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A Survey on Hybrid model to Forecast Wind Power using LSTM

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ABSTRACT: Forecasting renewable production is a key activity in power systems. With the growing penetration of renewable energy sources, there is a pressing need for best manage supply/demand balance; therefore a reliable forecasting method of intermittent energy resources is an important issue. In this field, among renewable sources, the wind power one is characterized by the higher criticalities, due to the inherent intermittency not correlated with the day-night cycle. Moreover, the intermittent nature of wind power produces a heavy effect on the power system. As wind energy is considered as a major source of electricity nowadays there is a need to predict the amount of wind power. When there is no availability of wind, the electricity needs to be replaced with others like water in order for a continuous supply. The idea suggested, uses types of neural network technology to forecast the wind power. LSTM is a class of neural network for forecasting with high accuracy. The forecasting helps in analysing the amount of wind so that it can be replaced and can provide a continuous supply. The speed of wind is measured for a particular time period and the latter will be predicted using neural network mechanism.

KEYWORDS: Wind speed forecasting, time series, LSTM model.

I. INTRODUCTION

As the renewable energy sources are available everywhere and renewable energy has the advantage of being environmental friendly. Energy from renewable sources like wind can replace the existing power sources, an alternative to fossil fuels. Wind energy being an integral system has been successful in modern power and energy systems. Winds are caused by uneven heating of the atmosphere by sun, earth's rotation and irregularities of earth surface. The total contribution from wind power is expected to be 30% by 2030. For more than two millennia wind powered machines are being used. Wind power was widely available and has significantly increased in recent years. In case of wind power generation, wind speed modelling and forecasting is a major factor. A number of statistical models like ARMA and ARIMA models are fit into wind speed analysis. Artificial neural network models are already developed by many authors for short term prediction of wind speed power (Mohandes et al., 1998; Cadenas and Rivera, 2007; Bilgili et al., 2007; Monfared et al., 2009). Already existing models based on time series analysis are not capable of significantly reducing the prediction error.

Many other models uses algorithms for wind speed forecasting including physical models, artificial intelligence models, spatial correlation models etc[8,9]. Physical models are based on some parameters including temperature, pressure, geographic locations for forecasting [10-12]. In spatial correlation method, to forecast the wind speed estimated points time series and its neighbouring data are considered.[13-16]. Statistical equations are used for prediction in statistical model [17, 18]. Artificial neural network found application in various fields including medical, engineering, industries, agriculture etc. a short term wind speed forecasting based on ANN hourly time series model was presented by Candenas [20]. Mean squared error and mean absolute error values were estimated at 0.0016 and 0.0399 respectively.

In order to maintain a continues power supply, hence the prediction is necessary. The less amount of wind is needed to replace with some other source in order to maintain continuity. The purpose of this work is to reduce the loss and in order to predict accurate values. Recurrent neural network technique, back propagation and regression mechanism are used in calculating the values. In this work, the prediction of the wind speed for a short period is calculated based on long short term memory (LSTM), a variant class of recurrent neural network approach. In a recurrent neural network connection between units form a directed cycle. It uses its internal memory to process a sequence of data inputs.

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II. RELATED WORK

As the prediction of wind speed found to be an important aspect for a continuous flow of energy many algorithms had been proposed. Some of the algorithms are implemented for off shore prediction, parametrical method, ARMA, ARIMA models etc.

Our proposed system uses Long Short Term Memory (LSTM) for the forecasting of wind speed. Some of the related works to the proposed mechanism are mentioned.

1. Hybrid forecasting of time series data is considered to be a potentially effective alternative compared with the conventional single forecasting modelling approaches such as autoregressive integrated moving average (ARIMA) and artificial neural network (ANN). Hybrid forecasting typically consists of a classic prediction model for the linear component of a time series and a nonlinear forecast model for the nonlinear component. This paper presents a hybrid approach combining ARIMA and radial basis function neural network for forecasting wind speed and wind power. Results obtained by a case study show that the proposed method is suitable for short-term forecasting applications [2].
2. The main objective of this work is short-term forecasting of wind speed on the basis of historical time series meteorological data. Nonlinear data driven model is used here for forecasting the wind speed as it is a powerful and adaptive modeling tool for forecasting purpose. Five different ANN models are developed. The minimum mean square error (MSE) for these models is found on the basis of network performance. The developed model with least error can be used for forecasting wind speed for predicting power generation from wind turbines within error of $\pm 30\%$ (as perCERC) [1].
3. In general wind speed is mainly influenced by factors that change rapidly over small spatial resolutions such as elevation, roughness and obstacles. Data from operational offshore wind farms is only available over a short time period. Consequently, it is difficult to extrapolate current data to future deployments. The alternative approach is to estimate wind climate using wind speed data from met masts. Predicting the short term wind speed and the resulting energy is of high importance with regards to energy markets, generating more profits, or for the determination of weather windows used for construction, installation and repairs of offshore wind turbines, overall described as wind farm management. Fuzzy logic, linear prediction from feed forward neural network is used [3].
4. The focus was on finding out the most influential parameters for wind speed prediction purposes. These parameters when incorporated into any Numerical Weather Prediction (NWP) model would lead to best prediction results. Results have been verified over a time horizon of 6 and 12 hours ahead using 1 and 2 year models, respectively. Data from VABB airport, Mumbai was used for modelling and prediction purposes. An effort has been made to determine the numerical weather parameters which would result in best short-cum-medium term wind speed prediction when modelled into yearly models. For this purpose an artificial neural network based yearly auto-regressive model was configured and tested for different yearly model, time horizon and parametrical combinations. Observations depicted that historical wind speed and temperature are the appropriate parameters for short-cum-medium term prediction purpose. It was concluded that, when these parameters are used together (W+T) they lead to optimum results [4].

Our proposed model uses LSTM recurrent neural network technique for wind speed prediction using already obtained values.

III. PROPOSED METHODOLOGY

Based on the calculated/observed values using neural network mechanism forecasting is done. Artificial neural network in which connections between units form a directed cycle is the recurrent neural network. A neural network comprises of training mod and a using mode. Backpropagation algorithm is used in training as the parameters are

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shared in all the steps. Each output gradient depends not only the current time sequence but also on the previous values. This mechanism is the Backpropagation Through Time. In order to calculate a gradient at 5 we need to backpropagate 4 steps and sum the gradient value [6]. LSTM uses different functions in calculation of hidden states. LSTM contains a memory cell, having four main elements including an input gate, a neuron, a forget gate and output gate. The interaction between environment and memory cells modulate through gates.

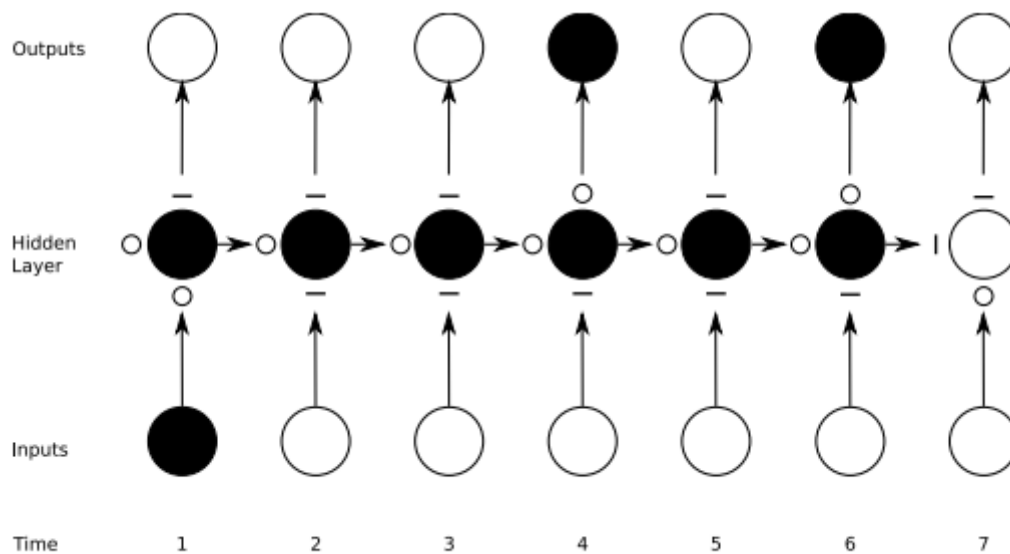


Fig 1: working of gates in LSTM

The figure shows the working of gates in a network, straight lines representing the closed gates, open ones are represented using blank circles. The circles and lines running horizontal down the hidden layer are the forget gates. Recurrent network is capable of handing many to one, many to many and one to many mapping. The input is given to the network as time series and the output value obtained will be based on the previously obtained values. The observed value is compared with the calculated value to find the error in prediction. The RMSE (root mean square error) value is calculated. It's a measure of difference between the estimated value and predicted value. The hidden layer assumes weight along with the given input and the output value is calculated. Different sets of weights filter the input and gate is represented as a linear function.

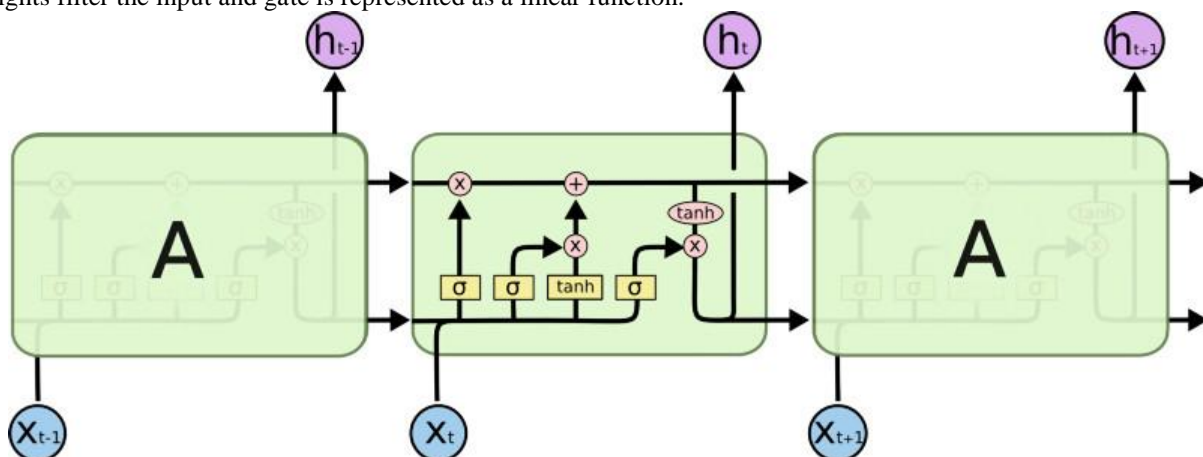


Fig 2: LSTM interacting layer

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As explained in figure it poses a chain like structure having four repeating network layer. The output of one node is carried as the input to the other node, it doesn't have capability to add or remove information to cell states. The decision about the input is made by the forget gate, h_{t-1} and x_t and the output for each cell will be 0 or 1 in the cell state C_{t-1} . In the next step the information in the cell state is updated in two parts. A sigmoid layer called input gate layer determines the value to update and next tan h layer a new candidate value \tilde{C}_t . In the next step these two values are combined to create and update state. The old state C_{t-1} is updated to C_t using the equation format

$$C_t = f_t * C_{t-1} + i_t * \tilde{C}_t$$

It also merges cell state, hidden state in updating cells. LSTM has becoming popular in various fields including forecasting, pattern recognition etc.

IV. CONCLUSION

An artificial neural network model in order for the forecasting the wind speed has been proposed. The model uses a class variant of recurrent neural network, LSTM. The model using time series method to predict wind power is simple and requires a small amount of data. There are less errors and the model is suitable for situations where data acquisition has certain difficulty. But the prediction errors in some points of the prediction results are very large, especially in the time series turning points.

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