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A Heuristic Method for Short Term Load Forecasting Using Historical Data

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A HEURISTIC METHOD FOR SHORT TERM LOAD FORECASTING USING HISTORICAL DATA

Strictly as per the compliance and regulations of:

A Heuristic Method for Short Term Load Forecasting Using Historical Data

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Abstract- Load forecasting plays an important role in power system planning and operation. In the present complex power system network under deregulated regime, power generating companies must be able to forecast their system demand and the corresponding price in order to make appropriate market decisions. Therefore, load forecasting, specially the short-term load forecasting (STLF) plays an important role for energy efficient and reliable operation of a power system. It provides input data for many operational functions of power systems such as unit commitment, economic dispatch, and optimal power flow and security assessment. This paper proposes a new and simple technique to calculate short term load forecasting using historical data and applied it to the Damodar Valley Corporation (DVC) grid operating under Eastern Grid (ERLDC-Eastern Regional Load Despatch Centre), India. This gives load forecasts half an hour in advance. The forecast error i.e. difference between calculated forecast load and real time load is a measure of the accuracy of the system, is found to be lower than other existing techniques like Holt's Method, Chow's Adaptive Control Method, Brown's One-Parameter Adaptive Method.

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I. Introduction

In the present day, there are many issues and challenges in the deregulated electric power industry worldwide. The Indian power sector is undergoing structural metamorphosis and the various power generations, transmission and distribution companies are getting ready to take their rightful place in this sector to offer efficient service for which load forecasting is an effective tool.

Load forecasts with lead times from a few hours to seven days are essential in certain scheduling functions such as unit commitment and interchange evaluation. A wide variety of modeling techniques for STLF have been suggested in the literature in ref. 1-6.

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Conventional load forecasting methods like regression method in ref. 7 and time series modeling in ref. 8 have not considered the influence of all kinds of random disturbances into account. Artificial neural networks (ANN) in ref. 9-10 and fuzzy neural networks in ref. 11 are also applied to STLF which provide forecast models with enhanced learning capabilities.

The short term load forecast plays an important role in economic operation and reliability of power systems. The main objective of the STLF is to advise the dispatcher in making a decision for economic dispatching. Therefore with an accurate model, it could also benefit dispatch systems to:

- supply load consistently
- estimate fuel allocation
- determine operational constraints
- determine equipment limitations

The second objective of the STLF is security assessment and system updation. STLF system requires offline historical data to do predictions. The data helps to run the model in advance, therefore allows dispatcher to provide corrective counter measure to the system.

In the proposed technique, historical load data obtained from DVC from the year 2010 to 2011 was used. The inputs used for the proposed method are, load at the particular time in the previous year, and two readings at half hour intervals of the same year along with the load of the half hour intervals in the present year. A mean absolute percentage error of 0.05% was achieved over the period of data which was tested on 1 week data. This represents on average a high degree of accuracy in the load forecast.

II. Load Forecasting Tools & Methodology

Load forecasting is one of the most important inputs for prediction of electricity prices. The vital initiative behind prediction involves increasing number of models that estimate future values of an indicator based on its past values.

Load forecasting can be done for different durations i.e. long term forecasts with lead time of more than one year, medium term forecasts with the lead time of one week to one year, short term forecasts with lead

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time of 1 to 168 hours and very short-term load forecasting with lead time shorter than a day.

STLF is a dynamic nonlinear input/output mapping function of many variables such as weather conditions, temperature etc. Auto regressive models and moving average mapping are well known examples that come under linear autoregressive models.

The various tools available for load forecasting are

- Artificial Neural network.(ANN)
- Fuzzy logic (FL)
- Autoregressive model
- Similar day approach
- Time series
- Expert system
- Support vector machine

Out of these methods, ANN and FL are the popular and commonly used mathematical tools in ref. 12-15 for load forecasting applications.

The traditional Approaches in ref. 16 like Holt's Method, Chow's Adaptive Control Method, Brown's One-Parameter Adaptive Method have been applied on the historical load data of DVC for month of February 2011.

A historical data method has been used in this work to develop a model to make predictions of the load half an hour in advance, based on the relationship of processed data of previous year and data available for the current year. In this paper, the proposed short term load forecast using historical data (STLFHD) method has been tested on DVC load data in which the forecast has been made based on load data at a particular time of the previous year in steps of half hour and one hour and corresponding load data of the current year.

An assumption has been made that the environment factor of power production system is same on the present day and the same day in the last year. Also, the two real time loads in thirty minutes difference is included in the calculation to make the forecast value more accurate.

The equations devised for load forecasting using historical data are as given below:

$$L^{\sim}_{t\,1/2} = |(L^{p}_{t-1/2} - L^{c}_{t-1/2})/2| \qquad \text{Eqn (1)}$$

$$L^{\sim}_{t\,1} = |(L^{p}_{t-1} - L^{c}_{t-1})/2| \qquad \text{Eqn (2)}$$

$$L^{C}_{t} = L^{p}_{t} + (\, L^{\sim}_{t\frac{1}{2}} + L^{\sim}_{t\,1}\,) \qquad \text{Eqn (3)}$$

Where,

L^{C}_{t}= Forecast load of current year at required time.

L^{p}_{t}=load of the previous year at the same time at which forecast is being done in current year.

$L^{p}_{t-1/2}$=load of the previous year half hour before the current forecast time.

L^{p}_{t-1}=load of the previous year one hour before the current forecast time.

$L^{c}_{t-1/2}$=load of the current year half hour before the current forecast time.

L^{c}_{t-1}=load of the current year one hour before the current forecast time.

$L^{\sim}_{t\frac{1}{2}}$=Absolute average value of difference of half hour values.

$L^{\sim}_{t\,1}$=Absolute average value of difference of hour values.

The mean absolute percentage error (MAPE) which indicates the efficiency of the devised model for predicting the load in advance and studying the performance of the system and it does not accentuate large error. Equation (4) illustrates the MAPE formula.

$$\text{MAPE} = \frac{1}{N}\sum_{i=1}^{N} \left|\left|\left[\frac{L^{C}_{t} - L^{p}_{t}}{L^{C}_{t}}\right]\right|\right| \text{..........eqn (4)}$$

Where L^{c}_{t}= Forecast load of current year at required time.

L^{p}_{t}=load of the previous year at the same time and N represents the total number of data (time samples=48).

Mean Absolute Deviation (MAD) is the final accuracy measurement. This error measurement is the average of the absolute value of the error without regard to whether the error was an over estimate or underestimate.

$$MAD = \frac{1}{N}\sum_{i=1}^{N}[|\,[L^{a}_{t} - L^{f}_{t}]|] \qquad \text{Eqn (5)}$$

Where L^{a}_{t} = actual load at particular time instant and L^{f}_{t}= forecast load at that time.

III. Results & Discussion

The proposed technique was tested on historical data from the period 2010 to 2011. The data of first week February 2011 has been considered here for discussion and plotted graphs show for better understanding. Table 1 shows morning peak and Table 2 shows evening peak of Load data & load forecast data respectively. Where FL represents Forecast Load and HD represents Historical data

Table 1: Load data (HD) & Load forecast (FL) for the given duration (morning peak)

Time	Year 2011	01.02.11 Load (MW)	05.02.11 Load (MW)	07.02.11 Load (MW)
600	FL	1487	1837	2049.5

	HD	1488	1838	2045
630	FL	1498.5	1836.5	2047.5
	HD	1502	1836	2046
700	FL	1507.5	1837	2053.5
	HD	1509	1838	2052
730	FL	1498	1849.5	2051
	HD	1494	1851	2053
800	FL	1517	1875.5	2055
	HD	1512	1875	2053
830	FL	1508.5	1894.5	2028.5
	HD	1508	1894	2029
900	FL	1503.5	1892	1993
	HD	1504	1891	1994
930	FL	1498	1896.5	1898
	HD	1499	1894	1895
1000	FL	1489.5	1883	1866.5
	HD	1489	1885	1871

Table 2 : Load data (HD) & Load forecast (FL) for the given duration (evening peak)

Time	Year 2011	02.02.11 Load (MW)	04.02.11 Load (MW)	06.02.11 Load (MW)
1800	FL	1504	1744	1961
	HD	1505	1746	1964
1830	FL	1515.5	1754	1968.5
	HD	1516	1759	1967
1900	FL	1503	1750.5	1977.5
	HD	1501	1743	1976
1930	FL	1506	1749	1978
	HD	1508	1748	1978
2000	FL	1504.5	1761	1986
	HD	1503	1764	1988
2030	FL	1489.5	1805.5	1982
	HD	1489	1806	1981
2100	FL	1511.5	1864	1994
	HD	1513	1869	1997
2130	FL	1502.5	1876.5	1992
	HD	1495	1871	1993
2200	FL	1499	1867	1994.5
	HD	1497	1870	1993

The mean absolute percentage error (MAPE) and Mean Absolute Deviation (MAD) results are shown in table 3 & 4.

It has been observed that error depends on several factors such as the homogeneity in data, the choice of model, the network parameters, and finally the type of solution. From the result shown in table 1 & table 2 the following three graphs developed. It is observed that the forecasted values are in good agreement with exact values and the calculated error, shown in table 3 and 4, is very small.

Also, the results obtained clearly demonstrate that the proposed method is simple, fast, reliable, accurate, and effective for short term load forecasting and that this method can perform good prediction with least error.

Table 3 : MAPE (%) values for different Load Forecasting Methods

Date	HM	CACM	BOPAM	STLFHD (Proposed Method)
01.02.11	0.853771	0.085133	0.649826	0.088758
02.02.11	1.823455	0.09901	0.721414	0.0955
03.02.11	2.181319	0.381517	1.265112	0.054279
04.02.11	1.635235	0.135338	0.824362	0.208704
05.02.11	1.687037	0.661841	1.644067	0.134027
06.02.11	0.682334	0.224032	0.664018	0.16012
07.02.11	1.143343	0.3451	0.906755	0.18286

Table 4 : MAD values for different Load Forecasting Methods

Date	HM	CACM	BOPAM	Proposed Method STLFHD
01.02.11	0.673998	0.120297	0.404542	0.08681
02.02.11	1.122309	0.178835	0.516869	0.09902
03.02.11	1.588924	0.847906	1.126689	0.045264
04.02.11	1.522361	0.260466	1.014949	0.284057
05.02.11	1.18465	1.633852	1.571948	0.171404
06.02.11	0.543446	0.44989	0.71449	0.144841
07.02.11	1.306622	0.728371	1.189224	0.215153

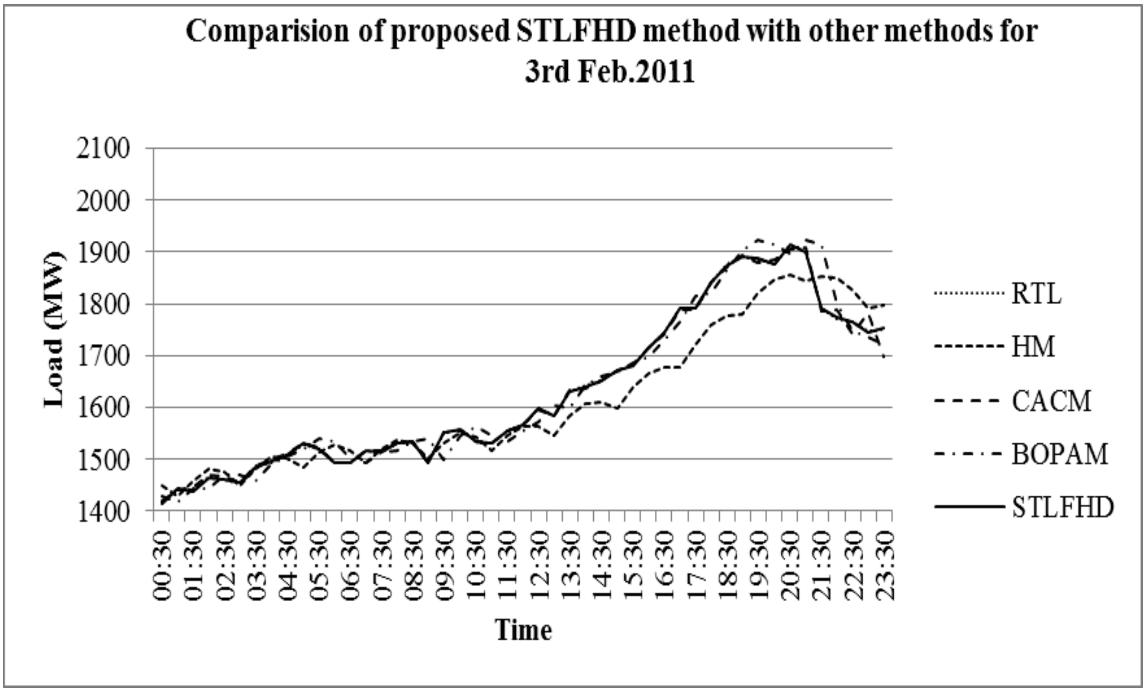

Figure 1 : Comparison of proposed STLFHD method of forecasting with other methods for 3rd Feb.2011.
Figure 1

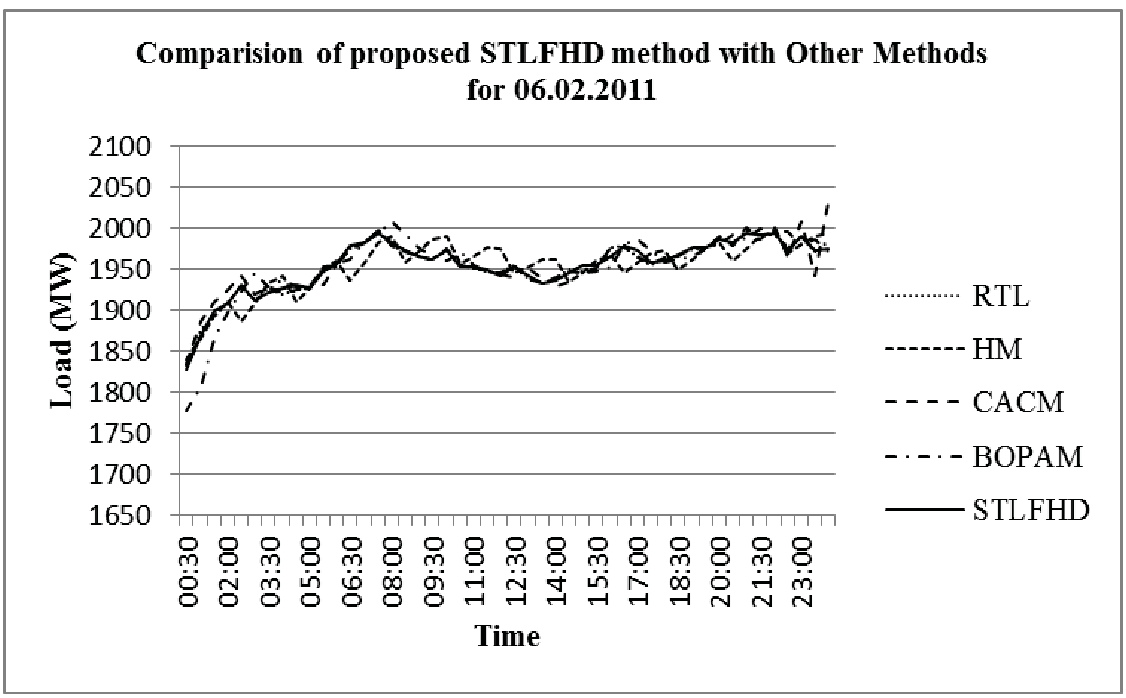

Figure 2 : Comparison of proposed STLFHD method of forecasting with other methods for 6th Feb.2011.

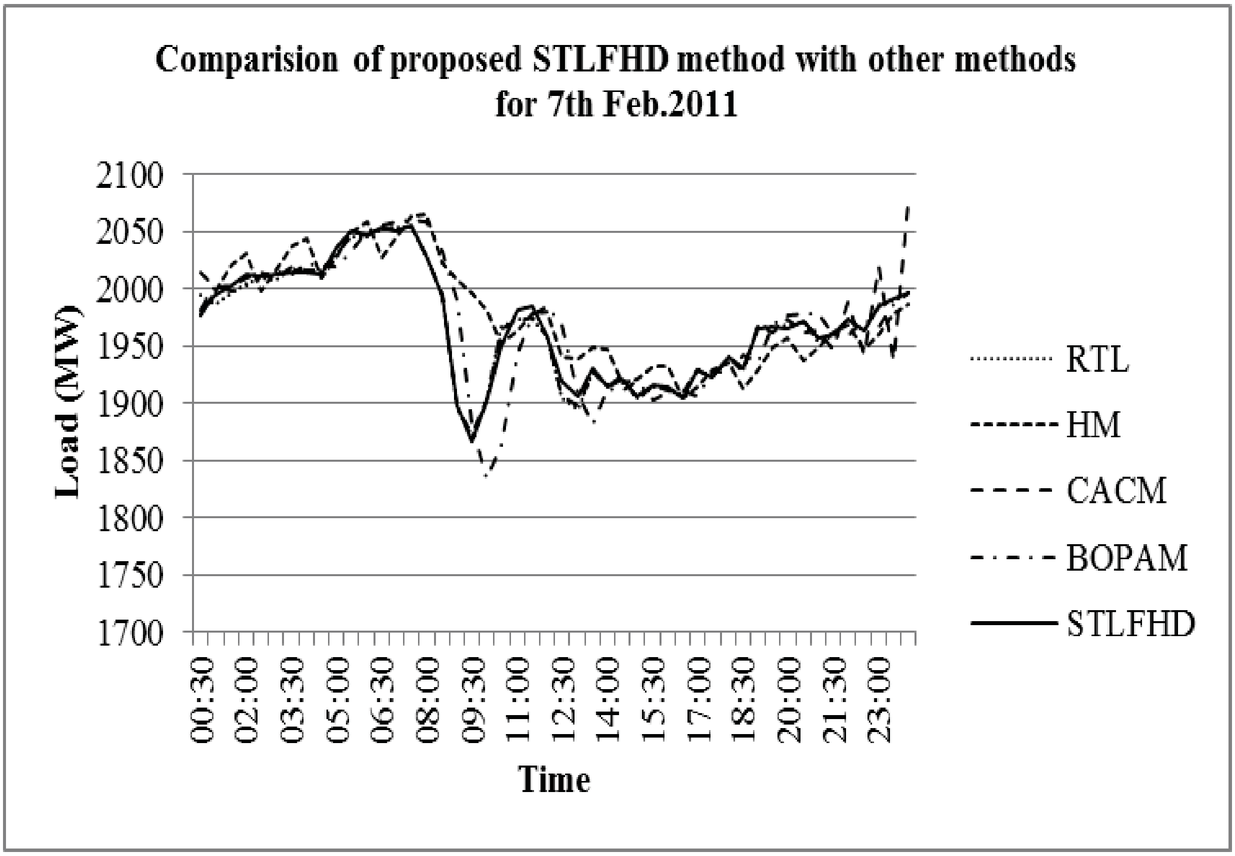

Fig.3: Comparison of proposed STLFHD method of forecasting with other methods for 7th Feb.2011

IV. Conclusion

The results obtained in this work confirm the applicability as well as the efficiency of the proposed method in short-term load forecasting for the DVC grid load pattern located in eastern part of India. The method applied was able to determine the nonlinear relationship that exists between the historical load data supplied and on that basis, to make a prediction of what the load would be in the next half an hour.

The forecasting reliability of the proposed method was evaluated by computing the mean absolute error between the real time load and forecasted load. The results have shown that the prediction is more accurate with least error. Finally, we concluded this technique is simple and fast and could be an important tool for short term load forecasting for inter connected grid systems.

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