**Title page**:

**Enhancing Intelligent Building Energy Efficiency with Advanced Predictive Modelling: A Comparison of Random Forest and ANN Models.**

- G Venkata Chalapathi Dr Moorthy A

G Venkata Chalapathi,

Research Scholar,

Department of Computer Science and Engineering,

Saveetha School of Engineering,

Saveetha Institute of Medical and Technical Sciences,

Saveetha University, Chennai, Tamil Nadu, India, pincode:602105.

VenkataChalapthiGujjala1150.sse@saveetha.com

Dr Moorthy A,

Project Guide, Corresponding Author,

Department of Computer Science and Engineering,

Saveetha School of Engineering,

Saveetha Institute of Medical and Technical Sciences,

Saveetha University, Chennai, Tamil Nadu, India, Pincode:602105,

MoorthyA.sse@saveetha.com.

**Abstract:**

**Aim:**

Explore the world of advanced predictive modeling as you set out to transform intelligent building energy efficiency. This study compares and contrasts the capabilities of Random Forest and ANN models to push the boundaries of innovation. The ultimate objective is to find the most creative solution that may improve energy consumption prediction accuracy while acting as a lighthouse for redefining sustainability and resource optimization requirements in the ever-changing field of smart building management.

**Materials and Methods:**

To improve intelligent building energy efficiency, we used cutting-edge machine learning techniques, namely Random Forest (RF) and Artificial Neural Networks (ANN). The methodology was implemented on Compact RIO and used real-world data from solar panels and smart building appliances for training and validating the model. For training and testing, the dataset for our hybrid Random Forest and ANN classification model was split 80/20. Combining the results of the two algorithms, SPSS analysis produced 20 values that represented various functional operations. A G power of 0.80, alpha, and a confidence interval (CI) of 0.05 were used to ensure statistical rigor. This method guarantees a solid assessment of the model's functionality.

**Results:**

The Random Forest (RF) approach demonstrated an accuracy rate of 77%, however, the Artificial Neural Networks (ANN) methodology demonstrated remarkable performance with an accuracy rate of 87.29%. This comparison demonstrates the unique advantages and disadvantages of ANN and RF in smart buildings. Although ANN is quite accurate, RF shows resilience when working with large datasets. These results highlight the crucial functions that each algorithm performs in real-world situations and show the possibility for future developments as datasets and technology advance.

**Conclusion:**

In conclusion, the analysis highlights the unique advantages and disadvantages of these algorithms in the context of smart buildings by contrasting the Random Forest (RF) approach, which achieves an accuracy rate of 77%, and the Artificial Neural Networks (ANN) methodology, which achieves an exceptional accuracy of 87.29%. While ANN's exceptional accuracy highlights its effectiveness, RF shows that it can handle large datasets with durability. These results highlight each algorithm's distinct contributions and the crucial roles they play in real-world circumstances. Furthermore, as information and technology advance, the observed contrasts provide opportunities for future developments and aid in the continuous improvement of smart building systems.

**Keywords:**

Keywords: Artificial Neural Networks (ANN), Random Forest, Predictive modeling, Intelligent building energy efficiency, Sustainability, Resource optimization, Smart building management, Compact RIO, Real-world data.

**Introduction:**

Modern research has focused on smart buildings, which are defined by intelligent systems that optimize energy use. A smart building incorporates technology to improve sustainability and efficiency, claims [[Amasyali et al 2021].](https://www.sciencedirect.com/science/article/pii/S1364032121000113) Achieving energy efficiency in smart buildings is essential in the modern world, when resource conservation and environmental issues are of utmost importance. Applications are documented [[Wang et al 2020](https://www.sciencedirect.com/science/article/pii/S0306261920300738)], with successful implementations ranging from cutting carbon footprints to minimizing operating expenses.

It is essential to have a thorough understanding of the state of the field. There has been a noticeable increase in the number of papers about smart building energy efficiency over the past five years in databases like Science Direct and Google Scholar. The extensively cited works of [[Amasyali et al 2021].](https://www.sciencedirect.com/science/article/pii/S1364032121000113)and [[Wang et al 2020](https://www.sciencedirect.com/science/article/pii/S0306261920300738)],] stand out among them. The study by [[Shapi et al 2021](https://www.sciencedirect.com/science/article/pii/S266616592030034X)] in particular sticks out as a superb addition to the area.

Even with the progress made, there is still a significant disparity in resource consumption and prediction accuracy in smart building energy efficiency programs. There isn't a clear-cut answer in the existing studies for precise forecasts and efficient resource use. Our group understands the need to close this gap because we have experience with cutting-edge research. Our study compares the effectiveness of Random Forest algorithms and other independent models with Artificial Neural Networks (ANN) as the primary algorithm for predicting energy usage [Bui 2020](https://www.sciencedirect.com/science/article/pii/S0360544219320651). By doing this, we want to greatly improve smart building accuracy and resource consumption, which will further the larger objective of effective and sustainable energy management.

**Materials and Methods:**

The Department of Computer Science and Engineering at the Saveetha School of Engineering carried out this project at the Saveetha Institute of Medical and Technical Sciences. Using twenty samples, the Random Forest and Artificial Neural Networks (ANN) classifiers were used in this investigation. To predict energy use in smart buildings, the Python compiler was used. We used IBM SPSS software version 26 for the statistical analysis in our study.

**Artificial Neural Networks (ANN):**

A perfect kind of neural network for several uses, such as classification and pattern recognition ([Ekonomou, L. 2010](https://www.sciencedirect.com/science/article/pii/S0959652620325890)). Artificial neural networks (ANNs) are made up of interconnected layers of nodes that are distinguished by weighted connections, which are altered during training to enhance the model's performance. It can handle a wide range of organized and unstructured data types thanks to its flexible architecture. The network is trained to vary weights during both forward and backward propagation to reduce the error between expected and actual outputs.

**Pseudo Code:**

Input: Features and Labels

Outcome: Precision

Step 1: Gather a large enough dataset.

Step 2: Get the pre-processing phase started.

Step 3: For data integrity, eliminate any noise and blank spots.

Step 4: Deal with null values correctly.

Step 5: Extraction of features.

Step 6: Use the retrieved features and matching labels to train the model.

Step 7: Create the categorization model and train it.

Step 8: Set aside 20% of the dataset for testing and dedicate the remaining 80% to training.

Step 9: Classify data, keeping an eye on the target accuracy range.

End of Return Accuracy

**Random Forest:**

Our proposal uses the Random Forest algorithm, a creative idea that aims to make buildings smarter through energy efficiency. Imagine it as a robust and varied forest, where every tree enhances the ecosystem's overall health. In a similar vein, Random Forest leverages a variety of decision-making techniques to process large amounts of data, improving our ability to forecast building energy consumption [Pham et al 2020](https://www.sciencedirect.com/science/article/pii/S095965262031129X). This innovative fusion of nature-inspired technologies hopes to enhance forecasts and open the door to a more eco-friendly and productive future for smart buildings.

**Pseudo code:**

Input: Spatiotemporal Dataset

Output: Accuracy

Step 1: Gather the necessary volume of the dataset.

Step 2: Pre-process the data for analysis.

Step 3: Eliminate any noise or empty spaces to enhance data quality.

Step 4: Handle and eliminate null values to ensure a clean dataset.

Step 5: Utilize the Random Forest algorithm to capture spatiotemporal features.

Step 6: Train the model using the extracted features.

Step 7: Construct and train the classification model based on Random Forest principles.

Step 8: Split the dataset, dedicating 80% for training and 20% for testing purposes.

Step 9: Execute the classification process, aiming for the desired accuracy range.

Return Accuracy

End

**Statistical Analysis:**

Using Python, Google Collab, and SPSS, a statistical study of the suggested machine learning model for smart building energy consumption prediction and scheduling was carried out (IBM 2021). Several features of the structure itself, the surrounding area, and past trends in energy use are the independent factors in this study. The main goal is to create a model that precisely estimates and plans the energy use in smart buildings, with a focus on improving accuracy as a vital performance indicator (input parameters). Here, the accuracy measures—which indicate how well the model predicts and optimizes energy use—are the dependent variables. The primary objective of this thorough investigation is to confirm the stability and effectiveness of the smart building energy management concept.

**Results:**

The present work employs a comprehensive methodology that utilizes advanced predictive modeling to improve energy efficiency and sustainability in smart buildings. To optimize the entire system, two well-known methods are used: Random Forest and Artificial Neural Networks (ANN).

The main goal of the project is to improve prediction models for smart buildings' accuracy, with a focus on sustainability and energy efficiency metrics. The Random Forest and ANN algorithms were chosen due to their ability to handle complex time-series data that is present in the operational dynamics of intelligent buildings.

The study's conclusions show that the selected algorithms' accuracy has significantly improved. An accuracy of 87.29% demonstrates how well ANN can identify patterns and temporal relationships in the data. Concurrently, Random Forest demonstrates an impressive accuracy rate of 77%, indicating its effectiveness in predictive modeling for smart building systems.

To fully assess the results, the analysis makes use of statistical software like SPSS. A component of the statistical analysis is the comparative mean test, which combines independent sample testing and group statistical analysis. For both Random Forest and ANN, group statistics provide mean accuracy, standard deviation, and standard error mean, providing useful information. For example, ANN yields a mean accuracy of 87.29%, where X is the standard deviation and Y is the standard error mean. Random Forest, on the other hand, produces mean accuracy scores of 77% along with standard deviation and standard error mean values.

A graphical illustration of the mean accuracy comparison is shown in Figure 1. The positions of Random Forest and ANN are shown on the X-axis, and the accuracy values that correlate to them are shown on the Y-axis. Based on their mean accuracy values, the graphic illustrates how well ANN (87.29%) and Random Forest (77%) perform in terms of sustainability and energy efficiency in smart buildings.

**Discussion:**

By using Artificial Neural Networks (ANN) and Random Forest techniques in advanced predictive modeling, the study sought to improve sustainability and energy efficiency in smart buildings. The main goal was to improve prediction model accuracy by emphasizing energy efficiency and sustainability indicators in the context of the operational dynamics of smart buildings.

The results of the investigation show that the selected algorithms' accuracy has significantly improved. ANN showed its ability to recognize patterns and temporal correlations in the data with an accuracy of 87.29%. Simultaneously, Random Forest demonstrated an impressive 77% accuracy rate, highlighting its efficacy in predictive modeling for smart building systems.

A comprehensive examination of the data was made possible by the usage of statistical software like SPSS. By combining group statistical analysis with independent sample testing, the comparative mean test provided insightful information. Mean accuracy, standard deviation, and standard error mean were provided by group statistics for both Random Forest and ANN, which helped to provide a thorough comprehension of the results. For example, an ANN with X as the standard deviation and Y as the standard error mean had a mean accuracy of 87.29%. Random Forest, on the other hand, yielded mean accuracy scores of 77% and similar values for the standard deviation and standard error mean.

**Conclusion:**

To sum up, this study improved prediction models for smart buildings with an emphasis on sustainability and energy efficiency by utilizing Random Forest and Artificial Neural Networks (ANN). The results showed notable gains in accuracy, with Random Forest scoring 77% and ANN scoring 87.29%. These results highlight how well the algorithms handle the complicated time-series data that is a part of the operations of smart buildings. The results were confirmed by statistical analysis using SPSS, which demonstrated the algorithms' strong performance. The significance of sophisticated predictive modeling in optimizing intelligent building systems is highlighted by this research, which offers insightful contributions to the advancement of sustainability and energy efficiency in smart buildings.

**Declaration:**

**Conflicts of Interest:**

Regarding this manuscript, the authors have no conflicts of interest.

**Author Contributions:**

Author G Venkata Chalapathi is involved in writing, analyzing, and collecting statistics. Author A Moorthy is involved in the conceptualization, validation of the statistics, and important synopsis of the work.

**Acknowledgement:**

The author would like to thank Saveetha School of Engineering, SIMATS, and Saveetha University for giving them the tools and space they needed to conduct their research.

**Funding:**

We thank the following organization for providing financial support that enabled us to complete the study

1. Dreams plus
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

**References:**

[Pham, A. D., Ngo, N. T., Truong, T. T. H., Huynh, N. T., & Truong, N. S. (2020). Predicting energy consumption in multiple buildings using machine learning for improving energy efficiency and sustainability. *Journal of Cleaner Production*, *260*, 121082.](https://www.sciencedirect.com/science/article/pii/S095965262031129X)

[Olu-Ajayi, R., Alaka, H., Sulaimon, I., Sunmola, F., & Ajayi, S. (2022). Building energy consumption prediction for residential buildings using deep learning and other machine learning techniques. *Journal of Building Engineering*, *45*, 103406.](https://www.sciencedirect.com/science/article/pii/S235271022101264X)

[Wang, R., Lu, S., & Feng, W. (2020). A novel improved model for building energy consumption prediction based on model integration. *Applied Energy*, *262*, 114561.](https://www.sciencedirect.com/science/article/pii/S0378778821002139)

[Shapi, M. K. M., Ramli, N. A., & Awalin, L. J. (2021). Energy consumption prediction by using machine learning for smart building: A case study in Malaysia. *Developments in the Built Environment*, *5*, 100037.](https://www.sciencedirect.com/science/article/pii/S266616592030034X)

[Wang, R., Lu, S., & Feng, W. (2020). A novel improved model for building energy consumption prediction based on model integration. Applied Energy, 262, 114561.](https://www.sciencedirect.com/science/article/pii/S0306261920300738)

[Bui, D. K., Nguyen, T. N., Ngo, T. D., & Nguyen-Xuan, H. (2020). An artificial neural network (ANN) expert system enhanced with the electromagnetism-based firefly algorithm (EFA) for predicting the energy consumption in buildings. Energy, 190, 116370.](https://www.sciencedirect.com/science/article/pii/S0360544219320651)

[Hafeez, G., Alimgeer, K. S., Wadud, Z., Khan, I., Usman, M., Qazi, A. B., & Khan, F. A. (2020). An innovative optimization strategy for efficient energy management with day-ahead demand response signal and energy consumption forecasting in smart grid using artificial neural network. IEEE Access, 8, 84415-84433.](https://ieeexplore.ieee.org/abstract/document/9075174/)

[Amasyali, K., & El-Gohary, N. (2021). Machine learning for occupant-behavior-sensitive cooling energy consumption prediction in office buildings. Renewable and Sustainable Energy Reviews, 142, 110714.](https://www.sciencedirect.com/science/article/pii/S1364032121000113)

[Wang, R., Lu, S., & Feng, W. (2020). A novel improved model for building energy consumption prediction based on model integration. Applied Energy, 262, 114561.](https://www.sciencedirect.com/science/article/pii/S0306261920300738)

**Tables and Figures:**

**Table 1** shows the accuracy comparison between the RF and the ANN. The group's mean accuracy, standard deviation, and the accuracy of the suggested (RF) and existing (ANN) methodologies were investigated to support the results that were previously reported. ANN mean accuracy was 87.29%, and RF mean accuracy was 77.00%.

|  |  |
| --- | --- |
| **RF** | **ANN** |
| 77.00 | 87.29 |
| 76.80 | 87.00 |
| 77.20 | 86.80 |
| 76.50 | 87.50 |
| 77.30 | 86.90 |

**Table 2.** The mean and standard deviation of the group and the accuracy of the existing and proposed methods were 87.098%, 0.234, 84.03%, and 0.178 respectively.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Group Statistics** | | | | | |
|  | **GROUP NAME** | **N** | **Mean** | **Standard Deviation** | **Standard Error Mean** |
| **Efficiency** | **ANN** | 10 | 87.098 | 0.234 | 0.074 |
| **RF** | 10 | 76.96 | 0.178 | 0.056 |

**Bar Graph:**

**Fig. 1.** Bar graph showing the improvement in comparison of energy consumption prediction between the ANN and RF. ANN and RF are represented on the X-axis, and the mean accuracy is shown on the Y-axis.