A Study on Recent Trends for Load Forecasting with Artificial Intelligence

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Abstract

In order to manage and maintain the power supply in distribution grids. The decision makers in the power grids must predict/forecast the energy demand with the least possibility of error. With the appropriate load forecasting, a stable, continuous and cost-effective power can be supplied to the consumers. Various factors such as load density, geographical factors, population growth, whether etc. can affect the accuracy & effectiveness of the load forecasting. Load forecasting is divided into three types: Long-Term load forecasting [LTLF], Medium-Term load forecasting [MTLF] and Short-Term load forecasting [STLF]. This paper gives an overview for load forecasting and its types. Out of which, STLF plays a very significant role in ensuring that power systems works efficiently, safely and economically. Various STLF techniques were proposed by the researchers that are discussed in literature survey, in order to optimize the distribution in electrical power grids. However, STLF is complex method as its prediction accuracy gets altered by the various complicated and non-linear external parameters. To overcome the drawbacks of STLF, a large number of STLF, MTLF and LTLF methods such as MLR, KBES etc. were proposed. From the literature survey conducted, it is observed that if these methods are incorporated with the artificial intelligence systemsalong with various dependency factors then the efficiency of these systems can further be increased. In the present work, Real time data of Haryana VidyutPrasaran Nigam Limited [HVPNL] has been used. The Forecasting is done using the various parameters and simulating the same using MATLAB and the results thus obtained have been compared with the actual load. The efficiency in Load Forecasting for all the three types i.e. Short Term, Medium Term and Long Term has been increased using the CNN network.

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Keywords

Load forecasting, Artificial intelligence, STLF, MTLF, LTLF, Power systems etc.

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1. Introduction

Load forecasting provides helps to electric utility for making critical decisions such asdeveloping an infrastructure, buying and producing electric power and managing the load requirements. For decades, forecasting has been used for predicting future load demand. This entails accurately predicting electric loads geographical location as well as its magnitudes locations throughout various planning horizon periods [1].It also helps the utility firm to schedule accurately as it knows potential usage or demand for load. Load forecasting has the ability to manage and predict the patterns of energy consumption which in turn helps in monitoring load in future systems [2].Electrical load forecasting is often used for predicting future electric loads based on prior load and weather and current and predicted information on the weather [3].The energy sector members have faced several new problems with rising electricity and oil costs. Different methods are applied to model wind power, electricity markets and energy demand, according to consumer needs [4]. The market risk associated with trading is important as energy costs are highly volatile[5]. Demand forecasting is an essential element in developing any energy planning model, especially in today's power system framework[6]. The load forecasting can be classified into three basic groups, in accordance with the time zone of the planning strategies: Short Term load forecasting [STLF], medium term load forecasting[MTLF], long term load forecasting[LTLF] [7].

Short term load forecasting is a method that generally covers a period of between one hour and one week. Short-term forecasts are used to provide compulsory information on everyday operating structure management and on unit interaction [8].MTLF is an important stage in electric power system that predicts the load for months [9]. In general, long term forecasts span from one year ahead up to ten years and they are often complex in nature due to future uncertainties such as political factors, economic situation, per capita growth etc.[10]. These load forecasting systems helps to locate essential resources such asthe fuels required to run the generating capacity, along with other assets needed to ensure that power generation and delivery to customers is efficient andeconomical. There are a large number of influential factorssuch as historical data, land use, geographical factors, load density, population growth, alternate energy sources,appliances in the area and their age, standard and style of living of the economy, sales data etc. [11]that directly or indirectlyaffect the load forecasting.To overcome issues related to these factors, in the field of Artificial Intelligence (AI), various researchers have proposed number of techniques by fuzzy logic, least square vector machine, neural networks, etc.

2. Literature Review

Management of supply and demandpower has become a vital aspect in the Power sector and several methods have been proposed to overcome limitations of load forecasting, out of which some are discussed here: **KunXie et al. [12],**provided a method for short-run power load forecasting together with the Elman neural network (ENN) and particle swarm (PSO). **K. Park, et al. [13],**a day-ahead prediction scheme for a mixed-use complex is proposed for characteristic load decomposition (CLD)in order to avoid this unfeasibility.**Q. Jiang, et al. [15],**studied power load from Estonia, translate the load information into supervised learning data, and use the long-term recurrent memory (LSTM) network for model training and forecastingwhich determines that LSTM can extract the power characteristic more accurately and precisely.**J. Cui, et al. [16],** created the new LSTM networks and super-pose as the end load forecast to effectively predict and upgrades short-term load prediction accuracy.**Faisal Mehmood Butt et al. [17],**suggested long short-term memory (LSTM), multilayer perceptron, and convolutional neural network (CNN) to understand the connection in the time series to increase the precision of forecasting.**ShwetaSengar and Xiaodong Liu [18],**suggested neural network (NN) power load forecast merged with Levy-flight from cuckoo search algorithmcalled hybrid neural network (HNN), and identified as LF-HNNto maximize the overall energy performance of the device using all available energy resources.**AqeelSakhyJaber et al. [19],**focused on the benefits of an advanced hybrid computational algorithm and proposed GA-PSO method to improve the efficiency of the electrical power system.**Zhao Liu et al.** [20], a forecasting model was proposed by integrating kernel principal component analysis (KPCA) with back propagation neural network to boost the accuracy of midterm power load forecasting.**P. Borthakur and B. Goswami [21],**suggested a hybrid approach that is based on AFTER (Aggregated Forecast through Exponential Reweighting) algorithm to integrate the k-means clustering-Naive Bayes classification algorithm and the ARIMA (Autoregressive Integrated Moving Average) for short term load forecasting.

After carrying out the Literature survey above, it was analyzed that for forecasting power loads several methods were proposed. In traditional models, different optimization algorithms like PSO, GA and so onwere used to improve the accuracyof load forecasting. The main goal of traditional methods was to reduce the difference between the predicted and actual values as much as feasible.However, these methods took a long time to complete estimations and provided inconsistent outcomes for different population sizes which lead to slow convergence rate and also had a risk of becoming stuck at the local minima. In addition to this, these shortcomings affected the performance of the traditional systems.

3. Present Work

To overcome the issues related to traditional techniques, novel techniques based on Convolutional Neural Network (CNN) is proposed in this paper. The CNN is considered as a special neural network that is utilized in power system to process data The CNN is utilized in the proposed technique as it takes less time to train data, generates more accurate results with varying values. In addition to this, CNN works efficiently on large datasets and does not necessitate the creation of an optimization network. The proposed model workson predictingSTLF, MTLF, LTLF.Furthermore, in the suggested work a feature extraction method is adopted so that significant data may be recovered from the large database and the model's time consumption and complexity can be decreased. The proposed model utilizes a dataset that is taken from the real world and is described briefly below:

4. Data Used

The dataset used in the proposed work to predict the loads is taken from Real Time Load data of Transmission Company in Haryana namely, Haryana VidyutPrasaran Nigam Limited (HVPNL).The data sets period will be dependent on the type of forecasting.The different parameters that are taken into consideration are temperature, humidity, wind, transmission loss, holiday, transmission system availability, gross domestic product etc.

5. Methodology

The workflow opted in the suggested model to effectively and precisely anticipate load in the STLF, MTLF and LTLF in this section.
Step 1: After initializing the system, the suggested model would extract data from the available dataset. The suggested model's first phase, after initializing the system, is to extract information from the supplied dataset. The dataset employed in the suggested model was collected from the real world.
Step 2: After the dataset information has been put into the system, the next step is to pre-process the data to eliminate data redundancy.
Step 3: Then, the CNN model is initialized, with various parameters like max epochs, learning rate, the total number of layers, and minimum batch size. Aside from that, a number of other factors are employed, which are shown in table 1.

Table 1
CNN parameters

CNN Parameter	Value
Max Epochs	150
Initial Learn Rate	0.001
Learn Rate Drop Factor	0.1
Learn Rate Drop Period	20
No of Layer	18
Min. Batch Size	2
Input Layer	8 x 8
Conv. Filter Window size	3 x 3
No of stride	2 x 2
No of Pool Size	2 x 2
Dropout Layer Probability	0.2

Step 4: The processed data is then sent to the CNN model for training purposes. The model is trained by supplying it with training data. This data is then used to predict loads in STLF, MTLF and LTLF.
Step 6: At last, by using the MATLAB simulation software, the efficiency of the suggested CNN model is evaluated and validated in terms of RMSE, max and min error, and MAPE. The results are briefly explained in the next section.

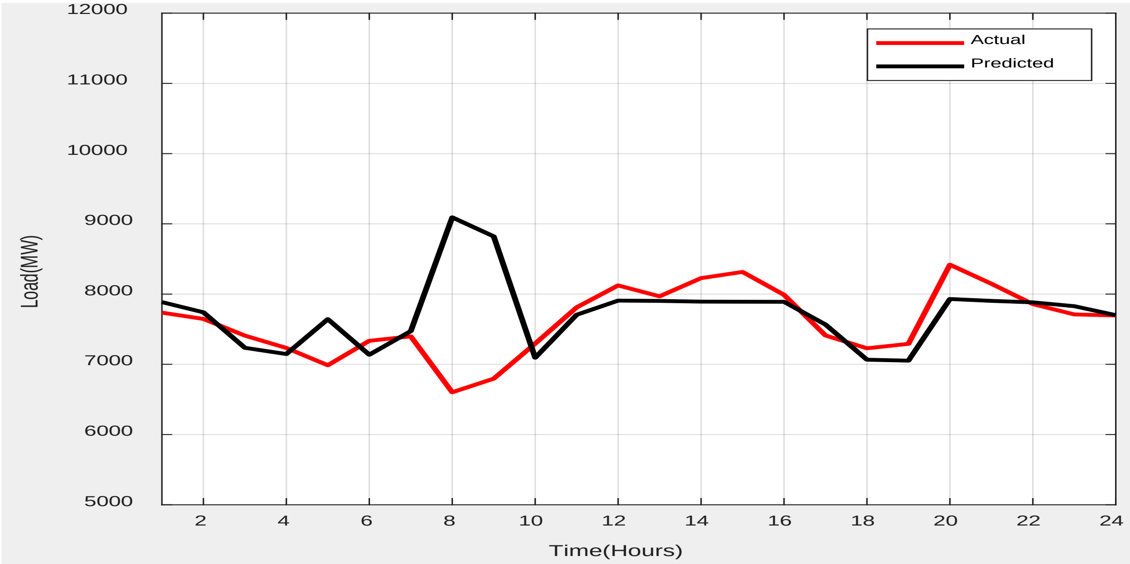
6. Result and Discussion

6.1. Discussion

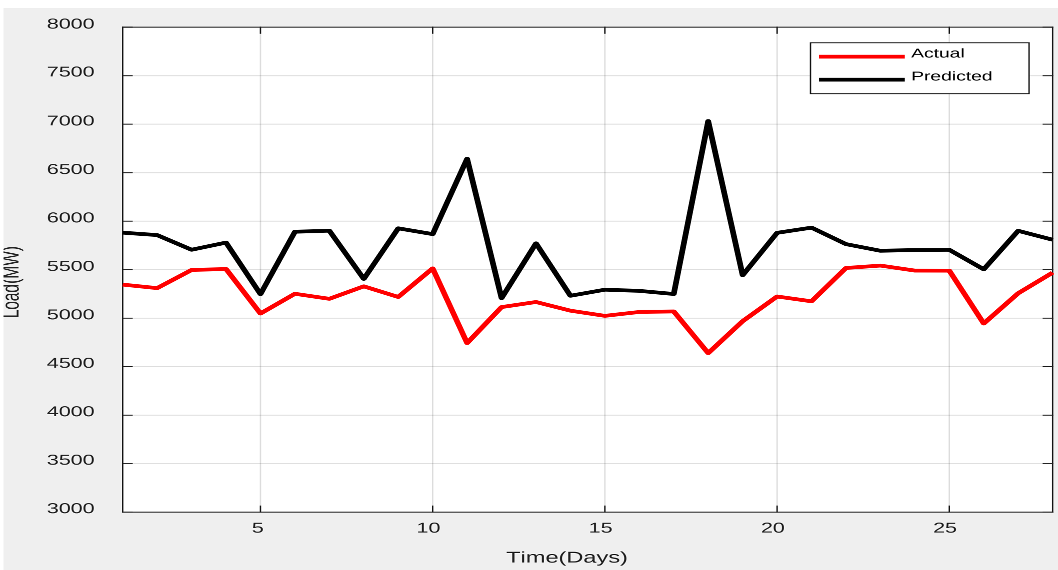
In the MATLAB simulation software, the proposed model's performance is analyzed. The simulation results were obtained by comparing actual and expected load demand, in short, medium, and long-term load forecasting to assess performance in terms of RMSE, Max and Min errors, and MAPE.

6.2. Performance Evaluation

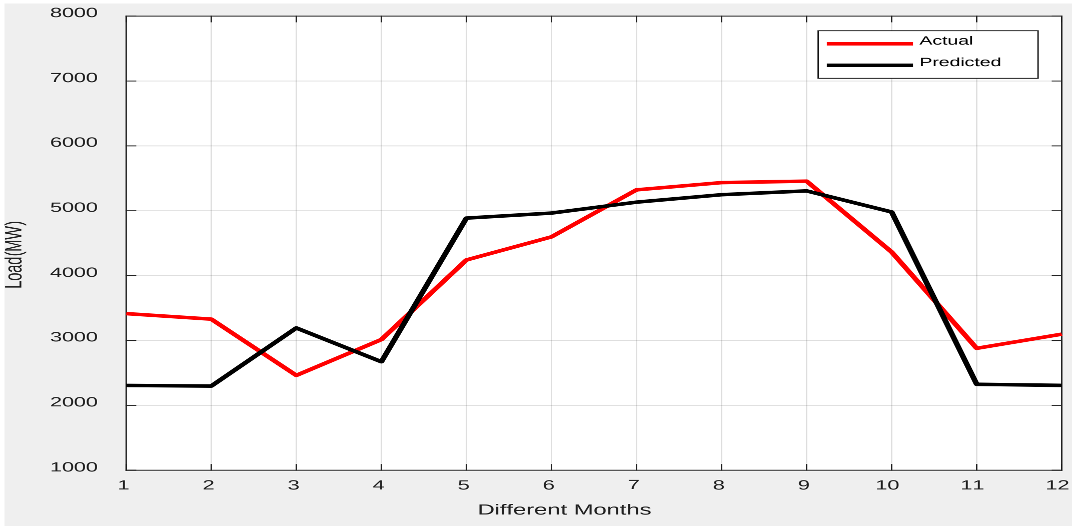
Figure 1 (a), (b) and (c)depicts the load comparison graph derived using the suggested CNN model in terms of real and expected loadsin short term, medium term for long term systems.



(a)



(b)



(c)

Figure 1: Comparison of actual and predicted loads in STLF (a), MTLF (b) and LTLF(c)

Figure 1 (a), (b) and (c) represented the suggested CNN model's comparison graph for actual and predicted load for short term, medium term and long term respectively. After analyzing the graphs, it is observed that in the majority of cases, the predicted values are higher than the actual load values in STLF.However, the anticipated value is lower than the real load demandin some circumstances, but the gap between the actual and predicted values is not huge. Moreover, the projected values are always higher than the actual load value for MTLF, demonstrating the effectiveness of the suggested CNN model. Furthermore, in figure 1 (c), the discrepancy between the projected and actual values is significant in the beginning and end of the graph, but other than that, the predicted valuesare very near/close to the actual value for predicting loads in long term, thus indicating the reliability and efficiency of the proposed CNN model. In addition to this, the effectiveness of the proposed CNN model is depicted in terms of RMSE, Max and Min error and MAPE, whose specific values are given in Table 2.

Table 2

Values of parameters in STLF, MTLF, and LTLF

S. No	Parameter	STLF	MTLF	LTLF
1	RMSE	0.69756	0.71746	0.6389
2	Max error	2.4907	2.3928	1.1.73
3	Min error	0.0040633	0.076681	0.14987
4	MAPE	4.4563	8.4719	19.144

6.3. Conclusion

A novel scheme based on CNN is proposed in the paper foraccurateprediction of the loads in short-term, medium-term, and long-term systems. In MATLAB software, the proposed CNN model's efficiency and effectiveness are displayed. The experimental results were determined in terms of its RMSE, min and max error, and MAPE values for STLF, MTLF, and LTLF.

According to the findings,the Root Mean Square Error (RMSE) in the STLF, MTLF, and LTLF was 0.69756, 0.71746, and 0.6389 respectively. Furthermore, the suggested CNN model's max error and min error values were calculated and found to be 2.4907 and 0.0040633 in STLF, 2.3928 and 0.076681 in MLTF, and 1.1073 and 0.14987 in LTLF respectively.Furthermore, the MAPE values for the STLF, MTLF, and LTLF systems are 4.4563, 8.4719, and 19.144, respectively. The difference between actual load and forecasted load is extremely small in LTLF during peak hours this means that the suggested CNN model is capable of forecasting loads more precisely and effectively even in LTLF.

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