University of Tabriz

Journal of Civil and Environmental Engineering
Volume 54 (2024), Issue 1 (Spring), 36-45

EXTENDED ABSTRACT

Temperature Optimization of Small Smart Residential Buildings Using Fuzzy Inference Rules Considering User Comfort

Yazdan Daneshvar [a], Majid Sabzehparvar [b,*], Seyed Amir Hossein Hashemi [c]

[a] *Department of Civil Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran*
[b] *Department of Industrial Engineering, Faculty of Engineering, Karaj Branch, Islamic Azad University, Karaj, Iran*
[c] *Department of Civil Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran*

Received: 22 December 2021**;** **Review:** 22 February 2022; **Accepted:** 26 February 2022

Keywords:
Smart home, Smart temperature regulation, Expert rules, Energy optimization, User comfort.

1. Introduction

The present article is a model for the optimal management of energy consumption of smart residential buildings by considering the emotional characteristics to ensure the comfort of residents. In order to smarten the indoor temperature based on emotional components (clothing, outdoor temperature, age, body mass index (BMI[1]), humidity and number of residents) by expert system and questionnaire, temperature has been determined as a basis. Mogles et al, in an article entitled Designing Behavioral Interactions of Energy Changes for a Computational Model, investigated creating a structure to fit various types of models and using the simulation model as a tool for evaluation, which affects consumption decisions. According to the results, the presented model can predict the energy saving behavior much better than the existing stochastic models and correctly estimate the effect of the accepted technologies. Also, the analytical model can become a decision-making system in accordance with the change of energy behavior (Mogles et al., 2018).

2. Methodology

This article intends to model the energy consumption behaviors of individuals with the help of the presented expert system. In this article, energy consumption behavior is studied and its statistical population is selected from people of different genders and ages in different environments. The tool used is based on Excel software. According to the purpose of this article, the factors affecting the energy consumption behavior of people in the environment should be identified first and then the existing laws should be extracted and validated by examining the observations. Therefore, the factors affecting consumption are identified. Considering that the main purpose of the research is to present a model of rules with the help of set theory of questions, a summary of set theory of these questions and the basic concepts related to it are described. Then, with the modeling process of the existing theory, it continues with the help of data on the behavior of people in selected environments, and finally, the outputs of the implementation of different models are presented with the help of software. Finally, a comparison between the results of the models in terms of temperature determination and energy consumption and optimization is performed.

Publisher: Vice Chancellery for Research & Technology, University of Tabriz
DOI: 10.22034/CEEJ.2022.49552.2107 Online ISSN: 2717-4077
* Corresponding Author:
E-mail addresses: yazdandaneshvar@gmail.com (Yazdan Daneshvar), msabzeh@gmail.com (Majid Sabzehparvar), hashemi@qiau.ir (Seyed Amir Hossein Hashemi).

2.1. Output temperature validation

For validation of this article, the standard of determining PMD and PPD thermal indices and local thermal comfort criteria have been used. For this purpose, 5 items of validation rules have been validated. The result of this validation is acceptable compliance with the mentioned standard (Determination of PMD thermal indices And PPD and local thermal comfort criteria, 1992).

2.2. Validation result

The results of the validation show that there is only a difference of 0.5 degrees between the existing laws in the second law, and considering that the PMV value is between 0.5 and -0.5, so the expert system and the temperature determined by this The system has worked properly.

3. Modeling and design of fuzzy expert system

Considering that the purpose of this research is to design an expert system and present a model, therefore, a design method for measuring people's satisfaction with optimal temperature with respect to six factors has been presented, which is an expert system that can be used in all residential buildings.

3.1. Membership functions used for emotional indicators

Six factors that determine the emotional characteristics of residents (age, body mass index, coverage, humidity, outdoor temperature and number of users) are included as input. For example, the coverage of different people is divided into five coverage groups (very low, low, medium, high, very high) and its trapezoidal membership function is symbolically shown in Fig. 1.

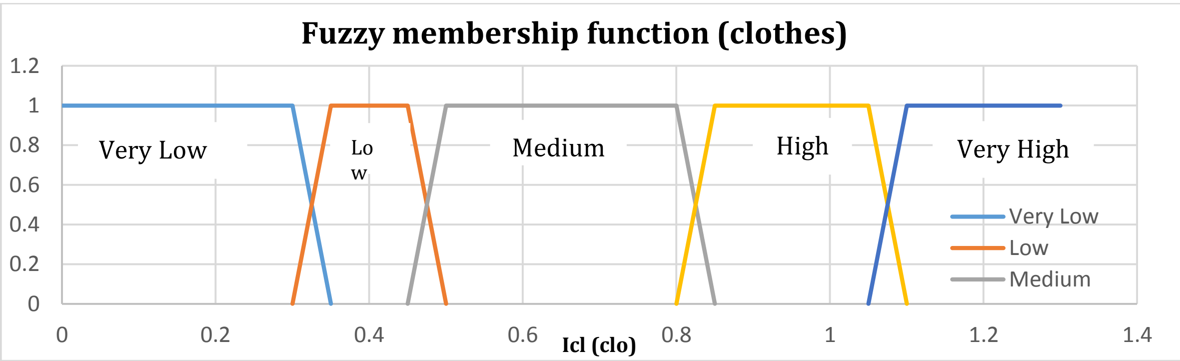

Fig. 1. The coverage trapezoidal membership function

4. Interpretation of results and outputs

According to the expert system designed and using the written rules, an intelligent system for determining the output temperature is written in Excel, which determines the output temperature based on the quantitative and qualitative values of these six inputs according to the rules.

4.1. Compare charts

For better comparison and more detailed review of the results, two graphs, namely the amount of consumption in the temperature setting mode manually and the consumption rate based on the temperature setting in the smart mode using the expert system and dashboard designed in the diagram in Fig. 2 for hot days and in The diagrams in Fig. 3 are for the cold day.

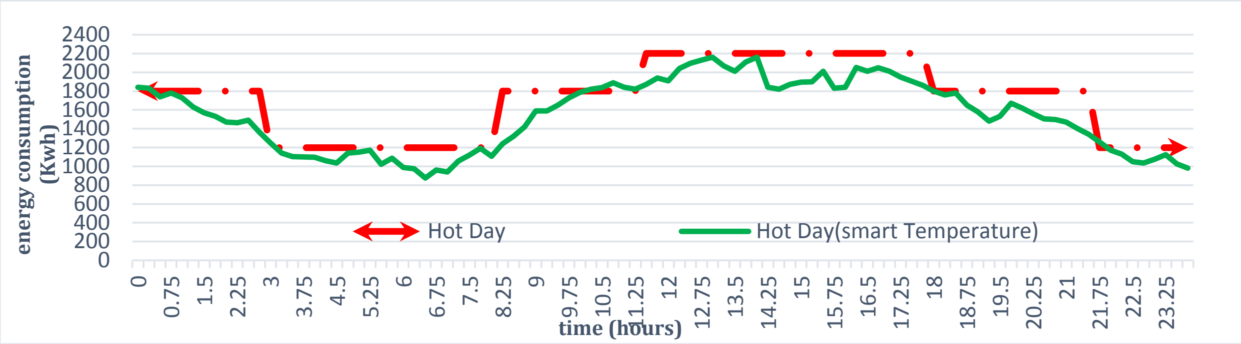

Fig. 2. Comparison of cooling energy consumption charts based on intelligent and manual temperature adjustment

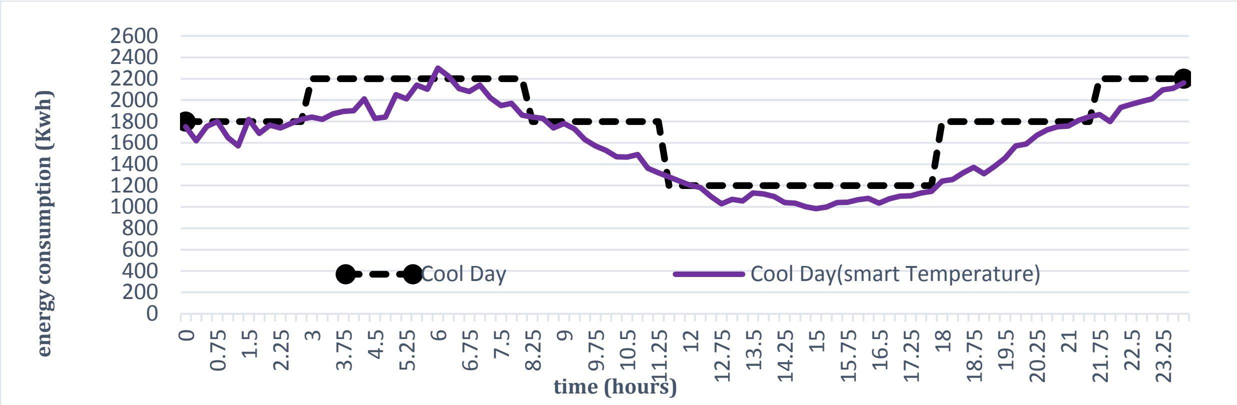

Fig. 3. Comparison of cooling energy consumption charts based on intelligent and manual temperature adjustment

5. Conclusions

By implementing the smart system model, temperature determination shows a significant reduction in energy consumption per hour of the day and night, so that the amount of cooling energy consumption on hot days of the year by reducing the intelligent temperature of the expert system has decreased by about 10.2% compared to manual temperature adjustment. Also, the amount of heating energy consumption on the cold day of the year by adjusting the intelligent temperature of the expert system has decreased by about 9.7% compared to manually adjusting the temperature. Therefore, it can be concluded that using this system designed in the building can save a lot of energy consumption and with a small cost, reduce the amount of energy bills by up to 10% in 24 hours, which is a significant amount in the long run. For future research, it is suggested that other emotional and ethnic characteristics be considered to create the model.

5. References

Standard "Determination of PMD and PPD thermal indices and local thermal comfort criteria", National Standard Organization of Iran, 1992, First Edition.

Mogles N, Padget J, Gabe. Thomas E, Walker I, Lee J, "Computational model for designing energy behaviour change interventions", User Model User-Adap Inter, 2018, 28, 1-34. https://link.springer.com/article/10.1007/s11257-017-9199-9