Chapter 3
Large-Scale Renewable Energy Monitoring and Forecast Based on Intelligent Data Analysis

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ABSTRACT

Intelligent data analysis techniques such as data mining or statistical/machine learning algorithms are applied to diverse domains, including energy informatics. These techniques have been successfully employed in order to solve different problems within the energy domain, particularly forecasting problems such as renewable energy and energy consumption forecasts. This chapter elaborates the use of intelligent data analysis techniques for the facilitation of renewable energy monitoring and forecast. First, a review of the literature is presented on systems and forecasting approaches applied to the renewable energy domain. Next, a generic and large-scale renewable energy monitoring and forecast system based on intelligent data analysis is described. Finally, a genuine implementation of this system for wind energy is presented as a case study, together with its performance analysis results. This chapter stands as a significant reference for renewable energy informatics, considering the provided conceptual and applied system descriptions, heavily based on smart computing techniques.

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INTRODUCTION

Applications of intelligent data analysis methods such as machine learning algorithms are commonly observed in diverse domains including energy, health, education, and media. Considering the energy domain, such intelligent methods are used in order to improve energy forecast, management, planning, and optimization, among others. For instance, machine learning algorithms such as linear regression, artificial neural networks (ANNs), and support vector machines (SVMs) are known to perform well for tasks such as forecasting load or electricity consumption as well as renewable energy resources such as wind, solar, hydro, and wave energy (Ahmad et al., 2014; Mocanu et al., 2016).

In this chapter, we first describe a generic and large-scale renewable energy monitoring and forecast system which employs various intelligent data analysis techniques. Monitoring different renewable energy plants is achieved through deployment of meteorological sensors and power analyzers at these plants, and collecting data from them into a central database. On the other hand, forecasting renewable energy resources and electrical power generated from them is achieved by training several different machine learning algorithms on this database which also includes meteorological forecasts obtained from related meteorological services.

This generic system is realized for wind energy and the latest version of this large-scale wind power monitoring and forecast system is described as a case study. The system makes use of different machine learning algorithms to perform wind power forecasts required for operational and trading purposes. Wind energy is a ubiquitous renewable energy resource with limited disadvantages compared to other energy resources and hence its share in overall energy production is consistently increasing worldwide. High-performance wind energy forecasts are useful both for the operation of the overall electricity grid (by the transmission system operators) and for optimized trading of the produced energy (by the plant owners). The presented system is built within the course of Wind Power Monitoring and Forecast Center (Rüzgar Gücü İzleme ve Tahmin Merkezi (RİTM) in Turkish) project is developed for General Directorate of Renewable Energy of Turkey[1]. The system provides facilities for almost real-time monitoring of the wind power plants as it automatically collects high-resolution and synchronized energy production data from these plants. It also automatically collects mesoscale numerical weather predictions from international and national weather services, to be used by the wind power forecasting modules. The implemented system performs wind power forecasts employing singleton physical, statistical, and machine learning algorithms, as well as hybrid methods combining these algorithms. In addition to producing very short-term and short-term forecasts for each plant, the system is able to produce regional forecasts. The system performs both point forecasts and probabilistic (interval) forecasts. Descriptions and comparative evaluation results of the employed algorithms for all of these forecast types are provided. The operational system currently covers more than 150 wind power plants in Turkey with a total installed capacity of about 6.7 GW.

As the presented system for wind energy is an implementation of a generic one for renewable energy plants, the system can be extended to monitor and forecast the energy production of hydro-power and solar power plants by applying the existing implemented infrastructure for wind energy forecasting using singleton and combined machine learning algorithms. We provide discussions on this system extension for monitoring and forecast of different renewable energy resources. Other important directions of future work based on the presented intelligent system architecture are also provided at the end of the chapter.

Below listed are the main objectives of this chapter: