Chapter 11
Hybrid Neural Networks for Renewable Energy Forecasting:
Solar and Wind Energy Forecasting Using LSTM and RNN

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ABSTRACT

One of the key applications of AI algorithms in power sector involves forecasting of stochastic renewable energy sources. To manage the generation of electricity from solar or wind effectively, accurate forecasting models are imperative. In order to achieve this goal, a sophisticated hybrid neural network formulation is discussed here in this chapter. long-short-term memory and recurrent neural networks combination is formulated for very short-term forecasting of wind speed and solar radiation. In intervals of 15 and 30 minutes, time series forecasts are made that are ahead by multiple steps. For maximum energy harvest, both point wise and probabilistic forecasting approaches are combined. Historic data is collected for solar radiation, wind speed, temperature, and relative humidity, and are used to train the model. The proposed model is compared with convolutional and LSTM neural network models individually in terms of RMSE, MAPE, MAE, and correlation, and is identified to have better forecasting accuracy.

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INTRODUCTION

Increasing demand of electric power across the world and the issue of global warming are having a complimenting effect, pushing the power generation trend around the globe toward environment friendly energy resources. Besides, the sustainable development goals make it imperative to develop and extract energy form renewable resources, rather than relying on the non-renewable conventional kind, whose availability and affordability are going downhill, daily. Then again, there are issues like CDM (Clean Development Mechanism), climate change, insufficient and unreliable supply of power in developing countries etc., all advising the urgency of identifying alternate and nature-friendly sources of development.

Among all the alternate power production options, nested under renewable energy, wind & solar power are the most promising substitutes. These sources being economic, as well as, being available throughout the clock (wind) (Li, Wu, & Liu, 2018), minimal maintenance requirement and ease of installation (solar), have an upper hand above the other sources. As per (Hu & Chen, 2018), wind power is also one of the most cost-effective sources, that has a huge potential to compete with the traditional fossil fuel-based power plants and is eco-friendly too. These pros have provided a rapid boost to solar & wind-based power generation throughout the world, with a growth rate of 28% per year (Varanasi & Tripathi, 2016).

Background

Though a renewable source of energy, wind as well as solar, in opposition to hydro and biomass, has introduced a certain sense of uncertainty in the power production (Lu, 2019). Their variable nature reduces the suitability of the generator as a dispatchable source, and thus upset the stability of the power system (Boudour, 2016). This also affects the power quality of the sources, security of grid and market economics (Al-falahi, Jayasinghe, & Enshaei, 2017). This stochastic nature, which is absent in the conventional generators, necessitate the requirement of a new paradigm shift in the fields of power system modelling and analysis to control and operation. A review of models applied for solar and wind related forecasting are included here.

Though controlling this stochastic nature is not possible, forecasting these renewable sources in advance, shall enable us to efficiently manage and coordinate the generation of power from the wind farms. In other words, improve the dispatching capability of the renewable power sources, making them controllable (Lee, 2016) and finally, replacing the fossil fuel-based power generation completely. A proper forecast will also help in reducing the cost and increasing the revenue from the electricity market (Ummels, Gibescu, Pelgrum, Kling, & Brand, 2007). There are a lot of forecasting methods available for prediction that can be categorized into statistical (AR, MA, ARMA, ARIMA) (Cadenas & Rivera, 2010; Shukur & Lee, 2015) physical (NWP) (Lynch, OMahony, & Scully, 2014; Wang & Li, 2016) artificial intelligence (AI) (neural networks) (Kaur, Kumar, & Segal, 2016; Marugán, Márquez, Perez, & Ruiz-Hernández, 2018; Yadav, Singh, & Chaturvedi, 2017) and hybrid (combination of NNs or NN with other approaches) (Alencar, Affonso, Oliveira, & Filho, 2018; Doucoure, Agbossou, & Cardenas, 2016; He, Wang, & Lu, 2018; Li, Shi, Han, Duan, & Liu, 2019; Qu, Mao, Zhang, Zhang, & Li, 2019; Sun, Zhou, Liu, & He, 2019).

In (Shukur & Lee, 2015), a time series forecasting of solar irradiance for a day ahead using ARMA model is discussed. A wide variety of time series models for the hour ahead forecasting is discussed using moving average techniques, models based on exponential smoothing techniques, and ARMA mod-