PERFORMANCE EVALUATION OF SHORT TERM SOLAR POWER FORECASTING SYSTEM USING WAVELET AND ANN

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Abstract
The objective of this research is to create a dependable solar power forecasting system that can decrease the errors that come with estimating distant generation under a variety of weather conditions. The wavelet transform (WT) is applied to solar parameters of 20KW capacity namely panel temperature, sun energy, power and solar irradiance using four different wavelets namely Daubechies, Haar, Coiflet and Biorthogonal. Further, data is decomposed from different wavelets producing approximate and detailed coefficients for each parameter. These coefficients values are fed to ANN for forecasting the power. In this study, results are demonstrated with actual and forecasted values showing the error. Also, shows that daubechies is the better mother wavelet compared to other wavelets for power forecasting. The demonstrated are statistical compared with performance metrics in terms of MSE, RMSE, and R.

Keywords: Artificial Neural Network (ANN), Mean square error (MSE), renewable energy, Root mean square error (RMSE), Regression (R), solar power, Time series, wavelet transform.

I. INTRODUCTION

Energy demands in terms of comfort and consumption have risen as the world has increased as the globe has progressed, in order to meet both financial and personal demands. As a result of global climate change and carbon emission limitations, there is a growing movement to build renewable power grids and energy networks [1]. Renewable energy is a clean, steady, cost-effective, and long-term resource that will increasingly be utilized to replace renewable energy sources in the future years [2]. For example, as energy conversion efficiency has improved, the cost of generating power from solar panels has fallen substantially. The levelized cost of energy [3] for large-scale PV panels fell by 73 percent between 2010 and 2017. PV panels have emerged as a potential renewable energy source due to their simplicity of processing and increased efficiency [4]. In academia [5], time series analysis using machine learning is a popular issue. Machine learning techniques are commonly used for short-term solar forecasting [6], which is in direct conflict with renewable energy deployment and power system scheduling. This work contributes to such a hybrid solar power forecasting model namely WT-ANN via the use of wavelet decomposition, the original time series is divided into approximate and detailed sections and another work is to assess the impact of the approximate and detail components of the WT-ANN comparing the original and predicted outcomes with and without the elements of time series. In contrast for a proper assessment analysis all of the observed predictions were contrasted to the consistency proposed framework.
II. LITERATURE REVIEW

The wavelet transform (WT) is used with ANN and SARIMA models in this approach. According to the study, comparing statistical output measures in terms of MAPE and RMSE demonstrated the suggested models' reliability by [7] Gaizen soufiane.

According to Xu-Li, Qiao [8], photovoltaic (PV) power plants’ grid connections are heavily dependent on power predictions. Power forecasting methods based on linear or time series models are no longer reliable. The findings support the effectiveness of the method outlined in.

Luca Massidda and Marino Marrocu’s [9] proposed technique (WT–ANN) significantly outperformed the conventional ANN method. They created a method that combines artificial neural networks (ANN) with wavelet decomposition to produce worldwide horizontal solar radiation predictions for the near term (WD). The suggested method (WD-ANN) enhanced the results considerably.

III. MATERIALS AND METHODOLOGY

This framework first proposes GNITS college data from the Administration block of a 100-kilowatt power plant, from which we have taken one 20-kilowatt unit. Solar irradiation, and power are the few input factors used in historical data to illustrate the efficiency of hourly forecast.
3.1 WAVELET TRANSFORM

Solar irradiance time series comprises a range of fluctuations, bursts, and non-stationaries. The WT may be regarded of as a filtering procedure for separating such spikes. A forecasting system's prediction efficiency will be boosted by the quality of the training dataset, which will increase forecast accuracy [10].

As a consequence, this transformation may be used to enhance forecasting and minimise forecasting error. Historical PV output data is processed using the wavelet transform (WT) method. Continuous wavelets (CWT) and discrete wavelets (DWT) are two types of WT. The following is a definition of the CWT [11]:

\[ \text{CWT} x(\alpha, b) = \frac{1}{|\alpha|} \int \psi \ast (t)x(t)dt, \alpha > 0 \]

\[ \psi(t) = \frac{1}{|\alpha|} \psi \left( \frac{t - b}{\alpha} \right), \alpha > 0, -\infty < b < +\infty \]

The high and low frequency components of a signal give detailed and non-detailed information about it. By discretizing the mother signal and interpreting it as follows, the DWT may be performed [11].

\[ \text{DWT} x(m, n) = 2^{-(m/2)}T^{-1} \sum x(t) \psi \left( \frac{t - n2^m}{2^m} \right) \text{ at } t = 0 \]

High and low pass filters are utilised to transform the original solar PV output into detailed and approximation components as shown in Fig’s 2 and 3 respectively.

![Fig 2. Decomposition of wavelets](http://www.gjstx-e.cn/)

![Fig 3. Historical data on solar electricity that has been decomposed](http://www.gjstx-e.cn/)
3.2 ARTIFICIAL NEURAL NETWORK (ANN)

The method is usually made up of a group of fictitious neurons that are linked together via numerical change capabilities. 'X' is the input vector, and 'f' is the non-direct capacity, also known as the enactment work. 'W' refers to the weight lattice that connects the neuron's information layer to the covered up layer, and then connects the covered up layer to the yield layer.

ANN has been used to tackle a number of problems in power systems [12]. The popularity of ANNs stems from their ability to learn from prior experiences and resemble natural intelligence [13]. A human brain [14] is made up of basic processing components known as neurons.

To compute the quantity of hidden layers, one step forward forecasting is utilised to forecast RMSE and MSE. In this work, Levenberg-Marquardt algorithm is used to increase network learning with 70% training and 30% testing the data. The neural network with sigmoid hidden neurons (8) and linear output neuron as shown in Fig.4 respectively.

IV RESULTS AND DISCUSSION

The ANN model with WT is used to estimate future solar power from historical solar power time series. The MSE and RMSE are the output assessors for the suggested method. In this study, 80 percent of global data is utilized to fit the model, while the remaining data is used to evaluate the model. In addition, the performance of the hybrid wavelet-ANN prediction model was compared to that of the persistent reference model are as shown in Table I

<table>
<thead>
<tr>
<th>S no</th>
<th>Wavelets</th>
<th>parameters</th>
<th>RMSE</th>
<th>MSE</th>
<th>R</th>
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<td>1.3177</td>
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<td></td>
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<td>2</td>
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</table>
The Approximate and detailed components (CA3, CD1, CD2, CD3) of the RMSE, R and MSE are compared using daubechies wavelet. As a consequence, the outcomes are established in order to improve accuracy as shown in Fig 5(a) respectively. Approximate and detailed coefficients (CA3, CD1, CD2, and CD3) of the RMSE, R and MSE are compared using coiflet wavelet as shown in below Fig 5(b) respectively.

Fig 5(a) RMSE, MSE and R values using daubechies

Approximate and detailed coefficients (CA3, CD1, CD2, and CD3) of the RMSE, R and MSE are compared using coiflet wavelet as shown in below Fig 5(b) respectively.

Approximate coefficient (CA3) of actual and forecasted values using daubechies wavelet with ANN as shown in Fig 6(a) respectively,

Fig 6(a) &6(b) approximate coefficient (CA3) of original and forecasted power (db3) and (coif3)

The actual and forecasted values of approximate component using coiflet wavelet employed to ANN as shown in Fig 6(b). The actual and forecasted values of detailed coefficient (CD1) using daubechies wavelet fed to ANN as shown in below Fig 6(c) respectively,
Detailed coefficient (CD1) of actual and forecasted values using coiflet wavelet with ANN as shown in Fig 6(d) respectively.

Detailed coefficient (CD2) of actual and forecasted values using daubechies wavelet with ANN as shown in fig 6(e) respectively.

The actual and forecasted values of detailed coefficient (CD2) using coiflet wavelet which is fed to ANN as shown in below fig 6(f) respectively.

The actual and forecasted values of detailed coefficient (CD3) using daubechies wavelet which is fed to ANN as shown in Fig 6(g) respectively,
Detailed coefficient (CD3) of actual and forecasted values using coiflet wavelet with ANN as shown in Fig 6(h) respectively.

V. CONCLUSION

This study analyses a wavelet technique for forecasting solar power time series data using 20 kW capacity. Performance evaluation of actual and forecasted waveforms using wavelet fed to ANN is analysed by MATLAB software. Wavelet decomposition by minimizing errors concept, we observed their three level decomposition which is employed to ANN. RMSE, R and MSE using daubechies mother wavelet is better when compared to other wavelet coiflet wavelet. Performance analysis using different wavelets which is employed to ANN are observed and compared to the four mother wavelets of short term forecasting system (24hours).

References


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