Review Paper : Short-term based load forecasting of Chhattisgarh grid using Artificial Neural Network

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Abstract—Load forecasting is that the prediction of future many an influence system. it's a vital element for power grid energy management. Precise load forecasting helps to form unit commitment choices, scale back spinning reserve capability and schedule device maintenance set up properly. Besides taking part in am key role in reducing the generation value, it's conjointly essential to the reliability of power systems. By forecasting, consultants will have Associate in Nursing idea of the masses within the future and consequently will build important decisions for the system. This work presents a study of short term hourly load forecasting exploitation differing types of Artificial Neural Networks. It has several applications as well as energy getting and generation, load shift, contract analysis, and infrastructure development. an outsized type of mathematical ways have been developed for load forecasting. during this chapter we tend to discuss varied approaches to load forecasting. Results ,conclusions and comments square measure created on future analysis directions.

Index Terms—Load forecasting, ANN, Power system.

I. INTRODUCTION

Load forecasting is one amongst the central functions in power systems operations and it's extraordinarily vital for energy suppliers, money establishments, and alternative participants concerned in electrical energy generation, transmission, distribution, and supply. Load forecasts may be divided into 3 categories: short-term forecasts, medium-term forecasts and semi permanent forecasts. Short-term load forecasting (STLF) is a crucial part of the facility generation method. antecedently it absolutely was employed by traditional approaches like statistic, however new strategies based mostly on artificial and procedure intelligence have began to replace the recent ones within the trade, taking the method to newer heights. Load forecasting may be created by totally different strategies like multivariate analysis, applied math methods, artificial neural networks, genetic rule, mathematical logic, etc.In the recent years, many researchers have tried to use the trendy techniques supported computer science. Of all techniques, the substitute neural network (ANN) receives the foremost attention. ANN is regarded as a good approach and is now commonly used for electricity load forecast. The reason for its quality is its easy use and its ability to be told advanced input-output relationship. the flexibility to be told gives ANN a much better performance in capturing nonlinearities for a time series signal. Therefore, the study during this paper proposes a model comprising neural networks as its forecasting tool.

Vital Factors for Forecasts

For short load forecasting many factors ought to be thought-about, such as time factors, weather information, and doable customers' categories. The medium- and long-run forecasts take into consideration the historical load and weather information, the quantity of consumers in several classes, the appliances within the space and their characteristics together with age, the economic and demographic information and their forecasts, the appliance sales data, and alternative factors.

The time factors embody the time of the year, the day of the week, and the hour of the day. There square measure vital variations in load between weekdays and weekends. The load on totally different weekdays can also behave otherwise. for instance, Mondays and Fridays being adjacent to weekends, might have structurally totally different hundreds than Tuesday through Thursday. this is often significantly true throughout the summer time. Holidays are tougher to forecast than non-holidays due to their relative infrequent prevalence.

Weather conditions influence the load. In fact, forecasted weather parameters square measure the foremost vital factors in short load forecasts. Various weather variables can be thought-about for load forecasting. Temperature and wetness square measure the foremost normally used load predictors. Among the weather variables listed higher than, 2 composite weather variable functions, the THI (temperature-humidity index) and WCI (wind-chill index), square measure broadly speaking employed by utility corporations. THI could be a live of summer heat discomfort and equally WCI is cold stress in winter. Most electrical utilities serve customers of various varieties like residential, commercial, and industrial. the electrical usage pattern is totally different for customers that belong

to totally different categories however is somewhat alike for customers among every category. Therefore, most utilities distinguish load behavior on a class-by-class basis..

II. LOAD FORECASTING

A prediction state of affairs of future events and things is named as forecast, and also the act of constructing such predictions is named statement. statement is that the basic technique of deciding in numerous areas of life. the aim of statement is cut back} the danger in deciding and reduce out of the blue price. one among the foremost necessary works of an electrical power utility is to properly predict load needs. Load statement may be a methodology of quantitatively determinant future load demand. the first perform of an influence utility is to produce electricity to the customers economically. Limitations of energy resources additionally to environmental factors, needs that the electricity ought to be used additional expeditiously.

Load statement incorporates a important importance in installation energy management system. Precise load statement helps the electrical utility to form unit commitment selections, cut back spinning reserve capability and schedule device maintenance arrange properly. Besides enjoying a key role in reducing the generation price, it's conjointly essential to the dependableness of power systems. Load statement plays a very important role in installation coming up with, operation and management. coming up with and operational applications of load statement needs an exact lead time‟ conjointly known as statement intervals.

Power sector is extremely capital intensive and whole coming up with of generation, transmission Associate in Nursingd distribution follows an axiomatic approach supported load statement. For this purpose, the anticipated load demand ought to be famed. The resources offered within the country for wattage generation (thermal, hydro and atomic energy stations) will then be developed considering the wattage and energy needs and also the locations or regions wherever demand is anticipated. Load forecasting is vitally necessary for the electrical business within the deregulated economy. it\'s several applications together with energy getting and generation, load switch, contract evaluation and infrastructure development.

Load statement is one among the most functions in installation operation and it's extraordinarily necessary for energy suppliers, money establishments, and alternative participants concerned in electricity generation, transmission and distribution. antecedently ancient approaches were used for load statement, however currently new strategies supported artificial and procedure intelligence have began to replace the recent strategies within the power business. a decent load forecast reflects the present and future trends within the installation. correct models for load statement square measure essential for the operation and coming up with of an influence utility company.

III LOAD FORECASTING:TYPES

Electrical load prediction is that the method of predicting future electrical load demand on the idea of given historical load info. Load prediction is an important and integrated method in designing and operation of electrical power utilities. It involves the correct forecast of each the magnitudes and geographical location of electrical load over the various periods of designing horizon. the essential amount of interest in load prediction usually the fundamental quantity in reference to the load demand studied. Load prediction may be divided into 3 major classes on the idea of prediction time-periods.

Long-Term LOAD forecasting

Long-term load forecasting is connected with load growth and supply/demand aspect resource management changes. The forecasting time-period or the prediction time for long load forecasting ranges from 2 to 25 years .the design for the addition of latest generation, transmission and distribution facilities is predicated on long load forecasts and begins 2 to 25 years before of the particular in-service. In India, long electricity load forecasts at the national, regional and state levels ar ready by the Annual Power Survey Committee beneath Central Electricity Authority (CEA).

Medium-Term LOAD forecasting

Medium-term load forecasting is employed for the aim of planning fuel provides and unit maintenance operations. The forecasting time-period or the prediction time for medium-term load forecasting ranges from one month to 2 years. Medium-term load forecasts ar aimed to see monthly electrical load and energy necessities. Medium-term load forecasting is used for deciding the rate-structure for charge of various shopper classes.

Short term LOAD forecasting

Short-term load forecasting is employed to produce necessary data for the facility system management in day-after-day operations and unit commitment. The forecasting time-period or the prediction time for short load forecasting will be hour-by-hour, day-by-day, week-by-week. With the recent trend of release of electricity markets, short load forecasting has gained additional importance and bigger challenges.

IV.LOAD FORECASTING:OBJECTIVES

Load prediction is a necessary and integrated method in designing and operation of electrical power utilities. Load prediction plays a very important role in grid energy management system. Precise load prediction allows the electrical utility to create unit commitment selections, cut back spinning reserve capability and schedule device maintenance set up properly. the most objectives of 3 styles of load prediction are:

Long-run LOAD FORECASTING:OBJECTIVES

(a) Exploration of natural fuel and water resources.

(b) Development of trained human power.

(c) Reinforcement planning of generation, transmission and distribution equipment.

(d) Establishing future fuel demand.

(e) Examining the energy supply problems.

Medium-TERM LOAD FORECASTING:OBJECTIVES

(a) Deciding rate-structure for request of various client classes.

(b) Power exchange contract with neighboring utilities and interchange schedules.

(c) Annual designing and budgeting for fuel needs and alternative operational needs.

(d) Maintenance planning of generation and transmission instrumentation.

(e) planning of captive plants.

Short-term LOAD FORECASTING:OBJECTIVES

(a) Operational designing for unit commitment and economic dispatch calculations.

(b) Formation of maintenance planning programs.

(c) Operational designing for on-line load flows.

(d) Spinning reserve calculations.

(e) short-run interchange schedules with neighboring system.

(f) System security analysis.

(g) planning of tense storage units.

(h) Load management planning.

V. SHORT TERM LOAD FORECASTING:TECHNIQUES

Short-term load forecasting is employed to provide necessary info for the facility system management in regular operations and unit commitment. The forecasting time-period or the prediction time for short load forecasting are often hour-by-hour, day-by-day, week-by-week. the facility utilities use past normalized load demand knowledge for short load forecasting of:

(a) Peak load conditions for system during a day.

(b) System load at numerous intervals of your time (hour/half-hour) during a day.

(c) Hourly or time unit energy needs. (d) Individual bus load prediction.

(e) a number of minutes to many hours ahead forecast that is helpful in utility‟s systems to manage economic load dispatching and security assessment. The various techniques for short load forecasting ar classified as:

SIMILAR-DAY methodology

Similar-day methodology for short load forecasting is supported looking historical knowledge for days among one, two, or 3 months with similar characteristics to the forecast day. Similar characteristics embrace weather, day of the week, and also the date. The load of an identical day is taken into account as a forecast. rather than one similar day load, the forecast are often a linear combination or regression procedure which will embrace many similar days. The trend constant scan is employed for similar days within the previous months.

2.3.2 REGRESSION methodology

Regression strategies are wide wont to model the link of load consumption and different factors like weather, day for short load forecasting. Regression strategies functionally relate load demand to different economic, competitive, or weather variables associated estimate an equation mistreatment the smallest amount squares technique. multivariate analysis involves the need of mistreatment judgment in conjunction with applied mathematics analysis. Regression of your time series knowledge could be a unremarkably used apply in utilities wherever following necessary measures of performance on a weekly, monthly or quarterly basis is conducted. Mbamalu and El-Hawary (1993) used the following load model for applying this analysis:

$$Yt = Vt*At + Ct$$

Where , t = sampling time

Yt = measured system total load ,

Vt = vector of adapted variables such as time, temperature , light intensity , wind speed , humidity , day type (workday , weekend)

At = Transposed vector of regression coefficients ,

Ct = Model error at time t.

Regression methodology for short load forecasting is additionally appropriate in domestic, business and public-lighting sectors.

Time series methodology

Time series strategies for short load forecasting are based on the idea that the load demand knowledge has an internal structure, like auto-correlation, trend, or seasonal-variation. statistic forecasting strategies observe and explore such a structure. statistic are used for many years in such fields as social science, digital signal process, in addition as electrical load forecasting. ARMA (Auto Regressive Moving Average), ARIMA (Auto Regressive Integrated Moving Average), ARMAX (Auto Regressive Moving Average with exogenous variables)and ARIMAX (Auto Regressive Integrated Moving Average with exogenous variables) are the foremost usually used classical statistic methods for short load forecasting. ARMA models ar sometimes used for stationary processes whereas ARIMA is associate extension of ARMA to non-stationary processes. ARMA

and ARIMA use the time and cargo because the solely input parameters. Since load typically depends on the weather and time of the day, ARIMAX is that the most natural tool for short load forecasting among the classical statistic models.

Some of the time series model used for load forecasting are :

- Autoregressive (AR) model of order m,

$L_k = \sum_{i=1}^{m} \alpha_{ik} \; L_{k-i} \; + w_k$

Where L_k is the predicted load at time k (min) , w_k is a random load disturbance , α_i , i = 1 , …., m are unknown coefficients.

- Autoregressive moving – average (ARMA) model : In the ARMA model the current value of the time series y(t) is expressed linearly in terms of its values at previous periods [y(t-1) , y(t-2) , …] and in terms of previous values of a white noise [a(t) , a(t-1) ,…] . For an ARMA of order (p,q) , the model is written as :

$Y(t) = Ø_1 y(t-1) + \ldots\ldots + Ø_p y(t-p) +$

$a(t) - \theta_1 a(t-1) - \ldots\ldots\ldots - \theta_q a(t-q).$

- Autoregressive integrated moving – average (ARIMA) model : if the process is non stationary , then transformation of the series to the stationary form has to be done first. The transformation can be performed by the differencing process. By introducing the ∇ operator , the series ∇ y (t) = (1-B)y(t). For a series that needs to be differenced d times and has orders p and q for the AR and MA components , ie ARIMA (p,d,q), the model is written as :

$Ø(B)\nabla^d y(t) = Θ(B)a(t).$

ARTIFICIAL NEURAL NETWORK methodology (ANN)

Artificial neural network (ANN) is wide used for short electrical load forecasting. Artificial neural networks ar non-linear circuits that have the incontestable capability to try and do non-linear curve fitting. The outputs of a man-made neural network ar some linear or non-linear function of its inputs. The inputs could also be the outputs of different network components in addition as actual network inputs. In apply network components ar organized during a comparatively little variety of connected layers of components between network inputs and outputs. Sometimes feedback methods are used. Artificial neural networks have succeeded in many grid applications, like load forecasting, security analysis, fault diagnosing, planning, analysis, and protection. The ANN ‟ s ability in mapping complicated non-linear relationships is liable for its growing variety of applications in short load forecasting. the foremost fashionable artificial neural specification for short load forecasting is back-propagation. Back-propagation neural specification uses unendingly valued functions and supervised learning. beneath supervised learning, the particular numerical weights assigned to the part inputs ar determined by matching historical knowledge (time and weather) with desired outputs (historical loads) during a pre-operational “training-session”. perennial neural network (RNN) methodology and Feed-forward back propagation (FFBP) neural network methodology is employed for forecasting the height load. Radial basis operate network (RBFN) methodology is employed for quick coaching and higher following of the peak-loads and valleys.\

Expert SYSTEM methodology

Rule based mostly forecasting makes use of rules which are usually heuristic in nature for correct load forecasting. Expert systems in corporate rules and procedures employed by human specialists within the field of interest into computer code that's the unable to mechanically create forecasts while not human help. The use of expert system methodology for short load forecasting began in the1960‟s for applications like geologic prospecting and laptop style. knowledgeable systems work best once somebody's knowledgeable is offered to figure with computer code developers for a substantial quantity of your time in impartation the knowledgeable‟s data to the expert system computer code. The expert‟s data should be applicable for codification into computer code rules.

Fuzzy logic methodology

Fuzzy logic management systems ar rule-based systems within which a collection of fuzzy-rules represent a sway call mechanism to regulate the consequences of bound stimulation. Fuzzy logic could be a generalization of the standard symbolic logic used for digital circuit design. associate input beneath symbolic logic takes a truth worth of „0‟ or „1‟. associate input is related to bound qualitative target mathematical logic. for example a electrical device load can be „low‟, „medium‟ and „high ‟. Fuzzy logic allows the user to logically deduce outputs from fuzzy inputs. mathematical logic the technique for mapping inputs into outputs i.e., curve fitting and it's used for short-term load forecasting. mathematical logic methodology are often combined with neural network for coaching it and so getting a more robust short load demand forecasting.

SUPPORT VECTOR MACHINE (SVM) methodology

The support vector machines (SVM‟s) are supported the principle of structural risk minimization (SRM) instead of the principle of empirical risk minimization (ERM) which is conducted by the standard neural network method model. Support Vector Machines (SVMs) are more recent powerful techniques in short load forecasting used for finding classification and regression issues. not like artificial neural networks, that tryto outline complicated functions of the input feature house, support vector machines perform a non-linear mapping by

mistreatment so called kernel functions of the info into a high dimensional feature space. Then support vector machines use straightforward linear functions to form linear call boundaries within the new house. The task of selecting associate architecture for a neural network is replaced by the task of selecting an appropriate kernel for the support vector machine (SVM) methodology.

Artificial neural networks are primarily non-linear circuits that have the in contestable capability to try to non-linear curve fitting. The outputs of a man-made neural network square measure some linear or non-linear function of its inputs. The inputs is also the outputs of alternative network parts yet as actual network inputs. In follow network parts square measure organized during a comparatively tiny range of connected layers of parts between network inputs and outputs. generally feedback methods also are used. Artificial neural networks have succeeded in many facility applications, like load Forecasting, security analysis, fault designation, planning, analysis, and protection.

An artificial neural network is sometimes fashioned from several lots of or thousands of straightforward process units, connected in parallel and feeding forward in many layers. as a result of the quick and cheap personal computers accessibility, the interest in ANN‟s has redoubled in today‟s world. The ANN‟s ability in mapping advanced non-linear relationships is to blame for its growing range of applications in short load Forecasting. the foremost well-liked artificial neural specification for short load Forecasting is back-propagation. Back-propagation neural specification uses endlessly valued functions and supervised learning. The structure of ANN is shown within the figure one. it's 3 layers named as input layer, hidden layer and output layer.

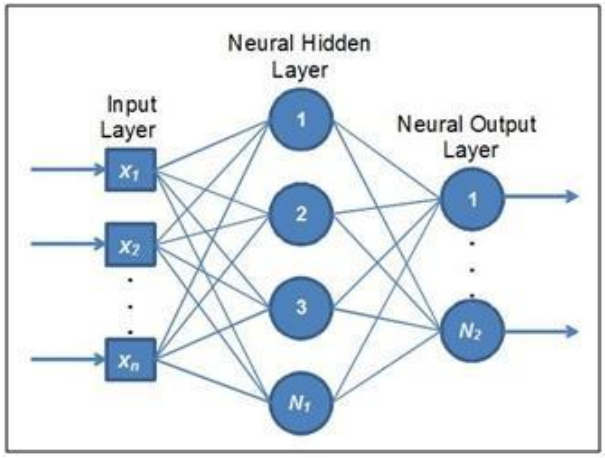

Fig.1.Structure of artificial neural network

The three-layer totally connected feed-forward neural network is mostly used for load Forecasting. It includes of associate degree input layer, one hidden layer associate degreed an output layer .Signal system is allowed solely from the input layer to the hidden layer and from the hidden layer to the output layer. Input variables return from historical knowledge, that ar date, hour of the day, past system load, temperature and wetness, comparable to the factors that have an effect on the load. The outputs ar the Forecasting results. the quantity of inputs, the quantity of hidden nodes, transfer functions, scaling schemes, and coaching ways have an effect on the Forecasting performance and thence should be chosen fastidiously. In applying a neural network to load Forecasting, the user should choose one design from variety of architectures (e.g. hopfield, back-propagation, Ludwig Boltzmann machine), the quantity and property of layers and components, use of bi-directional or uni-directional links and also the variety format (binary or continuous) to be employed by inputs and outputs.

VI. MATHEMATICAL MODEL OF A NEURON

A neuron is Associate in Nursing IP unit that's basic part for the operation of a synthetic neural network. The 3 basic parts of a synthetic neuron model are:

(a) a collection of weights.

(b) Associate in Nursing adder for summing the input signals.

(c) Activation perform for limiting the amplitude of the output of a neuron.

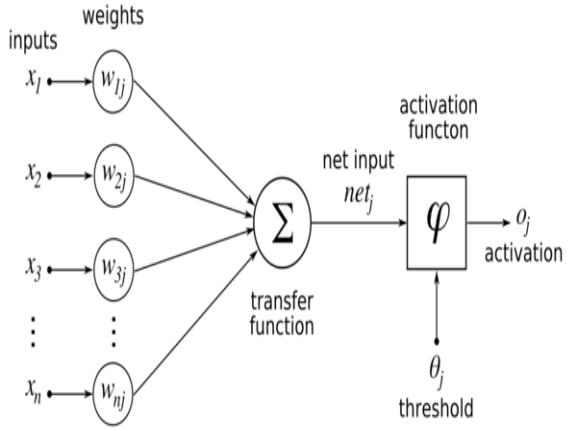

Fig.2.Mathematical model of an artificial neuron

FEED FORWARD BACK PROPAGATION (FFBP) NEURAL NETWORK

Feed forward back propagation neural network consists of input layer, hidden layer and output layer. in an exceedingly feed forward network, data forever moves in one direction and it ne'er goes backwards. Back-propagation learning formula is employed for coaching these networks. throughout coaching, calculations square measure meted out from input layer towards the output layer, and error values square measure fed back to the previous layer. the foremost fashionable artificial neural spec for load foretelling is back propagation. This network uses incessantly valued functions and supervised learning. below supervised learning, the particular numerical weights appointed to part inputs square measure determined by matching

historical knowledge (such as time and weather) to desired outputs (such as historical loads).

Feed forward networks have one or additional hidden layers of sigmoid neurons followed by associate degree output layer of linear neurons. Multiple layers of neurons with nonlinear transfer functions permit the network to find out nonlinear and linear relationships between input and output vectors. The linear output layer permits the network to provide values outside the vary –1 to +1. If the outputs of a neural network between zero and one square measure created, then the output layer ought to use a sigmoid transfer operate (tansig). The design of a feed forward back propagation neural network is shown within the figure three. the burden connecting node i within the input layer to node j within the hidden layer is denoted by Wji. the burden connecting node j to the output node is painted by Vj.

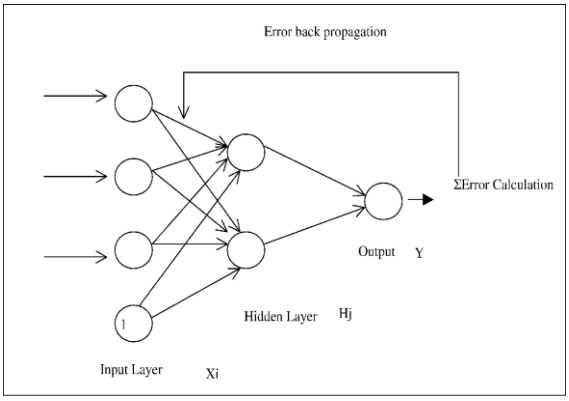

Fig.3.Architecture of a feed forward back propagation neural network

Feed forward back propagation may be a terribly helpful methodology for coaching multilayered feed forward networks. Back propagation may be used with any feed forward network that uses a activation operate that is differentiable. This spinoff operate is employed throughout coaching. to coach the neural network, a way should be determined to calculate the error. because the neural network is trained, the network is given with samples from the coaching set. The result obtained from the neural network is then compared with the anticipated result that\'s a part of the coaching set. The degree to that the output from the neural network differs from this anticipated output is termed the error. to coach the neural network, the user should try and minimize this error. to reduce the error, the vegetative cell association weights and thresholds should be changed. The user should outline a operate which will calculate the speed of error of the neural network. This error operate should be mathematically differentiable. as a result of the network uses a differentiable activation operate, the activations of the output neurons may be thought of as differentiable functions of the input, weights, and thresholds. If the error operate is additionally a differentiable operate, like the total of sq. error operate, the error operate itself may be a differentiable operate of those weights. this enables the user to judge the spinoff of the error victimization the weights. Then, victimization these derivatives, weights and thresholds may be evaluated, which will minimize the error operate. The flow diagram of back-propagation rule is shown within the figure

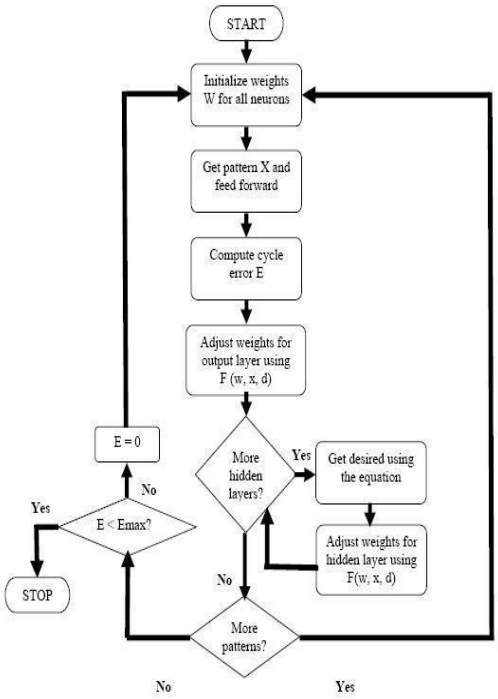

Fig.4.Flowchart of back-propagation algorithm

Recurrent Neural Network

A recurrent or perennial Neural Network (RNN) may be a category of neural network where connections between units kind a directed cycle. Unlike feed-forward neural networks, RNNs will use their internal memory to method impulsive sequences of inputs. A perennial neural network consists of a minimum of one feedback circuit. It may consist of one layer of somatic cells with every neuron feeding its output signal back to the inputs of all the opposite neurons.

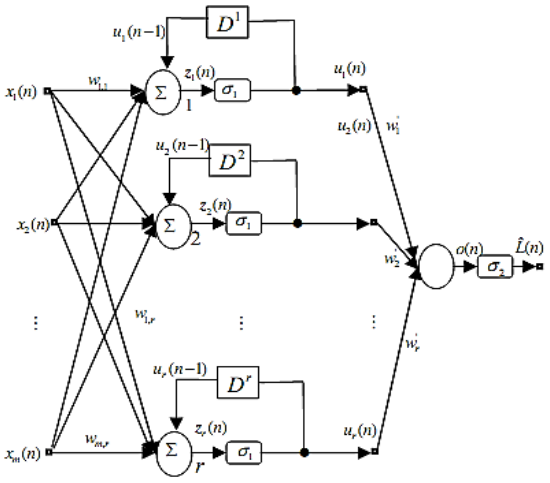

Fig.5.Elman recurrent neural network topology.

In this work, Elman's recurrent neural network has been chosen as the model structure that has shown to perform well in comparison to different recurrent architectures . Elman's network contains recurrent connections from the hidden neurons to a layer of context units consisting of unit delays that store the outputs of the hidden neurons for only once step, and so feed them back to the input layer. Figure is Elman's recurrent neural network wherever w denotes a vector of the junction weights, xand u area unit vectors of the inputs to the layers, m is that the range of input variables, and r is the range of neurons within the hidden layer. The weighted sums for the hidden and also the output layers are:

$$z_k(n) = \sum_{l=1}^{m} w_{l,k} x_l \quad + \quad w_{D^k} u_k \quad u(n-1) \qquad (1)$$

$$o(n) = \sum_{k=1}^{r} w_k^{'} u_k \qquad (2)$$

where,k = [1,r], n = [1,N], and N is that the range of information points used for coaching of the model. The outputs of the neurons within the hidden layer and output layer area unit computed by passing the weighted total of inputs through the tan sigmoid and pure linear transfer functions severally. Mathematically, the outputs of the hidden layer and also the output layer are often outlined as:

$$\sigma_1(z_k(n)) = 1/1+e^{-z_k(n)} = u_k(n) \qquad (3)$$

$$\sigma_2 o(n) = K\, o(n) = L(n) \qquad (4)$$

where,K may be a constant of the pure linear transfer perform. Another coaching parameter thought of is that the momentum issue as an effort to forestall the network to urge stuck in a very shallow local minimum. Equation (5) shows however the synoptic weights are adjusted and the way the network determines the worth of the increment on the premise of the previous worth of the increment

$$\Delta w(n) = \frac{\delta \epsilon(n)}{\delta_w} \quad + \quad \psi \Delta w(n) \qquad (5)$$

The other necessary coaching parameter is that the learning rate that controls the quantity of amendment obligatory on affiliation weights during coaching and to supply quicker convergence. Mathematically, the weights area unit updated mistreatment the equation:

$$w(n+1) = w(n) - \eta \Delta w(n) \qquad (6)$$

where, η is that the learning rate.

Features

Feed forward back propagation may be a terribly helpful methodology for coaching multilayered feed forward networks. Back propagation may be used with any feed forward network that uses a activation operate that is differentiable. This spinoff operate is employed throughout coaching. to coach the neural network, a way should be determined to calculate the error. because the neural network is trained, the network is given with samples from the coaching set. The result obtained from the neural network is then compared with the anticipated result that's a part of the coaching set. The degree to that the output from the neural network differs from this anticipated output is termed the error. to coach the neural network, the user should try and minimize this error. to reduce the error, the vegetative cell association weights and thresholds should be changed. The user should outline a operate which will calculate the speed of error of the neural network. This error operate should be mathematically differentiable. as a result of the network usesa differentiable activation operate, the activations of the output neurons may be thought of as differentiable functions of the input, weights, and thresholds. If the error operate is additionally a differentiable operate, like the total of sq. error operate, the error operate itself may be a differentiable operate of those weights. this enables the user to judge the spinoff of the error victimization the weights. Then, victimization these derivatives, weights and thresholds may be evaluated, which will minimize the error operate.

CONCLUSION

Several models for short load predictionwere studied during this work. once measurement of these approaches , we will observe a transparent trend toward new , stochastic , and dynamic prediction techniques . It appears plenty of current try is targeted on neural network techniques and it offers a brand new hope during this direction of analysis .This type of network will be very efficient in terms of predictingfuture hundreds.The data required for load forecasting of Chhattisgarh Electricity Board grid had been collected from "Chhattisgarh Load Dispatch Centre Danganiya Raipur" and proceeding the analysis of this research the next paper contains the result of the ANN based load forecasting of grid.

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