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Fuzzy logic controller based operating room air condition control system

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Abstract: In this study, a Fuzzy Logic Controller was designed to provide the conditions necessary for operating room. For this purpose, real operating rooms have been studied to see if there are more useful, reliable & comfortable ones. How an operating room can be controlled with FLC & its advantages & disadvantages have also been researched. In this system heat, particle humidity & oxygen are used as input parameters and fresh air entrance & the fan circulation are chosen as output parameters. With the help of an expert, appropriate language expressions were and the membership functions of these expressions were defined. In this study input, output & other necessary parameters were saved in the computer. Consequently, in this study we obtained very good results and these result indicates that the controlled performed with FLC provide more economical, comfortable, reliable & consistent controls & that they are feasible in real operating room.

Keywords: Operating Room, Temperature, Fuzzy Logic Control System, Fuzzy tech.

I. INTRODUCTION

Fuzzy logic basically uses a logic & decision mechanism which doesn't have certain boundaries like human logic. One of its most common implementation was in fuzzy-logic based control mechanisms. Fuzzy Logic Control (FLC) systems don't require complete model knowledge as other control systems like PID. The Fuzzy Logic Controller (FLC) is easy to perform in industry due to its simple control structure, ease of design and inexpensive cost. In this study we have tried necessary condition and suitable for air balance and temperature in the operating room, using a fuzzy logic controller. The main reason for using fuzzy logic in this type of air conditioning is for energy conservation and human comfort. Fuzzy control systems are specifically used in controlling operating rooms in which complex and uncertain parameters play a difficult role hence, require careful control and vital importance. During the surgery, it is necessary to support a certain level of temperature to be done. With this, the number of infectious particles in the air will be reduced, and helps to provide adequate heat so that biological functions can work properly. Air circulation in the operating room is the major determinant for the patient and operating room staff. There are some standards and publications about hospital air-condition and ventilation systems. DIN 1964/4 is accepted as a reference in Turkey and Europe. In this standard, the design of hospital air-condition and ventilation system, the technical specifications of the devices to be used, the assembly of the devices, the things to be considered during use, test and maintenance information are given in detail. According to these standards, in hospital environments especially in operating rooms –in addition to hygiene, temperature, humidity and fresh air level- the number of particles and the air pressure in the environment are also to be kept under desired levels [1]. The air circulations in operating rooms are of crucial importance for the patient and operation personnel. The dirty air outside, very high level of noise outside the building, heavy heat outside, very common strong winds and the height of the building make the filtration, isolation and air-conditioning of the other parts the personnel use necessary. Because of the above mentioned unsuitable conditions inside and outside, certain levels of criteria (heat, humidity, fresh air level etc.) are to be kept in the operating room environment. In this study, the problem of controlling the optimum conditions required for operating rooms-ventilation, exhaust, heat, and humidity and particle levels-with the FES assessing the simultaneously taken data obtained by sensors. To achieve this, an operating room control system was designed in which the data obtained from the heat, humidity, particle and oxygen sensors are assessed by FLC to activate air-condition cooling, heat choice, blowing speed and the determination of the fan circulation.

II. OPERATING ROOM AIR CONDITIONING REQUIREMENTS

A. Temperature-

During a surgery, it is necessary to keep the temperature at a certain level. Temperature is the level of heat (energy) .The lowest temperature is -460 °F. The sun's temperature is approx. 27,000,000 °F. Most people feel comfortable if the indoor air temperature is between 68 °F & 78 °F [2]. Standard Temperatures on the Fahrenheit and Celsius Scales-

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Freezing point of (pure) water is: (32°F) and (0°C).
Boiling point of (pure) water is: (212°F) and (100°C).
Temperature Conversions for Fahrenheit and Celsius:
°C = (°F - 32) ÷ 1.8 (1)
°F = 1.8 (°C) + 32 (2)
The following is a quick reference for estimating and converting everyday temperatures from Celsius to Fahrenheit:
0°C = 32°F, 16°C ≈ 61°F, 28°C ≈ 82°F, 37°C = 98.6°F, 100°C = 212°F.

Heat and Temperature
Heat is energy in the form of molecules in motion. As a substance becomes warmer, its molecular motion and energy level (temperature) increases. Temperature describes the level of heat (energy) with reference to no heat. During an operation, heat is released according to the activity of the human body. So the heat gain and temperature produced from the members of the operating team owing to the nervous energy released is shown in table 1.

Surgen, Assistant	
Operating Room Sister	640 KJ/ h at 210C
Anesthesiologist	420 KJ/ h at 210C
Other team members	320 KJ/ h at 210C

Table 1. Heat gain & temperature produced by the members of operating team

The total heat production per hour caused by the staff, operation room lighting and equipment may be about 2 KW or 1750 Kcal/h.

B. Oxygen-

In hospitals environments especially in operating rooms fresh air level (oxygen) is also to be kept under desired level. The oxygen plays a very important role in operating rooms for the patient and operation personnel. To maintain oxygenation for 10 persons in the operating room, a volume of about 28 m 3 of air will be required per hour. How much outside air is required for the dilution of odour will depend on the nature and intensity of odour producing sources. It is indicated by some studies that air supplied at 0.24 m 3 per minute per person is the critical level of odour suppression.

C. Humidity and Particle-

In operating rooms where surgeries are carried out such important features as the Hygiene, heat, light, air and particle are to be observed carefully. These are important for both the health of the patients and the operation personnel, for the success of operation and to prevent possible complications during and after operation. Some special conditions like keeping the temperature in operating rooms at a certain level, reducing the particles in the room to the minimum level, keeping the humidity level at the desired level and constantly keeping the same level of fresh air are necessary and their control is required. It is necessary to reduce the level of humidity present in the air, usually for health reasons, as humid air can cause mold and mildew to grow inside homes, which has various health risks. Relative humidity is preferably 30 to 50 %.Higher humidity is also preferred by most insects including clothes moths, fleas and cockroach [3].

III. OPERATION AND METHOD

Fuzzy control input and output values; are defined in three linguistic expressions- as low, normal and high. Four parameters are chosen as input- temperature, humidity, particles, and oxygen. Two parameters are chosen as output- speed of a c motor, speed of exhaust motor. The features and fuzzy linguistics operations of input/ output system variants are given in Table 2 and Table 3.

S.No.	Parameter	Type	Linguistic Expression
1.	Temperature	Input	Low, Medium, High
2.	Humidity	Input	Low, Medium, High
3.	Oxygen	Input	Low, Medium, High
4.	Particle	Input	Low, Medium, High
5.	Speed of air condition motor	Output	Low, Medium, High
6.	Speed of exhaust motor	Output	Low, Medium, High

Table 2. The fuzzy linguistic expressions of input/output system variants

Parameters	Min	Max	Denomination
Temperature	16	30	°C
Humidity	20	70	%
Oxygen	15	50	%
Particle	1	2000	ppm
Speed of air condition motor	1000	1800	sp/min
Speed of exhaust motor	1000	1800	sp/min

Table 3. The features of input/output system variants

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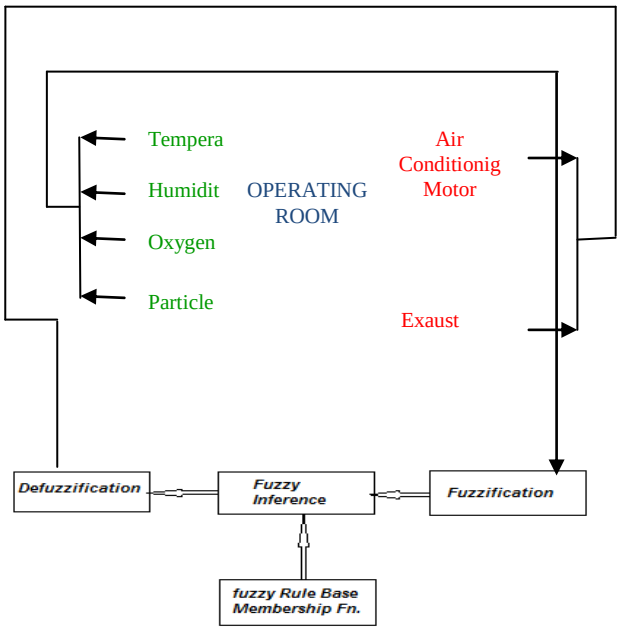


Figure 1. The Fuzzy control system model for the control system

Note: Speed of A C motor & Speed of exhaust motor will be same for an air conditioner so each and every observation will be same for both

A. Fuzzy Logic Controller Design-

The design & developed fuzzy logic controller for air conditioning in operating room is illustrated in figure, there are four inputs to fuzzy controller namely Temperature, Humidity, Particle and Oxygen & two outputs namely Speed of A C Motor (S1) and Speed of Exhaust Motor (S2) [4].

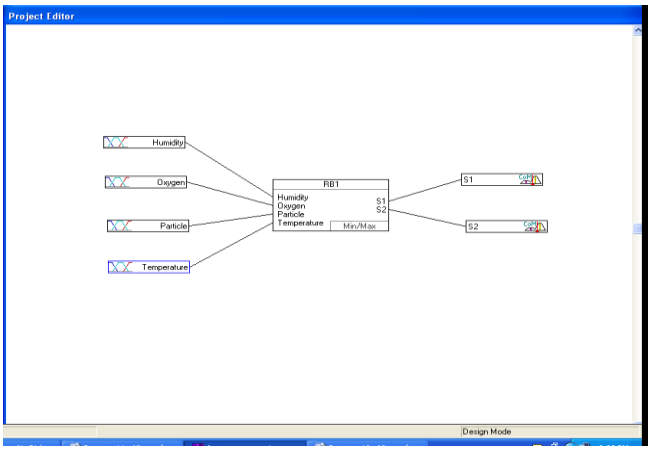


Figure 2. Fuzzy Logic Controller for air conditioning in operating rooms

B. Membership Functions-

Before designing the controller, we must determine the range of possible values for the input & output variables. In the present case; we have taken following range of possible values for input & output.

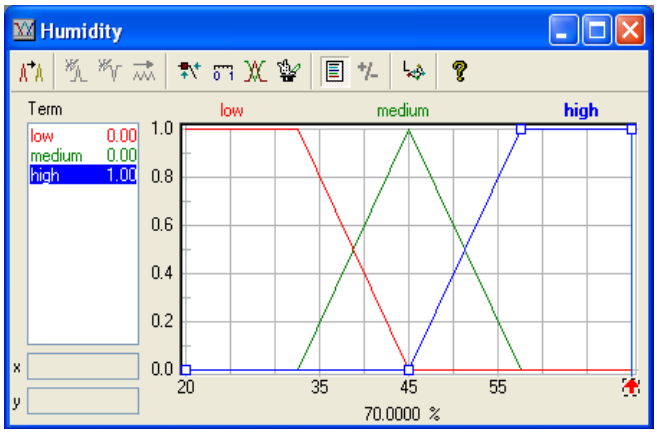
Input Variables- Temperature (16-30 °C), Humidity (20-70 %), Particle (1-2000 ppm), Oxygen (15-50%).

Output Variables- Speed of A C motor S1 (1000-1800 sp/min), Speed of Exhaust motor S2 (1000-1800 sp/min).

Membership functions are used to translate these real word values to fuzzy values & back.

Input membership functions for control temperature, oxygen, particles, humidity-

Following figure shows the input & output variables with their associated membership functions:



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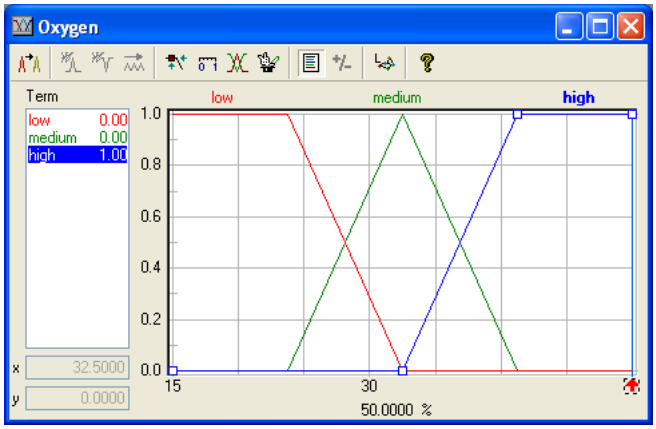


Figure 3. Triangular Membership Function for Humidity and Oxygen.

C. Fuzzy Rule base for air conditioning in operating room-
A typical intuitive rule is as follows-
"IF 'temperature, oxygen, particles, humidity' are high THEN Speed of A C Motor (S1) and Speed of Exhaust Motor (S2) should be high."

Rules made for the air conditioning control in operating room, are following:

#	IF Humidity	Oxygen	Particle	Temperature	THEN DoS	S1	THEN DoS	S2
1	low	low	low	low	1.00	low	1.00	low
2	low	low	low	medium	1.00	low	1.00	low
3	low	low	low	high	1.00	medium	1.00	medium
4	low	low	medium	low	1.00	medium	1.00	medium
5	low	low	medium	medium	1.00	medium	1.00	medium
6	low	low	medium	high	1.00	medium	1.00	medium
7	low	low	high	low	1.00	medium	1.00	medium
8	low	low	high	medium	1.00	high	1.00	high
9	low	low	high	high	1.00	high	1.00	high
10	low	medium	low	low	1.00	low	1.00	low
11	low	medium	low	medium	1.00	medium	1.00	medium
12	•••	•••	•••	•••	••	•••	••	•••
13	•••	•••	•••	•••	••	•••	••	•••
72	high	medium	high	high	1.00	high	1.00	high
73	high	high	low	low	1.00	medium	1.00	medium
74	high	high	low	medium	1.00	medium	1.00	medium
75	high	high	low	high	1.00	high	1.00	high
76	high	high	medium	low	1.00	medium	1.00	medium
77	high	high	medium	medium	1.00	high	1.00	high
78	high	high	medium	high	1.00	high	1.00	high
79	high	high	high	low	1.00	high	1.00	high
80	high	high	high	medium	1.00	high	1.00	high
81	high	high	high	high	1.00	high	1.00	high
82								

Figure 4. Fuzzy Rules For rule block

By applying these rules to the controller & using centre of maxima method for defuzzification desired output is obtained .

RESULT

Figure 5 below shows that (a) when temperature, humidity, particles and oxygen are high; speed of A C motor & exhaust motor is high. (b) When temperature, humidity, particles and oxygen are medium; speed of A C motor & exhaust motor is medium. (c)When temperature, humidity, particles and oxygen are low; speed of A C motor & exhaust motor is low. (d)When temperature is 26.4087 C, humidity is 62.3841%, particles are 1682.2781 ppm and oxygen is 49.6137%; speed of A C motor & exhaust motor is 1875 sp/min.

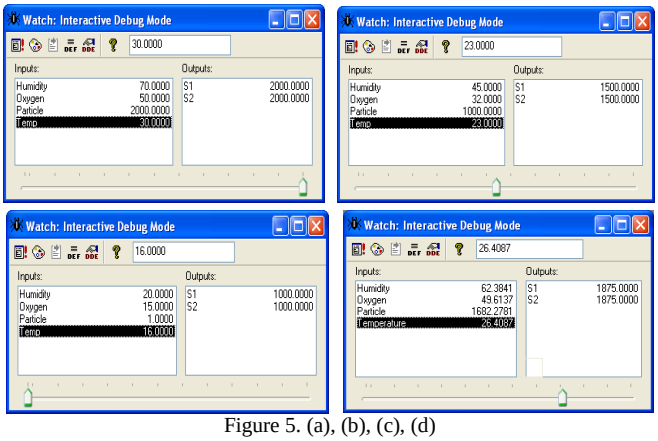


Figure 5. (a), (b), (c), (d)

D. Output membership functions for control temperature, oxygen, particles, humidity-
Following figure shows the output variables with their associated membership functions:

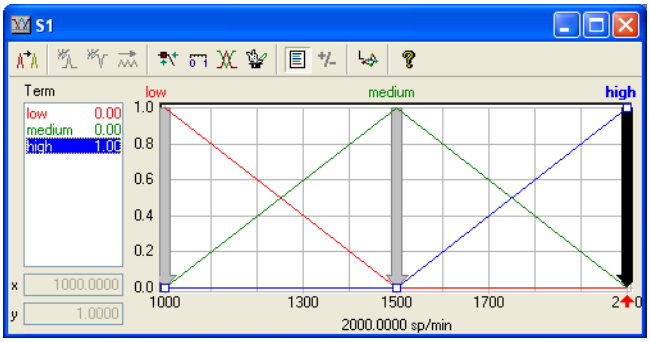
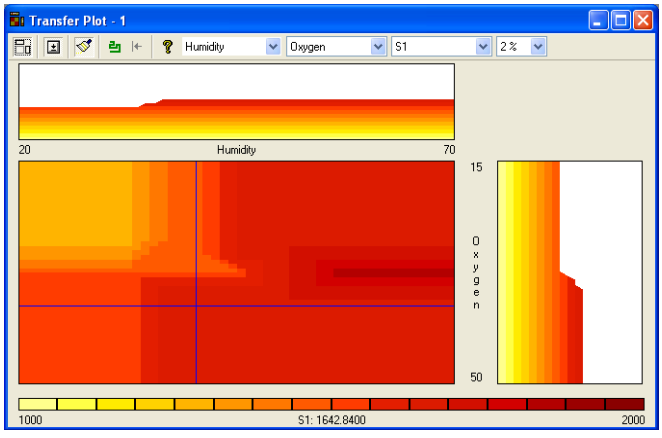


Figure 6: Membership Function plot of output variable` Speed of AC motor S1 (Speed of Exhaust motor S2) using triangular membership function type. In this figure, three membership functions are used namely Low, Medium, and High.

E. Figures below show the Transfer Plots, Time Plots & 3D Plots for oxygen, humidity & S1/S2-



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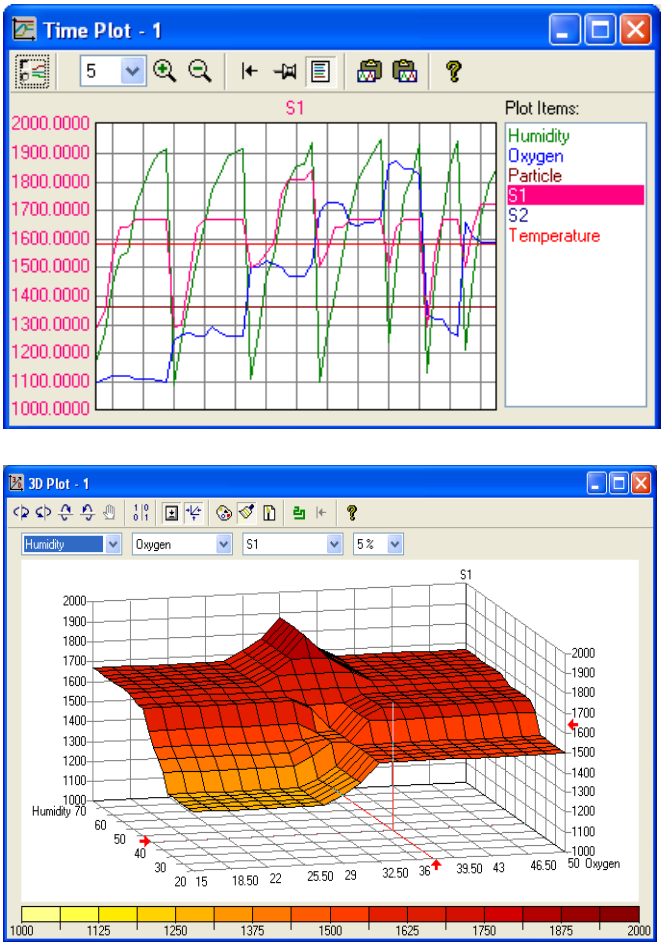

Figure 7: Transfer plot, Time plot & 3D plot for oxygen, humidity & speed of AC /exhaust motor

The plot show that when oxygen, humidity increased; S1/S2 is Also increased. According to fig. humidity is 40% & oxygen is 37% then speed of S1/S2 will be 1642.8400 sp/min. There are five other combinations also which we can plot in Transfer plot, Time Plot & 3d plot in above manner.

CONCLUSION

In present paper work a novel fuzzy control methodology for air conditioning in operating room is proposed. A fully automatic air conditioning system is designed using fuzzy logic. The salient feature of the proposed controller is that it doesn't require an accurate model of the controlled plant & the design process is lower than that of the other traditional controls methods. This implemented system can-

- Determine the necessary processed to be carried out by examining the values in the operating room.
- Act in a planned way by studying more than one parameter (using the data defined by the expert) rather than working with the simple logic which requires cooling when it is hot as in the traditional control systems.
- Keep the operating room always clean and in the desired conditions.
- Provide a more comfortable environment for the patient and the operation staff.
- Make sure the existence of the same amount of fresh air at the desire temperature.
- Provide a very effective, faster, excellent, determined and reliable control quality compared to traditional control systems.

REFERENCES

[1] "Air conditioning requirements in hospitals" -by Lt Col (Dr) SKM Rao Peker, T.,
[2] "Standard, statutes of operating rooms, " http://www.mmoistanbul.org/ Yayin/tesisat/ 73/7, Accessed April 2007..
[3] M.J.Patyra and D.M Mlynek.Fuzzy Logic Implementation and Applications. Wiley and Teubner, Chichester, NY, 1996.
[4] Fuzzy TECH 5.5 User's Manual, 2001 INFORM GmbH/inform software corporation.
[5] D.Driankov, H.Hellendoorn, M.Reinfrank. An Introduction to Fuzzy Control. Narosa Publication.
[6] Timothy J.Ross.Fuzzy Logic with Engg.Applications.Mc Graw-Hill International Editions Electrical Engg.Series, 1995.
[7] Allahverdi N, "Expert Systems, An Application of Artificial Intelligent", Atlas Press, Istanbul, 2002.
[8] Malpica-Romero A. D, Assad G. D, "Fuzzy environmental control of surgical rooms in hospitals".
[9] Güven K.O., "Hygienic air-conditioning in operating room", 2003.
[10] Constantin Von Altrock. Fuzzy Logic and Neuro Fuzzy Applications Explained .PHI Private Ltd.