Implementation of Adaptive Electronic Acupuncture System using Intelligent Diagnosis System

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Abstract

In this paper, we proposed the adaptive electronic acupuncture system in which patients' biometric information is collected and patients' condition is found automatically and then, patients are treated by their condition. In the proposed system, the electronic acupuncture with built in multi pad is used to relieve the pain that patients feel when they get acupuncture. We calculated the exact time of electronic acupuncture optimal for patients' physical condition using fuzzy rules. By calculating the exact time, the patients can be treated with optimally, and acupuncture time can be shortened and strength of acupuncture can be moderated considering their condition. And also this system is safe for the infection by acupuncture and do not leave acupuncture injection mark. This system is useful for remote medical examination and treatment.

Keywords: *Intelligent diagnosis system, Fuzzy rules, Adaptive Electronic acupuncture*

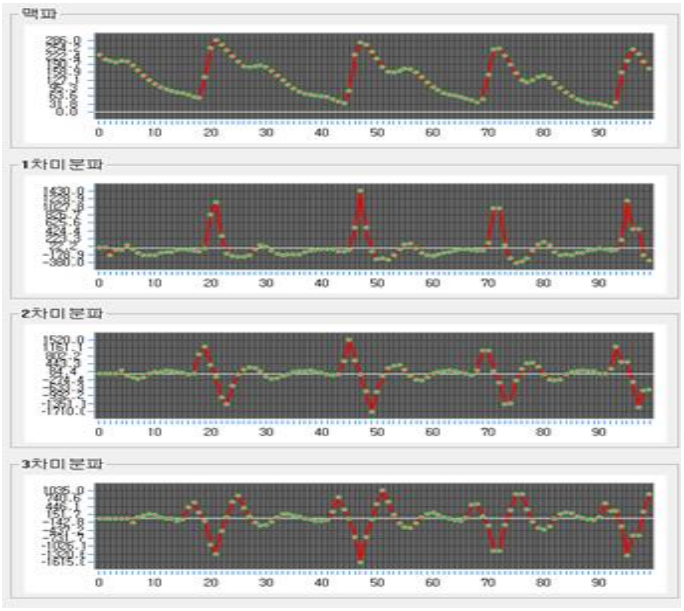
1. Introduction

Oriental doctors have considered pulse rates as important data in diagnosis. Recently, the pulse is considered an important factor in oriental medicine because observation of a person's pulse rate may reflect their health and illness [1-3]. It is difficult to standardize pulse exactly because thickness of their blood vessels is different even if the thickness of two person's forearm are equal. The current blood pressure pulse analyzer may be considered flawed, since it is uncertain whether the blood pressure pulse analyzing sensor is located precisely on the radial artery. Furthermore, the analogue type blood pressure pulse analyzer has the issue of objectifying the blood pressure pulse. Although some people may have the same forearm length but the thickness of their blood vessel may differ and therefore there is no set of data that is considered reliable enough to judge the accuracy of blood pressure pulse rates [4, 5]. Oriental doctors should not only judge the basic biological signals such as checking the pulse's size, strength, and speed, but should also consider the basic and quantitative analysis of the pulse in order to gain an accurate diagnosis. Also, the doctor should consider physical characteristics, such as the thickness of the skin and blood vessels, in order to reach an accurate conclusion. Therefore, measurement of the blood flow rate is a vital indicator in understanding the blood pressure rate and how the substances in the blood are transported. To

solve this problem, we analyzed the fine distinction considering thickness of skin and blood vessels and pulse, weather big or small, strong or weak and fast or slow. We proposed the algorithm that analyzes patient's condition using 2nd differentiation of pulse wave. Big change in person's pulse means that he has diseases and risk factors affected in the parts of body. Moreover, measurement of blood flow is the important indication how blood carries. Existing pulse checker does not take pulse exactly because it does not consider patient's sex, age and skin thickness etc. In this study, to solve these problems, we proposed the method that we can take pulse suitably considering patient's physical condition. While more than 60% of electronic acupunctures developed in the country are made by using low frequency, the rest are made by using momentary electrostimulation. The electronic acupunctures using low frequency are simple frequency generator. It generates low frequency (16~32Hz) signal after attaching the electrodes to patient's painful part. It can't treat the patients effectively because it uses uncertain and vague frequency. Furthermore, it can't find acupuncture points because it has no consideration for patient's sex, age, weight, illness, etc. And it causes problem that children and elderly people are bruised or wounded after getting electronic acupuncture because of inappropriate acupuncture time and strength [6, 7]. In this paper, to solve these problems, we simulated acupuncture time, strength and point suitable for patient's condition using intelligent fuzzy algorithm. We classified the patients by their body, illness and age, and calculated the exact time of electronic acupuncture suitable for patient's physical condition using fuzzy logic and inference. The composition of this paper is as follows. Section 2 is about pulse diagnosis system and fuzzy rules, Section 3 is about electronic acupuncture system using fuzzy, Section 4 is about the simulation of electronic acupuncture, and finally Section 5 concludes.

2. Pulse diagnosis system and fuzzy rules

The doctors are analyzing the patient's health condition through studying the blood circulation and changes in pulse wave. In other words, differentiating the pulse wave of the patient which is not stabilized nor has a distinct inflection point twice APG, the doctors are judging the patient's health condition in three states, positive which means safe, negative which means dangerous, and zero. During the first stage of studying the pulse, the pulse pressure was mainly used but recently due to simplicity of detection, volume pulse is being preferred. Second derivative of APG is a pulse wave that is derived from differentiating the volume pulse twice. The constant changes in accelerated APG as the patient's age increased. In this thesis, by analyzing the blood pressure pulse, we wish to accurately diagnose and verify the internal organs. When a patient is diagnosed with weak liver through checking the pulse, we should keep in mind that every person has a different physiological signal. In this case, we should verify this by electronically stimulating the hepatic pulse located on the patient's hand. If there is pain in liver when it is stimulated, then it can then be assured that the patient is suffering liver problem because when an area is wounded, the electric wave meets high resistance from the body. Therefore electric wave is weak in the wounded area and results in decrease of absolute current in tissue.



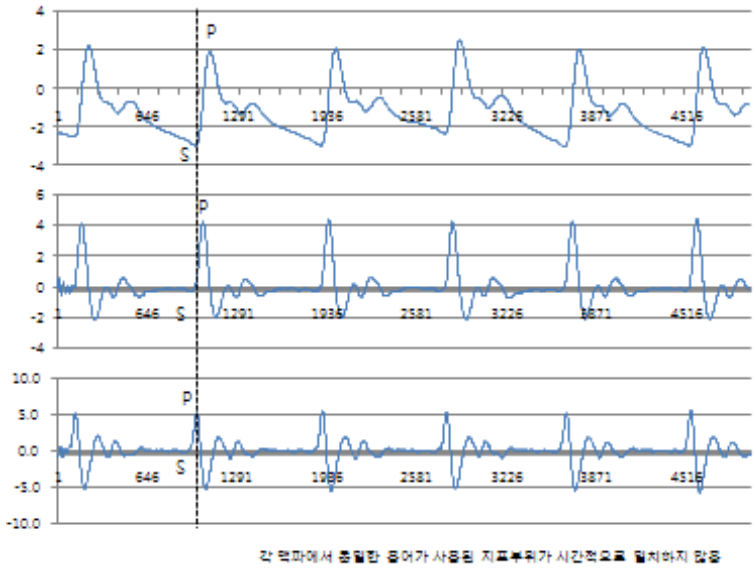


Figure 1. Second Derivation of Pulse Wave

Figure 1 explains when aortic valve is closed and capacity and pressure within the artery rises. Figure 2 shows aging index graph. Aging index is marked by b/a, c/a, d/a, e/a. especially, b/a and d/a are considered important. Aging index rises along with the age. Because a standardized aging index is set, the difference between the actual age of the patient and his/her blood vessel age can be seen. Table 1 shows a patient's pulse data.

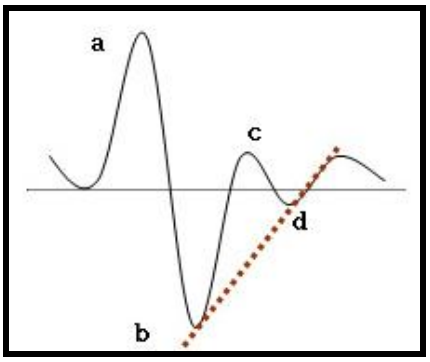


Figure 2. Aging Index Graph

Table 1. Patient's Pulse Data Sheet

High blood pressure 117.2 Low blood pressure 72.89

date		6.19~21		name			Ahn		age		sex	male		height				
No.	time	high	low	period	Reflected pulse reach time	Pulse no.	Corrected pulse reach time	dicrotic notch time	period/ dicrotic notch	Strengthen index	dicrotic notch index	b/a	d/a	contraction / expansion ratio	Measured high pressure	Estimated high pressure	Measured low pressure	Estimated high pressure
1	7:35	116	72	1.15	0.250	52.1	0.174	0.330	3.488	-18	0.718	-1.13	-0.254	0.969	116	117	72	74
2	7:37	116	72	1.1	0.249	54.8	0.182	0.330	3.318	-10	0.781	-1.06	-0.192	0.874	116	110	72	74
3	7:38	116	72	1.13	0.255	53.3	0.181	0.338	3.328	-7	0.801	-1.05	-0.231	0.834	116	109	72	74
4	7:45	114	74	1.15	0.255	52.2	0.178	0.340	3.379	-10	0.780	-1.09	-0.205	0.884	114	110	74	75
5	7:46	114	74	1.08	0.250	55.7	0.186	0.331	3.257	-5	0.807	-1	-0.239	0.881	114	110	74	72
6	7:52	114	74	1.05	0.247	57.3	0.189	0.324	3.235	-5	0.760	-0.95	-0.348	1.007	114	114	74	68
7	8:00	123	71	1.13	0.249	53.2	0.177	0.330	3.415	-4	0.832	-0.89	-0.249	0.834	123	122	71	71
8	8:01	123	71	1.17	0.245	51.1	0.167	0.333	3.526	-14	0.777	-0.94	-0.063	0.874	123	131	71	73
9	8:03	123	71	1.07	0.244	56.1	0.183	0.330	6.239	-19	0.694	-1.03	0.012	0.871	123	128	71	71
10	8:04	123	71	1.09	0.249	55	0.183	0.331	3.293	-13	0.758	-0.98	-0.079	0.864	123	127	71	72
11	8:10	120	67	1.09	0.252	55.1	0.185	0.335	3.251	-12	0.798	-1.02	-0.086	0.853	120	121	67	75
12	8:11	120	67	1.12	0.255	53.7	0.183	0.337	3.315	-14	0.751	-1.08	-0.138	0.821	120	119	67	74
13	8:13	120	67	1.19	0.255	50.3	0.171	0.343	3.475	-17	0.712	-1.13	-0.066	0.933	120	118	67	72
14	8:14	120	67	1.2	0.258	49.9	0.172	0.345	3.484	-11	0.754	-1.09	-0.121	0.866	120	114	67	72

The general algorithm comes to a conclusion of B on the assumption of 'A → B and equals A'. In this case the latter A should be completely consistent with the former A (of conditional clause). This kind of inference is called Modus Ponens and the Fuzzy algorithm is trying to expand as follows which will be called GMP (Generalized Modus Ponens);

Assumption 1 : If x equals A, y will be B.

Assumption 2 : x equals A'.

Conclusion : y equals B'.

When you use the Fuzzy Rules, the knowledge to judge a patient's health by using the pulse wave will be expressed in Fuzzy R and you will be able to carry out modeling like the following to observe Output (or Symptom) B to clarify Input (or Cause) A [8, 9].

Figure 3 shows the algorithm which calculates the patient's condition considering patient's disease and physical conditions using fuzzy rules.

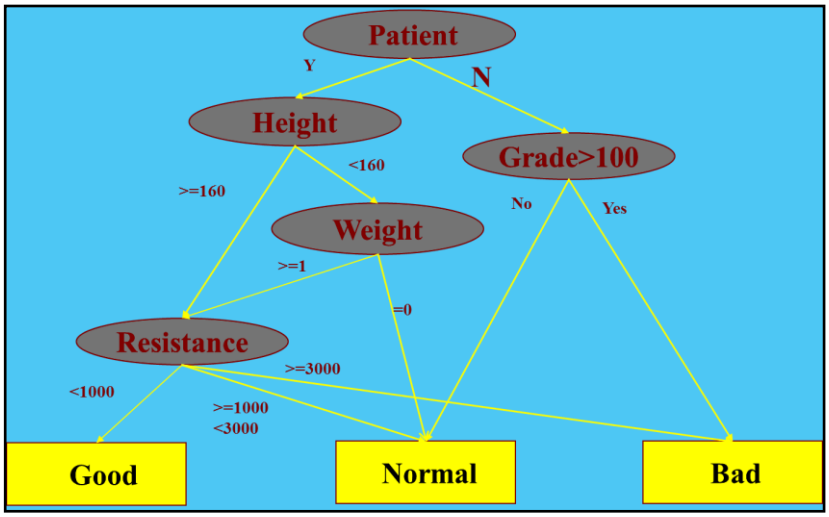


Figure 3. Calculation of Patient's Condition using Fuzzy Rules

In the Figure 4, the disease condition of patient c is medium as 0.5 and physical condition is healthy as 0.8. This patient's acupuncture time can be extended. In the case of the patient d, disease condition is the same with patient c as 0.5, but physical condition is weak as 0.1. His acupuncture time must be reduced.

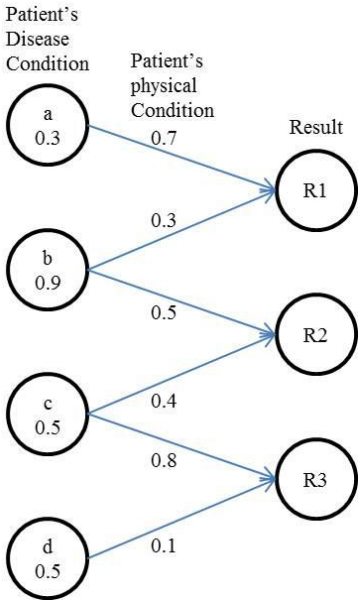
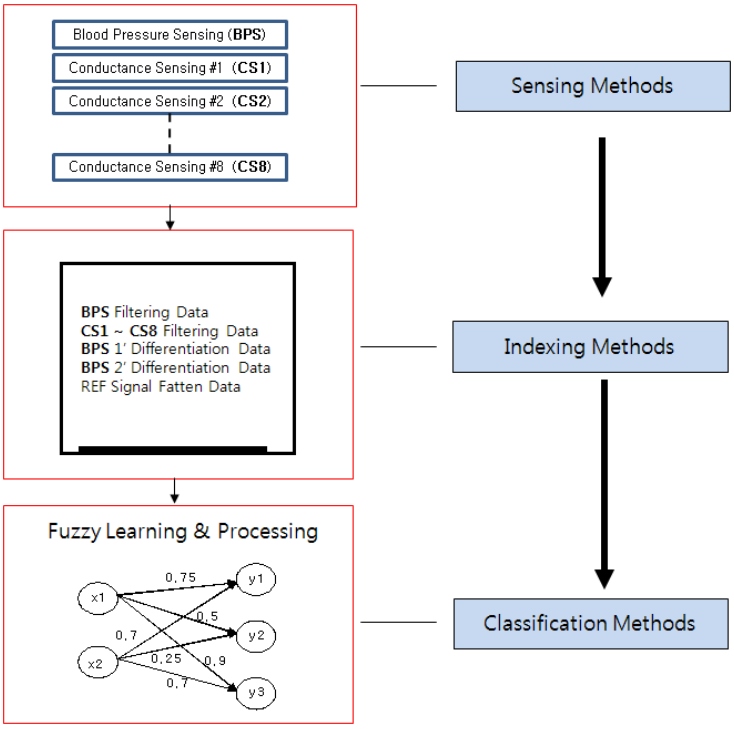


Figure 4. Calculation of Patient's Acupuncture Time using Fuzzy Rules

When patients use existing electronic acupuncture, it causes problem that children and elderly people are bruised or wounded after getting electronic acupuncture because of inappropriate acupuncture strength. To solve this problem, suitable acupuncture strength must be considered. We use fuzzy conversion factor to adjust the correlation coefficient in consideration of the weight, age, gender, and physical condition. Figure 5 shows sequence of classification of patients.

Figure 5. Patient Classification Sequence



The evidences of this kind of hypothesis are atopic disease, acne, and age spot. This skin related troubles happen because the diseased spots have high resistance of electricity. High resistance to electricity means inappropriate oxygen provision therefore the skin disorder occurs in various ways such as atopic disease or age spot. Existing blood pressure pulse analyzing system doesn't consider patient's sex, age, and condition therefore there is an inadequacy of choosing the right amount of pressure to press the needle into patient's skin. It also has a problem of inaccuracy in finding the right acupuncture points. Therefore if a needle is used on an aged patient or a young patient with weak skin it might leave bruises or wounds. In this paper, it tried to solve these problems using intelligent fuzzy rules [10, 11].

$e=R-Y$

$Ce=e2-e1$

Where, Y: optimum pulse feeling judgment

R: Criteria Input

e: Error

Ce: Error Displacement

e2: Current Error

3. Electronic Acupuncture System using Fuzzy

If the tissues of the human body are injured, the electric resistance of the injured part is increasing than around. So the current of the injured part is smaller than around, and in which total current is reduced. Oriental doctors examine the patients with hand acupuncture and

make a diagnosis of the illness, based on the fact that if the patients feel pain in their fingers, their internal organs are something wrong. This is well known theory of medical diagnosis in oriental medicine. Using this theory we implemented the hardware system which diagnoses a patient's diseases. This system, we called Multi-pad, composed of three parts. The first part is composed of the sensor detects the conductance which corresponds with injured part of human body, and reference signal generator to moderate the signal generated from patients is included. The second part is composed of DSP Board in which the signals are measured and to do a sort using fuzzy algorithm.

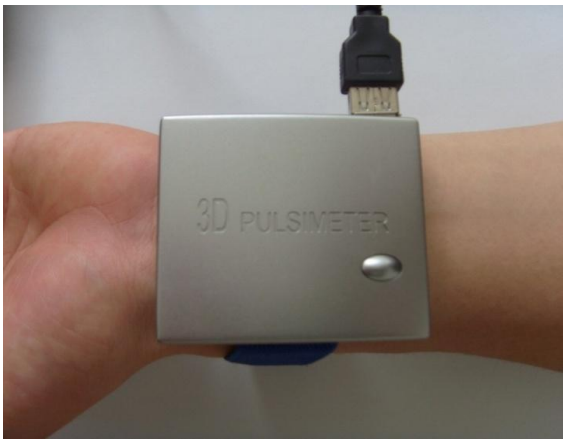


Figure 5. Diagnose System for Electronic Acupuncture

The last part is composed of computer system that displays the signal from DSP Board to the monitor, and analysis software to diagnose the patients. Figure 4 shows the whole diagnose system for electronic acupuncture. As shown in the Figure 5, the system diagnoses diseases in patients by sensing the fine distinction of the currents passing through sore part of body.

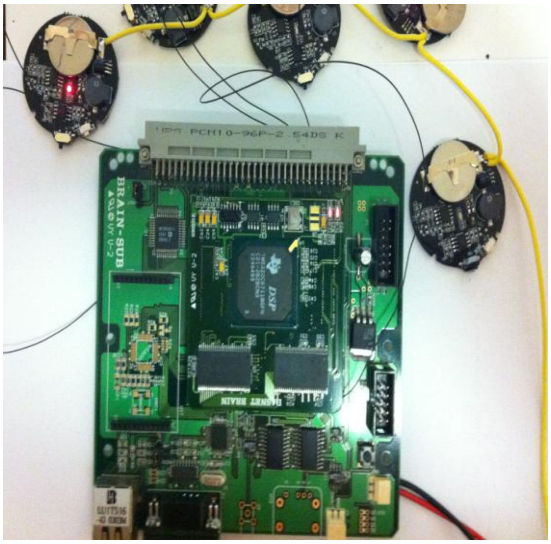


Figure 6. Electronic Acupuncture Sensing Panel

Figure 6 shows electronic acupuncture sensing panel. At the end of the finger sensing pad in contact with parts of gold plated to reduce resistance after treatment were distributed evenly throughout the area in order to access the array was produced in the form of stripes. Prototype, the sensing and the role of electronic acupuncture more detail type of gloves to be considered are the design requirements. Electronic acupuncture with active treatment is a photograph showing the scene for the experiments. Reference electrode located on the bottom of the palm pad and place for each knuckle of each finger tip by placing electrodes on the signal DSP through the signal processing, then sent to the main PC and fuzzy algorithm, the control variable with DSP D/A converter and the drive passes through the pad, power is doing procedures [12, 13]. The press in the palm of your hand, the pressure may appear differently depending on the strength. Therefore, for this data in order to minimize errors, use your fingers were slightly different ways.

4. Simulation

In this paper, in order to solve this kind of problem, it uses compositional inference while using the fuzzy rule. Fuzzy compositional rule of inference is applied to come up with a calibrating constant in order to derive an accurate result (considering the patient's physical condition) in analyzing the blood pressure pulse. In existing method, an oriental doctor infers one pulse wave out of 28 pulse wave and diagnoses the patient. Fuzzy compositional rule of inference is a rule made in order to come up with an inference by using fuzzy production rule which includes fuzzy variables. The form of fuzzy compositional rule of inference is as in the following.

Belief of fuzzy composite function: If fuzzy compositional rule of inference is applied in fuzzy production rule then belief of fuzzy evaluation function can't be used. So in order to calculate the belief of fuzzy function, the belief of fuzzy composite function is used.

$$\beta\ c = \beta comp(\beta(\beta f, \beta r))$$

$$= \min (\max (\beta (\beta fp, \beta rpq)))$$

In here, p=1, 2, ⋯, m, q = 1, 2, ⋯, n. m, n are the number of each fuzzy thesis in premise and conclusion. Belief of fuzzy union function in type 1 and 2 of fuzzy production rule which are the minimized version of type 5 and 6 can come up with the same node or conclusion using different inference. In this kind of node, same conclusion has two or more different belief of function. In this type of situation, in order to recalculate the belief of fuzzy function, fuzzy union function is used.

In this paper, the blood pressure is converted into a form for facilitating judgment via first and second derivative and the electrode to measure the conductivity filters each delivered signal to create the input data required by the fuzzy logic.

(RULE 1) IF DPSV IS PB
AND USPC IS NS
THEN OPRG IS PB
(RULE 2) IF DPSV IS PB
AND USPC IS NM
THEN OPRG IS PM
(RULE 3) IF DPSV IS PS
AND USPC IS NS
THEN OPRG IS PS

In above routine, the constrained condition is as follows.

DPSV: Patient condition error (E)

USPC: Degree of patient's disease

Skin: Error change amount (CE)
OPRG: Optimal acupuncture time

To consider fuzzy control rule and patient's physical condition, it produces the most Optimal acupuncture time output (OPRG).

IF (70<TPR)AND(100>=TPR) OR (51<TPR)AND(52>=TPR) OR
(81<TPR) AND (100>=TPR) THEN
TPRQ:=0.7;
IF (41<TPR)AND(69>=TPR) OR (49<TPR)AND(50>=TSP)AND(51<TPR)AND
(53>=TPR) OR
(41<TPR) AND (80>=TPR) THEN
TPRQ:=0.5;
IF(1<TPR)AND(40>=TPR)OR
(47<TPR)AND(48>=TPR)AND(51<TPR)AND(52>=TPR) OR
(8<TPR) AND (40>=TPR) THEN
TPRQ:=0.3;

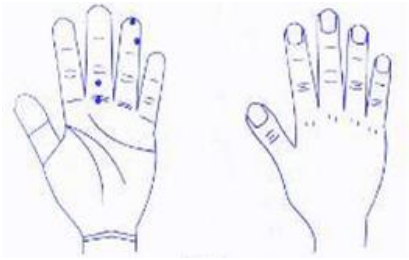


Figure 6. Point Calculation for Electronic Acupuncture

Figure 6 shows the function of indicating the patient's acupuncture points in relation to their disease conditions if they choose electronic acupuncture menu. It shows the four input conditions to calculate the optimal acupuncture time considered patient's sex, age, physical conditions.

Figure 7. Time Calculation for Electronic Acupuncture

Figure 7 shows the result of the exact acupuncture time of the patient after input their sex, weight, height and disease conditions. It uses the fuzzy rules to find out exact acupuncture points and time suitable for patient's physical conditions. In the Table2, the result shows that the electronic acupuncture time of patients can be extended or reduced by considering patient's conditions. In existing method, it is difficult to adjust the acupuncture time, but in proposed method, it is possible to adjust the acupuncture time suitable for patients.

Table2. Simulation Results for Electronic Acupuncture Time

Input data			Acupuncture time
Physical	Disease	Age	
Big	Small	Big	Extend
Big	Med	Big	Reduce
Big	Big	Big	Reduce
Med	Med	Med	Normal
Med	Med	Small	Reduce
Med	Big	Big	Normal
Small	Big	Big	Reduce
Small	Big	Med	Reduce
Small	Big	Small	Extend

5. Conclusion

It is very difficult to analyze the conventional pulse wave in oriental medicine. Recently, oriental doctors have been able to distinguish the condition of blood vessels in seven types and can judge a patient's illness conditions through the observation of the pulse. But in order to accurately analyze the pulse wave of a person, factors such as height, weight, age, skin type, skin impedance, thickness of skin and blood vessels should be considered. In this paper, we simulated the process to calculate the exact time of electronic acupuncture suitable for patient's physical condition using fuzzy logic and inference. We classified the patients by their body, illness and age to calculate exact time of electronic acupuncture. By calculating the exact time, the patients can be treated with optimally, and acupuncture time can be shortened and strength of acupuncture can be moderated considering their condition. We proposed the electronic acupuncture with a built in multi-pad. It has advantages to find out the patient's conditions and treat the patient with acupuncture simultaneously. And also this system is safe for the infection by acupuncture and do not leave acupuncture injection mark. This system is useful for remote medical examination and treatment.

Acknowledgements

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