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A Performance Comparison of Machine Learning Algorithms for Load Forecasting in Smart Grid

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Abstract: With the rapid growth of the world's population, global electricity demand has skyrocketed. As a result, effective energy management mechanisms are required. Because energy consumption trends are rather volatile. To develop the optimization and control mechanism, precise energy demand estimation and short and/or long-term forecasting results with higher accuracy are required. As a result, machine learning (ML) techniques, in conjunction with distributed demand response programs, are being used to accurately predict future energy demand requirements. In this paper, the performance of various state-of-the-art ML algorithms such as logistic regression (LR), support vector machines (SVM), naive Bayes (NB), decision tree classifier (DTC), K-nearest neighbor (KNN), CatBoost and Extra Tree is examined. The primary goal of this paper is to present a comparison of machine learning (ML) algorithms for short-term load forecasting (STLF) in terms of accuracy and forecast error. Based on the implementation and analysis, we discovered that, when compared to other algorithms, the DTC produces comparatively better results.
Keywords: Machine learning, logistic regression (LR), support vector machines (SVM), naive Bayes (NB), decision tree classifier (DTC), K-nearest neighbor (KNN), CatBoost and Extra Tree. And ML techniques, evaluation.

I. INTRODUCTION

The tremendous growth of the world economy and population, combined with rapid urbanization, may increase the demand for energy in the coming years. Electricity, a critical energy source, can be generated using a variety of methods, including water, wind, solar cells, fossil fuels, and thermal and nuclear reactors. Furthermore, as our population grows and progresses, so does the demand for electricity, necessitating increased energy production. The primary concerns in energy management (EM) Zhouyang Ren was the associate editor in charge of coordinating the review of this manuscript and approving it for publication. are electricity generation, transmission, and distribution. The current electrical power system (PS) has remained unchanged for several decades, according to scientists. As the population grows, so does the demand for electricity. Traditional PS flaws include a lack of visibility, mechanical switches that result in a slower response time, and a lack of monitoring and power control. Climate change, component failure, energy demand, population growth, demand for fossil fuels, a drop in electric power output, a lack of energy storage, unilateral communication, and a variety of other issues all contribute to the need for new grid technology. As a result, a new grid framework is required to address such issues. The smart grid (SG), a next-generation energy infrastructure, appears to be a critical technology for meeting high-priority demands and improving the quality of modern human life [10]. In comparison, traditional EG provides one-way communication limited to energy users, whereas SG provides extensive two-way communication. Power quality issues in traditional EG are resolved slowly; however, in the case of SG, a rapid self-healing facility is provided. The traditional EG system is more vulnerable to cyber-attacks and natural disasters, and it responds much more slowly. The SG, on the other hand, is far more resilient to natural disasters and cyber-attacks. The traditional EG system responds gradually to system disturbances, whereas the SG detects them automatically. Climate change, component failure, energy demand, population growth, demand for fossil fuels, a drop in electric power output, a lack of energy storage, unilateral communication, and a variety of other issues all contribute to the need for new grid technology. As a result, a new grid framework is required to address such issues. The smart grid (SG), a next-generation energy infrastructure, appears to be a critical technology for meeting high-priority demands and improving the quality of modern human life .In comparison, the traditional EG only allows for one-way communication with energy users.

II. LITERATURE SURVEY

1) B. Zhao, L. Zeng, B. Li, Y. Sun, Z. Wang, M. Shahzad, and P. Xi, ‘‘Collaborative control of thermostatically controlled appliances for balancing renewable generation in smart grid,’’ IEEJ Trans. Electr. Electron. Eng., vol. 15, no. 3, pp. 460–468, Mar. 2020.

2) K. Berk, A. Hoffmann, and A. Müller, ‘‘Probabilistic forecasting of industrial electricity load with regime switching behavior,’’ Int. J. Forecasting, vol. 34, no. 2, pp. 147–162, Apr. 2018.
3) J. R. Cancelo, A. Espasa, and R. Grafe, ‘‘Forecasting the electricity load from one day to one week ahead for the Spanish system operator,’’ Int. J. Forecasting, vol. 24, no. 4, pp. 588–602, 2008.
4) M. Djukanovic, S. Ruzic, B. Babic, D. J. Sobajic, and Y. H. Pao, ‘‘A neuralnet based short term load forecasting using moving window procedure,’’ Int. J. Electr. Power Energy Syst., vol. 17, no. 6, pp. 391–397, Dec. 1995.
5) L. J. Soares and M. C. Medeiros, ‘‘Modeling and forecasting short-term electricity load: A comparison of methods with an application to Brazilian data,’’ Int. J. Forecasting, vol. 24, no. 4, pp. 630–644, Oct. 2008.

III.EXISTING METHODS

The increasing growth of machine learning, computer techniques divided into traditional methods and machine learning methods. This section describes the related works of classification of Load Forecasting in Smart Grid Using Machine Learning Model Detection and how machine learning methods are better than traditional methods. The existing method in this project have a certain flow is used for model development Support Vector Machine (SVM) are used algorithms in existing system. But it requires large memory and result is not accurate.

Disadvantages

- High Complexity
- Time Consuming

IV.PROPOSED MTHODS

Proposed several machine learning models model to classify but none have adequately addressed this misdiagnosis problem. That can be used for this purpose are Stevens Multi Performance Comparison of Machine Learning Algorithms for Load Forecasting in Smart Grid. Also, similar studies that have proposed models for evaluation of such tumors mostly do not consider the heterogeneity and the size of the data Therefore, we propose a machine learning-based approach which combines a new technique of preprocessing the data for features transformation,logistic regression (LR), naive Bayes (NB), decision tree classifier (DTC), K-nearest neighbor (KNN), CatBoost and Extra Tree give the best accuracy techniques to eliminate the bias and the deviation of instability and performing classifier tests based.

Advantages

- Highest Accuracy
- Reduces Time Complexity
- Easy to Use

V. METHODOLOGY

The project utilizes supervised learning models to predict electricity usage patterns and identify potential threats in real-time, enhancing the overall resilience and performance of the Smart Grid system. The system demonstrates how machine learning techniques can significantly improve the Smart Grid’s responsiveness and security. This integration of data-driven intelligence paves the way for smarter energy management and a more secure infrastructure for the future.

A. Technologies Used

The application leverages the following technologies;

Fronted Development: HTML and CSS are used to design a responsive and clean user interface for visualizing forecasting results and user interactions.

Back end Development: Python’s Django framework is used to manage user requests, backend logic, and integrate machine learning components.

Machine learning algorithms are implemented using:

Pandas and NumPy for data preprocessing.

Scikit-learn for traditional ML models (Linear Regression, Decision Tree, KNN, Random Forest).

XGBoost for gradient boosting enhancements.

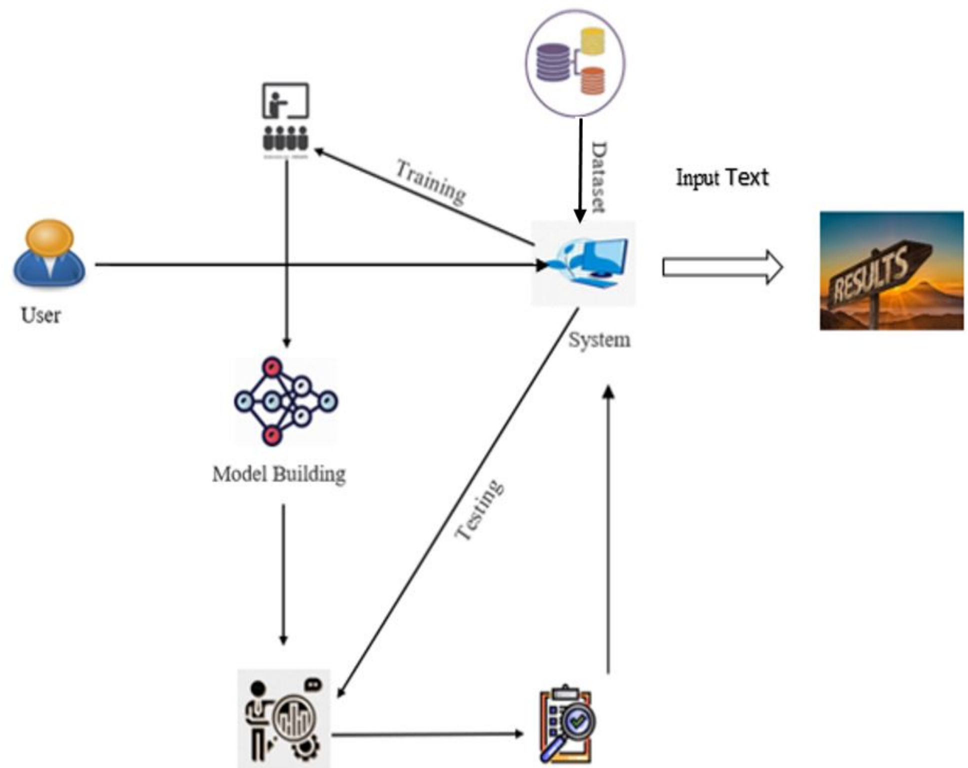
TensorFlow/Keras for LSTM deep learning models.

Database Management: Django's built-in ORM is used to manage structured data efficiently.
User data, uploaded datasets, and model results are stored securely using a connected relational database.

B. System Design and Workflow

Theapplicationisdesignedwithauser-friendlyinterfaceandabackendworkflowtosupportseamlessnavigation.

Architecture Diagram



1) User Registration and Login:
- Users register and log in to access system features.
- Django's authentication system ensures secure credential management.

2) Data Upload and Preprocessing:
- Users upload datasets (CSV format).
- The system performs feature engineering, normalization, and handling of missing data.

3) Model Selection and Training:
- Users choose from a list of models (LR, DT, KNN, RF, XGBoost, LSTM).
- Selected models are trained and validated on the uploaded dataset.

4) Performance Evaluation and Visualization:
- Evaluation metrics such as MAE, RMSE, and R^2 are computed.
- Results are visualized and presented through interactive charts.

C. HomepageNavigation

The homepage includes navigation links for:

1) Home

2) Upload Dataset
3) Select Model
4) Train Model
5) View Results
6) Feedback

D. Database Management

Django ORM manages all application data:

- User Data – Registration and authentication credentials.
- Uploaded Datasets – Historical smart grid data.
- Model Results – Metrics and visual plots from ML algorithms.
- Feedback – User-submitted comments for system improvement.

E. User Authentication and DataSecurity

Django's built-in authentication system ensures secure access.Passwords are encrypted, and session management protects user privacy.Access to sensitive information is restricted based on user roles.

F. Purely Web-Based Application

This platform is designed exclusivelyas a web application, accessible through browsers. It prioritizes simplicityand accessibilityto cater to users.

VI. REQUIREMENTS

A. Software Requirements

Software's: Python 3.6 or high version
IDE: PyCharm.
Framework: Flask, pandas, NumPy and Scikit-Learn

B. Hardware Requirements

Operating system: Windows 7 or 7+
RAM: 8 GB
Hard disc or SSD: More than 500 GB
Processor: Intel 3rd generation or high or Ryzen with 8 GB Ram

VII.RESULTS

1) Home Page:

Here user view the home page of smart grid web application.

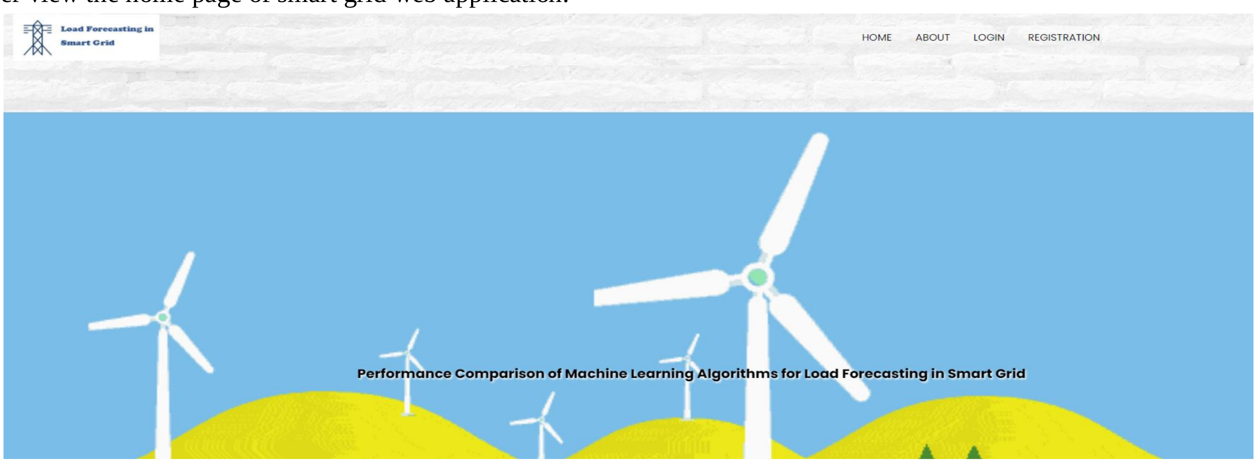


Fig1: Home Page

2) ABOUT:

Here we can read about our project..

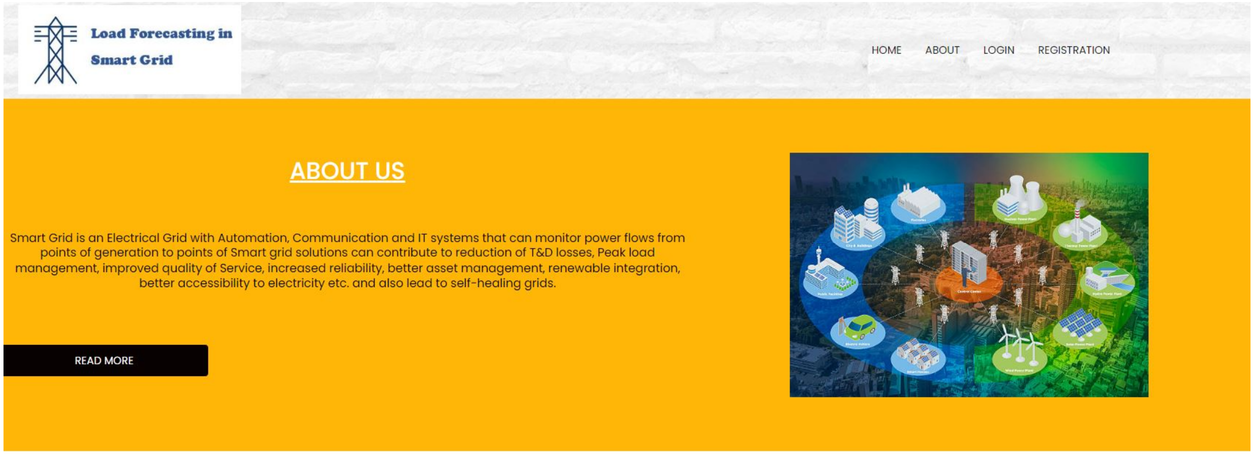


Fig2: About Page

3) Login:

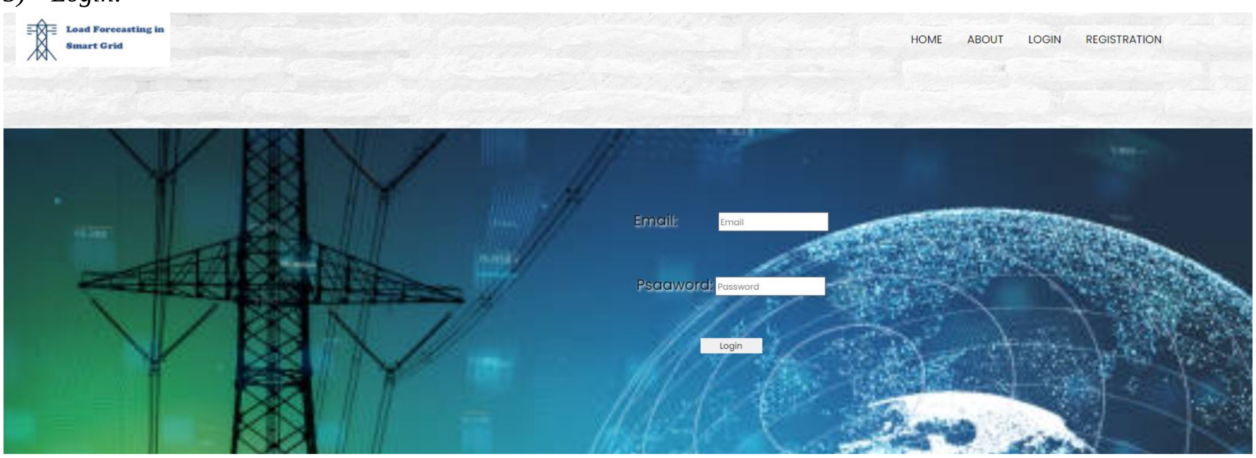


Fig3: Login Page

4) Registration:

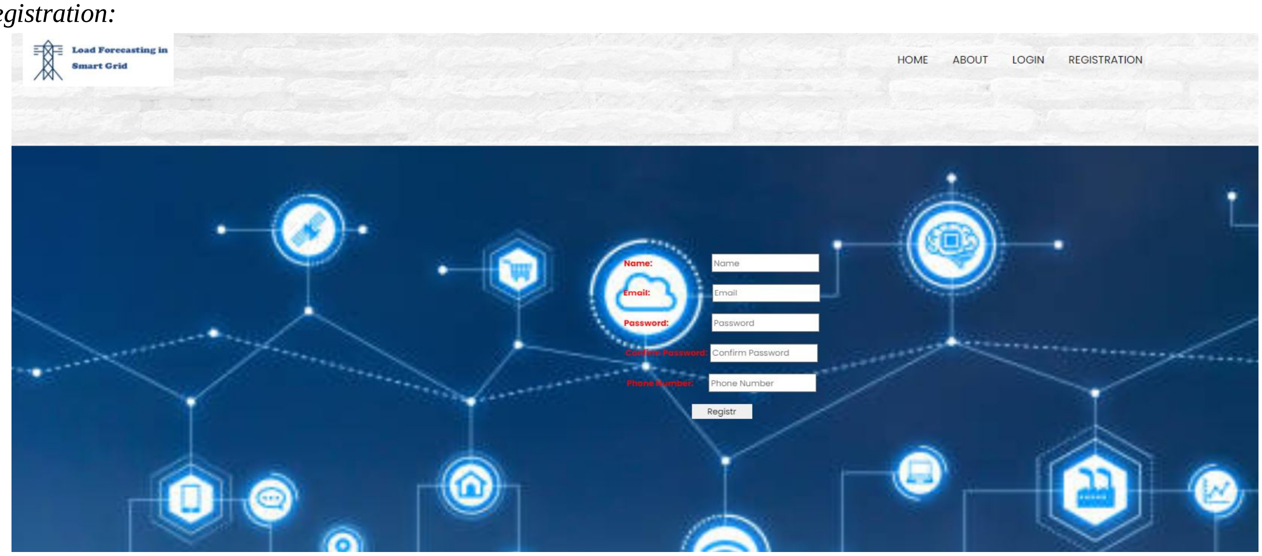


Fig4: registration page

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5) *User Home page:*

Fig5: User Home page

6) *Load:*

In the load page, users can load dataset.

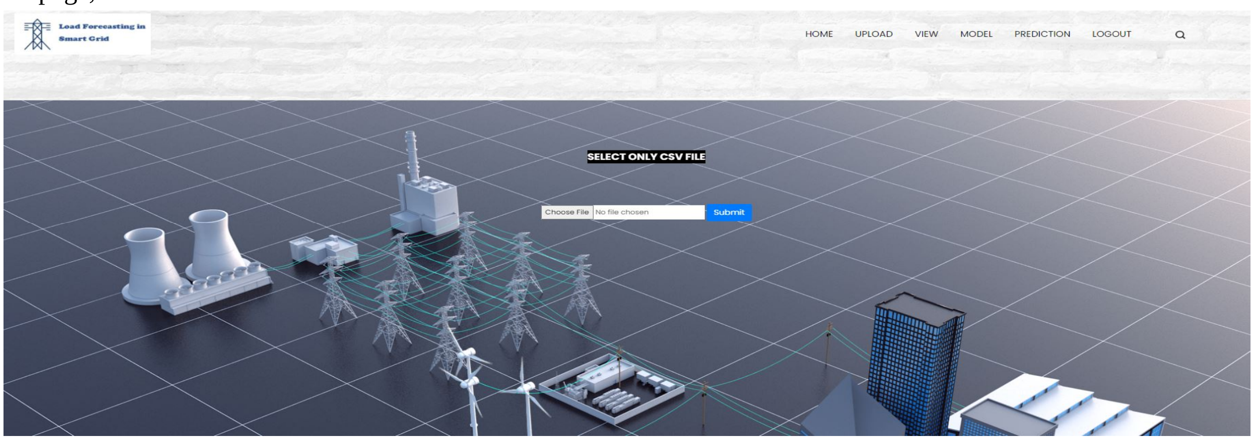
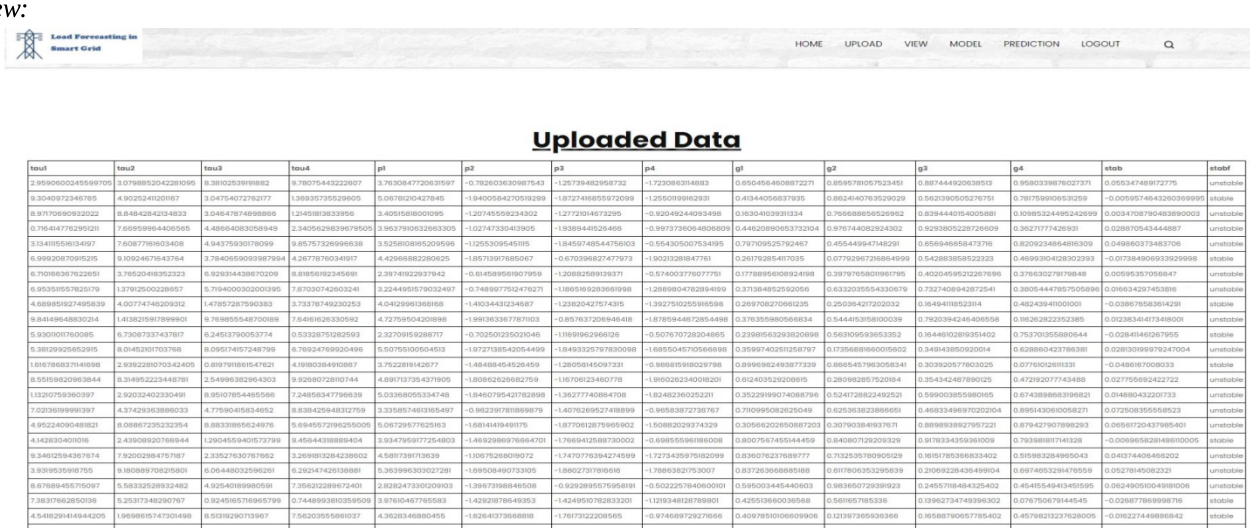


Fig6: Load page

7) *View:*



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9.84149648830214	1.4138215917899901	9.769855548700189	7.64161626330592	4.72759504201898	-1.9913633677871103	-0.857637206946418	-1.8785944672854498	0.376355980566834	0.5444153158100039	0.7920394246406558	0.116262822352385	0.012383414173418001	unstable
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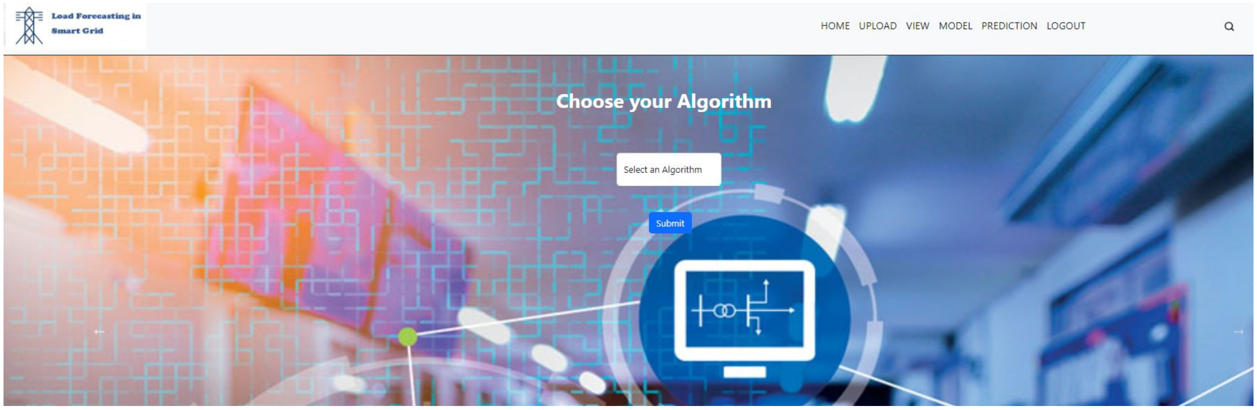
Fig7: View page

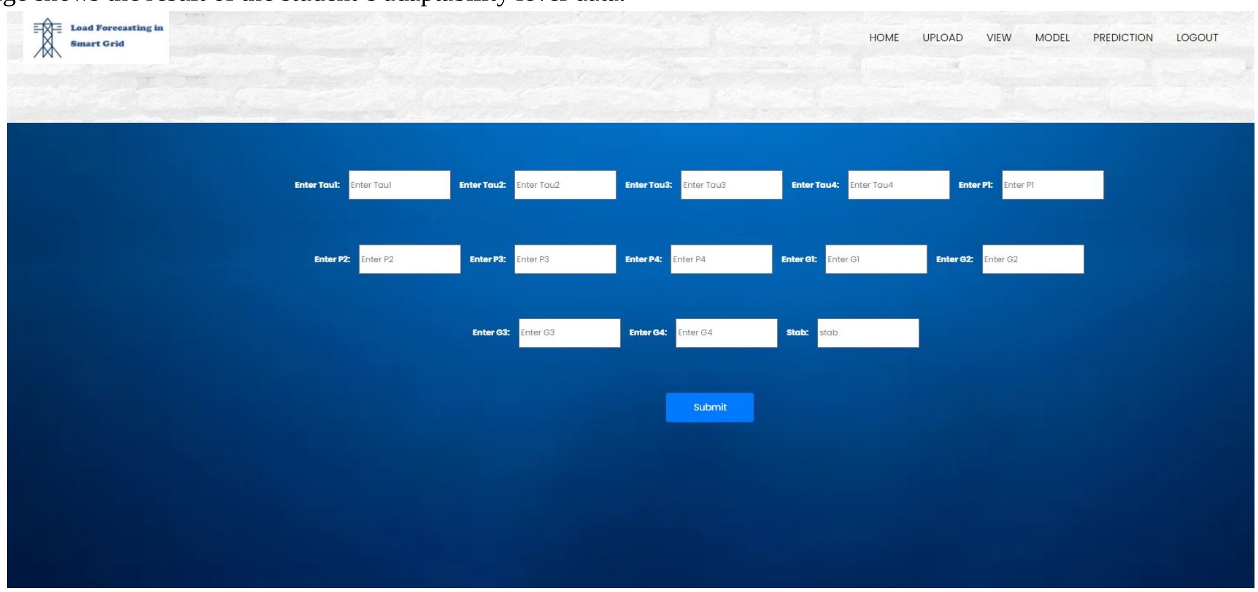
8) Model:

Here we train our data with different ML algorithms.



9) Prediction:

This page shows the result of the student's adaptability level data.



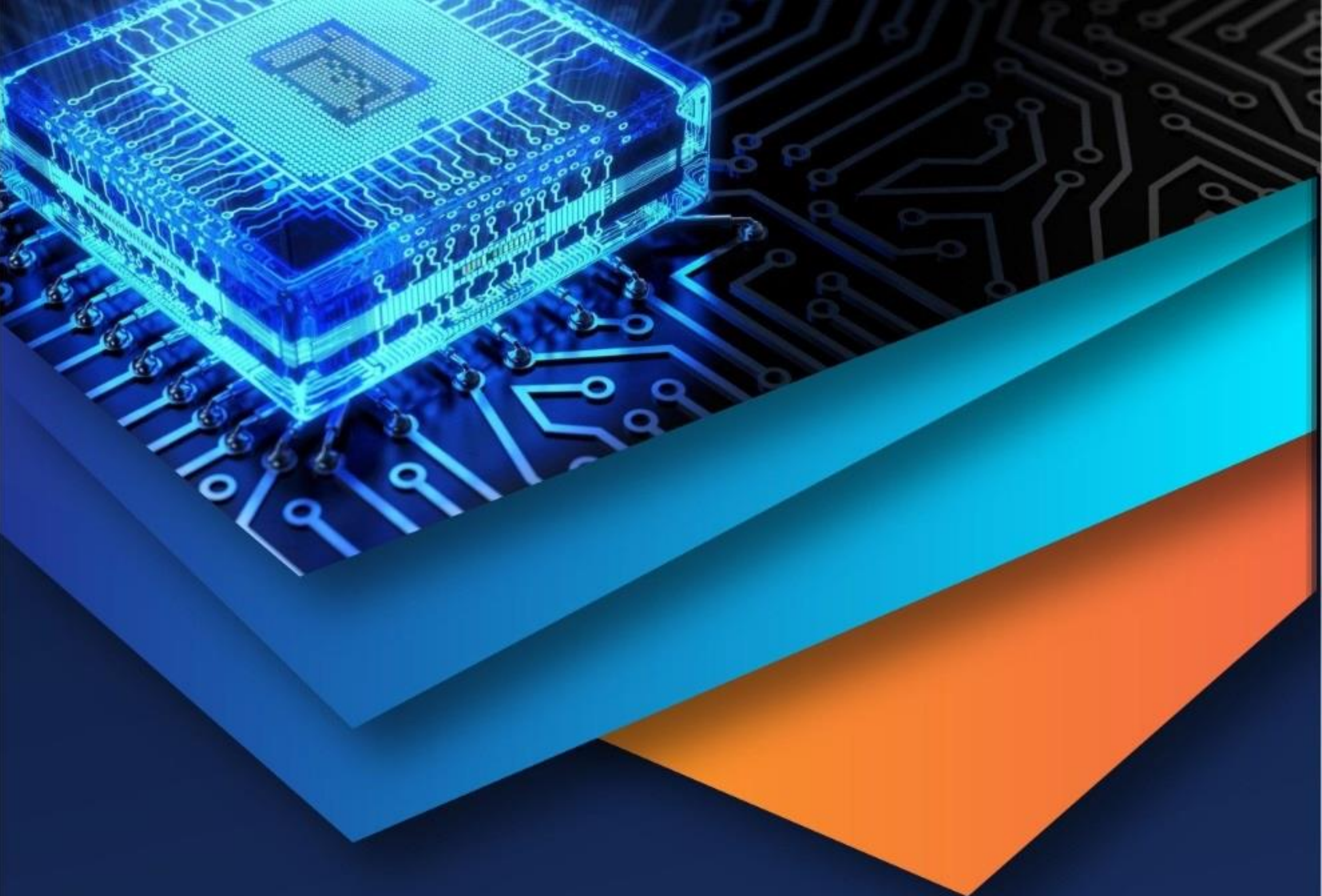
VIII. CONCLUSION

The SG's stability is critical for efficient power distribution to the control stations. ML techniques are crucial in indicating the resilience of the SGs. With the emergence of various Ml algorithms, the primary challenge is to identify the most appropriate algorithm to predict the SG's stability. To accomplish this, a comprehensive survey of state-of-the-art ML algorithms for predicting the stability of SGs was conducted. A novel EDTC model is presented in this paper to predict the stability of the smart grid.The proposed model was tested using the NYISO smart grid dataset. EDTC's performance is compared to that of traditional ML models such as SVM, KNN, CB,ER, LR, and DT. As part of the future work context aware paradigm, dynamic power requirements can be met while also making the SGs more reliable.

REFERENCES

[1] B. Zhao, L. Zeng, B. Li, Y. Sun, Z. Wang, M. Shahzad, and P. Xi, ''Collaborative control of thermostatically controlled appliances for balancing renewable generation in smart grid,'' IEEJ Trans. Electr. Electron. Eng., vol. 15, no. 3, pp. 460–468, Mar. 2020.
[2] K. Berk, A. Hoffmann, and A. Müller, ''Probabilistic forecasting of industrial electricity load with regime switching behavior,'' Int. J. Forecasting, vol. 34, no. 2, pp. 147–162, Apr. 2018.
[3] J. R. Cancelo, A. Espasa, and R. Grafe, ''Forecasting the electricity load from one day to one week ahead for the Spanish system operator,'' Int. J. Forecasting, vol. 24, no. 4, pp. 588–602, 2008.

[4] M. Djukanovic, S. Ruzic, B. Babic, D. J. Sobajic, and Y. H. Pao, ''A neuralnet based short term load forecasting using moving window procedure,'' Int. J. Electr. Power Energy Syst., vol. 17, no. 6, pp. 391–397, Dec. 1995.
[5] L. J. Soares and M. C. Medeiros, ''Modeling and forecasting short-term electricity load: A comparison of methods with an application to Brazilian data,'' Int. J. Forecasting, vol. 24, no. 4, pp. 630–644, Oct. 2008.
[6] R. Hu, S. Wen, Z. Zeng, and T. Huang, ''A short-term power load forecasting model based on the generalized regression neural network with decreasing step fruit fly optimization algorithm,'' Neurocomputing, vol. 221, pp. 24–31, Jan. 2017.
[7] A. Kavousi-Fard, H. Samet, and F. Marzbani, ''A new hybrid modified firefly algorithm and support vector regression model for accurate short term load forecasting,'' Expert Syst. Appl., vol. 41, no. 13, pp. 6047–6056, 2014.
[8] Z. H. Osman, M. L. Awad, and T. K. Mahmoud, ''Neural network based approach for short-term load forecasting,'' in Proc. IEEE/PES Power Syst. Conf. Expo., Mar. 2009, pp. 1–8.
[9] N. Zeng, H. Zhang, W. Liu, J. Liang, and F. E. Alsaadi, ''A switching delayed PSO optimized extreme learning machine for short-term load forecasting,'' Neurocomputing, vol. 240, pp. 175–182, May 2017.
[10] V. C. Gungor, D. Sahin, T. Kocak, S. Ergut, C. Buccella, C. Cecati, and G. P. Hancke, ''Smart grid technologies: Communication technologies and standards,'' IEEE Trans. Ind. Informat., vol. 7, no. 4, pp. 529–539, Nov. 2011.
[11] S. K. Desai, A. Dua, N. Kumar, A. K. Das, and J. J. P. C. Rodrigues, ''Demand response management using lattice-based cryptography in smart grids,'' in Proc. IEEE Global Commun. Conf. (GLOBECOM), Dec. 2018, pp. 1–6.
[12] M. Alazab and R. Broadhurst, Cyber-Physical Security: Protecting Critical Infrastructure at the State and Local level, 1st ed, M. C. Robert and H. Simon Eds. Cham, Switzerland: Springer, 2017, pp. 251–266.
[13] L. Hernandez, C. Baladron, J. M. Aguiar, B. Carro, A. J. Sanchez-Esguevillas, J. Lloret, and J. Massana, ''A survey on electric power demand forecasting: Future trends in smart grids, microgrids and smart buildings,'' IEEE Commun. Surveys Tuts., vol. 16, no. 3, pp. 1460–1495, 3rd Quart., 2014.
[14] A. Rahman, V. Srikumar, and A. D. Smith, ''Predicting electricity consumption for commercial and residential buildings using deep recurrent neural networks,'' Appl. Energy, vol. 212, pp. 372–385, Feb. 2018.
[15] L. Xiao, W. Shao, C. Wang, K. Zhang, and H. Lu, ''Research and application of a hybrid model based on multi-objective optimization for electrical load forecasting,'' Energy, vol. 180, pp. 213–233, Oct. 2017.



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