

Acupuncture System Based on Computer Techniques and Database Diagnosis

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ABSTRACT: The paper introduces the EA (electric acupuncture) treatment system based on expert database diagnosis technique. The system is a expert database of automatic reasoning diagnosis by the combining the maximum likelihood method and relation database. It integrates symbolic measurement theory, computer technology and electronic technology, which develops EA needling method by imitating classical acupuncture techniques. The system effectively achieves the integration of diagnosis and treatment.

Subject Categories and Descriptors

I.2.10 [Databases]: Medical Diagnosis and Treatment; **I.4.10 [Data Mining]**

General Terms: Video Frame Processing, Content Processing

Keywords: Acupuncture, EA (Electric Acupuncture), Expert Database, The Maximum Likelihood Method

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1. Introduction

In acupuncture clinical treatment, to improve the medical effect and reduce the misdiagnosis rate, the expert database of automatic reasoning, diagnosis with treatment program has been developed, which could help to solve complex medical problems as the assistant of the doctor's diagnosis and treatment. Acupuncture technique is the

key to improving the clinical effect and also one of the difficulties of inheriting and developing forward classical acupuncture treatment. This paper simulates EA needling of classical acupuncture techniques by computer technology, which improves the clinical medical effect of EA. These have important significance for promoting the progress of acupuncture technique.

2. Systematic Structure Design

2.1 Systematic Hardware Design

The main hardware includes: computer, I/O interface equipment (data acquisition card), and control circuit for EA signal and acupuncture treatment, and the whole hardware systematic structure sees Figure 1. The generation of EA signals: pulse signal ($-5V \sim +5V$) of classical imitation acupuncture technique; to meet the demand of EA signal, it needs to boost the signal. Human temperature monitoring: the temperature data of human skin surface measured by temperature sensor will be collected by data acquisition card through a temperature measurement circuit. The host computer reads the data on the acquisition card for the interface temperature display and light source control. Light source control part: light source consists of halogen lamp and laser, with the spectral range of $600nm \sim 6\mu m$, and corresponds to moxibustion spectrum. Based on the fuzzy control algorithm and the acquired temperature value, the computer modulates the duty cycle of pulse signal from the acquisition card, and control the on-off time of light source thus to control the light power (acupuncture control

system will be discussed in other paper).

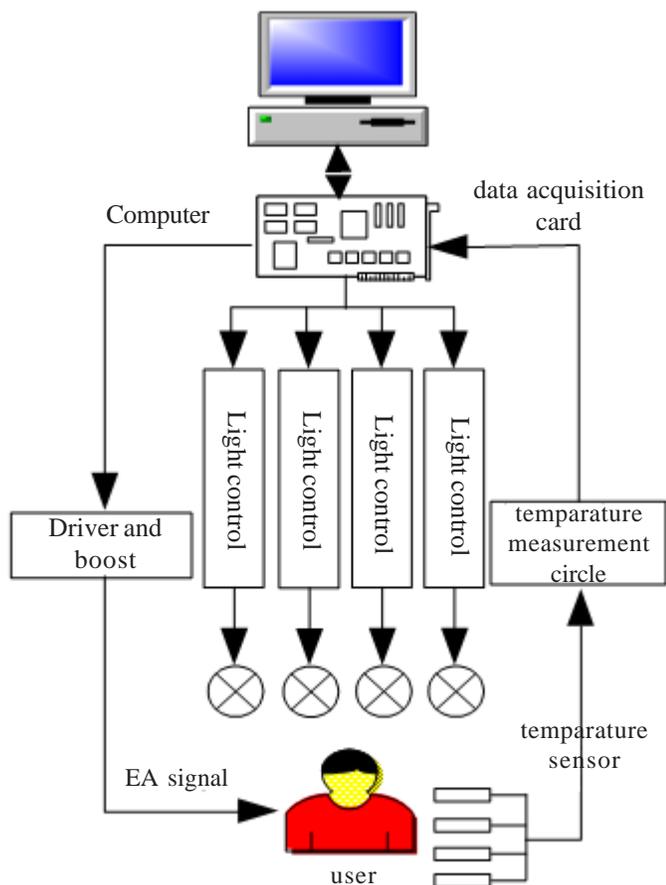


Figure 1. Hardware Systematic Structure

2.2 Systematic Software Design

The system will be developed by Visual C++. NET, which applies to OLE DB database access technology for the links and calling of application procedure and front-end database, uses SQL Server as the development tool for systematic database, and finally achieve the expert database of automatic diagnosis. Meanwhile, with the help of Visual C++. NET, the system produces a needle pulse signal by operating database acquisition card. The systematic development, multi-menu windows see Figure 2.

3. Expert Database Diagnostic System

The so-called Expert System is actually a TCM diagnosis system with intelligence (intelligence procedure). On the basis of TCM medical knowledge system and the corresponding symptom of the patient and combined with the diagnostic information and experience with TCM expert, it applies for the credible reasoning to greatly simulate the TCM expert's thought process [1].

3.1 Design Ideas of Diagnostic System

Based on the diagnosis for the patient and the ratio statistic model's maximum likelihood method, the computer calculates the likelihood collection of suffering from various kinds of diseases, of which the maximum corresponds to the possible suffered disease, diagnose the disease from the credible reasoning, make explanation on the symptom and disease based on the rule reasoning

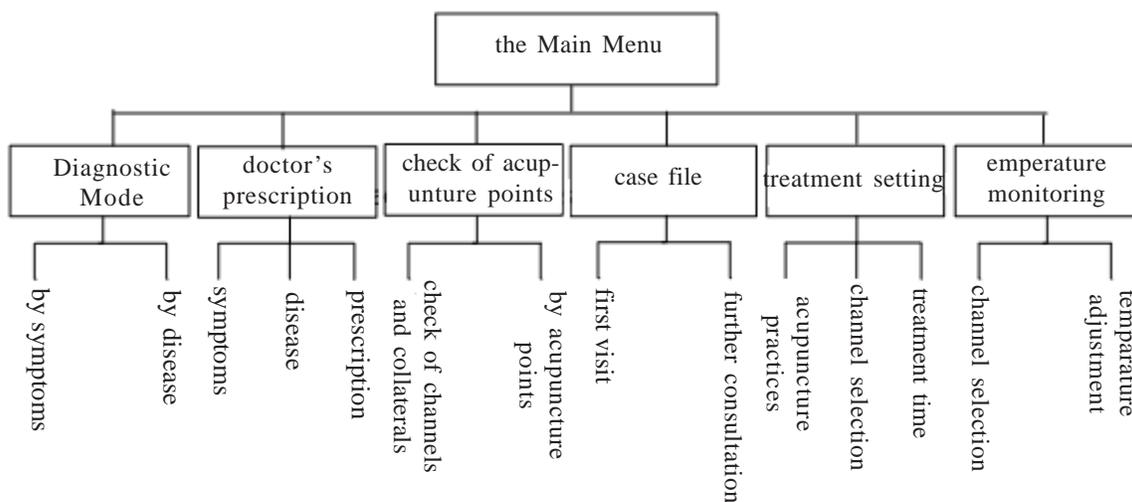


Figure 2. Function Structure of the System

according to TCM diagnosis database, and meanwhile, issue the diagnosis and treatment prescription. The function of the systematic module design sees Figure 2.

3.2 Module Structure of Expert System

Medical expert systems generally consists of a knowledge base, reasoning subsystem, integrated database, explanation subsystem, knowledge acquisition subsystem and human-computer interface. (1) Diagnosis module: the main module which includes diagnosis

information acquisition part and diagnosis reasoning part. Diagnosis information acquisition (knowledge acquisition) means input the patient's symptom or diagnosed disease information for the diagnosis of the computer. Diagnosis reasoning (reasoning subsystem) means that the computer conducts reasoning and final diagnosis based on the acquired information and corresponding rules and algorithm. (2) Explanation subsystem: give out necessary explanation on the diagnosis reasoning process for the

system and make out a certain diagnosis rules for the reasoning machine. (3) Knowledge base management module: managing the knowledge base within the module, including add, modify, delete or inquire the database stored with symptom, disease and case history. The quantity and quality of the knowledge within the database is the key factor measuring the performance and problem solving ability of an expert system. (4) Integrated database: storing information and reasoning result from the initial facts, problem description and reasoning process provided by the current user, and the content is always changing [2]. (5) Human-computer interface: a module for the interaction of the system and the user, and the user could make diagnosis consulting through menu selection and tips [3]. The design principle of expert system sees Figure 3.

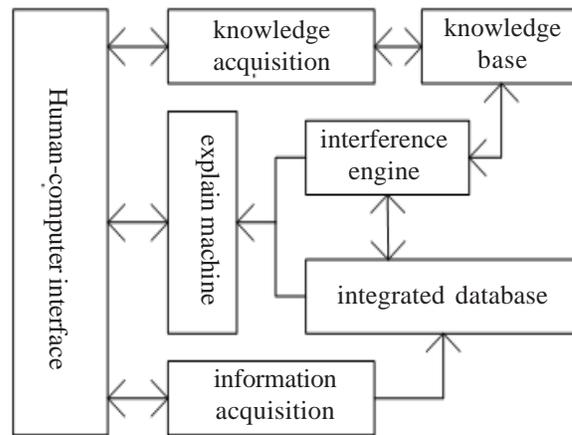


Figure 3. The System Principle Diagram

While the using process sees Figure 4.

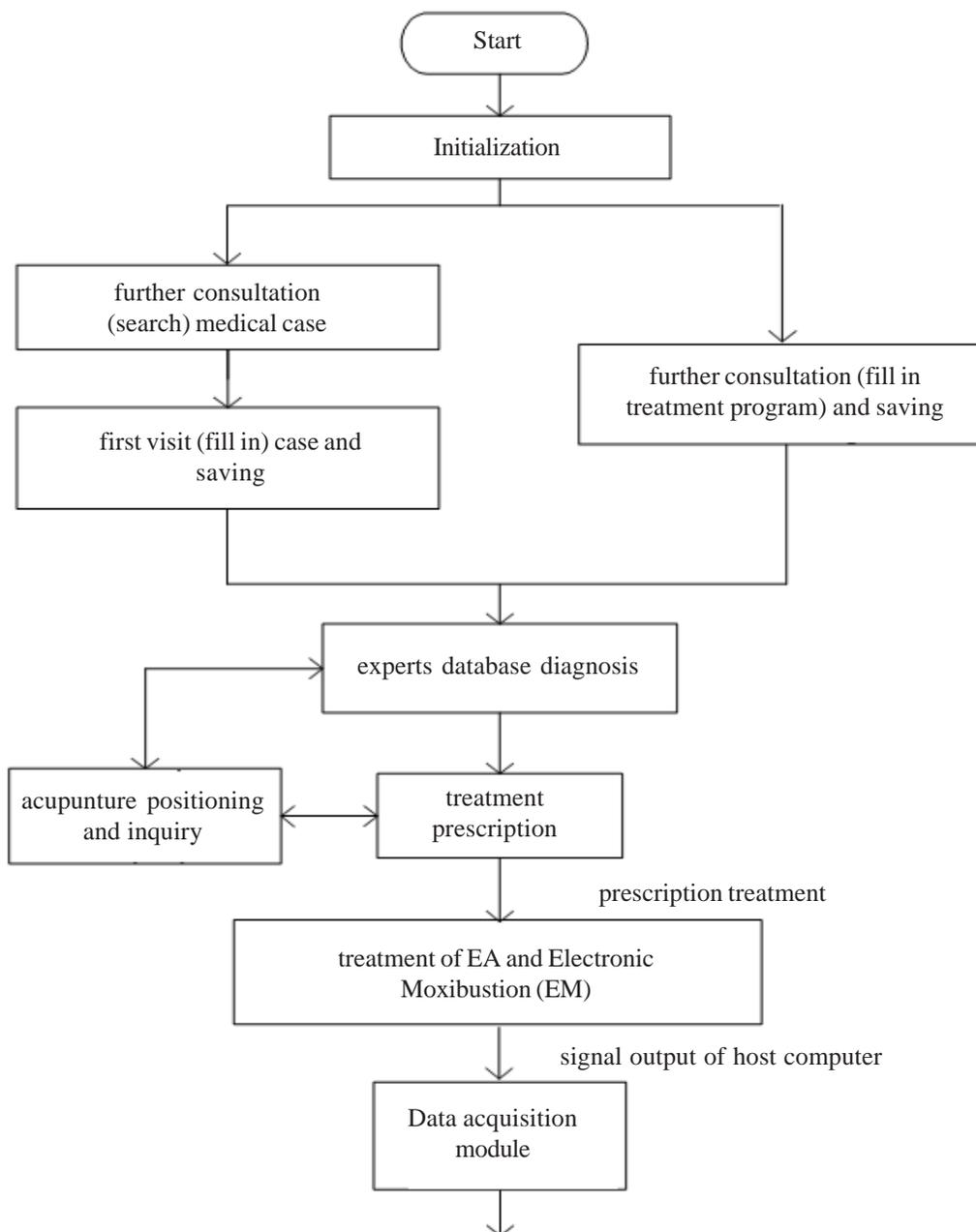


Figure 4. Application Flow Diagram

3.3 Knowledge Representation of Expert System

Knowledge representation studies on how to store the field knowledge into the computer for easy processing, and the main objective is to seek the mapping relationship between the knowledge and representation and to transform the knowledge into the computer's internal representation form [4].

The mission of expert system knowledge representation is to abstract the fundamental concept of disease diagnosed by TCM expert and clear up the relationship among those concepts, while TCM disease diagnosis relation knowledge embodies the causality of the symptom, disease and prescription. $R = \{S \cup D \cup P\}$ shows the knowledge of the symptom, disease, and the prescription of the TCM diagnosis object.

TCM diagnosis problem and its solution can be expressed as: $DR = f(S, D, P, R, S^+)$, of which: S – collection of all symptoms; D – collection of all diseases; P – collection of all prescriptions; R – the knowledge among symptom, disease and prescription; S^+ – the known symptom collection, $S^+ \in S$; f – the reasoning process of TCM expert diagnosis. The essence of the TCM diagnosis problem is the process of TCM expert getting the diagnosis result (DR) from S, D, P , and R through diagnostic performance S^+ [5].

3.4 Realization of Reasoning Disease by the Maximum Likelihood Method

When the patient has a group of the clinic symptoms S , the maximum likelihood method could be used to calculate the likelihood collection L of all possible diseases, thus to take the maximum likelihood value as the basis for the disease diagnosis.

Suppose there are m kinds of diagnosed diseases, respectively respectively marked as: $D_1, D_2, D_3, \dots, D_m$, and the probability of diseases as: $P(D_1), P(D_2), \dots, P(D_m)$, $s_1, s_2, s_3, \dots, s_n$ represents n kinds of corresponding symptoms, while $P(D_i / S_j) = (S_j | S_j \in S)$ means the occurrence probability of S_j when there is disease D_i . According to Bayes' theorem, we could get, the formula is as follows:

$$P(D_i / S_1, S_2, \dots, S_K) = \frac{P(D_i) P(S / D_j)}{\sum_{j=1}^m P(D_j) P(S / D_j)} \dots \dots (i=1, 2, 3, \dots, m)$$

The occurrence probability of the possible disease can be calculated from the above formula, and through comparison of all values, if the occurrence probability of the disease D_i is bigger than that of others, then it can be diagnosed that the patient is most likely is suffering from such disease. While if supposing the occurrence probability of all symptoms of a disease and the denominators in the Bayes' theorem are the same, then the denominator $P(D_j)$ can be deleted, and the value of $P(D_i / S_1, S_2, \dots, S_K)$ depends on that of the numerator, then we could get:

$$L_i = P(S_1 / D_i) P(S_2 / D_i) P(S_3 / D_i) \dots \dots, P(S_K / D_i)$$

Suppose the maximum value of $L_1, L_2, L_3, \dots, L_m$ is L_i , and if the difference of the maximum and the second largest value is greater than that of the supposed diagnosed effective threshold, then the possible disease of the patient can be diagnosed as D_i corresponding to L_i , and D_i is the maximum likelihood diagnosis; and if the difference of the maximum and the second largest value is smaller than that of the supposed diagnosed effective threshold, the computer will ask the user to complement the relevant symptom according to the method of sequential module, and then conduct the reasoning diagnosis again until the difference is greater than the threshold, and finally make the diagnosis. The setting of the threshold value is based on the experience of the medical expert, which shall conduct repeated verification and adjustment for confirmation.

3.5 Realization of Knowledge Representation Module based on the Database

We can use the extensible tuple in the relation database to describe the increasing concept and rules and complete the reasoning based on the knowledge by inquiry. According to the conceptual definition and formal elaboration of TCM knowledge, it firstly divides TCM diagnosis knowledge into concepts, facts and rules and etc. The concepts and facts quantitatively or qualitatively describe the information of TCM diagnosis, including the connection information of symptom, disease and prescription. Therefore, symptom table $S-DB(S-ID, S, St)$, disease table $D-DB(D-ID, S, D_t)$ and prescription table $P-DB(P-ID, P, P_t)$ constitute the expert knowledge database; rules reflect the internal necessary linking of facts and concepts, including symptom-disease base, disease-prescription base, condition-disease base, and disease- diagnosis and treatment base, and those four rules sub-bases connected together based on database relationship, which accomplishes the representation of TCM diagnosis knowledge. Details see Figure 5.

3.6 Rules Conjunction and Reasoning Realization Diagnosis System

Each sub-base has its own rules antecedent database and rules consequent database, of which the former is used to store the corresponding prerequisites of all rules while the latter the results of all rules. Within the rules antecedent database, it will deduce the rules and results under a certain condition with the help of rules name field; while in the rules consequent database, the prerequisite for a certain result will be deduced through rule name field. These two databases are both related with knowledge database, therefore, the correlation derivation of three databases bring about the expert database diagnosis system [6].

4. Generation of FM EA Needle with Classical Acupuncture Techniques

According to the TCM treatment principle of reinforcing

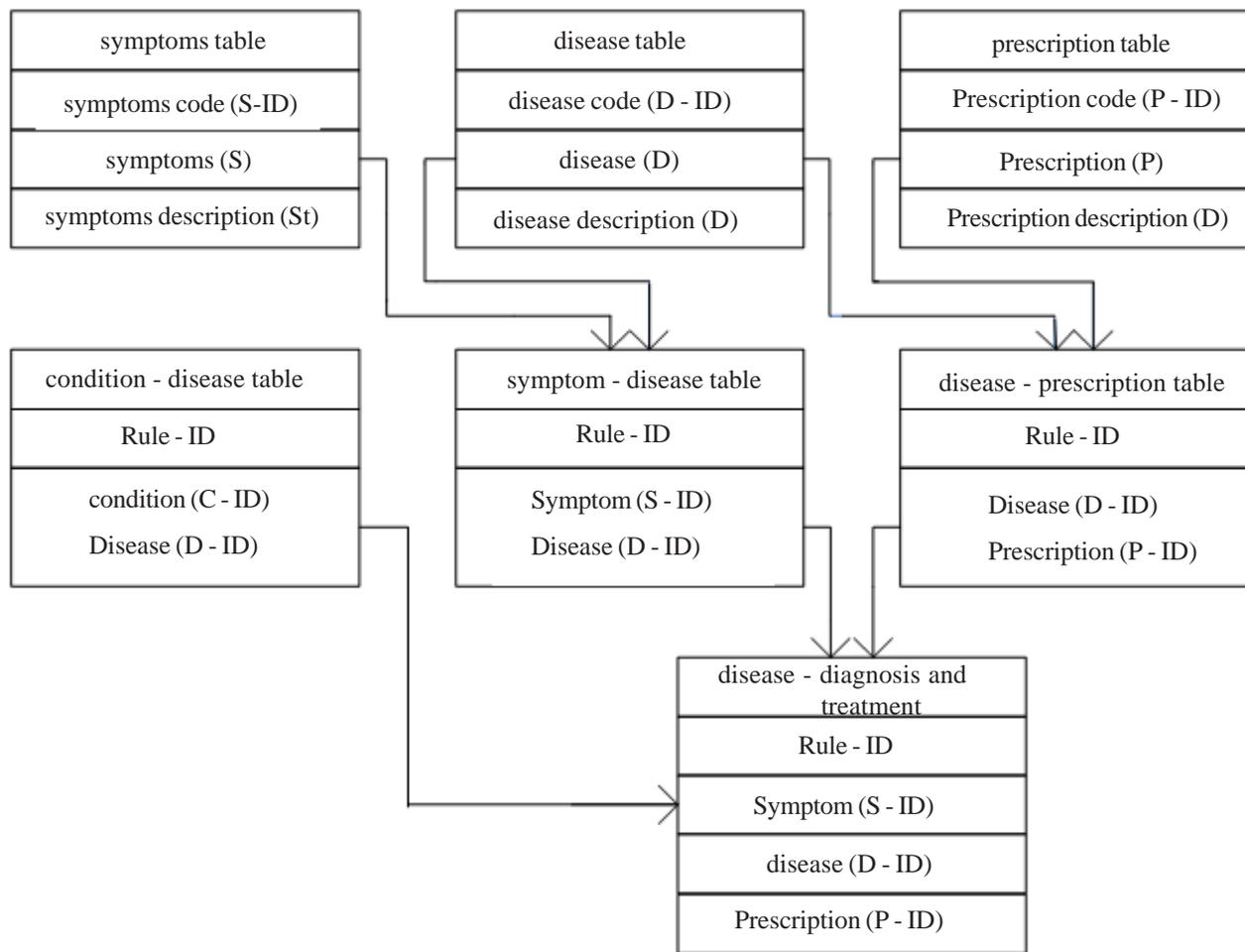


Figure 5. TCM Diagnosis Knowledge Representation Model of Database

the debilitated body and purging the excess, it is necessary to adopt different acupuncture method for different physical bodies, causes of disease and symptoms. Reinforcing method means help to boost the body upright and recover the weakening physical function while reduction manipulation means purging the excess and calm the hyper function. Clinically, the acupuncture reinforcing and reduction method is divided into basic (single type) method and comprehensive (duplex) method, with “*heat-producing needling*” and “*cool-producing needling*” as the typical of the comprehensive method. This paper takes heat-producing needling as an example to utilize pulse EA needle with classical imitation acupuncture method.

4.1 Briefing on Heat-producing Needling Acupuncture Method

Heat-producing needling combines slow-quick needling, lifting and thrusting needling, and nine-six reinforcing and reducing method. The name of heat-producing needling is for that the patient has the warm feeling when receiving the treatment. Such method is applied to for treating deficiency disease, which divides the depth of needling into three layers: the first layer (the shallow layer), the middle layer, and the third layer. First punch the needle into the first layer and press and slowly raise for nine times up and down, then punch it into the middle layer

and repeat the previous action, and then punch it into the third layer and also repeat the nine press and slowly raise up and down. Finally, slowly retreat the needle to the first layer and then repeat the above mentioned actions. The detailed needling method sees Figure 6.

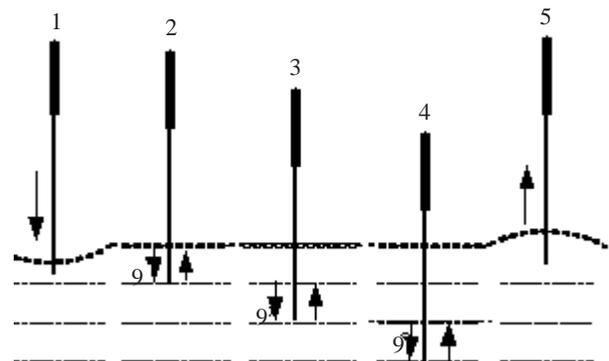


Figure 6. Heat-producing Needling Acupuncture Manipulation

4.2 Symbolic Measurement Theory

Symbolic measurement is brought forward when studying the measurement result symbolic representation and measurement definition extension. Symbolic measurement theory certainly involves in four kinds of transformations between two universes and value and

symbol, and through the following four transformations: numerical range Q and symbolic range S; number-number transformation (Q-Q), number-symbol transformation (Q-S), symbol-symbol transformation (S-S) and symbol-number transformation (S-Q), of which Q-S transformer's function is to realize the transformation of number and symbol involving two universes Q and S. S-S transformer describes the transformation, relationship of two variables in symbolic range, and the function of S-Q transformer is to realize the transformation of two variables of symbolic range and numerical range. Based on the above simple discussion, topological structure, the most abstractive and common representative symbolic measurement system with transformation module, could be given out, which exists in two different universes and the same universe with two different variables. Symbolic measurement generalized module sees Figure 7. The significance of establishing symbolic measurement generalized module is studying the information transformation of problem within the given range and information feature extraction and mapping method among different ranges. Range mapping method is used to establish the scientific connection of problems among different ranges, thus to solve specific issues [7].

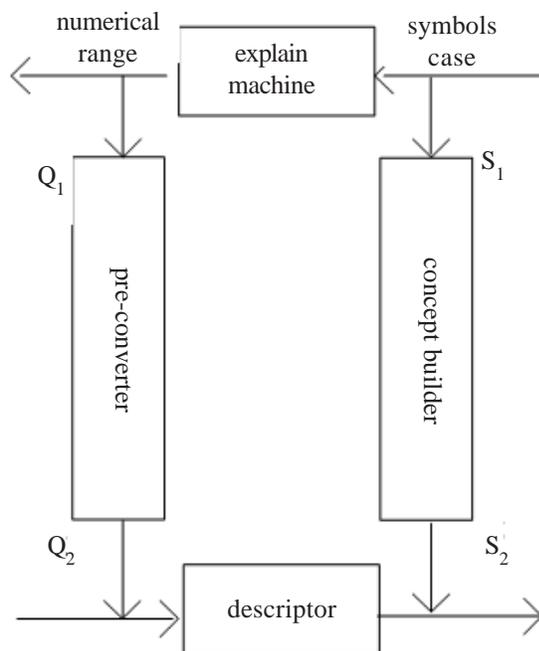


Figure 7. Symbolic Measurement Model

4.3 Generating Method of EA Needling on Symbolic Mapping Principle

1. Relationship of Classic Acupuncture Method and Electric Signal Parameter. Based on the feature extraction and mapping theory of symbolic measurement theory in different universes, it is necessary to map the traditional acupuncture needling to the electric signal parameter universe and establish a correspondence relationship. And according to the different feeling of the human body to the different frequency of equivalent strength, the depth of acupuncture into the skin corresponds to the degree of

the strength. As for FM theory, the depth of lifting and thrusting of acupuncture needling corresponds to the frequency of the electric signal while the twirling to the polarity of the electric signal. Therefore, the depth of needling depends on three different frequency pulse signal.

2. Selection of EA Signal Frequency Point. The research on the mechanism of acupuncture analgesia shows that acupuncture may cause nervous system to release opioid peptides with analgesic effect. There are more than twenty kinds of opioid peptides for three types including enkephalin, endorphin and dynorphin. Han JS, Sun RQ and Jiang YX observed that different electric stimulation frequency may cause the brain and nerve to release different opioid peptides and thus lead to different effect[8-10]. Low frequency 2Hz of electric stimulation may cause the brain to release endorphin and spinal cord to release a large number of enkephalin; 100Hz frequency may cause spinal cord to release a lot of dynorphin, while 15Hz frequency to release enkephalin and a small amount of dynorphin. Enkephalin has an analgesic effect to the brain and spinal cord, endorphin in the brain while dynorphin to the spinal cord. Besides, enkephalin has good effect on the heat pain of the skin while dynorphin on the pain caused by the visceral chemical stimulus.

Based on the above facts, we choose pulse frequency signal 2Hz, 15Hz and 100Hz respectively, for the first layer, the middle layer and the third layer, thus to realize the integration of EA needling of classical imitation acupuncture method.

3. Generation of FM EA Signal. On the basis of TCM theory and principle of reinforcing (weak to strong and shallow to deep) and reduction manipulation (strong to weak and deep to shallow), it could be grasped that the frequency variation rule of reinforcing is from shallow, middle and then to high and the strength shall be weak to strong, while the frequency variation of reduction manipulation is in the reverse order. Therefore, we choose pulse frequency signal 2Hz, 15Hz and 100Hz respectively, for the first layer, the middle layer and the third layer, and each frequency continuously for nine times. Such is the mission of acupuncture method imitating heat-producing needling [11]. Figure 8 is the waveform generating graph of heat-producing needling. The sequence of acupuncture method imitating cool-producing needling shall be the reverse order with each frequency continuously six times.

It shall be pointed out that the human body has certain adaptability to electric stimulation, thus EA needling with chaotic signal shall be applied on the basis of the original needling signal to eliminate such adaptability of electric stimulation[12] (it will be discussed in other paper). Figure 9 and Figure 10 are the heat-producing needling waveform with chaotic signal respectively observed in the display interface and oscillograph. So Figure 9 shall clearly show the small difference of pulse needling in the same frequency.

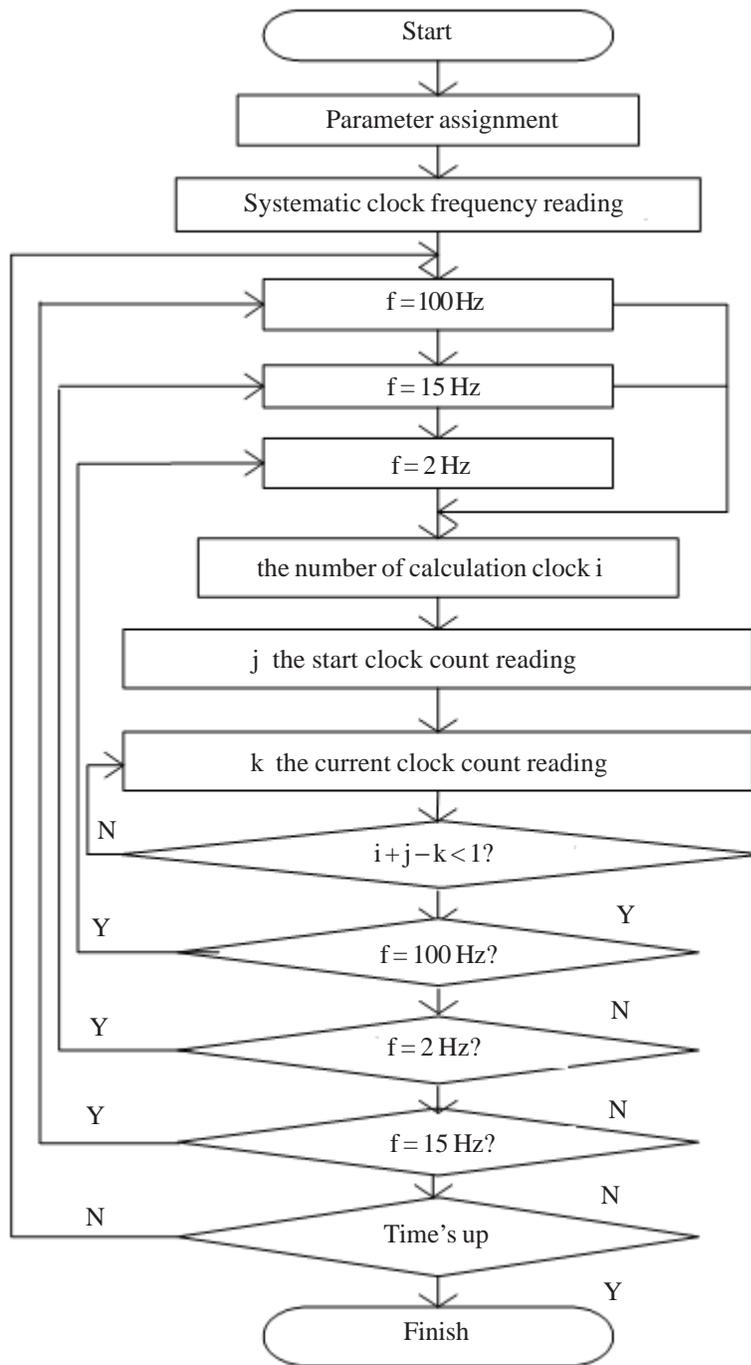


Figure 8. Waveform Generation Flowchart from Heat-producing Needling

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5. Conclusions

This paper realizes the mapping of acupuncture needling method universe to the electric parameter universe and the application of TCM needling on the platform of modern signal generator on the basis of symbolic theory besides



Figure 9. The Waveform of Heat-producing Needling With Chaotic Signal Observed in the Display

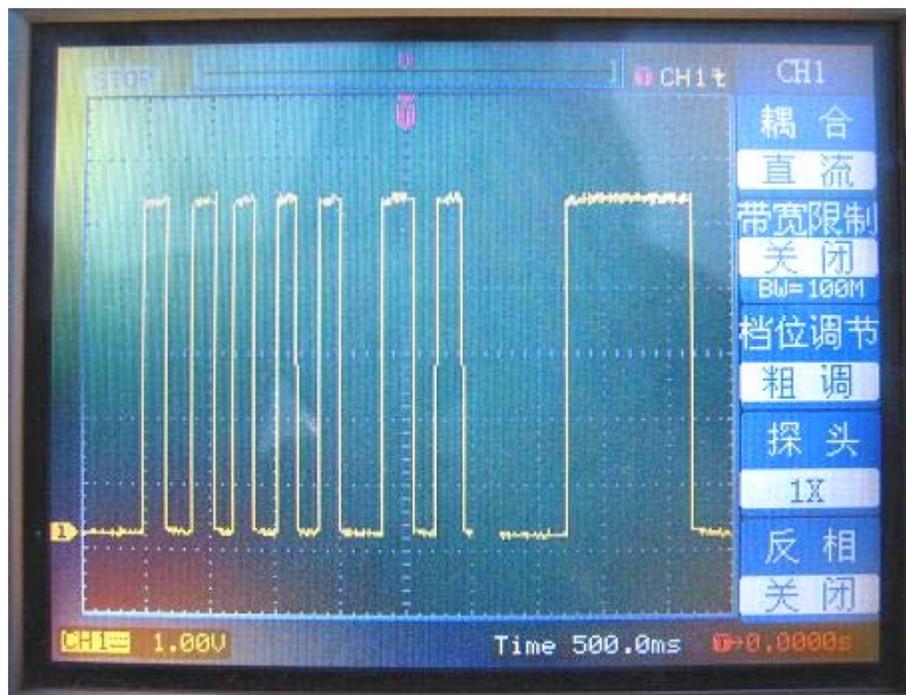


Figure 10. The Waveform Heat-producing Needling With Chaotic Signal Observed in the Oscilloscope

establishing computer expert diagnosis system. It completes the further development of modular software for doctor diagnosis and treatment and acupuncture points query and positioning, as well as the design of a set of integrated intelligent acupuncture system. All these promote the intelligence of modern acupuncture instrument with good effect, which plays a fundamental importance part in the creation of featured modern physical therapy.

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