Research on Key Technology in Traditional Chinese Medicine (TCM) Smart Service System

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Abstract. This paper studies the combination of information network technologies like Internet of Things (IoT) and big data with traditional Chinese medicine (TCM) to build a system framework oriented to TCM smart service. TCM-oriented knowledge representation technology is also explored so as to realize computer recognition and calculation of TCM health service, the self-learning reasoning technology of system is further studied, and TCM knowledge fuzzy model and modified BP neural network algorithm are introduced into TCM smart service system to conduct machine learning and smart judgment upon various diseases. These technologies will promote the scientific research and artificial intelligence aided diagnosis of TCM.

Keywords: Big data · Traditional Chinese medicine · Self learning
Knowledge representation · Fuzzy processing · System framework

1 Introduction

Due to the problems in TCM like secluded development, lack of innovation and brain drain, a great number of TCM theoretical essences, academic ideas and experience have failed to be promoted [1], hence making TCM walk on a path of rapid decline. Furthermore, the development of internet of things, big data and mobile internet has exerted a profound influence upon society, and also changed our ways of production, living and working, not only promoting the updating of various traditional sectors but also driving the innovative development of society.[1] It serves as a huge opportunity in TCM history of development as to how to utilize information network technology to combine TCM with big data [2] and further develop it.

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The combination of information network technologies and TCM will bring revolutionary changes to the latter, and the development of TCM will step into a new era. It is expected to combine advanced technology like big data, internet of things and internet+ with TCM [3] so as to use a huge database to store previous wealth, integrating and categorizing rich data, timely collecting and processing new information to realize system self learning and reasoning functions, and achieving information transparency and resources sharing with internet [4]. By such a way, the problems like TCM informationization, networking and lack of intelligence will be solved.

Part two of this paper introduces related work on TCM's informationization and networking. Part three presents TCM smart service oriented system framework studies. Part four and five introduce TCM oriented knowledge representation and system reasoning model. The last part brings the summary and expectation.

2 Related Work

Many scholars have done a lot of related work on TCM's informationization, networking and datamation. In 2010, Chen developed a data digging method to study related TCM therapies of clinical cancer cases as well as herbal medicine dosage. It was proposed that scientific research methods of TCM were suitable not only for cancer but also for other diseases [5]. In 2010, Cui expounded that data digging should be regarded as a useful technology that can be applied into the discussion of TCM studies of treatment rules, and used to detect treatment principles through established network as well as relevance between herbal medicine and suitable technologies of TCM [6]. In 2012, Wen developed a development information management system able to satisfy TCM hospital function features when studying the building mode of TCM hospital informationized management system, hence laying data foundation for medical administrative management, medical insurance and TCM treatment based on symptoms. Up-to-date computer and network technology can be effectively utilized to build TCM hospital informationized management system with TCM characteristics to uplift modern management level of TCM hospitals [7]. In 2012, Zhou introduced the concept of fuzzy information granulation into TCM smart diagnosis system and developed a computer-aided smart diagnosis prototype with a combination of database technology. The system had self-learning function, with diagnostic precision of sexual precocity child diseases reaching 96% [8]. In 2016, Li used the collected big data pulse condition features and three-layer forward-type BP network in building TCM pulse condition recognition smart judgment model. Self-adapting learning speed method and momentum factor were introduced to optimize the enormous pulse condition connection weight and threshold; as a result, precise pulse condition recognition judgment results were obtained. Tests showed that using big data pulse conditions could improve the precision in TCM disease recognition judgment [9]. In 2016, Ma proposed a topic model to help capture the relation between symptom and disease, with the view to informationizing it with computer obtained medical knowledge to help doctors for symptom diagnosis [10].

This paper studies the key technology of TCM smart service system, in which the IoT-based four-layer system framework conducts informationized collection of observation, listening, inquiry and pulse feeling (four methods of diagnosis in TCM). This system stores TCM theoretical essences, academic ideas and previous experience into database. For convenience of computer recognition and calculation, TCM disease knowledge is to be expressed through informationization. This system is also equipped with self learning and reasoning ability, which can ensure constant information updating in it, helpful for machine learning, saving cost and improving efficiency, hence convenient for realizing resources sharing through internet. TCM, after combining solid model of western medicine, is no longer a traditional phenomenological model [11], thus solving the issue of TCM westernization.

3 TCM Smart Service Oriented System Framework

By referring to the four-layer system framework of internet of things [12], TCM smart service system framework includes four layers, namely smart perception layer, network transmission layer, information layer and application service layer. As shown in Fig. 1.

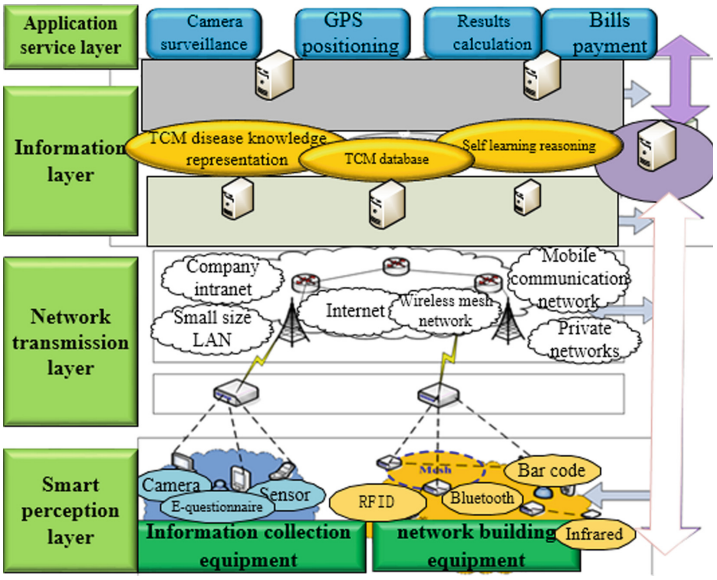

Fig. 1. Architecture of TCM intelligent diagnostic service system

3.1 Smart Perception Layer

Smart perception layer is the foundation of TCM smart service system. It is mainly consisted of information collection equipment and network building equipment. Through collecting relevant information about patient complexion, breath, symptom

and pulse with information collection equipment, the four methods of diagnosis of "observation, listening, inquiry and pulse feeling" were realized. Then the collected information will be transmitted to network transmission layer with network building equipment. Information collection equipment recognizes human body and collects data through means like camera, e-questionnaire, and sensor; network building equipment constructs information collection equipment into network and then aggregates and transmits to the next layer with infrared, site bus, bar code, Bluetooth, RFID, etc. [13].

3.2 Network Transmission Layer

Network transmission layer is the "courier" in TCM smart service system for data transmission, conveying the data obtained at smart perception layer. The information can be transmitted through internet, company intranet, mobile communication network, small size LAN, various private networks and wireless mesh network. Data transmission layer works as a bridge by undertaking the data from the smart perception layer below and initiating the information layer above, and thus realizing the precise transmission of data.

3.3 Information Layer

Information layer is the "brain" of the whole TCM smart service system, a database containing enormous resources like TCM theoretical essences, academic ideas and previous experience and formulizing TCM disease knowledge representation. Self learning, self representation and self reasoning can be realized of the enormous data in the database through relevance, perceptibility and traceability. After going through network transmission layer, data will extract relevant information from the database at information layer for representation.

3.4 Application Service Layer

Application service layer is the "envoy" in TCM smart service system, which will realize intelligence and informationization according to patient needs. Application layer can realize the integration of basic data in TCM smart service system and feedback the results to patients. Application service layer provides interface for application interaction between humans and various devices. This layer is responsible for data integration and results feedback, including camera surveillance, GPS positioning, results calculation and bills payment. It serves as further incorporation of IoT and mobile internet technology into TCM smart service system [14].

4 TCM Oriented Knowledge Representation Technology

4.1 Observation for Diagnosis

Observation for diagnosis means using eyes to observe the surface conditions of patients, including complexion, normality of five sense organs, tongue and connection

position of different parts. The visual sense involved therein is replaced by computer visual image processing.

Steps are as follows:

Step1: Store all images of face and tongue characterizing TCM diseases into information layer database of smart service system;
Step2: Use camera equipment to take pictures of patient face and tongue;
Step3: Transmit images to main network through short distance transmission technology like RFID, bar code, site bus, Bluetooth and infrared and further to database;
Step4: Process the images at application service layer, and output corresponding face and tongue features based on images with high similarity to patient images.

4.2 Listening for Diagnosis

Listening for diagnosis refers to using ears for diagnosis mainly for patient utterance, breath and coughing sound. According to Inner Canon of Yellow Emperor, the five internal organs of humans can produce five notes like nature [15–17]. Yu proposed a set of five notes frequency decomposition method based mathematical model suitable for any kind of periodic time domain sound signals, which could be used for five notes decomposition of human physiological signals, putting in place a new mathematical model for TCM diagnosis [18]. The five notes are the same as the "gong (do), shang (re), jue (mi), zhi (sol), yu (la)" in ancient times; their difference lies in the tones, which can be shown in a sine cosine function. That is to say, the sounds produced by human body can be decomposed into the expression formula containing five notes frequency components, through which human sounds can be expressed via mathematical formulas and transformed into the language that can be recognized by computer.

First of all, the basic rule of the five notes frequency is given [10–13]. Assuming that one "gong" sound is produced by an ideal object which can be seen as a particle, then the rule of its amplitude changing with time can be expressed with a sine function:

$$f_g(t) = asin(\omega t + \varphi) \tag{1}$$

If the translation can be increased on time, then it can also be expressed with a sine function:

$$f_g(t) = msin\omega t \tag{2}$$

According to the rules of Pythagorean intonation, the object can be divided into three sections. The sound generated by the remaining two sections after abandoning one is "zhi" [10–13]. Then the sound of "zhi" can be expressed as:

$$f_z(t) = msin\frac{3}{2}\omega t \tag{3}$$

The object producing the sound "zhi" is further divided into three parts with another one added, and then the sound will be "shang" [10–13]. Then the sound of "shang" can be expressed as:

$$f_s(t) = nsin\frac{3}{2} * \frac{3}{4}\omega t \tag{4}$$

If the object producing the sound of "shang" is kept, then the sound produced will be "yu". Then the sound of "yu" can be expressed as:

$$f_y(t) = nsin\frac{3}{2} * \frac{3}{4} * \frac{3}{2}\omega t \tag{5}$$

If the sound of "yu" is added, then the sound produced will be "jue" [19–21]. Then the sound of "jue" can be expressed as:

$$f_j(t) = nsin\frac{3}{2} * \frac{3}{4} * \frac{3}{2} * \frac{3}{4}\omega t \tag{6}$$

On the basis of "gong", five notes of "gong, shang, jue, zhi, yu" can be obtained through two times of decrease and three times of increase.

Every kind of periodic sound can be seen as a function of particle amplitude. According to Fourier series expansion rules, this kind of sound is consisted of several sine waves with different frequency. The sine waves of several different frequencies are different five notes frequencies.

The frequency value of a series of five notes produced through the above five notes generation principles is the different powers of the basic frequency fraction as shown below:

$$g_{k1}(t) = m_k \sin\left(\frac{3}{2}\right)^k \left(\frac{3}{4}\right)^{k-1} \tag{7}$$

$$g_{k2}(t) = n_k \sin\left(\frac{3}{2}\right)^k \left(\frac{3}{4}\right)^k \omega t \tag{8}$$

Then based one above rules, the sounds obtained through listening for diagnosis can be expanded by a trigonometric function with a series of five notes frequency:

$$\begin{aligned} f(t) = &\frac{m_0}{2} + msin\omega t + n\cos\omega t + \sum\nolimits_{k=1}^{+\infty} [m_k \sin(\frac{3^{2k-1}}{2^{3k-2}})w_0 t + n_k \sin(\frac{3^{2k}}{2^{3k}})\omega t \\ &+ p_k \cos(\frac{3^{2k-1}}{2^{3k-2}})\omega t + q_k \cos(\frac{3^{2k}}{2^{3k}})\omega t] \end{aligned} \tag{9}$$

To obtain the coefficient of expansions, expand the series to k_0 term and obtain the coefficient for each term:

$$\begin{aligned} m_k &= \frac{1}{\pi}\int_{-\pi}^{\pi} f(t)\sin\left(4*3^{2k-1}\right)x*dx \\ &= \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x*2^{3k_0}}{\omega}\right)\sin\left(4*3^{2k-1}\right)x*dx \end{aligned} \tag{10}$$

Similarly, we can get

$$n_k = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x*2^{3k_0}}{\omega}\right)\sin\left(3^{2k}\right)x*dx \tag{11}$$

$$p_k = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x*2^{3k_0}}{\omega}\right)\cos\left(4*3^{2k-1}\right)x*dx \tag{12}$$

$$q_k = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x*2^{3k_0}}{\omega}\right)\cos\left(3^{2k}\right)x*dx \tag{13}$$

When the series is expanded to k_0 term, the value for the following calculation of the integral:

$$\int_{-\frac{\pi}{\omega}}^{\frac{\pi}{\omega}} f(t)dt = \int_{-\frac{\pi}{\omega}}^{\frac{\pi}{\omega}} \frac{m_0}{2}dt \tag{14}$$

Then:

$$m_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x}{\omega}\right)dx \tag{15}$$

In the same way, the value for the successive multiplication at both sides followed by integral:

$$m = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x}{\omega}\right)sinxdx \tag{16}$$

$$n = \frac{1}{\pi}\int_{-\pi}^{\pi} f\left(\frac{x}{\omega}\right)cosxdx \tag{17}$$

Mathematical language is used to describe the rules of Pythagorean intonation, and formulas for any periodic time domain sound signals decomposed into several five notes frequency signal combinations are given. Through five notes decomposition method, human physiological signals can be analyzed and processed, providing an effective mathematical model conforming to TCM theory for TCM diagnostic equipment and further promoting its development. In this way, in TCM diagnosis diagnostic equipment can collect sounds and transform them into five notes frequency

expansions, which are mathematical knowledge formulas recognizable by computers. Hence, the modernization and informationization of TCM knowledge representation can be realized, so as to keep up with the times and promote the development of smart diagnosis.

4.3 Inquiry for Diagnosis

Inquiry for diagnosis means inquiring about patient conditions carefully. TCM smart service system, apart from inquiring about patient conditions orally, can also adopt e-forms or machine language expression for inquiry. In this way, diagnostic equipment voice recognition function can be utilized to transmit keywords of patient conditions into database through network transmission network and use other diagnoses of application service layer to process informationized results, so as to obtain corresponding diagnostic results and treatment methods.

4.4 Pulse Feeling for Diagnosis

Pulse feeling for diagnosis means feeling and examining the pulse. According to the state of pulse condition, it can be divided into eight types, namely surface pulse–floating; internal pulse–sinking, solid and hidden; cold pulse–delay, slow, solid and intense; hot pulse–frequent, moving, rapid and hurried; feeble pulse–feeble, weak, slight, scattered, short; solid pulse–solid, long, slippery; qi pulse–flooding, moist; blood pulse–tiny, elastic, unsmooth, hollow [22].

Pulse feeling for diagnosis is very important in TCM. Factors like human respiration, mental state and disease can all affect the results, so there are many variations for human pulse signals, because using singular spectrogram cannot conduct complete representation for common features of one pulse condition is determined by various spectrograms. Hence, Lei Li chose 8 feature parameters out of three major spectrogram features (power spectrum, cepstrum and transfer function spectrum) as the basis for TCM pulse condition recognition and judgment. Feature parameters included (1) power spectrum fundamental frequency, basic frequency of pulse beating; (2) cepstrum feature RC that can describe the type of pulse cepstrum wave; (3) cepstrum null component that can describe the strength of pulse beat; (4) spectrum energy ratio that can describe the relation between pulse energy and frequency; (5) ratio between cepstrum wave amplitude and cepstrum null component that can describe the smoothness of pulse beat; (6) average distance of formant that can describe the average distance of formant in transfer function; (7) number of formant in transfer function that can describe the features of formant in human pulse conditions; and (8) harmonic wave number in power spectrum that can describe human pulse beat rhythm [24].

5 System Self Learning and Reasoning Model Technology

After completing TCM knowledge representation, TCM self-learning reasoning model is also needed to realize TCM smart service system.

System self learning reasoning model is based on the database containing enormous TCM theoretical essences, academic ideas and previous experience. This model can imitate professional TCM judgment processes and conduct self learning and reasoning based on TCM knowledge and experience to aid human expert judgment to ultimately reach the effect of smart diagnosis. This model regards physiological indexes of patient as input parameters, mobilizes knowledge in database and utilizes reasoning mechanism for diagnosis (Fig. 2).

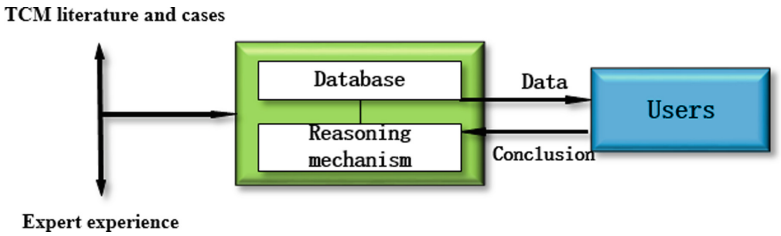

Fig. 2. Self learning and reasoning model

Self-learning and reasoning model of TCM system contains two parts, namely TCM knowledge fuzzy model and modified BP neural network algorithm.

BP neural network adopts self-adapting learning process of external environment, approximates to non-linear relationship with high precision, so it can be used for non-linear system [23]. However, due to the large influence of feature parameters upon neural network layer to be input, the modeling output effect of BP neural network will be affected if feature parameters are fuzzy without extracting fuzzy information therein, so the difference to expectation will be large and precision be affected [23]. Therefore, fuzzy processing has to be conducted of input layer of BP neural network in advance.

5.1 TCM Knowledge Fuzzy Model

(1) **Fuzzy Membership Function**

Assuming that there is one fuzzy set on the area to be discussed, there is one correct pair of membership for any element there. The mapping relationship is:

$$\mu_A : U \rightarrow [0, 1] \tag{18}$$

$$u \rightarrow \mu_A(u) \tag{19}$$

This mapping is the membership function of the fuzzy set. The evaluation scope is $[0, 1]$, and it shows the membership degree of elements [24]. Larger evaluation of membership indicates that this element has a higher affiliation degree to current fuzzy set.

In this way, TCM knowledge fuzzy set can be characterized by membership function, which can be determined according to the type of TCM diagnosis. For example, before the 8 feature parameters of the above pulse conditions are input in BP neural network, fuzzy processing is needed. Function can be resorted to in obtaining the membership degree of each node.

(2) **Fuzzy Rules**

There are many fuzzy concepts in the expression of TCM knowledge. Fuzzy rules can help understand the fuzzy meaning of TCM knowledge. Rules are effective tools for quantitative modeling of word or sentence in natural or artificial language, in which reasoning based on rules can be used to draw conclusion from one set of fuzzy rule and known facts. There are two parts for fuzzy rules, namely IF, precondition for fuzzy rules, and THEN, conclusion for fuzzy rules [23]. Commonly seen rules have two forms, namely Mamdani fuzzy rules and T-S fuzzy rules [25]. Among them, T-S fuzzy rules are those applied for non-linear system recognition. Given that big data based TCM smart diagnostic service in most cases is non-linear system, T-S fuzzy rules are adopted in our system. The general form of T-S fuzzy rules is:

$$R^j : IFx_1 \, is \, A_1^j and \, x_2 \, is \, A_2^j \ldots x_m \, is \, A_m^j. \tag{20}$$

Then

$$y = c_0^j + c_1^j x_1 + \ldots c_m^j x_m j = 1, 2 \ldots r \tag{21}$$

Where, R^j is item of fuzzy rule, and x_m is input and output variables of fuzzy system, A_i^j is output subset of item of ith rule, r is total number of rules, and c_m^j is coefficient of input variables.

It can be seen that one experience of TCM can be seen as a fuzzy rule. That is, when the priori condition of experience is satisfied, it will output in the form of non-linear combination. After the database stores TCM theoretical essences, academic ideas and previous experience, it possesses fuzzy rules for TCM disease reasoning.

5.2 Modified BP Neural Network Algorithm

BP neural network algorithm is one kind of multi-layer feed-forward neural network algorithm, composed of forward propagation and back propagation. Forward propagation is the weight and function calculation from signal input at input layer to hidden layer to be output through output layer. Back propagation is the feedback output error signals with forward propagation to network. Through BP algorithm and based on error signal, when error signal becomes smaller, weight and threshold at each node have to be modified. This solves the problem of difficulty in training inside multi-layer forward and back networks, which can facilitate further expansion of neural network.

BP neural network includes input layer, hidden layer and output layer. Interlayer connection between neurons at each layer is there, but no connection inside layers. The diagram is as shown below (Fig. 3):

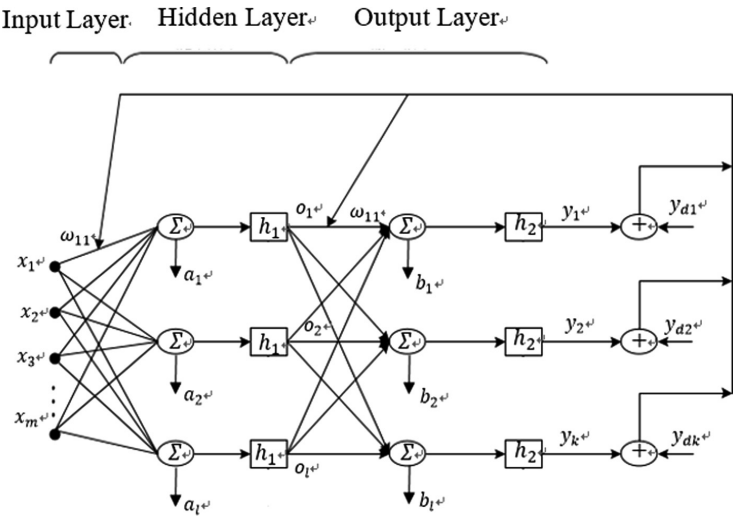

Fig. 3. The three-layer BP network structure diagram

Input vector of input layer is $X = (x_1, x_2, \ldots, x_m)^T$, output vector of hidden layer is $O = (o_1, o_2, \ldots, o_l)^T$, actual output vector of output layer is $Y = (y_1, y_2, \ldots, y_k)^T$, expected output is $Y_d = (y_{d1}, y_{d2}, \ldots, y_{dk})^T$.

$\omega_{ij}$is the connection weight of nodes in mode, ω_{ik} is the connection weight between nodes at different layers in model, a and b are the threshold of nodes between hidden layer and output layer.

Hidden layer:

$$o_j = h(z_j) \tag{22}$$

$$z_j = \sum_{i=1}^{m} \omega_{ij} x_i - a_j \tag{23}$$

Output layer:

$$y_k = h(z_k) \tag{24}$$

$$z_k = \sum_{j=1}^{i} \omega_{jk} o_j - b_k \qquad k = 1, 2, \ldots, m \tag{25}$$

Where, h is excitation function. The error between actual output and expected output should be kept low, so as to ensure high precision for BP neural network. Error is described through error of mean square:

$$E = E\left[(y_d - y)^T (y_d - y)\right] \tag{26}$$

Weight and threshold of each node are adjusted through the steepest descent algorithm. Then the $K+1$ iteration

$$\omega_{jk}(k+1) = \omega_{jk}(k) - \eta \frac{\partial E_k}{\partial \omega_{jk}} \tag{27}$$

$$b_k(k+1) = b_k(k) - \eta \frac{\partial E_k}{b_k} \tag{28}$$

Obtain partial derivative to get output layer results:

$$\omega_{jk}(k+1) = \omega_{jk}(k) + \eta \delta_k o_j \tag{29}$$

$$b_k(k+1) = b_k(k) + \eta \delta_k \tag{30}$$

In the same way, obtain the hidden layer output results:

$$\omega_{ij}(k+1) = \omega_{ij}(k) + \eta \delta_j x_i \tag{31}$$

$$a_j(k+1) = a_j(k) + \eta \delta_j \tag{32}$$

Where, δ_k is inverse transmission error of output layer:

$$\delta_k = (y_{dk} - y_{dk}) h'(z_k) \tag{33}$$

δ_j Is inverse transmission error of hidden layer:

$$\delta_j = h'(z_k) \sum_{k=1}^{l} \delta_k \omega_{jk} \tag{34}$$

Although BP neural network enjoys sound precision in seeking optimal solution, we still find out that it also has long convergence time, and the optimal solution obtained is most likely to be the local optimal solution instead of global optimal solution [26]. Therefore, the above BP neural network has to be modified. Hereby the concepts of momentum factor and learning rate are introduced.

The momentum factor γ is introduced when modifying the weight of nodes from input layer to hidden layer.

$$\Delta\omega_{ij}(k+1) = (1-\gamma)\alpha\delta_j x_i + \gamma \Delta\omega_{ij}(k) \tag{35}$$

$$\Delta a_j(k+1) = (1-\gamma)\alpha\delta_j + \gamma \Delta a_j(k) \tag{36}$$

Where, ω_{ij} is connection weight between nodes, γ is momentum factor, α is self adapting learning rate, x_j is error signal, x_j is the input quantity at node, a_i is threshold detected at node.

In the same way, the modification of weight and threshold from hidden layer to output layer is completed.

The following formula can be used to self-adaptingly regulate learning rate:

$$\alpha(k+1) = \begin{cases} 1.05\alpha(k) & E(K+1) < E(k) \\ 0.7\alpha(k) & E(K+1) > 1.04E(k) \\ \alpha(k) & others \end{cases} \tag{37}$$

To establish formula (35), the following restrictions have to be satisfied.

$$\gamma = \begin{cases} 0.95 & E(k) < E(k-1) \\ 0 & E(k) > 1.04E(k-1) \\ \gamma & others \end{cases} \tag{38}$$

5.3 Observation for Diagnosis

Neural network processing information scope and ability are expanded through introducing TCM knowledge fuzzy reasoning model into modified BP neural network algorithm. Therefore, the combination of TCM knowledge fuzzy reasoning model and modified BP neural network algorithm constitutes the self learning and reasoning model for TCM smart diagnostic service system.

This model firstly builds T-S fuzzy rules based on TCM theoretical essences, academic ideas and previous experience through conducting fuzzy processing of initial variables to be input to obtain input layer variable and then using modified BP neural network algorithm to establish the neural network between input and output variables. Then it obtains the weight and threshold of each node in network through self learning function of network and ultimately builds self learning and reasoning model. The structure diagram of self learning reasoning model is shown as follows (Fig. 4):

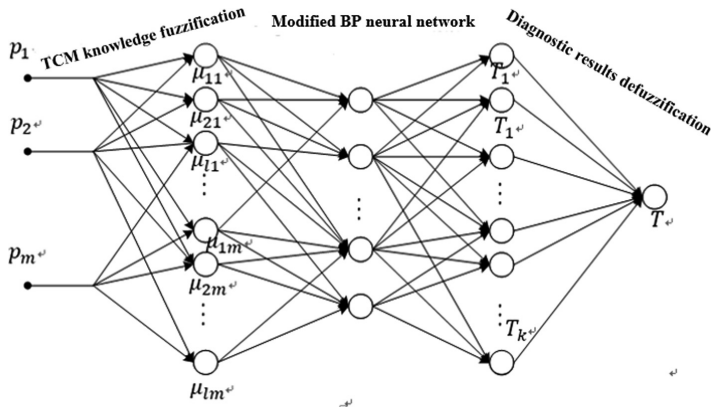

Fig. 4. Self learning and reasoning structure diagram

6 Conclusion

This paper discusses the key technology of TCM smart service system, in which advanced technologies like internet of things, big data and mobile internet are combined with TCM, conducting informationized collection by machine from observation, listening, inquiry and pulse feeling, and storing TCM theoretical essences, academic ideas and previous experience into database. This system can build self learning reasoning model through TCM knowledge fuzzy model and modified BP neural network algorithm, so as to enable it to update information in database and keep up with the times. The updated database resources and informationized expression of TCM knowledge will facilitate machine learning and diagnosis of various diseases. The buildup of TCM database will also provide a shortcut for realizing resources sharing through internet, hence saving cost and improving efficiency. With these technologies, medical equipment can realize more comprehensive, thorough and deeper smart judgment, further promoting development of TCM and providing higher service quality for patients. The informationization, intelligence and networking of the system can solve the problems like TCM westernization and lack of innovation through machine with the philosophy of "high efficiency and supreme quality." These technologies will no doubt realize lasting prosperity and booming development.

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