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ELECTRICAL LOAD PREDICTION OF CONVENTIONAL BUILDING AFTER IMPLEMENTING BUILDING AUTOMATION

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Abstract
The conventional buildings are the most energy-intensive globally due to the evolution of high-power equipment and devices. All current publications provide various ways to reduce energy losses. The economics and degree of loss reduction of various strategies generally differ, making it challenging to choose one. The only solution that seems to be effective is to replace existing building design with new design. In order to proceed with this solution, ML model are required for the whole building cooling and heating load prediction. Based on which the design of the building can be modify. The focus of this study is to implement ML model for building cooling and heating load prediction. Various model used for this research are DecisionTreeRegressor, K Neighbors Regressor, MLP Regressor, RandomForestRegressor, GradientBoostingRegressor. The results depicted that DecisionTreeRegressor outperformed the other models.
Keywords: Building Automation, Electrical Load Prediction, Cooling and heating load.

1. Introduction

Energy preservation of a conventional building involve a difficult procedure with a large number of different elements that need to be watched, evaluated, and analyzed in a systematic manner in order to discover the highest number of chances for energy reduction. a significant influence on the decrease in energy consumption as well as the cost savings associated with energy in a conventional building. In addition, the project includes as one of its goals the provision of a structure for the execution of an audit in a conventional building, as well as assessment techniques and analyses to bring forth relevant and significant possibilities for energy saving in a way that is easy to put into reality. Any working engineer would be able to use this project work as a reference guide, making it simple for them to conduct an energy audit in a professional capacity at a building as complicated as implementation of automation.

The use of energy by conventional building accounts for anywhere between thirty and seventy percent of the total energy utilized in some nations. The conventional building consumes a substantial quantity of energy in its daily operations. Therefore, whether on a local or global scale, there is a pressing need to devote a significant amount of attention to the reduction of environmental emissions associated with energy use. According to some estimates, this sector is responsible for around 15 percent of the world's overall energy use. Because of the high amount of energy required, this sector of the industry frequently accounts for between fifty and sixty percent of total manufacturing costs. The average amount of electrical energy that a conventional building uses is around 110–120 kWh per tonne of cement produced. It has been shown that this industry can achieve the potential for saving thermal energy in the range of 0.25–0.345 GJ/t, a potential for saving electrical energy in the range of 20–35 kWh/t, and a potential for reducing emissions by 4. 6–31.66 kg/t.

Because of how often they are used, having effective ways of managing equipments is of the utmost importance. A conventional building may have as many as electrical equipments, all of which would have different power ratings. Electrical equipments are responsible for a variety of tasks in a building. These tasks include the movement of fans, the heating and cooling in the building according to weather. In the conventional building, improved control systems for electrical equipments are essential since they use a significant part of the total amount of electricity. Even though the majority of Electrical equipments are of the constant in use, it is normal practice to operate them at partial or variable loads. This is particularly true when considering the load fluctuations that often take place in building.

Before looking into all of these aspects and making any changes in the building, a thorough assessment of energy consumption is required. The same can only be possible through a systematic prediction of heating and cooling load requirement in the building and the same has been the agenda of present research work. In the present research work, the author has proposed to predict the heating and cooling load fir its energy efficiency assessment.

2. Literature Review

A detailed literature review has been conducted based on the different techniques and methodologies used previously by the research for energy efficiency assessment of high-power-need buildings or industries.. This section will give the details of the techniques and methods that have been employed to tackle the current problem area. For example in [1] author demonstrated the process of scenario development in this article. This process involves searching for crucial aspects, identifying individuals along with their activities, positions, alliances, and conflicts, and evaluating seeds of change For the purpose of achieving this goal, interpretive structural modeling was applied to generate direct connection matrices. The formation of fuzzy optimize matrices is accomplished by stacking fuzzy factors; these matrices are then used in the development of stabilized fuzzy indirect connection matrices. Actor's strategies tables are used in the process of conflict and alliance analysis among the players. Article [2] gives an outline of the primary concerns that come up when assessing the environmental impact of industrial raw material consumption, as well as providing examples of energy. In addition, the article contains examples of energy audits. This article covered both the fundamentals of environmental audit as well as examples of real audits that have been conducted. In many contexts, the environmental emissions that result from the consumption of energy (in terms of the fuel type), as well as the environmental emissions that result from processes that are not linked to energy, as well as the environmental emissions that result from processes that are not linked to energy are more key aspects of something like the economic cost of raw materials. Author in [3] emphasis that as a result of its high energy consumption, cement manufacturing is often regarded as one of the world's most energy-intensive businesses. Cement plants often use rotary kilns as well as clinker kilns to prepare their raw materials. The RM can process 82.9 tonnes of materials per hour. The RM was found to be 84.3 % efficient in terms of energy consumption, and its energy efficiency was calculated to be 25.2 percent, for the sake of analyzing and improving the plant's performance. The present approach is proposed as a useful instrument for analyzing energetic and energetic consumption, formulating energy policy, and putting energy conservation measures into action. Similarly in [4] author has conducted a survey on chemical business uses the most particular electricity, followed by the textile industry as well as the fabricated metal processing. According to the findings, the use of liquid fuels contributes significantly to the CO2 emissions produced by the SMI sector. In 1993, the small industrial sector was responsible for about 366,000 tonnes worth of the total 46 million tonnes worth of production that was generated by all manufacturing industries. Further in [5] author’s statistics indicates that the effect of energy audits has an influence on the adoption adopting energy-saving measures. As a consequence of this, efficient legislation need to include quality criteria for energy analysis, auditor's report formats, and obligatory energy audit monitoring. This may be done as part of an effort to expand the applicability of our methodology. In [6] a building simulation programme was used to estimate the savings (Design Builder). In the end, the findings were put through a cost benefit analysis, which found that the payback times for both not upgrading and the most effective retrofitting processes were less than six months. In [7] sustainability has been explored while sustainability initiatives are applied in the cement sector. In [8] author examine the energy needs of a wide range of businesses and to investigate the potential for future reductions in energy usage. This article provides a projection scenario for 2001–2031 for possible catching up in terms of reductions in energy consumption in the aforementioned fields, and it does so under a variety of potential scenarios. The research shows that certain practical methods for enhancing energy efficiency are now being used by these companies. In [9] a brief case study of 3M Corporation is used to demonstrate the actual implementation of environmental technology. Environmental technology' strategic implications for competitiveness are investigated. In [10] research has been focused on a wide variety of policy kinds and nations, however it could only reveal common characteristics. In [11], the impact of major operational and design factors on kiln energy consumption is investigated using numerical experiments. As per results After slaking two of a cement kiln road dust with the highest free lime contents (34% and 37%), the pH was statistically identical to that of the commercial content automatically sample with 87% CaO.. In [12], the study's purpose is to provide scholars a picture of the current state of scientific research as well as to uncover scientific works that could assist business practitioners in energy management. The methodologies and tools were split into three major areas (energy analysis, energy assessment, and energy-saving measures approaches) and the individual results for each category were synthesised using the ISO 50001 framework. Finally, the study discusses outstanding concerns and obstacles, as well as research objectives for the future. Author in [13] examines the function of supplemental services in firms and their potential for DR efforts. There are a number of barriers that prevent the widespread implementation of these programs in certain industries. In [14], an energy efficiency gap has been found as a result of the lack of adoption of energy-saving solutions across industries, according to a recent research. A lack of budgetary resources and "access to capital" were determined to be the most important roadblocks to the adoption of energy-efficient technologies in businesses, according to the study. An insufficient regulatory framework for industrial energy efficiency is also cited as a contributing factor in the report's findings. According to the report, the most common reasons for adopting energy efficiency measures or technologies are "cost savings via lower energy usage" and "threats of growing energy prices." In [15], author examines Nigeria's national energy forecast. The country's energy consumption pattern was analyzed, and potential areas of energy saving in the key economic sectors (industrial, transportation, office and residential buildings) were evaluated.

From the literature review it has been found that, the area of the present research work has been under the scope of improvement. However various approaches have been developed in this. With the same goal author has proposed the present work.

The next section gives a detailed description of the method used to conduct the present research work.

3. Material and Method

For the proposed research work the material and methodology used has been described in the following sections.

3.1 Dataset

The proposed approach aims to create a model for building cooling and heating load prediction The publicly available data was gathered to verify the suggested methodology. Machine learning (DL) methods have been used to simulate this dataset in order predict the load.

The dataset for load prediction contain the conventional building information in term of following parameters.

Input variables are:
relative compactness,
roof area,
overall height,
surface area, glazing area,
wall area,
glazing area distribution of a building,
orientation.
Output variables are:
heating loads, and
cooling loads of the building.

3.2 Machine learning models

There has been two ML models has been used for the present research work. The name are given below.

1. DecisionTreeRegressor,
2. K Neighbors Regressor,
3. MLP Regressor
4. RandomForestRegressor
5. GradientBoostingRegressor.

3.3 Performance evaluation parameters

The following testing parameters have been chosen.

1. Coefficient of determination
2. MSE
3. RMSE

3.3.1 Coefficient of determination

For forecasting the event's outcome, this has been used being a statistical tool to check the variation between two variables.

The Coefficient of determination has been representing by the equation 1.

$$R^2 = 1 - \frac{RSS}{TSS} \quad (1)$$

RSS stand for sum of squares of residuals

TSS is total sum of squares

3.3.2 **Accuracy**

Accuracy is defining **as** the ratio of correct predicted instances or samples to all instances or

$$\textbf{Accuracy} = \frac{True\ Positive + Tru\quad Negative}{True\ Positive + Tru\quad Negative + Fals\quad Postive + False\ Nagative} \quad (2)$$

4. Results and discussion

In this section the detailed results analysis of proposed ML model on given heating and cooling load prediction dataset has been presented. The results in term of training parameters results and regression with various errors MSE, RMSE has been presented below.

Thermal energy in a building includes the two measurements of cooling load (CL) and heating load (HL), and the HVAC system controls both of these measurements. The HL and CL of the area are calculated by the HVAC system, which creates a comfortable interior climate. In this regard, some studies have compared cosy yet energy-efficient spaces. Estimates of necessary cooling and heating capacity are mostly based on fundamental variables including building characteristics, how it is used, and weather conditions. An accurate evaluation of a building's energy performance (EPB) and the best design of the HVAC system can ensure more sustainable energy use. Even when many nations take these steps, there is still a lot of energy available.

4.1 Results of Correlation Matrix

A Correlation Matrix can be used to more effectively describe the performance of the categorization models. The effectiveness of a classification on a set of train or test data is described by a confusion matrix. Figure1 provides a description of the proposed categorization model's Correlation Matrix.

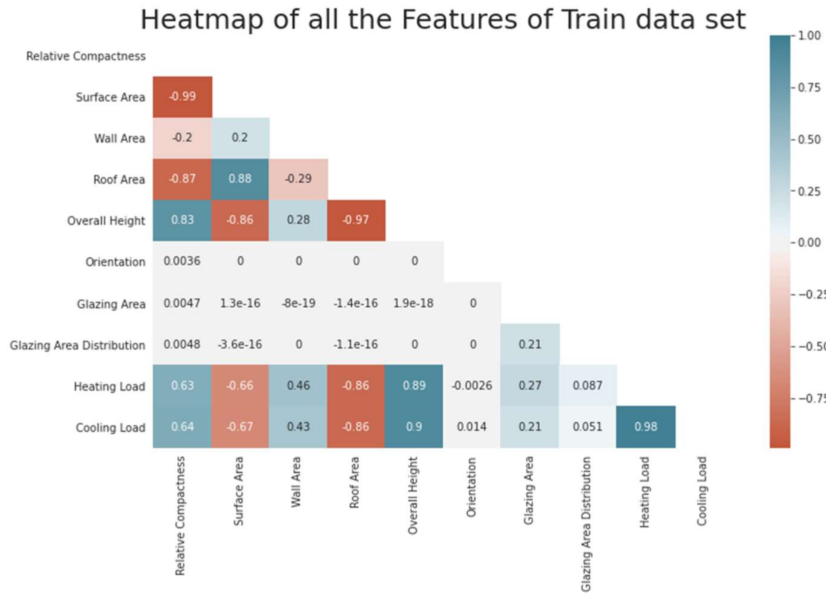

Figure 1: Correlation matrix of train data

4.2 Accuracy Comparison of different models

Here in this section, the performance comparison of different models has been made based on their accuracy. Table 1, show the results obtained for accuracy between different models.

Table1: Accuracy Comparison of different models

	model	train_Heating	test_Heating	train_Cooling	test_Cooling
4	MLPRegressor	0.872329	0.877098	0.809424	0.830457
0	SVR	0.930662	0.910593	0.892578	0.887385
2	KNeighborsRegressor	0.946098	0.904272	0.926993	0.888316
5	AdaBoostRegressor	0.968448	0.964007	0.936370	0.933946
1	DecisionTreeRegressor	1.000000	0.997223	1.000000	0.950263
3	RandomForestRegressor	0.999492	0.997454	0.995555	0.965203
6	GradientBoostingRegressor	0.998173	0.997641	0.979423	0.976044

From this section it has been observed that, the GradientBoostingRegressor outperformed other models.

4.3 R-Squared result of best model

Here in this section R-Squared results for best model is given below.
R-Squared on train dataset=0.9986725239252359
R-Squaredon test dataset=0.9915762746604587

5. Conclusion

The primary goal of this project is to examine how much energy has been used in the coventional building. The goal of the energy prediction in term of cooling load and heating loads was to assess the system's energy losses and identify possible areas for improvement. We computed the overall load as well as the energy usage. Different ML model was simulated on the dataset for best results. It has been found that GradientBoostingRegressor outperformed other models.

References

1. J. P. Saxena, Sushil, and P. Vrat, “Scenario building: A critical study of energy conservation in the Indian cement industry,” *Technol. Forecast. Soc. Change*, vol. 41, no. 2, pp. 121–146, 1992, doi: 10.1016/0040-1625(92)90059-3.
2. R. J. Cole and D. Rousseau, “Environmental auditing for building construction: Energy and air pollution indices for building materials,” *Build. Environ.*, vol. 27, no. 1, pp. 23–30, 1992, doi: 10.1016/0360-1323(92)90004-9.
3. Z. Utlu, Z. Sogut, A. Hepbasli, and Z. Oktay, “Energy and exergy analyses of a raw mill in a cement production,” *Appl. Therm. Eng.*, vol. 26, no. 17–18, pp. 2479–2489, 2006, doi: 10.1016/j.applthermaleng.2005.11.016.
4. A. Priambodo and S. Kumar, “Energy use and carbon dioxide emission of Indonesian small and medium scale industries,” *Energy Convers. Manag.*, vol. 42, no. 11, pp. 1335–1348, 2001, doi: 10.1016/S0196-8904(00)00127-8.
5. T. Fleiter, J. Schleich, and P. Ravivanpong, “Adoption of energy-efficiency measures in SMEs-An empirical analysis based on energy audit data from Germany,” *Energy Policy*, vol. 51, pp. 863–875, 2012, doi: 10.1016/j.enpol.2012.09.041.
6. A. Alajmi, “Energy audit of an educational building in a hot summer climate,” *Energy Build.*, vol. 47, pp. 122–130, 2012, doi: 10.1016/j.enbuild.2011.11.033.
7. L. E. RESENDEZ DE LOZANO, “Concreting Sustainability: Renewing the cement industry through sustainability implementation,” *Ethnogr. Prax. Ind. Conf. Proc.*, vol. 2012, no. 1, pp. 102–116, 2012, doi: 10.1111/j.1559-8918.2012.00013.x.
8. M. Dutta and S. Mukherjee, “An outlook into energy consumption in large scale industries in India: The cases of steel, aluminium and cement,” *Energy Policy*, vol. 38, no. 11, pp. 7286–7298, 2010, doi: 10.1016/j.enpol.2010.07.056.
9. P. Shrivastava, “Environmental technologies and competitive advantage,” *Bus. Ethics Strateg. Vol. I II*, vol. 16, no. 1 995, pp. 317–334, 2018, doi: 10.4324/9781315261102-20.
10. K. Tanaka, “Review of policies and measures for energy efficiency in industry sector,” *Energy Policy*, vol. 39, no. 10, pp. 6532–6550, 2011, doi: 10.1016/j.enpol.2011.07.058.
11. R. Saidur, M. S. Hossain, M. R. Islam, H. Fayaz, and H. A. Mohammed, “A review on kiln system modeling,” *Renew. Sustain. Energy Rev.*, vol. 15, no. 5, pp. 2487–2500, 2011, doi: 10.1016/j.rser.2011.01.020.
12. I. B. Dar, A. Z. Khan, and S. Kashif, “Exploring the Marketing Analytics Practices in Cement Industry: A Case Study Approach for a Cement Company Associated with Indigenous Conglomerate,” *Glob. Manag. Sci. Rev.*, vol. V, no. IV, pp. 10–22, 2020, doi: 10.31703/gmsr.2020(v-iv).02.
13. L. De Santoli, “Guidelines on energy efficiency of cultural heritage,” *Energy Build.*, vol. 86, pp. 534–540, 2015, doi: 10.1016/j.enbuild.2014.10.050.
14. R. W. Apeaning and P. Thollander, “Barriers to and driving forces for industrial energy efficiency improvements in African industries - A case study of Ghana’s largest

industrial area," *J. Clean. Prod.*, vol. 53, no. 53, pp. 204–213, 2013, doi: 10.1016/j.jclepro.2013.04.003.

15. S. O. Oyedepo, "Efficient energy utilization as a tool for sustainable development in Nigeria," *Int. J. Energy Environ. Eng.*, vol. 3, no. 1, pp. 1–12, 2012, doi: 10.1186/2251-6832-3-11.