Simulating The Air-Condition Controlling In Operating Room And Improvement

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Abstract

In this study we have tried necessary condition and suitable for air balance and temperature in the operating room, using a fuzzy expert controller system and thermal cameras are designed. Condition for implementation and simulation of this system has been studied to see if it can be true or not performed in hospitals. This is a completely new method, all the operating room by a fuzzy controller with thermal picture environment has been properly balanced to ventilation system work properly. Therefore, the operating room is simulated using MATLAB software so fuzzy control system is supposed to be shown the benefits of this control system. Input parameters of the system are important factors in determining the balance temperature and ambient temperature. The publication of these parameters is considered as an output parameter. By the expert system, an account statement with the membership functions for input parameters were defined. After classification of ventilation systems and related information, using a concept designed interface that with MATLAB software has been simulated, transferred to the computer and also whole system operation in the operating room during hundred minutes is shown. The results revealed by this controller showed that in terms of economic and reliability and other has more advantages than the previous single-phase system.

Keywords: Expert Systems, Operating Room Control, Fuzzy Controller

1. INTRODUCTION

Fuzzy logic like human logic has no limits and is based on decision making methods. Therefore, to make a better decision, controlling the operation is needed which has in turn led to use fuzzy control mechanism that is based on logic [1]. Fuzzy logic controller systems do not require full knowledge of the model, while in other known controller this knowledge is required [2]. The use of uncertainty tests of fuzzy systems and expert's knowledge as controls has become popular and used in many different fields of science [3].

The major objective of this research is using a fuzzy control system based on logic so that it can provide ventilation of the desired place in optimum conditions. Investigating and studying the ventilation is usually done in places such as sports pools, heat homes and greenhouses that need more suitable and controlled ventilation [4]. These systems are generally known as heating, ventilation and air conditioning system [1]. The main reason for using fuzzy logic in this type of air conditioning is for energy conservation and human comfort [5]. 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 [6].

According to research [11], "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. In operating rooms, some specific standards and controls are necessary to observe whether or not they are effective in the biological functions, in reducing the patient's blood loss, protecting from infection, and operating room staff [7]. According to a series of standards proposed by [10], "in hospital environments, especially in the operating room – hence, in the health science, humidity temperature, fresh air, number of particles and microorganisms and air pressure in the environment are kept under desirable levels [9], [8]. Air circulation in the operating room is the major determinant for the patient and operating room staff. According to the standards, three different systems-diffuser, Laminar and turbulence-are employed [10]".

Factors influencing the ventilation of the operating room include pollution, high noise, heat and strong winds out of the filtration building, separation and other factors which lead to the necessary use of ventilation systems. In [11], the issue of controlling optimum conditions required for ventilation system, drainage, heat, humidity and dust levels in the operating room with the data taken were tested simultaneously by the sensors. To resolve this problem, Operating room control system in which data heat, moisture, particles and oxygen sensors are obtained Hybrid fuzzy expert system and image processing has been designed for keeping the air conditions cool, the heating selection, ventilation and circulation and determining the speed and flow.

This paper has been organized as follows: The theoretical background is presented in Section 2; Developmental structure and evaluation of the system are given in Section 3 and Section 4 is devoted to examining and testing the system. Eventually, the results are discussed in Section 5.

2. THE THEORITICAL BACKGROUND

In complex systems that are difficult to understand or issues dependent on reasoning, decision making and inference on the part of human, fuzzy logic is considered as an effective tool. Selecting a suitable method and approach for simulating a system totally depends on the complexity rate of the system; and complexity is in turn inversely associated with our knowledge and understanding of that system. Human has always attempted to simulate a system with the highest possible accuracy; however, if he does not have enough knowledge about it, he is forced to adapt the desired accuracy of the model to his own knowledge of the system. Over the years, two-valued logic and mathematics based on it have been the bases of all the world's sciences and approximations of black and white from gray has been used as the acceptable methods [12].

This logic which has been the basis of science and mathematics for more than two centuries, tries to give true or false value for all propositions. With the rapid advancement of science and knowledge, the Aristotelian two-valued logic to explain issues such as the uncertainty in some phenomena in the universe faced with some problems. What today is called the fuzzy theory has been founded by Professor Lotfi zadeh, Berkeley University, America. In the early 60s, he came to this conclusion that classical theory has too much emphasis on accuracy, thus, complex systems do not have good performance based on this theory. In a classic set, each member can have an amount awarded of zero or one, whereas in a fuzzy set, the awarded function is as a continuous function in the range of zero and one. Therefore, the fuzzy set A in U can be arranged as pairs of x and its function μ (x) according to the following relationship:

$$A = \{(x, \mu(x)) \mid x \in u\}$$

Various forms of membership functions have been presented. Five standard types which have more uses include: Triangular type, Trapezoidal type, Gaussian type, types Z and S. Triangular membership function, for example, for the three parameters {a, b, c} represents the coordinates of the vertices of the triangle-shaped membership functions are defined as the following and the diagram shows it:

$$Trimf(x; a, b, c) = Max\left[Min\left[\frac{x-a}{b-a}, \frac{c-x}{c-b} \right], 0 \right]$$

3. SYSTEM ARCHITECTURE AND EVALUATION

In the simulated operating room, surgeons investigate special operations such as health science, heat, light, air and necessary particles so that patients and operating room staff during and after surgical operations are safe in terms of health. One of the most important conditions in this field is maintaining the ambient air temperature at specified levels, reducing particles in the room for balancing heat level which are effective in successful performance and controlling the room.
Pollution, high noise, heat and strong winds out of the refining building, make separation and air ventilation of other parts necessary to use for employees. Issues such as heating the medical instruments which are emitted by anesthetic gases, disinfectants and other bad odors, balancing the flow, lack of front window, causing dirty air due to breathe and spreading germs to the entire building is soluble. Due to aforementioned unfavorable conditions outside and inside, a certain level of criteria (temperature, humidity, fresh air and surfaces...) is maintained in the operating room environment.

In this study, the issue of controlling optimum conditions required for ventilation system, drainage, heat, humidity and dust levels in the operating room with the data taken is simultaneously tested by the sensors. Operating room control system in which data heat, moisture, particles and oxygen sensors are obtained Hybrid fuzzy expert system and image processing has been designed for keeping the air conditions cool, the heating selection, ventilation and circulation and determining the speed and blow. We will first try using thermal picture no.2 taken from the operating room using image processing located on the ceiling, find parts of the room that need more fresh air. Then we control one of the few groups of the operating room engines using fuzzy logic.

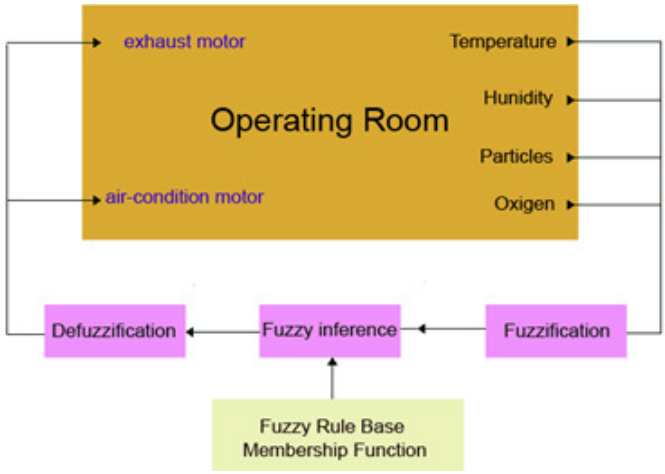

FIGURE1: The fuzzy control system designed for control systems (general view)

The values of input and output of fuzzy control in three arithmetic linguistic expressions are defined as weak, normal and high levels. Four parameters were selected as input and linguistic and mathematical expressions are listed in Table 1. Limitations of the sensor have been raised according to the following standards:

Linguistic expression	Type	Parameters
Low, medium, high	Input	Temperature
Low, medium, high	Input	Moisture
Low, medium, high	Input	Oxygen
Low, medium, high	Input	Dust
Very low, low, medium, high, and very high	Output	Engine speed of air ventilation
Very low, low, medium, high, and very high	Output	Engine speed of air discharge

TABLE 1: Mathematical linguistic expressions of fuzzy variables of input output system

1- For heat, the acceptable value between [10 ... 55] 0C
2 - For moisture, the acceptable value between [0 ... 100] %
3 - The level of oxygen values between [0 ... 100] %
4 - The global cluster for the particles [0 ... 4000] PPM

The value of rotating of propeller engine is between1000 to 4000 (rpm) in the output parameters. Heating and cooling values in air ventilation system is between 15 and 28 degrees Celsius. Parameters system evaluates moisture, oxygen, and the number of air particles and propeller speed, adaptive heating and cooling with air ventilation. For all fuzzy inferences, we use the obtain inference mechanism that will be easier and more convenient for designing fuzzy system. Characteristics and fuzzy linguistic equivalence of input and output variables are given in Tables 1, 2 and 3. The operating room parameters were built for fuzzy expert systems. We selected the most suitable triangular fuzzy method, according to the mentioned cases in the papers [13]. Membership function of the parameters have been considered as triangular, their mathematical formulas have been accumulated by a proper method. Fuzzy sets, moisture, oxygen, dust, propeller cycle and heating and cooling have been considered as examples of temperatures.

Unit	Maximum	Minimum	Parameter
℃	28	16	Temperature
%	60	20	Room humidity
%	45	10	Oxygen
ppm	200	1	Dust

TABLE 2: Input features of the implemented fuzzy system variables

Unit	Maximum	minimum	Parameter
$\frac{sp}{min}$	1600	1000	rotation speed of the ventilation engine
$\frac{sp}{min}$	1600	1000	Rotation speed of the motor discharge

TABLE3: output features of the implemented fuzzy system variables

To provide adequate conditions for surgery in the operating room, we need to provide a fuzzy inference system. This system has four inputs and two outputs in accordance with Table 2 and 3. General view of the fuzzy system is given in Figure 2.

For the grade (A) the linguistic expression and fuzzy membership functions are as follows: (Temperature=A, temperature value=a)[14]:

$$\mu_{Low}(A)=\begin{cases}1; & 0\leqslant a<18,\\ \frac{21-a}{3}; & 18\leqslant a<21,\\ 0; & 21\leqslant a<28,\end{cases}\quad \mu_{Medium}(A)=\begin{cases}0; & 0\leqslant a<18\\ \frac{a-18}{3}; & 18\leqslant a<21,\\ \frac{24-a}{3}; & 21\leqslant a<24,\\ 0; & 24\leqslant a\leqslant 35,\end{cases}\quad \mu_{High}(A)=\begin{cases}0; & 0\leqslant a<21,\\ \frac{a-21}{3}; & 21\leqslant a<24,\\ 1; & 24\leqslant a<35.\end{cases}$$

Therefore, fuzzy sets obtained for the temperature are obtained as follows:

$$\mu_{Low}(A)=\left\{\begin{matrix}1/15+1/16+1/17+1/18+0.67/19+0.33/20\\ +0/21\end{matrix}\right\},$$

$$\mu_{Medium}(A)=\left\{\begin{matrix}0/18+0.33/19+0.67/20+1/21+0.67/22\\ +0.33/23+0/24\end{matrix}\right\},$$

$$\mu_{High}(A)=\{0/21+0.33/22+0.67/23+1/24+\cdots+1/28\}.$$

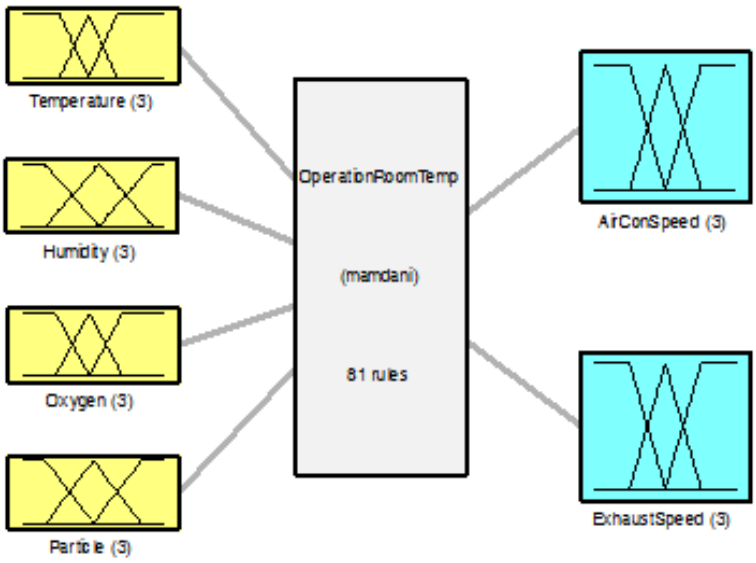

FIGURE 2: implemented fuzzy systems for the operating room includes 4 inputs and 2 outputs

Both fuzzy sets and other input and output parameters that are shown in Figure below have been obtained. Some rules combined with the expert for ventilation and drainage of engine speed for both groups had been formed for the operating room that is shown in Table 3. Generally, there are 81 rules.

3.1 Selecting Ventilation and Drainage Engines

For smoother air flow in the operating room, we decided to use two ventilation and drainage engines in the operating room. The engines have been shown in Figure 3.

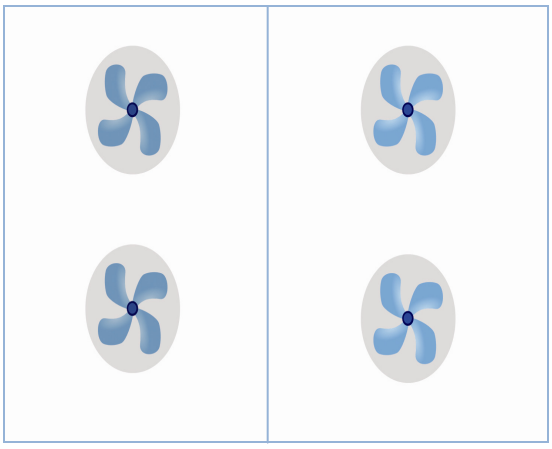

FIGURE 3: positions of the engines on the roof

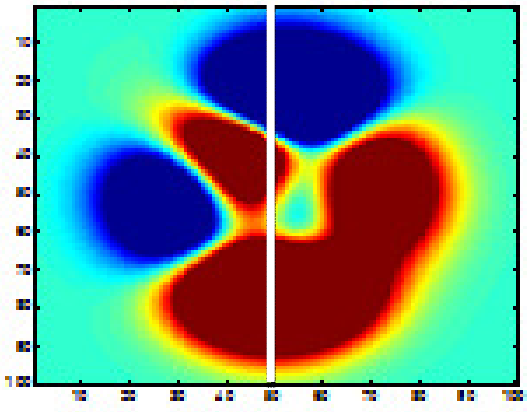

FIGURE 4: Thermal images taken from the operating room

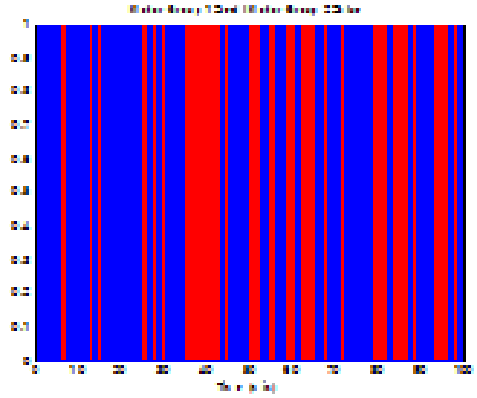

FIGURE5: the order of on and off for each engine

Firstly, thermal picture is taken from the operating room. The location of heat accumulation can be found using this picture. This picture is shown in figure 4. We divide the taken picture into two parts. Next, we obtain the average energy of all pixels in each segment. Then, we compare the average energy of both parts. Whichever involves more energy, fuzzy system is applied to it and the other engine is turned off. Thus, we will have smoother air flow in all parts of the room. Figure 5 illustrates the connecting and disconnecting order of each engine. At any moment, only one of both groups of engines is remaining light. The red color illustrates that the group of engine 1 is light and the blue illustrates that the group of engine 2 is light.

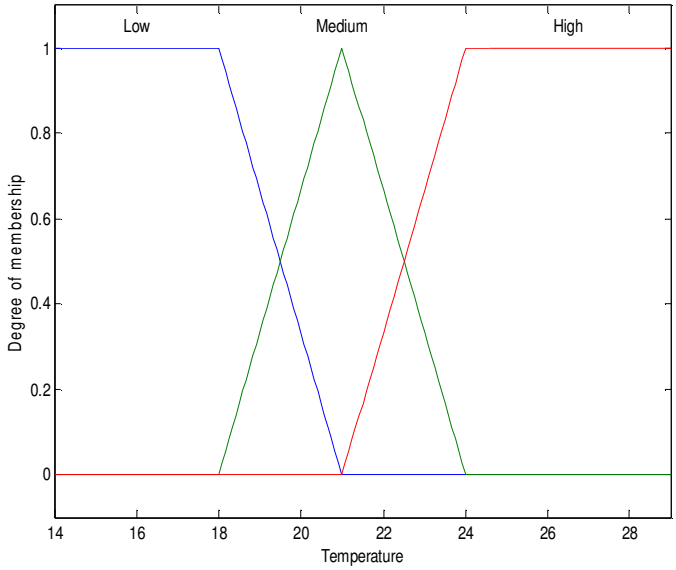

FIGURE6: membership function of temperature input

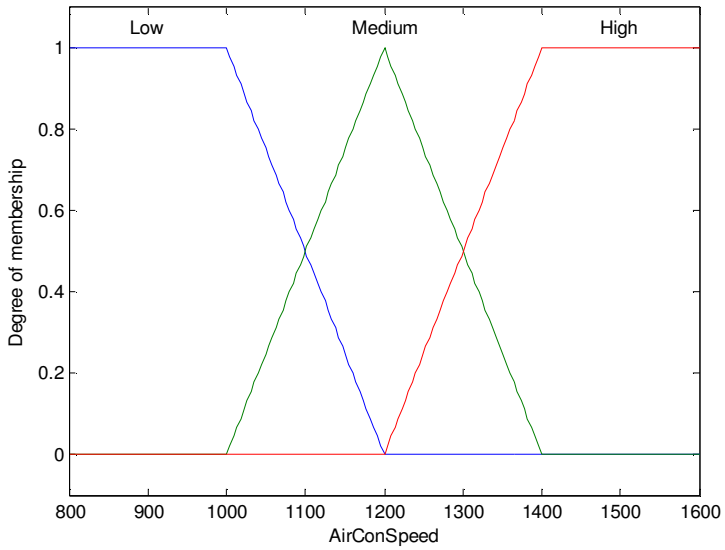

FIGURE 7: membership function of input speed rotation of discharge engine

Also, a part of these rules can be seen in Table 4.

Number of the rule	temperature	humidity	oxygen	Particles	Ventilation engine	Drainage engine
1	1	1	1	2	3	3
2	1	1	1	1	3	3
3	1	1	1	3	3	3
. . .	. . .	. . .	. . .	. . .	. . .	. . .
80	3	3	3	1	3	3
81	3	3	3	3	3	3

TABLE4: codified fuzzy rules, 1 = low, 2 = moderate, 3 = high

3.2 Investigating and Testing the System

In this section, to investigate the function of the developed fuzzy controller, a test was implemented.

Producing input data are needed for the test. First, initial values for input parameters are considered. These initial values are the initial values of parameters used in the desired operating room. As we know, all the values of input parameters (temperature, humidity, oxygen and suspended particles) in addition to engine speed are related to the processes taking place in the operating room. Therefore, the role of engines is only to control the situation. Generating this data is independent of the output of the fuzzy system. Two of data can be seen in Figures 8 9. The test duration is 100 minutes.

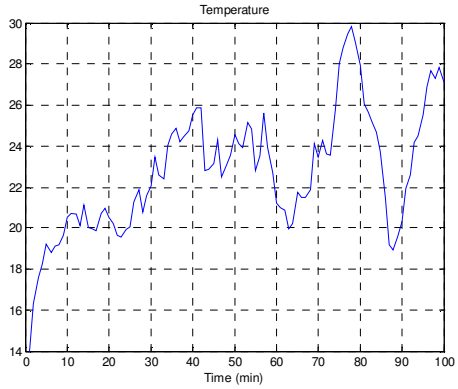

FIGURE8: temperature in the operating room during 100 min

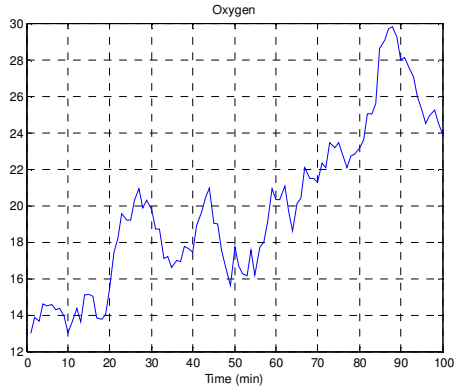

FIGURE9: the oxygen level in the operating room during 100 minutes

We continued the simulation. After performing this process, the obtained outputs correspond to Figures 10 and 11.

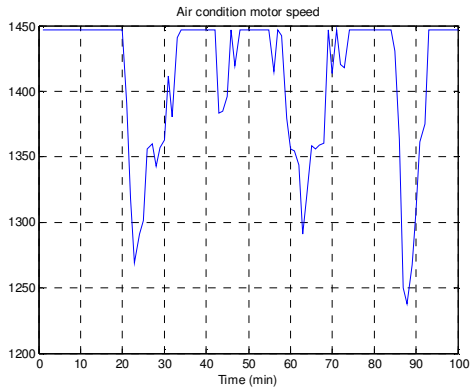

FIGURE10: the speed of the ventilation engine of the operating room after the simulation

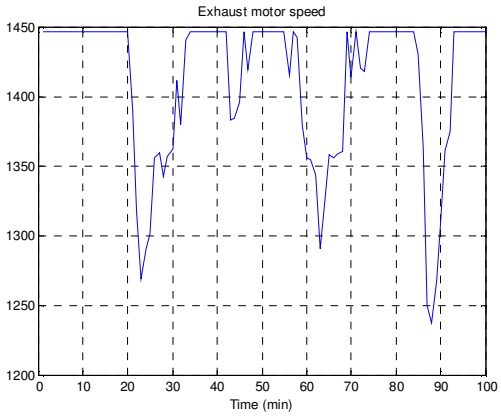

FIGURE11: the speed of the drainage engine of the operating room

4. CONCLUSION AND FUTURE WORK

As you can see, the fuzzy controller response in all experimental conditions is quite as expected. For example, at the onset of the experiment, due to unsuitable conditions, we need the engines to operate at higher speeds that the controller does it well. The response has always been stable and produces a logical answer. Among the advantages of the designed controller is that it does not require complete information about the system that through it we could well control an unstable and uncertain system.

The advantages of the designed controller by fuzzy logic and image processing than the previous method which was in the form of a fuzzy control include the followings:

- ✓ Determining the required process by testing the values extracted from the operating room
- ✓ Planned behavior by studying more than one parameter using the data defined by the expert
- ✓ Personalization capabilities: in the way that it defines different working principles for any air conditions
- ✓ Slower and more regular flow of dirty air discharge
- ✓ Maintenance of the operating room in good conditions
- ✓ Providing an environment with higher comfort for the patient and operating room staff as well
- ✓ Ensuring fresh air at the desired temperature
- ✓ Providing faster and more reliable control than traditional control methods

A fuzzy controller provides more reliable and faster results compared to traditional control systems that its use in the ventilation of an operating room is predicted to be beneficial. However, a controller with these conditions saves energy waste and provides optimum advantage of the ventilation system. In subsequent studies, using SA and GA techniques and creating a newer system we can obtain a more optimal solution.

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