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Review of Forecasters Application to Solar Irradiance Forecasting

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ABSTRACT

Solar irradiance forecasting is an ongoing research area, because of the improved and advanced utilization of renewable energy resource plenty of researchers have turned their attention to constitute intelligent solar irradiance forecasting tool. This paper provides the overview of the solar irradiance forecasting process, review the researches regard to solar irradiance forecasting and suggested future works to the forthcoming researchers.
Keywords: Intelligent, Renewable Energy, Forecasting, Solar Energy, Solar Irradiance

I. INTRODUCTION

The deployment of solar energy for electricity generation pursued to eliminate the environment hazards due to global warming, stabilize the concentration of GHG (greenhouse gas) and energy crises. Solar power forecasting is directly obtained by solar irradiance forecasting outcome with PV (photovoltaic) material and orientation. Solar irradiance is known as the rate at which solar electromagnetic flux acquired by a surface per unit area. The unit of solar irradiance is W/m^2 (watts per meter squared). The beforehand planning of future electricity power production from intermitted resources (solar, wind and etc.) is a tough and critical process compared to nonrenewable energy resource due to the meteorological effect to avoid this fact of solar irradiance forecasting is highly essential and significant concerning to solar energy system. General pictorial representation of the solar irradiance forecasting process is showcased in Fig. 1.

First, gather related information or data (cloud cover, precipitation of water content, sunshine hours, relative humidity, temperature, wind speed and etc.) to process the initial stage of solar irradiance forecasting after completion of data collection perform data preprocessing with the help most relevant methods from the available methods like data cleaning (example: resolve missing data issue (principle component analysis)), data transformation (example: normalization (min max)), data discretization (example: empirical mode decomposition, prediction intervals) and data integration (example: grouping (cluster)), followed by the data preprocessing a suitable forecaster is selected from the available forecasting methods like physical, statistical, innovative methods. Using the individual method alone is not sufficient to produce the better forecast, thus suitable optimization algorithm is adopted to build hybrid forecaster. At last the best forecasting of solar irradiance is obtained and qualified by error metrics like MAPE (mean average percentage error), MSE (mean square error), MRE (mean relative error) and RMSE (root mean square error). Complete available forecasting methods are depicted in Fig. 2, which convey the better perseverance concern to forecasting methods. With the help of investigation of historical data statistical methods are developed, similarly with the help of reconstruction of physical facts and historical data NWP methods are constructed. Persistence is standard method suitable for very short time scale forecasting. NWP (numerical weather prediction method) is suitable for long time scale forecasting. Statistical methods are suitable for medium;

short time scale forecasting and innovative methods are suitable for all time scale forecasting.

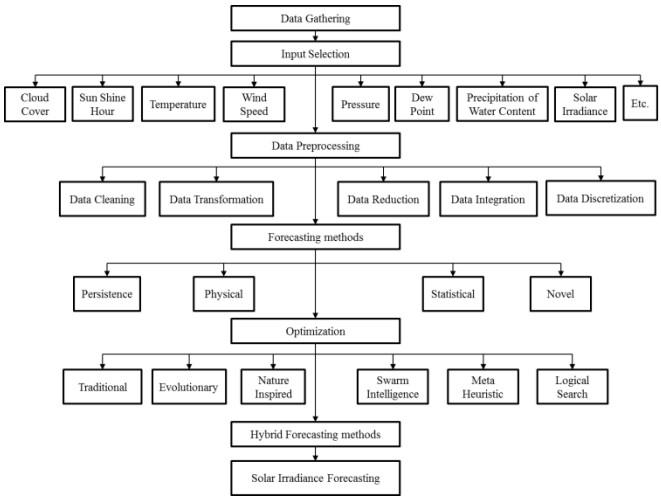

Figure 1. General pictorial overview of solar irradiance forecasting process

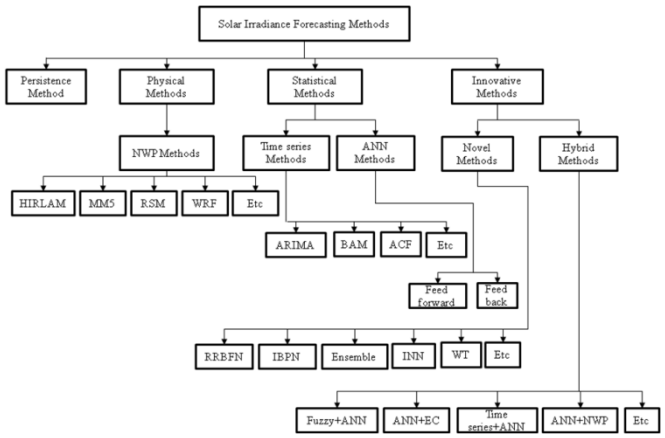

Figure 2. Common Solar irradiance forecasting Methods

II. EXISTING WORK REVIEW

Because of the meteorological parameter impacts, the photovoltaic system based power production possesses uncertainty. Thus, forecasting of solar irradiance is requisite due to the huge penetration of solar energy into electricity power production. In this connection plenty of research works performed in this area.

Madhiarasan and Deepa 2016 [1] implemented forecaster for wind speed and solar irradiance forecasting regards to various time horizons using deep neural network with new training strategy and the best framework of the proposed approach is identified. Remark: results the best forecasting outcomes with reduce number of iterations.

Madhiarasan and Deepa 2016 [2] attempt innovative neural network (INN) and proposed a novel deciding standard, which is used for the purpose of proposed innovative neural network required hidden neurons identification. A suggested model is utilized for the solar irradiance estimation.

Azimi et al. 2016 [3] established different time horizons forecasts of solar radiation by means of multilayer perceptron neural network wit association of transformation based K-means algorithm, the suggested algorithm overcomes the problem associated with k-means and clustering based techniques. Hence, the presented algorithm improves the forecasting on various runs and obtains constant results.

Federica Davò et al. 2016 [4] proposed solar irradiance and wind power forecasting based on a neural network, AnEn (analog ensemble technique) and principle component analysis (PCA). The forecast gridded data size is reduced by PCA. Hence, forecasting accuracy is improved.

Vishal Sharma et al. 2016 [5] developed Morelet wavelet and Mexican hat wavelet based mixed wavelet transform neural network (WNN) model to forecast solar irradiance in a short term time scale. The back propagation algorithm is used for training process of WNN; the result proves that comparison with ANN, ARIMA, ETS and persistence models, proposed model returns good performances.

Cornaro et al. 2015 [6] presented forecasting models using artificial neural networks (ANN) with the master optimization process, the proper ensemble and neuron numbers of ANN are obtained by the master optimization process. The result proves that the numerical weather prediction and statistical model achieve relatively same output, compared to persistence method 29 % of forecasting accuracy is betterment by model output statistic.

Ghayekhloo et al. 2015 [7] suggested short-term forecasting of solar radiation by means of BNN (Bayesian neural network) with GTSOM (game theoretic self organizing map), the mapping quality a learning ability are improved neural network neural gas

(NG) and Competitive Hebbian learning (CHL). DWT (discrete wavelet transforms) is used for solar radiation data decomposition and the number of clusters is determined with the help of elbow method. Pointed out approach perform well in comparison with K-means, SOM, NG and clustering methods.

Jianzhou Wang et al. 2015 [8] pointed out optimally prune extreme learning machine (OP-ELM) with a cuckoo search algorithm for solar radiation forecasting, the proposed model weight coefficient are properly determined by cuckoo search algorithm.

Silva et al. 2015 [9] performed solar irradiance forecasting in the short term horizon using a probabilistic model, compared to naïve bayes and linear regression based model probabilistic model performs well for fixed w=2.

Watetakarn and Premrudeepreechacharn 2015 [10] suggested back propagation incorporated artificial neural network for solar irradiance forecasting, which results in better accuracy for changing condition weather.

Farshid Yahyaei and Amin Hajizadeh 2014 [11] pointed out the hybrid prediction model based on ant colony optimization and multi layer perceptron network for solar irradiance prediction, the MLP network weights are optimized by ACO. The results show that compared to NN-ICA, NN-PSO and NN, the presented NN-ACO performs better with RMSE and MMAPE of 6.2 and 0.48 respectively.

Jiaming Li and John K Ward 2014 [12] suggested SVM (support vector machine) regression based forecasting algorithm for solar irradiance forecasting which results better performance for 5 minutes forecasting. Limitation: accuracy decay with increase of time horizons.

Kadirgama et al. 2014 [13] carried out work on an artificial neural network with quick propagation algorithm to estimate solar radiation in Pahang, during evaluation on testing station suggested achieve R^2 of 98.9% and mean absolute percentage error max of 7.74%.

Chatziagorakis and G. Ch. Sirakoulis 2014 [14] pointed out HYRES (hybrid renewable energy system) power management improvisation based on the prediction of solar radiation concerning to hourly and daily ranges using RNN (recurrent neural network).

Saad Saoud et al. 2014 [15] performed complex-value neural network based daily global solar irradiance prediction, the great Maghreb region data are utilized for validation.

Yang et al. 2013 [16] suggested SVM (support vector machine) with similar data based short term prediction model for solar radiation prediction.

Chen et al. 2013 [17] developed fuzzy and neural network incorporated forecasting model to forecast solar radiation, the result reveals that the compared to different methods such as statistical, fuzzy, neural network, the proposed method obtain 6.03- 9.65% of MAPE.

CHUA et al. 2012 [18] suggested multilayer perceptron (MLP) based 12 hour solar isolation forecasting, the back propagation algorithm adopts for MLP network training and trial and error method is used to select the best network model.

Amit Kumar Yadav and Chandel 2012 [19] performed solar radiation prediction using artificial neural network, ANN trained by Levenberg Marquardt (LM) algorithm and validated with 12 different Indian location data sets. The result shows that output is within the range of RMSE 0.0486-3.562.

Ibeh et al. 2012 [20] pointed out forecasting of global solar radiation by means of the multilayer perceptron network and the relation between temperature and solar radiation is studied.

Ricardo Marquez et al. 2011 [21] performed artificial neural network (ANN) based direct and global solar radiation forecasting, genetic algorithm incorporated Gamma test method adopt to select the appropriate input to the ANN. The result reveals that compared to reference method the suggested method based forecasting.

Salman Quaiyum et al. 2011 [22] developed endogenous and exogenous based solar radiation forecasting model and genetic algorithm used for cost

function minimization in order to assist PV system sizing.

Zhe Wang et al. 2011 [23] proposed a BP neural network based time series prediction model for short term solar irradiance prediction, the suggested prediction model on validation returns MABE (mean average bias error) of 0.0138, R^2 (Co efficient of determination) of 0.9912 and MPE (mean percentage error) of 0.7720.

Christophe Paoli et al. 2010 [24] pointed out multilayer perceptron network with a preprocessing technique based daily prediction model to predict global solar radiation, ad hoc time series used for preprocessing. Compared to the reference and conventional method, the presented approach obtains better forecasting accuracy with minimal error.

Chaouachi et al. 2009 [25] performed 24 hours ahead solar power forecasting with the help of MLPNN, RBFNN, RNN and neural network ensemble (NNE). Remark: compared to conventional neural network such as RNN, RBFNN, MLPNN, NNE obtains better forecasting accuracy.

Moreno-Munoz et al. 2008 [26] pointed out auto regressive moving average based solar radiation prediction in very short term horizons. Remarks: Suggested model assists in utility linked inverter and MPPT (maximum power point tracker) control operations.

Lo´pez et al. 2005 [27] proposed solar irradiance estimation model using multilayer perceptron network, the relevance input parameters are estimated with the help of automatic relevance determination method.

III. DISCUSSION

In universe, various countries focus on solar energy due to the following points:

- To solve the electricity requirements of rural area
- To fulfil the bridge gap between power generation and power demand related to energy crises.
- To safeguard the environment and non-renewable resources.
- To strengthen world economy and energy security.

Thus, an operation and management strategy regards solar energy system necessitate the solar irradiance forecasting. As a result in the past decades much forecasting methods are introduced to forecast the solar irradiance. The diversification of review with existing work of solar irradiance forecasting is carried out; from the review the following points are noted to improve the appropriate forecaster and scientific publication.

The forecasting methods which considered the parameters like cloud cover, sunshine hours, relative humidity, temperature, wind speed and so on as the inputs yield the best forecast thus seem to be a promising forecaster.

The deficiency related to traditional methods and statistical methods are overcome by hybrid and novel forecasting method. Hybrid forecaster is competent than individual based forecasters.

IV. CONCLUSION

Detailed diversified review has been performed with respect to solar irradiance forecasting, analyzed some of the on-going research of solar irradiance forecasting and recommend some of the future works to enhance the solar irradiance forecasting. This information is used to select the best renewable energy forecasting system. Recommendation of future works concern to efficacy improvisation, advances computing strength and processing speed, enrich reliability and sustainability regard to solar energy system. This review is used to the researchers update the recent researches in the area of solar irradiance forecasting. Thus, lead to focus on the novel concept to maximize the generalization.

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