International Journal of Multimedia Data Engineering and Management
Volume 11 • Issue 1 • January-March 2020

User-Based Load Visualization of Categorical Forecasted Smart Meter Data Using LSTM Network

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ABSTRACT

Electrical load forecasting is an essential feature in power systems planning, operation and control. The non-linearity and non-stationary nature of the data, however, poses a challenge in terms of accuracy. This article explores a deep learning technique, a long short-term memory recurrent neural network-based framework to tackle this tricky issue. The proposed machine learning model framework is tested on real time residential smart meter data showing promising results. A web application has also been developed to allow consumers to have access to greater levels of information and facilitate decision-making at their end. The performance of the proposed model is also comprehensively compared to other methods in the field of load forecasting showing more accurate results for the function of forecasting of load on short term basis.

KEYWORDS

Load Forecasting, Long Short-Term Memory (LSTM), Recurrent Neural Network (RNN), Residential Load, Smart Grid, Smart Meter, Support Vector Machine (SVM)

INTRODUCTION

Key role in any power system planning, operation and control is played by load forecasting and thus, the accuracy of load forecasting is crucial for any electric utility. Throughout the evolution of the power system, primary focus has always been load forecasting. The paradigm shift from traditional grid to smart grid, allows the smart grid to provide more intelligent and accurate power services by making use of modern machine learning methods. Power system operations can be enhanced with reliable short-term load forecasting at the consumer end. It can effectively strike the balance between demand and supply, by allowing load-balancing reserve, which in turn would greatly enhance load factor, decrease production cost and hedge market costs. This massive infrastructure development and technological development has also allowed flexibility of load forecasting at the consumer level.

DOI: 10.4018/IJMDEM.2020010103

Nowadays, the electric load prediction is a vital process with applications that are used in various fields because of large demand of power supply and consumption in an electric power houses and in households respectively. So, there is a need to develop model for accurate electricity load forecasting and visualization. The reasons for accurate electricity load forecasting and visualization are:

- Purchasing and generating electric power;
- Transmitting, transferring and distributing electric power;
- Managing and maintaining the electric power sources;
- Managing the daily electric load demand;
- Financial and marketing planning.

Buildings are identified as a major energy consumer worldwide, accounting for 20%-40% of the total energy production. In addition to being a major energy consumer, buildings are shown to account for a significant portion of energy wastage as well. As energy wastage poses a threat to sustainability, making buildings energy efficient is extremely crucial. Therefore, in making building energy consumption more efficient, it is necessary to have accurate predictions of its future energy consumption. Further, demand or load forecasting is crucial for mitigating uncertainties of the future. In that, individual building level demand forecasting is crucial as well as forecasting aggregate loads. In terms of demand response, building level forecasting helps carry out demand response locally since the smart grids incorporate distributed energy generation. Most of the research for prediction of electricity load forecasting concentrate on aggregate load at the system level. However, variation at the individual level also play an important role in determining accuracy of load prediction.

Scope of Research Work

Smart grids are capable of providing more intelligent and accurate power services by making use of modern machine learning methods. Load forecasting has been an indispensable task throughout the development of the modern power system. It can effectively strike the balance between demand and supply that is, provide load-balancing reserve, and would greatly enhance load factor, decrease production cost and hedge market costs. Accurate forecasting of load can help in predicting the demand of electricity load in near future which will be beneficial for an electrical industry in terms of administration and economics. It can also provide recommendations such as when to use electricity throughout a day which further can help in consuming energy more efficiently. It can allow consumers to have access to greater levels of information on their electricity use and facilitate their efforts in managing electricity more efficiently.

Auto Regressive Integrated Moving Average (ARIMA), Radial Basis Function (RBF), K-Nearest Neighbors (KNN) and many more methods have been used for load forecasting (Bianchi et al., 2015; Napoli et al., 2010; Pascanu et al., 2013). However, very few of them have addressed this issue directly for individual customers. The nature of the loads of individual consumers being volatile are considered trivial, however, their issues need to be considered for analysis. Recently, deep learning has been explored as a data analysis tool in many research areas. Deep learning refers to having multiple hidden layers, number of which is relatively more than Feed Forward Neural Networks. It enhances task performance and better abstraction (Zheng et al., 2017). In this regard, long short-term memory (LSTM) recurrent neural network (RNN), introduced by (Kong et al., 2017) proposed some new approaches in the field of sequence learning. The use of LSTM has found various applications like natural language translation (Ryu et al., 2016) image captioning (Bengio et al., 1994; Hochreiter et al., 2001; Gers et al., 2000) and speech recognition (Medsker & Jain, 2001). Majority of the applications handle data classification.

This paper attempts to make a contribution in addressing the issues on short-term residential load forecasting. Comparison is made between Support Vector Machine (SVM) and Long Short Term Memory-Recurrent Neural Networks (LSTM-RNN). On the aggregation level;