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Short-term Load Forecasting using Genetic Algorithm based Artificial Neural

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ABSTRACT. *The electrical load Forecasting is considered one of the main and important points for the planning for the future in the electric power networks in both of transmission and distribution systems. In this paper, the genetic optimization algorithm (GA) with the artificial intelligent network (ANN) methods are proposed to forecast the electrical load of the building of Electrical Power Distribution office in the Iraq /Anbar Governorate. Moreover, the optimization method of GA is presented to train the ANN weights using MATLAB software with simple programming code. Then, the proposed method is applied to the actual load and the results are compared with that obtained in traditional method such as ANN and regression trees (RG trees) methods. Hence, from the simulation results and the comparison, we can confirm that the proposed method is better than the traditional methods, and it achieved a good agreement with actual load and it provide a good total RMSE of 6% when compared with other methods*

Keywords: Genetic optimization algorithm, artificial intelligent network, electrical load Forecasting, regression trees.

1. Introduction. Recently, the trend towards smart methods for managing networks, transmission and distribution of electric power, as well as electric power plants, due to the observed results of modern smart grid methods and techniques [1]. These modern technologies have been resorted to for several reasons, the most important of which is to increase the stability of the system and the electrical network, as well as reduce the impact of electrical faults on the electrical network, increase the reliability of the electrical network, and ensure optimal generation of electrical energy, as well as ensuring that the current is delivered to the user in a more economical way to the distributed companies as well as to the consumer in terms of Reducing the cost of the electric bill to the consumer [2-5] .

However, the load Forecasting and the plan to increase and expand generation is considered one of the main and important points for successful and fruitful planning for the future of electric power transmission and distribution systems [6-10]. Also, load forecasting is also an important pillar in ensuring

a system capable of accommodating any sudden operational scenario that occurs in the electrical network. Modern economies depend mainly on electrical energy , Therefore, in addition to the trend in the previous years to develop methods for predicting loads, because they are of great importance in calculating the generation and consumption of electrical energy in the future, and that it leads to reducing the costs of generation, transmission and distribution, and increasing welfare, in addition to maintaining the balance of the energy transmission system and increasing the reliability of the system [11,12]. Therefore, the world has an urgent need to develop Load forecasting studies. In solar PV systems that is integrated to utility grid, the load forecasting is a complex process that requires a comprehensive and accurate analysis with direct and indirect factors affecting the process of generation. So, great challenges facing load forecasting techniques, the most important of which are the low-accuracy information that is entered into the forecast program as well as the weather information, which has a noticeable impact on the data. There are other factors that affect the forecasting process, such as energy consumption information for the previous day or a previous period, demographic data, devices in the area in which the forecast is being studied. The information on the previous loads is one of the most important factors in the prediction process as well as the prediction results. Actually, using the information of old loads, weather data and historical events closely related to the area, then a careful analysis of all the data collected is then tested and many [13-18]. However, through the study of some previous research, we found that there are several methods of forecasting loads used in order to predict the need for future energy. A review of several methods will be conducted according to the applications used. One of the most important classifications is those that depend mainly on the applications such as Short-term forecast (1 hour - 1 week), Medium-term forecast (up to 3 years), and Long-term forecast (10-20 years) [19].

However, for the long-term prediction, the determinants that affect the accuracy of the results in it have a clear and significant impact, such as accelerated changes in population, expansion of infrastructure, and the using of a new types of energy generators, such as solar and wind energy, and the results obtained are less accurate than those obtained from the short-term prediction because the factors that are included in the calculations are more difficult to predict. Among the techniques used to predict loads are Artificial Neural Network (ANN), Arima, and SVR. The Neural Network is considered the most used [19-21]. These methods are considered more efficient than other methods which forecasted the loads from week to week and from the beginning of the week to its end, but it needs a large number of data in order to have more accurate results.

2. Literature Review. In [22] the authors discussed the aim of forecasting the load which to reduce the errors and maintain the stability of the system and the researcher used the Meta learning method. The authors is interested in temporary events such as carnivals, celebrations and tournaments, which need electrical energy temporarily, as well as festivals that occur away from electrical energy networks. Also it discussed the cost of using the diesel to generate the electrical energy, and in this research, pre-event forecasting and real time forecasting was used, and the forecast was studied for a short period. In [23] the researchers mentioned that economic growth is closely related to the electricity infrastructure, and

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his study aims to find the best methods that work to estimate the future demand for electric energy. They mentioned that the interest in the topic of load forecasting was in two axes. Prediction algorithms used and their appropriate capacity in this field Theories and factors affecting electricity consumption. The researcher found that 90% of the models used to predict loads in recent years were based on artificial intelligence. In [24], the researcher used the temporal convolutional network (TCN) technology, which consists of One Dimensional Conventional Neural Network, to obtain short term forecasting.

X. Peng et al. [25] worked to develop a set of methods for predicting short-term loads. Through analysing the results and making a comparison between the improved prediction method and individual prediction methods, he found that the improved method is better than the individual in terms of prediction accuracy and the prediction effect is more ideal. In [26], the researchers conducted a prediction process to forecast wind, solar energy and loads combined, as well as a comparison with traditional prediction methods such as support vector machine (SVM). In [27] one of the energy storage methods is presented using load prediction as well as forecasting of renewable energy in relation to South Korea's tariff. The goal of this algorithm is to increase the customer's gain.

Authors in [28], proposed a new power load forecasting algorithm using Boolean weighted feature recursive algorithm also this paper analyses the advantages and disadvantages of various traditional load forecasting algorithms models, like GM, SVM, BP, NNM, CFM and ESM [29-32].

In [33-35] a short-term load prediction based on Neural Networks (ANN) adaption is presented using optimization such as (BSO), (GEO) and (EHO). So, the ANN is trained and the error rate is minimized. As a result, the researcher concluded that (NN) a two-layer is the best for predicting loads because it gives the most accurate results with a lower error rate.

In this research an electric load forecasting for a specific facility will be performed using GA based ANN for the solar PV system. Hence, the main aims of this paper to schedule their generation resources units by meet the maximum load- demand, to optimize the capacity and the size of the PV to reduce cost and make sure that the most economic units are used in this process, and to determine and calculate the maximum and minimum consumed load during a specific short period of time, this will lead to know the required number of PV solar panels and battery's power in the facility to supply it by electric energy. In this research, a short-term load forecasting was made for the loads of the building of the control and operations department building in the Iraqi Anbar Governorate. This building is an administrative department that contains various loads such as cooling and air conditioning devices, central computers and lighting, in addition to the control and monitoring devices, which include communications system, PLC devices, large screens and internet devices.

3. Load Forecasting Methods.

Regression Method.

The traditional Forecasting is one of the most important topics in planning the work of the electrical system in the future, establishing infrastructure and development trends [1-5]. It has become giving inaccurate results, so new methods have emerged whose results are more accurate than traditional methods. Therefore, these traditional methods must be added to other studies to obtain better results and with a lower error rate. Regression is one of the most methods used for load forecasting. It uses regression

method to model the relationship between power consumption and other factors such as customer categories and weather. It assumes the load in dependent variable and independent variables. It mathematical representation can be written as:

$$L(k) = L_h(k) + \sum \alpha_i A_i(k) + n(k) \quad (1)$$

where $L_n(k)$ is the nominal load at time k, α_i is the slow varying coefficient, $A_i(k)$ is the independent variable, $n(k)$ is the noise factor, h is the number of the hours in day which is generally 24. However, this method uses some parameters that can be determined from historical load data by suitable cross validation technique.

Multiple Regression Method

It commonly used in field of load forecasting which considered a modified regression method [12,13]. So, some factors should be inserted in original regression equation to obtain this method where the least square technique to multiply the regression analysis predication which can be expressed as [13]:

$$L(k) = V_{k\,\alpha_k}(k) + e_k \quad (2)$$

where $L_n(k)$ is the total load at time k, α_i is the slow varying coefficient, V_k is the vector of variables, e_k is the model's error at time k. The effect of the variables of polynomial can be selected from 1 to 5, therefore the linear dependency given the good results.

In addition, the regression trees model is the one of the most used forecasting load because it specify form of the relationship between the forecasted values and response [32]. As a result, the tree model is created and then after the leaves values to the forecasting input as same as in ANN.

Artificial Neural Network

In this work, the ANN method is used for load forecasting with optimal weights that training by using GA optimization as present in Fig.1. The ANN is consisted from many numbers units that are operated in parallel connection or in feeding forward with many layers. Also, ANN operates similar of nervous system which can be train and learn as the humans [29]. Moreover, the neuron of the ANN formed from the linear combination of single or multiple numerical inputs and a fixed input term [30,31] as reports in Fig.1. However, in load forecasting, the ANN can be works with feed-forward back propagation, feed-forward time delay, and layer recurrent layer recurrent network. So, every network has an advantage and disadvantage depends on the type of the used system [5]. Hence, the back propagation is most common network which is works with continuously valued functions and supervised learning.

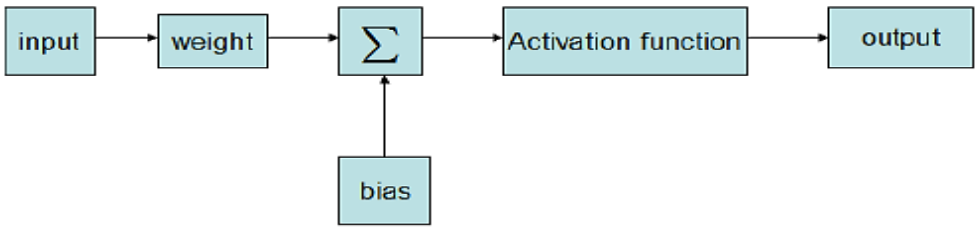

FIGURE 1: The ANN neuron model for back propagation algorithm [30].

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4. Proposed ANN-GA Method:

The worst errors in the ANN method can be minimized using optimization algorithm. In this paper, we proposed a GA algorithm to training the ANN and obtain the optimal weights for this technique. The flowchart of the GA algorithm used in this work can be seen as shown in Fig.2. As a results, the best performance of the ANN is achieved and the optimal load forecasting method is presented with minimum error between the actual and the forecasted load during fort-term (24h) load forecasting the code program of the GA-ANN in MATLAB/software is used and it can be shown in Appendix A. in order to calculate the error between the actual and forecasted load using root mean square error RMSE is used as defined in Eq. 3.

$$RMSE = \sqrt{\frac{1}{N} \times \sum_{k=1}^{N} \left(Y_k - \widehat{Y_k}\right)^2} \quad (3)$$

Where N is the number of samples (number of hours 24h for one day), Y_k is the actual load at time k, and $\widehat{Y_k}$ is the forecasted load at time k.

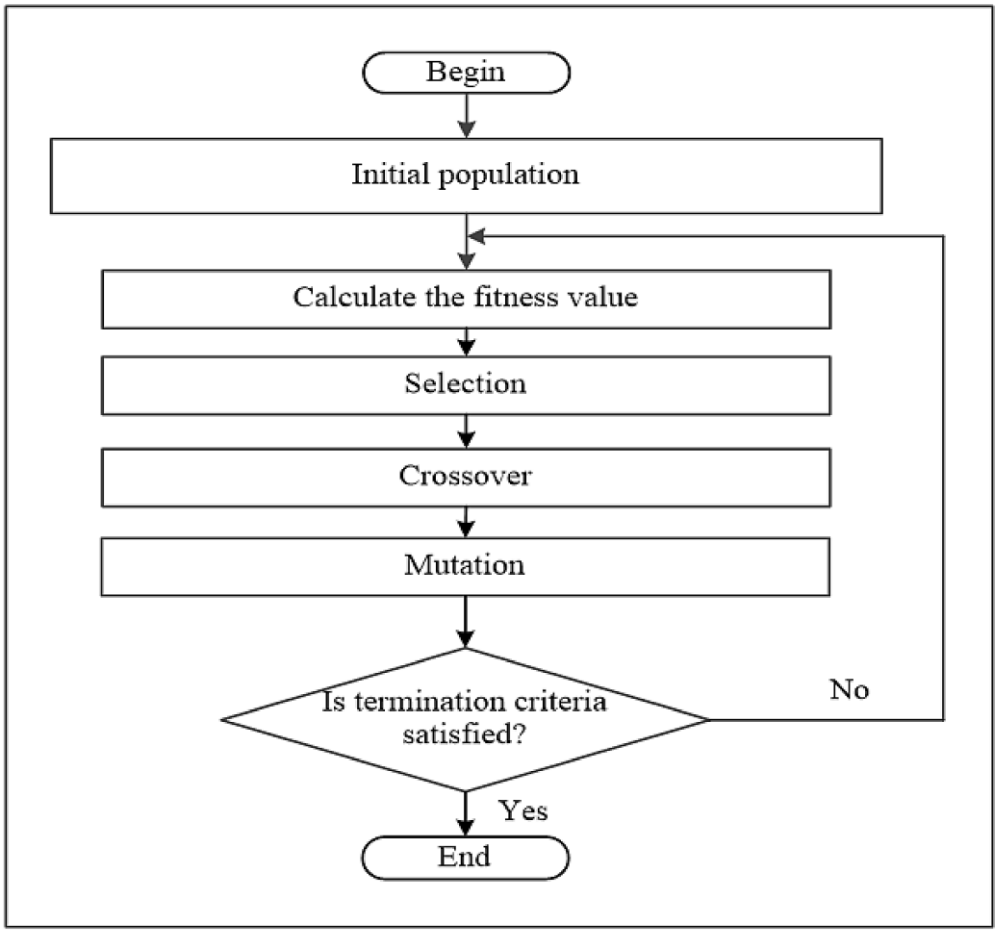

FIGURE 2: GA algorithm flowchart used in load forecasting

5. Simulation Results and discussion. In this paper, three LF methods are applied to predicate the load compared to the actual electrical load which are regression trees, ANN, and ANN-GA methods. The actual electrical load was obtained from the building of the Electric Power Distribution office in the Iraq / Anbar Governorate, this building is an administrative department that contains various loads such as cooling and air conditioning devices, central computers and lighting, in addition to the control and monitoring devices, which include a communications system, large screens and Internet devices .The previous actual load for short-term 24 hours at 1/7/2020 at summer season of Iraq is listed in Fig.3. as observed, peak load the electrical actual load vs time in hours for one day is occurred in 1:00 PM which is about 126.3704 kW. This value is represented the peak demand load at day after this point, the load demand is decreased because of the consumers is leaved the building after 2: PM and thus the supplied power from the PV system can be delivered to battery charging. Figure 4 shows the actual load profile that used in this paper.

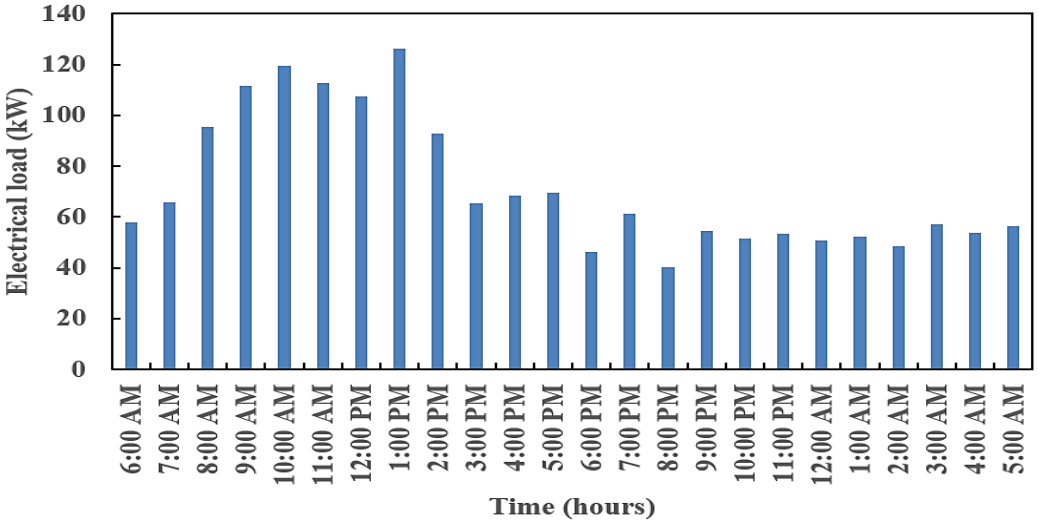

FIGURE 3: the actual electrical load vs time in hours.

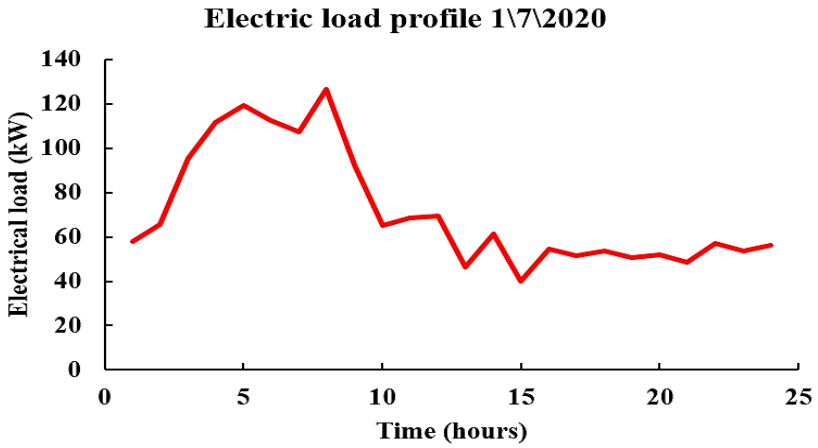

FIGURE 4: actual load profile for 24 hours.

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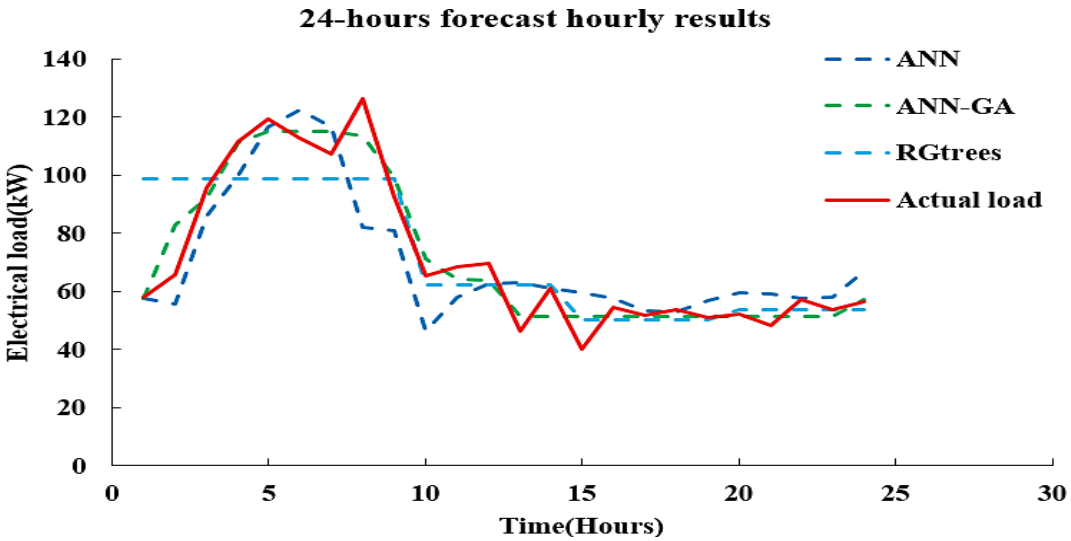

FIGURE 5: comparison between the load forecasting of RG trees, ANN, and ANN- GA methods.

As present in Figure 5 the actual load is forecasted using these methods to reach a small error between the actual and forecasted during one day for 24 hours. n order to verify the proposed work, the comparison between proposed method results and that obtained by other authors as shown in Table 1. As observed, the proposed work is provided a more accuracy in forecasting the load compare to the other techniques that implemented by [31, 32], where these methods generate large RMSE error. Therefore, the ANN-GA considered a simple method, higher efficiency in predication of load. As indicated here, there are a little error between the actual and forecasted load by proposed method where the prediction process trucks the actual load to enhance it as perfect. In addition, the proposed code of MATLAB software used in this method is presented in appendix. It very simple code, and the user can be used without any problem or complex procedure.

TABLE 1. Actual and forecasted load values for one day (24 h) using ANN, RG trees and proposed ANN-GA methods

Hour	Actual load (kW)	Forecasted load (kW)		
		RG trees	ANN	Proposed ANN-GA
1	57.81447	98.803	57.6461	57.77264
2	65.71262	98.803	55.7482	82.78563
3	95.62029	98.803	85.8963	92.12718
4	111.6272	98.803	100.0672	111.2567
5	119.3147	98.803	116.5454	114.9314
6	112.6803	98.803	122.4002	115.162
7	107.4149	98.803	116.6182	115.052
8	126.3704	98.803	82.1534	113.465
9	92.67165	98.803	48.723	99.0099

10	65.29139	62.1532	46.444	71.03132
11	68.45065	62.1532	57.8266	64.40178
12	69.50373	62.1532	62.806	63.81966
13	46.33582	62.1532	62.9835	51.30413
14	61.18435	62.1532	61.0788	51.30076
15	40.22792	50.1691	59.5022	51.30051
16	54.5499	50.1691	57.4669	51.30049
17	51.60126	50.1691	53.4018	51.30049
18	53.60212	50.1691	52.9373	51.30049
19	50.8641	50.1691	56.718	51.30049
20	52.1278	53.56	59.4309	51.30049
21	48.442	53.56	59.2103	51.30046
22	57.18262	53.56	57.7001	51.30006
23	53.70743	53.56	58.1253	51.30482
24	56.34015	53.56	66.8795	57.07461
		RMSE=17.6%	**RMSE=13%**	**RMSE=6%**

6. Conclusions

In this paper, a simple genetic optimization algorithm (GA) used for training the artificial intelligent network (ANN) is presented. First, the most load forecasting techniques that used recently are reviewed in this paper. Second, the optimization method of genetic algorithm is presented to train the ANN using Matlab software. The actual load data for the building of the Electric Power Distribution office in the Iraq / Anbar Governorate are given and the proposed method is applied to these actual load data with simple programming code. The results analysis provided a good accuracy with minimum RMSE. Also, to prove the proposed work, comparison between the proposed method and the other methods of ANN and RG trees is done. As can be seen form the results obtained in Table 1, the proposed method has achieved a good agreement with actual load and it provide a good total RMSE of 6% compared with other methods.

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Appendix: Genetic code in Matlab

Appendix. Genetic algorithm code in Matlab

```
%forecasting load PV system using ANN-GA
rng default
A=hour24';
B=load24';
%No. of hidden neurons
H=10;
net=feedforwardnet(H);
net.divideFcn='dividetrain'
net=configure(net,xp,xq);
view(net)
num_weig=net.numWeightElements;
wb=getwb(net);
fun=@(wb)nmse(wb,net,xp,xq);  %NMSE
opts=optimoptions('ga','PopulationSize',100,'Generations',1000,'TolFun',1e-8,'display','iter')
 [wbopt,fval]=ga(fun,num_weig,opts);
net=setwb(net,wbopt'); y=sim(net,xp);
function nmse_calc=nmse(wb,net,inputs,targets)
var_t=mean(var(targets,1,2));
net=setwb(net,wb'); y=net(inputs);
nmse_calc=mean((targets(:)-y(:)).^2)/var_t;
end
```