

# Using artificial intelligence to deliver optimised energy consumption

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Optimising buildings' heating, cooling, lighting and operation plant performance is a major task of facility managers and operators. Such issues as carbon foot print, cost of operations and standards compliance make it even more important to study building performance. Knowledge gained from building performance information informs decisions regarding building control, operation, maintenance and management. To enhance this process, knowledge discovery through analysis of building performance data in databases presents many advantages.

However, it is difficult for users to explore such data and understand the underlying patterns. This is especially true in buildings which involve complex interactions of ventilation, solar gains, internal gains and thermal mass. To model and optimise buildings' energy consumption, it is necessary to collect data concerning energy consumption and ambient environmental conditions. This research focuses on building energy performance of geothermal, solar and gas energy systems.

Building performance analysis, based on wireless sensor networks (WSNs) data, have found a wide spectrum of exciting applications. The aim of this research is to assess how data mining (DM), especially the Decision Trees (DTs) method, will enable facility management to find valuable data patterns in order to predict room temperature, and lead to potential optimization in building energy and equipment costs. In this paper Weka (University of Waikato 2009) is used for data mining, based on the Knowledge Discovery in Databases (KDD) process. The aim is to predict a single room's comfort level temperature. This technique can also assist to:

1. Make recommendations on the number and types of sensors required to support optimum building intelligence,
2. Carry out comparative analysis to develop generic rules on heating requirements for rooms, zones and buildings.

Classification data mining models have been successfully used for different kinds of data in many areas, such as the support of building control systems. The C4.5 Weka classification model was used in this research to develop these classification rules. Results of this analysis demonstrate the value of data mining to analyse large data sets and prove a useful tool in developing general patterns.

A development of classification data mining models is reported to study building performance data and develop user comfort concepts. Multi-dimensional data of internal and external weather conditions are used to train and evaluate models. Similar data is then used to make predictions and develop classification rules. These rules may be used as precursors to building control algorithms. Under the same constraints, different rooms' performance may be analysed without necessarily maintaining extensive sensing systems.

Different attributes were used in the model to determine their importance in user comfort. By running models under different conditions it was established that wind speed and direction plays an

insignificant part in the room comfort. Data was available for radiant room temperature which was found to be strongly correlated to room comfort and therefore could not be used in this model.

By carrying out this data mining analysis it was possible to generate indications of the general control approaches as feedback mechanisms and modifications to control processes.

Often the heat generated will be wasted or disposed of unless there are mechanisms for predicting its generation and demand constraints. The intelligent control of an actuator system would positively affect the energy consumption of the building.

This research is carried out using data from the Environmental Research Institute (ERI), University College Cork, Ireland. The ERI is a living laboratory giving researchers access to measureable parameters such as humidity, temperature, wind, and carbon dioxide through the building's wired and currently deployed wireless sensors (Menzel et al. 2008). It is a full scale test bed that looks not only at how sustainable buildings can perform but also at the methods used to assess a building's performance. Data is streamed from sensors into a central data warehouse system within the building. The Building was inaugurated in 2007 and provides offices and laboratories for over one hundred researchers and staff. Individual rooms have temperature, carbon dioxide, humidity and light sensors enabling collection of over 17 million records since its inauguration.

The results of this study can be generalised for an entire building or a set of buildings under a single energy network subject to the same constraints. In this research the researchers are cognizant of the fact that the energy utility sector is no longer characterized by a linear value chain – from generation, transmission, and distribution to the final customer. Individual buildings or communities may generate heat/energy beyond their actual demands. This is particularly evident in decentralized energy generation.

According to Assen et al (2009) there are many ways to categorise business models. Two broad classifications focusing on use and function were discussed. These classifications were management decision making (strategic, operational, tactical) and business function. Based on decisions made as a result of the decision making process described in this paper the business model would allow managers decide on the requirements for the use of energy in the most optimal circumstances. The results given in relation to temperature, humidity, CO<sub>2</sub> etc from sensors that determine user comfort and based on decision tree analysis will allow managers determine the optimum usage of energy. This will allow operators fine tune energy equipment to the extent that not only can the information be used for one building but also be used for buildings of the same construction and energy provision. This means that based on the parameters determined by one particular building designers and facility managers can apply a model based on an existing building. This is because the business model for energy savings and provision will be based on the optimal user comfort as decided by a decision tree analysis which in turn decides the business model to employ. Of course this generic model can only be applied to buildings that are like constructed and energy provided for. Naturally should the decision tree process using data mining be applied to buildings of a different construction the business model could be applied based on the construction and energy design parameters of that building.

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