Cold-Heat Diagnosis System for Selection of Suitable Daily Meals Using Fuzzy Logic

Nguyen Hoang Phuong\textsuperscript{a}, Trinh Hien Anh\textsuperscript{a}, Cao Thang\textsuperscript{a}, Vu Trong Tuan\textsuperscript{a}, Yun Sik Kwak\textsuperscript{b}, Hune Cho\textsuperscript{b}

\textsuperscript{a} Institute of Information Technology, National Center for Natural Science and Technology, Vietnam
\textsuperscript{b} Department of Medical Informatics, Kyungpook National University School of Medicine, Daegu, Korea

Abstract:

According to the Oriental Medicine, a health is the balance between Yin and Yang, vital energy and blood etc. Loosing the balance between Yin and Yang, one gets a disease. In syndrome differentiation of Traditional Oriental Medicine, Cold belongs to the category of Yin and Heat of Yang, therefore the Cold and Heat states of patient are basic syndromes which play a principal role in diagnosis and treatment according to the traditional oriental medicine. In this paper, we apply fuzzy logic for development of the system for diagnosis of Cold-Heat states and advice in therapy according to Traditional oriental medicine. We also describe the consultation system for diagnosis and treatment of Cold-Heat states.

Keywords:
Cold-Heat diagnosis, fuzzy logic, daily meals.

Introduction

Nowadays, the combination of Occidental and Oriental Medicine for diagnosis and treatment plays an important role in the health care for many countries in the world because this combination often results in the best diagnosis and treatment of Oriental medicine into Occidental medicine [1].

In recent years, there was a number of applications of fuzzy set theory and fuzzy logic in Oriental traditional medicine. Fuzzy set theory and fuzzy logic are helpful mathematical tools for managing uncertainty in medical diagnosis and treatment [2,3,4,5,7,8,9,10,11]. In this work we intend to analyze the standardization of Cold-Heat diagnosis using in standardization of meals selection and herbal plants utility of Oriental Traditional Medicine.

Let $S=\{S_1, S_2, ..., S_n\}$ denotes the set of symptoms. Symptoms $S_i$ take values $\mu_i$ in $[0,1]$. Values $\mu_i$ indicates the degree to which a patient exhibits symptom $S_i$ where $\mu_i=1$ means symptom $S_i$ surely present for patient $P_q$, $\mu_i=0$ means symptom $S_i$ surely absent for patient $P_q$, symptom $S_i$ takes value $\mu_i$ in $(0,1)$ means possible hypothesis of presence of symptom $S_i$ for patient $P_q$ and value $\mu_i=\varepsilon$ means that symptom $S_i$ is undefined ($\varepsilon$ takes a value closing to 0).

Let $E=\{E_1, E_2, ..., E_n\}$ denotes the set of all elementary conjunctions of symptoms, conjunction of some symptoms and some other negated symptoms. Computing the weight of $E$ using truth functions of fuzzy logic over $[0,1]:$ $\text{NEG}(x)=1-x$ for negation, $\text{CONJ}(x,y)=\min(x,y)$ for conjunction.

Let $CH=\{C_1, C_2, ..., C_n, H_1, H_2, ..., H_n, CH_1, CH_2, ..., CH_n\}$ denotes the set of pathogenesis labeled with Han-Nhiet (CH) including syndromes Cold(C), Heat(H) and Mixed Cold-Heat (MCH). Pathogenesis labeled with Han-Nhiet CH takes values $\mu^c_{\text{PCH}}(P_q,C_i)$, $\mu^h_{\text{PCH}}(P_q,H_i)$, $\mu^c_{\text{PCH}}(P_q,C_i)$, $\mu^h_{\text{PCH}}(P_q,H_i)$, $\mu^c_{\text{PCH}}(P_q,CH_i)$, $\mu^h_{\text{PCH}}(P_q,CH_i)$, where the values $\mu^c_{\text{PCH}}(P_q,C_i)$ confirms Cold state, $\mu^h_{\text{PCH}}(P_q,H_i)$ confirms Heat state, and $\mu^c_{\text{PCH}}(P_q,CH_i)$ confirms Mix Cold-Heat state.

The value $\mu^c_{\text{PCH}}(P_q,C_i)$ is total degree for confirmation of Cold $C_j$ and the values $\mu^h_{\text{PCH}}(P_q,H_i)$ is total degree for confirmation of Heat $H_j$. The values $\mu^c_{\text{PCH}}(P_q,C_i)$, $\mu^h_{\text{PCH}}(P_q,H_i)$, $\mu^{ct}_{\text{PCH}}(P_q,C_i)$, $\mu^{ht}_{\text{PCH}}(P_q,C_i)$, $\mu^{ct}_{\text{PCH}}(P_q,H_i)$, $\mu^{ht}_{\text{PCH}}(P_q,H_i)$, takes values in $[0,1]$ and $\mu^c_{\text{PCH}}(P_q,CH_i)$ takes $(0,1)$ (because it is impossible that the patient has the state Cold and Heat with certain degree 1).

The value $\mu^c_{\text{PCH}}(P_q,C_i)=1$ indicates that the Pathogenesis $C_j$ is confirmed. The value $\mu^c_{\text{PCH}}(P_q,C_i)=0$ indicates that the pathogenesis $C_j$ is excluded $0<\mu^c_{\text{PCH}}(P_q,C_i)<1$ indicates possible pathogenesis $C_j$.

The value $\mu^h_{\text{PCH}}(P_q,H_i)=1$ indicates that the Pathogenesis $H_j$ is confirmed. The value $\mu^h_{\text{PCH}}(P_q,H_i)=0$ indicates that the pathogenesis $H_j$ is excluded $0<\mu^h_{\text{PCH}}(P_q,H_i)<1$ indicates possible pathogenesis $H_j$.

Based on the inference features above, we propose a model of approximate reasoning for rule based compositional system for Cold – Heat diagnosis using in standardization of meals selection and herbal plants utility.
The value $\mu^{c}_{\text{PCH}}(P_q,CH)$, takes values in (0,1) indicates possible pathogenesis $CH$.

Let $T=\{T_1, T_2, ..., T_n\}$ denotes the set of Meals and Herbal Plants $T_k$ take values $\mu^{\text{PT}}(P_q,T_k)$ where the values $\mu^{\text{PT}}(P_q,T_k)$ confirms $T_k$ for patient $P_q$.

The value $\mu^{\text{PT}}(P_q,T_k)=1$ indicates that the Treatment $T_k$ is confirmed. The value $\mu^{\text{PCH}}(P_q,C_j)$ indicates that the Treatment $T_k$ is excluded, $0<\mu^{\text{PCH}}(P_q,C_j)<1$ indicates possible Treatment $T_k$.

The relationships between entities in Cold- Heat (CH) diagnosis, meals selection and herbal plants utility of Oriental Traditional Medicine may be the following:

$$E_i \Rightarrow C_j \left( \mu^{c}_{\text{SCH}}(E_i,C_j) \right),$$
$$E_i \Rightarrow H_j \left( \mu^{c}_{\text{SCH}}(E_i,H_j) \right),$$
$$C_j \Rightarrow T_k \left( \mu^{c}_{\text{CHT}}(C_j,T_k) \right),$$
$$H_j \Rightarrow T_k \left( \mu^{c}_{\text{CHT}}(H_j,T_k) \right),$$
$$CH_j \Rightarrow T_k \left( \mu^{c}_{\text{CHT}}(CH_j,T_k) \right).$$

Where $E_i$ is a symptom or elementary conjunction of symptoms, $C_j$ is a pathogenesis labelled with Han, $H_j$ is a pathogenesis labelled with Nhiet, $CH_j$ is a pathogenesis labelled with Han- Nhiet, $T_k$ is a Treatment. The values $\mu^{c}_{\text{SCH}}(E_i,C_j)$, $\mu^{c}_{\text{SCH}}(E_i,H_j)$ indicate degrees in which present symptom or elementary conjunction of symptom $E_i$ confirm the pathogenesis $C_j$ and $H_j$. The values $\mu^{c}_{\text{CHT}}(E_i,T_k)$ indicate degrees in which the pathogenesis $C_j$ and $H_j$ and $CH_j$ confirm Treatment $T_k$.

The inference rules are used to deduce pathogenesis labelled with Han $C_j$ suffered by patient $P_q$ from the observed symptoms $S_i$:

$$R^{c}_{\text{PCH}}(E_i,C_j)=R^{c}_{\text{PCH}}(P_q,C_j)$$

defined by:

$$\mu^{c}_{\text{PCH}}(P_q,C_j)=\bigvee_{E_i \in S} \min \{\mu^{c}_{\text{PT}}(P_q,E_i), \mu^{c}_{\text{SCH}}(E_i,C_j)\}$$

where $\bigvee$ stands for a t- conorm. (see [12,13, 14]).

We define a relation of total degree for confirmation of Pathogenesis Cold as following:

$$\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)=\mu^{c}_{\text{PCH}}(P_q,C_j) \oplus -\mu^{c}_{\text{PCH}}(P_q,H_j)$$

if $\mu^{c}_{\text{PCH}}(P_q,C_j) > \mu^{c}_{\text{PCH}}(P_q,H_j)$.

In similar way , we define a relation of total degree for confirmation of Pathogenesis Heat as the following:

$$\mu^{\text{tot}}_{\text{PCH}}(P_q,H_j)=\mu^{c}_{\text{PCH}}(P_q,H_j) \oplus -\mu^{c}_{\text{PCH}}(P_q,C_j)$$

if $\mu^{c}_{\text{PCH}}(P_q,C_j) > \mu^{c}_{\text{PCH}}(P_q,H_j)$.

where $\oplus$ is an extended ordered Abelian group operation on [-1,1].

One can see the notion of an extended ordered Abelian group operation on [-1,1] as the combining function of EMYCIN is the following [1]:

$$x \oplus_{\text{MCY}} y = x + y - x y$$

for $x, y \geq 0$,

$$x \oplus_{\text{MCY}} y = x + y + x y$$

for $x, y \leq 0$,

$$x \oplus_{\text{MCY}} y = \frac{1}{2} \{ \min \{ |x|, |y| \} \}$$

for $x, y \leq 0$.

To obtain a conclusion, the following criteria for diagnoses of pathogenesis labeled with Cold, Heat Mixed Cold - Heat and criteria for Treatment are proposed.

**Criteria for diagnosis of pathogenesis labeled with Cold:**

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)=1$ then absolutely confirmed diagnoses of pathogenesis labeled with Cold $C_j$ for patient $P_q$ are identified.

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)=0$ then absolutely disconfirmed diagnoses of pathogenesis labeled with Cold $C_j$ for patient $P_q$ are identified.

+ If the value $0<\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)<1$ then a “possible” diagnoses of pathogenesis labeled with Cold $C_j$ for patient $P_q$ are identified.

**Criteria for diagnosis of pathogenesis labeled with Heat:**

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,H_j)=1$ then absolutely confirmed diagnoses of pathogenesis labeled with Heat $H_j$ for patient $P_q$ are identified.

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,H_j)=0$ then absolutely disconfirmed diagnoses of pathogenesis labeled with Heat $H_j$ for patient $P_q$ are identified.

+ If the value $0<\mu^{\text{tot}}_{\text{PCH}}(P_q,H_j)<1$ then a “possible” diagnoses of pathogenesis labeled with Heat $H_j$ for patient $P_q$ are identified.

**Criteria for diagnosis of pathogenesis labeled with Mixed Cold-Heat:**

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)=\mu^{\text{tot}}_{\text{PCH}}(P_q,H_j)$ in (0,1) then possible diagnosis of pathogenesis labeled with Mixed Cold- Heat $CH_j$ for patient $P_q$ are identified.

**Criteria for Treatment of Meals and Herbal Plants $T_k$:**

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)=1$ then absolutely confirmed Treatment $T_k$ for patient $P_q$ are identified.

+ If the value $\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)=0$ then absolutely disconfirmed Treatment $T_k$ for patient $P_q$ are identified.

+ If the value $0<\mu^{\text{tot}}_{\text{PCH}}(P_q,C_j)<1$ then a “possible” Treatment $T_k$ for patient $P_q$ are identified.

**Implementation of the COLD-HEAT diagnosis system for selection of suitable meals.**

The COLD-HEAT diagnosis system and selection of suitable meals is written in VB 6.0 and consisted of three main modules:

**Interface**

Cold-Heat diagnosis system for selection of suitable meals uses the graphical interface. It could be able to use by Mouse Click and Keyboard.

As you can see in Figure 1, the Cold-Heat diagnosis system has four command buttons:

- **Knowledge Acquisition**: View the symptoms list and create new rules.
- **Cold and Heat Diagnosis**: The system diagnoses when the symptoms are given with the fuzzy degree in [0,1]. After diagnosing, it will give some suitable meals as an advice to help the patient make balance between Yang and Yin.
- **Help**: Help you to use the system
- **Exit**: Ending the work.
Knowledge Acquisition

When you choose Knowledge Acquisition you will see the list of the Cold-Heat symptoms.

-Review the rule base: Rules for the system have general form:

IF <premise> THEN <conclusion> with Degree in [0,1]

<premise> such as set of symptoms about Cold (or Heat)

For example: <fade lip and hand & feet are cold>

<conclusion> that is the Cold (or Heat) which appears on Patient.

<degree> the confirmation of the <conclusion>. It takes value in [0,1].

In the “Edit rule” window (Fig. 2), you can create new rule just by choosing symptom on the list of your left hand. Once the symptom chosen it will be appear on the textbox in the right hand side. In case you select the wrong symptom, you must choose the symptom on the textbox then press deselect symptom. After choosing all the necessary symptoms to diagnosis the expert give the cold or heat degree into the appropriate box below.

- Review and edit symptoms (Figure 3): We all know that the symptoms use to make diagnosis is devided into four main groups: Inspection, Interrogation, Olfaction and Auscultation, and Palpation. Due to this reason, before writing a new symptom you must define which of the four groups the symptom belongs to.

By choosing Write command the symptom you create will be add to the symptoms list. From this window, you can remove the symptom that you think it is unnecessaty or they are redundant by choosing the Remove Symptom command.

Refresh command help you to refresh the symptom list.

Back is used when you want to return to the previous page.

Figure 1: The interface of the program

Figure 2: The Editing rule window

Figure 3: Review and Edit Symptoms window

- The Data rule base Figure 4.

Figure 4: The rule base

Fig. 4 illustrate the rule base. All the rule are store in the knowledge base. These rule has the Premise and its weight. One rule has only one character: Cold or Heat.

You can remove one rule from this list if this rule is redundant or does not sensible by choosing Remove rule.

Back help you to return to the previous page.

One of the key components in the system is the cold-heat diagnosis. In this block, you will see 4 groups of symptoms
on the left hand side. You find the symptom that appear on patient in the left column, decide the degree then press select symptom button. After pressing select symptom, the symptom you choose will place on the right hand side table. You can choose one or more symptom. After selecting all the symptoms just press diagnosis, the system will help you to decide whether the patient is Cold or Heat. (Figure 5)

- Hand and feet are cold
- Tasteless mouth
- Like to eat hot-spicy food
- Faded lips
- Faded palm
- Like to have thick clothes
- Forehead is cold

After choosing these symptoms, press diagnosis you will get the result Cold 0.52. Press Select Food, the program will provide you the meals you should try such as: sparrow, beet, carrot... Each of the meals has its own degree, and the way to cooking. In our example, Carrot has the degree of 0.4 of Heat nature. It helps to make balance with the Cold nature of patient the degree 0.52.

Conclusions

We have described the formalism of the Cold-Heat diagnosis system for selection of suitable meals using fuzzy logic. The implementation and the performance of the system were presented. The system is able to advise suitable meals according to the Cold-Heat state of the patient in order to make balance between Yang and Yin i.e. to prevent diseases.

References


Address for correspondence

Professor Nguyen Hoang Phuong
Institute of Information Technology, National Center for Natural Science and Technology
18 Hoang Quoc Viet Road, CauGiay District, Hanoi, Vietnam
Email: nhphuong@fmail.vnn.vn