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A Machine Learning Approach to Cooling Load Prediction: Integrating Orientation-Specific U-Values with Random Forest Modelling

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Abstract. Accurate cooling load prediction is crucial for the design of energy-efficient buildings. This study proposes the development of a predictive model for cooling load based on the building orientation and envelope (represented by U-values) using machine learning algorithm. A physics-based simulation approach, combined with optimization outputs, was employed to generate data for training and evaluating the predictive performance of the machine learning (ML) model: Random Forest (RF). Key optimization features include the U-values of external walls across different façade orientations (South, West, East, North) and the Roof. Results indicate that South and West U-values exhibit the strongest correlation with cooling load, whereas Roof U-values have the least impact. the tested models RF demonstrated high accuracy, achieving an R^2 score of 0.934. The findings confirm that cooling load is highly dependent on envelope insulation properties, and RF model can effectively predict it based on thermal transmittance characteristics. This study underscores the importance of ML-based methods which significantly reduce computational time which encourage more stakeholders such as designers and policymakers to produce more energy efficient buildings.