Republic of Iraq
Ministry of Higher Education and Scientific Research
University of Kufa
Faculty of Computer Science and Mathematics
Department of Computer Science

Artificial Neural Networks for Simulation of Digital Control Systems

A Thesis

Submitted to the Council of the Faculty of Computer Science and Mathematics / University of Kufa in Partial Fulfillment of the Requirement for the Degree of Master of Science in Computer Science By

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Supervised by

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2020 A.D 1442 A.H

بسم الله الرحمن الرحيم

وَعِنْدَهُ مَفَاتِحُ الْغَيْبِ لَا يَعْلَمُهَا إِلَّا هُوَ وَيَعْلَمُ مَا فِي الْبَرِّ

وَالْبَحْرِ

صَدَقَ اللهُ العَظِيم

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Dedication

To the teacher of humanity and the source of knowledge: our Prophet Muhammad (May God bless him and grant him peace and his progeny)

To the pride of Iraq.................................our honorable martyrs

To the highest ideals ……………………. my dear father

To my heart's first sweetheart … my loving mother

To those who paved the way for me to reach the climax of science my friends

Ghadeer Ibrahim

Acknowledgments

First Praise be to Allah Almighty. A special gratitude is due to my honorable Professor (Dr. **Zahir M. Hussain**) for his support and guidance in advising and correcting, and my thanks are directed to the Faculty of Computer Science Department Mathematics and the computer department in particular.

And then my parents for all their efforts from my birth to these moments

I am pleased to thank all those who advised, guided, directed, or contributed in preparing this research by referring to the required references at any stage of its stages.

Abstract

Research on artificial neural networks (ANN) is still being active leading to many new network types as well as hybrid algorithms and hardware for neural information processing. An artificial neural network consists of a pool of simple processing units which communicate by sending signals to each other over a large number of weighted connections. On the other hand, most control systems, today, use digital computers (usually microprocessors) to implement the controllers such as: Machine Tools, Metal Working Processes, and Chemical Processes. Most electronic systems are designed according to the device and then manufactured as an attached electronic device. But if conditions change or the factory is updated, then the control device must be replaced. Due to the complexity of the control system units represented by the program implementation algorithms, the complexity of mathematical analysis, the time delay caused by digital to analog converter DAC or analog to digital converter ADC, and the deterioration of the system's stability due to the conversion of the system to be digital, this conversion causes the loss of some signal information. In this study, another controller based on Artificial Neural Network control is examined to replace the system controlling the motion of a worktable at a certain location; that is an important positioning system in manufacturing systems. Simulation after training the neural network (supervised learning) has shown that results are acceptable with the advantage of simplicity and adaptability to new updates and applicability in industry processes for reference control applications. The study also indicates that an artificial neural network controller could be less complex and cheaper to implement in industrial control applications compared to some of the other proposed schemes.

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List of Abbreviations

Abbreviation	Description
IPD	Integral Propotional Dervitive
PD	Propotional Dervitive
CV	Current Value
ADC	Analog to Digital Converter
DAC	Digital to Analoug Converter
TF	Transfer Function
PID	Propotional Integral Dervitive
AI	Artificial Intelligent
NN	Neural Network
ANN	Artificial Neural Network

List of Symbols

C(s)	Output of Digital Control System
R(s)	Input of Digital Control System
G(s)	Transfer Function of Control System
y(s)	Output of Digital Control system
W_{ij}	Weight in NN
e_i	Error Signal
u_i	Control Signal
y_i	Output of System

List of Publications

1.

Date : 10/31/2020
Paper ID : ICMAICT_CS_105
Ref. No : 086_ICMAICT

Letter of Acceptance

Dear Authors,

On behalf of the ICMAICT -20 Committee, we are pleased to inform you that your paper entitled

"Deep Learning for Control of Digital Systems"

Written by

Ghadeer I. Maki, Zahir M. Hussain

Has been accepted and will be proceeded to publication in the IOP Journal of Physics: Conference Series (Online ISSN: 1742-6596, Print ISSN: 1742-6588). We congratulate you for your achievement, the technical details about the publication will be informed later. The publication of the accepted paper will be provided by the end of February 2021.

We Will encourage more quality submissions from you and your colleagues in future

Shubham Sharma

Regards,
Prof. Dr. Shubham Sh. Sharma
Special Issue (Guest Editor ICMAICT-20)

Accepted papers will be published in:
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Chapter One

Introduction

CHAPTER ONE

INTRODUCTION

1.1 Introduction

In typical applications of science and engineering, signals must be processed by using systems and must be controlled using control systems which in turn represent the processing of the input signal to provide output signal variables. The control system is a means used for achieving the optimum performance of the dynamic and mechanical systems and ensuring the stable behavior of these systems.[1] Control systems must be available as they are necessary in industrial processes that require temperature control, pressure or liquid flow[2]. Control systems have become an important part of modern industrial processes. The control system is the interconnection of the components that make up a system to achieve a specific goal [3] .The control systems that deal with the error signal in order to determine the required output were traditional analog systems consisting of analog inputs and outputs. In recent decades, analog control systems have been replaced by digital control systems that are in the form of digital circuits or digital computers. [4]

Artificial neural networks (ANN) are considered of the most important and vast developments in the field of artificial intelligence and are applied at the present time in a variety of applications including industrial, medical, engineering and military applications. The ANN are used to develop a system that simulates the human brain as they consist of a group of mathematical units interconnected with each other. ANN are based on the principle of training and are distinguished by their adaptation to external variables. [5]

ANN's use learning algorithms to solve complex problems and are able to extract complex patterns from data and apply them to invisible data so that the neural network would be trained.[6] Neural networks are divided into different types according to several factors including: speed where there are networks qualified to deal with fast and slow data, number of layers where one or several layers are hidden, and the direction of the data. The general architecture of neural networks consists of an input layer, an output layer, and one or more hidden layers. Neural networks today can reach hundreds or thousands of layers.[7]

1.2 Literature Review

There are many researchers work in this field, some of them are:

Martin T. Hagan. (2002) this paper presents three control systems structures and the use of multiple neural network algorithms as a basic building block. Control structures are: the typical reference control: The factory model is used to train the controller and it takes a long time to train and requires a lower cost computation. Predictive control model: Neural Network is used to predict future plant behavior and requires network algorithm feedforward and requires more computation.NARM-L: There is a variation in the control unit in the feedback and the control here is to rearrange the model in the factory and does not require copmutation.Practical systems for implementing control units are the robot arm, tank reactor, and magnet lift system. The results proved that the typical reference control structure is better at controlling where the errors that are noticed is a few.[8]

Leila F. Araghi. (2008) in this paper, use 4 methods to control the robot, the first method depends on proportional control PD, the second method relates the derivative proportional control PID, the third method relates to artificial neural networks by PD, and the fourth method relates to artificial neural networks by PID control. The use of neural networks is carried out with two basic steps: System identification , System design .In the system definition stage, you develop a neural network model for the plant you want to control. In the control system design phase, the neural network plant model is used to design (or train) the controller. The results showed good performance for the neural networks used with the control system PID where steady state error is 0.0016 for the link and it is 0.005 in the link2 ,that represent the minimum value .[9]

Yusuf Perwej. (2011) in this research, neural networks were used to develop a system that can recognize handwritten English alphabets, where the system inputs are a representation of each English alphabet with binary values. The structure of the neural network is dedicated to processing 25 units in the input layer because the English alphabets are divided into 25, the network structure consists of an input layer, two hidden layers, output layer, the number of units in the hidden layer 25 and used the activation function for the first hidden layer Log and for the second hidden layer is Tan. The training set includes the binary symbols for the English alphabet, where each letter has a symbol for the different writing styles. The results showed the success of a system in recognizing English alphabets with average accuracy %82.5 but it needs more training to recognize similar letters such as I,l and e,c, because they are difficult to distinguish even by human eyes easily.[10]

Adam Barton. (2017) in this research, a control method is designed for an independent robot using neural networks. The robot possesses information from the sensors and the knowledge base, and based on this information it creates a plan of action and tries to predict and the robot can react very quickly to changes in the environment, after the robot scans the surroundings using sensors It takes information that goes into the self-learning neural network to work together. The architecture of the neural network consists of three layers: the input layer has 20 units, the hidden layer has 20 units, and the output layer has 4 units. The controlling neural network is adapted through the training group that is classified, and the results have proven the ability of the neural network to control the movement of the robot by setting specific targets in individual experiments where the robot moves effectively in wide areas without stopping, but by using more accurate sensors, the robot will be able to direct better in The space.[11]

Mohammed Al-Shawwa. (2018) the research aims to reveal the possibility of using an artificial neural network model to predict the temperature value with the least possible time and with high accuracy in the results. The structure of the neural network consists of an input layer with 12 units and the hidden layer with six units and the output layer contains 2 units. 60% of the total data was used for network training, 30% of the total data for testing and 10%of the total data for validation. The network inputs represent a number of factors that affect the temperature value such as (proximity to water surfaces, the level of subsidence and height below sea level, the nature of the place). The sensor data that provides the ability to implement and test the neural network was used to train the network and then test it using the test data set and the result was 100% this proves the ability of an artificial neural network to predict temperature.[12]

Alexander N. Sokolov.(2018) this paper, machine learning algorithms are reviewed to detect anomalies in industrial control systems that come due to electronic attacks, interference and noise in the device or due to an update with each change in the structure of the industrial process. Among these algorithms: SVM: The training time is high and the accuracy is low due to the number Excessive data. Lasso, Logist: It requires a lot of data, insufficient accuracy in addition to the simplicity of the algorithms. Linear algorithms: It is not suitable for detecting anomalies even with long training and the data should be independent and sensitive to the extreme data. The decision tree: here is the greater the number of decisions. The accuracy of the results decreased and the problem is solved by placing restrictions on the model. Artificial Neural networks: Accuracy depends on the time of training, as the more training time, the greater the accuracy and requires a lot of computing power. The results prove that the algorithms of neural networks include the greatest efficiency and high accuracy.[13]

Ibrahim M. Nasser. (2019) in this paper, an artificial neural network model was proposed to diagnose autism spectrum disorder, the network structure of a neural consists of an input layer, a hidden layer, and an output layer. The training set that represents the input units is the result of the autism test answers for the users in this study. 80% of the total data were used to train the network and 20 % for verification. The results demonstrated the ability of neural networks to diagnose autism spectrum disorder with an accuracy of 100%.[14]

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. ANN with two hidden layers was used to develop a simulation model of a fluid friction bearing rotor with five inputs (displacement, velocity, rotor vibration, average bearing clearance, training sample rotor). The results showed that ANN which works on the principle of reinforcement learning and is used as a clearance control system that allows to reduce losses for friction and vibration in a rotating machine through direct bearing control and indirect control of the hydrodynamic force in the rotor path .[15]

Song Xu. (2020) A control method was proposed 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 Mat lab 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. [16]

1.3 Statement of the Problem

A control system is a system that adjusts the operation of digital systems by sensing one or more parameters then adjusting their values to avoid system breakdown. Most electronic systems are designed according to the device and then manufactured as an attached electronic device. But if conditions change or the factory is updated, then the control device must be replaced.

Due to the complexity of the control system units represented by programs implementation algorithms, the complexity of mathematical analysis, the time delay caused by digital to analog converter DAC or analog to digital converter ADC, and the deterioration of the system's stability due to the conversion of the system to be digital, this conversion causes the loss of some signal information.

In this research, the electronic system of the control system will be replaced by a software that works as a neural network and tests the network effect if it contains more than one hidden layer. There is no need to redesign the electronic system because the artificial neural network is able to adapt to the new variables. The artificial neural network organizes the work of the system instead of the control system. It replaces the traditional control system. Due to the complexity of the control systems unit represented by the program implementation algorithms, the complexity of mathematical analysis, the time delay caused by digital to analog converter DAC or analog to digital converter ADC, and the deterioration of the system's stability due to the conversion of the system to digital, this conversion causes the loss of some signal information.

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1.4 Objective of the Study

The study aims to simulate digital systems with neural networks and study the possibility of neural networks resilience as for changing conditions for the digital system through:

1- Studying and simulation of digital control systems
2- Studying and simulation of neural network types and their efficiency and try to use them to control digital systems through training the network to do the same work.
3- Studying and Simulation of ANN methods
4- Studying the possibility of networks resilience to changes

1.5 Structure of the Thesis

The remaining chapters of the thesis are organized in the following order:

- Chapter Two: “Theoretical Background”, introduce theoretical background about digital control system, neural network and deep learning.

- Chapter Three: “The Proposed method”, explains the practical stages of the digital control system and deep learning.

- Chapter Four: “Results and discussion”, presents the results and the discussion over a set of experiments

- Chapter Five: “Conclusions and Future Works”, discuss the advantages and disadvantages of the proposed methods via conclusions section, in addition to future works suggestions.

Chapter Two

Theoretical Background

CHAPTER TWO
THEORETICAL BACKGROUND

2.1 Introduction

This chapter explains the basic concepts of the control system and focuses on the theoretical background of the digital control system and shows its types and methods of design and how to represent it, then overview of the most famous types of control systems and explains the ANN and it is components. This chapter deals with the work of artificial neural networks and their types and applications.

2.2 Digital Control System

System for controlling industrial, household, or automated systems and it consists of input and output, for example: car driving, body temperature .The output is the current value (CV), and the input is the one that control. The response represented behavior of system output . [17] as shown in the Figure 2.5.

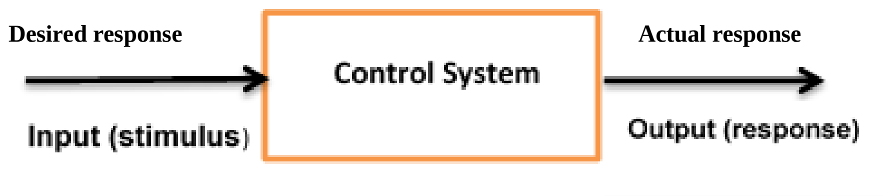

Figure 2.1 Control System

Digital signals are used in this system and the digital computer is used to process 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. [19][20]

Objective :It will connect components to achieve optimal performance (to improve system behavior and reduce resulting error).

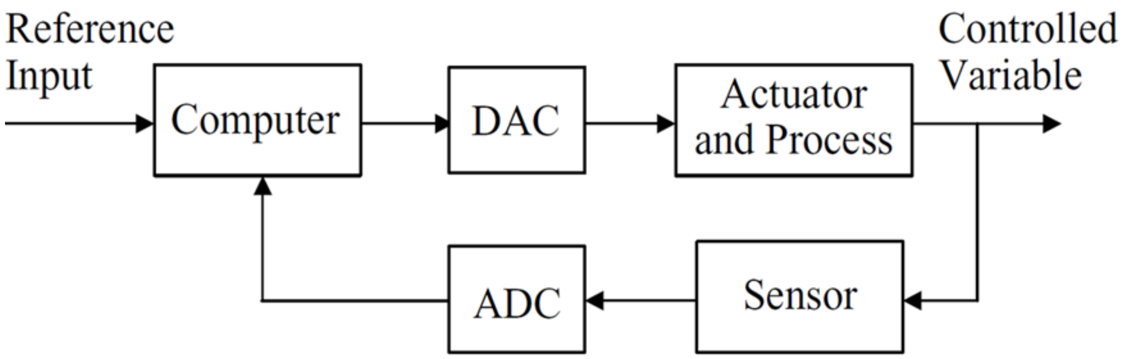

Figure 2.2: Digital Control System[20]

2.3 Digital Control Systems have Two Main Configurations

❖ Open Loop System

Work done without feedback to achieve the desired output, i.e. the actual system response will not be calculated. The control action is not related to the output .[20][21]

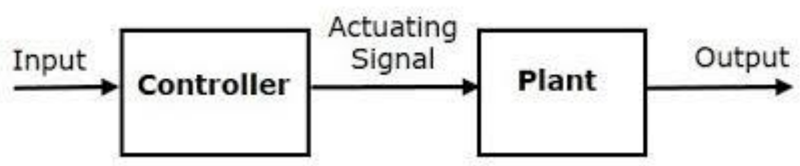

Figure 2.3: Open Loop System[21]

❖ Closed Loop System

The closed loop system measure of actual output is used, the feedback system, a closed-loop control system that compares the current output with the desired output, and then uses the difference between the two quantities to get to minimal the error a greater extent than the reference inputs. (The control work is dependent on the output) the closed loop system is shown in Figure (2.9). [19][20] the feedback uses in the control process a specific relationship between reference inputs and outputs. Error is the difference between the actual output and the output required, set by the control unit and must be reduced.[21]

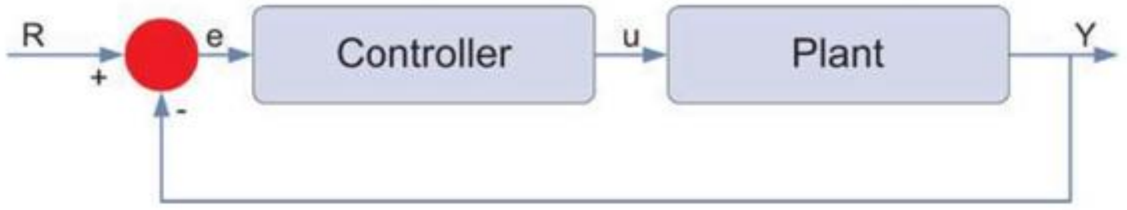

Figure 2.4 Closed Loop System[21]

2.4 Implementation of Digital control systems

Where the control system works to control the output of the system and make it equal to the input by controlling the error value through feedback, it works to take a copy of the output and enter it into the sensor, and then subtract it from the required output, as shown in the Figure (2.14).

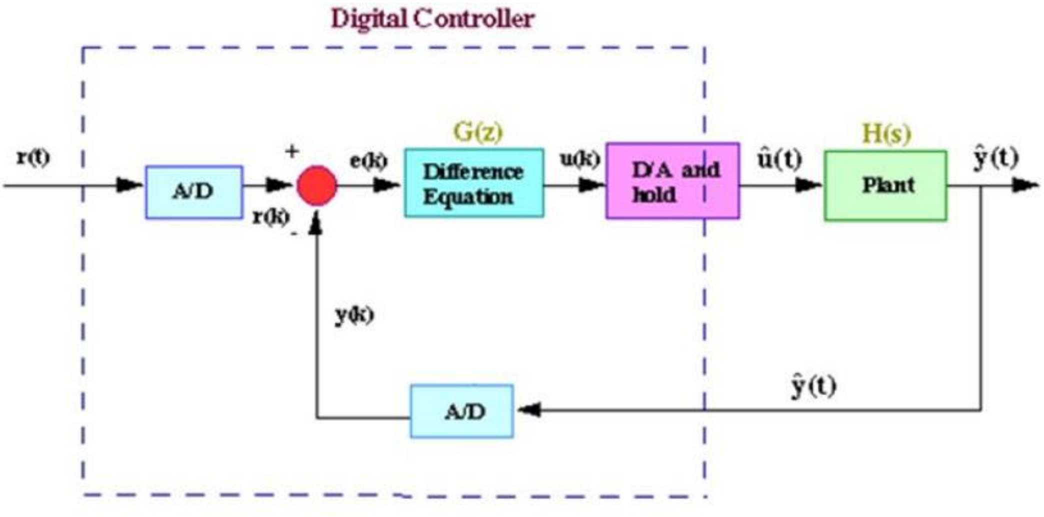

Figure 2.5 Block Diagram of Digital Control System[23]

the system is control the motion of the following equations are implemented in digital control (second order system) [22]

e= r-y (2.1)

u(k)+h*u(k-1)=k*e(k)+k*g*e(k-1) (2.2)

y(k)+q*y(k-1)+f*y(k-2)=b*u(k)+c*u(k-2) (2.3) e=error signal

r= unit step signal input represented (1) value

y=output of digital control system

u(k)=control signal

h= -0.73, g= -0.95, q= -1.996 , f=0.996 , b= 0.003475 , c=0.003471.[28]

From substitution of initial values of input and output in the above equations obtained the new following equations:

$$e_{1=} r_1 - y_1 \tag{2.4}$$

r_1 =1 (unit step signal), y_1 is zero as initial value

$$e_1 = 1 - 0 = 1 \tag{2.5}$$

$$u_1 = k * e_1 \tag{2.6}$$

To compute the output and control signals for number of iteration by applying the following equations :

$$e_i = 1 - y_i \tag{2.7}$$

$$y_i = -q * \ y_{i-1} - f * y_{i-2} + b * u_{i-1} + c * u_{i-2} \tag{2.8}$$

$$u_i = \ -h * \ u_{i-1} + k * g * e_{i-1} \tag{2.9}$$

2.5 Artificial Intelligence

It is a branch of computer science that aims to create smart machines that simulate the human person in knowledge, thinking, learning and problem solving and has today become one of the most important applications in the field of technology, developing computer systems to be able to perform tasks that require human intelligence. [24][29]

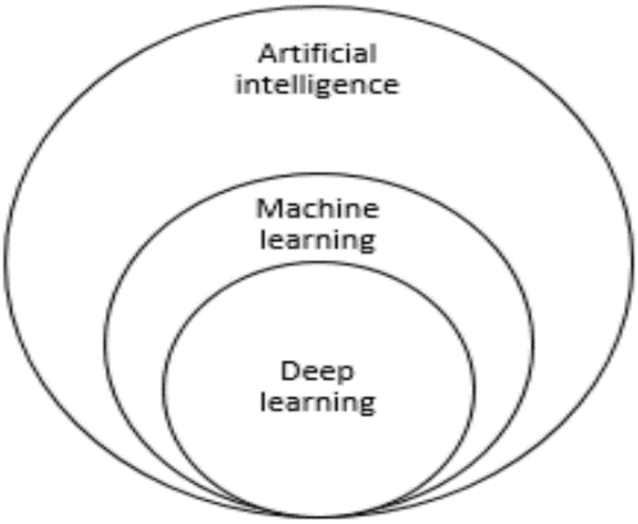

Figure 2.6: Deep Learning Development Stages[32]

2.5.1 Machine Learning

That is a branch of AI that gives computers the ability to learn without being explicitly programmed that adopts the principle of training and learning and mimics the human brain. [28][31]

2.5.2 Types of Learning

1-Supervised: Learning with a labeled training set

Example: email classification with already labeled emails

2-Unsupervised: Discover patterns in unlabeled data

Example: cluster similar documents based on text

3-Reinforcement learning: learn to act in order to maximize reword.

Example: learn to play go, reward: win or lose. [28][31]

2.5.3 Application of Machine Learning

Machine learning is a solution to problems in many areas, including:

- Natural language processing
- Computer image processing and vision
- Biology to detect tumours and DNA sequences .[29]

2.6 Artificial Neural Network

ANN is a connection between units called neurons that simulate the human brain in terms of training and learning and is considered one of the common machine learning techniques. [30]

An artificial neural network is composed of many artificial neurons that are linked together according to a specific network architecture. The objective of the neural network is to map the inputs into required. [31]

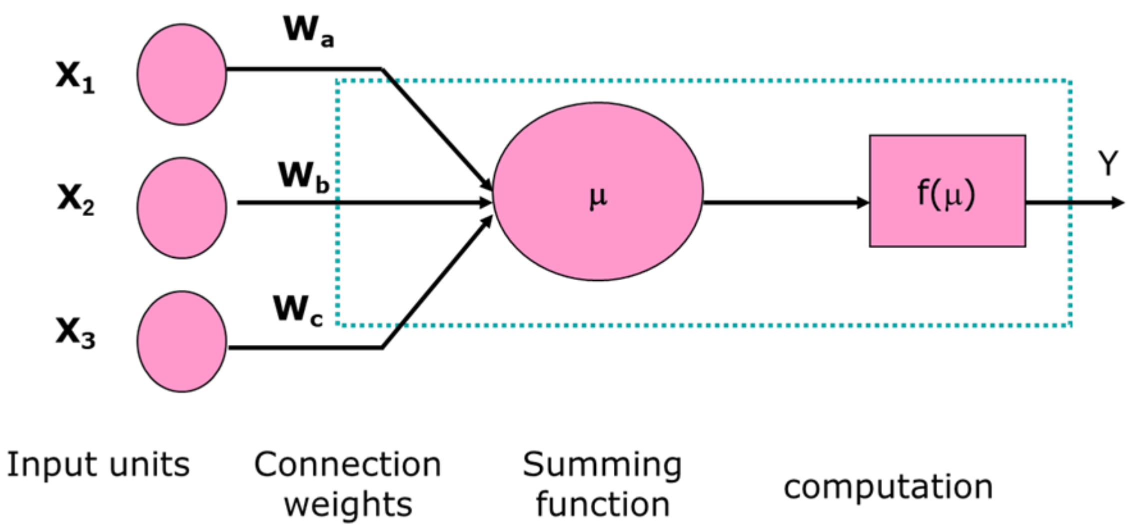

Figure 2.8: Artificial Neural Network[30]

2.6.1 Type of Neural Net

Neural networks were classified into two types according to the history of their development, where they started with a simple neural network consisting of an input layer and an output layer which is called a monolayer neural network or a shallow neural network and then evolved by adding hidden layers to the monolayer to produce multi-layer neural networks which are also called deep neural networks. [4] [31]

1-Single layer (perceptron):

The simplest neural network is the one that contains one hidden layer and usually called perceptron, which contains the input contract, which represents the passage and transmission of signals from the input layerto the nodes in the hidden layer and the output nodes that produce the final output of the network and usually the input contract contains more than one input binary, as shown in the Figure (2.9). [33] It also contains the weights that affect the inputs, which represent the importance of the inputs in the output. Therefore, if the input signal has a greater weight, it is more important in the new output. [34]

The unit in the input are represented by variable P, influencing the weights represented by variable W then it is processed with (activation function) to produce the output.[35][38] as shown in Figure(2.9)

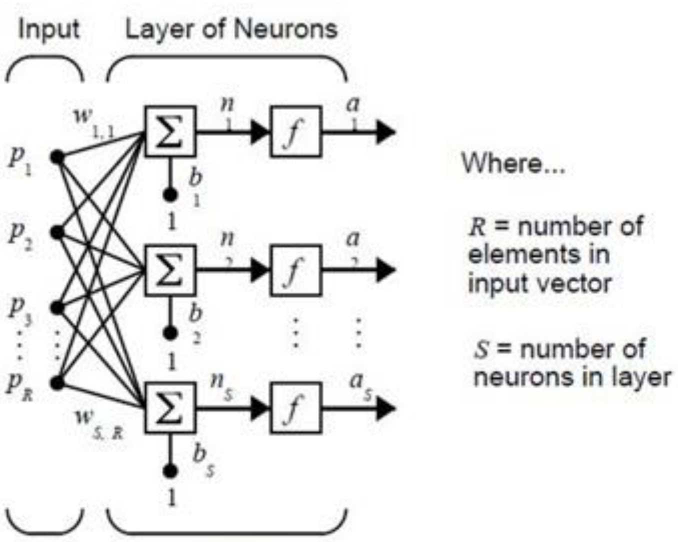

Figure 2.9: Single Layer NN[35]

2-Multi Layer Neural Network

It is a neural network that contains more than one layer so that the output of neurons from a layer is input to the next layer and the output of the last layer is the output of the neural network in the multi-layer of the neural network each neuron of a layer is linked to all the neurons of the next layer and has no association with neuron. It is powerful network and it has wide use in most applications. [31]in recent years due to advances in technology that led to a rapid development of neural networks from classic to deep learning with a number of layers and hidden nodes in each layer where a number is used always few layers although there are no specific .Restrictions on the number of layers referring to depth. [35][37]

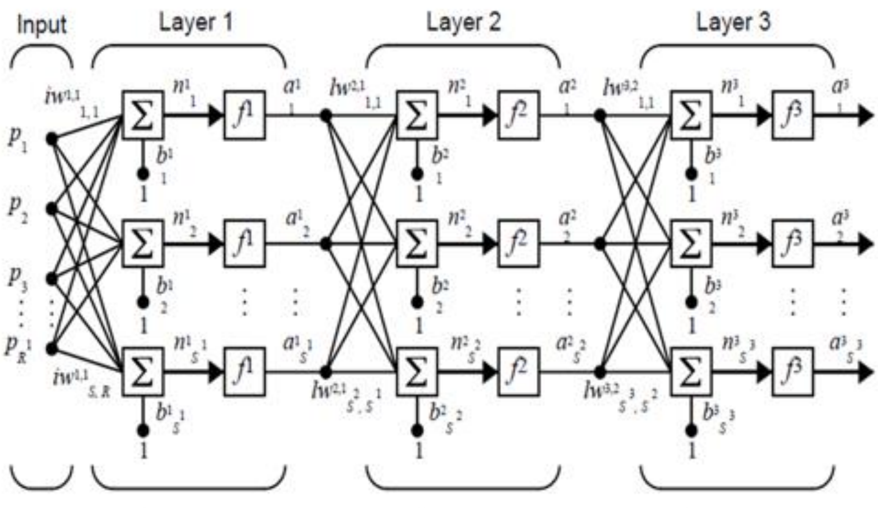

Figure 2.10: Multi-Layer NN[35]

In this Figure, a neural network of three layers and the input layer represented by the variable (P) and as we note that the output of the first layer represents the input for the second layer, and so on to the final output and is symbolized by (a) and in each layer the addition and the activation function are executed

2.6.2 Architecture of Neuron

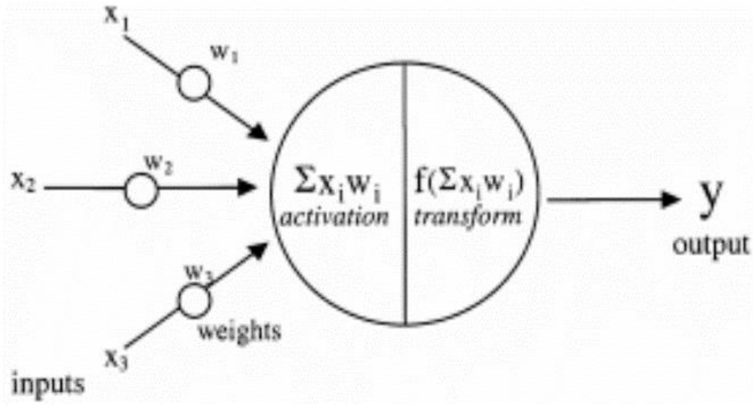

Figure 2.11: Architecture of Neuron [35]

Architecture of neuron it contain:

1-Adder to summation signals in the weighted income [50]

$$activation = x_1 w_1 + x_2 w_2 + \cdots + X_m w_m \quad (2.10)$$

2-Activation function or squashing which makes the output within the range [0, 1] or [-1, 1]. [30][37]

2.6.3 Activation Functions

It is determined that the neuron can be activated or not by calculating the weighted sum of the inputs with biases .[48]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. One of the most important types are:

1. Sigmoid: Takes a real-valued number and "squashes" it into range between 0 and 1. It is usually used in the output layer if the output is for a binary classification[39][40]

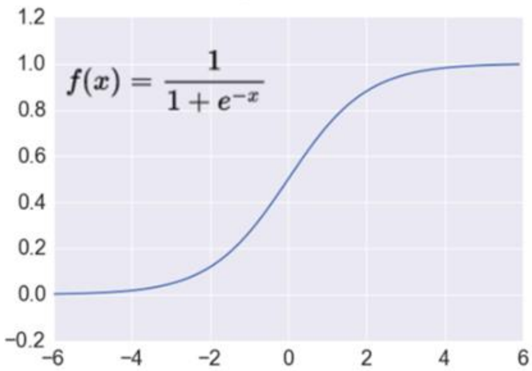

Figure 32.12: Sigmoid [40]

2. Tanh: Takes a real-valued number and "squashes" it into range between (-1 and 1).It is a mathematically derived function from the sigmoid and it performs better than the sigmoid, because it is usually used in hidden layers unlike sigmoid, which is used in the directing layer, which greatly facilitates the learning process in the next layer.[40]

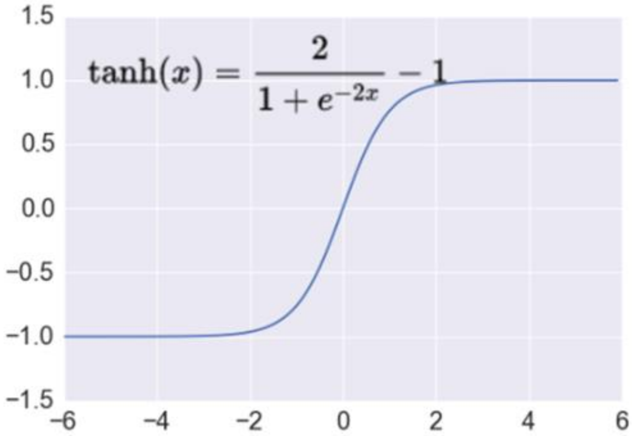

Figure 2.13: Tanh[40]

3. ReLU: Takes a real-valued number and thresholds it at zero. It is the most used function as it is implemented mainly in the hidden layers and includes simpler mathematical operations than Tan and Sigmoid, where a few neurons are activated and scattered, and this leads to making them effective. [40][50]

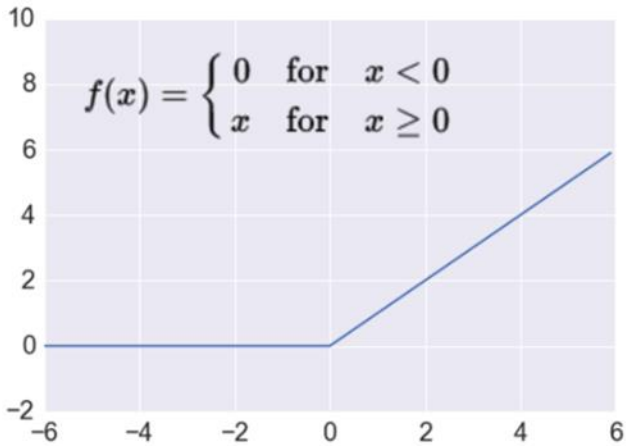

Figure 2.14: Relu [49]

2.7 Learning in Neural Network

2.7.1 Supervised Learning

In this type of learning, a training set is provided where it represents the network's inputs. After applying the outputs from the network, they are compared to the goals and then one of the learning rules is applied to adjust the weights in order to reduce the difference between the correct outputs and the network. Used for classification ,this learning is more accurecy .[44]

2.7.2 Unsupervised Learning

In this type of learning , the training set consists of inputs only without defining the goal and this is called self-learning, meaning you learn the network without presenting examples and without prior knowledge and weights are modified without a learning base but in response to the network inputs.used in clustering .[52]

2.8 Learning Algorithm

Weights are the primary information by which is learned, and it must be updated during the training phase to reach the t difference between the correct outputs and the outputs produced by the network. Various algorithms were used for this purpose, including the Back propagation algorithm that is implemented in two stages.[50]

A: Feed forward

At this stage, weights are not adjusted, the network begins by taking the inputs from the training set to be processed in the next layer and moving to the output layer to produce the final network output and this represents a forward spread of the input towards the outputs. This algorthim is fully connected because each unit is connect to the other units in each layer. [49][52]

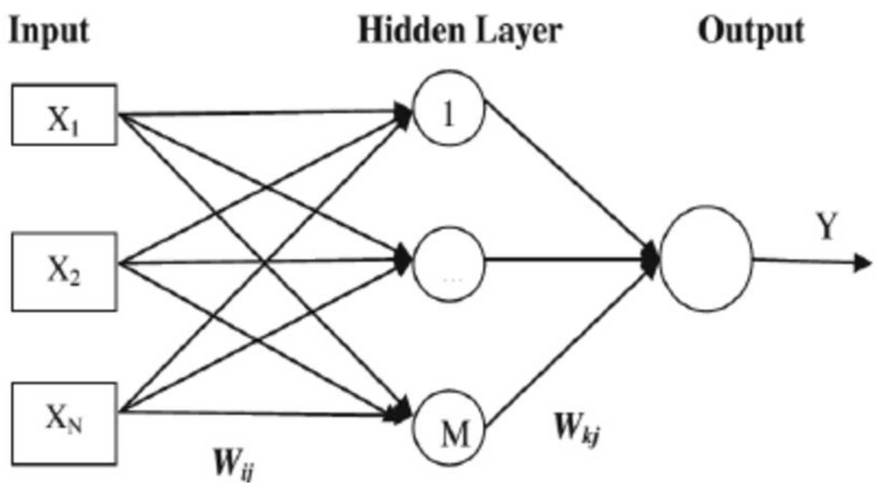

Figure 2.15: Feed Forward Network [49]

B: Back Propagation

At this stage, the network weights are adjusted according to the following algorithm to reduce the difference between the target outputs and the network outputs, as it allows the output signal to reverse back to the entry to modify the weights. [52][53]

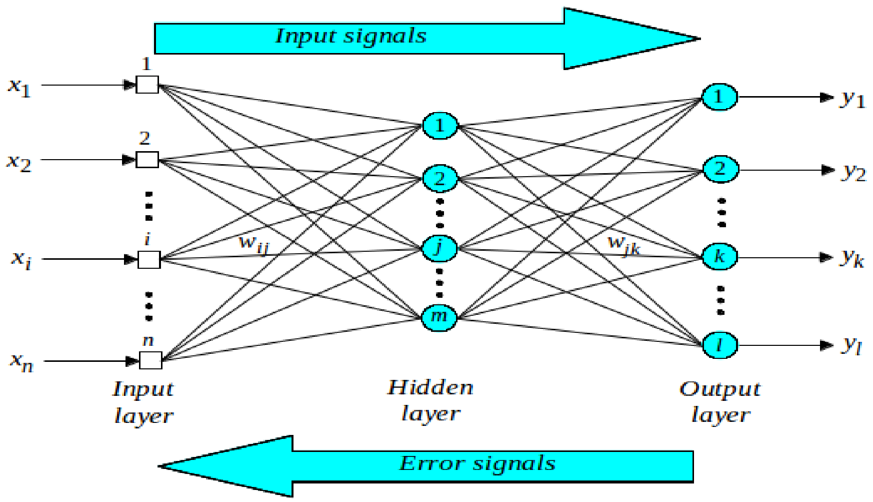

Figure 42.16: Back-Propagation [58]

2.8.1 Back propagation algorithm

Algorithm (2.1) : Back Propagation Algorithm

Input: initializes weights (W).

Output: optimal of the weights.

Begin:

Step 1: while stopping condition is false do steps 2 to 9

Step 2: for each training pair, do steps 3 to 8

Feed Forward Stage:

Step 3: Input unit (X_i) .

Step 4: Hidden unit (Z_j) sum of product

$$Z_j = \sum_{i=1}^{n} X_i W_{ij} + b_j \qquad (2.11)$$

Where b_j is a bias and applies activation function

$$f(Z_j) = Z_j \qquad (2.12)$$

Step 5: Output unit (Y_k) sum of product to hidden unit value as follows:

$$Y_k = \sum_{i=1}^{p} Z_j W_{jk} + b_k \qquad (2.13)$$

Where b_k is a bias, where the activation function is the binary sigmoid:

$$f(Y_k) = \frac{1}{1+e^{-Y_k}} \qquad (2.14)$$

Back Propagation of Error stage:

step 6: Output unit receives a target pattern (Y_T) corresponding to the input training pattern, computes the error as follows:

$$\frac{\partial E}{\partial W_{jk}} = (Y_T - Y_k)\, Y_k\, (1 - Y_k) Z_j \qquad (2.15)$$

step 7: Hidden unit computes the error and weight update V_{ij} as follows:

$$\frac{\partial E}{\partial V_{ij}} = (Y_k - Y_T) \times Y_k\, (1 - Y_k) \times W_{jk} \times Z_j (1 - Z_j) \times X_i \qquad \textbf{(2.16)}$$

Update the weights stage:

step 8: Update the weights W_{jk} and V_{ij} :

$$W_{jk}(new) = W_{jk}\text{ (old)} + \Delta W_{jk} \quad (2.\ 17)$$

$$\text{where } \Delta W_{jk} = -\eta \frac{\partial E}{\partial W_{jk}} \quad (2.18)$$

$$V_{ij}(new) = V_{ij}\text{ (old)} + \Delta V_{ij} \quad (2.19)$$

$$\text{where } \Delta V_{ij} = -\eta \frac{\partial E}{\partial V_{ij}} \quad (2.20)$$

Step 9: Test stopping condition, if it's true then error equal zero.

End

There are many measures to evaluate the results and in this study the Root Mean Squared Error (RMSE) scale was used and defined as:

$$RMSE = \sqrt{[\frac{1}{N}(u-k)^2]} \quad (2.21)$$

Where, N=number of realization

u =network before training

k =network after training

Chapter Three

Proposed Method

CHAPTER THREE

PROPOSED METHOD

3.1 Introduction

In this chapter, the types and efficiency of neural networks will be simulated, and then try to use them to control digital systems, simulating deep intelligence methods and comparing them with digital methods or traditional neural networks, knowing that deep intelligence is currently the most recent method for smart systems. The working environment will be n Matlab.

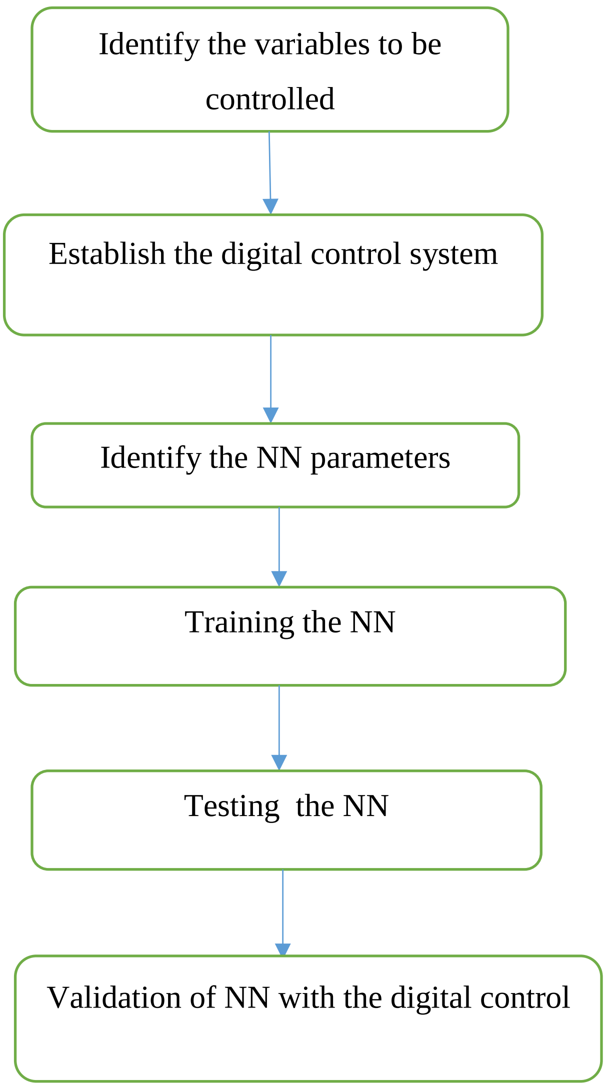

Figure 3.1 Diagram illustrates the main steps of the propose method .

3.2 phase1 : implementation the Digital control system

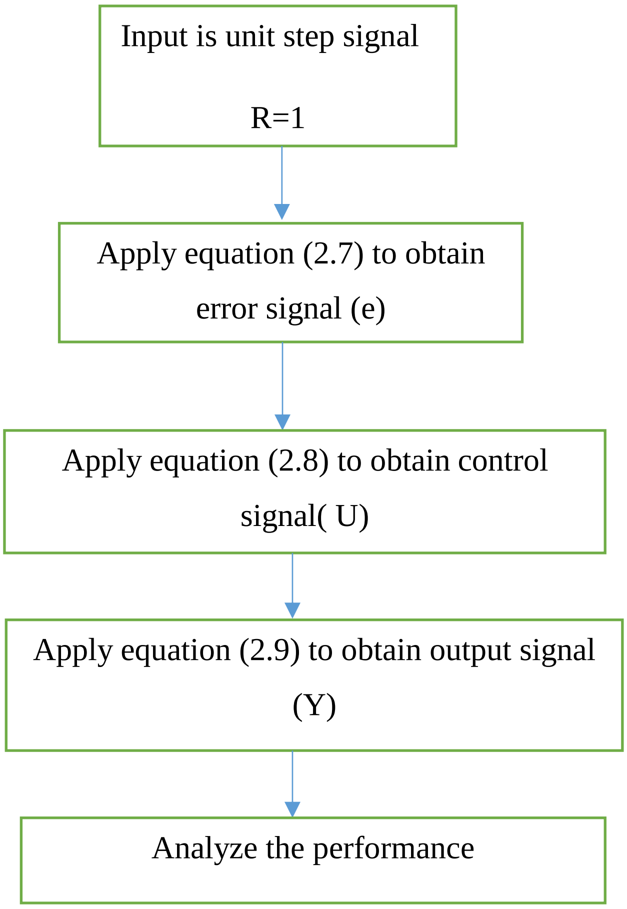

Figure 3.2 Diagram illustrates the main steps of the first stage for the propose model .

In this phase, the digital control system is implemented, where the following equations (2.7)(2.8)(2.9) are implemented to find the output signal by determining the error signal and the control signal. It can be represented step by step as the diagram (3.2).

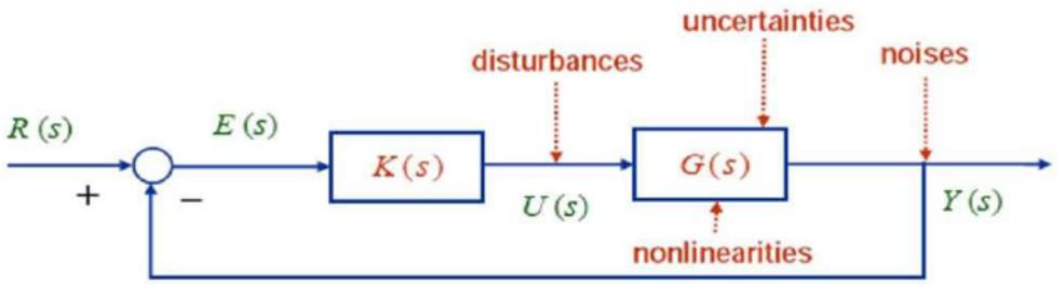

Figure 43.3 Architecture of Digital Control System[12]

R(s) = input signal

E(s) = error signal

U(s) = control signal

Y(s) = output signal

K(s) = digital control system

G(s) = plant or system to be controller

It is assumed that the first output is zero and the input is unit step which represents 1 then find the first error signal (e)then calculation of the output signal (Y) through the calculation of the error signal and the control signal (U) by application the equations (2.7)(2.8)(2.9) with the parameters that is defined previously

3.3 phase 2 : Initialize the neural network

3.3.1 Define the parameters of NN

In this phase (define the parameters of NN) a simple neural network (one hidden layer) and (a two- hidden layer neural network) are applied to replace digital control and are carried out through training. Define the learning rate (must be no high maximum or no small minimum) usually (0.01) as initial value and can be increased to notice that effect to the result .The generation of random weights between (0,1)where the error signal is inserted into the neural network instead of the control system (The maximum permissible error is infinity and the minimum allowed 0.1 is the default value(to be combined with the weights previously generated. . define bias value usually (1).as shown in the Figure(3.3),(3.4)

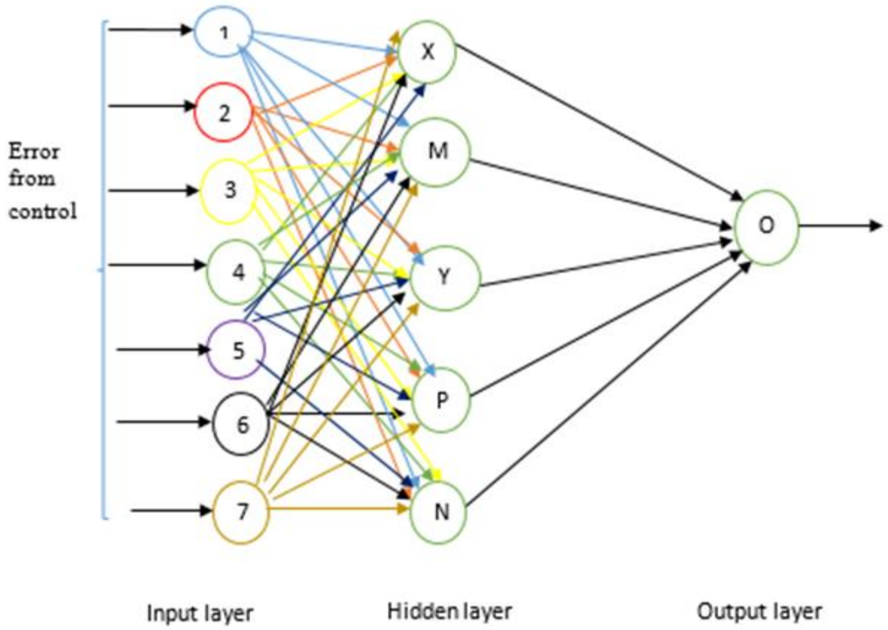

Figure (3.4) architecture of 1-hidden layer NN

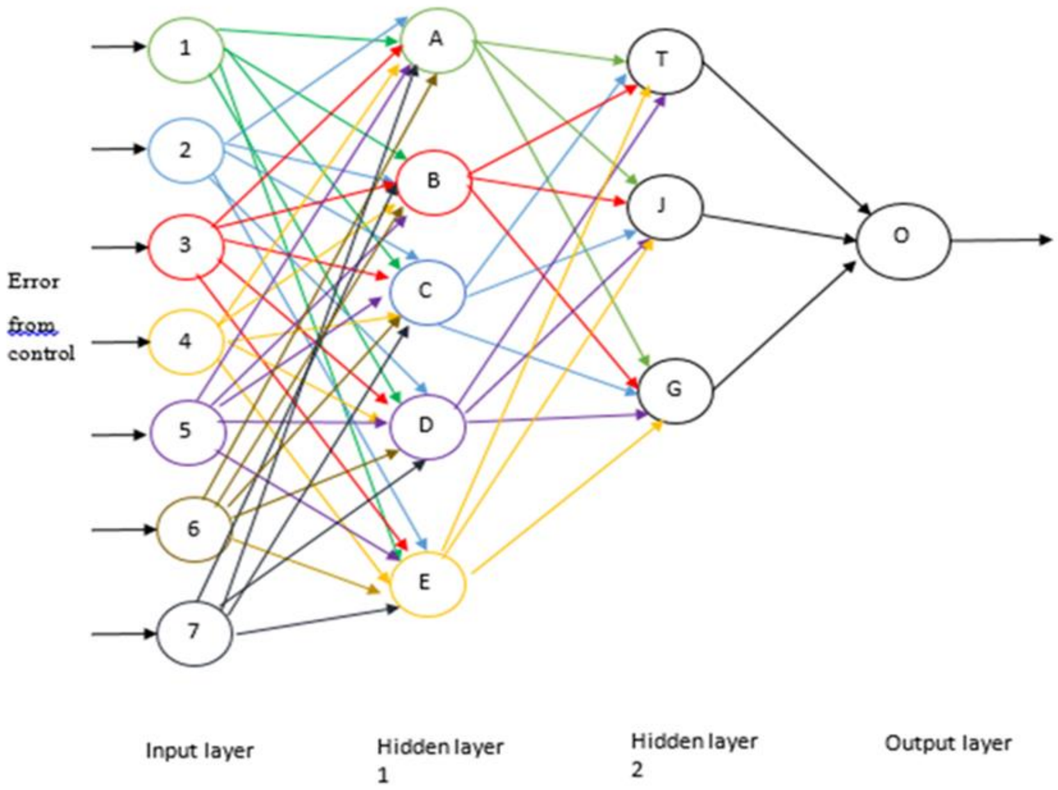

Figure (3.5) architecture of 2-hidden layer NN

also notice from the Figure (3.4) the use of a 1- hidden layer neural network with use 7 nodes in input layer (can be increase) and 5 nodes in hidden layer and the output contain one node . In the Figure (3.5) the use of a 2- hidden layer neural network this leads to accuracy in the results where the output of the first layer is the input to the second layer and use 7 nodes in input layer (can be increase) and 5 nodes in hidden layer 1 and 3 nodes in hidden layer 2 and the output contain one node . Weights are generated random between (0,1) and it is adjusted through training stage that is leads to the optimal result

3.3.2 Training the NN

Which is to operate the circuit of digital control with the presence of the electronic control and take 100 samples of the input and output of the electronic control, then train the network. So that the data is divided into parts, part for training the network (training data), part for work generalization, and part for verification. Where training is done by giving the network a set of data (training data) to be entered into the network and choosing the weights randomly, and then it is treated in the hidden layer by activation function to give the desired output and comparing it with the actual output, as the difference between them represents the error, and if its value is less or greater than threshold, the weights are adjusted using the learning rate. This stage is repeated on the number of iterations are called (epoch) until we reach the minimum error value, which is zero for each stage and thus training is completed. then the activation function (Relu and Linear) is to justify the weights that is leads to optimal result with minimum error value .

3.3.2.1 First Algorithm neural network.

Algorithm (3.1): Neural network.
Input: error of DC and initializes weights (V, W). **Output:** optimal of the weights. **Begin:** **Step 1**: while stopping condition is false do steps 2 to 9 **Step 2**: for each training pair, do steps 3 to 8 **Feed Forward Stage:** **Step 3**: Input unit (X_i) DC error. **Step 4**: Hidden unit (Z_j) sum of product $Z_j = \sum_{i=1}^{n} X_i V_{ij} + b_j$ (3.1) Where b_j is a bias and applies activation function, where activation function is the linear : $f(Z_j) = Z_j$ (3.2) **Step 5:** Output unit (Y_k) sum of product to hidden unit value as follows: $Y_k = \sum_{i=1}^{p} Z_j W_{jk} + b_k$ (3.3) Where b_k is a bias, where the activation function is Relu:

$$f(Y_k) = \max(0, y_k) \quad (3.4)$$

Back Propagation of Error stage:

step 6: Output unit receives a target pattern (Y_T) corresponding to the input training pattern, computes the error as follows:

$$\frac{\partial E}{\partial W_{jk}} = (Y_T - Y_k)\, Y_k\, (1 - Y_k) Z_j \quad (3.5)$$

step 7: Hidden unit computes the error and weight update V_{ij} as follows:

$$\frac{\partial E}{\partial V_{ij}} = (Y_k - Y_T) \times Y_k\, (1 - Y_k) \times W_{jk} \times Z_j\left(1 - Z_j\right) \times X_i \quad (3.6)$$

Update the weights stage:

step 8: Update the weights W_{jk} and V_{ij} :

$$W_{jk}(new) = W_{jk}\,(\text{old}) + \Delta W_{jk} \quad (3.7)$$

$$\text{where } \Delta W_{jk} = -\eta \frac{\partial E}{\partial W_{jk}} \quad (3.8)$$

$$V_{ij}(new) = V_{ij}\,(\text{old}) + \Delta V_{ij} \quad (3.9)$$

$$\text{where } \Delta V_{ij} = -\eta \frac{\partial E}{\partial V_{ij}} \quad (3.10)$$

Step 9: Test stopping condition, if it’s true then error equal zero.

End

.

3.3.3 Testing the NN

In this stage the NN is testing with new error values from digital control , by using the weights that are adjusted (in training stage) to reach the optimal output . NN testing by implement the digital control system such as explained in the first phase ,then implement NN after training stage

3.3.4 Validation of NN

To simulation of NN with digital control system firstly implement the digital control to produce the error signal and control signal such as in the first phase , then initialize NN with the weighted adjusted by training phase that reaches to optimal result, compare the result using RMSE this steps done according to the flowing algorithm.

3.3.4.1 Second Algorithm Simulation NN for Conventional Digital Control

Algorithm (3.2): Simulation NN for Conventional Digital Control.
Input: signal. **Output: Estimation error.** Begin: Step 1: initial the output Y_1=0 Step 2: find the error for output Y_1 and find the control signal U_1 Step 3: find the secondary output $Y_2 = b * k$ and error $e_2 = 1 - b * k$ (3.11) Step 4: find control signal by applying the equation (2.9) Step 5: after find the Y_1 and Y_2 find Y_n for n iteration For ⟵ 3 to n Apply equation (2.7) Apply equation (2.8) End Step 6: pass result from step 5 to neural algorithm(only forward) Step 7: find testing error $error = \sqrt{\frac{(target - output)^2}{N}}$ (**3.12**)

End

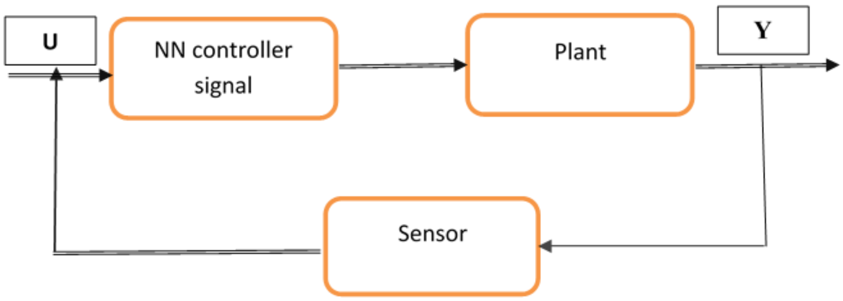

Figure 3.6: Block diagram of Simulation Digital Control with ANN

This is last stage , the simulation of neural networks and the digital control system is carried out in one where the error signal and the control signal are calculated on the assumption of the first output signal equal to 1 and then the second error and control signal is calculated according to the previously mentioned equations(2.7)(2.8) then the error and output signal is calculated for a number of n and then the error signal (calculated from digital control in previous stage)is entered to the neural network to find the output signal and then the mean squared error is calculate to evaluate the results .

Chapter Four

Experimental

Results

CHPTER FOUR EXPERIMENTAL RESULTS

4.1 Introduction

In this chapter, the experimental results are analyzed for the use of ANN and the implementation of conventional digital control system, the results were evaluated through some quality measures including Root Mean Square Error (RMSE) and graph analysis. The environment used is the Windows 10 and Mat lab R2018b.

4.2 parameters are effect on the result digital control

The input to the system is unit step signal as standard test signal. Several parameters are used that effect the result, parameters are:

Number of realization

Learning error rate

Epoch number of iteration in NN

Number of node in hidden and input layer

These parameters are increased and decreased to show the perfect result, as shown in the following tables.

Table 4.1 RMSE value with 1 hidden layer NN

Par / case	Learning rate	realization	epoch	n.of node in hidden& input layer	RMSE
Case1	0.01	100	100	H=5,I=4	0.07
Case2	0.03	100	100	H=5,I=4	0.08
Case3	0.09	100	100	H=5,I=4	0.11

Case3	0.01	100	150	H=5,I=4	0.07
Case4	0.01	100	400	H=5,I=4	0.05
Case5	0.01	100	50	H=5,I=4	0.08
Case6	0.01	100	100	H=8,I=10	0.05
Case7	0.01	100	100	H=4,I=3	0.11
Case8	0.01	200	100	H=5,I=4	0.06
Case9	0.01	300	100	H=5,I=4	0.04
Case10	0.01	50	100	H=5,i=4	0.11

In this table (4.1),shows the results of the performance of the artificial neural network one hidden layer with the different variables, and the results show that the best result is the case 9 where the value of RMSE is 0.04 ,it represents the lowest percentage ,where the lowest result is shown is case 10 and case 3 ,where the RMSE value is 0.11 that represent high value

Table 4.2: RMSE value with 2 hidden layer NN

Par / case	Learning rate	realization	epoch	no node in hidden& input layer	RMSE value
Case1	0.01	100	100	H=5,h2=3,I=4	0.06

Case2	0.03	100	100	H=5,H2=3,I=4	0.03
Case3	0.09	100	100	H=5,H2=3,I=4	0.02
Case3	0.01	100	200	H=5,H2=3,I=4	0.04
Case4	0.01	100	50	H=5,H2=3,I=4	0.09
Case5	0.01	100	100	H1=9,H2=5,I=7	0.03
Case6	0.01	100	100	H1=3,h2=2,I=5	0.09
Case7	0.01	200	100	H=5,H2=3,I=4	0.02
Case8	0.01	50	100	H=5,H2=3,I=4	0.08
Ideal Case	0.09	300	300	H1=7,H2=5,I=8	0.00

In this table (4.2),shows the results of the performance of the artificial neural network two hidden layers with the different variables, and the results show that the best result is the ideal case where the value of RMSE is 0.00 ,it represents the lowest value by increasing all of parameters, where the lowest result is shown is case 4 and case 6,where the RMSE value is 0.09 that represent high value.

4.3 Simulation of DL in Two Cases:

4.3.1 Case 1: The implementation of one layer neural network

First Figure shows the training NN

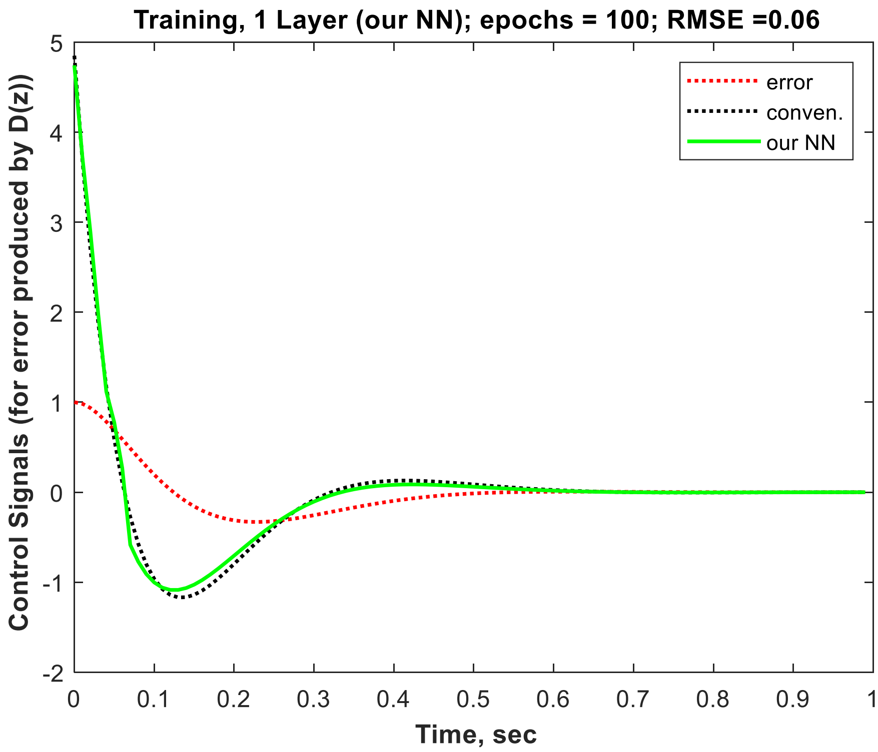

Figure 4.1 Training 1NN

1. Implementation NN in cases, with (100) Realization and epoch (100) by change learning error rate and show the following result that are obtained after several experiments :

Learning error rate =0.01 (Initial value), the result that is noticed is not good where RMSE=0.07(the maximam overshoot 0.1 T& steeling time 0.5)

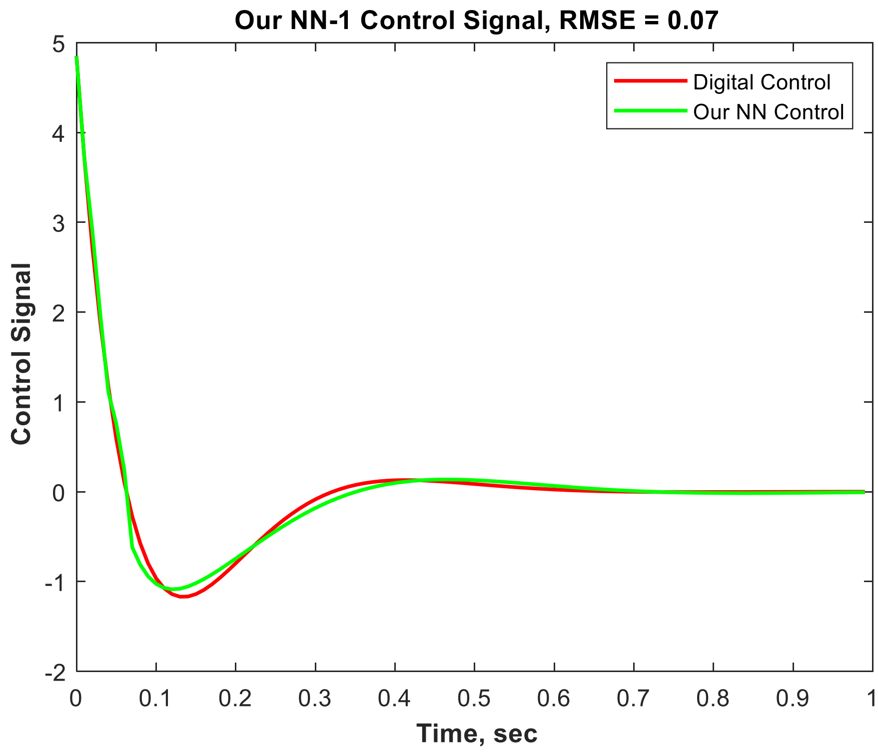

Figure 4.2 1NN with Larning Error 0.01

Learning rate 0.03, the result that is noticed is not good where RMSE=0.08

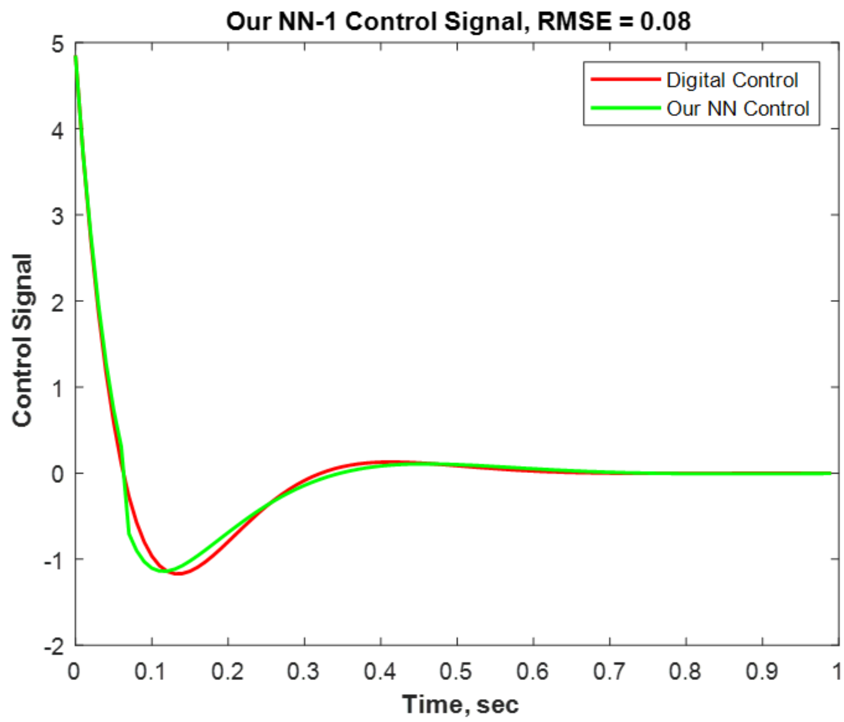

Figure 4.3 1NN with Error Rate 0.03

Learning error rate = 0.09, the result that is noticed is not good where RMSE=0.11

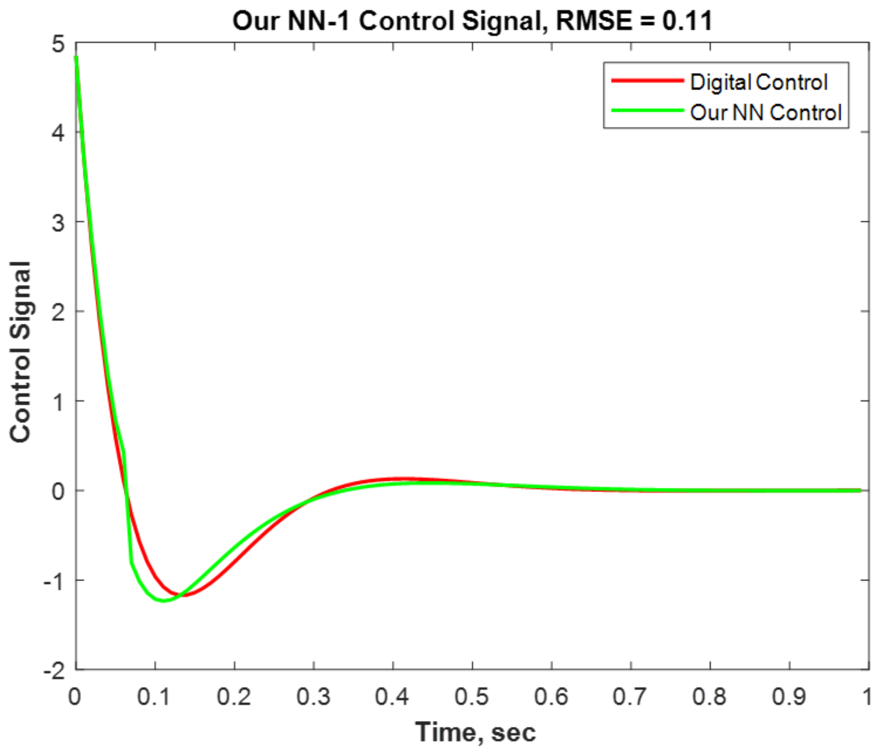

Figure 4.4 1NN with Error Rate 0.09

2. Implementing one layer NN with (100) realization and learning error rate (0.01)when epoch is changed and the following results are shown that are obtained after several experiments :

Increase epoch to 150, the result that is noticed is not good where RMSE=0.07

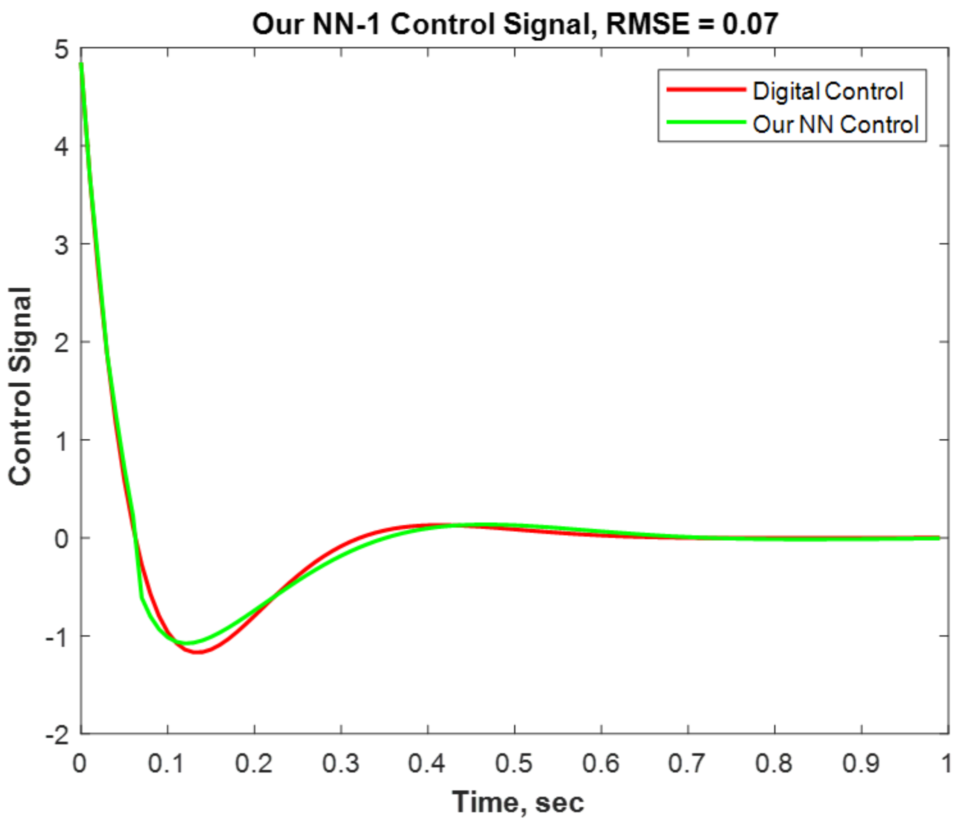

Figure 4.5 1NN with Epoch 150

Increase epoch to 400 with initial learning rate, the result that is noticed is good where RMSE=0.05

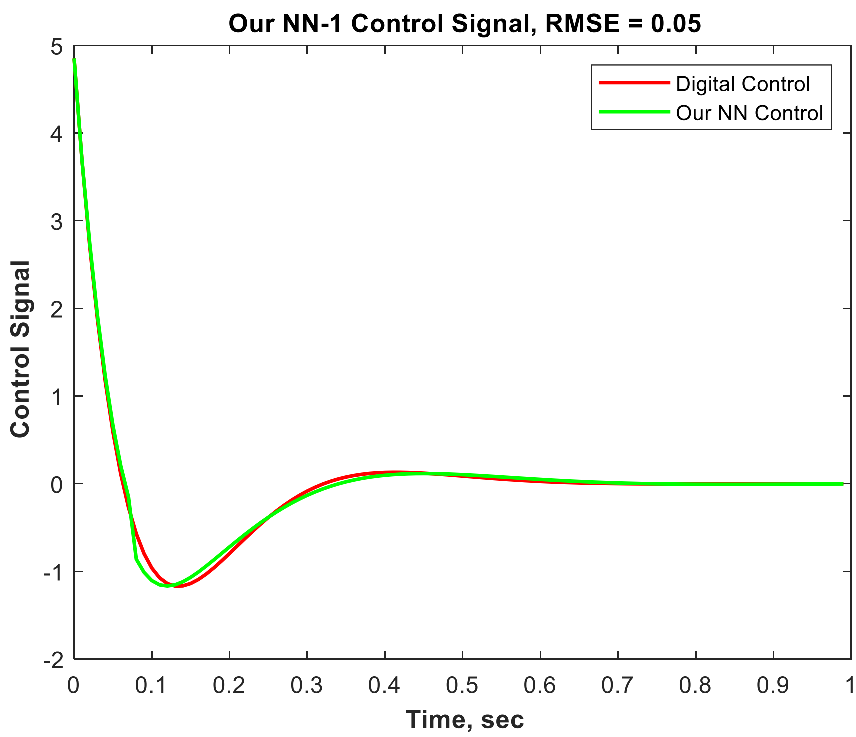

Figure 4.6 1NN with epoch 400

Decrease epoch to 50 with initial learning rate, the result that is noticed is not good where RMSE=0.08

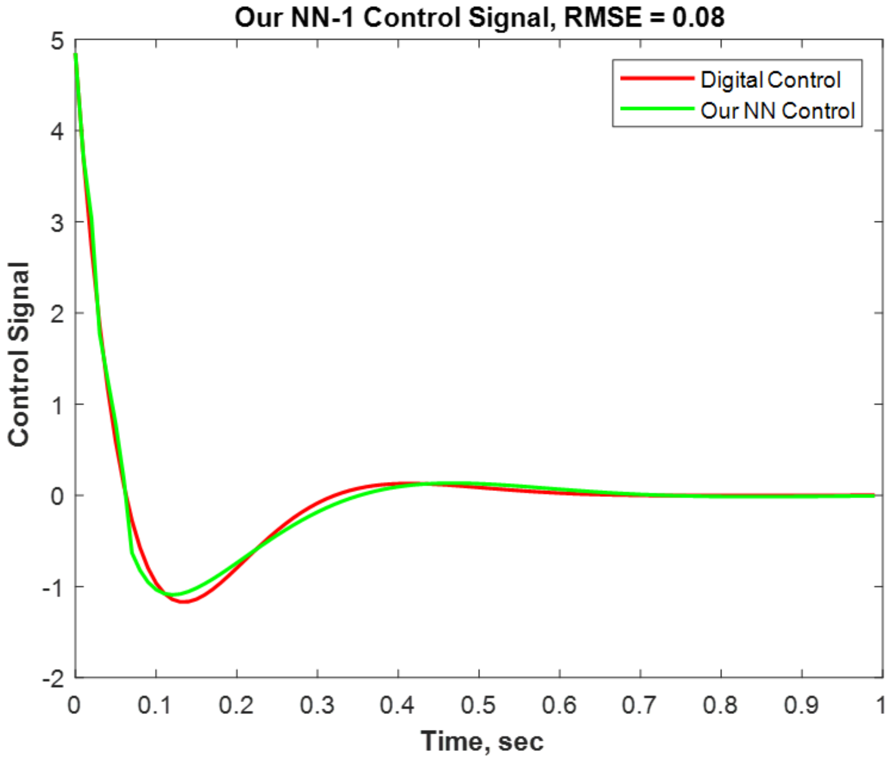

Figure 4.7 1NN with Epoch 50

3.Implementing one layer NN with Increase N to 200 and learning error rate (0.01), the result that is noticed is good with RMSE =0.06

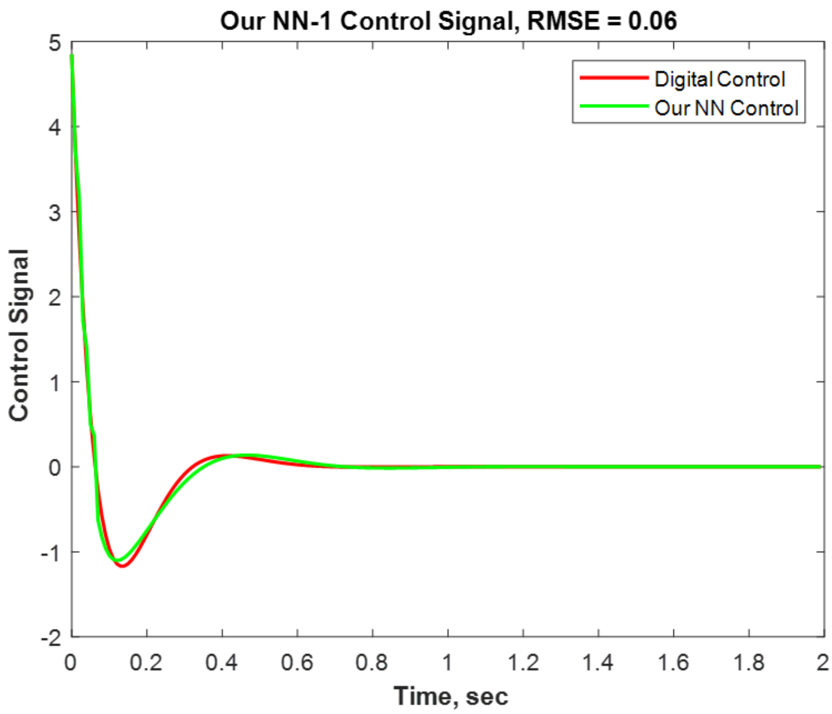

Figure 4.8 1NN with N200

Increase N to 300, the result that is noticed a very good result where RMSE=0.04

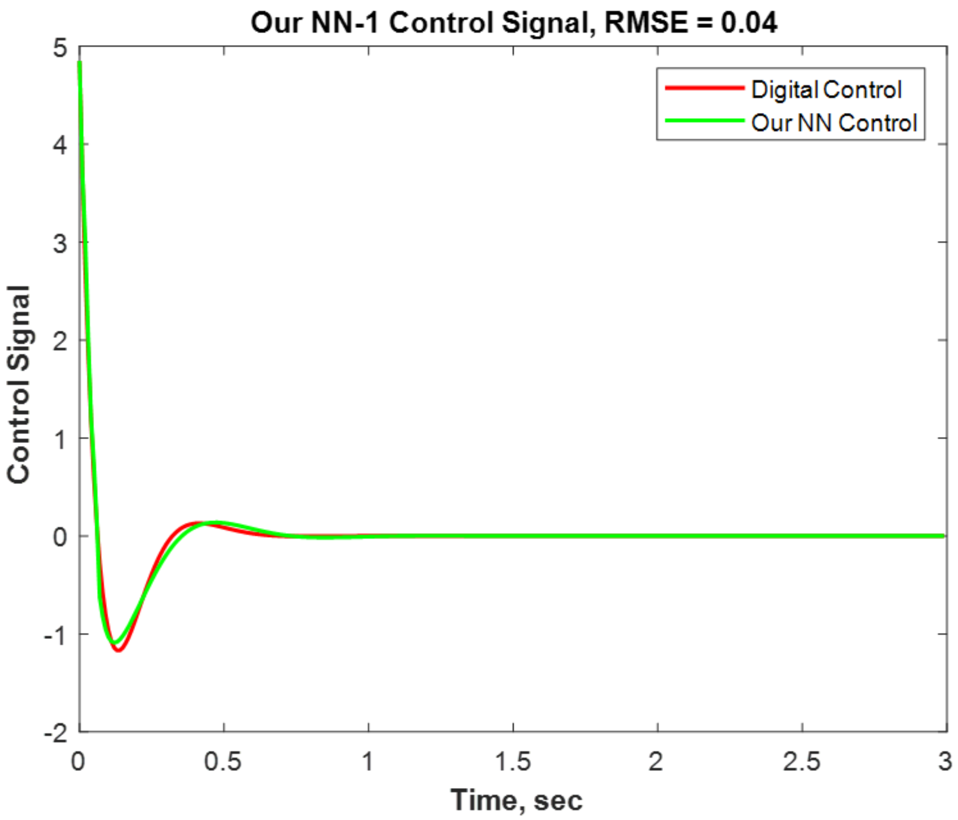

Figure 4.9 1NN with N300

Decrease N to 50, the result that is noticed bad result where RMSE=0.11 that is high value

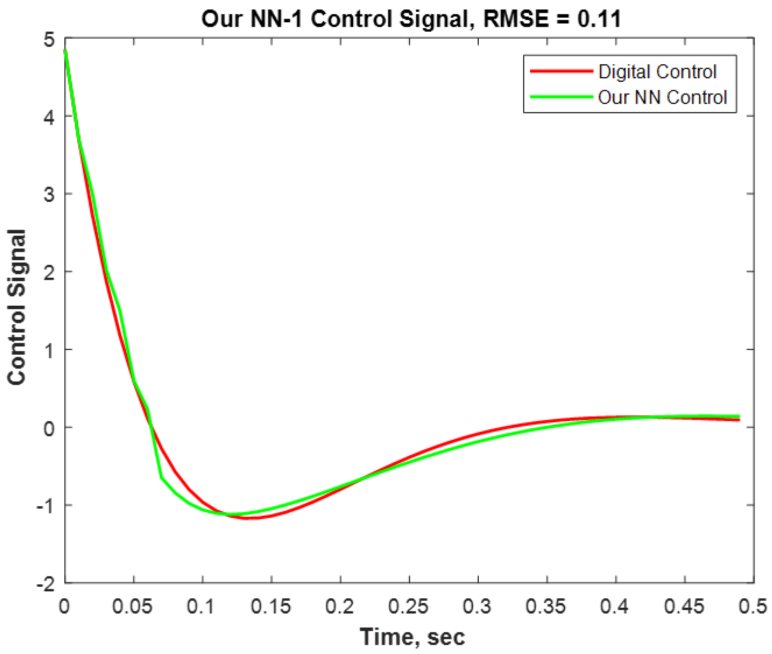

Figure 4.10 1NN with N50

4.3.2 Case 2: Implementation of two layer Neural Network

First Figure show the training 2 layer NN

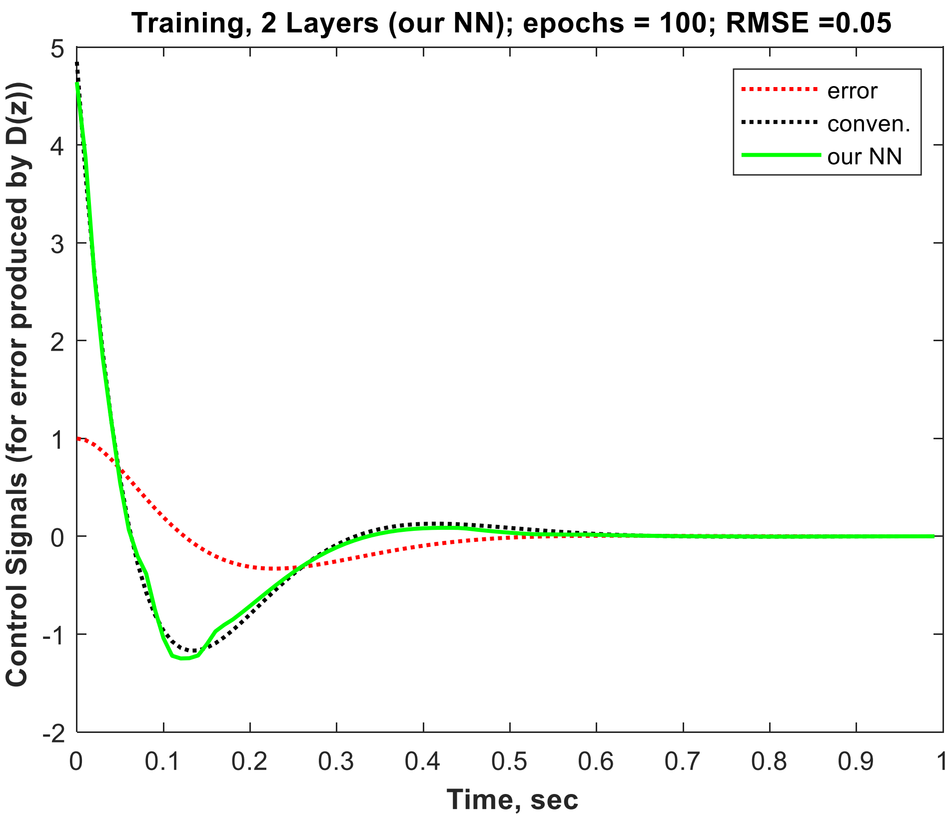

Figure 4.11 Training 2 layer NN

1. Implementation of tow layer NN with (100) realization and epoch (100) when learning error rate is changed and the following results are shown that are obtained after several experiments:

With learning error 0.01, the result that is noticed is not good where RMSE=0.06

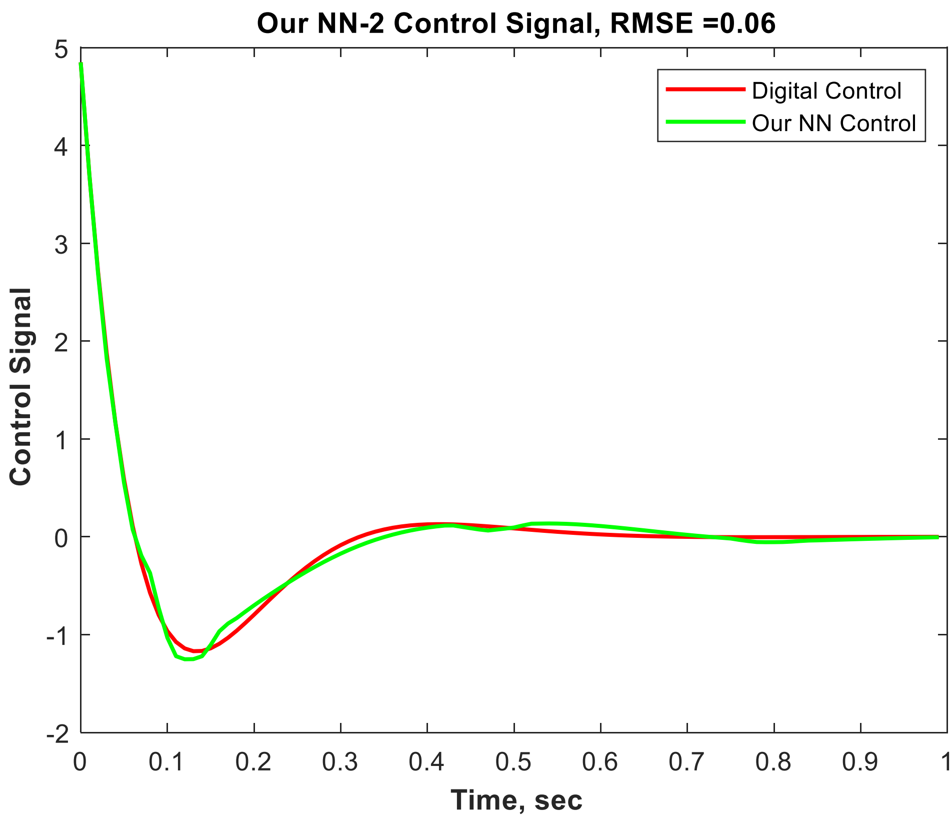

Figure 4.12 2Layer with Learning Rate 0.01

Increase learning rate to 0.03 ,the result that is noticed is a good result ,where RMSE=0.03

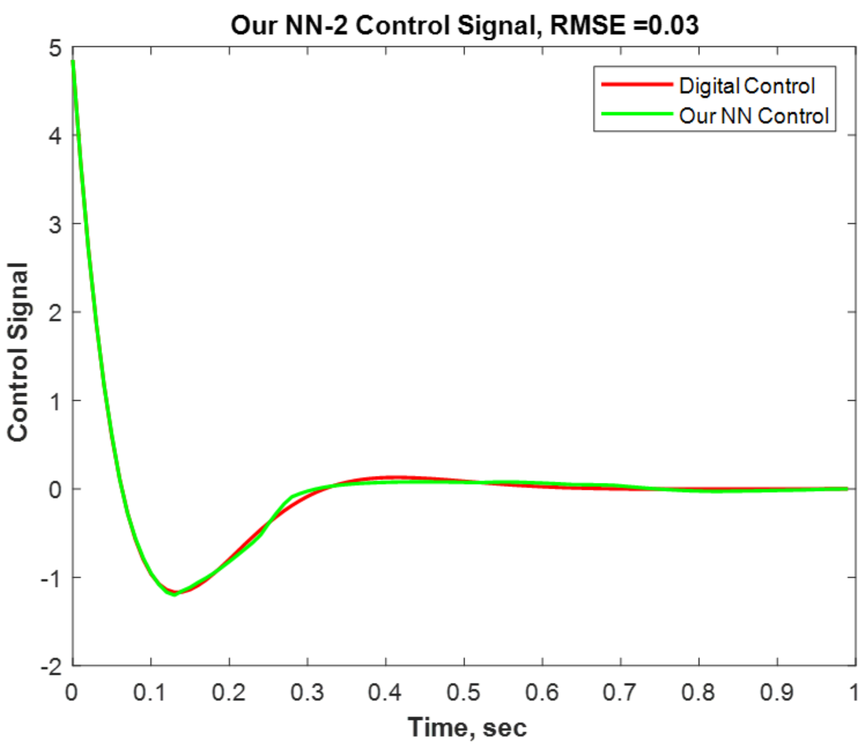

Figure 4.13 2Layer NN with Learning Rate 0.03

increase learning rate to 0.09 , the result that is noticed is a very good result where RMSE=0.02 that is typical result

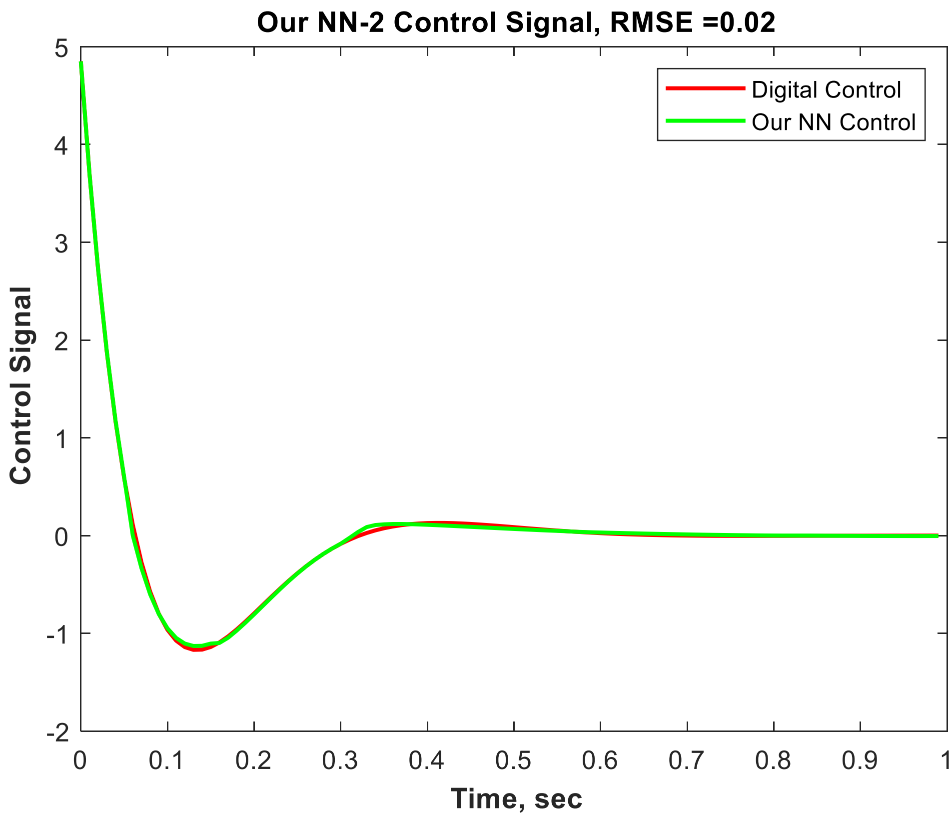

Figure 4.14 2layer NN with Learning Rate 0.09

2. Implementation two layer NN with (100) realization and learning error rate (0.01) we change epoch and show the following result:

Increase epoch to 200, we show relatively good result where RMSE=0.04

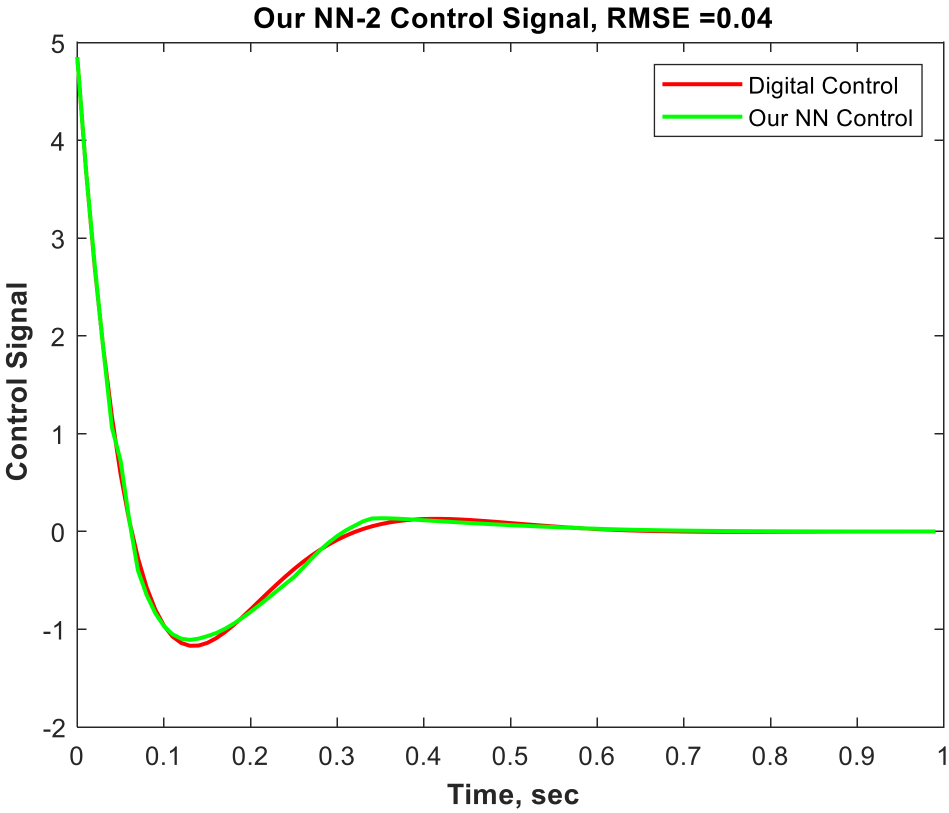

Figure 4.15 2Layer NN with Epoch 200

Decrease epoch to 50 ,the result that is noticed is bad result where RMSE=0.09 is high value

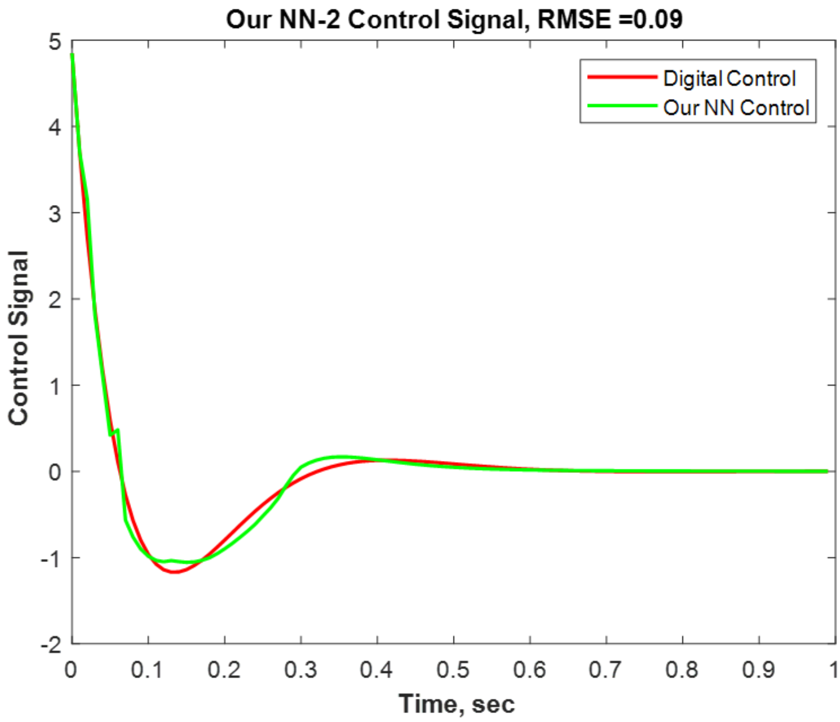

Figure 4.16 2Layer NN with Epoch 50

3. Implementation of two layer NN with (100) realization , learning error rate (0.01) and epoch (100)we change number of node in the hidden and input layer and show the following result **:**

Increase number of nodes in first hidden layer to 9 and second hidden layer to 5 and input layer to 7,the very good result can be shown where RMSE=0.03

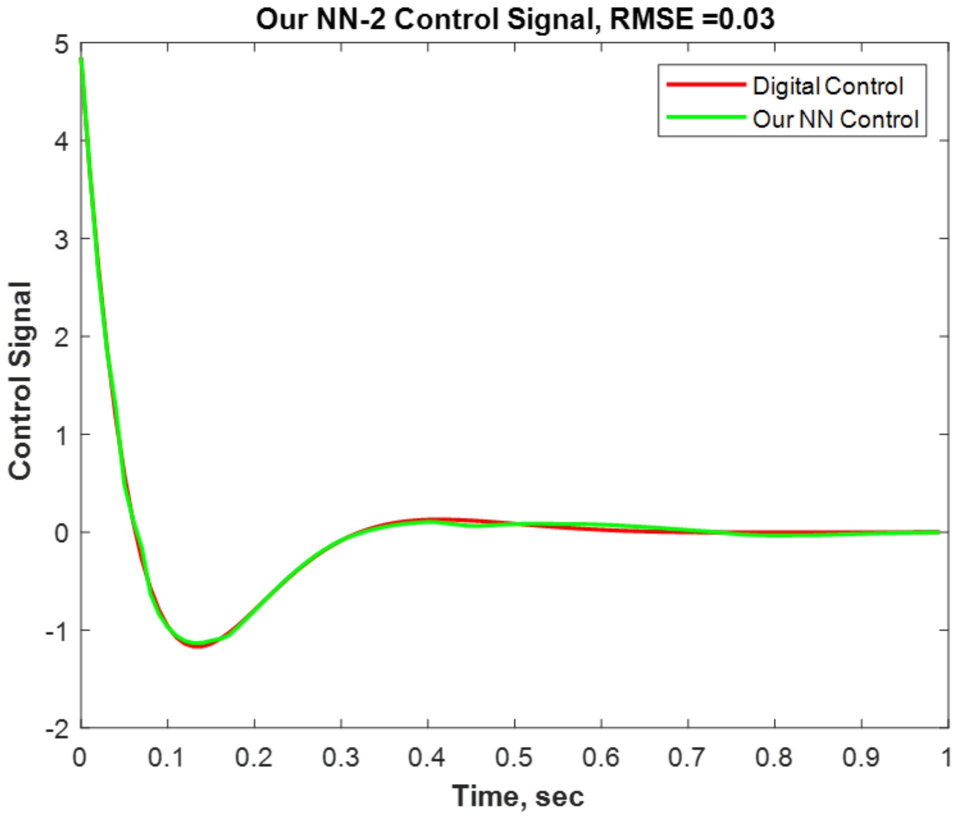

Figure 4.1 2Layer NN with Increase Node in Hidden Layer

Decrease number of nodes in in first hidden layer to 3 and second hidden layer to 2 and input layer to 5, the result that is noticed is bad result where RMSE is of high value 0.09

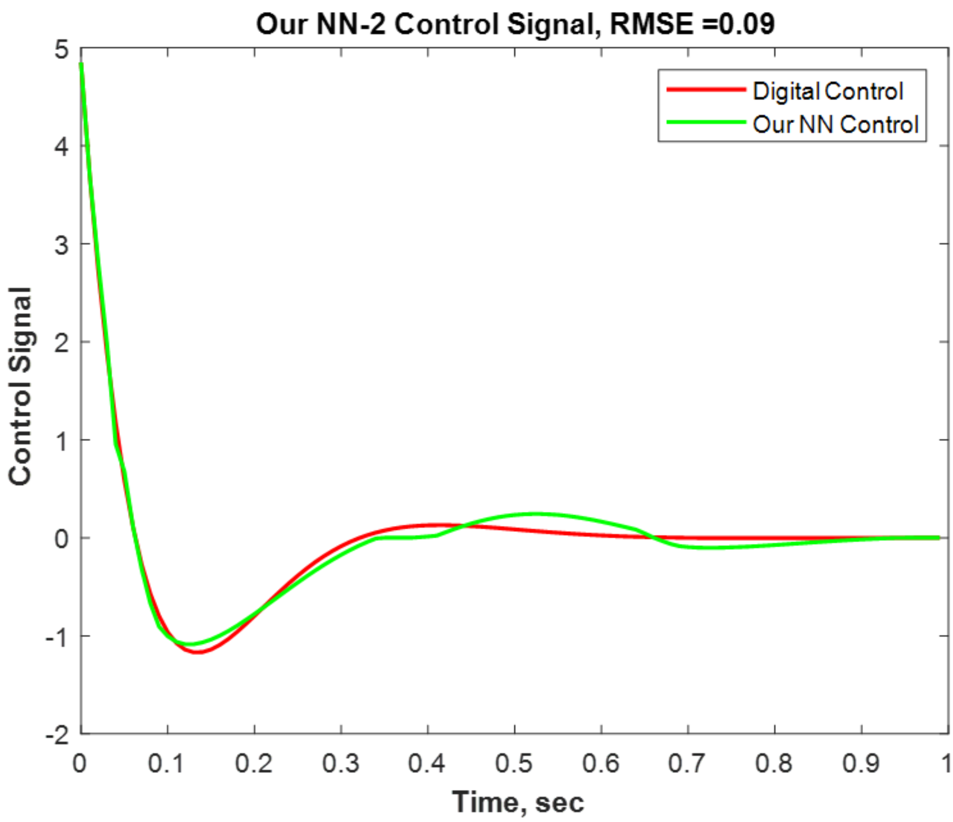

Figure 4.2 2Layer NN with Decrease Node in Hidden Layer

4. Implementation two layer NN with learning error rate (0.01) and epoch (100) the number of realization is changed which shows the following result:

Increase N to 200, the result that is noticed how the good result, where RMSE=0.02

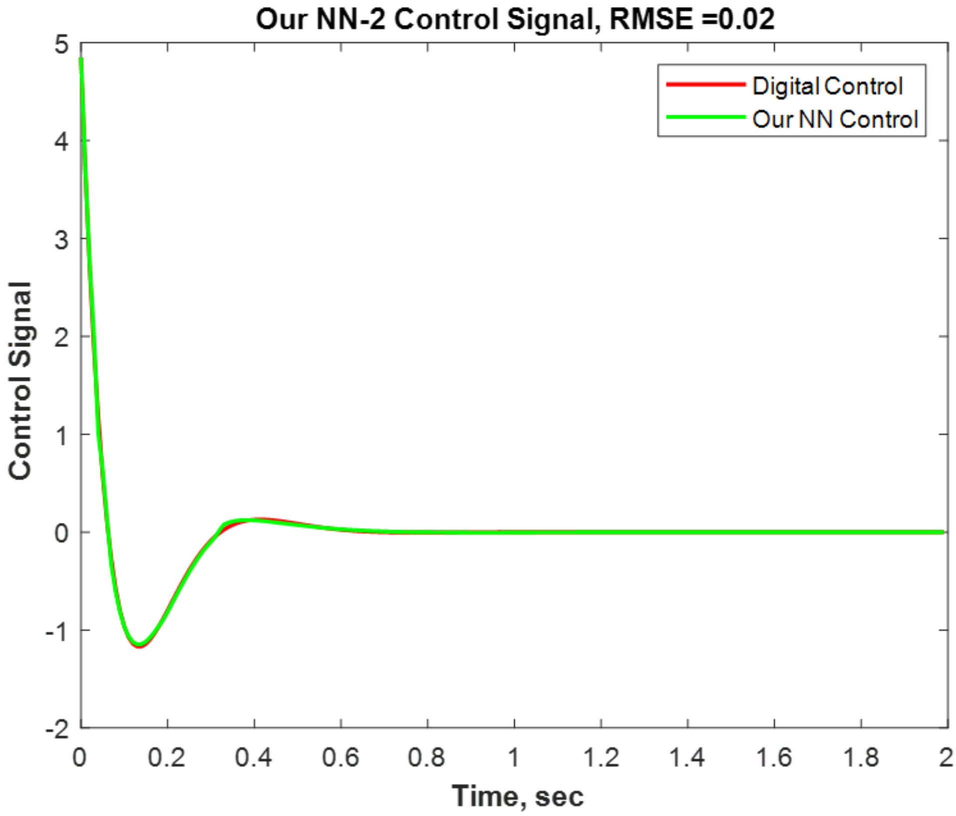

Figure 4.19 2Layer NN with N200

Decrease N to 50 , the result that is noticed is bad result ,where RMSE =0.08 that is of high value

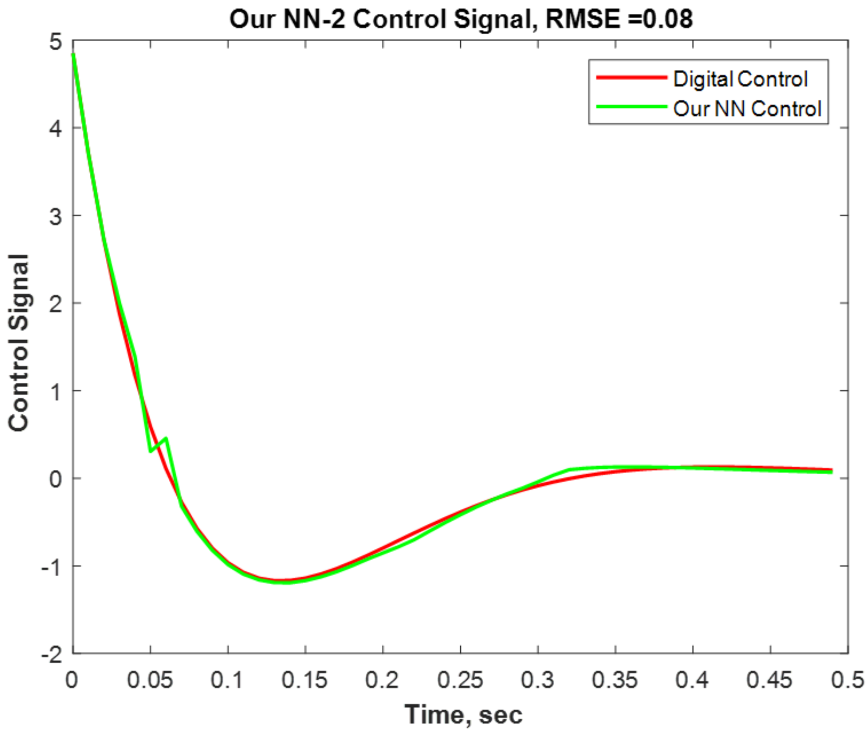

Figure 4.20 2Layer NN with N50

5. Implementing two layers NN with learning error rate (0.09), N=300 epoch=300, the result that is noticed is the ideal result where RMSE =0.00, as shown:

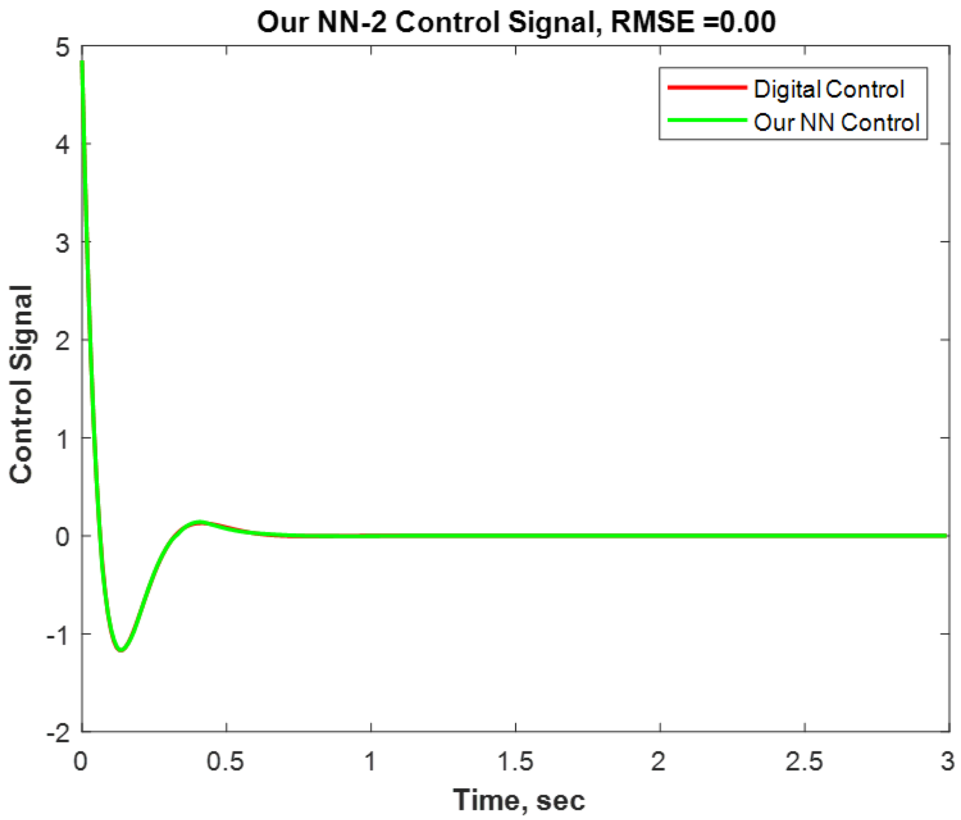

Figure 4.21 Final Result

Chapter Five

Conclusions and Future Works

CHAPTER FIVE

CONCLUSIONS AND FUTURE WORKS

5.1 Conclusions

The proposed method can be summarized when testing the similarity between the work of the control system and the work of Neural Networks, as follows:

A: When a single layer neural network is used, the following can be noticed:

Overall, the performance is not good, as the RMSE is 0.04 as the lowest

1. Increasing the number of nodes in the hidden layer leads to a good error reduction as it RMSE reaches 0.05.
2. Increasing the number of realization and epoch leads to a significant decrease in the RMSE reaching 0.04.
3. When the number of nodes in the hidden layer decreases, it leads to bad results in terms of increased RMSE reaching 0.11.
4. The decrease in the number of realization and number of epoch leads to an increase in the error clearly, which indicates an incorrect result
5. The learning error rate has a negative effect on the RMSE value, as the higher the value of the learning error rate, the greater the error, and thus leads to an incorrect result.

B: When using two-layer deep learning networks, the following can be noticed

1. The performance is very good compared to the one-layer neural networks where the RMSE is very low and it almost disappears completely, which indicates a better performance.
2. Increasing the number of nodes in the hidden layers leads to a good result, as the error percentage reaches 0.02
3. Increasing both the number of realization and number of epoch leads to a noticeable improvement in the result, where the RMSE is 0.01
4. The learning error rate also has an effect on the result as the greater its value leads to a significant decrease in the error rate
5. When the number of nodes in the hidden layer decreases, it leads to bad results in terms of increased RMSE reaching 0.11
6. The decrease in the number of realization and number of epoch leads to an increase in the error clearly, which indicates an incorrect result.
7. It is the increase of the above both together (number of realization and number of epoch to 300) with increase learning error rate to0.09, we reach the ideal result, which is RMSE 0.00.

5.2 Future Works

1. Since increasing the number of layers in NN led to good results from one layer as the number of layers increases, the number of nodes per layer increases, which in turn leads to good results, it is recommended that increasing the number of layers to more than two to the good and accurate results .

2. Where it was found that it is the most used type of control it is PID control in digital control system , especially in industrial fields due to the lack of changing parameters as well as the ease of investigation , deals with

error in the present, past and future and contains three terms (proportional, integral, and derivative). As a future study it was suggested the use of type PID control

3. Consider high-order control systems, with the development taking place in industrial systems, many factories today are described through higher ordering systems where these systems are approximated by using the lower order system through the method of reducing the model and usually these systems are of type PID, where the order ranges from 3 to 7.

References

References

[1] Jacquot, R. G. (2019). Modern digital control systems. Prentice Hall, Englewood Cliffs, NJ.

[2] Mutambara, A. G. (2017). Design and analysis of control systems. International Standard Book Number 0-8493-1898-X . LLC. Corporate Blvd., Boca Raton, Florida 33431.

[3] M.S. Fadali, "Digital Control Engineering – Analysis and Design".(2009). Elsevier. ISBN: 13: 978-0-12-374498-2 .

[4] Davison, D. M. (2007). Control System Design (Goodwin, GC et al; 2001)[Book Review]. IEEE Control Systems Magazine, 27(1), 77-79.

[5] Williams, Jacob M., "Deep Learning and Transfer Learning in the Classification of EEG Signals" (2017). Computer Science and Engineering: Theses, Dissertations, and Student Research. 134.

[6] Warren S. Sarle, Neural Networks and Statistical Models (1994,April). Proceedings of the Nineteenth Annual SAS Users Group International Conference.USA .

[7] Nielsen, M. A. (2015). Neural networks and deep learning .Book(Vol. 2018). San Francisco, CA: Determination press.

[8] Hagan, M. T., Demuth, H. B., & Jes'us, O. D. (2002). An introduction to the use of neural networks in control systems. International Journal of Robust and Nonlinear Control: IFAC-Affiliated Journal, 12, 959--985

[9] Araghi, L. F., Habibnejad, M. K., Nikoobin, A., & Setoudeh, F. (2008, October). Neural Network Controller Based on PID Controller for Two

links-Robotic Manipulator Control. In The World Congress on Engineering and Computer Science WCECS. San Francisco. USA (pp. 1018-1023).

[10] Perwej, Y., & Chaturvedi, A. (2012). Neural networks for handwritten English alphabet recognition. arXiv preprint arXiv:1205.3966.

[11] Barton, A., & Volna, E. (2017, July). Control of autonomous robot using neural networks. In AIP Conference Proceedings (Vol. 1863, No. 1, p. 070002). AIP Publishing LLC.

[12] Al-Shawwa, M. O., Al-Absi, A. A. R., Hassanein, S. A., Baraka, K. A., & Abu-Naser, S. S. (2018). Predicting Temperature or Humidity in the Surrounding Environment Using Artificial Neural Network. International Journal of Academic Pedagogical Research (IJAPR).

[13] Sokolov, A. N., Pyatnitsky, I. A., & Alabugin, S. K. (2018). Research of classical machine learning methods and deep learning models effectiveness in detecting anomalies of industrial control system. 2018 Global Smart Industry Conference (GloSIC), (pp. 1--6).

[14] Nasser, I. M., Al-Shawwa, M., & Abu-Naser, S. S. (2019). Artificial Neural Network for Diagnose Autism Spectrum Disorder. International Journal of Academic Information Systems Research (IJAISR).

[15] Kornaev, A., Zaretsky, R., & Egorov, S. (2019). Simulation of Deep Learning Control Systems to Reduce Energy Loses due to Vibration and Friction in Rotor Bearings. Book 3rd School on Dynamics of Complex Networks and their Application in Intellectual Robotics (DCNAIR), (IEEE).

[16] Xu, S., Hashimoto, S., Jiang, Y., Izaki, K., Kihara, T., Ikeda, R., & Jiang, W. (2020). A Reference-Model-Based Artificial Neural

Network Approach for a Temperature Control System. Multidisciplinary Digital Publishing Institute Processes.

[17] Dorf, R. C., & Bishop, R. H. (1995). Modem control systems. Addison-Wesely Publishing, Reading, MA, 6th Eddition, v 199.

[18] Nagrath, I., & Gopal, M. (2008). Text of control systems engineering . nagrath2008textbook, New Age International

[19] Hashimoto, S., Xu, S., Jiang, Y., & Nishizawa, Y. (2019, December). AI-Based Feedback Control Applicable to Process Control Systems. In Proceedings of the International Conference on Mechanical, Electrical and Medical Intelligent System, Japan.

[20] Franklin, G. F. (2002). Control system design [Book Review]. IEEE Transactions on Automatic Control, 47(1), 203-204.

[21] Uys, J. J., & Beukes, H. (2003). Dynamic digital control schemes for three-phase UPS inverters. IEEE 34th Annual Conference on Power Electronics Specialist, 2003. PESC'03., 3, pp. 1414--1419.

[22] Dorf, R. C., & Bishop, R. H. (2011). Modern control systems.Book, IEEE Transactions on Automatic Control, Japan.

[23] Goodwin, G. C., Graebe, S. F., & Salgado, M. E. (2001). Control system design .Book , upper Saddle River, NJ: Prentice Hall,.

[24] Mitchell, T. M. (1999). Machine learning and data mining. Journal Communications of the ACM, ACM New York, 42(11)

[25] Nielsen, M. A. (2015). Neural networks and deep learning . Determination press San Francisco, CA

[26] Kaur, S. (2018). An Ensemble based Framework for Eye State Prediction from EEG data , thesis (Doctoral dissertation).

[27] Ongsulee, P. (2017). Artificial intelligence, machine learning and deep learning.15th International Conference on ICT and Knowledge Engineering (ICT&KE), (pp. 1--6).

[28] Zenke, F., & Ganguli, S. (2018). Superspike: Supervised learning in multilayer spiking neural networks.Juornal Neural computation, 30(6), 1514-1541.

[29] Kun, Z., & Qi, Z. (2017). Application of machine learning in network intrusion detection. Journal of Data Acquisition and Processing, 32, 479--488.

[30] Petlenkov, E. (2007). Neural networks based identification and control of nonlinear systems: ANARX model based approach. TUT Press.

[31] Grossi, E., & Buscema, M. (2007). Introduction to artificial neural networks. European of gastroenterology & hepatology, 19, 1046--1054.

[32] Kim, P. (2017). Matlab deep learning. Journal with Machine Learning, Neural Networks and Artificial Intelligence, springer.

[33] Nwankpa, C., Ijomah, W., Gachagan, A., & Marshall, S. (2018). Activation functions: Comparison of trends in practice and research for deep learning. Juornal arXiv preprint arXiv:1811.03378.

[34] Demuth, H. B., & Beale, M. H. (2000). Neural network toolbox; for use with MATLAB; computation, visualization, programming; user's guide, version 4. Math Works.

[35] Benadjila, R., Prouff, E., Strullu, R., Cagli, E., & Dumas, C. (2018). Study of deep learning techniques for side-channel analysis and introduction to ASCAD database. ANSSI, France & CEA, LETI, MINATEC Campus.

[36] Karlik, B., & Olgac, A. V. (2011). Performance analysis of various activation functions in generalized MLP architectures of neural networks. International Journal of Artificial Intelligence and Expert Systems, 1(4), 111-122.

[37] Singaravel, S., Suykens, J., & Geyer, P. (2018). Deep-learning neural-network architectures and methods: Using component-based models in building-design energy prediction. Advanced Engineering Informatics, 38, 81--90.

[38] Li, G., Hari, S. K., Sullivan, M., Tsai, T., Pattabiraman, K., Emer, J., & Keckler, S. W. (2017). Understanding error propagation in deep learning neural network (DNN) accelerators and applications. Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis, (pp. 1--12)

[39] Sharma, S. (2017). Activation functions in neural networks. Journal Towards Data Science, 6.

[40] Babuska, R., & Stramigioli, S. (1999). Matlab and simulink for modeling and control. Delft University of Technology.

[41] LeCun, Y., Boser, B., Denker, J. S., Henderson, D., Howard, R. E., Hubbard, W., & Jackel, L. D. (1989). Backpropagation applied to handwritten zip code recognition. Neural computation, 1(4), 541-551.

[42] Taherkhani, A., Belatreche, A., Li, Y., & Maguire, L. P. (2018). A supervised learning algorithm for learning precise timing of multiple spikes in multilayer spiking neural networks. IEEE transactions on neural networks and learning systems, 29(11), 5394-5407.

[43] Auer, P., Burgsteiner, H., & Maass, W. (2008). A learning rule for very simple universal approximators consisting of a single layer of perceptrons. Neural networks, 21, 786--795.

[44] Wen, W. X., Jennings, A., & Liu, H. (1992). Learning a neural tree. Proceedings International Joint Conference on Neural Networks.

[45] Sharma, P., Malik, N., Akhtar, N., & Rohilla, H. (2013). feedforward neural network. Int. J. Adv. Res. Eng. Appl. Sci, 2, 25--34.

[46] Sharma, O. (2019, February). A new activation function for deep neural network. In 2019 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COMITCon) (pp. 84-86). IEEE.

[47] Majhi, S. K. (2018). An efficient feed foreword network model with sine cosine algorithm for breast cancer classification. International Journal of System Dynamics Applications (IJSDA).

[48] Khalil Alsmadi, Mutasem, et al.(2009) "Performance comparison of multi-layer perceptron (Back Propagation, Delta Rule and Perceptron) algorithms in neural networks." 2009 IEEE International Advance Computing Conference.

[49] Lim, S., Bae, J. H., Eum, J. H., Lee, S., Kim, C. H., Kwon, D., ... & Lee, J. H. (2019). Adaptive learning rule for hardware-based deep neural networks using electronic synapse devices. Neural Computing and Applications, 31(11), 8101-8116.

[50] Li, J., Cheng, J. H., Shi, J. Y., & Huang, F. (2012). Brief introduction of back propagation (BP) neural network algorithm and its improvement. In Advances in computer science and information engineering (pp. 553-558). Springer, Berlin, Heidelberg.

[51] Werbos, P.J., 1990. “Backpropagation through time:What it does and how to do it,” Proceedings of the IEEE, vol. 78, pp. 1550–1560.

الخلاصة

لا يزال البحث عن الشبكات العصبية الاصطناعية (ANN) نشطًا مما يؤدي إلى العديد من أنواع الشبكات الجديدة بالإضافة إلى الخوارزميات الهجينة والأجهزة لمعالجة المعلومات العصبية. تتكون الشبكة العصبية الاصطناعية من مجموعة من وحدات المعالجة البسيطة التي تتواصل عن طريق إرسال إشارات إلى بعضها البعض عبر عدد كبير من الاتصالات الموزونة. من ناحية أخرى ، تستخدم معظم أنظمة التحكم ، اليوم ، أجهزة الكمبيوتر الرقمية (عادةً المعالجات الدقيقة) لتنفيذ وحدات التحكم مثل: أدوات الماكينة ، وعمليات تشغيل المعادن ، والعمليات الكيميائية. تم تصميم معظم الأنظمة الإلكترونية وفقًا للجهاز ثم يتم تصنيعها كجهاز إلكتروني مرفق. ولكن إذا تغيرت الظروف أو تم تحديث المصنع ، فيجب استبدال جهاز التحكم. نظرًا لتعقيد وحدات نظام التحكم التي تمثلها خوارزميات تنفيذ البرنامج ، وتعقيد التحليل الرياضي ، والتأخير الزمني الناجم عن المحول الرقمي إلى التناظري DAC أو التناظرية إلى المحول الرقمي ADC ، وتدهور استقرار النظام بسبب التحويل أن يكون النظام رقميًا ، يؤدي هذا التحويل إلى فقدان بعض معلومات الإشارة. في هذه الدراسة ، تم فحص وحدة تحكم أخرى تعتمد على التحكم في الشبكة العصبية الاصطناعية لاستبدال النظام الذي يتحكم في حركة طاولة العمل في مكان معين ؛ هذا هو نظام تحديد المواقع المهم في أنظمة التصنيع. أظهرت المحاكاة بعد تدريب الشبكة العصبية (التعلم الخاضع للإشراف) أن النتائج مقبولة مع ميزة البساطة والقدرة على التكيف مع التحديثات الجديدة وإمكانية التطبيق في عمليات الصناعة لتطبيقات التحكم المرجعية. تشير الدراسة أيضًا إلى أن وحدة التحكم في الشبكة العصبية الاصطناعية يمكن أن تكون أقل تعقيدًا وأرخص في التنفيذ في تطبيقات التحكم الصناعي مقارنة ببعض المخططات الأخرى المقترحة.

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قسم علوم الحاسوب

الشبكات العصبية الاصطناعية لمحاكاة أنظمة التحكم الرقمية

رسالة تقدمت بها

الى مجلس كلية علوم الحاسوب والرياضيات / جامعة الكوفة جزءا من متطلبات نيل درجة الماجستير في علوم الحاسوب

الطالبة

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هـ 144 2　　**2020 م**