WIND AND SOLAR ENERGY FORECASTING SYSTEM USING ARTIFICIAL NEURAL NETWORKS

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Abstract—The Renewable energies, with effects in supporting sustainable development. The increasing use of renewable energy contributes to lower pollution generated by other methods of producing electricity, preserves different types of fuels with an effect on environmental protection and also lowers the price of electricity to consumers. Through its components and models, the prototype will have a positive impact on decision support process in the renewable energy field for both producing units and regulators. The forecasting method using the artificial neural network.

Keywords: Artificial neural network (ANN), wind power plants, photovoltaic generation, forecasting.

I. INTRODUCTION

The Variable energy generations, mainly from renewable energy resources such as wind and solar energy plants have created operational challenges for the electric power grid because of the uncertainty involved in their output in the short term. When the penetration level of the variable generation is high, the intermittency of these resources may adversely affect the operation of the electric grid. Thus, wherever the variable generation resources are used, it becomes highly desirable to maintain higher than average operating reserves and efficient energy storage systems to manage the power balance in the system. The operating reserves that use fossil fuel generating units should be kept as low as possible to get the highest benefit from the deployment of the variable generations. Therefore, forecasting these renewable resources takes on a vital role in the operation of power systems and electricity markets. The rest of the is organized as the includes a review of statistical forecasting models for a variable.

Generations and a brief introduction to artificial neural networks (ANN). The data used to build the ANN. Section IV discusses the various solar power forecasting modeling stages. The ANN is loosely a simple biological analogy of the brain. They are implemented in widespread applications with different AI approaches such as supervised, unsupervised, and reinforcement learning approaches.

In the supervised learning approach, the ANN learns from the data by training them to approximate and estimate the function or the relationship between the input and the output variables. The algorithm helps teach the ANN to recognize similar patterns. In the back propagation concept, information flows in one direction between the neurons (nodes) and the errors back propagate in the opposite direction, changing the strength (weights) of the synapses.
between the nodes while attempting to minimize the errors by using an appropriate optimization technique such as the gradient descent method. After sufficient training iterations with known input data, the weights between the nodes are adjusted until they give a correct response.

Then, the ANN will give the correct response to the (unknown) input data that it has never seen before. The ANN can learn to generalize in this fashion. More sophisticated algorithms are introduced for training ANNs with different optimization methods to improve the performance. The ANNs are capable of providing forecasting for the variable generations of wind and solar power when the historical data is available. The ANN is considered as a black box because it is not providing a sufficient qualitative understanding of the relationship between the input and the output variables. A review of ANN-based forecasting models that are implemented to forecast the solar irradiance and energy can be found in ANN model uses the most widely used vanilla feed-forward neural networks, sometimes called the single hidden layer network. The ANN model is used as a nonlinear statistical tool to forecast solar power. Its performance is compared with other models.

Renewable energy sources have a variable nature and are significantly depending on weather conditions. The load is also uncertain. Hence, it is necessary to use power reserve equipment to compensate unforeseen imbalances between production and capacity. However, this power reserve must be ideally minimized to reduce the system cost with a satisfying security level. The quantification of power reserve could be calculated through analysis of forecasting uncertainty errors of both generation and load. Therefore, a back propagation artificial neural network approaches are derived from forecasting solar radiations. Predictions have been analyzed according to weather classification. Some error indexes have been introduced to evaluate forecasting models performances and calculate the prediction accuracy. Forecasting results can be used for decision making of power reserve for renewable energy sources system with some probability or possibility methods.

II. LITERATURE REVIEW

Renewable generation brings a significant escalation of intermittency to the power and energy system. This variability requires a new degree of flexibility from the whole system. The protection small and medium players become essential in this context[1-5]. This is only possible by using adequate forecasting techniques applied both to the consumption and to generation. For both the statistical and AI approaches, high-quality time series data consisting of weather predictions and power outputs from the past are very important [6], [7]. One of the most common statistical learning models is the artificial neural network. However, the large number of uncontrollable factors, such as the presence of consumers in the building, the luminosity, or external temperature, makes the forecasting of energy consumption an arduous task. The operating reserves that use fossil fuel generating units should be kept as low as possible to get the highest benefit from the deployment of the variable generations [7-12]. This addresses the electrical energy consumption forecasting problem, by studying the correlation between the solar radiation and the electrical consumption of lights. This study is performed using three forecasting methods, namely a multi-layer the artificial neural network, a support vector regression method, and a linear regression method. The completed studies are analyzed using data gathered from a real installation campus of the Polytechnic of Porto, in real time. They are increasing forevery
hour until the end of the day and then start again in accumulation [12-15]. The variability of energy consumption, primarily due to a large number of uncontrollable factors, such as the presence of consumers in the building, or external temperature, makes the forecasting of energy consumption an arduous task. This addresses the electrical energy consumption forecasting problem, by using a data set gathered from a real installation, in real time. This physical site, located on the campus of the School of Engineering of the Polytechnic of Porto, provides a set of different types of data, which may be used for distinct analysis processes. The correlation between the solar radiation and the electrical consumption of lights is studied[16-20]. This study is performed using three forecasting methods, namely a multi-layer perceptron artificial neural network, a support vector regression method, and a linear regression method. These methods are fed with the historical consumption data and with the corresponding solar radiation data, to enable the means to take extra information from the relationship between the data series, with the objective of improving the forecasting quality. The achieved results are compared with those obtained by other methods, previously used to forecast the energy consumption using the same data[21-22]. The comparison of these results indicated that the proposed plans could achieve a lower forecasting error. This allows concluding that the correlation between the consumption of lights and the solar radiation is fact, valid, and advantageous for the forecasting process.

III.PROPOSED DIAGRAM

The artificial neural networks (ANN) model outperforms the multiple linear regression analysis (MLR) models and the persistence model. The performance of the artificial neural networks (ANN) depends on how well it is trained and on the quality of the data that is used. The normalized input data doesn’t improve the performance but improves the model performance. Plotting the data, investigating the correlation and sensitivity analysis between the variables, as well as data cleansing of outliers are essential data preparation steps before building the forecasting model. The more accurate weather forecasts we use, the more precise solar power forecasts will be produced. Using the classification variables and the interactions between the variables enhances the performance of the multiple linear regression analysis (MLR) model significantly, but this is not the case for the ANN model.

A Model Predictive Control
Model predictive control (MPC), an essential advanced control technique for difficult multivariable control problems. The dynamic model is developed from the plant test data by selecting a model form and then estimating the model parameters. However, first, it is essential to eliminate periods of test data during which plant upsets or other abnormal situations have occurred, such as control valve saturation or a DCS control loop having been placed in manual. Decisions to omit portions of the test data are based on visual inspection of the data, knowledge of the process, and experience. Parameter estimation is usually based on the least-squares evaluation. As part of the model development step, the model accuracy should be characterized, because this information is useful for subsequent system design and tuning. The characterization can include confidence intervals for the model predictions and model parameters. The confidence intervals can be calculated using standard statistical techniques.

**B Artificial Neural Networks (ANN)**

An artificial neural network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the system affects the structure of the (ANN) artificial neural network because a neural network changes - or learns, in a sense - based on that input and output. Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. This new approach to computing also provides a more graceful degradation during system overload than its more traditional counterparts.

These biologically inspired methods of computing are thought to be the next significant advancement in the computing industry. Even simple animal brains are capable of functions that are currently impossible for computers. Computers do rote things well, like keeping ledgers or performing complicated math. But machines have trouble recognizing even simple patterns much less generalizing those models of the past into actions of the future.

Now, advances in biological research promise an initial understanding of the natural thinking mechanism. This study shows that brains store information as patterns. Some of these models are very complicated and allow us the ability to recognize individual faces from many different angles. This process of storing data as patterns, utilizing those patterns, and then solving problems encompasses a new field of computing. This area, as mentioned before, does not use traditional programming but involves the creation of massively parallel networks and the training of those systems to solve specific problems. This field also utilizes words very different from traditional computing, words like behaving, react, self-organize, learn, generalize, and forget.

**C Statistical Variable Generation Forecasting Models**

Forecasting models are continuously being improved to generate more accurate forecasts of solar and wind power. In this section, the statistical models that use both non-learning and learning approaches are described.
D Statistical Non-Learning Approach Models

These models describe the connection between predicted solar irradiance from numerical weather predictions (NWP) and solar power production directly by statistical analysis of time series from historical data without considering the physics of the system. This connection can be used for forecasts of the future plant outcomes. Plenty of regression models are already implemented as time-series forecasting models, some of which include autoregressive integrated moving averages (ARIMA), and multiple linear regression (MLR) analysis models.

E Statistical Learning Approach Models

Artificial intelligence (AI) methods are used to learn the relationship between predicted weather conditions and the power output generated as historical time series. Unlike statistical approaches, AI methods use algorithms that can implicitly describe the nonlinear and highly complex relationship between input data and output power instead of an explicit statistical analysis. For both the analytical and AI approaches, high-quality time series data consisting of weather predictions and power outputs from the past are significant. One of the most common statistical learning models is the artificial neural network. It is widely acknowledged that increased use of variable generation forecasting will be necessary to maintain grid reliability as more variable generation is added. North American Electric Reliability Corporation stated that enhanced measurement and prediction of variable generation output is needed to ensure bulk power system reliability and that wind forecasting must be incorporated into real-time operating practices as well as day-to-day operational planning.

F Future of Variable Generation Forecasting

This part of the phone survey asked Balancing Authorities what they considered the strengths and weaknesses of variable generation forecasting; what advice they would give other Balancing Authorities who are thinking of implementing forecasting; how their use of predicting has changed over time and may change in the future and any recommendations they may have for the West as a whole regarding variable generation forecasting. Some of the Balancing Authorities mentioned that variable generation forecasting is helpful, but that it should be either discounted or viewed with caution. The CAISO stated that the accuracy of variable generation forecasting tends to be compared to the accuracy of load forecasting, but forecasting variable generation is much different than predicting for a load. Load, at least in the CAISO, is always above 20 GW, whereas variable generation will have more range between the minimum and maximum outputs. Northwestern Energy reports that it uses wind forecasting as a guide, but not as a hard target because the forecast errors can be high. Further, it expects wind forecasting to improve, but that predicting the peaks and valleys of wind power output can be difficult. Turlock Irrigation District reports that it also discounts its wind forecast and recommends comparing forecasting performance with that of persistence forecasts. Its wind forecasts have improved over time with the incorporation of historical wind output data that has helped train the forecasting model. Glacier Wind recommends comparing wind forecasts to persistence forecasts and using a ramping-oriented metric, such as an equitable threat score. An advantage of wind forecasting, Glacier Wind notes that a weakness of wind forecasting is that there can be substantial errors in the hour-ahead or intrahour, requiring the company to do some hedging around the forecast.
IV SOFTWARE DESCRIPTION

MATLAB

MATLAB is a high-performance language for technical computing that integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. It is a prototyping environment, meaning it focuses on the ease of development with language flexibility, interactive debugging, and other conveniences lacking in performance-oriented languages like C and FORTRAN. While MATLAB may not be as fast as C, there are ways to bring it closer. We want to spend less time total from developing, debugging, running, and until obtaining results.

It is an interactive system whose primary data element is an array that does not require dimensioning.

V SIMULATION RESULTS

MATLAB (matrix laboratory) is a numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulation, the creation of user interfaces and interfacing with programs written in other languages including C, C++, Java, and FORTRAN.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities.

Distributed Application Advantages

- The preventative and predictive maintenance.

Fig 2 A screenshot of the Mat lab

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• The Convolutional neural network and simple logistic regression method are investigated with results on data set.

• The Method benefit from all CNN advantages such as feature extracting and robustness to distortions.

• The Highest classification accuracy and lowest classification time in comparison with other machine learning algorithms.

Fig 2 Energy Forecast

The collection of data used for training and testing the ANN model is getting from the Software database as shown in Figure 2. This software is used for the free version on academic purpose to manage of energy and has an option to choose a variety of locations. Besides, the meteorological data can be direct download from this database and need to access the internet to get the data from the database. All the data use is of the meteorological data type.

As shown in Fig. 2, the actual and the forecasts are plotted with residuals plot. The residuals plot has both positive and negative values. There appear to be many residuals of the ANN that are lying at or near the zero value as shown on the top right plot which indicates that the generated forecasts are unbiased. The correlation coefficients between the actual power and the estimates for all models are also plotted.

VI CONCLUSION

The energy generations mainly from wind and solar energy resources in the power grid have led to these crops becoming a source of uncertainty with load behavior still being the primary source of variability. The Generation and load balance are required in the economic scheduling of the generating units and electricity market trades. The Energy forecasting can be used to mitigate some of the challenges that arise from the uncertainty in the resource. The solar power forecasting is witnessing a growing attention from the research community. The presents an artificial neural network model to produce solar power forecasts. Sensitivity analysis of several input variables for best selection, and comparison of the model performance with multiple linear regression and persistence models.
REFERENCE


