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The Application of Synthetic Neural Network in the Process Control Device

Adel Maghsoudpour[a], Khashayar Teimoori*[b], Mustafa Korzaledin[c]

[a, c] Department of Mechanical and Aerospace Engineering, Science and Research Branch, Islamic Azad University, Tehran Iran
[b] Young Researchers and Elites Club, Science and Research Branch, Islamic Azad University, Tehran, Iran

ABSTRACT

As a matter of an academic fact, modeling neuron is one of the most influential fundamentals in guiding and leading as well as the neural network efficiency, nonetheless the setting of the connections (Topology) in the network is a major role from affecting viewpoints. In this research the prediction of characteristics such as; temperatures, speeds and other parameters are as the outputs of an industrial process control device. First the outputs related to the speed, pressure and temperature are collected from the prepared tables of renowned corporations and then with the application of MATLAB software and the artificial neural network methods, a pertinent cliché for data is selectively collected. The final goal of this study is to attain the ideal regression which is recommended to be dealt with a Pre-assumption method. Besides, the final data calculated and sketched by graphs and diagrams were regulated then the variety of the mentioned methods in accord with their goals compared with one another and finally best ones of theirs chosen to be applied as the selective methods.

KEYWORDS: Artificial Neural Network, Multi layer Perceptron, Industrial System Information, neurons, post-issuing algorithm, Process Control Device

1. INTRODUCTION

One of the most significant and fundamental issues in designing the system identification in industrial segments is to identify the industrial system information (SI). There are different methodic approaches to identify it. Recognizing the industrial SI is completely and wholly accomplished providing that the transfer function of the SI is obtained nonetheless because of the complexity as well as being nonlinear of the industrial SI, the transfer function of the mentioned SI is hardly obtainable for some clues. The synthetic neural network is order to identify the industrial SI have demonstrated many capabilities on their own. The learning and correction of neural system parameters illustrated on figure 1 accordingly.

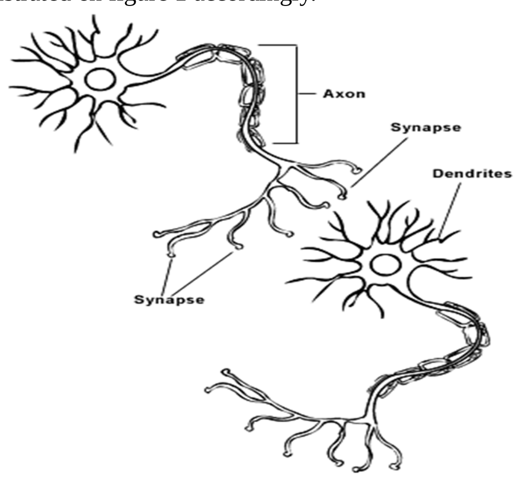

Figure 1: Sample Actual Neuron (Adapted from Drugabuse.gov Neural Network Study)

From then on it was enabled to sequentially overcome the learning stages and the experimentations which were majorly substituted as the major SI in computers so as to permit the control engineers to experiment the various controllers on the system information which therefore is enabled to monitor by computers. This is led to select the best function for the SI to design the target controller in order to finalize the SI controller. This research is to identify the existing UNIPRO devices in process control laboratories. Having input and output gates, the process of the identification stages is capably perceivable. Neural Networks are modeled as simplified as possible out of the real neural SI which is massively applied to solve solutions at various sciences. The domination of these networks is extremely vast which includes from the different categorizing applications to the interpolating, estimating, and discovering applications. Having applied the neural networks and the

***Corresponding Author:** Khashayar Teimoori, Young Researchers and Elites Club, Science and Research Branch, Islamic Azad University, Tehran, Iran Email: kh.teimoori@srbiau.ac.ir

multilayer Perceptron network, in this paper, the modeling origins and the analysis of a SI, which significantly is one of the applications on the networks, is reviewed. The first accomplished tasks in accord with the neural networks are referred to the year 1934. There were a neural physiologist Warren S. McCulloch, and a mathematician Walter Pitts from MIT University, who published a paper on a logical calculus of the immanent ideas in neural activity. [1, 2] It was said that a neural network could be done just by mathematics and algorithms. They explained for their assumption that the way neurons work in brains is a simple model of neural network which was made by electric circuits to illustrate a neural network. The result was the connections of different binary unit decisions which can directly be used to solve any computable problem. In 1949 Donald Hebb wrote a book about "Organizing Behavior" and psychologically introduced a teaching methodology in neural networks. [3] In 1959 Bernard Widrow and Marcian Hoff from Stanford University produced two neural model called "ADALINE" and "MADALINE" which were inspired from the multi-adaptive linear elements. [4]

In 1962 Widrow and Hoff presented a rule on upgrading weights (teaching) in the neural network which the weight change was equal to the EX-Proportion of weight in accord with the error proportion or the number of inputs. Formerly this idea was inspired when an active Perceptron has a major error, the weight proportions might be adjusted as if the error in the network could be distributed at least to the neighbored Perceptrons. Coincidently at a time, a neural biologist Frank Rosenblatt [5] started to work on Perceptrons. He had an interest on the fly optical SI. He believed that the most escaping process for the fly is executed in the eyes. The Perceptron resulted in Rosenblatt researches were later known as a hardware as well as the oldest neural network which is still being used. The single layer Perceptron was introduced as a helpful tool to classify the whole data into two categories. The abilities of neural networks in recognizing of samples were incredible. The latest consequences enormously draw the scientist's attention. However soon after in 1969 Marvin Minsky and Seymour Papert illustrated in their proposal and their book on Perceptrons; [6] the single layer neural network functions in isolating the data collection which themselves are weak and isolatable from nonlinear viewpoints. Besides it was mentioned that creating multilayer neural network wouldn't even slightly affect on the solutions to the mentioned restrictions. One of the most significant incidents in the course of the decades 1970-1980s was introducing teaching method of Post-Issuing errors by Paul Werbos in 1974 who permitted to work with the bigger tasks in the mentioned method which one neuron is allowed to issue its error among the layers where comprise the network. [7] David Rumelhart, Geoffrey Hinton and Ronald Williams played a major role in isolating data in1986 which are inseparable in nonlinear manner in the teaching multilayer networks. [8] Besides David Parker in 1982-1985 and Yann LeCun in 1986 mentioned this method in their works. [9] The associative memories created by Kohonen in 1972 and Anderson in 1972. [10, 11]

Accordingly, Perceptron has demonstrated that is academically valuable to be surveyed, nonetheless there are yet serious limitations. One of the capable methodic ways to solve the complicated problems is to break them down into more simplified ones which each of the resulted subcategories could be more comprehensible. Finally, the scientific contributions of this paper are as following;

I. Collecting the final data through different methodic ways in artificial neural network.

II. Contrasting the final resulted data out of the experiment with the data resulted in the other methodic ways of artificial neural network.

1.1 Artificial Neural Network

Through various kinds of networks, there is a node as artificial neuron which is called Artificial Neural Network (ANN). An AAN in fact is a calculating model inspired from the actual neural neurons in human beings. The natural neurons on the other hand, receive their inputs through the synapses located on dendrites of neurons. The received domination of pulses is changed by dendrites in a real neuron which this change isn't steady from time duration viewpoints which means it is acquired and recognized by the neuron.

A signal at the Oxon lengths is issued by the activated neuron providing that the received signal is sufficiently strong. This synapse permits responding other synapses at the rest of the neurons by itself.

1.2 Schematics of the Work

The applied schematic device in the experiment illustrated as bellow:

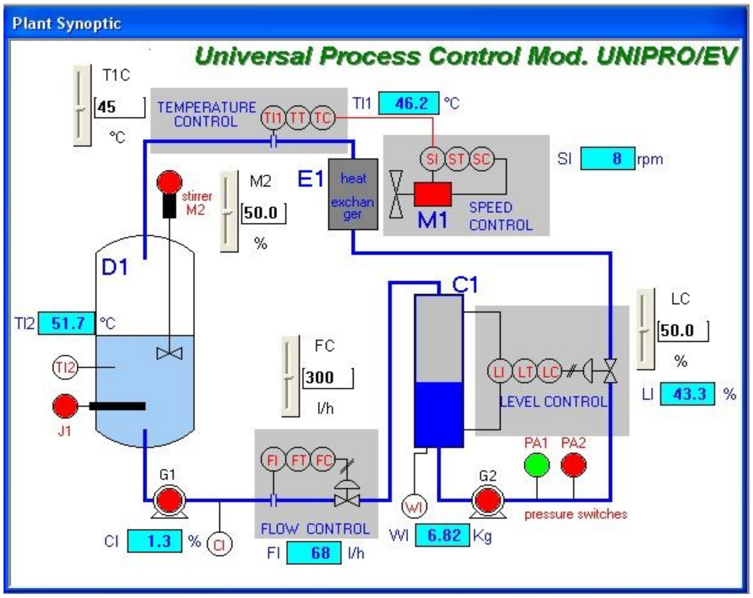

Figure 2: Schematics of the Applied Industrial Control Process Device

1.3 Mathematical Model of Artificial Neural Network

In order to model the neurons, it is recommended that their complexity must be ignored. In addition their basic concepts are required to be paid attention. Otherwise the modeling process would be extremely difficult. At a glance, a neuron model must consist of different inputs so that it can accomplish their responsibility to warred as the role synapse. The inlets are multiplied to the weights so as to assume the signal strength. At the final point a mathematical function determines whether the neuron is activated or not. If the answer is positive the outlet rate is recognized. As a result the artificial neural network follows the data processing with the aid of the simplified model out of the real neuron. The applied industrial control process device is illustrated on figure.

Multi layer Perceptron

Modeling neuron is one of the most influential fundamentals in guiding and leading as well as the neural network efficiency, however the setting of the connections (Topology) in the network is a major role from affecting viewpoints. As it is illustrated on figure 3 there is a multi layer perceptron network that the number of neurons in any layer works independently from other layers. It is noticeable that each gathered circle is the combination of the summation function and passing through nonlinear sigmoid. Each field circle in fact is a model of submission function and a nonlinear sigmoid block. With regard to the figure 3 the neuron output to the I'th (1, 2, 3… I) neuron at the last layer can be shown as bellow.

$$O_i = sgm\left(\sum_m sgm\left(\sum_l x_i w_{lm}^h\right) w_{mi}^o\right) \quad (1)$$

Which O and h sequentially demonstrate the inner layer on the output layer and w demonstrates the layer weights.

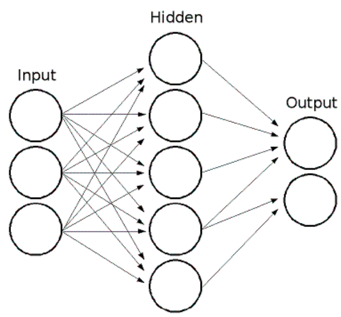

Figure 3: Three layer Perceptron with complete connections

SGM also is the sigmoid function which is illustrated on figure 4.

$$sgm(x) = \frac{1}{1+e^{-x}} \quad (2)$$

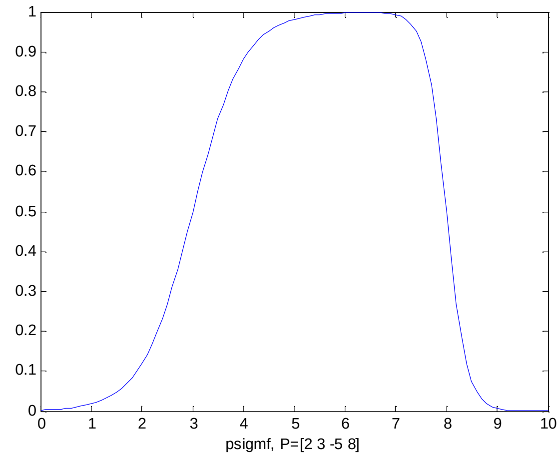

Figure 4: Sigmoid function behavior illustrated in the interval of [0, 10]

The sigmoid function and its derivative which are shown on figure 4 are used in a number of applications, including neural networks. Typically, within a neural network, the sigmoid is used as a learning function for training the neural network, while its derivative is used as a network activation function, specifying the point to which a true state should be switched by the network. For the purposes of this research, the input interval (0, 10) was selected due to its applicability to a number of neural network applications. Based on the symmetry properties of the sigmoid and its derivative, the approximation is made on [0, 10) and symmetry properties are used to obtain approximations on (0, 10).

2. The History of Post-Issuing Error Method

In 1986 this method (Error back propagation algorithm) was recommended by David Rumelhart. [8] It was applied in the feed forward neural network. The term Feed Forward (FF) illustrates that the artificial neurons located in successive layers to which their signal output is sent forward. The term post-issuing demonstrates that the errors are fed in the abaft of the network so as to correct the weights then the input direction is repeated forwarding to the output, again. The post-issuing error is supervising methodic approach which is meant the input samples are tagged and the expecting output each is already assumed. As a consequence, the network output is compared with ideal outputs in order to calculate the network errors. This algorithm at the beginning is highly assumable that the network weights are randomly selected and the network output is calculated at each pitch and the weights are corrected at the ratio of their tolerance with respect to the pertinent output so as to extremely minimize the final errors.

The stimulating function in each neuron as the input gathered-weights in accord with each neuron is considered in the post-issuing method which is then sequentially the incoherent weights (w) can be written among the input layer as well as the following layer.

$$A_j(\overline{x,\overline{w}}) = \sum_{i=0}^{n} x_j w_{ji} \quad (3)$$

It is obviously perceivable that the output of the stimulation function of neuron is only relied on the input as well as the incoherent weights. Considering the output function is sigmoid the following can illustrate the neuron output to the n'th (1, 2…, n).

$$O_j(\bar{x},\bar{w}) = sgm(A_j(\bar{x},\bar{w})) = \frac{1}{1+e^{-A_j(\bar{x},\bar{w})}} \quad (4)$$

3. The Method of Post-Issuing Error

As an example, consider to specify a housing price problem. There are input vectors as well as the relevant aim of this problem in "housing.mat" file. Having loaded this file at MATLAB work circumference, the network is created and the network teaching will be continued up to gaining the relevant and pertinent error. The most popular network which is applied for Post-issuing method is a two layer FF network. The "newff" function is applied as the underneath layer of a two layer network including 20 neurons in the hidden layer are constructed. The number of the output layer neurons is automatically considered as equal as 1 which they are the number of the aim vector members. The two layer forward networks are potentially capable to produce the relations among each output and input including the number of limited continuity providing that the number of the neurons in hidden layer is sufficient. With the aid of the Performance Key the teaching diagram window is observable as it is illustrated on figure 5.

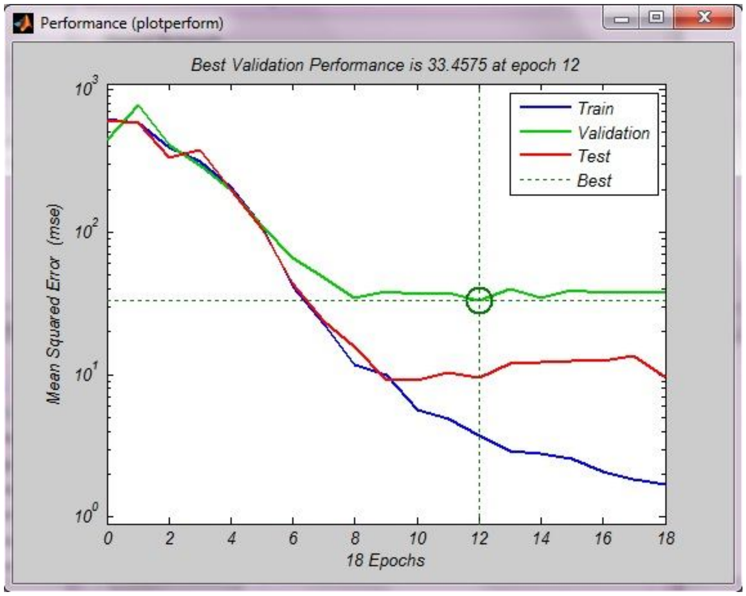

Figure 5: Validation performance diagram

As it is noticeable in the diagram above, the average error of the network squares started from a big proportion and it is gradually diminished which clarifies that there is a progression in the network learning process. The diagram above concludes three lines because 506 interval vectors and the aim are accidentally divided in three sets; 60 percent teaching, 20 percent evaluation and 20 percent experimentation. The evaluation set is applied with the aim of maintenance of the network generality. The teaching process is considered to be continued as long as the network error maintains the reduction about the evaluating network. Therefore the network pre-evaluation on teaching set is prevented. Simulating the new data is applied after the network teaching which enables the "sim" function as bellow.

$$y = sim(net, p); \qquad (5)$$

4. Assessment the Industrial Control Process Device Outputs by the Application of Neural Network

In this research the prediction of characteristics such as; temperatures, speeds, etc are as the outputs of an industrial process control device. First the outputs related to the speed, pressure and temperature are collected from the prepared tables of renowned corporations and then with the application of MATLAB software and the artificial neural network methods, a pertinent cliché for data is selectively collected. [12]

5. The Executable Method to Estimate the Outputs

The output of the industrial process control device at each Cascade modes, the speed and the temperature at specific time duration (in approximate 1sec timing tolerance) were collected. The variable outputs in the device in the course of measurement at different modes illustrated on Table 1.

Table 1: Industrial Process Control Device various outputs

TI2	**TI1**	**LI**	**WI**	**SI**	**FI**	**Cascade Mode**
TI2	TI1	LI	WI	-	-	**Speed Mode**
TI1	TI2	LI	WI	SI	FI	**Temperature Mode**

Following the sets of the data with the application of artificial neural networks, the combination of the outputs are divided into two categories; teaching and evaluating data under specific process in order to search the outputs. Here from each four successive record, one is considered in evaluating category and the rest three are located in teaching category. Table 2 illustrates the numbers of existing records in both teaching and evaluating categories at various modes.

Table 2: Records-Number of Experiment and Evaluation Sets

Evaluation Set	Teaching Set	Feature
220	662	**Cascade Mode**
141	426	**Speed Mode**
193	582	**Temperature Mode**

There is a sample of collected data as the volume 20 in the form of temperature that of course the data volume must be concerned much bigger so as to decrease the errors in neural network performance.

Table 3: Sample Collected Data's in State of Temperature at Volume rate of 20

FI	SI	WI	LI	TI2	TI1
65	763	5.13	28.3	61.5	33
65	762	5.11	28	61.7	32
66	762	5.08	27.7	61.9	31
66	762	5.07	27.5	62.1	30.1
63	762	5.05	27.3	62.3	29.3
64	761	5.04	27.1	62.4	28.7
66	761	5.02	26.9	62.6	27.8
65	761	5	26.6	62.8	27.1
66	762	4.99	26.5	62.9	26.5
65	762	4.97	26.2	63.1	25.7
65	760	4.96	26	63.2	25.1
66	761	4.95	25.9	63.4	24.6
65	761	4.93	25.7	63.6	24
66	761	4.91	25.5	63.7	23.4
65	761	4.89	25.3	63.8	22.9
65	761	4.87	25.1	64	22.4

Some data must be located in the neural network and other ones at the output collections. It must be considered that the inputs and the outputs are taken granted in accord with the Table 3.

Table 4: Two considered different conditions of cascade mode and temperature mode; one output vector for the first condition (1) and two output vectors are considered for the second condition (2)

Output		Input					State	Network
	TI2	TI1	LI	WI	SI	FI	Cascade Mode (1)	Network 1
TI2	TI1		LI	WI	SI	FI	Cascade Mode (2)	Network 2
	TI1			2TI	LI	WI	Velocity Mode	Network 3
	TI1	TI2	LI	WI	SI	FI	Temperature Mode (1)	Network 4
TI2	TI1		LI	WI	SI	FI	Temperature Mode (2)	Network 5

6. RESULTS AND DISCUSSIONS

With respect to the illustrated networks with regard to Table 4, the aim is to find pertinence function in accord with the network inputs and outputs in order to apply the evaluating category inputs to estimate the outputs. For the mentioned and expected results, the FF networks applied with the aim of programming MATLAB software as well as the application of the artificial neural network tool kit to perform to assume the various numbers of inner layer neurons for each network performance. Network (1) which is related to the cascade mode of an output vector (TI2) has 11 neurons which are used in a latent layer which figure 6 is the regression diagram between the network output (TI2) and the actual one that is already measured by the process control device.

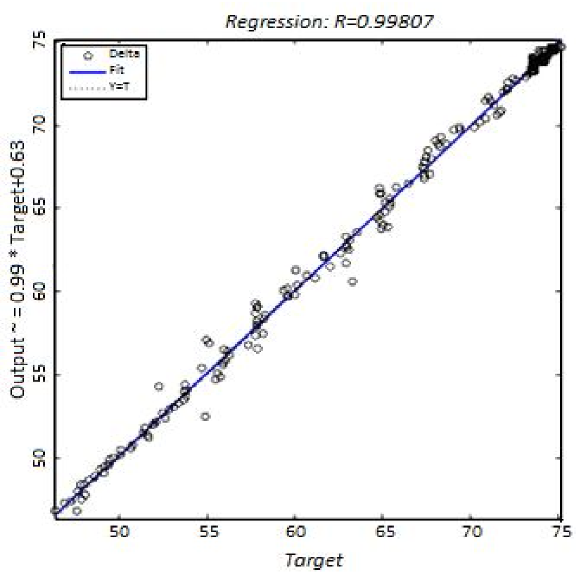

Figure 6: Diagram of Regression correspond with the Network (1)

It is specified, from figure 6, that the correlation coefficient between the actual output and the network output is 0.99807. It means that the approximation is completely ideal. Also the actual and estimated data are illustrated on figure 7.

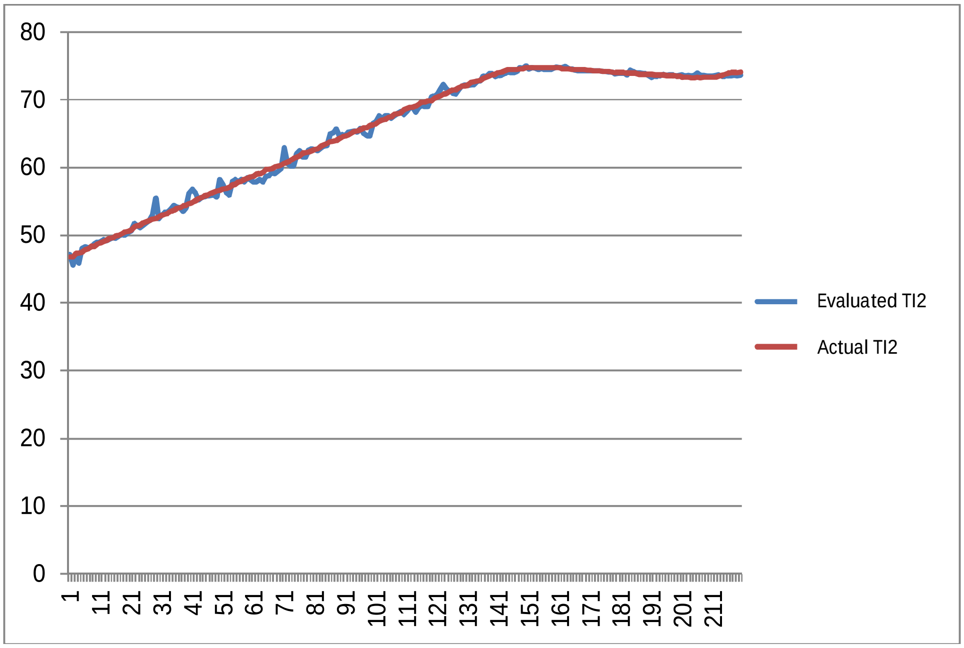

Figure 7: Diagram TI2 related to the actual data's and the network results

Network (2) is related to the cascade mode with two output vectors of TI1 and TI2 has 13 neurons which are used in a latent layer. The regression diagram is sketched between the network output (TI2) and the actual proportion by the process control device. Consequently, the correlation coefficient between the actual output and the network output is specified at 0.99807. Regression diagrams between the network outputs as (TI2 and TI1) and the actual ones measured by the process control device are illustrated on figure 8. [13]

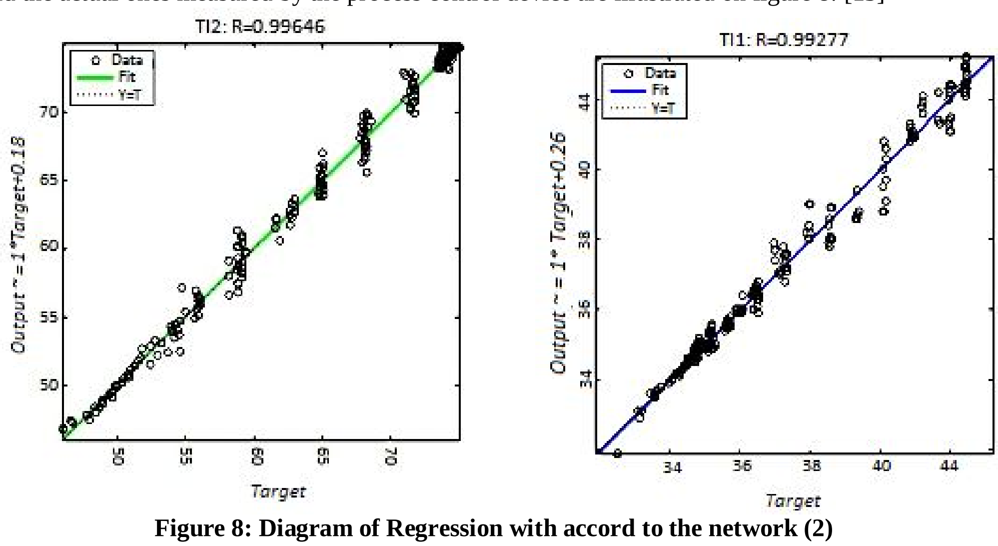

Figure 8: Diagram of Regression with accord to the network (2)

Which, here the available correlation coefficients illustrated on figure 8 are; 0.99277 and 0.99646 which are approximately close at 1 and demonstrated the high accuracy in approximation. Network (3) is related to the speed mode with one output vector of TI1 has 17 neurons which are used in a latent layer. After various performances, figure 9 obtained that is illustrated to show the regression diagram between network output (TI1) and the actual one measured by the process control device. Here the correlation coefficient between the actual output and the network output is 0.98338 which in a nutshell, the approximation is appropriate.

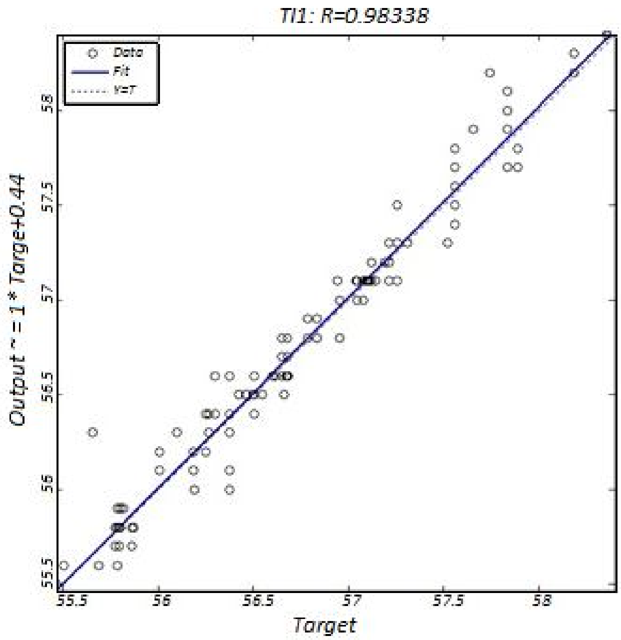

Figure 9: Regression diagram correspondent with the network (3)

Network (4) is related to the temperature mode with one output vector of TI1 has 14 neurons are used in a latent layer which figure 10 is the regression diagram between the network output (TI1) and the actual one that is measured by the process control device.

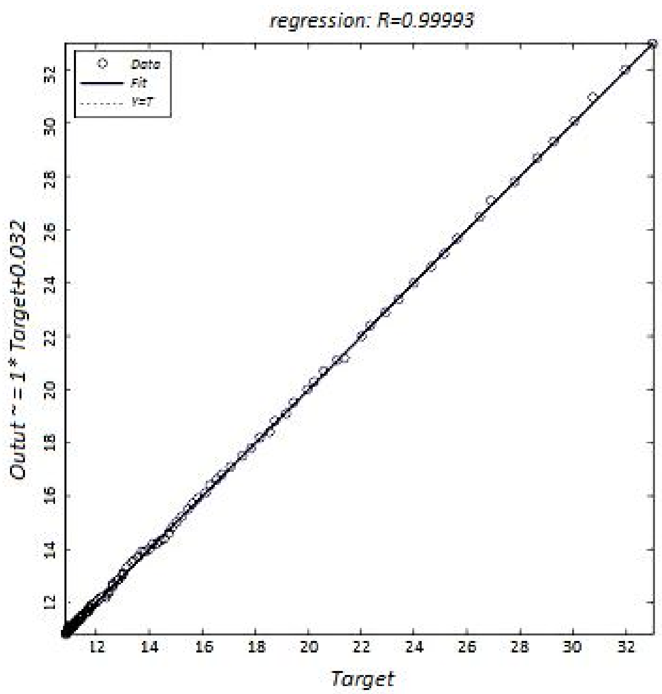

Figure 10: Regression diagram correspondent with the network (4)

This, here the correlation coefficient between actual output and network output is approximately close at 1. Network (4) is related to the temperature mode with two output vectors of TI1 and TI2 has 14 neurons are used in a latent layer which figure 11 is the regression diagrams between the network outputs (TI1, TI2) and the actual ones that are measured by the process control device. [14]

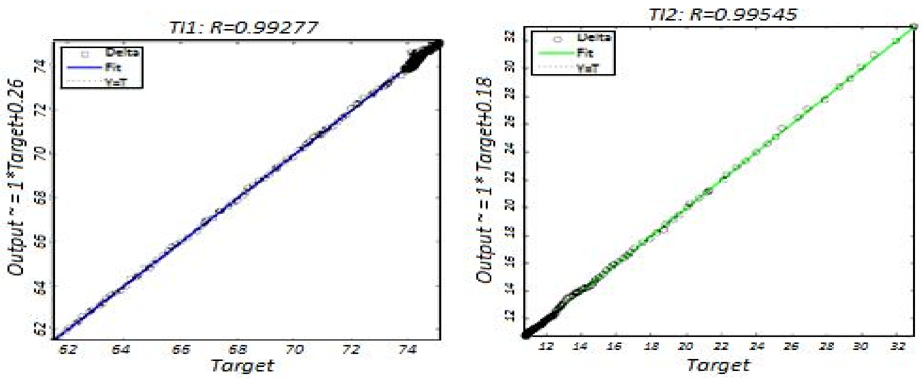

Figure 11: Regression diagram correspondent with the network (5)

Finally, here the correlation coefficients are; 0.99959 and 0.99986 which are approximately close at 1which indicates the high accuracy in approximation.

7. Conclusions and Future Scopes

At the first experimental industrial SI data has been tuned. Number of neurons in a latent layer in the FF network and the resulted regression of the attained networks in accordance with different instructions are illustrated on Table 5. Following considerations are demonstrated to show the various and different experiments data collected accordingly.

- There is a latent layer with several neurons in any Artificial Neural Network to empower the final fitted function of the survey. It is noticeable that the number of neurons in a latent layer is being changed at a time from one problem to another.
- It is highly recommended that, because of the changing in a number of attained neurons after work happen to make the worse regression which as a result the collected consequent data must be controlled.

The Pre-assumption method is taking granted in ratio of other methods in order to obtain the better regression from the final resulted data out of the experiment. In future, other methods of data-regression can be surveyed and processed so that they could be contrasted.

Table 5: Resulted attained regression from the various neural network processes in a different learning methods

TI2 Regression	TI1 Regression	Number of Neurons in a latent layer	Procedure	Status	Network
0.99807	--	11	Pre-Assumption	Cascade Mode (1)	Network 1
0.63512	--	15	Slope Decreased		
0.55300	--	8	Emission Issuance		
0.12001	--	9	Variant Learning		
0.43205	--	5	Duad Gradient		
0.780666	--	17	Quasi-Newtonian		
0.99646	0.99277	13	Pre-Assumption	Cascade Mode (2)	Network 2
0.43330	0.38299	9	Slope Decreased		
0.26882	0.73221	11	Emission Issuance		
0.08345	0.23542	8	Variant Learning		
0.02908	0.27722	5	Duad Gradient		
0.79077	0.83010	16	Quasi-Newtonian		
--	0.98338	17	Pre-Assumption	Speed Mode	Network 3
--	0.66672	12	Slope Decreased		
--	0.23635	11	Emission Issuance		
--	0.33299	13	Variant Learning		
--	0.92480	7	Duad Gradient		
--	0.85561	21	Quasi-Newtonian		
--	0.99993	14	Pre-Assumption	Temperature Mode (1)	Network 4
--	0.45872	11	Slope Decreased		
--	0.44451	9	Emission Issuance		
--	0.00345	8	Variant Learning		
--	0.76556	9	Duad Gradient		
--	0.92433	16	Quasi-Newtonian		
0.99969	0.99986	14	Pre-Assumption	Temperature Mode (2)	Network 5
0.65433	0.76232	16	Slope Decreased		
0.09932	0.23774	8	Emission Issuance		
0.10046	0.00239	10	Variant Learning		
0.45751	0.65552	14	Duad Gradient		
0.69858	0.68999	19	Quasi-Newtonian		

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