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Proceedings of the International Conference on Computing in Civil and Building Engineering
W Tizani (Editor)

# Developing energy efficient building design in machine learning

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*Keywords*: sustainability, machine learning, design, building, energy efficiency, BIM

Building energy simulation programs have been developed, enhanced, and are in wide-spread use throughout the building construction community. Energy modeling programs provide users with key building performance indicators such as energy use and demand, temperature, humidity, and costs. As the A/E/C industry is embracing the technology of energy simulation programs, building designers are currently encountering a large amount of data generated during energy simulations. From our experience, even a simple energy modeling run generates hundreds of pages of data. Examples of building features simulated include the estimated energy costs in terms of building orientation, HVAC system, lighting efficiency and control, roof and wall insulation and construction, glazing type, water usage, day-lighting and so on. Such volumes of data are simply beyond human abilities to identify the best combination of building components (insulation, windows, doors, etc.) and systems (heating and cooling systems, ventilation, etc.) during the building design process. Evaluating building energy modeling outputs clearly overwhelms the traditional methods of data analysis such as spreadsheets and ad-hoc queries.

This paper presents the necessary steps of 1) identification of problems, 2) data preparation, 3) data mining, 4) data analysis, and 5) refinement process for the validation. In order to test the feasibility of the proposed approach, a prototype of the data mining framework was developed and tested with a large dataset generated by energy simulation modeling. In order to establish a framework, case studies were conducted with on-going design projects by the U.S. Army Corps of Engineers (USACE) to perform energy analysis using BIM in early design. Then detailed steps and tools for energy analysis in early design are presented in a framework.

Main objective of this research is to develop a machine learning system which can help project teams discover useful patterns for more energy efficient building design and make efficient decisions to construct energy efficient buildings. This paper utilizes the technology of machine learning which is a data analysis process that combines different techniques from machine learning, pattern recognition, statistics, and visualization to automatically extract concepts, interrelationships and patterns of interest from a large dataset. One can identify valid, useful, and previously unknown patterns of energy simulation modeling, by applying machine learning technology to the analysis of energy efficient building designs.

In order to test the feasibility of the proposed approach, a prototype of the data mining framework was developed and tested with a dataset generated during the energy simulation modeling of a building. Then detailed steps and their results for energy analysis are presented in fifteen different climate zones of the United States.

A big trend in A/E/C industry today is designing sustainable buildings. For the past 50 years, a wide variety of building energy simulation (BES) programs have been developed, enhanced, and are

in use throughout the building energy community. Examples of the BES are BLAST, EnergyPlus, eQUEST, TRACE, DOE2, ECOTECT, and so on. From our experience, even a simple energy modeling run generates hundreds of pages of data. Examples of building features simulated include the estimated energy costs in terms of building orientation, HVAC system, lighting efficiency and control, roof and wall insulation and construction, glazing type, water usage, day-lighting and so on. Such volumes of data are simply beyond human abilities to identify the best combination of building components (insulation, windows, doors, etc.) and systems (heating and cooling systems, ventilation, etc.) during the building design process. Evaluating building energy modeling outputs clearly overwhelms the traditional methods of data analysis such as spreadsheets and ad-hoc queries. This research utilized a data mining approach to analyze a large amount of data generated during energy simulations..

In conclusion, advanced energy modeling techniques allowed us to generate a great amount of energy simulation results. Such volumes of data are simply beyond simple spread sheet or ad-hoc query to identify the best combination of building components during the building design process. From the energy analysis in this paper, we concluded that by using data mining techniques, we could identify patterns from a large amount of data and predict an estimated energy costs in different climate zones by utilizing data mining tools such as Decision Tree, Case Based reasoning and Factor Subset Selection. The Factor Subset Selection was used to determine which attributes are more relevant in predicting the estimated energy cost and its location. Decision Tree identified important patterns in various design alternatives in design process of a building. Lastly, Case Based Reasoning retrieved the most relevant case(s) from previously stored cases and determined its most likely climate zone.

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