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Indoor Climate Data Analysis Based a Monitoring Platform for Thermal Comfort Evaluation and Energy Conservation

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Abstract

A monitoring platform is designed, set up and used to store the measured indoor climate data such a temperature and humidity from an air-conditioned classroom to the purpose of thermal comfort evaluation. In addition, the measured current using smart current sensors at the power cables, which supply the air conditioning and ventilation system, was transmitted to the monitoring platform and calculated by soft code for the energy consumption when the air conditioner is switched on. The detail of energy and indoor climate monitoring system can be found in previous publication as well as the monitoring platform. In this paper, the data stored in the monitoring platform are used for the analysis of temperature and humidity distribution in the air conditioned room as well as the thermal comfort based on the predicted mean vote, PMV, with various occupant clothes simulated criteria. Temperature and humidity sensors are installed at various positions around the room provided 24/7 climate monitoring. In order to illustrate the thermal comfort, the comfort index is indicated by the calculation of the predicted mean vote that ranges from -3 to +3 where the zero meant neutral. The results show that the occupants wore long sleeve shirt with jacket and trouser for male, and short sleeve shirt with jacket and full-length skirt for female would reach the thermal comfort at lower temperature than others. In other words, the waste energy could be reduced simply by setting up higher cold temperature cooperated with switching off the air conditioner sometime before the end of the last class of the day, according to the indoor temperature curve analysis, which could save energy for roughly 18%.

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Keywords: Internet of thing; indoor climate; thermal comfort; energy conservation; building

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1. Introduction

Building energy consumption has been concerned by government and private energy organizations because the demand trend rapidly increases due to many reasons but mainly is people comfort. Numbers of new technologies are available every year to satisfaction for comfortable living. Electrical appliance highly consumes energy in all types of building whether private or public. The most energy consuming in the building is the HVAC (Heating, Ventilation and Air Conditioning). To reduce the amount of energy consumption, several strategies are introduced from the building design to the end use. Building energy management required the data collection for planning and controlling the use of energy in building; however, this could have to deal with large number of data in which the analytical procedure could be a challenging for the building service engineers or scientists. Another field of study related to the computer software dealing with big data that is being generated by digital processing from variety of sources, sensors and mobile devices. Thus interpreting data into something meaningful and benefit to the organization will involve handling, storage, good analytical process and skill. The data collection methods were used for energy consumption monitoring, thermal comfort and in use building operation [1]. Techniques were studied to be used to evaluate building performance. It needs to be aware that the occupant behaviour is hard to identify for comfort preference in the large variety. The first and prior study on the thermal comfort was using the Predicted Mean Vote (PMV) index this analytical model was introduced by Fanger [2]. The Fanger's PMV model can be calculated using two sets of variable that are physical variables (temperature, velocity, mean radiant temperature, and relative humidity) and personal variables (clothing insulation and activity level) [3]. The PMV model has been widely used and developed by researchers in the field to identify the thermal comfort of human under the micro climatic of air condition building. The PMV index indicated a numerical scale that ranges from -3 to +3 in which the middle point represents the neutral. Some disagree that the PMV index might not be appropriate to determine the thermal comfort for a natural ventilation building thus the adaptive Predicted Mean Vote (aPMV) model was introduced and could be called an adaptive model. Parallel model used is the Predicted Percentage of Dissatisfied (PPD) [3]. On the contrary, the use of PMV model for the air-conditioned space seems to satisfy with the results of field vote [4]. In non-air conditioned space, the published standard ASHRAE 55-2013 can be used to assessing the thermal comfort conditions by the analytical model and the adaptive model. The comfort index was predicted base on those two models and found that the analytical model was appropriate during air-conditioning operation but not for natural ventilation manner. The adaptive model was more suitable with one exception that was not guarantee on the mix-mode air conditioning. Another study pointed out from the results of the adaptive model that the temperature of 28°C was more preferable than 26°C at the constant airspeed of 0.2 m/s for the natural ventilation aspect [5]. The micro climate data taken from the indoor monitoring system can be used to evaluate the thermal comfort. The hourly power measurement from the power monitoring system is benefit to energy conservation [6, 7].

In the current research, the indoor climate data based a monitoring platform was retrieved for the analysis and evaluation of thermal comfort in an air conditioned space of an auditorium classroom. Then the Predicted Mean Vote (PMV) analytical model was simulated with various types of clothing insulation the occupant wear. The energy consumption related to the temperature setting can be identified for the potential of energy saving.

Nomenclature

M	metabolic rate (W/m^2)
W	effective mechanical power (W/m^2)
I_{cl}	clothing insulation ($m^2 \cdot K/W$)
f_{cl}	clothing surface area factor
t_a	air temperature (°C)
t_r	mean radiant temperature (°C)
v_{ar}	relative air velocity (m/s)
p_a	water vapour partial pressure (Pa)
h_c	convective heat transfer coefficient ($W/m^2 \cdot K$)