GUJARAT TECHNOLOGICAL UNIVERSITY
(Established by Government of Gujarat under Gujarat Act No. : 20 of 2007)
ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી
(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક :૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Abstract of the Thesis

Name: Rinku Vipulbhai Chavda

Enrollment No: 179999902002

Faculty: Computer Science

Discipline/Branch: Computer Science

Title of the Thesis: Efficient and Scalable Smart Meter Analytics of Electricity Consumption Patterns and Profiles for Load Forecasting

Abstract

In the eyes of researchers and policymakers, the implementation of electricity consumption and conservation practices within residential households is of the utmost importance due to the considerable amount of electricity consumed by homes. It is vital to address this issue as electricity consumption and conservation efforts can lead to a significant reduction in electricity consumption, thereby reducing greenhouse gas emissions and promoting sustainability. Thus, initiatives aimed at encouraging homeowners to adopt energy-efficient technologies and practices. In the proposed research, machine learning algorithms for pattern recognition and a dimension reduction methodology using Self-Organizing Maps followed by KMeans clustering algorithm on Daily Electricity Consumption (D-EC) data have been applied. Finding similarities using SOMKMeans Clustering Algorithm between (D-EC) data points and grouping them is the aim of Clustering Algorithms. Consumers were divided into four groups and assigned labels depending on their consumption patterns. They were also classed further as either consistent or inconsistent consumers based on how much power they consumed with respect to consistency. A proposed algorithm utilizing the SOMKMeans Clustering Algorithm has been proposed to promote consumer awareness and provide alerts regarding their electricity consumption patterns. The algorithm also offers timely recommendations based on their daily minimum and maximum electricity consumption, aiding in efficient electricity consumption. It would be helpful to discover the effect of different variables to produce consumer electricity consumption patterns and identification of Consumption Profiles by determining the link between daily electricity consumption with housing and the demographic characteristics of households. We have analyzed the relationship and interdependence of input and output features through various methods such as SOMKMeans Clustering Algorithm, Pearson's, Spearman's Rank, and Kendall's tau correlation techniques. Additionally, a statistical analysis employing correlation coefficients, correlation matrices, and internal assessment metrics has been done to ascertain the effect of housing and demographic characteristics on daily electricity usage. The dataset for the year 2013 consisted of 4,942 households used in the experiment, Studies have revealed that various factors such as household routines, demographic information, and the structural attributes of homes have an indirect effect on an individual's everyday electricity usage. Results of the evaluation metrics' scores of SOMKMeans Clustering Analysis with and without regard to household and demographic characteristics exposed that Housing and demographic factors did not have a significant impact on the training process of the classification model. Reason is that every variable, including family structure and age group, was present in each cluster. Daily Electricity Consumption has a 98%, 95%, and 89% success rate in predicting Consumption

Profile according to the ANOVA Test, Chi2 Test, and Mutual Information Feature dependence approaches, respectively.

To simplify the model and improve prediction accuracy for the Consumption Profile of customers, daily electricity usage is an essential feature in calculating the electricity consumption profile of consumers. Recognizing the profile of consumers based on their electricity usage helps electricity suppliers make decisions about their policies and informs consumers about any problems with their regular usage. We compared six classification methods in this study project: KNN, SVM, DT, RF, MLFFNN, and GNB. The performance of classification algorithms was compared using a variety of assessment measures, i.e., Accuracy, Precision, Recall, F1score, AUC, Cohen's Kappa, Hamming Loss, and Mathews Correlation Coefficient to determine which performed the best in categorizing the consumers based on the clustered dataset of daily electricity usage. MLFFNN accurately categorized the electricity consumption of numerous families, with an overall accuracy of 97%. The findings also showed that MLFFNN performed well across all classes, with a F1score of more than 80%. Additionally, the effectiveness of the MLFFNN Classification Model to forecast the Consumption Profile of Consumers has been improved with the implementation of Bayesian Optimization as Hyper Parameter Tuning. After tuning hyperparameters, the MLFFNN-HPT model improved prediction outcomes by 98% overall with class-wise performance exceeding 90% for each metric including Accuracy, Precision, Recall, F1score, AUC, Cohen's Kappa, Hamming Loss, and Mathews Correlation Coefficient.

This PhD Thesis would be useful in to offer an effective strategy for deciding area and region-wise future electricity essentials as well as household-wise consistent and non-consistent consumer information. Hence, the Electricity Consumption Profiles can result from applying Load Forecasting tools.

List of Publication(s):

1. Rinku Chavda, Dr. Sohil Pandya. 2018. "Analyzing Electricity Consumptions Pattern for Profiling and Forecasting-a Review." International Journal of Innovative Research & Studies 8(11): 236–42.
2. Rinku Chavda, Sohil D. Pandya, and Chetan D. Kotwal. 2022. "Electricity Consumption Patterns Using Som-Based Two-Level Clustering of Residential Households." Indian Journal of Computer Science and Engineering 13(1): 93–107 (Scopus Indexed Journal).
3. Rinku Chavda, Sohil D. Pandya. 2023. "Experimenting Sensor-based Effective Energy Saving Module for Household Electricity Consumption", GU - JET (Journal of Engineering and Technology), ISSN 2249 – 6157 (Peer Reviewed Journal).
4. Chavda R, Pandya S, Kotwal C 2023. Influence of Demographic-Household Features on Electricity Consumption to generate Consumption Patterns and Profiles. Indian Journal of Science and Technology 16(35): 2879-2888. https://doi.org/ 10.17485/IJST/v16i35.685 (Web of Science).