A Method for Short-Term Wind Power Prediction With Multiple Observation Points

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***Abstract*—This paper presents a method to improve the short-term wind power prediction at a given turbine using information from numerical weather prediction and from multiple observation points, which correspond to the locations of nearby turbines at a particular wind farm site. The prediction of wind power is achieved in two stages; in the first stage wind speed is predicted using our proposed method. In the second stage, the wind speed to output power conversion is accomplished using power curve model. The proposed wind power prediction method is tested using real measurements and NWP data from one of the wind farm sites in Australia. The performance is compared with the persistence and Grey predictor model in terms of Mean Absolute Error and Root Mean Square Error.**

***Index Terms*—Adaptive filtering, networked systems, prediction, renewable energy, wind power.**

I. Introduction

WIND power is undergoing the fastest rate of growth of any form of electricity generation in the world. Wind power provides a clean and cheap opportunity for future power generation, and many countries have set the ambitious goals for wind power development [1]. As wind power technology has become mature, it can now be considered as a valuable supplement to conventional energy sources. However, the drawback is that wind is a highly fluctuating resource. The maximum penetration of wind power in electricity networks is limited by its intermittency. Due to this intermittent nature of wind and built-in uncertainty, the efficient and cost-effective integration of wind power into the electricity grid has become the greatest challenge.

However, this challenge is not insurmountable. An accurate prediction system can make it possible for grid operators to schedule the efficient and economic power generation in order to meet the demand of utility customers [2] and to absorb a large fraction of wind power in electrical systems. Accurate prediction of the wind turbine's power output is useful for generators, schedulers, transmission operators, network managers, and energy traders [3]. Short-term wind power prediction contributes to power system security and stability, and it reduces the reserve demand. It is an important tool for utilities to ensure a favorable trading performance on the electricity markets. The improved prediction ability allows dispatchers to optimize portfolios to generate higher revenues and decrease costs in various power markets [4]. Accurate and reliable predictions of power generation are of importance to electricity transmission and also essential to competitive renewable energy supply.

Our system for the prediction of wind power is based on measurements from multiple observation points. These measurements are transmitted over communication channels to our designed predictor. In fact, our system is an example of a networked state estimation system. Such systems have attracted a lot of attention in recent years; see, e.g., [5]–[7]. The multiple observation points in our case are the locations of nearby turbines. Our focus is to improve the wind prediction at a given turbine in a wind farm using measurements from nearby turbines and data from numerical weather prediction (NWP) at that wind farm.

In the earlier research, similar type of study was carried out for only one nearby data point, (see, e.g., [8], [9]). Reference [8] focused on wind direction prediction using one nearby observation point while [9] proposed a speed prediction model based on spatial correlation models in one of its sections using data from one long-distance site. However, our study is based on the data from multiple observation points (i.e., turbines) inside the wind farm, in particular the information from NWP. The objective of this study is to propose a complete wind power prediction system capable of predicting the wind speed, direction, and power simultaneously rather than predicting the individual wind quantities. Furthermore, the prediction of wind power is based on the proposed direction dependent power curves to optimize the maximum wind power production. In addition, the wind power prediction is coupled with the wind speed and direction prediction to combine the benefits of both. The model is flexible enough to incorporate more information from nearby points and can be extended to the entire wind farm.

The prediction of wind power may be considered at different time scales within wind farm operation framework in order to predict the expected generation of power, to avoid any damages to wind turbines, and to improve the efficiency of a wind farm to increase the power production. The objective of this study is to improve the power prediction at 5- and 10-min prediction scales. In particular, 5-min dispatch interval is very important for the Australian national electricity market and also for electricity market operator. However, the effective use of such type of prediction may vary depending on the market structure of the electric power industry [10].

NWP models are generally accepted as an accurate technique for wind power prediction for the long-term prediction scales. These models are area averaged predictions and usually provide wind predictions for a grid of surrounding points around the wind farm with a spatial resolution of a few kilometers. In our case, NWP data is used as a supplement, being an additional

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Shortterm Wind Power Prediction

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Shortterm Wind Power Prediction:

Physical Approach to Short-Term Wind Power Prediction Matthias Lange,Ulrich Focken,2006-01-16 The effective integration of wind energy into the overall electricity supply is a technical and economical challenge because the availability of wind power is determined by fluctuating meteorological conditions This book offers an approach to the ultimate goal of the short term prediction of the power output of winds farms Starting from basic aspects of atmospheric fluid dynamics the authors discuss the structure of winds fields the available forecast systems and the handling of the intrinsic weather dependent uncertainties in the regional prediction of the power generated by wind turbines This book addresses scientists and engineers working in wind energy related R and D and industry as well as graduate students and nonspecialists researchers in the fields of atmospheric physics and meteorology *Short-term Wind Power Prediction* Fatemeh Marzbani,2014 Environmental considerations in addition to energy crises have forced many countries to consider alternative energy sources renewable energies are known as the best alternatives Among renewable energies wind power is the most promising energy source The chaotic nature of the wind is a major challenge against the integration of wind power into grids Integration of wind power results in several problems due to the fluctuations inherent in wind power such as power quality stability and dispatch issues The prediction accuracy of wind power affects its integration into power systems Several wind power forecasting techniques have been proposed and developed However not all of them are able to provide sufficient accuracy The main contribution of this thesis is to provide accurate short term wind power prediction A simple yet effective adaptiveparameter regression model is developed Specifically the proposed approach uses a window of previous observations to obtain the model parameters that minimizes the prediction error Regression based models are affected by measurement errors Thus other models with the capability of moderating the impact of measurement errors are needed In order to cope with such errors two hybrid grey based short term wind power prediction techniques are proposed GM 1 1 ARMA and GM 1 1 NARnet These techniques are combined with ARMA models and Nonlinear Auto Regressive Neural Network NARnet models respectively GM 1 1 ARMA and GM 1 1 NARnet are applied to wind power data and the obtained results are compared with those obtained from ARMA the traditional grey model as well as the persistent model The efficiency of both of the proposed techniques is confirmed In contrast to the GM 1 1 ARMA model the GM 1 1 NARnet model utilizes the nonlinear components of wind power during the forecasting procedure which results in more accurate prediction Abstract

Condition monitoring for renewable energy systems Yusen He,Tinghui Ouyang,Xun Shen,Shuang Zhao,Alan Wai Hou Lio,2023-04-12 **Advanced technologies for planning and operation of prosumer energy systems** Bin Zhou,Siqi Bu,Liansong Xiong,Hugo Morais, Junjie Hu,Jingyang Fang,Jian Zhao,Peng Hou,2023-04-28 *Applying Computational Intelligence for Social Good* ,2024-01-14 Applying Computational Intelligence for Social Good Track Understand and Build a Better World Volume 132 presents views on how Computational Intelligent and ICT technologies can be applied to ease or

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Alternative Energy and Shale Gas Encyclopedia Jay H. Lehr,Jack Keeley,2016-04-25 A comprehensive depository of all information relating to the scientific and technological aspects of Shale Gas and Alternative Energy Conveniently arranged by energy type including Shale Gas Wind Geothermal Solar and Hydropower Perfect first stop reference for any scientist engineer or student looking for practical and applied energy information Emphasizes practical applications of existing technologies from design and maintenance to operating and troubleshooting of energy systems and equipment Features

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and Control PMF2020 held in Nanjing China on August 15 16 2020 Hot topics and cutting edge technologies are included Advanced Power Transmission Technology AC DC Hybrid Power Grid Technology eIoT Technology and Application Operation Protection and Control of Power Systems Supplied with High Penetration of Renewable Energy Sources Active Distribution Network Technology Smart Power Consumption and Energy saving Technology New Technology on Substation Automation Clean Energy Technology Energy Storage Technology and Application Key Technology and Application of Integrated Energy Application of AI Block Chain Big Data and Other New Technologies in Energy Industry Application of New Information and Communication Technology in Energy Industry Application of Technical Standard System and Related Research in Energy Industry The papers included in this proceeding share the latest research results and practical application examples on the methodologies and algorithms in these areas which makes the book a valuable reference for researchers engineers and university students **Wind Energy Systems** John Dalsgaard Sørensen,Jens N Sørensen,2010-12-20 Large scale wind power generation is one of the fastest developing sources of renewable energy and already makes a substantial contribution to power grids in many countries worldwide With technology maturing the challenge is now to increase penetration and optimise the design construction and performance of wind energy systems Fundamental issues of safety and reliability are paramount in this drive to increase capacity and efficiency Wind energy systems Optimising design and construction for safe and reliable operation provides a comprehensive review of the latest developments in the design construction and operation of large scale wind energy systems including in offshore and other problematic environments Part one provides detailed coverage of wind resource assessment and siting methods relevant to wind turbine and wind farm planning as well as aeroelastics aerodynamics and fatigue loading that affect the safety and reliability of wind energy systems This coverage is extended in part two where the design and development of individual components is considered in depth from wind turbine rotors to drive train and control systems and on to tower design and construction Part three explores operation and maintenance issues such as reliability and maintainability strategies and condition monitoring systems before discussing performance assessment and optimisation routes for wind energy systems in low wind speed environments and cold climates Part four reviews offshore wind energy systems development from the impact of environmental loads such as wind waves and ice to site specific construction and integrated wind farm planning and of course the critical issues and strategies for offshore operation and maintenance With its distinguished editors and international teams of contributors Wind energy systems is a standard reference for wind power engineers technicians and manufacturers as well as researchers and academics involved in this expanding field Reviews the latest developments in the design construction and operation of large scale wind energy systems Offers detailed coverage of wind resource assessment and siting methods relevant to wind turbine and wind farm planning Explores operation and maintenance issues such as reliability and maintainability strategies and condition monitoring systems **Pattern Recognition** Shutao Li,Chenglin Liu,Yaonan Wang,2014-11-05 The two volume set CCIS

483 and CCIS 484 constitutes the refereed proceedings of the 6th Chinese Conference on Pattern Recognition CCPR 2014 held in Changsha China in November 2014 The 112 revised full papers presented in two volumes were carefully reviewed and selected from 225 submissions The papers are organized in topical sections on fundamentals of pattern recognition feature extraction and classification computer vision image processing and analysis video processing and analysis biometric and action recognition biomedical image analysis document and speech analysis pattern recognition applications

Fractional-Order Activation Functions for Neural Networks Kishore Bingi,Ramadevi Bhukya,Venkata Ramana Kasi,2025-05-23 This book suggests the development of single and multi layer fractional order neural networks that incorporate fractional order activation functions derived using fractional order derivatives Activation functions are essential in neural networks as they introduce nonlinearity enabling the models to learn complex patterns in data However traditional activation functions have limitations such as non differentiability vanishing gradient problems and inactive neurons at negative inputs which can affect the performance of neural networks especially for tasks involving intricate nonlinear dynamics To address these issues fractional order derivatives from fractional calculus have been proposed These derivatives can model complex systems with non local or non Markovian behavior The aim is to improve wind power prediction accuracy using datasets from the Texas wind turbine and Jeju Island wind farm under various scenarios The book explores the advantages of fractional order activation functions in terms of robustness faster convergence and greater flexibility in hyper parameter tuning It includes a comparative analysis of single and multi layer fractional order neural networks versus conventional neural networks assessing their performance based on metrics such as mean square error and coefficient of determination The impact of using machine learning models to impute missing data on the performance of networks is also discussed This book demonstrates the potential of fractional order activation functions to enhance neural network models particularly in predicting chaotic time series The findings suggest that fractional order activation functions can significantly improve accuracy and performance emphasizing the importance of advancing activation function design in neural network analysis Additionally the book is a valuable teaching and learning resource for undergraduate and postgraduate students conducting research in this field **Hybrid Advanced Techniques for Forecasting in Energy Sector** Wei-Chiang Hong,2018-10-19 This book is a printed edition of the Special Issue Hybrid Advanced Techniques for Forecasting in Energy Sector that was published in Energies **Wind Energy Conversion Systems** S.M. Muyeen,2012-01-05 Wind Energy Conversion System covers the technological progress of wind energy conversion systems along with potential future trends It includes recently developed wind energy conversion systems such as multi converter operation of variable speed wind generators lightning protection schemes voltage flicker mitigation and prediction schemes for advanced control of wind generators Modeling and control strategies of variable speed wind generators are discussed together with the frequency converter topologies suitable for grid integration Wind Energy Conversion System also describes offshore farm technologies

including multi terminal topology and space based wind observation schemes as well as both AC and DC based wind farm topologies The stability and reliability of wind farms are discussed and grid integration issues are examined in the context of the most recent industry guidelines Wind power smoothing one of the big challenges for transmission system operators is a particular focus Fault ride through and frequency fluctuation mitigation using energy storage options are also covered Efficiency analyses are presented for different types of commercially available wind turbine generator systems large scale wind generators using superconducting material and the integration of offshore wind and marine current farms Each chapter is written by a leader in the wind energy arena making Wind Energy Conversion System a valuable reference for researchers and students of wind energy **Renewable Energy Forecasting** Georges Kariniotakis,2017-09-29 Renewable Energy Forecasting From Models to Applications provides an overview of the state of the art of renewable energy forecasting technology and its applications After an introduction to the principles of meteorology and renewable energy generation groups of chapters address forecasting models very short term forecasting forecasting of extremes and longer term forecasting The final part of the book focuses on important applications of forecasting for power system management and in energy markets Due to shrinking fossil fuel reserves and concerns about climate change renewable energy holds an increasing share of the energy mix Solar wind wave and hydro energy are dependent on highly variable weather conditions so their increased penetration will lead to strong fluctuations in the power injected into the electricity grid which needs to be managed Reliable high quality forecasts of renewable power generation are therefore essential for the smooth integration of large amounts of solar wind wave and hydropower into the grid as well as for the profitability and effectiveness of such renewable energy projects Offers comprehensive coverage of wind solar wave and hydropower forecasting in one convenient volume Addresses a topic that is growing in importance given the increasing penetration of renewable energy in many countries Reviews state of the science techniques for renewable energy forecasting Contains chapters on operational applications

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