

Smart IOT based Short Term Forecasting of Power Generation Systems and Quality Improvement Using Resilient Back Propagation Neural Network

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Abstract

In modern times, the instant improvement of changeable energy generations especially as of wind and solar energy resources in the power grid led with these generations developing a significant resource of ambiguity with behavior of load however living being the major variable source. It is crucial for the economic scheduling in the generation and load balance of the generating units and in trades of electricity market. The forecasting of energy managed to alleviate several challenges to encounter which rises the resource uncertainty. Solar and wind power prediction is observing a intensifying interest from the community research and numerous investigations working on this topic are presented, but the conciseness and robustness of the existing models still need to be improved. Therefore, this work presents a Resilient Back Propagation Neural Network (RBPN) model to produce solar and wind power Short Term Forecasting (STF) and monitoring using Internet of Things (IoT).

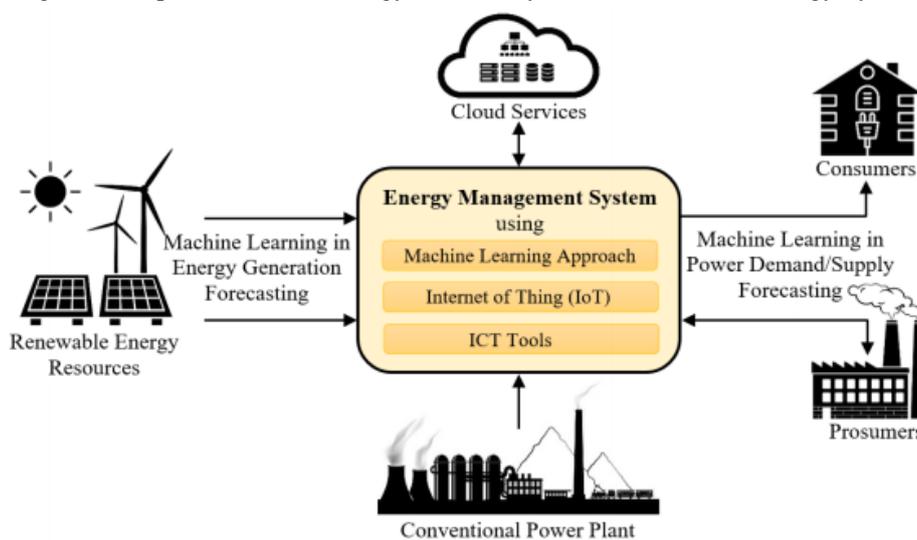
However, STF is very complex to handle due to the random and nonlinear characteristics of solar irradiance and wind speed under changeable weather conditions. But the proposed Resilient Back Propagation Neural Network (RBPN) is suitable for STF modeling and also the proposed forecasting system is directly connected to IEEE-9 bus to reduce Total Harmonics Distortion (THD) and also reduce the power quality issues in various conditions, such as voltage unbalance control, active and reactive power control. The performance of proposed forecasting system is validated through both hardware and simulation, the simulation is developed by using Matlab Simulink software. In the proposed system, the sensitivity analysis for varied variables and the model comparison with the aspect of proper selection incorporating the persistence and multiple linear regression models. Therefore, execution of the Internet of Things (IoT) in the supervising of solar PV and wind forecasting system was recommended and its implementation was analyzed. Suggested system comprised of data acquisition, data gateway, and smartphone application demonstration.

Key-words: IoT, Forecast, Power Quality, Back Propagation NN, Resilient BPNN, Wind Energy System, Power Generation, PV System.

1. Introduction

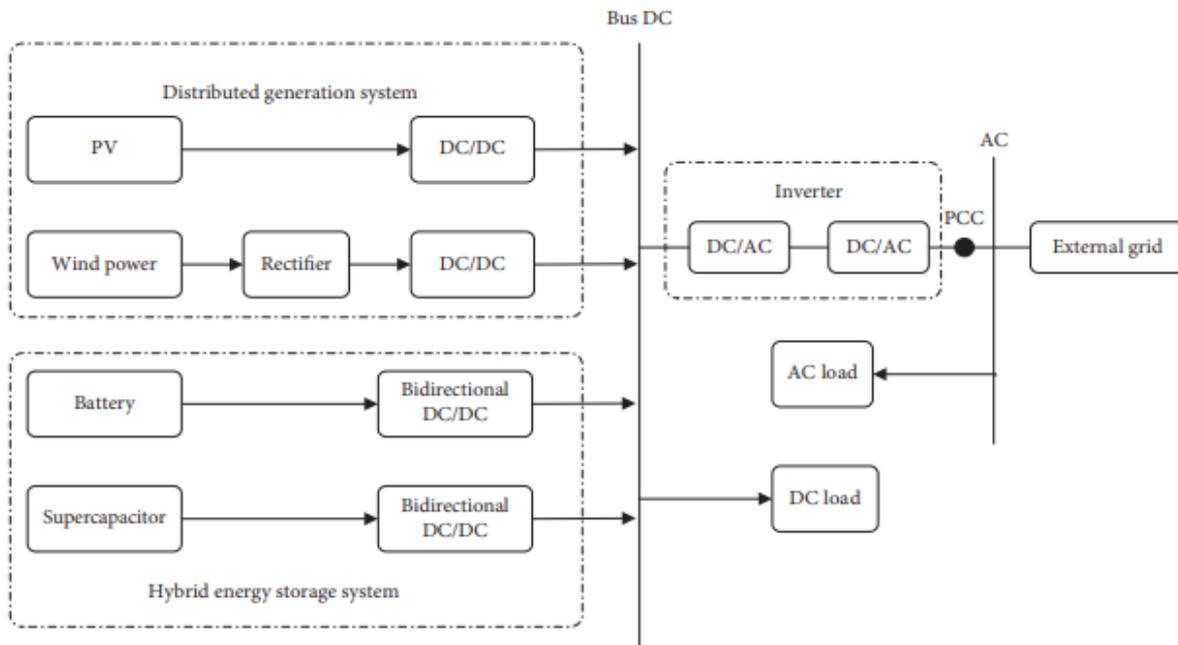
For predicting the future scenario, it is prominent to forecast the power and the quality of improvement for the better part in the system management towards the enhancement of effective energy supervision method in the crucial plan for the power system analysis. In the progressing lifetimes, various researchers surveyed on the concept behind developing the analysis for exact short-term forecast (STF) for its effectiveness in the influence of operations making the system reliable in the terms of performance factors of cost and lifetime. With the customer requirements attain the operation to be functions properly in support to the uninterruptable power supply. For instance, the operations of power system, in maintenance, scheduling, modification in the rates of tariff for evaluating the contract to be handled conveniently in forecasting the load into the achievement of accuracy. The decision for the making of policy in the accurate load forecasting made for the power and energy system to be based on the operating strategy, maintenance, and development. Valuable organizing of power systems will protect the count approximated to millions of dollars for its considerable responsibility in the commercial country development. With the existence of weather impact on the load demand with certain parameters such as humidity, temperature, pressure, dry bulb temperature, cloud cover, wind speed, and the human body mark will analyze the characteristics. Nevertheless, to accomplish forecasting outcomes with greater extent the factors for load demand in inputting the model of particular load data in the weather for obtaining the respective diagnosis. With the modernization in technology, the concept has been implemented for the precise forecasting applied to the renewable generation systems for influence to the storage capacity advancement.

Figure 1 - Sophisticated Technology with the Hybridized Renewable-energy System



In essence, the formation for the hybrid PV-wind based storage system depriving of the inverters, DC and AC bus, wind turbines, PV array, together associated to the generation of the power generation system to produce energy in which reached for the certain development of parameters. Generally, the hybrid systems normalize the produced power to guarantee the generated power in the hybrid system to offer stable power outcome form the grid and load. Due to the reason of unpredict and unsuitable case, the output of the power from the hybrid system in occurrence of fluctuation indiscriminately and irregularly. Consequently, contrasted in conjunction to the power resources in conventional aspect for certain applications of thermal, hydro dispatched to the grids in considerable for achieving the stable situation. Though extensive research is undergone for the energy storage system for the optimizing the energy storage in the performance of the grid-connected systems in optimizing the output produced. Furthermore, the crucial purposes for the short-term forecasting are explained as follows: a) Scheduling the power system generation, b) Power plants operating under reliable and secure conditions, c) Reliability and economic dispatch. The determination of the scheduled generation in the allocation of the resource generated for the limitations and operations with the constrained in the development utilized for the devices achieving the better accuracy. The production of minimum economic rate reached with the forecasting of power generation and quality in optimizing with certain FACT devices implementing the sending and receiving end of the power system with the computation of unit commitment concept. Additionally, the preparation of the information utilized with the actions of the load stated and the correlated parameters of the dispatch of the economical rate in reliability management with the associated fluctuations involved in the power system highly varied to the certain extent. For illustration, the underestimation of load demand for the power supply shortage in the system associated in the difficulty for the conditions linked in the overload of quality improvement in the overall making of policy in the accurate load forecasting made for the power and energy system to be based on the operating strategy, maintenance, and development. Valuable organizing of power systems will protect the count approximated to millions of dollars for its considerable responsibility in the commercial country development. With the existence of weather impact on the load demand with certain parameters such as humidity, temperature, pressure, dry bulb temperature assessment in the resources of the available generation in total economic investigation meant for the precision developed in producing the power system demand.

Figure 2 - Illustration of the Grid-connected HES Generation System

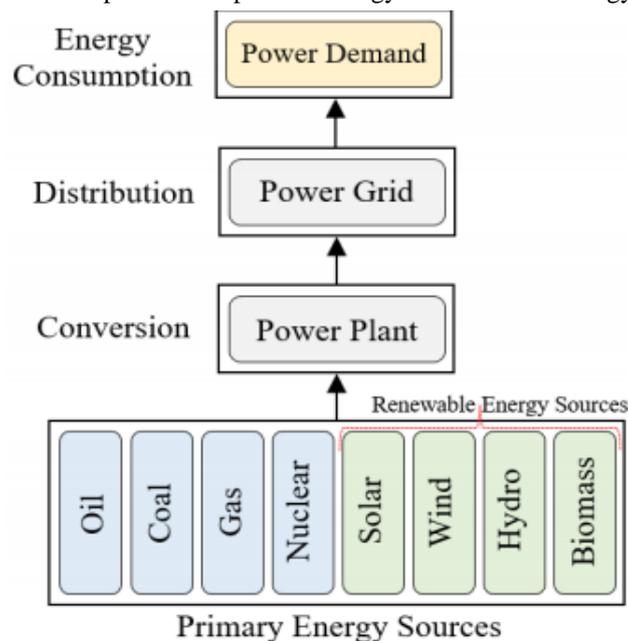


A Variety of methodologies employed for the models suitable in forecasting the power generated with the PV and wind-based storage systems. Corresponding with the models forecasting with the predicted power generation models subdivided with the statistical and physical models in the combination to the model developed with the PV system and wind-turbine system for associating to the possible management with the associated fluctuations involved in the power system highly varied to the certain extent. For illustration, the underestimation of load demand for the power supply shortage in the system associated in the difficulty for the conditions linked in the overload of quality improvement in the overall making of policy in the accurate load forecasting made for the power estimation of the data that has been meteorologically collected with respect to the temperature, solar irradiation, and wind speed etc., delivered with the power stations established. The methodology for the physical model so far obtained with the numerous quantities of data historically in complex to the accurate prediction in effect to the forecast made with the MPPT in the case of wind-turbine and the solar irradiation with the PV based system. Therefore, many methods integrated to the statistical approach has been applied to value for the PV generation predicted with the means of Markov Chain method, regression model, Neural network, Fuzzy logic, Genetic algorithm, Multivariate regression, Support vector machine, and particle swarm optimization etc., and the accuracy can be compared with all the methods available for prediction of the power quality and generation in a phase of different environmental conditions. Nonetheless, with the literature survey on the approach of forecasting the power generation with the smart IoT based method with the integration of artificial intelligence (AI)

calculation procedure based on NN and SVM achieves major forecasting advantages with the capability associated to the predicted models of nonlinear characteristics in the existence of intermittent output. Nevertheless, to accomplish forecasting outcomes with greater extent the factors for load demand in inputting the model of particular load data in the weather for obtaining the respective diagnosis. With the modernization in technology, the concept has been implemented for the precise forecasting applied to the renewable generation systems for influence on the storage capacity advancement.

Usually with the term “energy forecasting” associates with the methodology of predicting the generated energy with the means of various sources. The perception in the growing technology of the popular generated system in forecasting the approach of being produced in the hybrid technology for the highest performance in the context of bottom-up approach also called as build-up approach in the prediction quantity of the strategy in the levels of energy generated in the power plants at the terms of different inputs fed to the system in different load terms. In a hybrid system, it is evident that the technology is more meaningful in association to the exact consequential and appropriate value seeking for the individual components. The following figure depicts the procedure for the forecasted generated power in the process of build-up method.

Figure 3 - Build-up/ Bottom-up Methodology for Estimated Energy Granted



Owing to the parameters uncertainty in the machine learning based approach in developing the prediction in the irradiance of the solar system in the global assessment in the basis of monthly, hourly, or daily creation in the power generation. For the intermittence in the possible nonlinearity for the

forecast in the energy linked for the prediction of energy according to time-horizons. The practices of prediction are fluctuating with the statistical estimation for the time-series data in the analysis of the technique for later intermittent aspect built in the dynamic properties of methods.

2. Literature Survey

Cheddadi et.al 2020, IoT, minimal expense backhanded estimation technique required for the idea of conservative IoT with the cloud in checking the stations of PV towards creating the force of the constant investigation. Need to decrease information misfortune. Srivastava et.al 2018, IoT, Remote strategy Control (RPC), the significant benchmarks are moving among the PV just as wind energy. Future, such innovations of IoT are primarily utilized in downtown territories and roads to bring down limit utilization to secure the power delivered. R.Selvam et.al 2020, IoT, Fuzzy Logic, In this framework, the force from PV, Wind is gathered at normal DC transport and loads are taken care of with no interference. Energy the executives handles the impacts of sustainable power changes by working PV and wind. The required and created power data from PV and galaxies was used to control the general framework with fluffy rationale prevailing upon IoT. Need to decrease the exchanging misfortune. Winasis et al. 2018, IoT, Perturb and Observation strategy. Proposes an IoT-based framework for checking the electrical energy. The framework was fabricated comprising of segments of organization and web access, IoT worker parts and sensor hub segments. The framework that was made can be grown further to build up a dynamic and announcing framework even distantly control the framework. Pradip Barde 2018, IoT, Pyranometer for irradiance estimation strategy needs to execute for the procedure engaged with the IoT of the PV nearby planetary group in distant zones for working with the support and what's more identified with the gear for the examination of ongoing investigation. Kumar et al. 2020, Perturb and perception Algorithm suggested for the change frameworks of wind and PV to create with the relationship of converters in controlling the calculations to inspect the activity of crossover miniature networks. Zhu et al. 2020, Fuzzy double mode Control, fundamentally examined for the answer for explicit issue in the circulated power age framework in combination to the crossover energy stockpiling framework though burning-through the responsive energy to upgrade the stages in which the yield has intense improvement. Need to improve the general reaction. Khare et al. 2020, IoT, Decentralized steering convention. The reconciliation of a savvy matrix with sustainable power makes sustainable power all the more effectively. It additionally covers the part of IOT innovation in shrewd lattice for clean energy. Need to improve the security. Mani et al.

2017, IoT, Current Control Method, Developed an IoT-based framework where Fan and Bulb machines to begin with are controlled remotely dependent on dampness and light power information. This model framework created has accomplished energy preservation at each family. Inspecting rate and goal subtleties are not examined. Marinakis et al. 2018, IoT, information based dynamic calculation, Future could be utilized by the city specialists to screen and deal with the city's energy status in structures. Sampath kumar et al. 2019, IoT, Adaptive Neuro-Fuzzy Interfacing framework, This arrangement of IOT assumes an imperative part in following the PV based system and discover the current and voltage. The principle rules are exchanging between the two wellsprings of energy i.e. PV based and wind energy. The information is sent remote framework and controlling the wellsprings of energy. Need to improve the security. Kalaiarasi et al. 2016, IoT, Support Vector PWM. with moderate expense without harming the normal equilibrium. It could be extended to an innovation of perceiving other force age office later on. Putta Sindhuja et al. 2015, IoT, Kruskal's calculation, Internet of things diminishes the exertion of people by acquainting machine-with machine association. This work has been intended to carry out brilliant force checking and control framework through IoT utilizing cloud information stockpiling. Need to lessen the general energy utilization. Vibha et al. 2018, IoT, On-chip warm restricting control. Principally examines the checking of the arrangement of a coordinated breeze and PV based energy framework. This is accomplished utilizing the Internet of things. Wind and PV based energy have become mainstream alternatives for energy changes in the course of recent years. Need to improve the protection from electronic assaults. Ali et.al 2020, IoT. AI technique. From the survey of different strategies dependent on environmentally friendly power energy observing for the cloud/IoT climate, the few issues recognized identified with the proposed fill in as recorded underneath. PV based and wind energy expectation are trying as it relies upon the fluctuating PV powered radiations, wind speed and environment conditions.

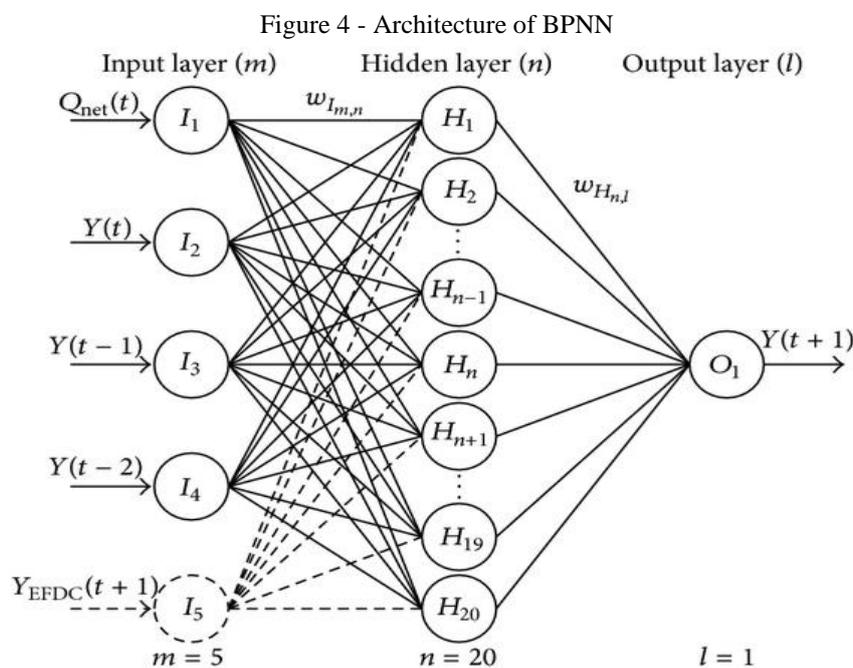
3. Various Techniques in Solving the Forecasting Issues

One of the methods involved in the neural network techniques is the back propagation neural network (BPNN) which is generally utilized in explaining the problems associated with the forecasting. Eventually, it reflects the kind of training methods integrated towards the ANN in conjunction to management. With the evident patterns composed with the pair of actions in the input and output side affixed with each network. While the network is viable for certain pattern developed with the minimal modification of the variations in the desired networks for the development caused with the patterns

designed in the architecture of the developed network deprived of certain layers such as input, hidden, and output layers. Several technologies associated with the neural network-based backpropagation technique chosen as easy implementation in handling the concerned issue of forecasting but maintaining the efficiency of network. The backpropagation deals with the data transferring from the preceding layer to the upcoming layer.

Resilient Backpropagation Network

Resultant of backpropagation method is Rprop algorithm. Based on effects on adjustable weights in the algorithm of backpropagation with the value of rate in the learning strategy resulted in the curve obtained by the slope with an error. There is trade-off between the learning rate and the learning approach. In which it is explained as the increase in learning rate with the value of weights at greater extent. Thus, the issue is ignored with the existing algorithm of Rprop. Making the utilization of the sign indicators whether positive or negative with the gradient approach of the adjustable weights in the size of the value and its path to the weight determined. The bias network for the weight's adjustment in the implementation of resilient algorithm processed with maximum iterations needed to target the local gradient value in attaining the information during the iteration. The error obtained is later minimized with the level of acceptance existed in the weights for updating of repeated value fed back with the layers to achieve the estimated outcomes.



In the updating of weight phase, each individual phase can be weighted towards the three layers in the process followed below: By multiplying the delta output behind the layers of input stimulation for the gradient approach of the factors weighted at the adjustable rate. Furthermore, with the addition of the gradient weights in the vitality of the updated weights in which the improvisation ignored with the existing algorithm of Rprop. Making the utilization of the sign indicators whether positive or negative with the gradient approach of the adjustable weights in the size of can be added to the updated occurrence to Δ_{jk} . The adjusted weights for the repair or replacement of hidden values in the development for the learning process in supervised approach of the error functioned in the rules associated which are formulated below.

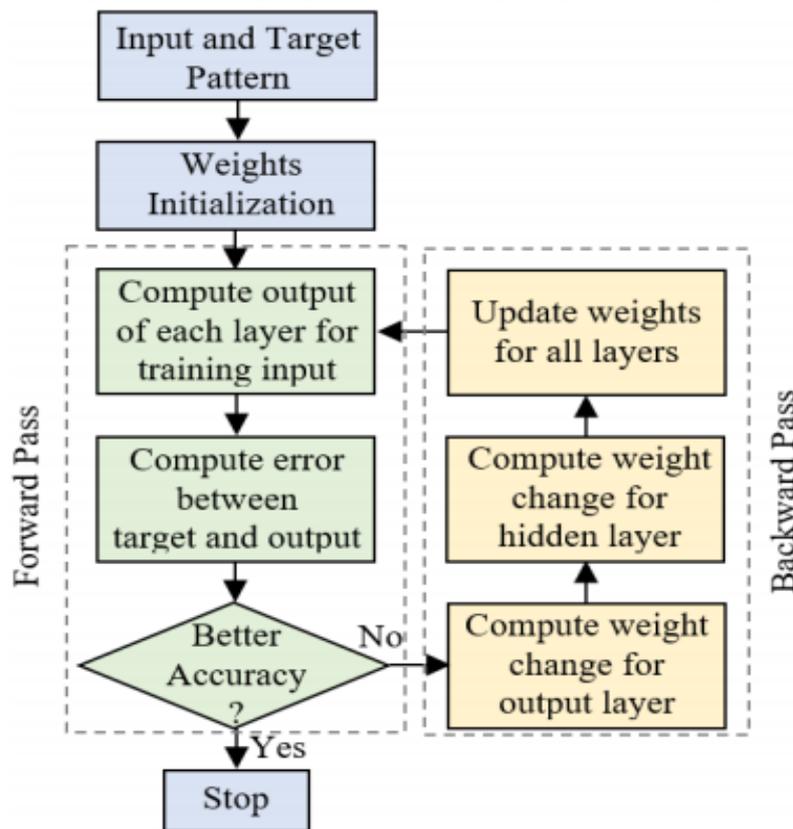
$$\Delta_{jk}(m) = \Delta_{jk}(m-1) * \eta^+, \text{ if } \frac{\partial E}{\partial w_{jk}}(m) \times \frac{\partial E}{\partial w_{jk}}(m-1) > 0$$

$$\Delta_{jk}(m) = \Delta_{jk}(m-1) * \eta^-, \text{ if } \frac{\partial E}{\partial w_{jk}}(m) \times \frac{\partial E}{\partial w_{jk}}(m-1) < 0$$

$$\Delta_{jk}(m) = \Delta_{jk}(m-1), \text{ for more}$$

$$\text{Where, } 0 < \eta^- < 1 < \eta^+,$$

Figure 5 - Training Algorithm for Back-propagation Technique



Moreover, the rules adapted for the weight differentiation in the iterations made successively for the enhancement of the algorithm in the local minimal range for the repair of the iteration made at the value of Δ_{jk} reduced within the constrained value of η^- . Accordingly, the sequential process in the iterations constantly raised for the zero obstinances in the updated value for the oscillated weight in the change of the weights in the accurate computation of weight in the trained output for the positive analysis in the rules associated in the same iteration values. The particular analysis with the adjusted weights are linked with repair values in the enhancement of formulation provides as equations ahead mentioned.

$$\Delta W_{jk}(m) = - \Delta_{jk}(m) \text{ jika } \frac{\partial E}{\partial w_{jk}}(m) > 0$$

$$\Delta W_{jk}(m) = + \Delta_{jk}(m) \text{ jika } \frac{\partial E}{\partial w_{jk}}(m) < 0$$

$$\Delta W_{jk}(m) = 0 \text{ for more}$$

$$W_{jk}(m+1) = w_{jk} + \Delta w_{jk}(m)$$

The weight associated among the neurons with the value of $W_{jk}(m)$ in the iterations made from two successive layers with the quantity of m iteration, $W_{jk}(m+1)$ correlated to the updated value.

Back-propagation set of guidelines is usually utilized by the gradient descent optimization set of rules to modify the fat of neurons thru calculating the gradient of dropping motive; Bp computes the gradient(s), despite the fact that (stochastic) gradient ancestry employs the gradients for guidance the product (thru optimization).

It is evident that principally the BP algorithm analyzed for the estimation process of weighted value in the components of the control action made by the power systems. Applied with the value weighted for active and reactive elements as (w_{aq} , w_{bq} and w_{cq}) and (w_{aq} , w_{bq} and w_{cq}) make use of the principle for the network of feed forward, back propagation, and supervised learning technique. The three phases associated to the input layers are equated as follows:

$$iL_{ap} = w_o + iL_{auap} + iL_{bubp} + iL_{cu} \quad (1)$$

$$iL_{bp} = w_o + iL_{bubp} + iL_{cucp} + iL_{auap} \quad (2)$$

$$iL_{cp} = w_o + iL_{cucp} + iL_{auap} + iL_{bub}$$

Where in w_o is the selected fee of the unique is weight and uap , and ucp .

Because this approach necessitates calculation of the error with the gradient function for the iteration value. To ensure the connection and differentiability of the featured error in the activation function relatively compared to the utilized characteristics of the discontinuity obtained. Nevertheless, the effort made in the computational techniques necessary for realizing the exact weights matching in

the enhancement of the weights in considerably achieved additional limitations and additional challenging network topology to be further considered in future development.

4. Conclusion

Targeted on outcomes, it's far mentioned that the IoT based forecasting would not take part inside the energy community in the course of regular operational, it simplest takes component whilst it senses operational disturbance from the touchy load, therefore it would not waste electric power needless and as an alternative it operates effectively. The article concentrates on the smart IoT based short term forecasting of power generation systems and quality improvement using resilient back propagation neural network model. However, STF is very complex to handle due to the random and nonlinear characteristics of solar irradiance and wind speed under changeable weather conditions. But the proposed Resilient Back Propagation Neural Network (RBPN) is suitable for STF modeling and also the proposed forecasting system is directly connected to IEEE-9 bus to reduce Total Harmonics Distortion (THD) and also reduce the power quality issues in various conditions, such as voltage unbalance control, active and reactive power control. The performance of proposed forecasting system is validated through both hardware and simulation, the simulation is developed by using Matlab Simulink software. Thus, the monitoring of power generation system with the smart IoT improves the performance and reliability factors with the proper assessment of the existing technology.

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