Prediction model for day-ahead solar insolation using meteorological data for smart grid

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Abstract. In the overseas market, power generation and energy service companies have been engaged in the business of providing personalized trading services for the production of electric power through the Internet platform. This is, so that the electric power sharing system between individuals is being developed through the Internet platform. The prediction of insolation is essential for the prediction of power generation for photovoltaic systems. In this study, we present a prediction model for insolation from data observed at the Meteorological Administration. We also present basic data for the development of the insolation prediction model through meteorological parameters provided in future weather forecasts. The prediction model presented is for five years of observation of weather data in the Seoul area. The proposed model was trained by using the feed-forward neural networks, taking into account the daily climatic elements. To validate the reliability of the model, the root mean square error (RMSE), mean bias error (MBE), and mean absolute error (MAE) were used for estimation. The results of this study can be used to predict the solar power generation system and to provide basic information for trading generated output by photovoltaic systems.

1 Introduction

Currently, the paradigm shifts from methods of transferring power generated by constructing a large-scale power plant that was promoted in the past industrialization period through the ultra-high voltage power grid to a small-scale power generation using distributed power [1]. The application of smart grid is being actively promoted around the world. The smart grid will allow users to use the energy generated by renewable energy system or sell them on the market [2].

Photovoltaic systems are one of the renewable energy systems that have high applicability in urban areas. Numerous buildings are installing and using these types of systems [3]. For peer to peer energy trading, it is necessary to decide in advance whether to use or sell the produced energy through the photovoltaic systems [4]. The prediction of insolation is essential to predict the energy produced by the photovoltaic system [5].

In this study, the insolation predictive model was proposed using the weather conditions experienced the day before. In order to determine the range of data for an optimal prediction model, we evaluated the prediction accuracy according to the range of the prediction data.

2 Method

We collected the meteorological data for the past 5 years from Seoul, South Korea. We excluded the missing data and selected the available data. The summary of data and prediction model are listed on Table 1. The artificial neural network (ANN), known as multi-layer feed-forward neural network (MLF) was used for the estimation of total daily insolation using meteorological data such as maximum temperature (Tmax), minimum temperature (Tmin), humidity (RH), wind speed (WS), sunshine duration (SD), continued sunshine duration (CSD), precipitation (PR), and precipitation duration (PD). The MLF was implemented in MATLAB. The MLF consists of activation functions, bias and neurons. The data was divided into every other day for training and checking. The architecture of this model is shown in Fig.1.

Table 1. The summary of data and the prediction model.

| Data location | Seoul, South Korea |
|---------------|--------------------|
| Year of data  | 2013~2017          |
| Number of days for training and checking | 182, 541, and 901 days |
| Input variables | Tmax, Tmin, RH, WS, SD, CSD, PR, PD |
| Training method | Levenberg-Marquardt |
| Number of hidden layers | 1 ~ 5 |
| Number of hidden neurons | 15 ~ 25 |

In this research, several statistical indexes such as the root mean square error (RMSE), mean bias error (MBE), and mean absolute error (MAE). Equations used for computing the indexes are mentioned below (1) ~ (3).

\[ RMSE = \sqrt{\frac{1}{n} \sum (P-M)^2} \]  
\[ MBE = \frac{1}{n} \sum (P-M) \]  
\[ MAE = \frac{1}{n} \sum |P-M| \]
large error was reduced. Fig. 2 plotted the comparison predicted value with the measured value for only one year out of the predicted value. Following the seasonal accuracy analysis, it was found that there was a large error in the summer especially when the insolation variation was severe.

4 Conclusion

When the smart grid is activated, peer to peer energy trading will take place. A photovoltaic system requires production amount according to the solar insolation. Therefore, it is necessary to predict solar insolation according to weather conditions. This study presents a model for predicting the solar insolation of the next day with the weather conditions of the previous day. At least three years of data is required to predict the optimum values of insulation. Moreover, it is necessary to correct the seasonal insolation in order to increase the prediction accuracy.

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