IoT Technology with Fuzzy Logic Control Integrated System to Achieve Comfort Environment

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Abstract: Internet of Thing technology is known for its capability to collect and store a massive amount of data for further research development. Researcher widely utilizes this technology as it has become a very convenient tool with a cost-effective advantage. Practically, the calculation is made before determining the best cooling device for every room with temperature, humidity and power consumption being an important element to be taken into account. This paper present the practical approach to acquire data using WSN and IoT technology which then lead to the development of fuzzy logic control of the air conditioner with the aim to reduce its overall power consumption. Classroom equipped with two non-inverter air-conditioners with 4HP each used as a testbed.

1. Introduction

The concern on reducing energy consumption is vital not only to industries player but also to a household as it contributes to big saving on operational cost. Diversify climates and weather play a significant role in designing building structure, shape and its internal space. Cooling and heating load vary depending on the structure of a building, and its designated function [1, 2] and indoor temperature [3] is directly affected by the outdoor environment change [4, 5]. Well-known as the device that consumes high electricity to control temperature does not stop air-conditioner from being widely installed worldwide, especially in the Asia region [6]. This trend will be likely to continue as many studies suggest that high demand of air-conditioner will increase significantly in the near future as temperature specifically in dense cities area is expected to keep on rising [7, 8].

Nowadays, smart buildings seem to be the right answer for global concern on managing energy consumption usage as it comprises intelligent technologies to regulate the energy demand of the building autonomously. The capabilities to provide comfort surroundings at low power consumption lead to a reduction in environmental pollution among the advantage of smart building [9]. The technologies utilized include the Internet of Thing (IoT) and Artificial Intelligent (AI). Monitoring building activities using the sensor network are actively implemented in the research area [10-14]. Mainly, to acquire data heavily related to operational of Building Management System (BMS). Compare to regular operation, up to 40% of energy are expected can be saved on building operational cost by utilizing sensor networks system [15-19].

Currently, the ASHRAE standards and ISO7730 are used in designing the heating, ventilation and air-conditioning (HVAC) system, which are based on the Predicted Mean Vote (PMV) model [20-23]. In this model, temperature setpoint is determined according to satisfaction by the majority. An alternative way of determining the comfort level of the building occupant is based on observation of human behaviour called 'adaptive approach'. This method acknowledges that occupants actively regulate thermal comfort by the opening window [24, 25], changing cloth [26-28], etc.

2. Research Method

Space involves in this experiment is classroom with 41.17-foot length, 21.82-foot width and 10.50 foot high. The classroom is designed to cater 61 occupants at a time, as shown in Figure 1. Air-conditioner sizing is imperative in order to control the ambient temperature of any given space successfully. They are calculating the accurate capacity required on-site valuation since several factors need to be taken into consideration. BTU's (British Thermal Units) is used to measure the power of air-conditioner. Conversion from BTU's into Kw is given by:BTU x 0.0002928 = kW
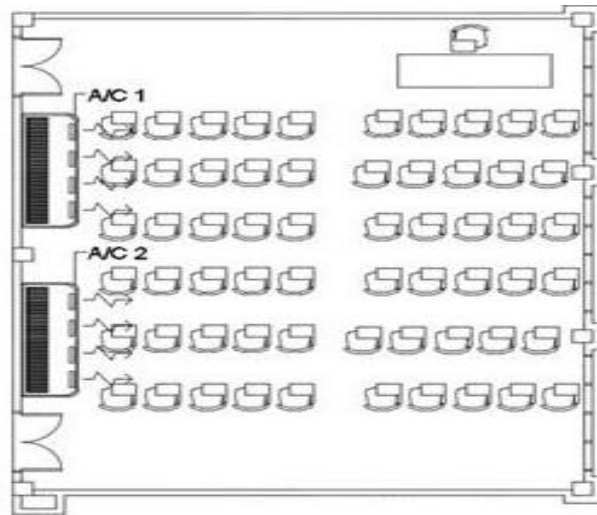
Figure 1. Space cooling of classroom

Figure 2 illustrates the connection made to obtain real-time data of power consumed by the air-conditioner. The system structure requires measurement of power consumption to be taken atthe electrical panel at the riser room. Two current transformers then were clamped at the outgoing cable from separate circuit breaker for both devices. A microcontroller is applied to link all the current transformer outgoing data to the cloud server. The real-time data then is processed and monitored using a computer.
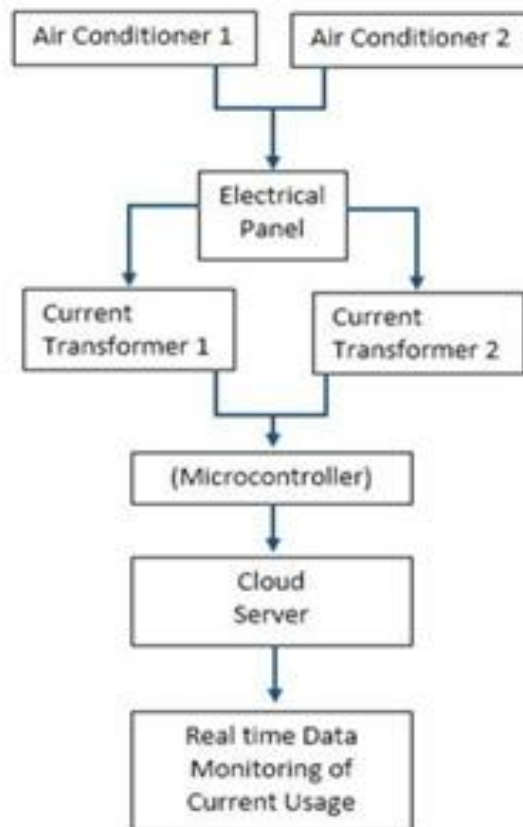

Figure 2. Network architecture

3. Results and Analysis

The type of air conditioner utilized in the experiment have single speed compressor and single tonnage. Figure 3 is the effect of changes in air-conditioner set to the ambient temperature and humidity of the room.
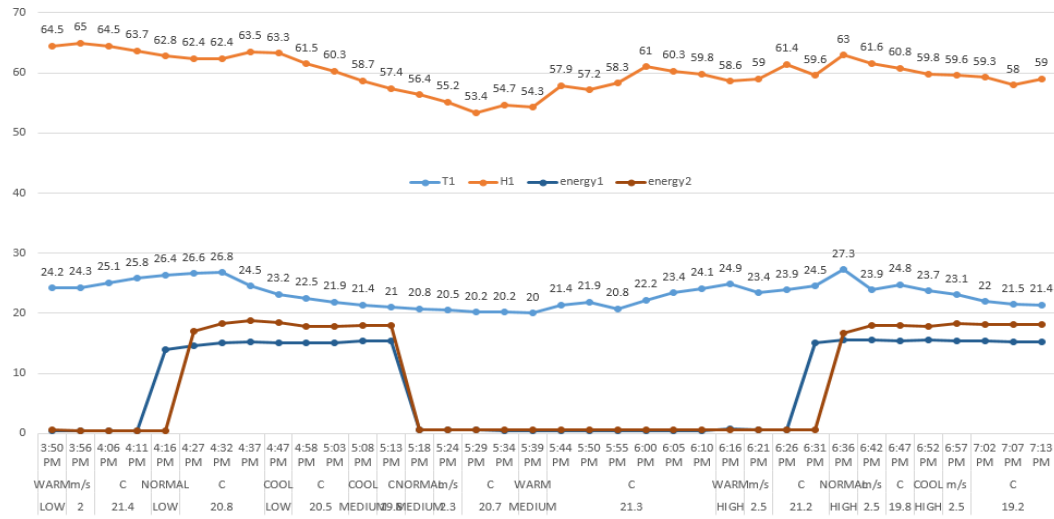
Figure 3. Effects of selecting different switching under dynamic condition

The setting was changed to nine different arrangement with a combination of fan speed and temperature. The graph demonstrates a substantial differencein energy consumption between the cold and warm setting of temperature. Throughout the experiment, the lowest reading is 20°C with 54.3% humidity, and the highest recorded temperature is 27.3°C at 63% humidity with initial ambient temperature measured at 24.2°C with 64.5% humidity. The lowest reading of temperature obtained at minimum used of electrical energy after the air conditioner has worked at high capacity to cool down the temperature during the start of the experiment.

3.1. Overall Tabulated Data

Table 1. Average Wind Speed in m/s

Air Temp /Fan	Low	Medium	High
Warm	2.0	2.3	2.5
Normal	2.0	2.3	2.5
Cool	2.0	2.3	2.5

Table 2. Average Cool Air Temperature in °C

Air Temp /Fan	Low	Medium	High
Warm	21.4	21.3	21.2
Normal	20.8	20.7	19.8
Cool	20.5	19.8	19.2

Table 3. Average Current Flow in Ampere (A)

Air Temp /Fan	Low	Medium	High
Warm	0.5	0.6	0.7
Normal	16.5	16.8	17.0
Cool	17.8	18.0	18.3

The average reading of wind speed and initial air temperature blowing out from the air-conditioner shown in Table 1 and Table 2. Shifting fan speed from low to medium giving percentage different of 13% and 8% from medium to high while the temperature of initial cool air ranging from 21.4°C to 19.2°C. Table 3 show the amount of current flowing to the air-conditioner for each different setting. The air-conditioner consumes significantly lesser energy when the temperature is set to warm regardless of the fan speed.

3.2. Fuzzy Logic Control

ASHRAE Standard 55-2013 state that comfort temperature can range from 19°C to 28°C and ASHRAE Standard 62.1-2016 mention relative humidity should be less than 65% to avoid a moist environment that can lead to microbial growth. Many factors such as season, clothing is worn, and activity levels need to be put under consideration before determining appropriate range for comfort environment.
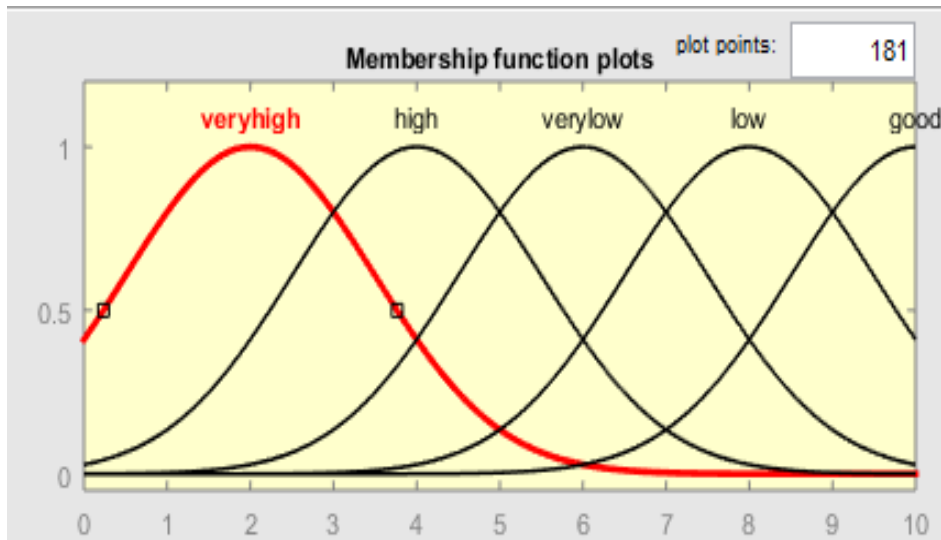

Figure 4. Input variable for temperature and humidity

Figure 4 shows the index of comfort level tabulated in the scale of one to ten with ten being the most comfortable and preferred environment. Base on normal environment condition, comfortable room temperature should be at 23°C with 45% humidity. Very high humidity is set to be above 60%, humidity in the range of 45% to 59% is considered high, 31% to 44% is set to low while less than 30% is very low and the most preferred humidity is set at 45%. Temperature above 26°C is set to be in very high and 24°C to 25°C is put under the high zone. The temperature in the range of 20°C to 22°C is low, less than 19°C is very low, and the preferred temperature is set at 23°C.
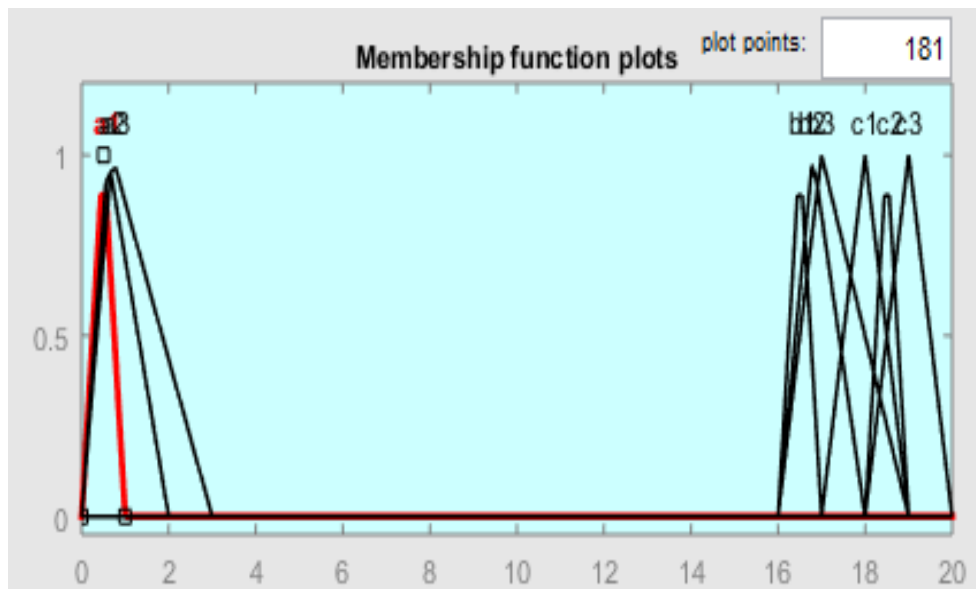

Figure 5. Output variable for current (ampere)

Nine membership function represent the different outcome of current accordingly. Based on Figure 5, the current usage surge to almost peak at average 17A when the temperature setting change to normal or cool while only 0.55A is used when the temperature is set to warm. This huge gap in power usage between settings exhibit the disadvantage of the cooling device involves in this experiment.
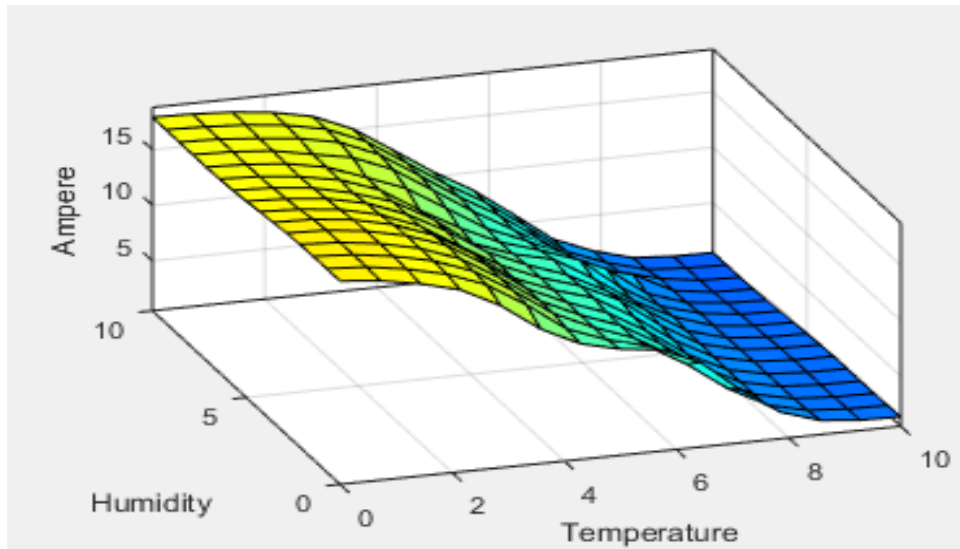
Figure 6. Output variable for current (ampere)

Surface view of fuzzy logic control shown in Figure 6 demonstrates a smooth operational current flow into the cooling device to maintain comfort environment. Power consumption reduces as ambient temperature, and humidity condition improves towards the best comfort parameter set at 10. Fuzzy logic control allows enhancement of energy efficiency to take place even though the compressor of an air-conditioner is not set for variable speed and tonnage.

4. Conclusion

This paper reveals the exact power consumption reading of non-inverter air-conditioner and demonstrate the benefit of fuzzy logic control to improve its energy efficiency. Utilizing WSN and IoT technology to record and store a massive amount of data has been tremendously helpful in attaining desire result. As the most significant power-consuming device, air-conditioner role in delivering comfort environment for building occupant need to be continuously improved from time to time. Without denying the importance of carrying out preventive maintenance of air-conditioner, there many ways that can be implemented to save cash on the electricity bill. Replacing the old existing traditional air-conditioner with newly better energy efficient inverter technology air-conditioner is very costly. Hence, the advantage of artificial technology (AI) and control system must be explored to tackle high energy usage issue and to assist in reducing operational cost.

5. Acknowledgements

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