Enhancing Energy Efficiency with Explainable AI: A Study in Smart Building Heating Load Prediction

Sandra Sačarić, Ivan Simić
University of Zagreb
Faculty of Organization and Informatics
Pavlinska 2, 42000 Varaždin, Croatia
{ssacaric20, isimic21}@student.foi.hr

Abstract. *In the context of increasing environmental concerns and the global imperative to optimize energy usage, artificial intelligence (AI) emerges as a powerful tool for achieving sustainable development goals. However, the complexity of many AI models - often referred to as "black boxes" - poses significant challenges in critical domains such as energy management. This paper explores the application of explainable artificial intelligence (xAI) techniques to enhance the transparency and reliability of machine learning models used for predicting energy consumption in smart buildings. The study focuses on analysing energy inefficiencies in modern residential buildings and aims to support more informed and sustainable decision-making. Using a dataset containing structural and physical features of buildings, a predictive model was developed based on the Random Forest regression algorithm. To interpret and explain the model's predictions, two xAI methods - LIME (Local Interpretable Model-agnostic Explanations) and SHAP (SHapley Additive exPlanations) - were applied. The results demonstrate that both xAI techniques effectively identify the key features influencing heating load predictions, thereby providing actionable insights into energy-saving strategies. Particularly, SHAP offers both local and global interpretability through advanced visualizations, making it a valuable tool for stakeholders aiming to implement environmentally responsible policies. Furthermore, the combination of machine learning and xAI methods fosters trust and accountability in AI-driven energy management systems. This work shows how AI can contribute to environmental sustainability by optimizing energy consumption, while also highlighting the value of xAI as a tool for transparent and responsible AI practices.*

Keywords. Python, prediction model, Random Forest, energy management, xAI, LIME, SHAP

Acknowledgments

This work is supported by Erasmus+ programme KA220-HED – Cooperation partnerships in higher education within project AI2SEP: Developing Talents in Artificial Intelligence to Solve -Disruptive Environmental Problems.

References

Goodfellow, Y. Bengio i A. Courville, Deep Learning. MIT Press, 2016., http://www.deeplearningbook.org.

Rudin, C. *et al.* (2022) 'Interpretable machine learning: Fundamental principles and 10 grand challenges', *Statistics Surveys*, 16(none). doi:10.1214/21-ss133.

Mosavi, A. et al. (2019) 'State of the art of machine learning models in Energy Systems, a systematic review', Energies, 12(7), pp. 1301. doi:10.3390/en12071301.

Muharemi, F., Logofătu, D. and Leon, F. (2019) 'Machine learning approaches for anomaly detection of water quality on a real-world data set', *Journal of Information and Telecommunication*, 3(3), pp. 294–307. doi:10.1080/24751839.2019.1565653.

Ribeiro, M.T., Singh, S. and Guestrin, C. (2016) '"why should I trust you?"', *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, pp. 1135–1144. doi:10.1145/2939672.2939778.

Panda, M. and Mahanta, S.R. (2024) 'Explainable artificial intelligence for healthcare applications using random forest classifier with lime and shap', *Explainable, Interpretable, and Transparent AI Systems*, pp. 89–105. doi:10.1201/9781003442509-6.

Zhou, S. and Mentch, L. (2022) 'Trees, forests, chickens, and eggs: When and why to prune trees in a random forest', *Statistical Analysis and Data Mining: The ASA Data Science Journal*, 16(1), pp. 45–64. doi:10.1002/sam.11594.

J. Priester. „Predicting a building's energy efficiency," Kaggle. (2022). Retrieved from: https://www.kaggle.com/code/jarredpriester/predicting-a-building-s energy-efficiency#6.-Conclusion