively low.

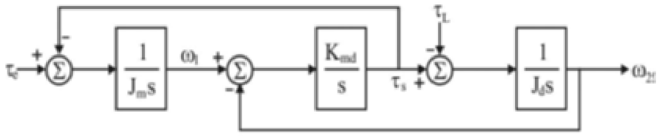

Fig.2. Considered system block diagram.

The analyzed two-mass system transfer function (fig.2) is given by:

$$G_{TMS}(s)=\frac{K_{md}}{s(s^2 j_d j_m + k_{md} j_m + k_{md} j_d)}$$

PROPOSED CONTROLLER

ANFIS has acquired an added fascination through the past decade as a strapping operating procedure to break the complexity in process control. Contrasting the typical techniques, the adaptive fuzzy controllers possess the competency of resolving complications with unconcluded elucidations. The combination provides a convenient data processing by stipulating mathematical relationships amid plentiful variables in a compound system, carrying out mappings with step of fuzziness. ANFIS gives a better detailed information about the system's responses over the application of neural networks and fuzzy logic.

For a conventional fuzzy inference, the parameters in the membership functions are firmed by practice or the trial-and-error method. Yet the adaptive neuro fuzzy inference system can overwhelm this detriment through the development of learning to mold the membership functions to the input/output data so as to interpret the natures of dissimilarities in the data values, afore capriciously electing parameters allied with a prearranged membership function. This proposed learning scheme works correspondingly to that of neural networks.

In MATLAB the fuzzy inference system is of two types one is mamdani and second is Sugeno. Mamdani is fuzzy controller in which we run input and output by means of assumptions. In Sugeno, we make available of inputs and the controller spontaneously train outputs which makes the variance between two fuzzy controllers in MATLAB. Therefore controller based on Sugeno-fuzzy inference was considered.

The architecture of adaptive neural fuzzy is shown in fig.3

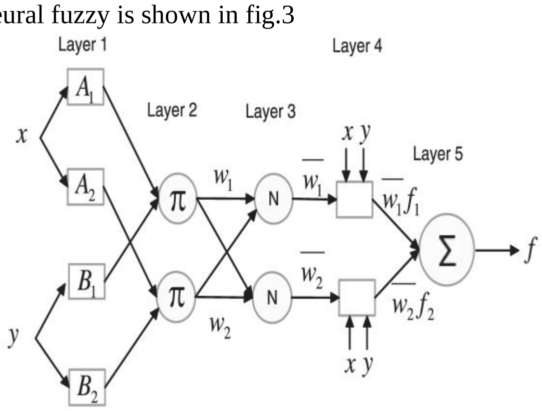

Fig.3. Adaptive neural fuzzy architecture

The considered weights 'w' are represented with the symbols as 'k' and the output function of each layer is represented with 'z'.

Stage 1: The membership functions from this stage will be

$$Z_i^1 = \Delta_{Ai}(x),$$
$$Z_i^1 = \Delta_{Bi=2}(x)$$

Here Δ_{A_i} and Δ_{B_i} consents the membership functions.
Stage 2: This stage selects least possible value from the input weights.

$$Z_i^2 = k_i = \Delta_{Ai}(x)\Delta_{Bi}(y)$$

Stage 3: Each node of this stage analyses the weight that is normalized.

$$Z_I^3 = \overline{k_i} = \frac{k_i}{k_1 + k_2}$$

Stage 4: This stage comprises the outputs composed of linear functions.

$$Z_i^4 = \overline{k_i} o_i = \overline{k_i}(p_i x + q_i y + r_i)$$

Here $\overline{k}_i$ is the output of third stage, and pi, qi, ri are parameter set.
Stage 5: This stage sums all the received signals.

$$Z_i^5 = \sum_{i=1}^{2} \overline{k_i} o_i = \frac{k_1 o_1 + k_2 o_2}{k_1 + k_2}$$

The output f in Fig.3 can be rewritten as:

$$f = (\overline{k_1} x) p_1 + (\overline{k_1} y) q_1 + (\overline{k_1}) r_1 + (\overline{k_2} x) p_2 + (\overline{k_2} y) q_2 + (\overline{k_1}) r_2$$

The ANFIS integrates fuzzy method with neural networks and provides better accuracy and robustness for a system based on Takagi-Sugeno model. The motive of ANFIS controller here is to alter the specifications of a fuzzy system by bringing the learning procedures into effect by employing input- output training data.
The ANFIS controller was implemented as follows

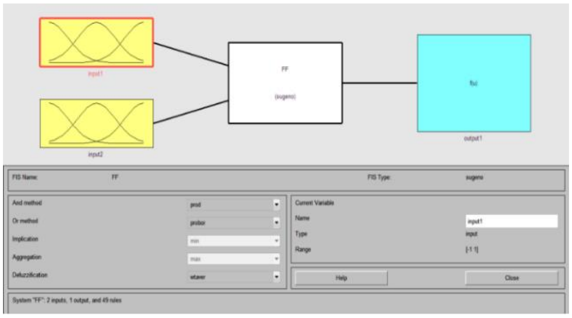

Fig.4

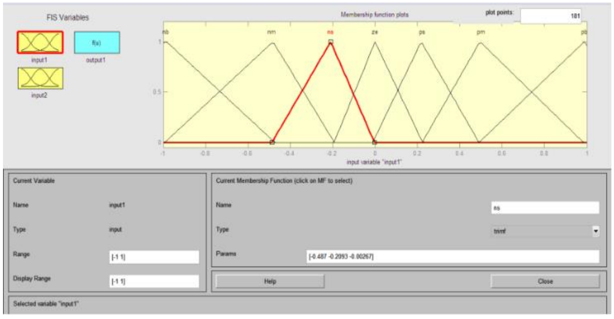

Fig.5

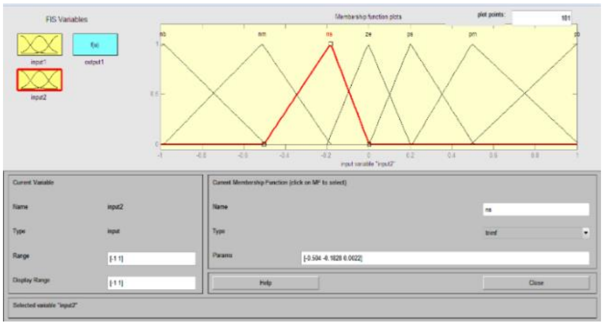

Fig.6.

Fig.7.

In Figure.4 The ANFIS controller was imported and in Figure.5 First input was taken from the error. Figure.6 shows The second input was taken from the overshoot and time delay error and Figure.7 shows Optimal value derived from input membership functions taken as output.

RESULTS

The results were the responses for considered nonlinear system. The responses include motor and load speeds, electromagnetic and shaft torques under the considered technique. From the results, it was observed that the overshoot is absolutely zero percent and the settling time of electromagnetic torque is 0.014sec, settling time of shaft torque is 0.016sec, settling time of Load speed is 0.045sec and the settling time of motor speed is 0.006sec for the proposed two mass system.

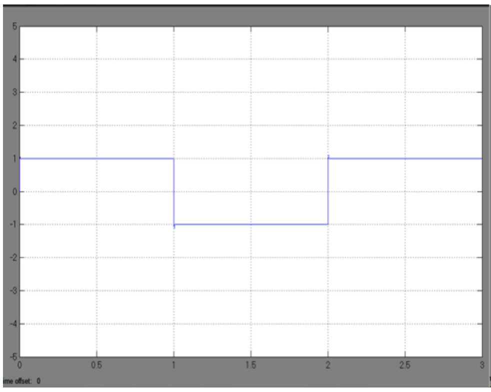

Fig. 8. Speed response of the motor

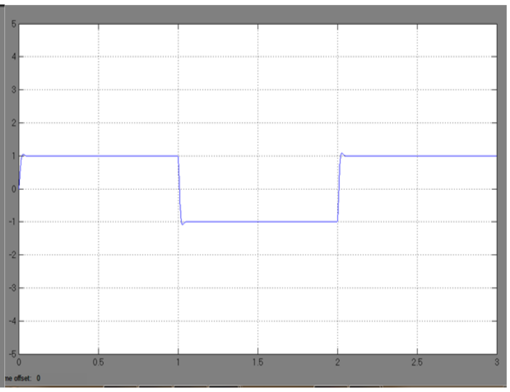

Fig. 9. Speed response of the load

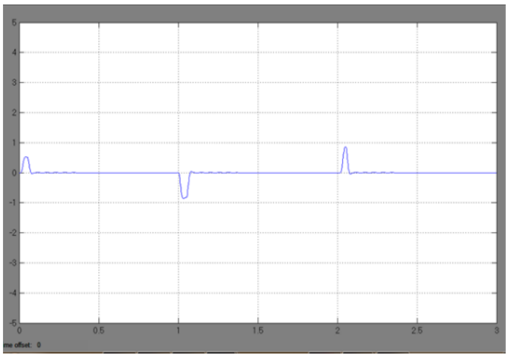

Fig. 10. Electromagnetic Torque response

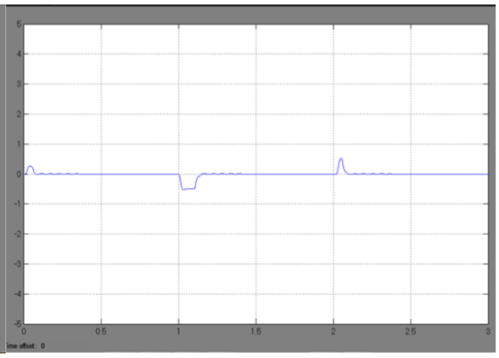

Fig. 11. Shaft torque response

CONCLUSION

The results showed that the implementation of two mass system using the fuzzy adaptive controller has been robust and provides reduced trembling which results in steady pindustry applications. Analysis and simulation shows better performance resulted using the adaptive fuzzy controlling strategy.

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