Smart control of Air conditioning system for thermal comfort

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ABSTRACT
Rapid growth in building industry has increased the power demand. Smart buildings are becoming a trend to cope with the energy needs and environment ease. This leads to the dependency of intelligent control. Reducing energy consumption and to ensure thermal comfort are two important considerations in designing an air conditioning system. They contribute significant part of total energy consumption. Studies suggest that in locations like auditoriums, indoor stadiums and conference halls, air conditioning can contribute as much as 75% of total energy intake. The control strategy proposed is fuzzy logic controller (FLC). The implementation of the Fuzzy Logic Control (FLC) system, allows a range of comfort to human body. A MATLAB fuzzy toolbox is used where a fuzzy logic controller is for temperature, air quality and artificial lighting comfort parameters. The presented control system is capable of achieving energy conservation in the buildings.

Keywords: Fuzzy Control, Comfort Index, Energy Consumption, Smart Building.

1. INTRODUCTION
The productivity and quality of life of the people within a commercial building depends on comfort level within it. The comfort factors also include visual and thermal comforts. These are provided by lighting and air conditioning systems. More comfort is satisfied by more energy consumption. Due to energy scarcity these days, a balance between the energy consumption and human comfort is required [1].

For reduction of power consumption and waste in buildings, an intelligent control system is needed, since energy consumption has been directly related to comfort and ultimately to operational costs. A building’s indoorenvironmental primary comfort factors, according to the consumers’ preferences are thermal, visual and indoor air quality [2].

In this study a fuzzy logic control mechanism is developed for an indoor environmental control, to come across the energy demand in the building, envelopes the users are central and dynamic entity and their preferences must be accounted in the control system demand. The parameters ranges are provided in the control system is in acceptable limits of users.

2. BUILDING AUTOMATION AND FUZZY LOGIC CONTROLLER
An intelligent fuzzy control technique yield promising results and is applied to a substantial case in buildings (Dounis et al., 2011; Alexandridis and Dounis, 2007; Lah et al., 2005). This indicating extensive total energy consumption reduction in contrast to the existing control system, achieving the preferred comfort level. The peripheral fuzzy logic controllers are employed to satisfy various comfort demands.

An indoor building environment is quite sensitive to variations and will closely follow the change. The nonlinear fuzzy linguistic mapping model of an input data set to a scalar output data will overcome this. A FIS contains four basic blocks: fuzzifier, rule sets, inference engine and defuzzifier. The general architecture is shown in Fig. 1. Initially, an input set of crisp data is accumulated and turned into a fuzzy set utilizing fuzzifying linguistic variables and membership functions called fuzzification. An inference is developed based on the ruleset and finally, the fuzzy output is mapped to crisp values using the membership function called defuzzification. [4].
3. Fuzzy Control for HVAC System

The thermal has high impact on occupant’s productivity and satisfaction. Usually the thermal comfort index is addressed as Predictive Mean Vote (PMV).

In this part the role of fuzzy modeling in heating, ventilation and air conditioning (HVAC) and control models are presented.

The PMV index prevails within the range of -3 to +3. This has a variation occurrence in between -0.5 and +0.5, and thus satisfies around 90% of the building dwellers [3]. The thermal comfort index has already been a prime feature in PMV index computation and the building’s temperature has generally been specified with [5]. Both heating and cooling techniques are associated with a one unit system actuator. The fuzzy control knowledge base inference consists of two set strategies, one is comfort optimization and the second is energy consumption minimization. The input and output membership functions are depicted in Fig. 2(a-c); whereas, the 3-D expert control plot is depicted in Fig. 3. The knowledge base of the FIS system is shown in Table I.

![Block Diagram of Fuzzy Logic Controller](image1)

**Fig 1.** Block Diagram of Fuzzy Logic Controller

![Input 1 (Etemp)](image2)

**Fig 2(a).** Input 1 (Etemp)
Fig 2(b). Input 2 (EDtemp)

Fig 2(c). Output (Ptemp)

Fig 3. Fuzzy Control Surface Plot for Temperature

Table 1. Knowledge Base for FIS Temperature Controller

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4. Fuzzy Controller for Lighting

Daylight is a dynamic source of lighting and the variations in daylight can be quite large depending on season, location or latitude, and cloudiness. Different skylight levels can be found under the same sunlight conditions, and, even when the sky pattern remains the same, the range of solar illuminances may increase as a result of a momentary turbidity filter or scattering of particles over the sun. In consequence, any prediction system has to be flexible to allow for the multivariate changes that characterize the combination of sunlight and skylight. The proposed daylighting fuzzy control uses two sensing devices (an occupancy/motion sensor and a photo sensor), continuously electronic dimming ballasts for every luminaries aiming the control of the electric lighting output, and a fuzzy controller.

A proposed algorithm is assigned to control the illumination:

if illuminance is between 500 and 550 lux and motion sensor is ON then all lamps is full powered else use the fuzzy controller for lighting control.

The input linguistic variables of the fuzzy controller are the level of the illuminance measured by the photo sensor while the output variable is the level of the DC control signal. The fuzzy membership functions of Input/output variables are shown in figures 4 and 5.

![Fig 4. Membership Functions of Input](image1)

![Fig 5. Membership Functions of Output](image2)

![Fig 6. Rule Base for the System](image3)
5. VENTILATION CONTROL

Air quality control space has been specified with level of CO2 concentration and is predominantly subjective to the concentration of pollutants in the indoor environment [7]. The indoor envelope air quality control space is predominantly subjective with the concentration of pollutants. It is specified with the CO2 concentration (Emmerich and Persily, 2001) and represents the presence of the dwellers and several pollution sources in the building (Zhu et al., 2010a). Thus CO2 concentration is used to indicate an air quality index in the building envelope, measured in ppm. A fuzzy controller is applied to the slave air quality subsystem to compute the power demand for the ventilator. The input of the local slave fuzzy controller is error among the outside concentration and the internal set point. Thus the output is the required electrical power exploited for control of the ventilation system.

6. CONCLUSION

The analysis clearly maps out advantage of fuzzy logic in dealing with problems that are difficult to study analytically yet are easy to solve intuitively in terms of linguistic variables. The study presented the comfort index of inhabitants according to the power consumption pattern to make the wise decision of energy management though fuzzy logic controller. MATLAB-simulation is used to achieve the designed goal. Three major systems were considered and a fuzzy controller was developed for each of them. Thus Building energy management with intelligent control can contribute the huge amount of energy savings and cost. This will make consumers aware properly to take wise actions accordingly.

REFERENCES


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**Fig 7. Fuzzy Control Plot for Illumination**

**Fig 8. Required power verses CO2 concentration**


Authors

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