International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

ELECTRICITY LOAD AND PRICE FORECASTING USING MACHINE LEARNING ALGORITHMS IN SMART GRID

JIM MATHEW PHILIP, K . KISHORE, M. MADHAN, G.NAVEEN

[1]*Associate Professor, Department of CSE, Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu , India*
[2 3 4]*UG students, Department of CSE, Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu , India*

Abstract—Energy intake prediction is crucial for energy supply companies, allowing thermo adjust pricing and anticipate high-demand periods based on consumer behaviour. Forecasting predicts future values of time series data. Load forecasting estimates energy consumption using customer behaviour data, with short-term forecasts helping to prevent overloads and improve network reliability. The system consists of two models: a network for load forecasting, designed to capture temporal patterns in energy consumption, and an XGBoost model for price forecasting, which is particularly effective with tabular data. A meta-learner combines the outputs of these two models to improve accuracy. Data is pre-processed and organized by key features, such as seasonality. Deployments can take place in real-time using Docker and SQLite3 as lightweight databases. Additionally, a REST API allows utilities to integrate with utility software, while a Grafana dashboard visualizes both historical and real-time forecasts. This system enables energy providers to optimize resource allocation, anticipate peak demand, and manage pricing strategies effectively. Ultimately, it enhances grid management and supports the development of a more resilient energy infrastructure.

I. INTRODUCTION

The Power Burden and Cost Estimating Utilizing AI in Savvy Frameworks tends to the rising difficulties in power network the executives, especially the need to adjust organic market while balancing out costs. In a period described by fluctuating energy requests, the coordination of environmentally friendly power, and unstable market costs, precise estimating is fundamental for energy suppliers' proficient matrix tasks and vital navigation.

This task use AI to give exact, ongoing expectations for power burden and evaluating. Thusly, energy suppliers can more readily oversee assets, expect request tops,and improve evaluating procedures.The task utilizes two specific AI models: model for load guaging, which really catches worldly conditions, and

a XGBoost model for cost estimating, which succeeds at handling organized, even information. Information from verifiable records, atmospheric conditions, and market patterns are cautiously reprocessed, coordinated into key highlights, and contribution to these models. A meta-student then joins the results of these models to upgrade estimating precision.

The last framework incorporates information assortment, pre-processing, model preparation, and constant sending. It is supplemented by a REST Programming interface for utility reconciliation and a Grafana dashboard for visual observing. This venture intends to furnish energy suppliers with information driven experiences, advancing a stronger and maintainable energy framework while propelling the capacities of brilliant matrices.

II. SCOPE OF THE PROJECT

The matrix the executives and cost control difficulties while supporting future energy request transformations and environmentally friendly power coordination its particular plan offers a common-sense answer for feasible energy the board and informed dynamic in a developing scene.

EXISTING SYSTEM

Customary factual techniques, including relapse investigation and time-series models (such ARIMA and remarkable smoothing), are the backbone of the ongoing
methodologies for anticipating energy b4urden and valuing. These techniques have been utilized widely and, in stable settings, can create conjectures that are genuinely exact; in any case, they can't adjust to the rising intricacy of contemporary energy framework. Various factors, including as weather conditions,

market cost vacillations, and the creation of sustainable power, affect these frameworks . Also, standard models are restricted in their viability in unique settings since they oftentimes miss the complicated worldly conditions and nonlinear connections present in power interest and valuing conformation. Moreover, a great deal of obsolete frameworks run on static information and aren't made for constant information investigation, criticism, or ingestion. This limitation creates.LITERATURE SURVEY

Zhang et al., (2019) introduce an innovative model for electricity load forecasting that combines Long Short-Term Memory (LSTM) networks with an attention mechanism. They address the limitations of traditional forecasting approaches, which often struggle with complex temporal dependencies in load data. By utilizing LSTM's ability to capture long- term dependencies and integrating an attention mechanism to prioritize key input features, the proposed model significantly improves forecasting accuracy. Experiments conducted on real-world electricity load datasets demonstrate the model's enhanced performance over conventional techniques. This research offers a robust approach for more reliable electricity demand prediction, contributing to improved energy management strategies.

Le et al., (2020) propose a hybrid machine learning model combining Long Short-Term Memory (LSTM) networks with Extreme Gradient Boosting (XGBoost) to improve load forecasting accuracy in smart grids. LSTM networks capture temporal dependencies within the data, while XGBoost handles facilitate deriving closed-form posterior and predictive probabilities for motion profile of network nodes. The learning algorithm requires around fifty transmission

X.Wang et.al [2019], discusses the importance of effective energy and efficiency of the electricity produced highlighting the limited and irreversible nature of node resources such as power and bandwidth. It introduces a pricing model for energy and bandwidth resources, emphasizing the need to consider factors such as the amount of energy used, initial energy of the node, and remaining when calculating resource prices. The concept of service pricing is introduced, where nodes with higher trust values and smaller ETX values are considered to have better service capabilities, and a service price is inversely proportional to service capacity. The document proposes a cost function design that takes into account the priority of the current

complex nonlinear relationships, enhancing prediction precision. In this model, LSTM extracts features from historical load data,which are then fed into XGBoost for final load predictions. Experiments on real-world smart grid datasets demonstrate that this hybrid model outperforms traditional forecasting methods, underscoring the value of integrated machine learning techniques for advancing
load forecasting in smart grid systems.

Li *et al.*, (2021) introduce a real-time electricity price forecasting method that combines Long Short-Term Memory (LSTM) neural networks with optimization techniques. The LSTM model captures temporal dependencies and complex patterns in electricity price data, while the optimization process fine-tunes model parameters to enhance forecasting accuracy. This hybrid approach achieves precise real-time price predictions, supporting better decision-making in energy markets and smart grid operations. Experimental results indicate that the proposed method significantly outperforms traditional techniques, providing energy providers, regulators, and consumers with a more reliable tool for effective electricity price management. Simulated Annealing (SA) algorithm, which starts with aggressive exploration rates and gradually leans toward more conservative decisions over time by cooling down the temperature parameter. The document also describes a hierarchical modelling approach with conjugate priors for model parameters to

rounds for full convergence,which remains in the millisecond range, while the motion changes for network nodes occur in the second

forwarding type of traffic flows, aiming to ensure that flows with higher priority receive a higher quality of service. Overall, the document focuses on the need for effective resource management, introduces pricing models for energy and bandwidth resources, and discusses the concept of service pricing to quality.

Nguyen and Penaeus et al., (2021) investigate the use of machine learning techniques for enhancing smart grid data visualization to support predictive analysis. They introduce a framework that combines machine learning algorithms with visualization tools to analyze energy consumption patterns, grid behavior, and detect anomalies. This approach utilizes advanced visualization to aid in predicting grid performance, identifying trends, and forecasting future energy demands or potential failures. The authors emphasize how data visualization integrated with machine learning enhances decision-making and operational efficiency, offering grid operators and energy managers real-time insights for improved grid monitoring and optimization.

Mustafa et al., (2023) present a comprehensive survey exploring various methodologies and techniques used in forecasting electricity load and price, with a focus on its essential role in energy management. The authors highlight the importance of accurate forecasting to enhance decision-making in energy management

systems, leading to better resource allocation and grid stability. This survey offers valuable insights for researchers and practitioners aiming to optimize energy management strategies through advanced forecasting practice.

PROPOSED SYSTEM

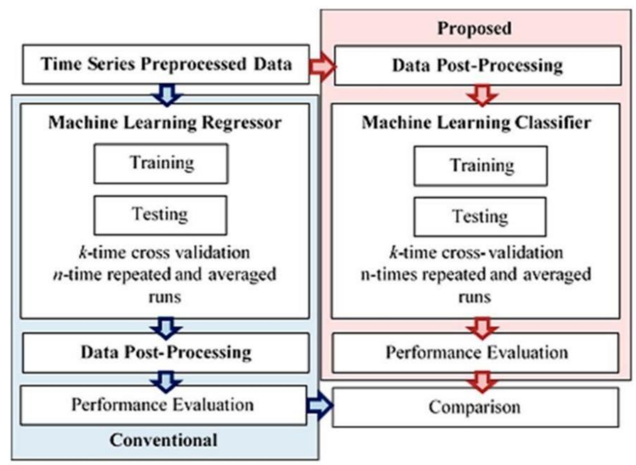
The methodology for the forecasting system involves collecting historical data on load, prices, weather, and market trends, storing it in an SQLite database, and simulating real-time updates. Data preprocessing includes cleaning, scaling, and feature engineering. EDA identifies key patterns, while LSTM and XG Boost models are trained for load and price forecasting, respectively, with a meta-learner combining outputs. Hyperparameter tuning and cross-validation optimize performance, aiming for MAPE below 10% and accuracy above 80%. The system is deployed using REST APIs, Docker, and Grafana for visualization, with continuous monitoring and model retraining for accuracy and adaptability.

The proposed system for electricity load and price forecasting leverages advanced machine learning algorithms to deliver real-time, accurate predictions for energy providers. It integrates multiple data sources, including historical load data, price data, weather conditions, and market trends, stored in a centralized SQLite database.

The system employs preprocessing techniques such as data cleaning, feature engineering, and scaling to prepare the data for analysis. A combination of LSTM (Long Short-Term Memory) networks for load forecasting and XG Boost for price forecasting is used to capture both temporal dependencies and non-linear relationships.

The proposed system collects real-time data from various sources, which is then stored in an SQLite database. The data undergoes preprocessing, including cleaning and feature engineering to create lagged features and rolling means. This prepared data is used to train machine learning models (LSTM for load forecasting and XGBoost for price forecasting). The models are evaluated for accuracy, deployed for real-time use, and continuously monitored for performance, ensuring ongoing improvements based on new data and changing conditions.

SYSTEM ARCHITECTURE



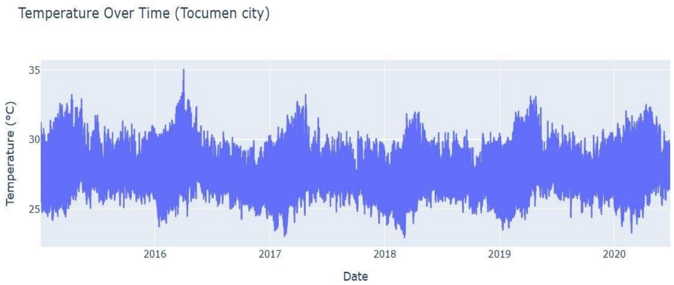
Methodology and comparison of the conventional and the proposed time series

Figure 1: System architecture of the proposed system

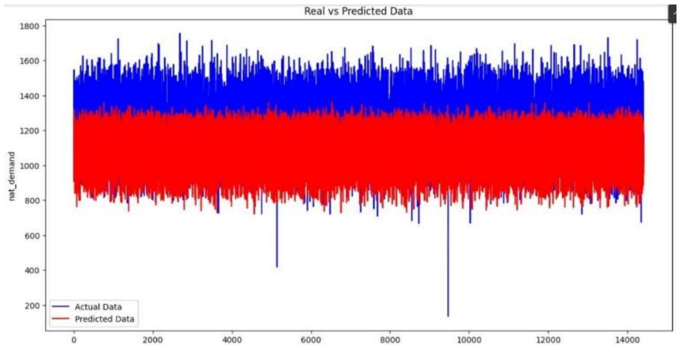
RESULT AND ANALYSIS

Electricity Demand Over Time

Temperature over time


Temperature Over Time (Tocumen city)
35
30
25
Temperature (°C)
2016
2017
2018
2019
2020
Date

Real vs Predicted Data



CONCLUSION

The goal of this research is to forecast the electricity load in certain areas. Thus, this electricity demand forecasting system will lessen the possibility of overloads and short circuits, which further harm electronic devices.The enhanced evaluation pipeline, which includes a meta-learner and additional model evaluation steps, contributes to improved prediction accuracy and reliability. Deployment using REST APIs and Docker enables seamless integration into utility systems, while the Grafana dashboard offers intuitive visualization of real-time forecasts, historical trends, and performance metrics. The results underline the system's robustness, scalability, and potential to optimize energy distribution and pricing strategies effectively. Key insights from performance monitoring indicate that periodic retraining further enhances prediction stability in dynamic environments.

The enhanced evaluation pipeline, which includes a meta-learner and additional model evaluation steps, contributes to improved prediction accuracy and reliability. Deployment using REST APIs and Docker enables seamless integration into utility systems, while the Grafana dashboard offers intuitive visualization of real-time forecasts, historical trends, and performance metrics. The results underline the system's robustness, scalability, and potential to optimize energy distribution and pricing strategies effectively. Key insights from performance monitoring indicate that periodic retraining further enhances prediction stability in dynamic environments.

Future work for the Electricity price and load forecasting includes enhancing the accuracy of fatigue detection algorithms through machine learning advancements and larger datasets. Integration of additional sensors, such as heart rate monitors and environmental sensors, could provide a more comprehensive assessment of real values . The system can be expanded to include features like weather forecasting and real-time communication with management systems. User feedback and data analysis will guide further refinements for improved usability and effectiveness.

REFERENCES

[1] Hossain, E., Khan, I., Un-Noor, F., Sikander, S.S.and Sunny,M.S.H.,2019.ApplicationofBigDataandMachineLearninginSmartGrid,and Associated Security Concerns: A Review. IEEE Access, 7, pp.1396013988.

[2] Kuster, C., Rezgui, Y. and Mourshed, M., 2017. Electrical load forecasting models: A critical systematic review. Sustainable cities and society.

[3] Tong, C., Li, J., Lang, C., Kong, F., Niu, J. and Rodrigues, J.J., 2018. An efficient deep model for day-ahead electricity load forecasting with stacked denoising auto encoders.

[4] Lago, J., De Ridder, F., Vrancx, P. and De Schutter, B., 2018. Forecasting day ahead electricity prices in Europe: the importance of considering market integration. Applied Energy.

[5] Mujeeb, S., Javaid, N. and Javaid, S., 2018, November. Data Analytics for Price Forecasting in Smart Grids: A Survey. In 2018 IEEE 21st International Multi-Topic Conference.

[6] Chen, Y., Kloft, M., Yang, Y., Li, C. and Li, L., 2018. Mixed kernel based extreme learning machine for electric load forecasting. Neurocomputing.

[7] Qiu, X., Ren, Y., Suganthan, P.N. and Amaratunga, G.A., 2017. Empirical mode decomposition based ensemble deep learning for load demand time series forecasting. Applied Soft Computing.

[8] Lago, J., De Ridder, F., Vrancx, P. and De Schutter, B., 2018. Forecasting dayahead electricity prices in Europe: the importance of considering market integration. Applied Energy.

[9] Fan, G.F., Peng, L.L. and Hong, W.C., 2018. Short term load forecasting based on phase space reconstruction algorithm and bi-square kernel regression model. Applied energy.

[10] Wang, J., Liu, F., Song, Y. and Zhao, J., 2016. A novel model: Dynamic choice artificial neural network (DCANN) for an electricity price forecasting system. Applied Soft Computing.