# Implementation of an interval Based expert system for diagnosis of Oriental Traditional Medicine

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**Abstract**

*This paper describes an implementation of the interval based expert system for syndrome differential diagnosis of Oriental Traditional Medicine (OTM). An approximate reasoning model using fuzzy logic for syndrome differential diagnosis is proposed. Based on this model, we implemented the system for diagnosing Eight rule diagnosis, organ diagnosis and then final differential syndrome of OTM. After carrying out inference process, the system will provide patient's syndromes differentiation diagnosis in the intervals and will give the explanation, which helps the user to understand the obtained conclusions.*

***Key words:***
Expert systems; oriental traditional medicine.

## Introduction

Medical informatics is the scientific field that deals with the storage, retrieval, sharing and optimal use of biomedical information, data, knowledge for problem solving and decision-making. It touches all basic and applied fields in biomedical science and is closely tied to modern information technologies, notably in the areas of computing and communication. In recent years, fuzzy set theory and fuzzy logic has been successfully applied in medical expert systems as CADIAG-2 [8,9] and integration of Western and Eastern medicine [2,5,12] etc. The imprecise nature of medical concepts and their relationships require a development of fuzzy set theory, of fuzzy set conceptual models and fuzzy inference models for medical fuzzy expert systems. On the other hand, the nature of Oriental traditional medicine is very fuzzy and imprecise. In recent years, some research on applying fuzzy set theory and fuzzy logic combining interval computations in the field of Oriental medicine were studied (see in [3,4,6,7]).

In this paper, we will propose an approach to design and implementation of an interval Based fuzzy system for medical diagnosis in Oriental Traditional Medicine. The rest sections of the paper consist of the following: reviewing some notion of diagnosis of Oriental Traditional Medicine; proposing the inference model of syndrome differentiation diagnosis of OTM; describing the implementation of the system and giving some conclusions.

## Some notions of diagnosis of Oriental Traditional Medicine

Let recall some notions of diagnosis of Oriental medicine [10]. The doctrine of Yin Yang and Five Elements, a combined name for the theory of Yin Yang and that of Five Elements (wood, fire, earth, metal and water), is a theory used to understand the nature from the nature itself, explain the nature phenomena and explore the laws of the nature.

Based on their long-standing clinical practice, the ancient doctors introduced the theory of Yin Yang and Five Elements into medical field, so as to explain the physiological functions and pathological changes of human body and to guide diagnosis and treatment of disease.

Yin Yang are a generalization of some related matter and phenomena, with opposite properties in nature. They stand for not only two opposite things, but also the two opposite aspects existing with in one thing. According to Yin Yang theory, the material world is a unity resulting from the unity and opposite of Yin Yang. Anything in the universe can be divided into the opposite Yin and Yang, such as the cold or hot of weather and the night and day. The contradictive movement of Yin and Yang lies in everything in the world, and occurrence, development and changes of all things in

nature are the results of the contradictive movement of Yin and Yang in their oppositing and supplementing.

In brief, Yin and Yang stand for the relative properties of things, which can be classified in accordance with Yin and Yang constantly. The mutual opposite and restriction of Yin and Yang, the mutual dependence and supplement, the wane and wax and balance as well as the transformation of Yin and Yang show that the relations between Yin and Yang are neither isolated nor still, instead they are interrelated and influenced, oppositing to each other and supplementing to each other. The mutual restriction and dependence of Yin and Yang signify that Yin and Yang, things or phenomena with different properties, exist in one unity, while the mutual restriction, supplement and transformation indicate that the opposite Yin and Yang are always in a state of movement and change caused by the restriction, supplement and transformation, and the wane and wax and ensuing the balance of Yin and Yang show that Yin and Yang maintain their relative dynamic balance in an absolute wane and wax movement.

Theory of Five Elements is a cosmos outlook and methodology using the properties of the Five Elements and their mutual generation, mutual restriction, encroachment and violation to understand the world, explain the natural phenomena and the law of movement and changes of the nature. The theoretical system of OTM in diagnosis is based on Five Elements theory and on Yin-Yang theory.

Oriental Traditional Medicine pays attention to syndromes differentiation (BienChung) and treatments (LuanTri) (drug-therapy and non drug-therapy) called "BienChung LuanTri". As the pathogenesis is convinced, then the prescription can be given. In detail, different diseases may be resulted from an identical pathogenesis, so the same way of treatment can be taken. On the other hand, different pathogenesis may be resulted from the same disease, so the way of treatment should be varied. According to Oriental Traditional Medicine, pathogenesis is the key of treatment. Syndrome differentiation called BienChung is the key link between theory and practice of Oriental Medicine. It may be considered as the essence of Oriental Medicine.

Below, we will briefly describe the diagnostic methodologies of Oriental traditional Medicine.

In general, the diagnostics in OTM includes a syndrome differentiation (BatCuong) (called Eight Rule Diagnosis) and internal organs differentiation (TangPhu). The diagnosis process in OTM called BienChung, which depends on the following four methods, namely:

- ✓ Inspection
- ✓ Questioning the patient and olfaction
- ✓ Interrogation
- ✓ Pulse examination and palpation

The differentiation syndromes with BatCuong include: Yin and Yang, Exterior and Interior, Cold and Heat, Deficiency and Excess. Among those four opposition pairs, Exterior, Heat and Excess belong to the category of Yang while Interior, Cold and Deficiency belong to Yin. In addition to the differentiation syndromes with BatCuong, the Viscera-state theory is also used to identify the relevant disease organ. These are five parenchymatous viscera: Heart, Liver, Spleen, Lung and Kidney, and six hollow viscera: Gall bladder, Stomach, Small intestine, Large intestine, Bladder and Triple Jiao. Furthermore, there are syndromes of Qi, Blood and Body Fluid. Because the Qi, Blood and Body Fluid are material facilities of activities of TangPhu and system of acupuncture points, so that they influence on activities of TangPhu and system of acupuncture points. This distinguishes Oriental Medicine from Occidental Medicine. According to the system of BienChung in OTM, the result of BienChung may be a composition of two or more syndromes of pathogenesis. Therefore the internal relations of symptoms, which consist of one or several elementary conjunctions of symptoms are established for each BatCuong (Deficiency-Cold, etc) or TangPhu (Stomach, Spleen, etc) or Qi, Blood and Body Fluid. Then pathogenesis may be composed of BatCuong and TangPhu (i.e Stomach-Spleen Deficiency-Cold) or TangPhu and Qi, Blood and Body Fluid (i.e Deficiency Qi Heart, Deficiency Blood Heart). In this system, after executing inferential process, the system will provide the interval for the diagnosis of pathogenesis with BatCuong, TangPhu, Qi, Blood and Body Fluid. Finally, the interval for the diagnosis of pathogenesis composed of syndromes as mentioned above is proposed.

Generally, we have reviewed the diagnosis process of Oriental Medicine. The following section, we will consider a inference model as diagnosis process of BienChung of Oriental medicine.

## Building the inference model of syndrome differentiation diagnosis of OTM

Based on the features of diagnosis of Oriental Traditional Medicine (OTM), we design a model of syndrome differentiation (BienChung) of OTM. At the end of this section, an example will be given.

Let $S=\{S_1, S_2,.., S_n\}$ denote a set of symptoms. Symptom $S_i$ takes fuzzy value $\mu_{S_i}$ in interval [0,1].

Value $\mu_{S_i}$ indicates the degree to which a patient exhibits symptom $S_i$, specifically:

If $\mu_{S_i}=1$, this means that the symptom $S_i$ is surely present for patient $P_q$.

If $\mu_{S_i}=0$, this means that the symptom $S_i$ is surely absent for patient $P_q$.

If $0 < \mu_{S_i} <1$ where $\mu_{S_i}$ expresses the degree to which a patient exhibits symptom.

Let $E=\{E_1, E_2, E_3,.., E_n\}$ denote a set of all elementary conjunctions of symptoms i.e. symptoms and negated symptoms. In this implementation, in computing the weight of $E_i$ using truth function of fuzzy logic over [0,1].

Let $B=\{B_1, B_2,.., B_n\}$ denote a set of pathogenesis labeled with BatCuong which classifies a patient according to four dichotomies. Pathogenesis labeled with BatCuong $B_j$ take values:

$\mu^{d+}{}_{PB}(P_q,B_j)$ : a degree to confirm $B_j$

$\mu^{d-}{}_{PB}(P_q,B_j)$ : a degree to exclude $B_j$

$\mu^{int}{}_{PB}(P_q,B_j) = [\mu^{d+}{}_{PB}(P_q,B_j), 1-\mu^{d-}{}_{PB}(P_q,B_j)]$: is the interval for the confirmation and exclusion of $B_j$ by patient $P_q$ from the observed symptoms.

Let $T=\{T_1, T_2,.., T_h\}$ denote a set of pathogenesis labeled with TangPhu. Pathogenesis labeled with TangPhu $T_k$ take values:

$\mu^{d+}{}_{PT}(P_q,T_k)$ : a degree to confirm $T_k$

$\mu^{d-}{}_{PT}(P_q,T_k)$ : a degree to exclude $T_k$

$\mu^{int}{}_{PT}(P_q,T_k) = [\mu^{d+}{}_{PT}(P_q,T_k), 1-\mu^{d-}{}_{PT}(P_q,T_k)]$: is the interval for the confirmation and exclusion of $T_k$ by patient $P_q$ from the observed symptoms.

Let $K=\{K_1, K_2,.., K_m\}$ denote a set of pathogenesis labeled with Qi, Blood and Body Fluid. Pathogenesis labeled with Qi, Blood and Body Fluid $K_m$ take values:

$\mu^{d+}{}_{PK}(P_q,K_m)$ : a degree to confirm $K_m$

$\mu^{d-}{}_{PK}(P_q,K_m)$ : a degree to exclude $K_m$

$\mu^{int}{}_{PK}(P_q,K_k) = [\mu^{d+}{}_{PK}(P_q,K_m), 1-\mu^{d-}{}_{PK}(P_q,K_m)]$: is the interval for the confirmation and exclusion of $T_k$ by patient $P_q$ from the observed symptoms.

Let $D=\{D_1 D_2,.., D_n\}$ denotes a set of pathogenesis. according to Oriental Medicine. Pathogenesis $D_l$ takes the interval value:

$\mu^{int}{}_{PD}(P_q,D_l) = [\mu^{d+}{}_{PD}(P_q,D_l), 1-\mu^{d-}{}_{PD}(P_q,D_l)]$

which indicates the possible pathogenesis interval of $D_l$. We have: $B,T,K \subseteq D$.

The relationship between entities in Oriental Medicine may be as the following:

$E_i \Rightarrow B_j(\mu^{d+}{}_{SB}(E_i,B_j))$

$E_i \Rightarrow \neg B_j(\mu^{d-}{}_{SB}(E_i,B_j))$

$E_i \Rightarrow T_k(\mu^{d+}{}_{ST}(E_i,T_k))$

$E_i \Rightarrow \neg T_k(\mu^{d-}{}_{ST}(E_i,T_k))$

$E_i \Rightarrow K_m(\mu^{d+}{}_{SK}(E_i,K_m))$

$E_i \Rightarrow \neg K_m(\mu^{d-}{}_{ST}(E_i,K_m))$

where $E_i$ is symptom or an elementary conjunction of symptoms.

$B_j$ : is a pathogenesis labeled with BatCuong

$T_k$ : is a pathogenesis labeled with TangPhu

$K_m$: is a pathogenesis labeled with Qi, Blood and Body Fluid.

$\neg B_j$ ,$\neg T_k$ ,$\neg K_m$: are respectively auxiliary pathogenesis corresponding to $B_j$, $T_k$, $K_m$

The values $\mu^{d+}{}_{SB}(E_i,B_j)$, $\mu^{d+}{}_{ST}(E_i,T_k)$, $\mu^{d+}{}_{SK}(E_i,K_m)$ indicate degrees to which the symptom or the elementary conjunction of symptoms, confirm the pathogenesis labeled with BatCuong and TangPhu, Qi, Blood and Body Fluid , respectively.

The values $\mu^{d-}{}_{SB}(E_i,B_j)$, $\mu^{d-}{}_{ST}(E_i,T_k)$, $\mu^{d-}{}_{SK}(E_i,K_m)$ indicate degrees to which the symptom or the elementary conjunction of symptoms, exclude the pathogenesis labeled with BatCuong and TangPhu, Qi, Blood and Body Fluid, respectively.

**Remark:** We assume the following conditions:

$\mu^{d+}{}_{SB}(E_i,B_j) = 0$ or $\mu^{d-}{}_{SB}(E_i,B_j) = 0$,

$\mu^{d+}{}_{ST}(E_i,T_k) = 0$ or $\mu^{d-}{}_{ST}(E_i,T_k) = 0$,

$\mu^{d+}{}_{SK}(E_i,K_m) = 0$ or $\mu^{d-}{}_{SK}(E_i,K_m) = 0$,

because it is impossible that "Condition" confirms and also excludes "Conclusion".

Some inference rules used to deduce the pathogenesis labeled with BatCuong suffered by patient $P_q$ from the observed symptoms $S_i$:

$$R^{d+}{}_{PB} = R_{PS} \circ R^{d+}{}_{SB}$$

defined by

$\mu^{d+}{}_{PB}(P_q, B_j) =$

T-CONORM $_{E_i \in E}$ T-NORM$\{\mu_{PS}(P_q, E_i), \mu^{d+}{}_{SB}(E_i, B_j)\}$

and inference rules which are used to deduce the negation pathogenesis labeled with BatCuong suffered by patient $P_q$ from the observed symptoms $S_i$:

$$R^{d-}{}_{PB} = R_{PS} \circ R^{d-}{}_{SB}$$

defined by

$\mu^{d-}{}_{PB}(P_q, B_j) =$

T-CONORM $_{E_i \in E}$ T-NORM$\{\mu_{PS}(P_q, E_i), \mu^{d-}{}_{SB}(E_i, B_j)\}$

Therefore, we have:

$$\mu^{int}{}_{PB}(P_q,B_j) = [\mu^{d+}{}_{PB}(P_q, B_j), 1-\mu^{d-}{}_{PB}(P_q, B_j)]$$

where

T-NORM is the operator: $x \oplus$ T-NORM $y = \min(x,y)$

T- CONORM is the operators:

$x \oplus$ T-CONORM $y = \max(x,y)$

or $x \oplus$ T-CONORM $y = x + y - x.y$
it depends on the nature of application.
In the same way, we have the inference rules for TangPhu $T_k$:

$$R^{d+}_{PT} = R_{PS} \circ R^{d+}_{ST}$$
$$R^{d-}_{PT} = R_{PS} \circ R^{d-}_{ST}$$

defined by

$\mu^{d+}_{PT}(P_q, T_k) =$

T-CONORM $_{E_i \in E}$ T-NORM $\{\mu_{PS}(P_q, E_i), \mu^{d+}_{ST}(E_i, T_k)\}$

$\mu^{d-}_{PT}(P_q, T_k) =$

T-CONORM $_{E_i \in E}$ T-NORM $\{\mu_{PS}(P_q, E_i), \mu^{d-}_{ST}(E_i, T_k)\}$

We have:

$$\mu^{int}_{PT}(P_q, T_k) = [\mu^{d+}_{PT}(P_q, T_k), 1 - \mu^{d-}_{PT}(P_q, T_k)]$$

as well as for Qi, Blood and Body Fluid $K_m$:

$$R^{d+}_{PK} = R_{PS} \circ R^{d+}_{SK}$$
$$R^{d-}_{PK} = R_{PS} \circ R^{d-}_{SK}$$

defined by

$\mu^{d+}_{PK}(P_q, K_m) =$

T-CONORM $_{E_i \in E}$ T-NORM $\{\mu_{PS}(P_q, E_i), \mu^{d+}_{SK}(E_i, K_m)\}$

$\mu^{d-}_{PK}(P_q, K_m) =$

T-CONORM $_{E_i \in E}$ T-NORM $\{\mu_{PS}(P_q, E_i), \mu^{d-}_{SK}(E_i, K_m)\}$

Thus, we also have:

$$\mu^{int}_{PK}(P_q, K_m) = [\mu^{d+}_{PK}(P_q, K_m), 1 - \mu^{d-}_{PK}(P_q, K_m)]$$

**Criteria for diagnosis of pathogenesis labeled with BatCuong $B_j$**

a) If $\mu^{d+}_{PB}(P_q, B_j) + \mu^{d-}_{PB}(P_q, B_j) \le 1$, then a "likely" diagnosis of pathogenesis labeled with BatCuong $B_j$ for patient $P_q$ are identified in the interval:

$$\mu^{int}_{PB}(P_q, B_j) = [\mu^{d+}_{PB}(P_q, B_j), 1 - \mu^{d-}_{PB}(P_q, B_j)]$$

b) If $\mu^{d+}_{PB}(P_q, B_j) + \mu^{d-}_{PB}(P_q, B_j) > 1$, then we have the following cases:

1) If $\mu^{d+}_{PB}(P_q, B_j) \ge \mu^{d-}_{PB}(P_q, B_j)$,
we put $\mu^{d-}_{PB}(P_q, B_j) = 1 - \mu^{d+}_{PB}(P_q, B_j)$
We make the priority for $\mu^{d+}_{PB}(P_q, B_j)$ and we get:

$$\mu^{int}_{PB}(P_q, B_j) = [\mu^{d+}_{PB}(P_q, B_j), 1 - \mu^{d-}_{PB}(P_q, B_j)]$$

2) If $\mu^{d+}_{PB}(P_q, B_j) < \mu^{d-}_{PB}(P_q, B_j)$,
we put $\mu^{d+}_{PB}(P_q, B_j) = 1 - \mu^{d-}_{PB}(P_q, B_j)$
We make the priority for $\mu^{d-}_{PB}(P_q, B_j)$ and we get:

$$\mu^{int}_{PB}(P_q, B_j) = [\mu^{d+}_{PB}(P_q, B_j), 1 - \mu^{d-}_{PB}(P_q, B_j)]$$

We have:

$$\mu^{min}_{PB}(P_q, B_j) = \mu^{d+}_{PB}(P_q, B_j),$$

$$\mu^{max}_{PB}(P_q, B_j) = 1 - \mu^{d-}_{PB}(P_q, B_j)$$

Similarly, we will have criteria for diagnosis of pathogenesis labeled with TangPhu $T_k$, Qi, Blood and Body Fluid $K_m$.

How to model the inference of the Oriental (Eastern) medical diagnosis of pathogenesis $D_l$?

According to the theory of Eastern (Oriental) medicine, a diagnosis of pathogenesis (syndrome) of Eastern medicine is combined from BatCuong syndrome (including Yin-Yang, Cold-Heat, Deficiency-Excess, Interior-Exterior), TangPhu syndrome (Heart, Lung, Liver, Spleen. Kidney ...) and Qi, Blood and Body Fluid syndrome.

.In the previous sections, we have proposed the way to find out the interval of BatCuong syndrome and TangPhu syndrome where their values are in [0,1]. Now, we should combine the BatCuong syndrome, TangPhu syndrome and Qi, Blood and Body Fluid syndrome to receive a Eastern medicine diagnosis of pathogenesis based on the following heuristic principles using a suitable operation $\oplus$ (max or min or average operation):

a) If both values of BatCuong syndrome and TangPhu syndrome (Qi, Blood and Body Fluid syndrome ) have a strong confirmation i.e. both values are grater than 0.5, then the operation $\oplus$ is a max operation.
b) If both values of BatCuong syndrome and TangPhu syndrome (Qi, Blood and Body Fluid syndrome) have a weak confirmation i.e. both value are less than 0.5, then the operation $\oplus$ is a min operation.
c) If one among BatCuong syndrome and TangPhu syndrome (Qi, Blood and Body Fluid syndrome) has a strong confirmation and the other has a weak confirmation, then operation $\oplus$ is an average operation.

We apply this principle for combining the lower endpoints and the supper endpoints of the interval of BatCuong syndrome i.e. $[\mu^{min}_{PB}(P_q, B_j), \mu^{max}_{PB}(P_q, B_j)]$ and of the interval of TangPhu syndrome i.e. $[\mu^{min}_{PT}(P_q, T_k), \mu^{max}_{PT}(P_q, T_k)]$ (or of the interval of Qi, Blood and Body Fluid syndrome i.e. $[\mu^{min}_{PK}(P_q, K_m), \mu^{max}_{PK}(P_q, K_m)]$ ) to receive an interval of syndrome differentiation of OTM.
For example, if we combine the interval with the interval of TangPhu, then we get:

$$\mu^{max}_{PD}(P_q, D_l) = \mu^{max}_{PB}(P_q, B_j) \oplus \mu^{max}_{PT}(P_q, T_k)$$
$$\mu^{min}_{PD}(P_q, D_l) = \mu^{min}_{PB}(P_q, B_j) \oplus \mu^{min}_{PT}(P_q, T_k)$$

**Criteria for diagnosis of pathogenesis of Oriental medicine:**

a) If $\mu^{max}_{PD}(P_q, D_l) = \mu^{min}_{PD}(P_q, D_l) = 1$ then absolutely confirmed Eastern medicine diagnosis of pathogenesis for patient $P_q$ are identified.

b) If $\mu_{PD}^{max}(P_q, D_l) = \mu_{PD}^{min}(P_q, D_l) = 0$ then absolutely disconfirmed Eastern medicine diagnosis of pathogenesis for patient $P_q$ are identified.

d) If $0 < \mu_{PD}^{max}(P_q, D_l) = \mu_{PD}^{min}(P_q, D_l) < 1$ or

If $\mu_{PD}^{max}(P_q, D_l) \neq \mu_{PD}^{min}(P_q, D_l)$ then a possible Eastern medicine diagnosis of pathogenesis for patient $P_q$ is identified in the interval $[\mu_{PD}^{min}(P_q, D_l), \mu_{PD}^{max}(P_q, D_l)]$.

In fact, we may have some possible Oriental medicine diagnoses of pathogenesis satisfied to the check list of combined syndromes of OTM. In this case, we choose the interval of diagnosis of pathogenesis having the maximum of all lower endpoints of the intervals of diagnoses of pathogenesis to be a final diagnosis.

## Implementation of the system

In this section, we describe the implementation of the system called Expert System for diagnosis of Oriental Traditional Medicine (ESOTM). This system is written in Visual C++ language on Windows 9x environment. The knowledge base was managed by MS Access administration system of Microsoft. The structure of ESOTM is illustrated as following:

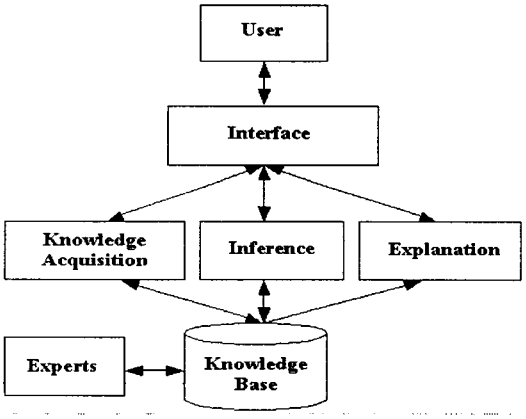


Figure 1. Structure of ESOTM

The main structure of ESOTM includes the following components:

- Interface Module
- Knowledge Acquisition Module (symptoms, syndromes and building rules)
- Knowledge Base
- Inference Engine (bring out the result of diagnosis)
- Explanation Module

**Interface Module (IM)**

The interface Module of the ESOTM system can help the user to dialogue friendly with the system by menu mode, window mode, etc.When ESOTM runs, the symbol of the system appears on screen as in Figure 2.

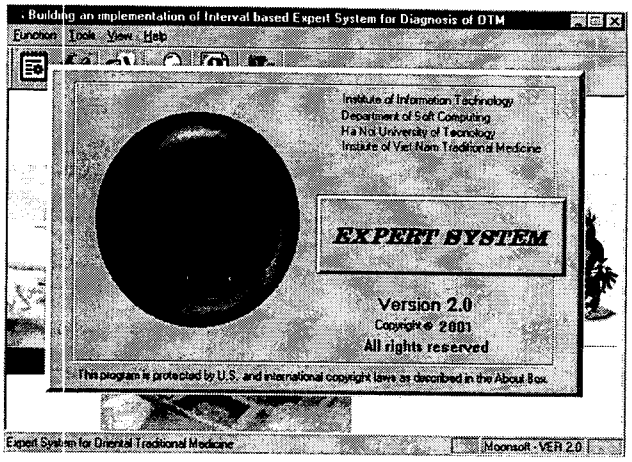


Figure 2. Symbol of ESOTM

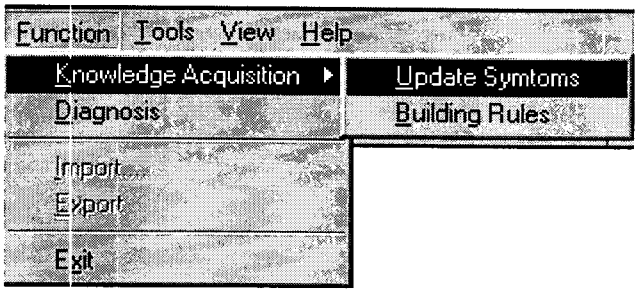


Figure 3. The main functions

**Knowledge Acquisition Module (KAM)**

The Knowledge Acquisition Module can help experts acquire knowledge and the patient's data relating to Oriental Medicine such as symptoms, syndromes of pathogenesis (or diseases). ESOTM gets the KAM in terms of symptoms and rules. This function composes of the following sub-functions:

- Update symptoms
- Building rules

Users can add, delete symptoms and rules or edit the knowledge base of system.

In Update symptoms step, user must enter the name of new symptoms, type of symptoms and degree of levels, then must select group that the new symptom belong to.

For example, the name of new symptom is "Red face", its levels may be "Very", "Above average", "Little", "Slightly". Medical experts assign the degrees for these levels as "0.9", "0.75", "0.5", "0.3". The

new symptom is belonging to "Inspection" group (as shown in figure 4).

We can also edit, delete or update symptoms in the knowledge base by selecting "Edit", "Delete" or "Update" button.

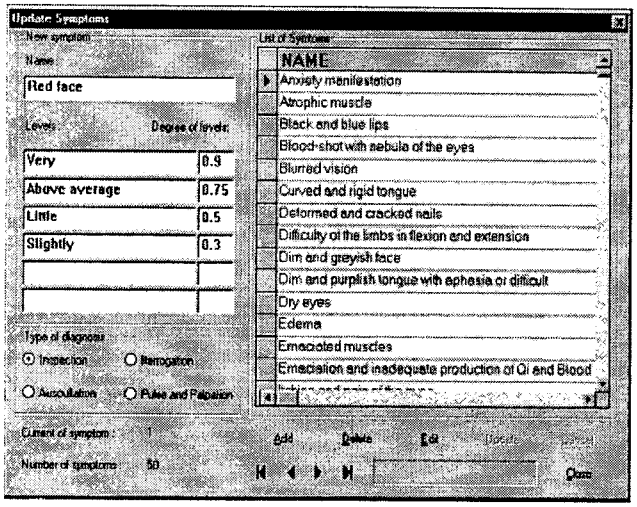


Figure 4. Update Symptoms

In Building rules step, user must select some symptoms in symptom base and put them in IF part. In THEN part includes: type of disease (BatCuong, TangPhu or Qi, Blood and Body Fluid), style of diagnosis (Confirm or Exclude)> In WITH DEGREE part is the weight of level diagnosis (in [0,1]).

For example, suppose the premises in IF part are "Cough", "Distending pain in head", "High pulse", "Moss of tongue is white and thin", "Nasal obstruction", In THEN part, type of disease is "BatCuong" and "Exterior". This diagnosis belongs to "Confirm" rules group. In WITH DEGREE part, the weight of level diagnosis is 0.55 (as shown in figure 5).

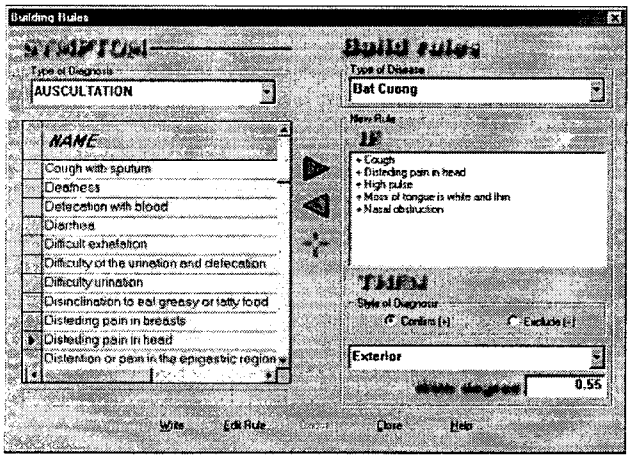


Figure 5. Building rules

We can also review, edit or delete rules in the knowledge base by choosing "Edit rules" command on "Building rules". The "Edit rules" window will appear as in the figure 6.

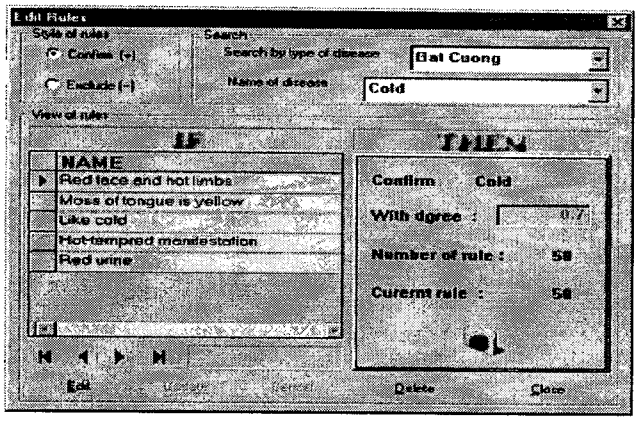


Figure 6. Edit rules

In addition, the system has also the dictionary, this allows user to add, delete, edit and update name of combined syndromes. For example: "Heart-Cold" (Figure 7).

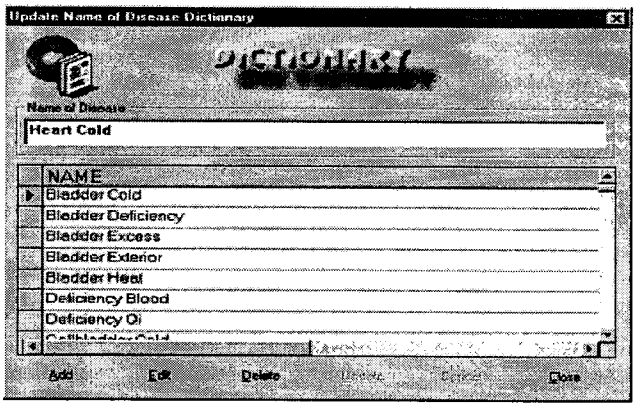


Figure 7. Update name of combined syndromes

**Knowledge Base**

For the experimental version, knowledge base of the system consists of more 1000 rules. Syndromes of the system consists of Eight rule diagnosis, Organs diagnosis, and diagnosis for Qi, Blood and Body Fluid and syndromes according to Oriental Traditional Medicine. For example:

*The pathogenesis labeled with BatCuong:* Cold, Heat, Deficiency, Excess, Exterior and Interior.

*The pathogenesis labeled with TangPhu:* Heart, Liver, Spleen, Lung, Kidney, Gallbladder, Stomach, Small Intestine, Large Intestine, Bladder and Triple Jiao

*The pathogenesis labeled with Qi, Blood and Body Fluid:* Deficiency Qi, Stagnated Qi, Reverse Qi, Deficiency Blood, Stagnated Blood, Heat Blood, Lack of Body Fluid and Stagnated Body Fluid.

Combined syndromes according to Oriental Traditional Medicine: Bladder-Excess, Bladder-Cold, Gallbladder-Deficiency, Heart-Deficiency Qi, etc (see[10]).

The rule base is a set of rules in the forms:

**Positive rule:**

IF <premise> THEN

CONFIRM <Conclusion> with <degree>

**Negative rule:**

IF <premise> THEN

EXCLUDE <Conclusion> with <degree>

Where:

<premise> is a set of symptoms or an elementary conjunction of symptoms.

<Conclusion> is a pathogenesis labeled with BatCuong or TangPhu or Qi, Blood and Body Fluid.

<degree> is the degrees of Confirmation or Exclusion of the <premise> for the <Conclusion >. It take values in [0,1].

For Example: **IF** Transparent urine
**THEN CONFIRM** Cold
**WITH** ($\mu^{d+}_{SB}$=0.11)
**IF** Rapid pulse
**THEN EXCLUDE** Cold
**WITH** ($\mu^{d-}_{SB}$ = 0.18)

**Inference Engine (IE)**

The inference process of ESOTM aims at generating syndrome differential diagnoses such as confirmed or excluded diagnoses or possible diagnosis according to Oriental Medicine by applying the inference model described above.

This function requires user to assign the degree to which a patient exhibits the symptom. The system will list all of symptoms of diagnosis pathogenesis according to Oriental Traditional Medicine therefore users can get symptoms as the patient's input data for making initial diagnosing process. Finally, the possible diagnosis of pathogenesis labeled with BatCuong, TangPhu and Qi, Blood and Body Fluid as well as combined diagnosis of syndromes according to Oriental Medicine for patient (as mentioned above), which obtained through realization of the system, in the interval have been proposed.

The system has also the dictionary of all combinations of syndromes of Oriental Medicine, such as Stomach-Spleen Deficiency-Cold, Deficiency-Qi Heart, etc. (Figure 7). The obtained conclusions will be compared with these syndromes of pathogenesis stored in the dictionary. If these conclusions correspond to them, then these conclusions will be derived. Otherwise, the conclusions are not determined.

An example of of the diagnostic process is illustrated in Figure 8. User collects the symptoms and their levels of observing the patient, then chose "Inference" command. The system returns the results are intervals of diagnosis pathogenesis labeled with BatCuong, TangPhu, Qi, Blood and Body Fluid and a conclusion according to Oriental Medicine. For example, the patient has the following symptoms: "Forgetfulness manifestation"(Always), "Like Cold" ("Much") (see Figure 8) . Select these symptoms and chose Inference command, then click "Result" command for more detail results. Here, we have the intervals of diagnosis pathogenesis labeled with BatCuong (Heat is [0.14...1]), TangPhu (Heart is [0.04...1]) and the pathogenesis according to Oriental Medicine (Heart-Heat is [0.04...1]) (see Figure 9). This example is illustrated as following:

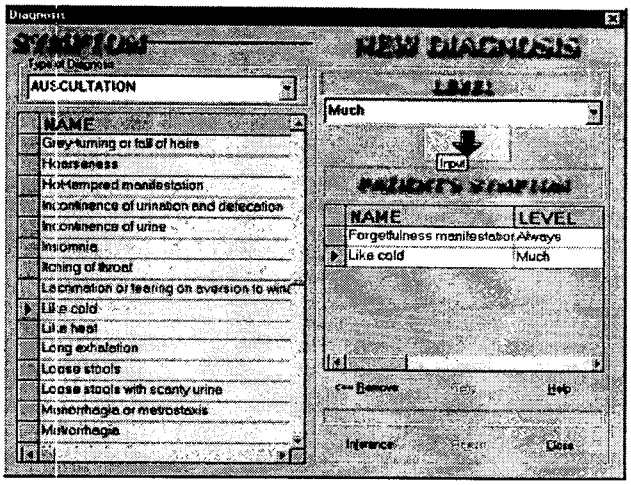


Figure 8. A diagnosis process

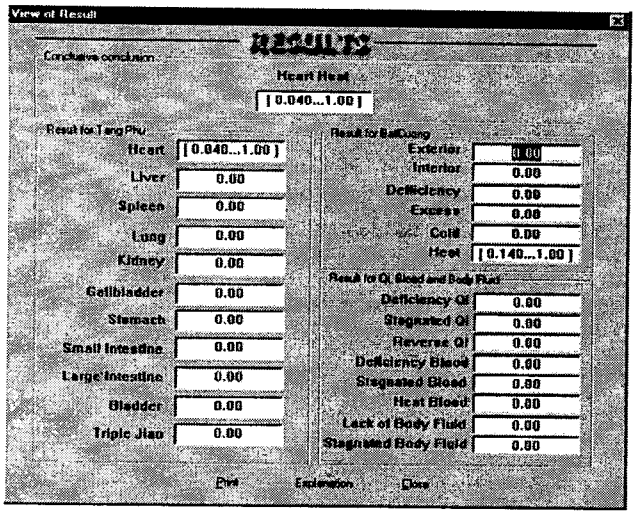


Figure 9. View of results

**Explanation**

It is necessary and importance for the system to provide explanations, especially for expert systems. ESOTM can explain *why* the conclusion is given and *how* it is reached. These features provide a more natural interaction and a transparency for the system's reasoning.

*Explains Why*

We mimic the medical expert's explanation why the diagnosis is given (or is not given) and we build this module for the system by showing all symptoms on the patient and based on these symptoms, the syndrome is given.

To illustrate this approach, consider the following example:

**USER: WHY?**

**SYSTEM: My answer:**

----------You told me----------

1. Right inclination-Level: Much
2. Pale green face-Level: Pretty
3. Purplish tongue and lips-Level: Much

=>You may get the following diseases (OTM):

-Heart and Heart Deficiency Cold

-But these diseases are not in the name of disease dictionary, so we have no conclusion

-Because your symptom related to these rules: 146, 253, 366, 367, 381

-You can refer to these rules below.

Providing this explanation, a user can see that the system is attempting to prove the reasons why the conclusion is given or not given.

A *why* explanation provides the user with an understanding of the influence of symptoms on the diseases.

*Explains How*

When using a conventional computer program we usually accept the results without question. In most case this is acceptable because this type of program is normally written for a well-defined problem for which the programming solution is exact and repeatable. However, the types of problem solved by expert systems are usually far less exact, which often leaves the user with some degree of belief about the result. In order to help alleviate this concern, an expert system must be able to explain *how* it derived its results.

To accommodate this request, ESOTM shows the logic behind its reasoning. It does this by providing the user a trace of the rules used to reach its decision based on the symptoms given.

To illustrate this how explanation utility, consider the following explanation drawn from the diagnostic example:

**USER: HOW?**

**SYSTEM: I refer to these rules:**

RULE 146 IF Pale green face
THEN CONFIRM Deficiency
WITH DEGREE 0.11

RULE 253: IF Pale green face
THEN CONFIRM Cold
WITH DEGREE 0.11

RULE 366: IF Right inclination
THEN CONFIRM Heart
WITH DEGREE 0.04

RULE 367: IF Purplish tongue and lips
THEN CONFIRM Heart
WITH DEGREE 0.2

RULE 381: IF Pale green face
AND Purplish tongue and lips
AND Right inclination
THEN CONFIRM Heart
WITH DEGREE 0.44

A *how* explanation provides the user with a justification of the system's inferences. It makes the system's reasoning more transparent, which increases the user's confidence in the diagnoses.

User also asks the system why it has that result by clicking on "Explanation" command. The system will show explanations. An example is shown in Figure 10.

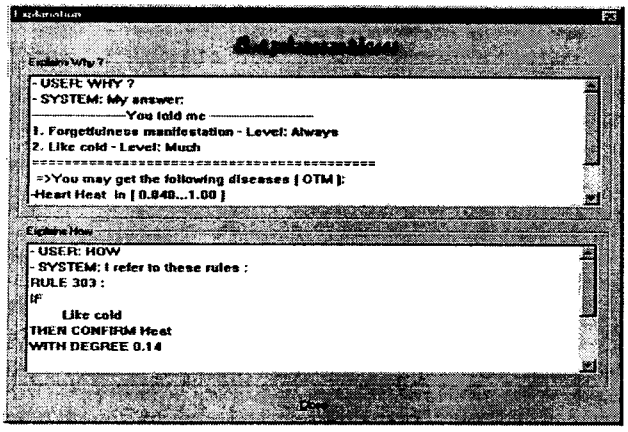


Figure 10. Explanation

**Help function:** This function as a documentation of the system. It can helps user to learn about basis concept and methodology of the interval based fuzzy expert system for diagnosis of Oriental Medicine such as the problem of diagnosis of Oriental traditional medicine and how to use program (update symptoms, Build and edit rules etc.) (see Figure 11)

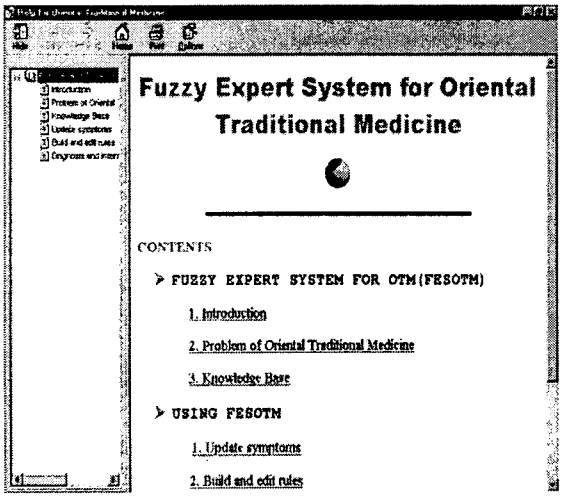


Figure 11. Help function

## Conclusions

In this paper, we have presented a model of inference for diagnosis of syndrome differentiation in Oriental Traditional Medicine applying the fuzzy logic and interval computation techniques. We also have described the implementation of the prototype system based on this model. Some examples to illustrate the system were given.

Our further works are:

(1) Developing a complete knowledge base for Eight rule diagnosis (BatCuong), organs diagnosis (TangPhu), Qi, Blood and Body Fluid and evaluate the system with the assistance of medical doctors who are not involved in the project.

(2) Improving the explanation mechanism for Eight rule diagnosis (BatCuong), organs diagnosis (TangPhu), Qi, Blood and Body Fluid.

(3) Developing the automatic checking component to check the inconsistence of rules in knowledge base of the system.

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