Controlling Digital Systems via Intelligent Networks

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Abstract: *Control is important to improve hardware performance. Most electronic systems are designed according to the device and then manufactured as an attached electronic device. However, if conditions change or the factory is modernized then the control device must be replaced. This is due to the complexity of the control unit represented by the program implementation algorithms, in addition to the time delay caused by digital and analog signal converters (ADC - DAC), and in this research it is replaced by deep neural networks It is a thriving field with practical and medical applications and is characterized by its ability to learn and train as it is a branch of machine learning and artificial intelligence. The results proved that the functioning of the neural networks and their performance are better than the control system where the value of the difference between the two is equal to zero.*

Keyword: Digital control system, Artificial Neural Network, Deep learning.

I. Introduction

In most modern engineering systems, System variables must be controlled and to ensure that a transient and satisfactory condition behaves satisfactorily to these systems, it will be necessary to need the controllers as the consoles today use negative feedback. The control unit is an analog system that handles the error signal for determining the desired control procedure, including electrical, or mechanical components, and all of these systems have outputs and inputs . [1] Deep intelligence networks have recently emerged as the best way to discover signal properties and track changes. Therefore, the world is now greatly concerned with deep intelligence networks to uncover areas of information such as image awareness, diagnosing diseases, knowing the targets for radar, and more. [2]. at present, it has been replaced traditional fixed controls with networks of intelligence and deep intelligence and performance comparison. The preference may be large, as we do not need to redesign the electronic system because the intelligence networks are able to adapt to the new variables. Deep learning is a branch of machine learning that has evolved from traditional neural networks. It adopts the principle of training and learning that consist of a number of arithmetic units called neurons. These cells are organized into units called layers, usually consisting of three layers the input layer, a hidden layer and the output layer. These cells perform a basic process and send the information to other neurons [4].

Literature Review

Song Xu (2020) A control method was proposed Artificial Neural Network (ANN), which is characterized by self-learning of a reference model with an integrated proportional derivative compensation IPD for temperature control systems, simulations were conducted in the Matlab environment where the experiments were based on digital signal processing in its experimental platform and the results were compared with the traditional control system IPD Where the error signal is used between the real output and the output of the reference control system, and the results indicate that the proposed method has been effective in improving the transient response and bypassing which indicates a good performance[5].

Alexey (2019) Liquid friction bearing is one of two types of bearings that implements the friction system without touching the friction surfaces. The rotor path control system is designed to ensure less energy loss due to rotation of the rotor as energy loss occurs due to loss of vibration and friction, the clearance control allows you to adjust the position of balance and the characteristics of flexibility, as reducing losses is difficult for the control system due to the physical condition of the rotor system and due to random external effects. The rotational force with and without controls and compare it. The results show that clearance control can reduce energy loss and vibration level in the rotor system .This research also discussed the use of

Proportional Integral Derivative (PID)control, which did not achieve positive results under random conditions, unlike artificial neural networks that operate according to the principle of training and learning, and thus it allows to reduce the losses of friction and vibration in the rotor machine and thus achieve the desired [4].

II. Methodology

1. Control system

System for controlling industrial, household, or automated systems and it consists of input and output, for example: to control the speed of a motor or heater .The output is the current value (CV), and the input is the one that controls, and the set value (SV) represents the factory you're working on [6]

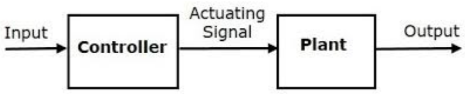


Fig. 1. Control system

2. Digital Control System

Unlike the analog control system, digital signals are handled in this system and the digital computer is used to handle digital signals in order to control the system where the computer receives named time series named data samples as it was created by taking samples of the data entered at specific time periods consisting of signal chains. It is called the sampling period (T). [7] [5].General goal: It will connect components to achieve optimal performance (to improve system behavior and reduce resulting error).

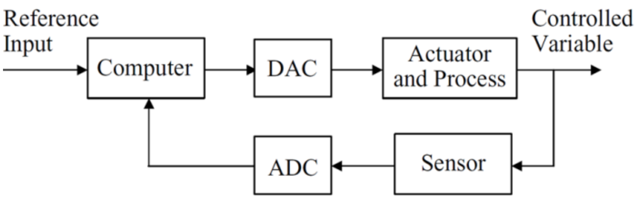


Fig. 2. Digital control system

❖ Closed Loop system

In the closed loop system measure of actual output is used, which is the feedback system, a closed-loop control system that compute difference between output and required output, and then uses the difference between the two quantities to get to a greater extent than the reference inputs. [8] [9]

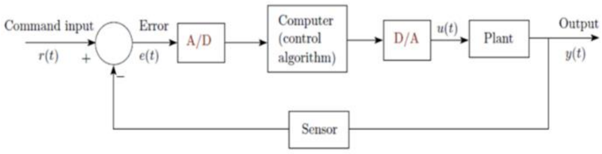


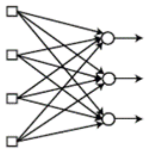
Fig.3. closed loop system

Closed loop transfer function (control ratio)

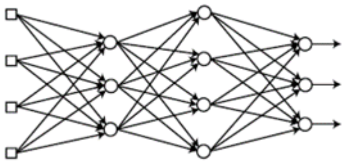
$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)} \qquad (1)$$

3. Artificial Intelligent Network (ANN)

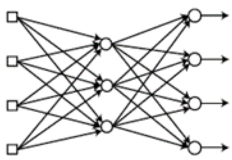
A computational model that is an interconnected set of nodes or neurons to represent the network. ANN is used to solve many complex problems, because of their ability to learn from complex patterns. Method to connect neurons together is different like simple neural network had architecture input and output layers only[10], this is called the single layer neural networks. Added hidden layers new into a single layer neural networks, then became known as multi-layer neural network. If multi-layer neural network have a single hidden layer it's called shallow neural network. If multi-layer neural network have two or three or more hidden layers is called deep neural network [11][12]. Figure (7) shows type of the neural network.



Single-layer Neural Network (Shallow)



Multi-layer Neural Network



Deep Neural Network

Fig. 4. Type of neural network

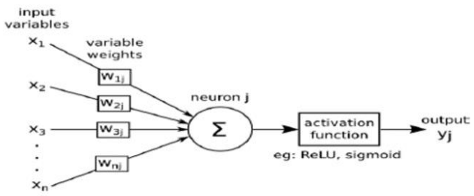


Fig. 5. Single layer

Each input represent by variable (x)is multiplied with the standard weight(w) formed by that which enters the summer to be combined with the bias to produce the net and then enter the conversion function that is chosen by the user and one of the most common (sigmoid-transfer function) to produce then the neuron output. [13]

$$net = \sum xw \qquad (2)$$

$$\sum xw = x1w1 + x2w2 + \cdots xiwi \qquad (3)$$

$$y = f(net + b) \qquad (4)$$

b=bais

It must be noted that the variables (w, b) is adjustable in the training phase of the network through the backpropagation by one of the learning rule. The signal with the largest weight has a greater effect so that if the entry has a zero weight, this entry is never passed to the node, meaning that it is not connected to the network, as well as the greater its weight Become an Alta.Learning by supervised learning in this type a training group is provided where it represents the network's inputs and when applied the outputs from the network are compared to the goals and then we apply one of the learning rules to adjust the weights.

Architecture of neuron

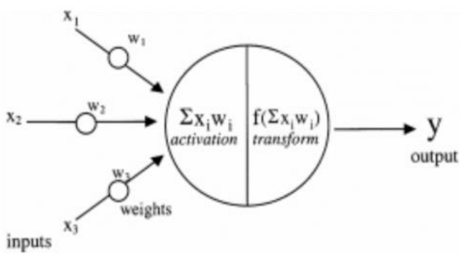


Fig .6. Architecture of NN

1-Adder to summation signals in the weighted income.

$$\sum xiwi = x1w1 + x2w2 + \cdots + xiwi \qquad (5)$$

2-Activation function or squashing which limits the output and makes it within the range [0,1] or [-1,1],where choice of activation function is by the user.[10]

$$y = f(\sum xiwi + b) \qquad (6)$$

Activation function It is determined that the neuron can be activated or not by calculating the weighted sum of the inputs with biases and it makes the neural network able to learn and perform the most complex tasks through non-linear transformation and this is a function of the activation function. [14], One of the most important types are: Sigmoid, Tanh and Relu.

Learning in the neural network are in two type (Supervised Learning and Unsupervised Learning**).**

Learning rules

Learning rules improve the performance of the neural network by updating the weights of the network .also it is a mathematical model that is used to adjust the Weights in the network by training the network on specific tasks through current conditions. The most important rules of learning are.[15]

1. **Hebbian learning rule:** Determines how weights are adjusted for the neurons in the network

$$W_{ij} = X_i * X_j \qquad (7)$$

2. **Perceptron learning rule:** The learning process here depends on assigning a random value to each weight in the neural network.

$$y=b+\sum(x*w) \qquad (8)$$

3. **Delta learning rule** : is most common use ,it depends on supervised learning here the adjustment in weights is equal to multiplying the error and input as follows **:**

$$\Delta W = \eta(t - y)x_i \qquad (9)$$

Proposed method

Neural networks are distinguished by their ability to adapt to modern variables. In this research, we worked to analyze the application of neural networks as an alternative to the control unit in digital systems, where neural networks operate under supervision, that is, a data set is provided to train the network before simulation to obtain outputs and then be tested with new data and compare the results Outputs with the results of control systems where the scale will be the mean square error rat, The following figure shows the general outline of the proposed method.

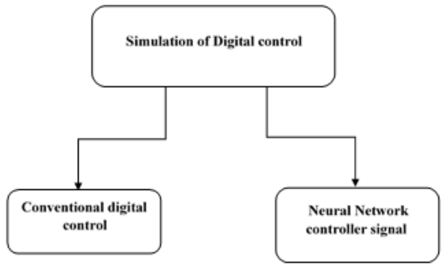


Fig .7. Block diagram explain the proposed method

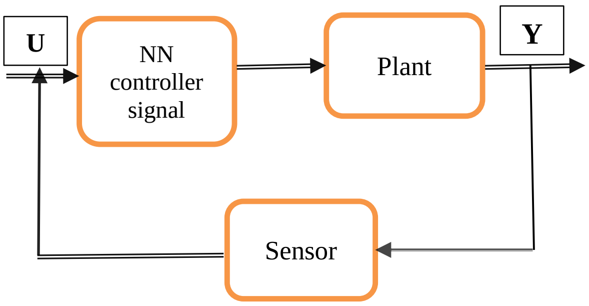


Fig. 8. Block diagram of NN instead of control system

III. Results and Discussion

The digital control system is implemented, where the following equations (10, 11, and 12) are applied to find the output signal by determined the error signal and the control signal, the unit step is represent the input signal to the system

$$Y_i = -q * Y_{k-1} - f * Y_{k-2} + b * U_{k-1} + c * U_{k-2} \quad (10)$$

$$e_i = 1 - Y_i \quad (11)$$

$$U_i = -h * U_{k-1} + k * g * e_{k-1} \quad (12)$$

The simulation results are analysed in Matlab depending on the number of parameters influencing the outcome whith learning error rate 0.01 and are as follows:

1. By using Neural Network one layer give the following result:

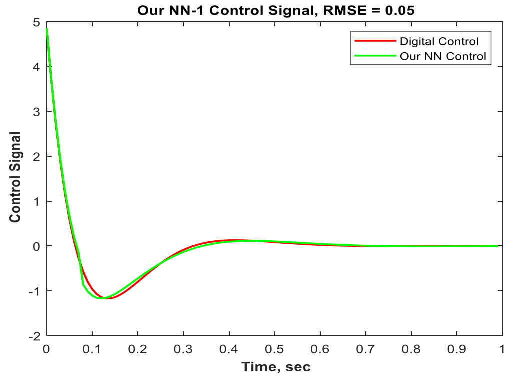


Fig. 9. NN with epoch 400

In this figure, the use of a single-layer neural network with an increase in epoch to 400, the result that is noticed is not good as (RMSE) its value is high.

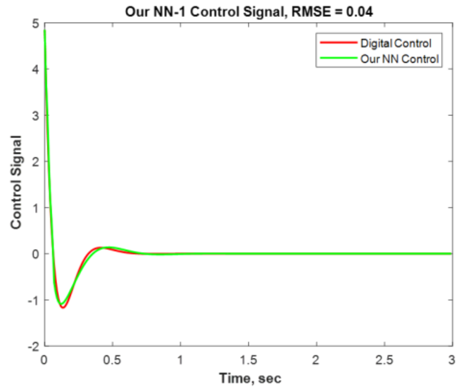


Fig .10. NN with N300

In this figure, the use of a single-layer neural network with an increase number of realization to 300, the result appears approximately good as (RMSE) its 0.04, it represents the lowest value that can be obtained for one layer Neural Network.

2. By using 2layer Neural Network ,give the following result

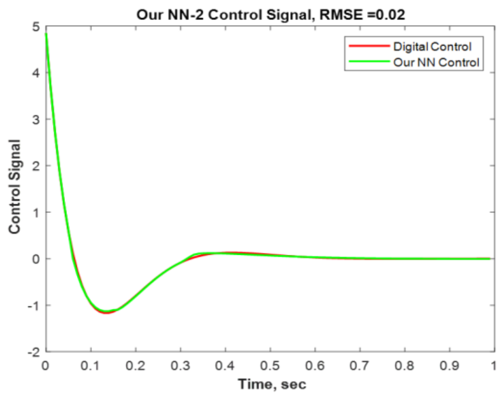


Fig .11. 2layer NN with N200

In this figure, the use of neural network two layer with an increase number of realization to 200 and increase learning error rate, the result that is noticed is a very good as (RMSE) its 0.02, it represents the lowest value.

The results can be summarized in the following table:

Table 1. RMSE value

The effect of parameters on RMSE value								
decrease				increase				
number of realization	number of heddin	learning rate	epoch	number of realization	number of heddin	learning rate	epoch	1layer NN RMSE
0.11	0.11	0.08	0.08	0.06	0.05	0.11	0.07	
0.08	0.09	0.03	0.09	0.02	0.03	0.02	0.04	2layer NN RMSE

Conclusion

The results showed a distinct and remarkable performance of multi-layer Neural Networks better compared to single-layer Neural networks by observing data analysis by simulation and a value (RMSE) that is less than what it is in multi-layer neural networks and these results were reached after repeating the experiment several times and increasing the parameters affecting the result, including (the number of nodes in the hidden layer, the number of times the experiment is repeated, the network training rate).

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