Deep Learning based Long Term Load Forecasting using Technical and Behavioural parameters

Report

Name: Amit Tiwari
Senior Project Associate
IIT Kanpur

Name: Praveen Prakash Singh
Junior Research Fellow
IIT Kanpur

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Introduction

- Buying/selling of electricity as a commodity in electricity market revolves around balancing load and generation in the process of making adequate returns on investment incurred in generation, transmission and distribution.
- The competitive power market needs to predict the electrical power in order to meet the demand in the short-term or long-term.
- The size of the future generating plant, type and the location can be determined using long-term load forecasting. Also, accurate load forecasting holds a great saving potential for electric utility corporations.
- SLDCs, RLDCs and NLDC shall compute forecasting error for daily, day-ahead, weekly, monthly and yearly forecasts and analyze the same in order to reduce forecasting error in future. The computed forecasting errors shall be made available by SLDCs, RLDCs and NLDC on their respective websites.

Introduction

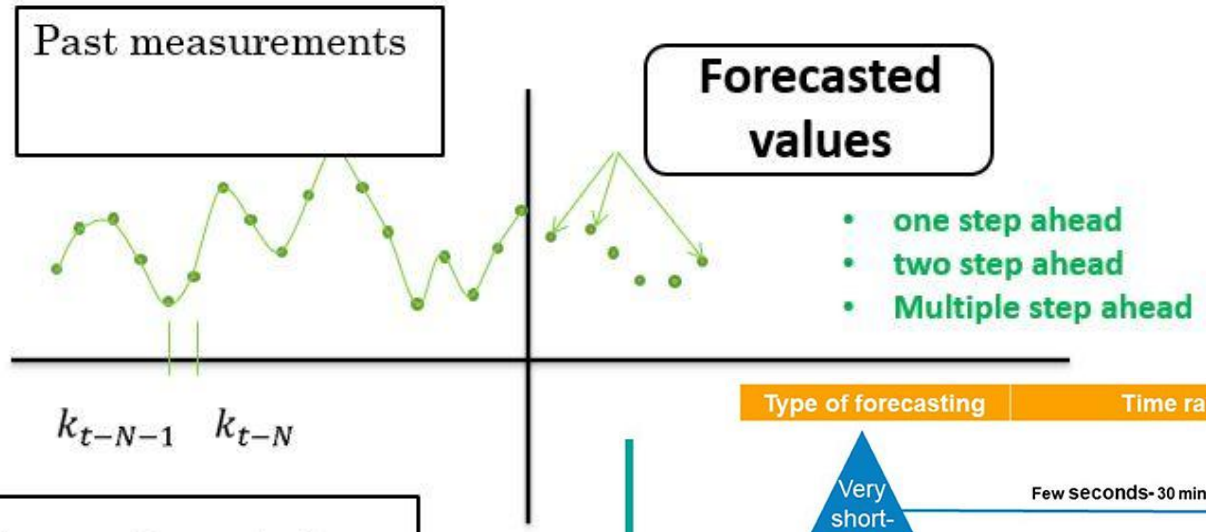
- Each distribution licensee within a State shall estimate the demand in its control area including the demand of open access consumers and factoring in captive generating plants, energy efficiency measures, distributed generation, demand response, for the next five (5) years starting from 1st April of the next year and submit the same to the STU by 31stJuly every year. The demand estimation shall be done using trend method, time series, econometric methods or any state-of-the-art methods and shall include daily load curve (hourly basis) for a typical day of each month.
- STU, based on the demand estimates furnished by the distribution licensees of the concerned State as per clause (i) of this sub-Regulation and in co-ordination with all the distribution licensees, shall estimate by 30th August every year, the demand for the entire State duly considering the diversity for the next five (5) years starting from 1st April of the next year.
- Forum of Regulators may develop guidelines for demand estimation by the distribution licensees for achieving consistency and statistical accuracy by taking into consideration the factors such as economic parameters, historical data and sensitivity and probability analysis.

Scope and Objectives

- In this project, a long-term demand forecasting will methodology will be developed based on deep learning technique.
- The deep learning technique will be based on multivariate Recurrent or Long Short-Term Memory (LSTM) Neural Network Using Bayesian Optimization.
- Multi-year data set will be utilized to forecast the electric load demand. Data set is gathered and processed from different resources available online.
- Different technical, economical and social factors will be considered (multivariate).

Literature Review

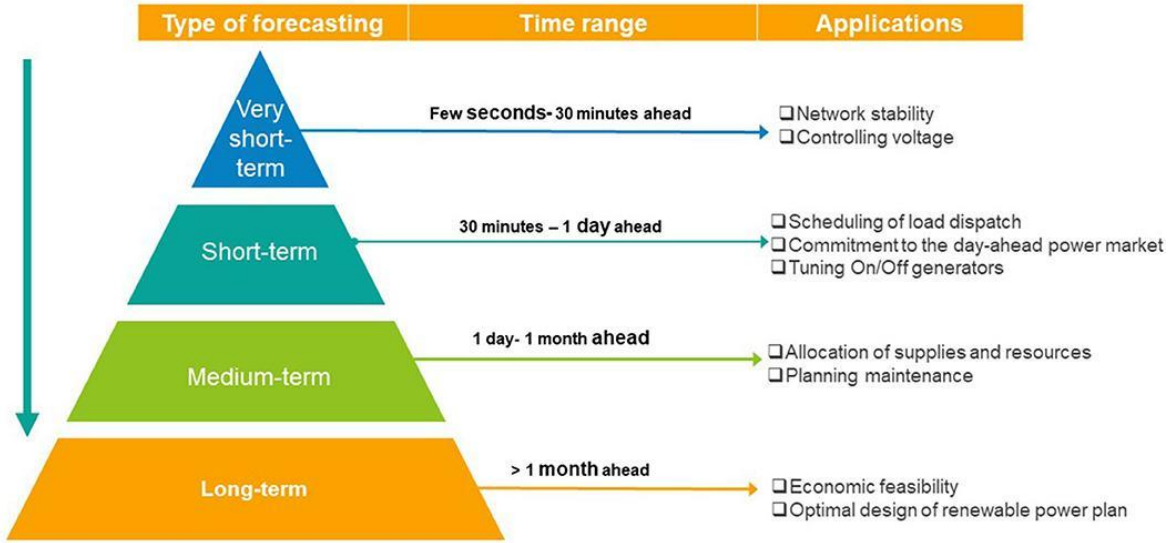
Forecasting is a problem of determining the future values of a time series from current and past values.



- one step ahead
- two step ahead
- Multiple step ahead

Time sampling can be in sec, min, hours, days, months and years

Increasing time



Literature Review

The following are some of the purposes of load forecasting.

- planning of the power system.
- planning of transmission and distribution facilities.
- power system operation.
- financing.
- manpower development.
- grid formation.
- electrical sales.

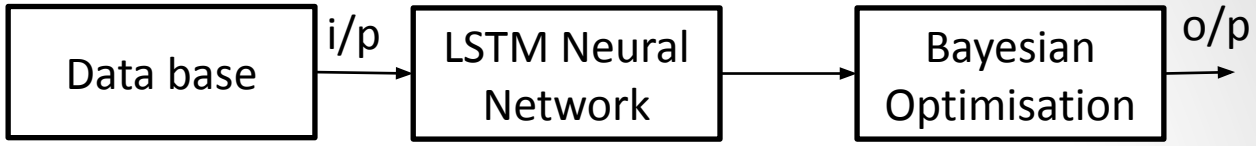
Literature Review

- Load forecasting technique can be classified as:
  - multiple regression;
  - exponential smoothing;
  - iterative reweighted least-squares;
  - adaptive load forecasting;
  - stochastic time series;
  - ARMAX models based on genetic algorithms;
  - fuzzy logic;
  - neural networks; → This is used for forecasting
  - knowledge-based expert systems.

Literature Review

- Classical models, such as HMM, symbolic regression have computation and feature selection challanges in multivariate long time series.
- SVM and linear regression technique have disregard for retention of the past data.
- ANN model are feed forward models that propagate the information while having temporal information being lost.
- CNN, most prominent in extracting from spatial data where as temporal data requires careful retention of past data .
- LSTM retains information better than any other deep neural networks due its memory cell configuration which allows LSTM to evaluate past data efficiently.
- LSTM cells are composed of several state boxes acquiring inputs sequentially through time and these stable memory sequence also eliminate the problem of vanishing gradient while retaining long temporal changes.

Methodology



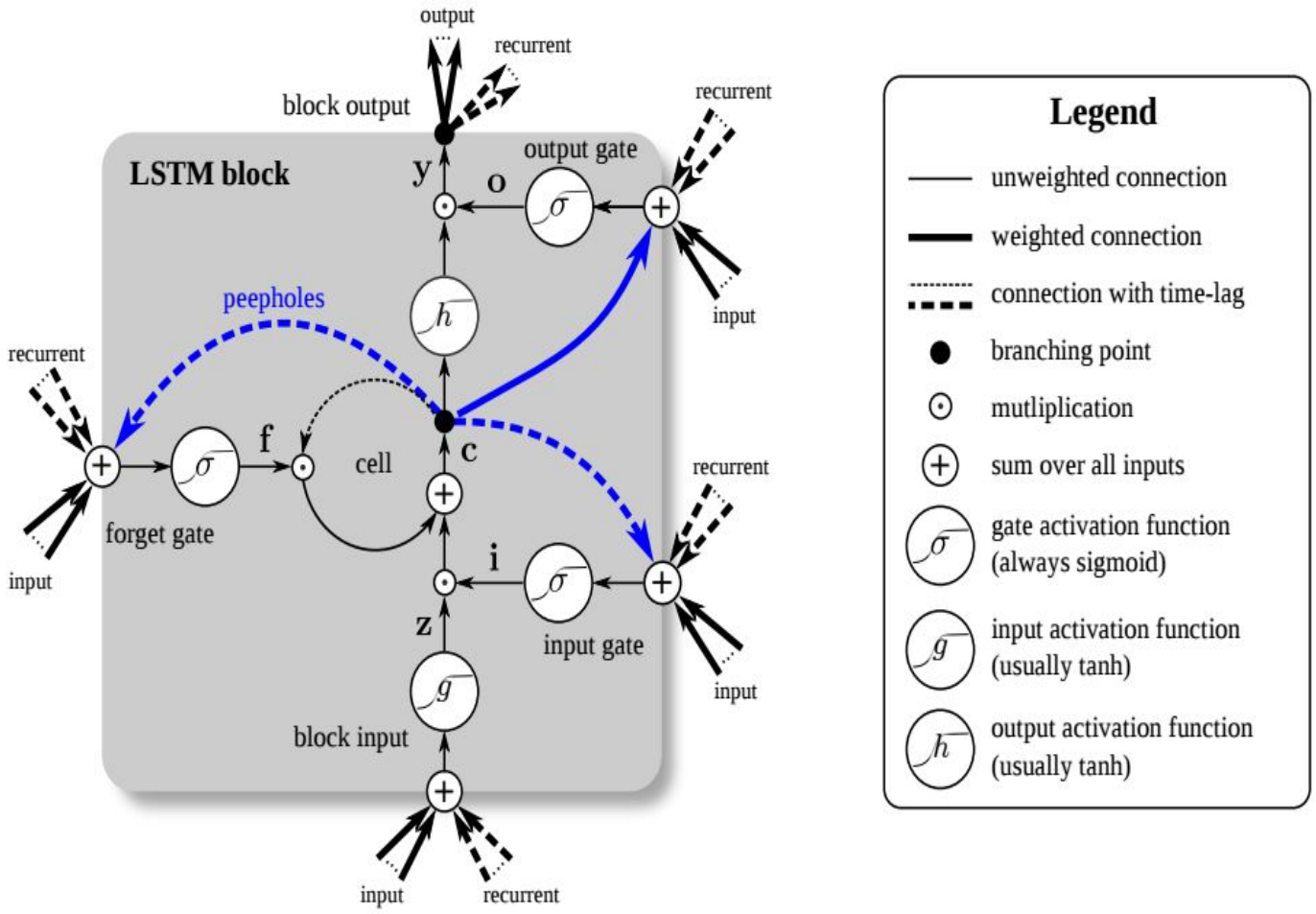
- Data collection and curation
- Developing LSTM Neural Network for training

  (LSTM is adequately employed deep learning neural network which retains information better than any other deep neural networks due its memory cell configuration)
- Develop Bayesian Optimization Technique
- (Bayesian optimization is a powerful strategy to find the extrema of a given objective function which estimates the objective function as a form of a Gaussian process and interprets it as a proxy function)
- Interpretation of result and determining the correlation the input parameters and their behavior.

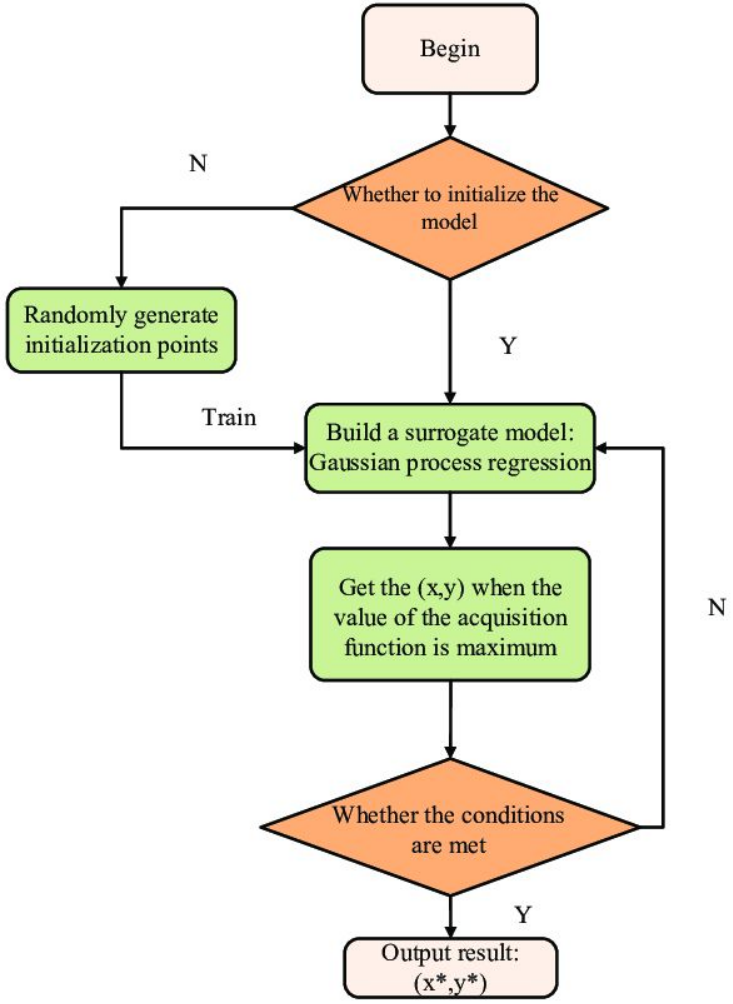
Methodology

- The flow of the Bayesian Optimisation-LSTM model is as follows:
- Step 1. To divide the experimental data into the training set and the test set.
- Step 2. To initialize the BO algorithm by taking hyper-parameters to tune (e.g batch size, optimizer learning rate, dropout layer etc) in the LSTM network model as optimization objects.
- Step 3. To randomly calculate the current function distribution according to the formula.
- Step 4. To adjust the current function distribution according to the strategy selected by the selection function.
- Step 5. To judge whether the termination condition is met. If it is met, the optimal hyperparameter values are returned; otherwise, Step 4 is returned.
- Step 6. To construct the LSTM network model with the optimal hyperparameters followed by training and testing of model.

Methodology



Methodology



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