Design of Room Cooler using Fuzzy Logic Control System

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ABSTRACT
The modification of Autonomous room air cooler using fuzzy logic control system is reported in this paper [1]. It consists of two crisp input values from temperature and humidity sensors and three defuzzifiers are used to control the actuators; Fan1 (cooler fan), water pump and Fan2 (room exhaust fan). This work will help in improves the autonomous room cooling system using fuzzy logic. Matlab simulation is used to improve the performance of the designed model [1].

Keywords
Fuzzifier, Temperature, Humidity and Matlab Simulation

1. INTRODUCTION
A control system is an arrangement of physical component which manages commands, directs or regulates the behaviour of other systems. A control system is used to achieve the desired output [2].Computational intelligence (CI) is a set of intelligence of information which deals with the branch of computer science and technologies. The fuzzy systems are prototype of CI. In the area of modern technologies the fuzzy sets are generally used [3].

In traditional, logic theory consists of two binary logic sets i.e. true or false. The truth value of fuzzy logic is ranges in degree between 0 and 1. The concept of partial truth has been handling by using fuzzy logic i.e. range between completely true and completely false [3].The fuzzy logic thinks like the logic of human thought. The calculation of fuzzy logic is more than the computer calculation. It recognizes its nature is different from randomness [3].The aim of the work is to design the room cooler using fuzzy logic control systems. In section 2 basic diagram of proposed model is explained with block diagram. Algorithm of fuzzy logic is explained in section 3.Section 4 describes the result and discussion; Section 5 describes the conclusion.

2. BASIC DIAGRAM OF THE PROPOSED MODEL
Figure 1 shows the Basic block diagram of Room cooling system using fuzzy logic. This system is mounted in a room which consists of Fan1, Pump and Fan2. Fan1 indicates the cooler fan; Pump indicates a water pump and Fan2 indicates the exhaust fan. Water is spread on the boundary walls of grass roots or wooden shreds by water pump. Fan2 is used to monitor the humidity and temperature sensors for room environment. There are three outputs of defuzzifiers which are connected through the actuators [1, 4]

3. ALGORITHM OF FUZZY LOGIC FOR ROOM AIR COOLER
This modified design algorithm is used to design the fuzzifier, inference engine, rule base and defuzzifier for the room air cooling system to maintain the room environment. In this model consists of two crisp input variables, temperature and humidity. For this model the scale range has been considered for temperature inputs is from 0°C to 40°C and 0% to 100% for relative humidity inputs of five membership functions.The five triangular membership functions for temperature input are termed as: very cold 0-10°C, cold 0-20°C, warm 10-30°C, hot 20-40°C, and very hot 30-40°C. As for humidity input, the five fuzzy membership functions are: dry 0%-25%, very dry 0%-50%, moist 25%-75%, wet 50%-100%, and very wet range 75%-100%. The amplitude of the voltage signal of fuzzy logic is 0-5 v. There are three outputs of defuzzifier; speed of Fan1, speed of Pump and speed of Fan2. Each output variable consists of four membership functions i.e. Low 0-50, Medium 40-60, high 50-90 and Very high 90-100 [1, 5].

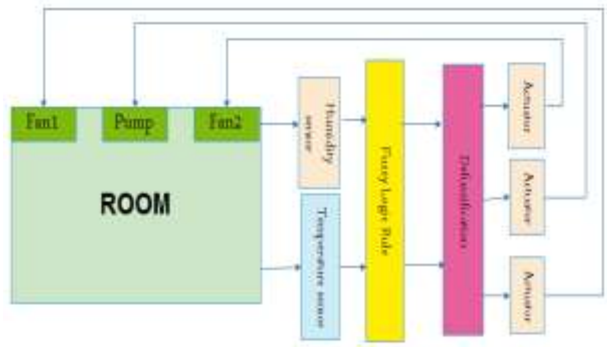

Figure 1. Block diagram of Room cooling system using Fuzzy Logic control system [1]

A. FUZZIFIER
The fuzzifier is real a mapping of fuzzy logic. It maps a real-valued crisp point value X∈ U to a fuzzy set ‘A’ in U. So it can be defined with a fuzzy membership function $\mu_A(X)$ as a function of X i.e. $\mu_A(x)$ **= f(x).** Five membership functions are used for fuzzifiers in each input variable as shown in Figure 2 and in Figure 3 [1, 6].

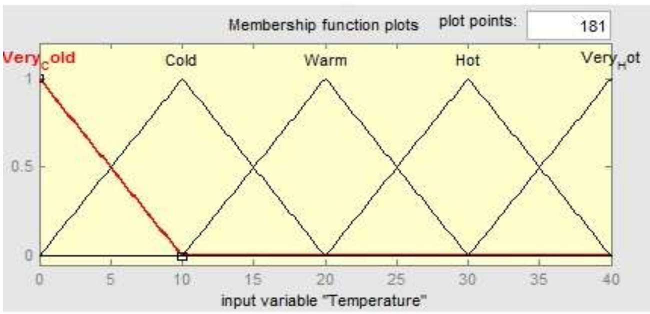

Figure 2. Plot of membership functions for "TEMPERATURE" [1]

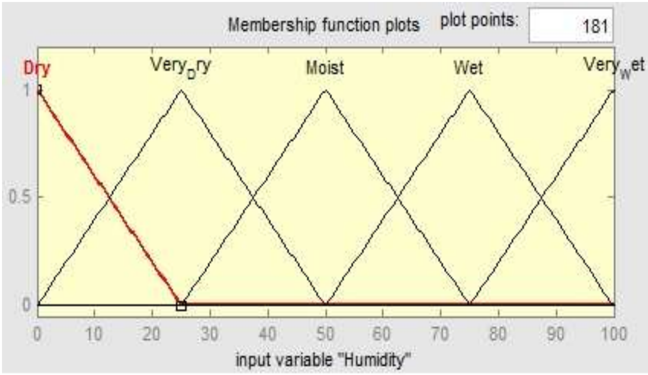

Figure 3.Plot of membership functions for "HUMIDITY"[1]

B. INFERENCE ENGINE

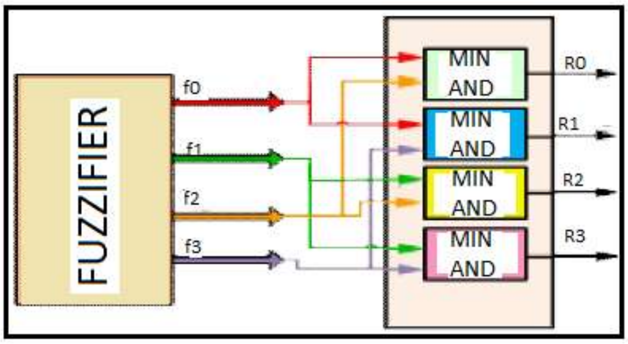

Figure 4.Block Diagram of Inference Engine [1, 5]

The inference engine consists of four AND operators in fuzzifier. It is not the logical AND operators. It accepts four inputs from fuzzifier. Figure 4 shows the block diagram of inference engine. Here, the output R value is obtained by using min-max composition. The min-max inference method uses min-AND operation between the four inputs. The total number of active rules = m^n**,** where m = maximum number of overlapped fuzzy sets and n = number of inputs [1, 6]. For this design, it has been chosen the values m = 4 and n = 2. The total number of rules is equal to the product of number of functions followed by the input variables in their working range [7]. There are five membership functions described here using two input variables. Thus, 4 x 4 = 16 rules required [8].There are 4 rules establishes which are used to corresponds mapping values of f1 [3], f1 [4], f2 [2], f2 [3]. Here f1 [3] means the corresponding mapping value of membership function "Normal" of temperature and the similar definitions are for the others [8].

C. RULE SELECTOR

It receives the two crisp values, temperature and humidity. It gives the output in the form of singleton values. Here four rules are needed to find the corresponding singleton values S1, S2, S3 and S4 for each variable [9]. The block diagram of rule base is shown in figure 5.

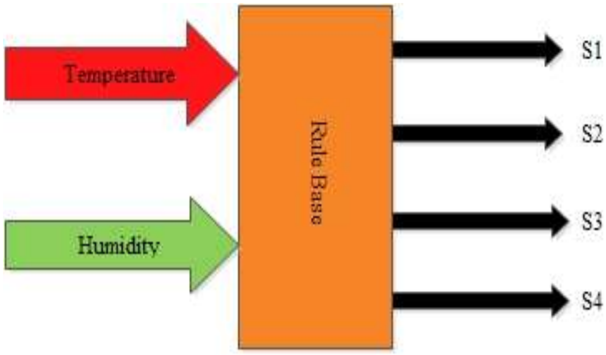

Figure 5.Block diagram of Rule Base [1, 5]

D. DEFFUZIFIER

In this design, there are three defuzzifiers control the actuators i.e. speed of Fan1, speed of pump, speed of Fan2. In this system 8 inputs are given to each of three defuzzifiers [9]. The four values of R1, R2, R3 and R4 are obtained from the outputs of inference engine and the other four values S1, S2, S3 and S4 obtained from the rule selector. The values of R and S are given to the defuzzifiers. Finally the estimated crisp value output is obtained from defuzzifier [10]. The output of defuzzifier is calculated by mathematically $\frac{\sum Si * Ri}{\sum Ri}$ **.** From figure 6, figure 7 and figure 8 shows that the plot of membership functions for output variables, "cooler fan speed", "exhaust fan speed" and "water pump speed" respectively.

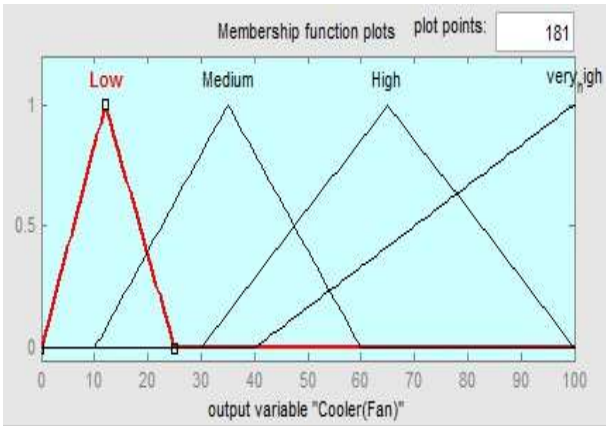

Figure 6.Plot of Membership Functions for Output Variable, "Cooler Fan Speed [1]

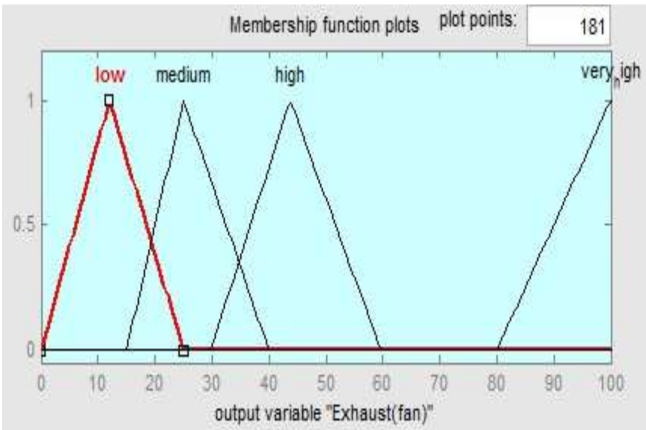

Figure 7. Plot of Membership Functions for Output Variable, "Exhaust fan Speed" [1]

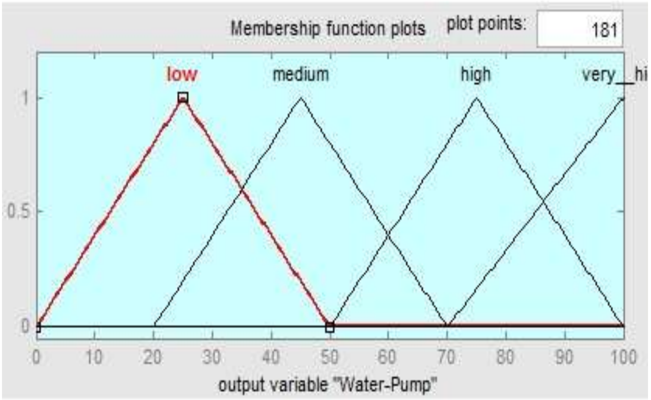

Figure 8. Plot of Membership Functions for Output Variable, "Water Pump Speed" [1]

4. RESULTS AND DISCUSSION

The proposed values for three outputs i.e. speed of Fan 1, speed of Pump and speed of Fan 2 are calculated in the table1. In table 1, 2nd, 3rd and 4th column show the proposed model and remaining three columns indicate the result obtained from the paper [1]. This proposed model is the modification of Autonomous Room Air Cooler Using Fuzzy Logic Control System (ARACUFCS).It is clear from the table 1 that the result shows better accuracy and minimizes the error. Also it increases the performance of the model. In figure 9 shows that the MATLAB simulations of crisp values for output variables were determined the result. The simulated system output is shown in figure 10 to figure 12. In figure 9 the input variables, Temperature = 28 and Humidity = 45 are shown. Various values of input and output variables match the dependency scheme of the system design.

Table.1. Comparison of Simulated and Calculated Result

Result	**Speed of Fan1**	**Speed of Pump**	**Speed of Fan2**
Proposed Values	$\frac{\sum Si * Ri}{\sum Ri}$=56.42	$\frac{\sum Si * Ri}{\sum Ri}$ =41.42	$\frac{\sum Si * Ri\mathbf{i}}{\sum Ri}$ =24.28
Matlab Simulation	57.3	40.4	23.1
%Error	**0.88**	**1.02**	**1.18**
ARACUFCS Values [1]	60.7	64.28	35.71
Matlab simulation[1]	54.1	67.3	32.9
%Error [1]	**10.8**	**4.6**	**7.8**

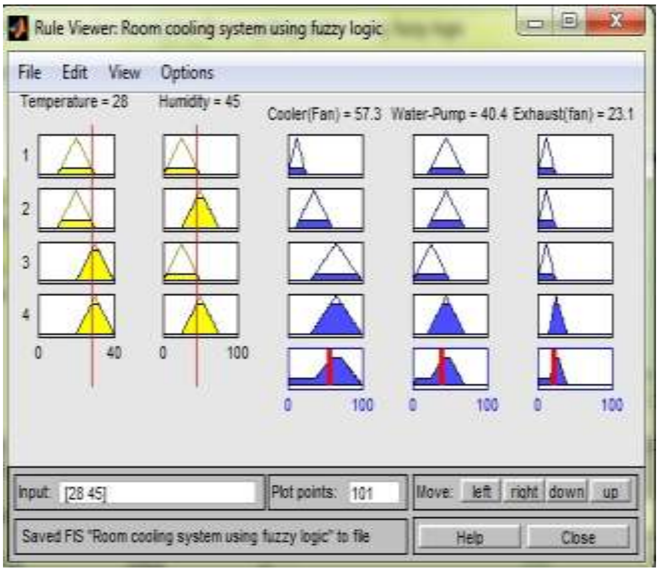

Figure 9. Matlab Rule-Viewer [1, 5]

5. CONCLUSION AND FUTURE WORK

Design model simulated results show the effectiveness of the room air cooler fuzzy logic processing control systems which were used to simply cool the room environment. The proposed model makes the system accurate and efficient. In future it will help to design the advanced control system for the various industrial applications in environment monitoring and management systems [1, 11]. It is worth to mention that there is approximately **91.85%** of improvement in proposed and simulated values for the fuzzy logic system.

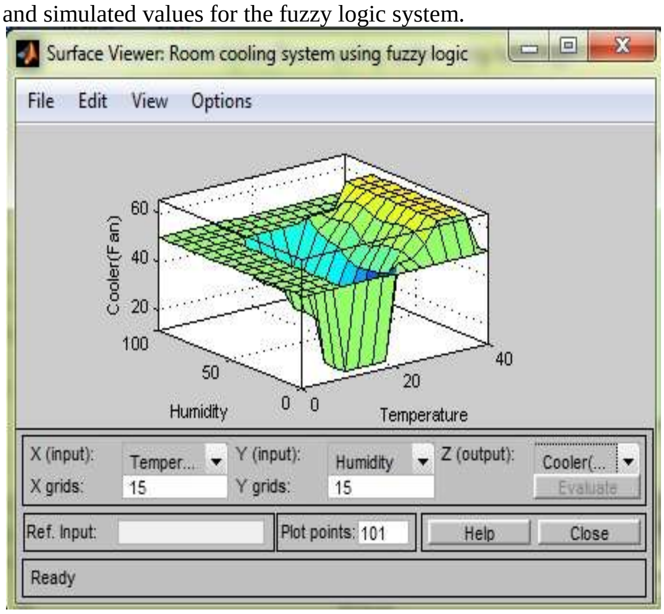

Figure 10. Plot between Temperature-Humidity & Cooler Fan Speed [1, 5]

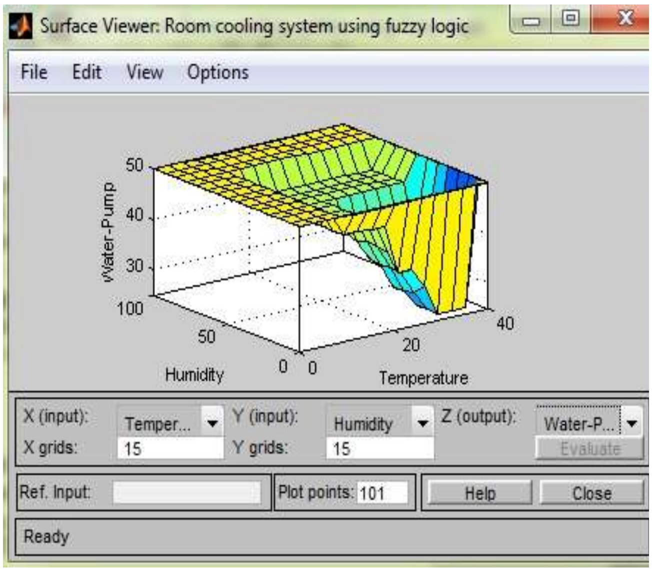

Figure 11. Plot between Temperature-Humidity & Water Pump Speed [1, 5]

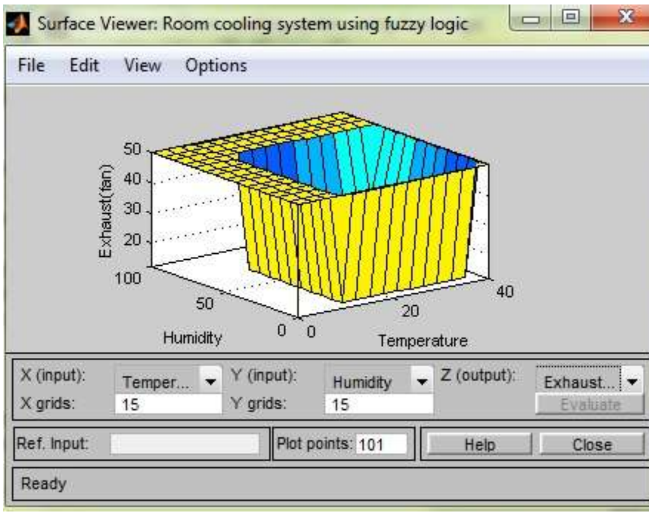

Figure 12. Plot between Temperature-Humidity & Room Exhaust Fan Speed [1, 5]

6. ACKNOWLEDGEMENT

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