ARTIFICIAL NEURAL NETWORK FITTING TOOL FOR WIND POWER FORECASTING

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Abstract: Electricity is the biggest necessity of every nation. And any country is deployed strong or weak on its capacity of generation and meeting the power itself. Electricity is widely generated by using a variety of fuel. And also in that it covers renewable and non-renewable sources of energy, In India Wind energy fulfill a large amount of power requirement. For increasing a deployment of this production, forecasting of wind becomes important. This also support in scheduling, dispatching, and proper balancing of power quality. Also for prize bidder for profit maximization it is also important. But wind power has intermittent flow characteristic over time scale so this forecasting having a major issue with accuracy. So it is must be necessary for proper methodology placed for wind power forecasting. And for that a neural network based forecasting technique can be used. This forecasting is an inter-disciplinary experimentation involving role of neural networks which is a special application of Machine Learning Techniques. This paper mainly focus on wind power forecasting by using a modern neural network with an integration of mathematical based power simulation model.
Keywords: Neural Network, Wind power, Forecasting of wind Power, Prediction, NN Tool

I. INTRODUCTION.

In India for Last five years a new strategy for power production is established by an act “Electricity 2003 for Ultra Mega Power Project (UMPPs)”. With that to increase a potential of power sector, an agreement of tripartite agreement between State Electricity board to Central Government Generators and States Capital Electricity Generation. Some latest survey and analysis say that a growth of India has increased by rate of 8% per year and will be up to 12% in next 10 years. With that it also mentions that a current requirement of electricity in India is around 120GW and will be increase from 315 to 335 GW till year 2017 [1]. And to achieve this level of demand a generation capacity must be raised. Currently India produces its major quota of electricity from fuel like coal, hydro, and nuclear plant. Some digit also provides information about tentative generation by different sources generation up to 2015. Like as, by using Coal Based Power generation plant we get 185,173 MW generation which is almost 62.1% part of generation, by using Hydroelectric plant 42,783MW m it is 14.4%, Renewable energy Provides 38,822MW and it is 13% and by using Gas based 24,509MW it is 8.25%, by Nuclear Plant 5,780MW, 1.9% and by Oil based plant has 994MW and it is 0.3% generated. Thus totally 2, 98,060MW generation take place [2]. Here as mentioned above a renewable energy fulfills a part of requirement. Sources of renewable power are biofuel, biomass, geothermal, hydropower, solar energy, tidal power, wave power, and wind power. Renewable energy sources are particularly of interest as they are naturally replenished on human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. A bio fuel and biomass are not directly considered as pure natural sources because it has human intervention. It require an organic waste from various places manually and going through bio fuel of bio plant. It is also a time consuming process.

In geothermal energy an efficient level research is not done yet. This energy is produced in core of earth and come out from the earth surface. Hydro power plant also works on a high scale. In hydro Power plant a small trouble also need huge manpower effort to resolve and also for creation.

In renewable energy major sources are available as Sun light, and wind. But with solar it has also a problem with efficiency level research and economical query till today. In case of wind energy an enough research has taken place. And it is optimal deployment and usage charges. The basic problem working with wind is unpredictability of generating power. This paper focus over a different activities pursed by the researchers for gaining required prediction of wind generation.

Better energy generation prediction is required for dispatch, scheduling, unit commitment, and maintenance. These predictions are on based on time scale of Short term, Medium Term and Long Term time scale. This paper focuses over mainly a short term prediction.

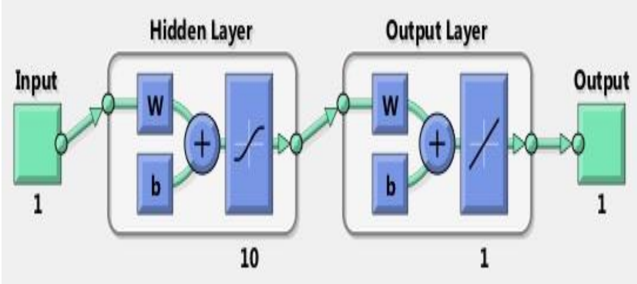
Structure of this paper is as follows: section II analyze about literature in area of wind power forecasting / prediction by using artificial neural network. Sections III analyze a calculation process of wind power. And section IV discusses about for proposed approach for predicting the wind energy and the analytic / systematic result expected therein. Section V concludes the paper with future scope.

II. LITERATURE SURVEY

A generated Wind power or electricity is majorly depending upon a wind power and that wind power has uncertain flow of characteristic. And due to that property an artificial intelligence system take in use. An artificial intelligence approaches have been applied to midterm load forecasting in several ways as per [9]. work has been done to use statistical method and artificial intelligence technology to achieve the midterm load forecasting. For an ease of planning of maintenance, scheduling, and energy reservation a load forecasting result required in energy generation. It can be classified in 3 types. That is short term, midterm and long term [10]. In these time domain a short term forecasting majorly used large amount of historitical data. In these data a parameters are day, time, wind velocity, season, and humidity. These data are used in many papers for short term forecasting. And for improvement a forecasting result a back-propagation learning algorithm used [11-17] .for short term forecasting by using back propagation algorithm a fuzzy logic also used [18].a genetic algorithm along with neural network are used for short term forecasting [19] while it is observed that for speeding up the computation and increasing a forecasting genetic algorithm is used [20]. By using Artificial Neural Network (ANN) an accuracy of forecasting gains at good amount of level. But to improve high accuracy result different model are also used like as auto regressive integrated moving average (ARIMA)[22][24].in this paper for short term forecasting by using fuzzy logic a input data is selected as time and temperature and this time domain is divided in different eight domain. And these sub domains are as mid night, dawn, morning, noon, forenoon, afternoon, dusk, and night. Even temperature is also divided in two domains of below normal and above normal for high membership function [21]. For short term forecasting in field of Turkey, a neural network based model used at a level of sixty neuron. And this network used a historitical data available from State meteorological department of Turkey of last 10 years [23].This model satisfy a requirement of electrical utility control centre of Turkey. Statistical model for wind speed and wind power forecasting using ARMA and ANN is proposed in [25]. Here it also mentions that ARMA model gives more accurate forecasting compare to ANN model, but it is more time consuming. An accuracy of forecasting is also varying on bases of different time domain. A prediction for short term time domain is more accurate than midterm. A prediction on advance of hour is more accurate than prediction advanced in several hours. ARMA model used for prediction gives best optimal result for short term duration. Detail review of various wind power forecasting model done by Wang etal. In that an internationally developed model also includes like as WPMS [27], WPPT [28], Prediktor [29], ARMINS [30], Previento [31], and WPFS Ver. 1.0 etc. in [26]. These all prominence bases of measured error and accuracy. A short term wind power predicted by using ANN model described in [32]. In it a short term wind power forecasting take place by providing 1440 data of measured wind speed, temperature, and pressure on 10min interval. A model with best performance having a two layer feed forward neural network and it also captures dynamics of non-linear system. It also concludes that increasing a hidden layer creates a problem of over fitting.

III. WIND POWER CALCULATION

Here below fig. 1 shows an internal structure of feed-forward neural network. And this feed forward neural network having back-propagation learning algorithm. It provides a best output for forecasting. It also shows in neural network tool of MATAB an algorithm randomly divide a data for Training stage, Validation stage and test stage. Also by changing a hidden layer and no. neuron in hidden layer a mean square error can also be reduced.



[Fig:1: Inner structure of Feed-Forward Neural Network]

As by above described manner for neural network for an available open source data of 1416 nos. will be placed in Feed-forward back propagation network a forecasted output will be gained. And that output of wind power will be fed in to the mathematical simulation of wind power generation system. And for that power conversion detail is described as below. Theoretical Power calculation for wind turbine system is mentioned in [3][5], before a long time ago a wind turbine placed having a vertical axis and small size. This are placed in farm and majorly used for water pumping and Grain grinding. These wind turbine types are small in size and very less efficient. It has limitation like a area swept by its blade is less and wind has intermittent direction flow so need to move direction of turbine manually. So to overcome this type of problem a new generation wind turbine comes in market said as horizontal axis wind turbine. This old generation wind turbine is worked on a Push based principle. In it a flow of air hit on a blade surface and due to that a energy of wind create some push force on blade and it will start to rotate. But in new generation system a calculation and working principle changed and they works on aerodynamics principal. A same principle on plane works. This principal is known as when wind flow hit on a surface of turbine blade, a two vector component takes place at particular point and these are Lift force and Drag fore. And a magnitude of resultant vector of these two vectors gives a value of force of displacement at particular point. And thus on entire blade at a different point this force crate and whole blade displace from its place and turbine start to rotate [4].

A calculative step for power conversion or power transfer from wind to turbine is as follows.

Kinetic energy of wind,

$P = ½mv^2$

Where, m = rate of air flow

v= Wind speed or wind velocity,

Here below equation shows a power extracted by any wind turbine with rate of change of air.

$P = ½A\rho v^3$

Where

ρ = Air Density and

A= Area of passing

This equation gives a detail about a power contain in air flow and max. possibility of power extracted by wind turbine.

Here in general case a air density is consider as ρ = 1.225 kg/m^3**.**

ρ is actually not constant but we considered it as general value. Above equation gives a value for max. possibility of power extracted but it Is not actual power extracted. Because wind power faced by front part of blade is calculated but on back side a wind flow variation also take place so it increase losses in system and due to a certain amount of power only absorbed and certain limit gives as betz-limit. It is described as a maximum limit of power extracted by turbine.

$P_w = ½ ρ A V∞^3 [16/27]$

So here, 16/27≈ 0.5925 is the max. Possible efficiency of system.

This shows the maximum energy to push back by wind Force = Change in movement

$P = Cp\ ρ\ a\ V∞^2$

Where Cp, is Power co-efficient is defined as, this power co-efficient depends on many factor like as pitch angle, tip speed ratio, internal co-efficient. And for that a equation given as,

$$\mathrm{Cp}\ (\lambda, \beta = \mathrm{C1}(\frac{\mathrm{C2}}{\lambda 1} - \mathrm{C2}\beta - \mathrm{C4}\ )\mathrm{e}^{-\frac{\mathrm{C5}}{\lambda 1}} + \mathrm{C6}\lambda 1$$

Here, λ = Tip Speed Ratio (TSR).it is a ratio between tangential speed of the tip of a blade and actual velocity of speed.

$$\lambda = \frac{\omega \mathrm{D}}{2\mathrm{v}}$$

And a rotor rotational speed in radian/sec or radian/meter is given as (ω) is Angular frequency, $\omega = 2\pi f$

And λ_1 = Internal Tip Speed Ratio.

$$\lambda 1 = \frac{1}{\frac{1}{\lambda + 0.089} - \frac{0.035}{\beta^3 + 1}}$$

And β= Pitch angle.

And thus a total power actually generated by wind turbine is given as,

$$P = Pw\ \times \mathrm{Cp}\ (\lambda, \beta)$$

This power is delivered to main shaft of turbine and that power is delivered to the gear box mechanism, here considered a gear mechanism is designed on base of lumped model. Gear box is a mechanical part which increases the rotation ratio from low to high. This system can assume all rotating mass can be treated as one concentrated mass [8].

High Torque and high rotation deliver to the generator system. As a generator a squirrel cage induction generator will be used. It is actually a motor. But Induction generator has a characteristic to works as a generator when it rotates over a synchronous speed. [6] For induction generator value of Stator Voltage (V_1), No. of Pole (P) , System Frequency (f) in Hz, Stator and Rotor Resistance (R_1 & R_2) , stator and rotor reactance (X_1 , X_2) , and Mutual Reactance (X_m), Parameters of squirrel cage induction generator are given by,

$$\text{Slip (s)} = \frac{\omega s - \omega m}{\omega s}$$

Where, ω_s = Synchronous speed.

ω_m = Actual rotating speed.

Here,

$$\omega s = \frac{120\ \times \mathrm{f}}{\mathrm{P}}$$

A stator current is given as,

$$\mathrm{I1} = \frac{\mathrm{V1}}{\mathrm{Zin}}$$

Here a Generator has two different types of winding and so voltage and current also vary so it is given as,

For Delta Connected system,

Line Voltage, $Vll = V1$

Line Current $I1 = \sqrt{3}\ \times I1$

And For Star Connected system,

Line voltage $Vll = \sqrt{3}\ \times V1$

Line Current $I1 = I1$

In that a Impedance given as,

$$\mathrm{Zin} = \mathrm{R1} + j\ \mathrm{X1} + \frac{j\ \mathrm{Xm}\ (\frac{\mathrm{R2}}{\mathrm{s}} + \mathrm{jX2})}{\frac{\mathrm{R2}}{\mathrm{s}} + j\ (\mathrm{X2} + \mathrm{Xm})}$$

For this generator a power across gap is also given as,

$$\mathrm{Pgap} = \frac{3\mathrm{I2}^2\mathrm{R2}}{\mathrm{s}}$$

Rotor Current (I_2),

$$I2 = \frac{j\ Xm}{\frac{\mathrm{R2}}{\mathrm{s}} + \ j\ (\mathrm{X2} + Xm)}\mathrm{I1}$$

And Torque Produced by Generator is given as,

$$\tau = \frac{P\mathrm{gap}}{\omega s}$$

Squirrel cage induction generator is basically motor, so it needs some external power to start. And due to that a Rotating magnetic field created across air gap and cut by rotor in motoring mode. And in case of generation that external reactive power required to provide constant magnetic field over a rotor.

Real and reactive power of generator given as,

$P\ elec. = 3 \times V \times Re\ \{I\}$

$Q\ elec. = -3 \times V \times Im\ \{I\}$.

A value of all the parameters mentioned are comes negative. So it indicates that Induction motor works as an induction generator [7].

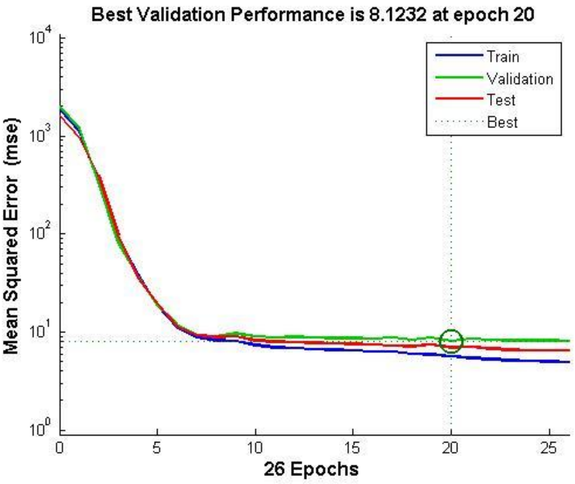
And that total capacitance required is given as,

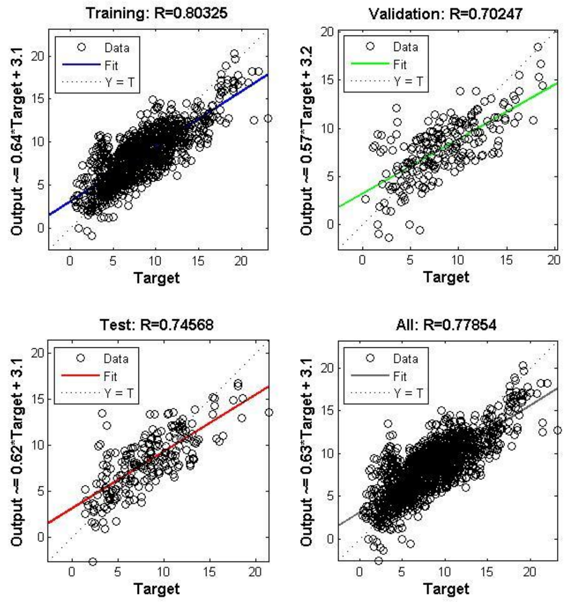
$$\mathrm{C} = \frac{1}{2 \times \pi \times \mathrm{Xc}}$$

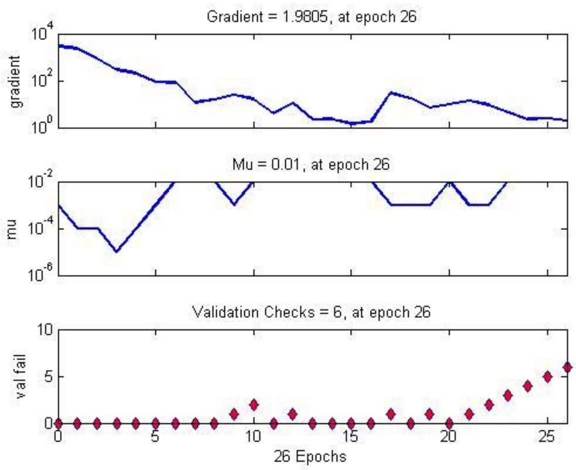
This gives a capacitance value per phase for a generator at variable output.

An induction generator required certain amount of constant reactive power. And this reactive power is absorbed from a system connected with it. If it is directly connected with grid then it is directly absorbed from grid. But in case of less air flow a generation is less and to overcome that, generator absorbs large amount of reactive power and it trip system and makes an unbalanced system. This is a drawback of induction generator. But to overcome this capacitor bank is used.

IV. RESULTS







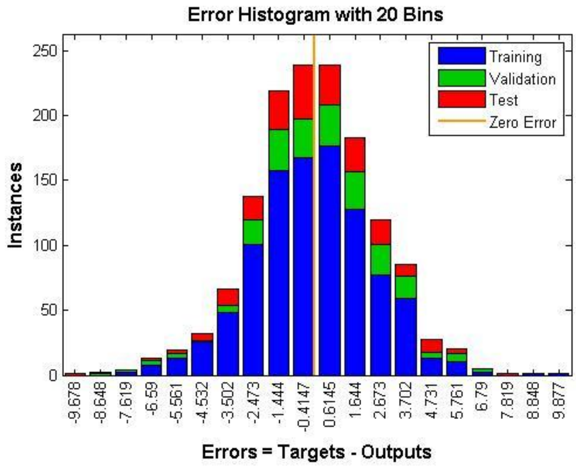
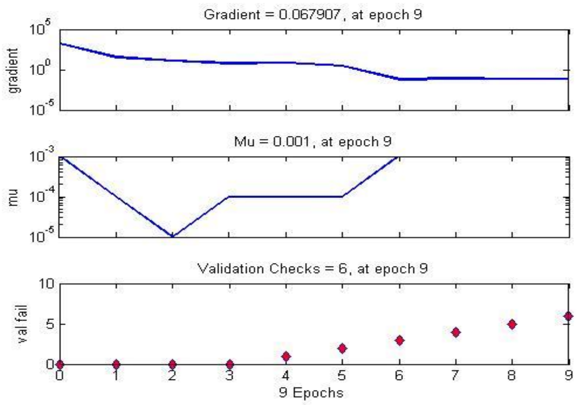
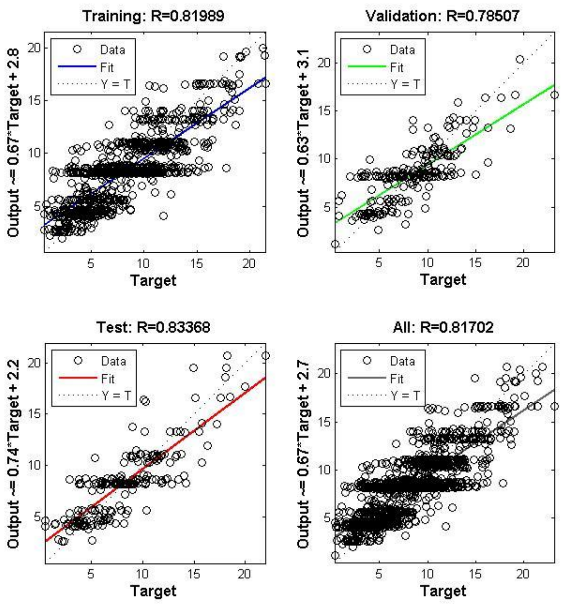


Fig:1: Results of Performance, Training state, Regression and Error Histogram for Single Hidden Layer Network for Validation of 15%, Test 5%, Train 70% at 40Nos. of Neuron.





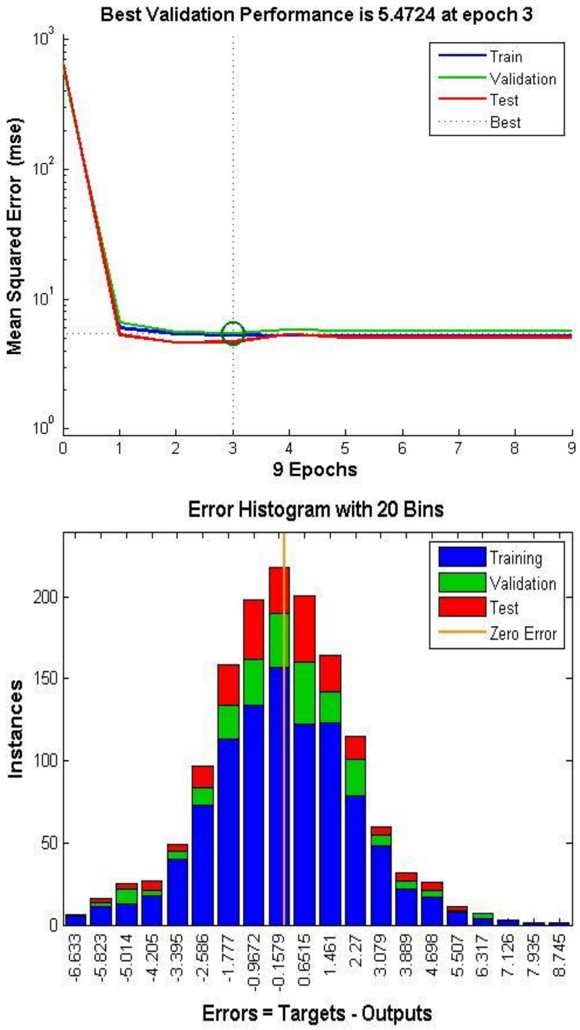
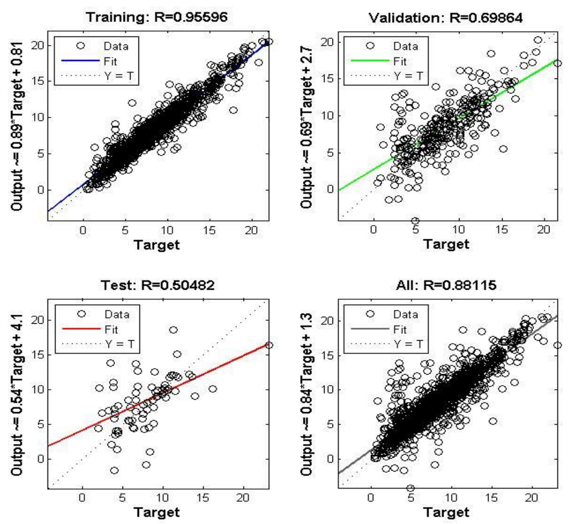


Fig: 2: Results of Performance, Training state, Regression and Error Histogram for Two Hidden Layer Network for Validation of 15%, Test 5%, Train 70% at 40Nos. of Neuron.



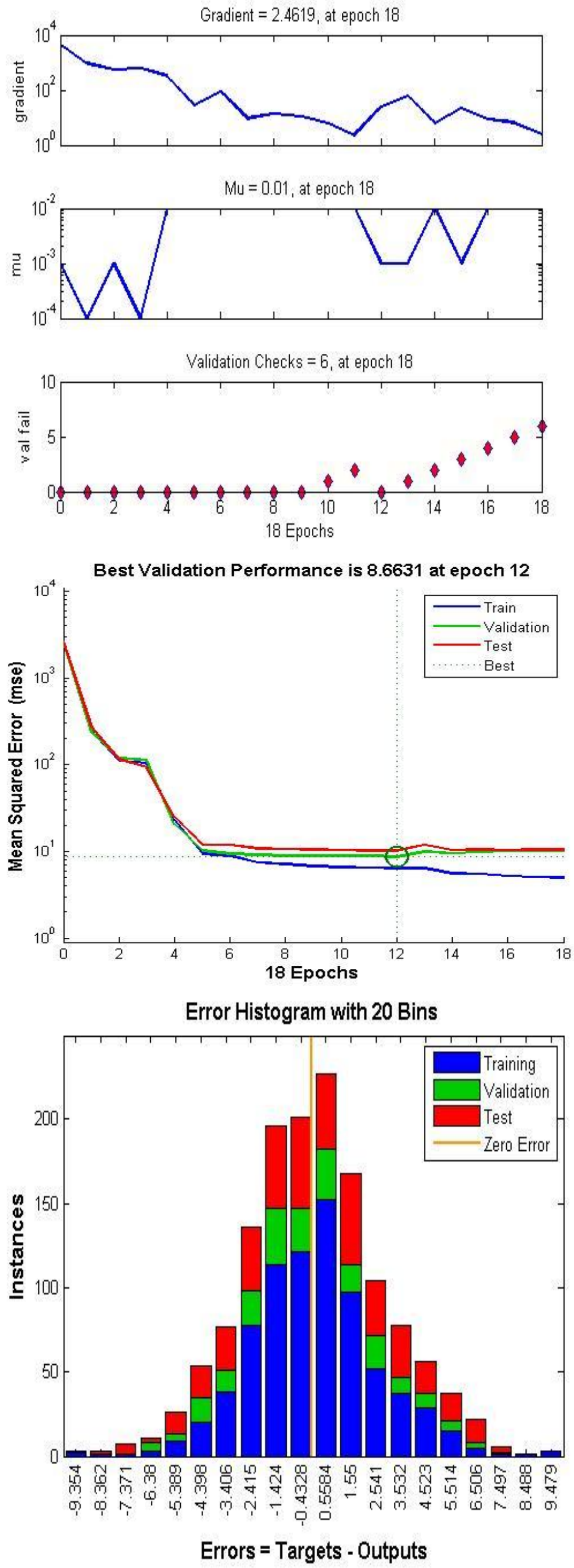
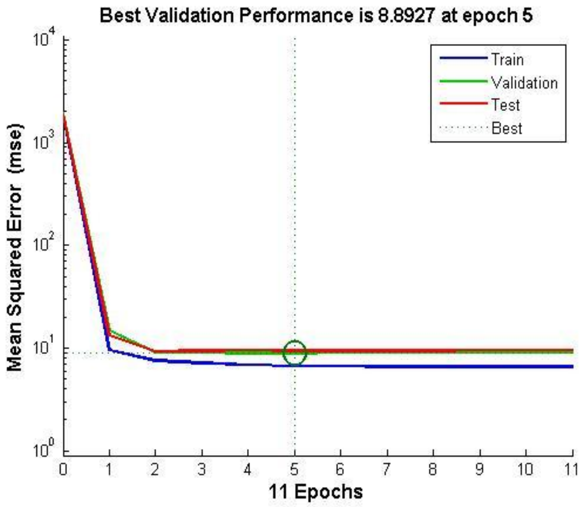
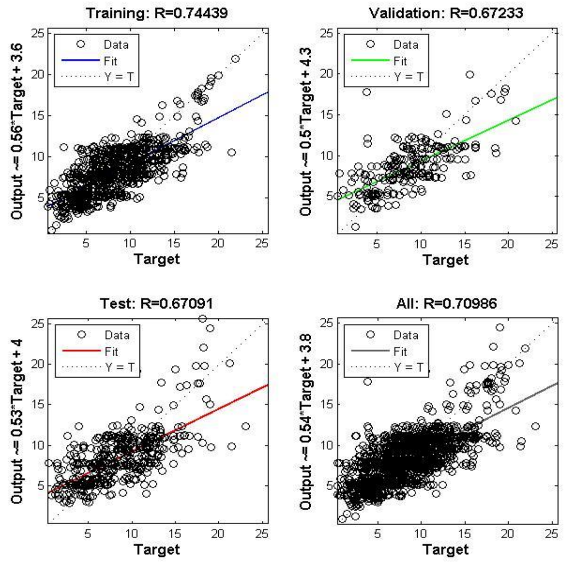
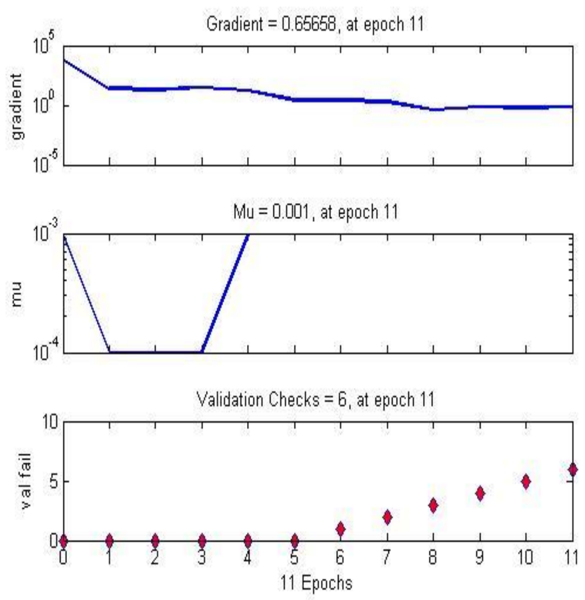


Fig: 3: Results of Performance, Training state, Regression and Error Histogram for Single Hidden Layer Network for Validation of 15%, Test 30%, Train 55% at 60Nos. of Neuron.







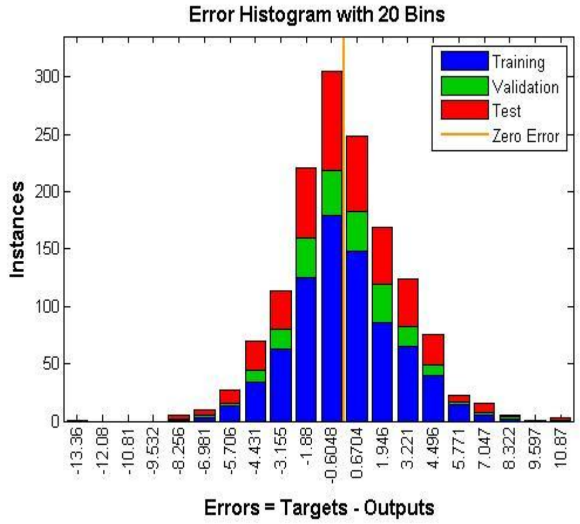


Fig: 4: Results of Performance, Training state, Regression and Error Histogram for Two Hidden Layer Network for Validation of 15%, Test 30%, Train 55% at 60Nos. of Neuron.

Here as shown in fig. 1 and 2 a model of neural network with 15% of Validation, 5% of test 70% of Train with Single Hidden Layer and Two Hidden Layer, with the same no of 40 Neurons. And for this both an Average value of error is 8.2735324 and error is 0.0003376 and for two layers Network Average value is 8.20185577 and Error is 0.07201428. The same for Fig. 3 and 4 shows the Network has Training of 55%, Validation of 15% and Test of 30%. Having a value of output for single layer is 7.910515 and error with 0.363354 and as same for two layers a value of output is 8.21084777 and error is 0.003022.

V. CONCLUSION

As by performing for variable Training, Testing and Validation state with proportion of hidden layer and neuron of system accuracy of system is varying. And in this paper it is shown that by performing a more than 135 different model, an accuracy of neural network is increased in case of Single layer neural network. In this paper a model presented offers the best result having a Single Hidden Layer structure with 40 Nos. of Neuron 15% of validation, 15% of Test and 70% of Training gives best output. With increasing a no. of hidden layer an over fitting problem also increases and therefore accuracy also decrease compared to single layer structure model.

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