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Feature Selection Optimization Solar Insolation Prediction Using Artificial Neural Network: Perspective Bangladesh

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ABSTRACT: *This paper presents a new climatological feature selection model using artificial neural network by utilizing the real world data for Bangladesh, called as FSOSIP. In this analysis back propagation algorithm is applied. To facilitate the search strategy FSOSIP model uses 12 different combinations of 10 climatological features and a series of experiments were done to select the best subset of relevant features. The monthly averaged data has been collected from Bangladesh Metrological Department for seven stations as Dhaka, Barisal, Chittagong, Khulna, Rajshahi, Rangpur and Sylhet. The 1176 data between 2000-2013 are used to train the neural networks while the 365 data from 2014 are used to test the neural network. Experimental results show that the proposed FSOSIP model can select only two salient features easily with increasing the prediction accuracy which are relative humidity and maximum temperature. Furthermore, to prove the robustness of the model seven different models for seven stations of BMD are used and the results are then being averaged. Minimum MSE (0.000173%) and MAPE (0.0868%) shows the higher efficiency to predict the solar insolation. In addition, the proposed model exhibit better performance with feature selection strategy than any other model used up to now in Bangladesh.*

Keywords: *Artificial Neural Network, Feature Selection, Solar Insolation, Prediction.*

I. INTRODUCTION

Fossil fuels are a controversial subject and they simultaneously pollute our environment and make the existence at danger for all species in earth. Also due to the scarcity of fossil fuels and high cost, renewable energy comes into limelight. The renewable energies are solar, ocean, tidal, wind and hydro. Among these sources at the point of reliability the solar energy get most priority which is seen in present grid system and self-contain power systems which used in cooking, drying, heating, illumination at home and road. The fossil fuel has been extracted from earth reserve is less than ten times of solar energy receives each year [4]. Optimum use of solar energy requires the information of availability of solar insolation at precise region. Solar insolation is the most important parameter for solar energy generation in desired limit. In Bangladesh maximum time of the year is endowed with ample sunshine. Since solar insolation varies time to time in certain place, so it requires information of solar insolation. In present world pyranometer is used to measure solar insolation. But due to high cost and scarcity of skilled personnel pyranometer is not available throughout the world. So empirical methods are used in different countries to predict solar insolation. But these empirical methods have some limitations. So at present ANN is used as an alternative method to predict solar insolation with higher accuracy and cost effective manner.

Rehman and Mohandes [5] estimated daily global solar radiation for Abha city in Saudi Arabia by taking air temperature, number of day and relative humidity as inputs to neural networks. The results obtained indicate that the mean absolute percentage error(MAPE) is 4.9%.Yadav and Chandel [6] predicted the solar radiation for Indian stations by taking latitude ,longitude, Height above sea level as inputs to the neural network. For Mumbai MSE and MAPE were 0.24% and 27.83%.

The remainder of this paper is organized as follows, the ANN are discussed in Section 2. The details of FSOSIP are discussed in Section 4. Experimental results are reported in Section 5.

II. ARTIFICIAL NEURAL NETWORK

Artificial neural network (ANN) provides a computational efficient way of determining an empirical , possibly nonlinear relationship between a number of inputs and one or more outputs. According to Haykin [11], a neural network is a massively parallel-distributed processor that has the capability for storing experimental knowledge and making it available for use. ANN has been applied for modeling, identification, optimization, prediction, forecasting, and control of complex systems. Artificial neural network are computers whose architecture model after the brain. The behavior of artificial neural network is that it mimic the way of learning human brain. They typically consists of many hundreds of simple processing units which are wired together in a hidden layer & also to the output layer. Each unit are node is a simplified model of a real neuron which fires signal from the other nodes to which it is connected. The strength (weight) of this connection's may be varied in order for the network to perform different tasks corresponding to different patterns of node firing activity. The propose model works on multilayer feed forward back propagation neural networks method. This algorithm is a supervised iterative training method that update the weights and bias values. And trial and error method was used to select the number of hidden neurons. Fortunately, the proposed model required only 3 hidden neurons in the hidden layer yielded the best results with reduced computational complexity. The flowchart of the ANN training is shown in Fig.1.

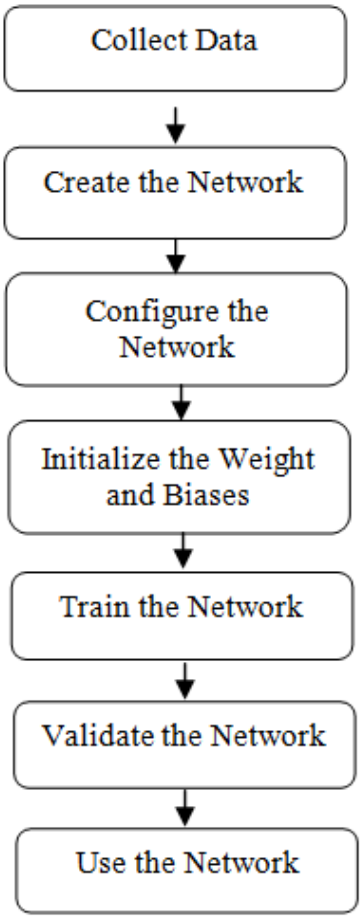


Fig: 1 Flowchart

III. DATA SET PREPARATION

In this paper seven stations of Bangladesh Meteorological Department (BMD) as Dhaka, Chittagong, Rajshahi, Rangpur, Barisal, Sylhet and, Khulna are selected. The geographical locations of these stations are shown in Table 1. The meteorological features are longitude, altitude, latitude, relative humidity, maximum temperature, cloudiness index, elevation, month of the year and sunshine duration were used as input data, while the solar insolation was the only output of ANN.

The data set was divided into three sets. First, a feed forward ANN has been trained to predict solar insolation based on 10 different climatological features of that features. The 1176 data during 2000-2013 were used for training purpose. On the other hand, the 265 data from the year 2014 were used for testing the performance. To validate the network last 200 data from training set were used.

Table.1. Geographical locations of seven stations in Bangladesh

Stations	Latitude(°N)	Longitude(°E)	Height above sea level(m)
Dhaka	23.78	90.38	8.45
Chittagong	22.35	91.82	33.20
Rajshahi	24.37	88.7	19.50
Rangpur	25.73	89.27	32.61
Barisal	22.72	90.37	2.10
Sylhet	24.9	91.88	33.53
Khulna	22.78	89.53	2.10

IV. FSOSIP MODEL

According to the afore-mentioned proposed models for predicting the solar insolation, it has been observed that, NN-based models cannot perform well in predicting the solar insolation using all the available features. The reason is that, the performance of NN always degrades if some irrelevant features exist in the available feature set. Therefore, selecting those irrelevant features from the original set is a crucial task in the NN-based SIP process. In this regard, Feature selection strategy is very important to increase the prediction capability of ANN. So, in this paper, there has been proposed a new model FSOSIP to select the relevant features to optimize the ANN prediction ability.

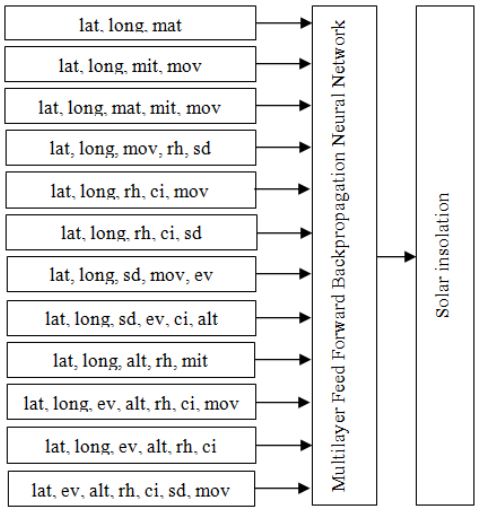
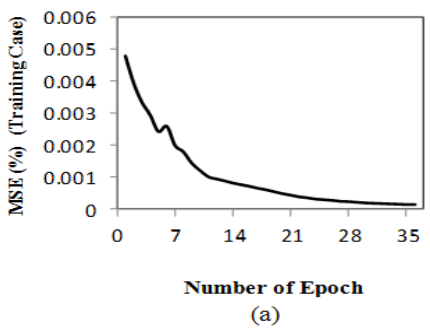


Fig: 2 FSOSIP model

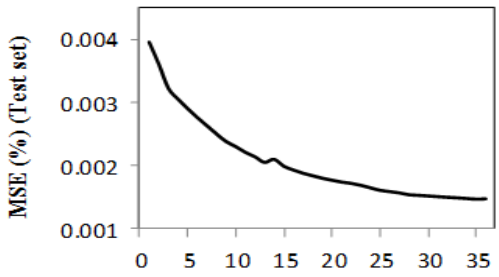
Fig. 2 shows the FSOSIP model with 12 different combinations of features which are commonly used by the researchers in solar insolation prediction purpose. Series of experiments were done with different feature sets to find out relevant features. To strengthen the prediction ability there has been developed seven different FSOSIP models for seven stations of BMD and their results are than being averaged.

V. RESULT AND DISCUSSION

FSOSIP shows better performance with only 3 hidden neurons in hidden layer of ANN structure when the network is trained up by the relative humidity and maximum temperature parameters. The performance of the neural network model is measured using MSE and MAPE.



(a)



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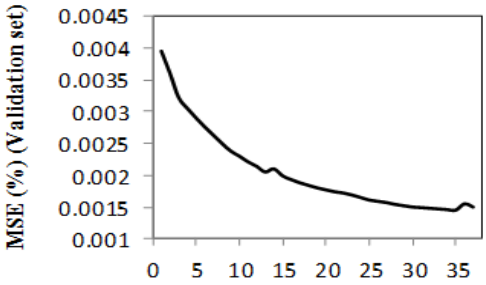

(c)

Fig. 3: Training process for evaluating the best features

Table 2 shows the MSE and MAPE results for seven FSOSIP models of seven BMD stations. It is clearly seen from table 2 that FSOSIP model exhibit minimum error for all stations with relative humidity and maximum temperature parameters.

FSOSIP uses a constructive ANN model that evaluates the best subset of features. As training process progresses, the training error for the training set converges to a certain limit up to 35 epochs (Fig. 3(a)).

However, at 35 epochs training is terminated because at this instant validation error increases due to over training (Fig. 3(c)). At the termination epoch it is observed that the training and testing errors are 0.000149% and 0.001476% respectively for Dhaka region for the input parameters are relative humidity and maximum temperature.

Table 2.Error values analysis of ANN during training

Features	Stations	MAPE(%)	MSE(%)(training)
Relative Humidity Maximum Temperature	Dhaka	0.07	0.000149
	Chittagong	0.085	0.000162
	Rajshahi	0.0836	0.000157
	Rangpur	0.11	0.000230
	Barisal	0.095	0.000177
	Sylhet	0.075	0.000152
	Khulna	0.089	0.000186

Table 3: Average result for seven stations of BMD

Optimized Features	Avg. MAPE (%)	Avg. MSE (%)
Relative Humidity and Maximum Temperature	0.0868	0.000173

To verify the strength to predict solar insolation results are being averaged of seven stations, shown in table 3. It is clear from the average results of MAPE and MSE that the FSOSIP model has a powerful capability for providing high quality solution. Moreover, Fig. 4 depicted that the actual and predicted values are highly correlated and error is minimum.

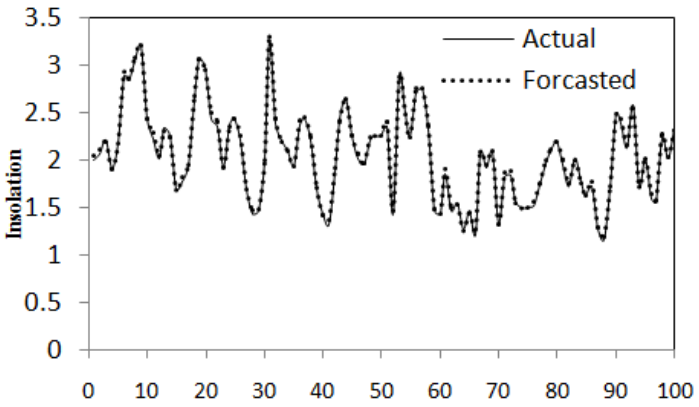

Fig. 4 Prediction curve for Dhaka region

VI. CONCLUSION

This paper presents the outcome of an attempt made to select the best features. This is important because relevant features to enhance the prediction ability of ANN. Data for seven stations in Bangladesh between 2000 and 2013 were used for training a feed forward ANN using back propagation algorithm. Data for 12 months in the year 2014 were used to test performance of the ANN system. Obtained results show that the relative humidity along with maximum temperature outperforms the other subsets of features with mean absolute percentage error of 0.07%. From this new analysis it is concluded that the maximum temperature and relative humidity are the best climatological features to predict the solar insolation with minimum error and higher accuracy.

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