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Research paper

Hybrid Expert System Advisor for Anaestetic Control and Intense Care Using Adaptive Neuro Fuzzy Inference System and Certainty Factors

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Abstract

Despite the great advances in medicine and technology, there are some risks to the life of the patient suffering from anesthesia and intensive care, and the reason that the human has a restricted capability to continuously and accurately analyse huge amount of patients data. Most methods previously used do not give accurate results because they use a single pointer. Therefore, in this research, many artificial intelligence techniques and quantitative measurements have been merge into an a to support doctors decision in controlling anesthesia and intensive care. This research was designed as an intelligent hybrid system as an anesthesia consultant by incorporating of rule-based, adaptive neuro-fuzzy inference system, fuzzy control and certainty factor theory that can simulate an anesthesiologist in thinking and making appropriate decisions in complex circumstances. The aim of this research is to improve clinical diagnosis and detect critical events during anesthesia by relying on artificial intelligence methods.

Keywords: *Expert system, anaesthesia, fuzzy control, ANFIS, certainty factor*.

1. Introduction

An expert systems (ES) in medicine is a Programs designed to assist the doctor in the process of diagnosis, decision-making and clinical management could solve many of the problems that occur in medicine and help specialists in curative or diagnostic suggestions, using information of the patient as parameters to combine with algorithms and models giving counsel in form visible messages, it does not eliminate the role of the doctor but improves the quality of healthcare and reduces errors in diagnosis [4-6].Mistakes of the human in anesthesia represent more than 70% of the tragedy that can be prevented [2]. The computer has the ability to monitor huge amounts of different information quickly, and computers will be able to provide great help to health care professionals and patient guidance, unlike humans, it is difficult to remember all the things related to the patient [1,3]. The use of expert systems in clinical management to solve many of the problems that occur in medicine and help specialists in curative or diagnostic suggestions and improve clinicians' Performance by carefully performing repetitive tasks that are not suitable for humans, such as physiological parameter analysis and surveillance [4, 5], decrease the happening of faulty diagnoses and curative [6]. This research is therefore aimed at developing such a Intelligent system as an anesthesia consultant mellitus by leveraging on a fuzzy neural network based expert system and a number of artificial intelligence techniques. In this research, we have developed and designed an Intelligent system as an anesthesia consultant mellitus by leveraging on a fuzzy neural network based expert system and a number of artificial intelligence techniques.The designer system is capable of training and evaluating anesthesiologists' responses to serious accidents occurring during anesthesia incidents including anaphylaxis,cardiac arrest, myocardial ischemia, malignant hyperthermia and bronchospasm.The system uses interfaces to display the patient state and allows the anesthesiologist to give the appropriate drug type and control the amount of anesthesia.The intelligent system in this research offers detailed help to the patient and clinical status. This means that the system acts as an anesthesiologist's consultant through continuous assessment of the patient and suggestion of curative periodically**.**

2. Fuzzy control

Fuzzy control is a powerful theory that can be used to deal with the characteristics of a complex system that cannot be manipulated by rigorous mathematical analysis. Fuzzy control relies on approximate logic, which plays a large role in simulating human thinking. The aim of fuzzy control is to makeup a flexible system for the processing of information that offers a soft decision-making strategy that is similar to human thinking. It provides a mechanism that can draw specific results from inaccurate or vague information. The fuzzy control uses a set of rules described with not accurate conditions[9-12]. Examples of these rules include:
"If (Haematocrit is low) and (Platelets is high) and (White Blood Cells is high) then (output1 is verydanger)." this rule contains inaccurate terms such as "a low" and "high", terms that are hard to express and manipulate in a computer.Humans do not have difficulty dealing with inaccurate data or uncertainties such as "white blood cell height", but it is an obstacle to dealing with them in the computer system because no language describes inaccurate data in a manner that the computer can understand. So the theory of fuzzy control is the way to model accuracy and complexity in the real world. The future of anesthesia may be fuzzier than we think.

3. Adaptive neuro-fuzzy inference system

ANFIS is a mixing of the intelligent methods in a fuzzy system and neural network in order to get a good thinking in quantity and quality. The purpose of the merge of fuzzy inference and the neural networks is to design a system that uses a fuzzy system to represent knowledge in a way that is interpretable and has the ability to learn from itself by the neural network that can regulate the linguistic rules and enhance the system efficiency. The ANFIS architecture is constructed by a five-layer as shown in Figure 1 [13-14].

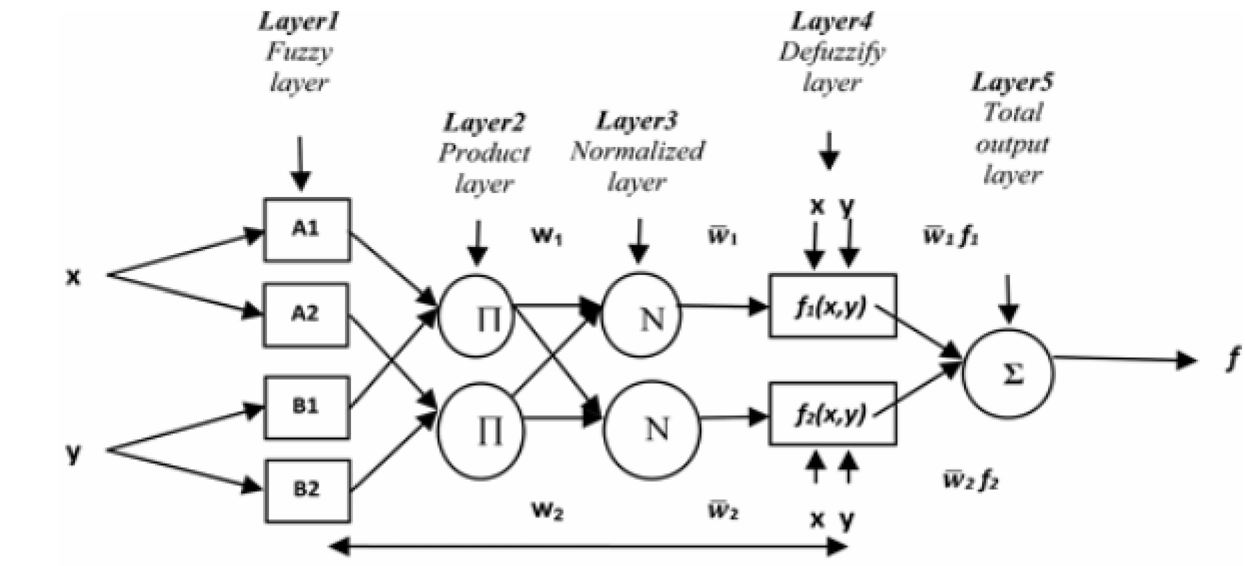

Fig. 1: ANFIS Structure

layer1: Determination of the degree of membership for each input by fuzzy membership function In this research we choose triangular function as membership functions (MFs).

$$O_i^1 = \mu_{A_i}(x), \qquad i = 1,2,3$$
$$O_i^1 = \mu_{B_{i-2}}(y), \qquad i = 3,4,5 \qquad (1)$$

Layer2:: all incoming inputs are receives from fuzzification neurons known as firing strength. The output is calculated by Equation 2

$$\theta_i^3=\overline{w_i}=\frac{w_i}{w_1+w_2+w_3} \qquad i = 1,2,3 \qquad (3)$$

Layer4: executes the conclusion part of fuzzy rules (defuzzification layer). The outputs of this layer are given by:

$$\theta_i^4=\overline{w_i}f_i = w_i(p_ix + q_iy + r_i) \qquad i = 1,2,3 \qquad (4)$$

Layer5: In this layer calculates overall output of the ANFIS from layer4 as.

$$\theta_i^5=\sum_{i=1}^{3}\overline{w_i}\,f_i = \frac{\sum_{i=1}^{3} w_i}{w_1+w_2+w_3} \qquad i = 1,2,3 \qquad (5)$$

4. Certainty factor method (cf) with anifs

Because of the great convergence between the rules of the subject of anesthesia, which was obtained from the expert specialist in this domain, sometimes appear more than the possibility of the ANIFS, so it was combined with the theory of the certainty factor, which is characterized by estimating the probability of output generated by the network with accurate mathematical analysis .This method is suitable for expert systems to diagnose something uncertain. because it is based on evidence or expert judgment. A certainty factor (cf), a number to measure belief of the expert. The great value of the certainty factor is, say, +1.0 (sure true) and the smallest -1.0 (sure false). The basic formula of Certainty Factor in the form of a rule if E then H [13] [15][16-17], as follows.

CF(H,e)=CF(E,e)*CF(H,E) (6)

CF (E,e) : CF evidence (E) be influenced via the evidence (e)

CF (H,e) : CF hypothesis (H) be influenced via the evidence (e).

CF (H,E) : CF hypothesis (H) assuming evidence that is exactly known, when CF (E,e)=1.

The following flowchart shows the research mechanism in figure 2:

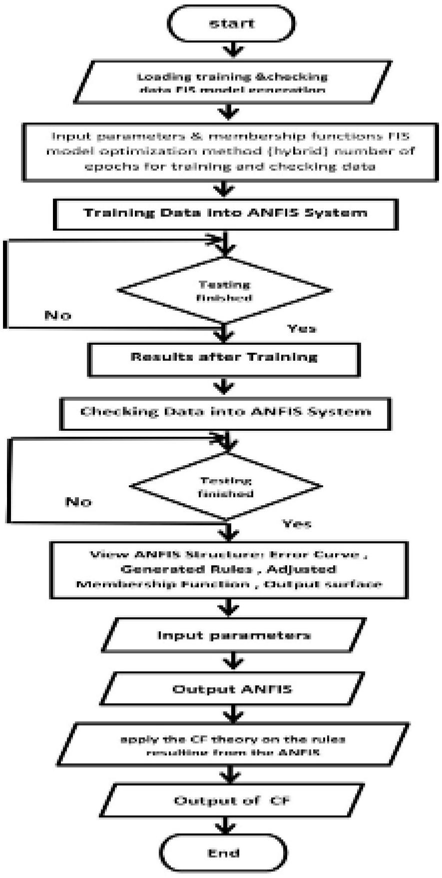

Fig. 2: Flow chart diagram of the research

5. Data collection

Data are collected from several sources; medical Colleges, research institutes, anesthetists and medical sites. We have 39 inputs which this system is based .The given table discusses the different ranges of input parameters. A sample of input fields (attributes) is displayed in Tables 1,2,3,4,5 and 6, and membership numbers 3,4,5,6,7 and 8 [18-21]:

Table 1: Membership Function of HB

Input	Parameter[1 30]	Fuzzy set
HB	[2 7]	Low
	[1 16]	Normal
	[2 25]	high

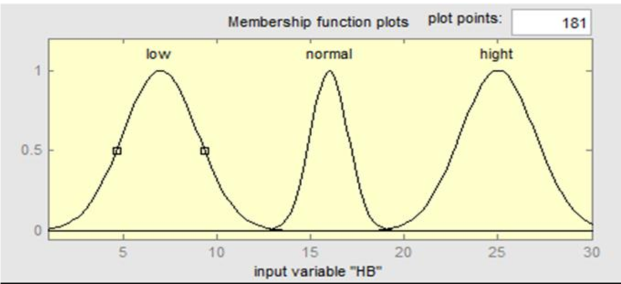

Fig. 3: Membership Function of HB

Table 2: Membership Function of HCT-PCV

Input	Parameter[10 100]	Fuzzy set
HCT-PCV	[5 25]	Low
	[3 45]	Normal
	[7 70]	high

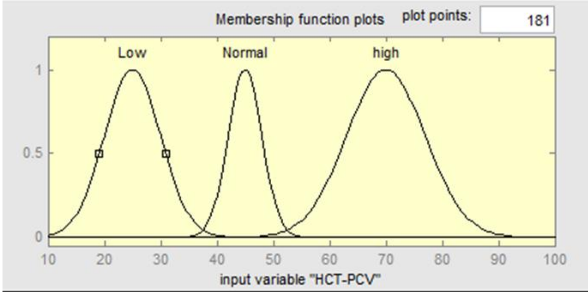

Fig. 4: Membership Function of HCT-PCV

Table 3: Membership Function of WBC

Input	Parameter[1 20]	Fuzzy set
WBC	[0.5 2.5]	Low
	[1.5 7.5]	Normal
	[1.2 15]	high

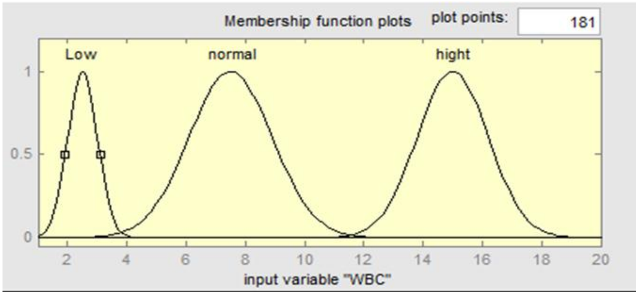

Fig. 5: Membership Function of WBC

Table 4: Membership Function of ECG

Input	Parameter[-0.5 2.5]	Fuzzy set
ECG	[0.2 0]	Normal
	[0.25 1]	ST-Tabnormal
	[0.2 1.8]	hypertrophy

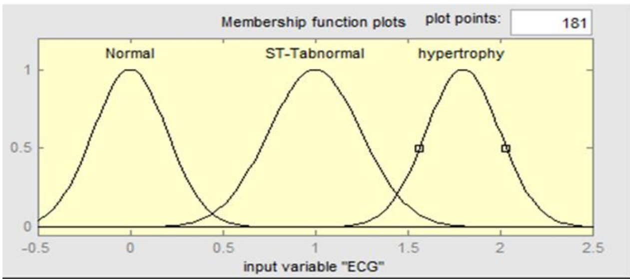

Fig. 6: Membership Function of ECG

Table 5: Membership Function of SUGAR

Input	Parameter[30 700]	Fuzzy set
SUGAR	[16 60]	Low
	[21 150]	Normal
	[120 500]	high

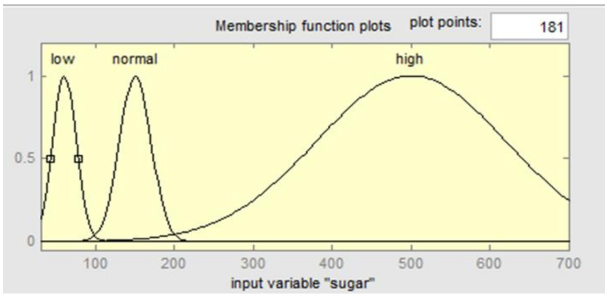

Fig. 7: Membership Function of sugar

Table 6: Membership Function of output

Input	Parameter[10 100]	Fuzzy set
output	[3.5 20]	Very Dangerous
	[4.5 40]	danger

	[5 60]	normal
	[7 85]	very natural

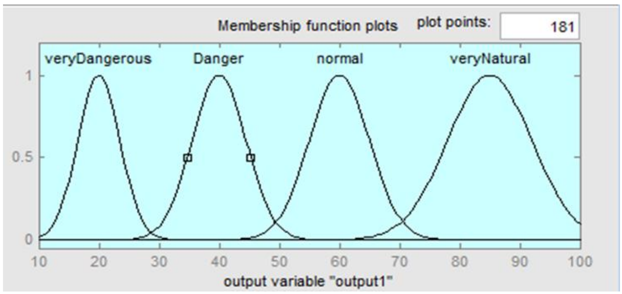

Fig. 8: Membership Function of Output

6. Results and discussion

In this section, we present the results of hybrid neural network combined with fuzzy logic and the end result by the certainty factor theory with the design illustrated in several paragraphs**:**

6.1 The working with ANFIS plus Result

- The rules are generated from domain expert (Doctors).The rules have been display in figure.8 by editor of the ANFIS

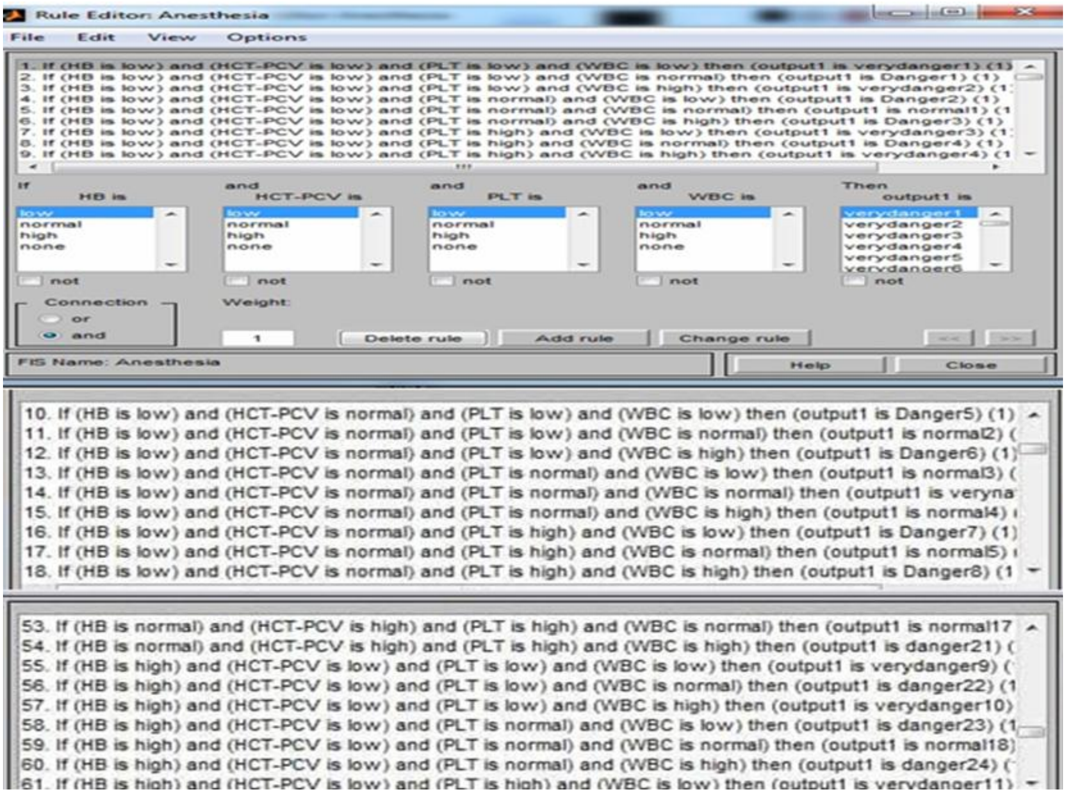

Fig. 8: Rule Editor

- Fig 9 display the generated FIS of the ANFIS. Input parameters and the result

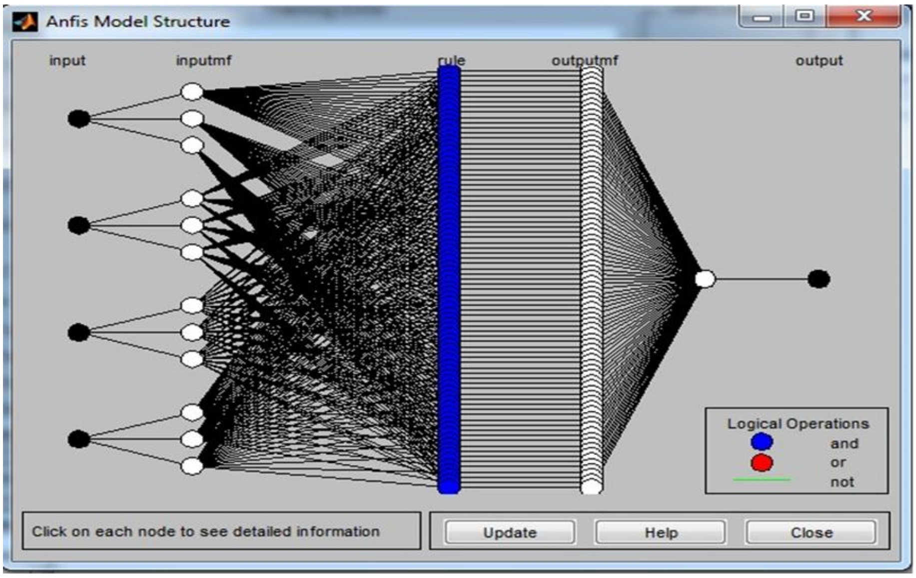

Fig 9: Generated FIS Structure

- Figure 10 display input , sugeno with 81 rules

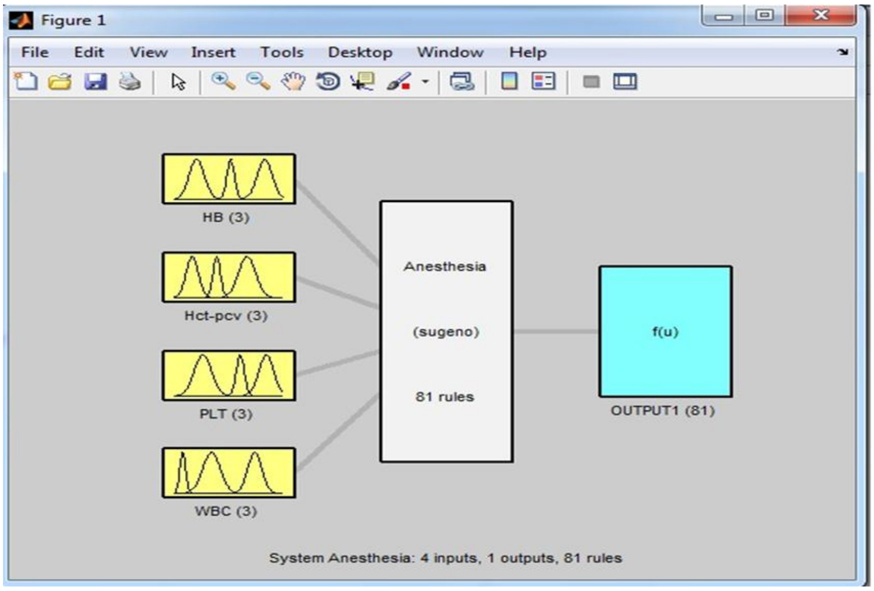

Fig. 10: Sugeno with 81

- Figure 11 display input parameters and result of the ANFIS by the rule viewer

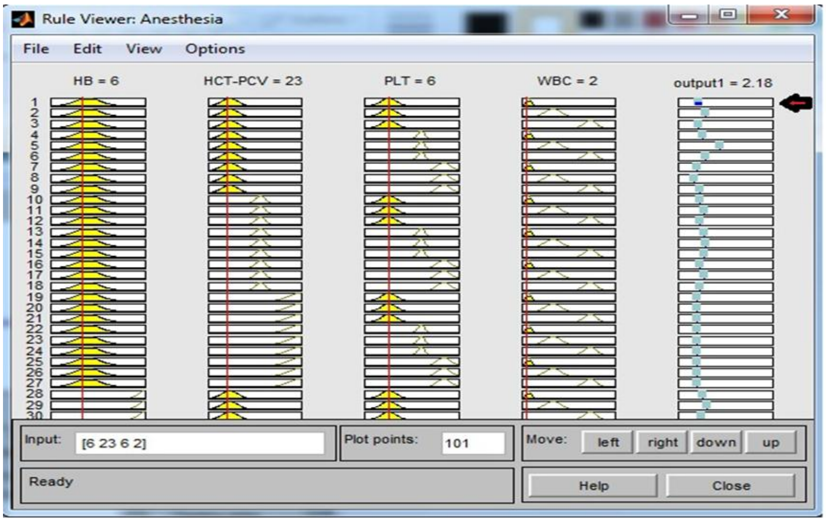

Fig. 11: Rule Viewerof ANFIS

6.2 Training and testing

We have trained and tested the designed system with following values for four inputs and result is shown in Table 13 and Table 14.

Table 7: Segment of the training data in ANFIS

Training data						Informations of ANFIS : nodes: 193 linear parameters: 405 nonlinear parameters: 24 Total of parameters: 429 Training data pairs: 442 Checking data pairs: 1 fuzzy rules: 81 Start training ANFIS ...
No	**input**				**output**	
1	1	11	1	1	1.12	1 0.0157217 0.102272
2	1	11	1	2	1.03	2 0.0669966 0.122201
3	1	11	1	3	1.03	3 0.0340451 0.0937718
. . .	. . .	. . .	. . .	. . .	. . .	4 0.0590698 0.121711 5 0.0339398 0.0922129 decreases to 0.009000 after epoch 5. 6 0.0590446 0.121728

416	23.20	11	5	5	38
417	23.20	11	6	6	38
418	23.20	11	7	7	38
419	23.20	11	8	8	38
420	23.20	11	9	9	38
421	23.20	11	10	10	39.60
422	23.20	11	12	12	45.40
423	23.20	11	13	13	39.80
424	23.20	11	14	14	28.50
425	23.20	11	15	15	12.20
426	23.20	11	16	16	12
427	23.20	11	17	17	12
428	23.20	11	18	18	12
429	23.20	11	19	19	12
430	23.20	11	20	20	12
431	23.20	11	13	1	38.90
432	23.20	11	13	2	38.70
433	23.20	11	13	3	39.20
434	23.20	11	13	4	62.70
435	23.20	11	13	5	66.70
436	23.20	11	13	10	66.70
437	23.20	11	13	11	65.20
438	23.20	11	13	12	45.10

7 0.0260351 0.0956534
8 0.0590337 0.121766
9 0.0260253 0.0956925
decreases to 0.008100 after epoch 9.
10 0.0590234 0.121801
11 0.0198921 0.0986959
12 0.0590118 0.12184
13 0.0198845 0.0987321
decreases to 0.007290 after epoch 13.
14 0.0590017 0.121873
15 0.0160105 0.101364
16 0.0589814 0.121921
17 0.0160055 0.101405
decreases to 0.006561 after epoch 17.
18 0.0589607 0.121947
19 0.0148797 0.103721
20 0.0589509 0.0825711

Training of ANFIS was completed at epoch 20.

	HB	HCT	PLT	WBC	OUTPUT
checking data =	1.500	11	1	1	1

Table 8: Sample of the input for testing in ANFIS

TEST					
input				Output in fuzzy	Output in ANFIS
HB	HCT-PCV	PLT	WBC		
20	50	10	10	69.5092	69.4799
1	10	1	10.6	15.3407	15.3413
1	10	1	20	1.8136	1.8098
16	46	12	2	75.9000	75.9000
16	71	12	7	79.9999	80.0002

*C.*Combine CF with ANFIS

Suppose you entered the following values shown in the Table 9:

Table 9: Input of user

HB	HCT-PCV	PLT	WBC	Output from ANFIS
1	10	1	10.6	**16.849**

Possible rules after ANFIS result:

- 81. If (HB is high) and (HCT-PCV is high) and (PLT is high) and (WBC is high) then (output1 is verydanger16) (1)

Output = 17

- 2. If (HB is low) and (HCT-PCV is low) and (PLT is low) and (WBC is normal) then (output1 is Danger1) (1)

Suppose the certainty factors (CF) for every rules = 1 and cf for evidence be show in the table 10:

Table 10: CF of Evidence

Symptoms	CF
HB is high	0
HB is low	0.01
HCT-PCV is high	0
HCT-PCV is low	0.01
PLT is high	0
PLT is low	0.004
WBC is high	0.001
WBC is normal	0.12

CF1 (Very Danger, E1 ∩ E2 ∩ E3 ∩ E4) = min [0 , 0 , 0 , 0.001] *1 = 0*1=0

CF2 (Danger, E1 ∩ E2 ∩ E3 ∩ E4) = min [0.01 , 0.01 , 0.004 , 0.12] *1 = 0.004*1=0.004

*D.*GUI

Fig. 12: Main Form

Fig. 13: Form1 Of Symptoms

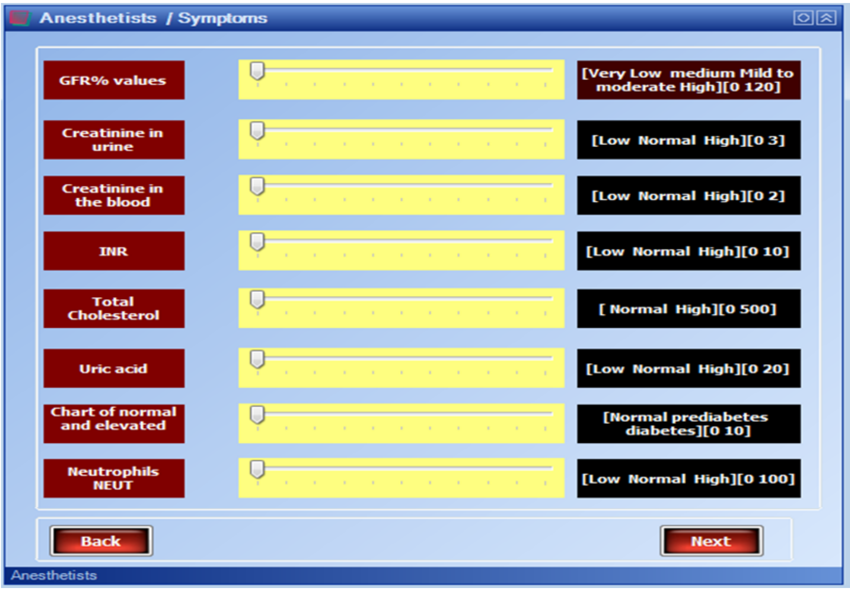

Fig. 14: Form2 Of Symptoms

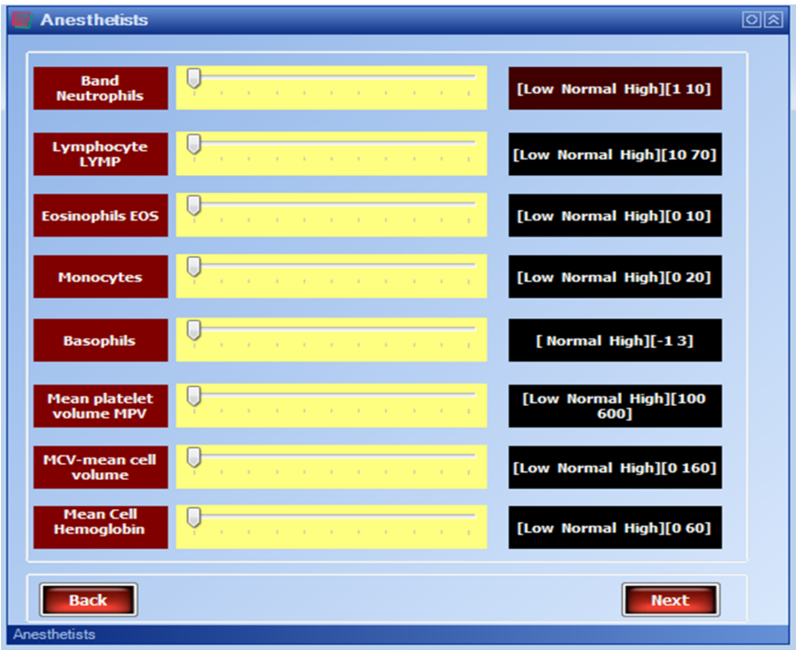

Fig. 15: Form3 Of Symptoms

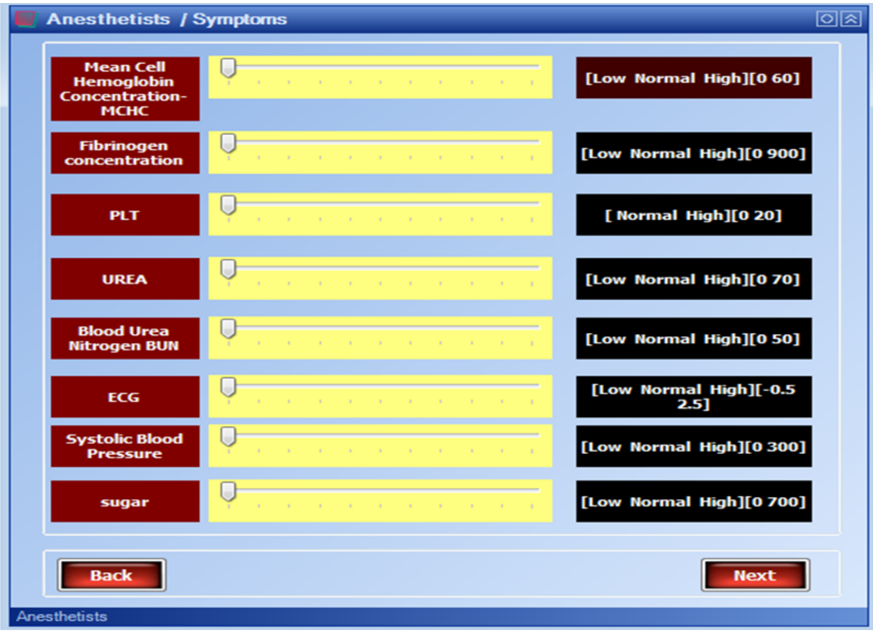

Fig. 16: Form4 Of Symptoms

7. Conclusion

In this research, a hybrid intelligent system (expert system) is designed, an advanced diagnostic alarm system based on evidence and accurate diagnosis during the operation. In this system, the patient is monitored in order to determine the type and level of anesthesia, administer the drugs given during anesthesia, and allowing the patient to wake up when completed without complications, and detect possible non possible changes in the patient's condition, and to prevent human errors from producing catastrophic events with high accuracy. In this system, many methods of artificial intelligence were used. This system aims to assist in early detection of potentially dangerous situations and can be useful in providing decision support to anesthesiologists and clinical medicine. In addition it manages a large number of patient data and follows it more efficiently.

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