Short Term Load Forecasting of Indian System Using Linear Regression and Artificial Neural Network

Presentation · November 2015

DOI: 10.13140/RG.2.2.15858.40645

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Paper id :- 532

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ME Power System

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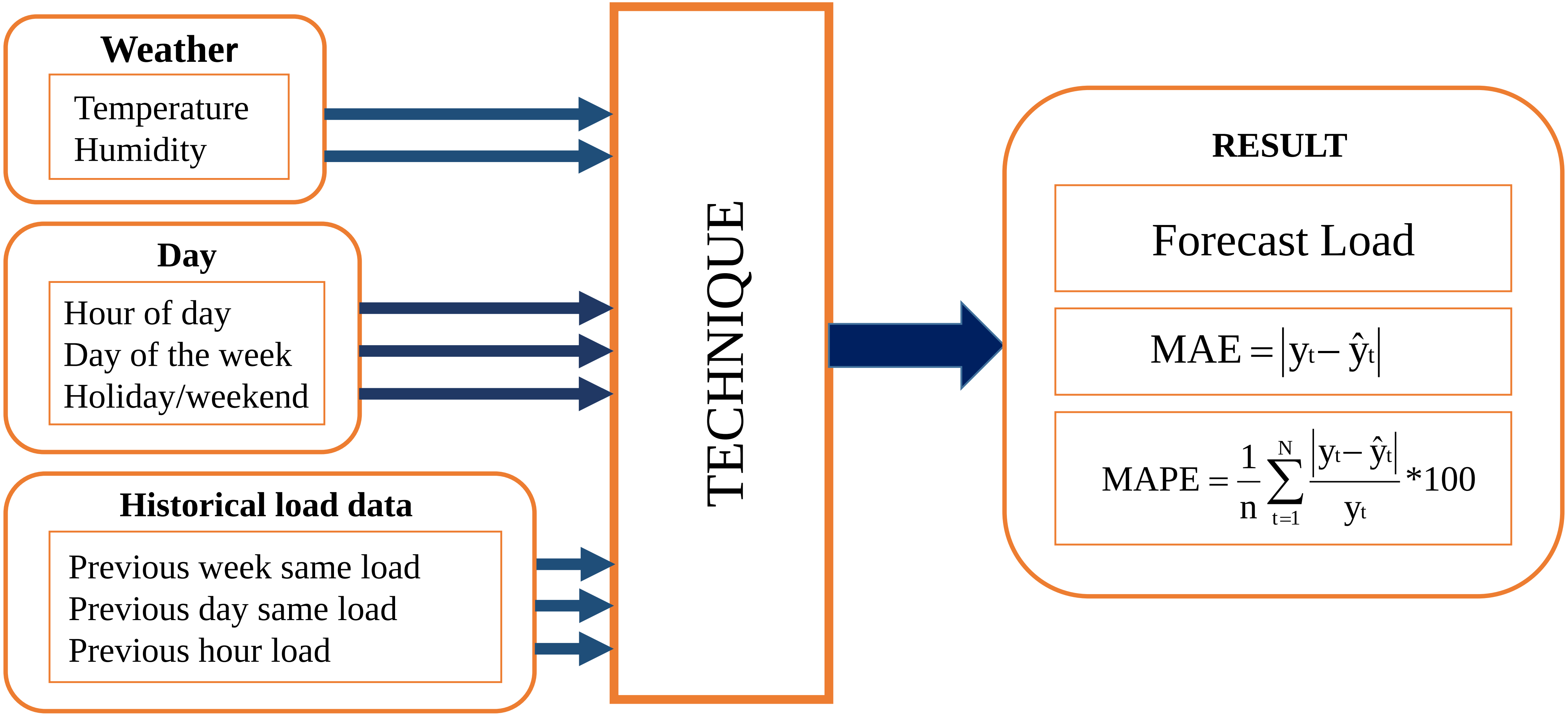
Outline

- *Introduction*
- *Block diagram of STLF*
- *Linear Regression*
- *Artificial Neural Network*
- *Levenberg - Marquardt Back Propagation algorithm*
- *Simulation & Results*

Introduction

- Short Term Load Forecasting (STLF) provides the basis for,
  - Unit Commitment
  - Spinning Reserve Capacity
  - To Prepare Schedule Maintenance Plan
- Accurate Load Forecasts provide the key information for energy planning and operation [1].
- STLF is useful for safe and economic planning of an electrical power system.
- It is also used for determining,
  - Start-up and Shut-down Schedules Of Generating Units
  - Overhaul Planning
  - Load Management [2].

Block diagram of Short Term Load Forecasting



Linear Regression

- Regression tries to find relationship between a dependent variable and one or more explanatory variables.
- The relationship between an input matrix and an output vector is easy to understand.
- When weather variables are included, linear regression algorithm assume a linear relationship between weather variables and load [1].
- Mathematically,

$$Y = X * \beta + r$$

$$\begin{bmatrix} y_1 \\ y_2 \\ . \\ y_n \end{bmatrix} = \begin{bmatrix} x_{11} & x_{21} & . & x_{p1} \\ x_{12} & x_{22} & . & x_{p2} \\ . & . & . & . \\ x_{1n} & x_{2n} & . & x_{pn} \end{bmatrix} * \begin{bmatrix} \beta_1 \\ \beta_2 \\ . \\ \beta_n \end{bmatrix} + \begin{bmatrix} r_1 \\ r_2 \\ . \\ r_n \end{bmatrix}$$

$$\text{Forecast Load} = X_T * \beta$$

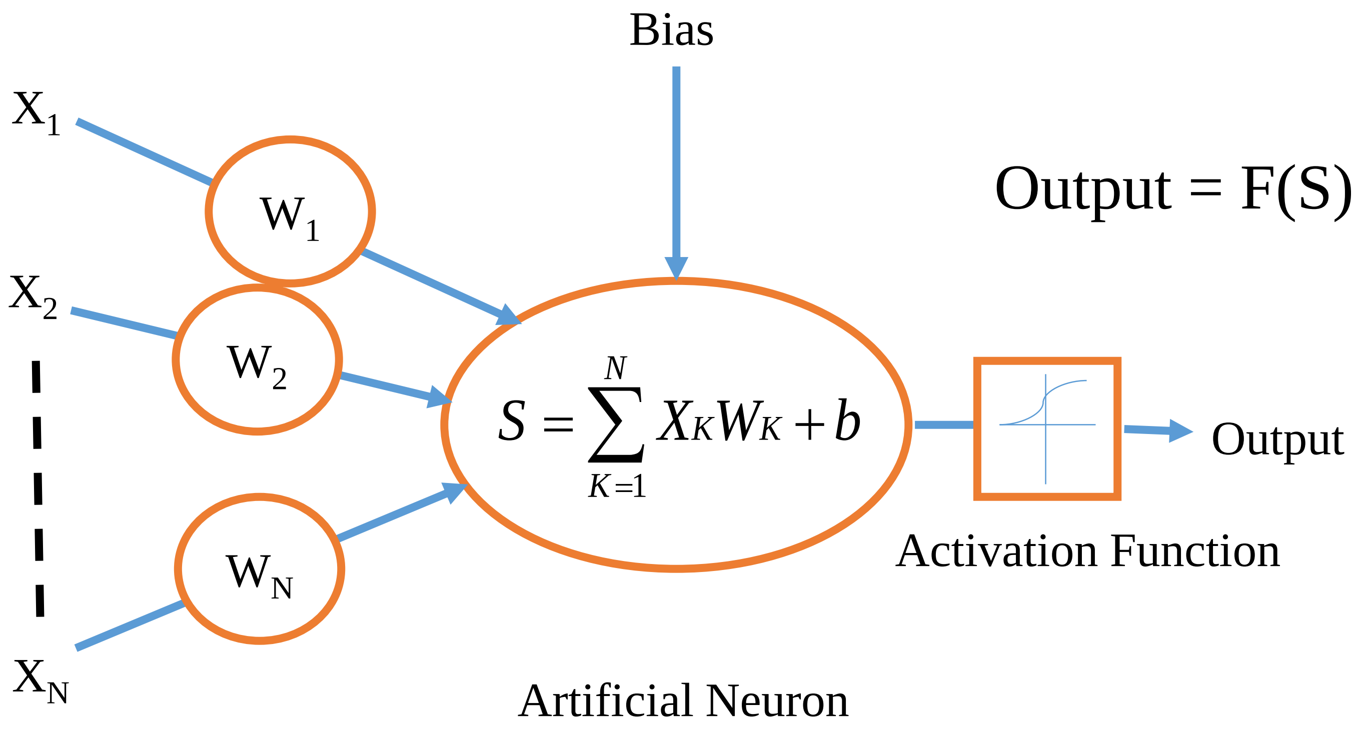
Where Y = Historical Load Vector

X = Input Matrix

β = Relationship Vector

r = Residual Vector

Artificial Neural Network



Mathematically,

$$S = X_1W_1 + X_2W_2 + \ . \ . \ . \ . + X_NW_N + b$$

$$S = \sum_{K=1}^{N} X_K W_K + b$$

Output = F(S) [6]-[9]

Levenberg Marquardt Back propagation (LMBP) Algorithm

- Levenberg – Marquardt Back propagation algorithm is specifically designed to minimize sum of-square error functions,
- $E = 1/2\ [e(j)]^2$
- $W(j+1) = W(j) - (J^T J + \mu I)^{-1} * J^T e(j)$
- $H \approx J^T J + \mu I$ H = Hessian Matrix
- Gradient = $J^T e(j)$
- Very large values of μ (10^{10}) amount to standard gradient descent, while very small values of μ (0.001) amount to the Newton method [8]-[11].

Network consideration for Simulation

- Feed forward neural network use.
- Log sigmoid transfer function is considered as an activation function.
- Hidden neurons vary from 1 to 20.
- For both technique inputs are considered same.
- Analysis carried out with 4 cases
  - Case 1: Without Weather data and with Linear Regression Method
  - Case 2: With Weather data and with Linear Regression Method
  - Case 3: Without Weather data and with Neural Network Method
  - Case 4: With Weather data and with Neural Network Method

Inputs for Simulation

- Hour
- Day of week
- Working day
- Previous Week same hour load
- Previous Day same hour load
- Previous Hour same hour load

- Humidity
- Temperature

Results for Residential Feeder

- Case 1: Without Weather Data LR
- Case 2: With Weather Data LR
- Case 3: Without Weather Data NN
- Case 4: With Weather Data NN

Case	MAE (kW)	MAPE (%)	HN
1	7.636	0.196	
2	48.791	1.251	
3	1.563	0.040	1
4	0.551	0.014	18

Actual and Forecast Load		
Case	Actual (MW)	Forecast (MW)
1	3.9	3.8924
2	3.9	3.8512
3	3.9	3.8984
4	3.9	3.9006

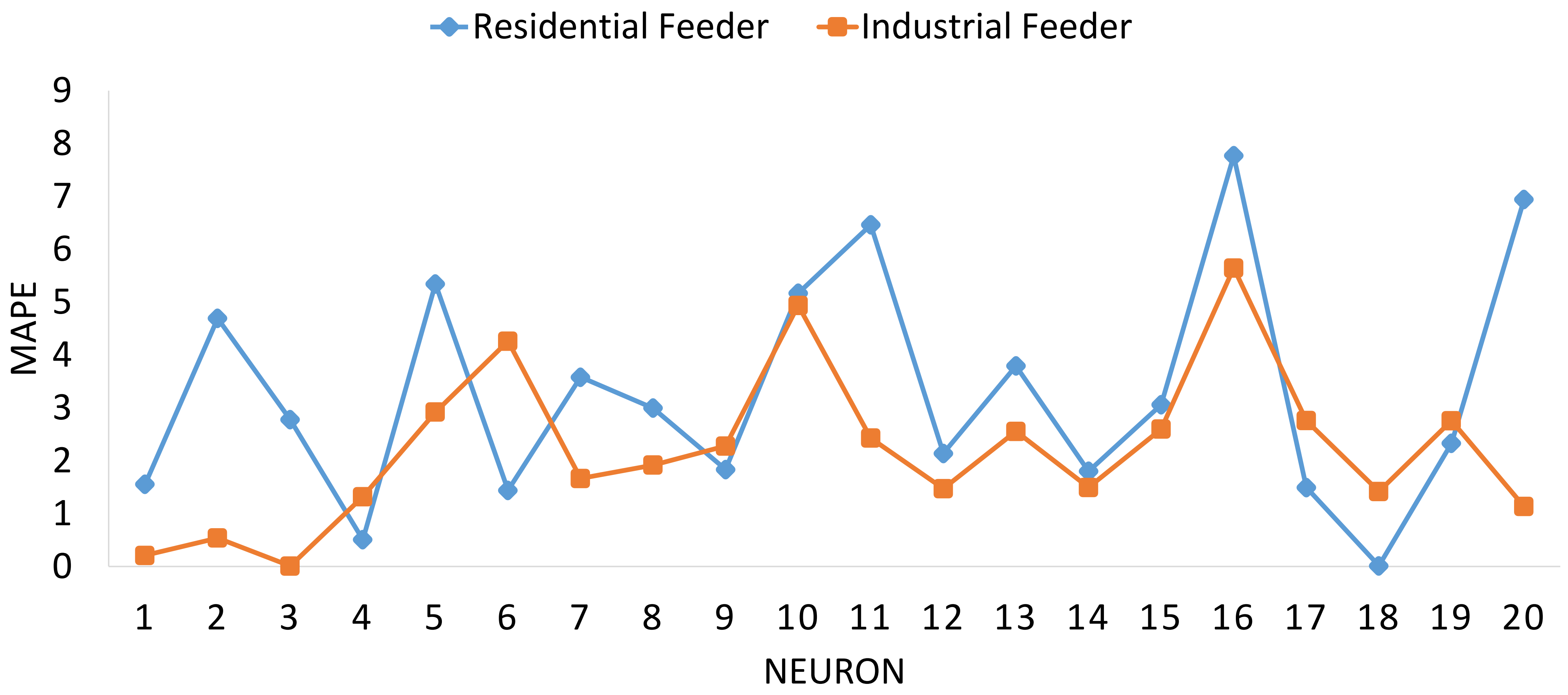
Results for Industrial Feeder

- Case 1: Without Weather Data LR
- Case 2: With Weather Data LR
- Case 3: Without Weather Data NN
- Case 4: With Weather Data NN

Case	MAE (kW)	MAPE (%)	HN
1	10.993	0.458	
2	7.937	0.331	
3	0.894	0.037	7
4	0.217	0.009	3

Actual and Forecast Load		
Case	Actual (MW)	Forecast (MW)
1	2.4	2.4110
2	2.4	2.3921
3	2.4	2.3991
4	2.4	2.3998

Graphical Representation of case 4 (MAPE)



Conclusion

- For Short Term Load Forecasting LR and NN models are developed. Indian systems are considered with and without weather data.
- Accurate number of Hidden neurons is important for STLF Result.
- ANN technique is providing reduction in MAPE with accuracy in forecasted load. The MAPE is reduced up to 0.156 % in residential feeder and 0.42 % in industrial feeder when ANN is used to forecast the load.
- When ANN is used with weather data then MAPE is further reduced up to 0.026 % in residential feeder and 0.028 % in industrial feeder.

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Thank You