ARGUS-PRIMA: Prediction-Intelligent Machine

Overview

ARGUS[1] PRIMA (Prediction Intelligent Machine) is a software platform for testing of advanced statistical algorithms for short-term wind power forecasting. The platform, which consists of a set of statistical algorithms to generate wind power point and uncertainty forecasts, can be used for systematic testing and comparison of different computational learning algorithms.

For wind power point forecasting, ARGUS PRIMA uses concepts from information theoretic learning (ITL) for training of a neural network. A key feature of ITL is that it does not assume a Gaussian probability distribution for the forecasting errors. In tests on real-world data from two large-scale wind farms in the U.S. Midwest, results show distinct advantages of using the new ITL training criteria as compared to the traditional minimum square error criterion (MSE) (see Figure 1) [1]–[3].

For wind power uncertainty forecasting, ARGUS PRIMA contains two new methods for estimating the uncertainty based on kernel density forecasting (KDF), as illustrated in Figure 2. Both KDF algorithms are time adaptive (i.e., suitable for online learning). The new algorithms have been tested on datasets from the Eastern Wind Integration and Transmission Study (EWITS), as well as on two wind farms located in the U.S. Midwest. Our testing show that the new KDF algorithms give a better match to the observed wind power distribution (i.e., better calibration) than results obtained through traditional quantile regression [4][5].

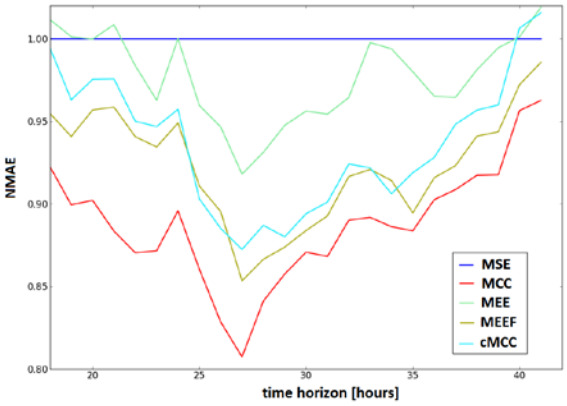

Figure 1 Relative comparison of mean absolute error (NMAE) for ITL criteria (i.e., MEE – Minimum Error Entropy, MCC – Maximum Correntropy Criteria, MEEF – Minimum Error Entropy with Fiducial Points, cMCC – Maximum Centered Correntropy Criterion) with MSE (Minimum Square Error) for a wind farm in the U.S. Midwest [1].

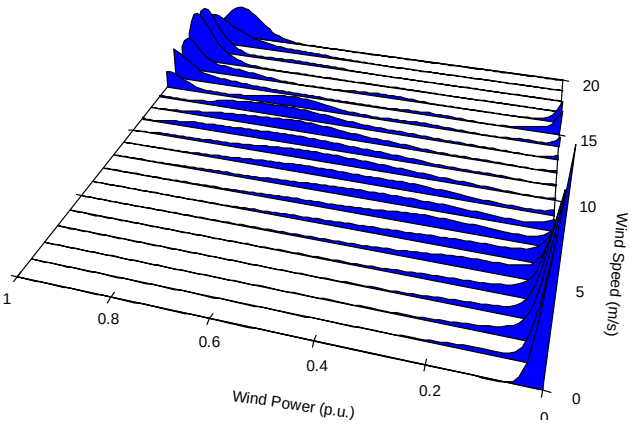

Figure 2 Illustration of uncertainty estimation with KDF: stacked conditional probability density function plot for wind power as a function of forecasted wind speed [1].

[1] ARGUS was the builder of the ship Argo, which was propelled by oars and wind energy, and used by Jason, relative of Aeolus, ruler of the winds (from Greek mythology).

Inputs and Outputs

The inputs to ARGUS PRIMA consist of time series of explanatory variables for the wind power forecast. This data can include numerical weather prediction variables (e.g., forecasted wind speed, direction, pressure), weather observations (e.g., current wind speed and direction), and power output from the wind power farms. The output of the model consists of wind power predictions, either in terms of deterministic point forecasts or probability density functions for different forecast horizons. Standard forecast evaluation scores can be calculated for assessing and comparing forecast quality.

Software Code

Four main software environments are used in ARGUS PRIMA:

1. A PostgreSQL relational database as a development backbone — all of the inputs and results are stored in this database. The database assures the validity of the input data to other algorithms by handling the tasks of input and output data storage and processing.
2. A neural network library developed in C++, implementing various ITL-based algorithms.
3. A kernel density forecast library developed in R, with the offline and time-adaptive versions of the Nadaraya-Watson and Quantile-Copula estimators.
4. Supporting algorithm codes implemented in two programming languages, Python and R.

The platform consists of source code without an explicit user interface. Users will need to possess considerable programming skills to set up and run the code.

Background

Since 2008, Argonne National Laboratory and INESC TEC (formerly INESC Porto) have conducted a research project to foster improved wind power forecasting and better use of forecasting in electricity markets. ARGUS-PRIMA is one of the results from this project. The software code is made available under a licensing agreement to facilitate transfer of the statistical learning algorithms developed in the project to the industry.

Improved wind power forecasting is a key tool to achieve more efficient operation of power systems with large shares of wind power and other renewable energy resources. The improved statistical algorithms in ARGUS PRIMA can contribute to lowering the cost of integrating wind power into the electric power grid.

The research has been sponsored by the U.S. Department of Energy's Wind and Water Power Program.

References

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More information is available at:
http://www.dis.anl.gov/projects/windpowerforecasting.html

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