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A NOVEL APPROACH TO MODELLING A DIAGNOSIS AND TREATMENT OF TRADITIONAL VIETNAMESE MEDICINE

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Abstract. Vietnamese Traditional Medicine (VTM) is based on the people's thousand-year experiences in the struggle against diseases; therefore, VTM is very important in the medical system of Vietnam. In this paper, we propose a novel model of an expert system for diagnosing disease syndromes and treating traditional Vietnamese medicine. In this model, the knowledge base consists of IF-THEN rules, in which the antecedent of a rule is an elementary conjunction of propositions and negated propositions. The inference mechanism for the diagnosis of disease syndromes and treatment of traditional Vietnamese medicine applies Abelian group operations. A comparison of the inference of our model with the fuzzy max-min inferences shows that our model can have very similar rules whose contributions sum up to high weight. On the other hand, in our model, a rule with a negative weight may diminish an effect of a rule with a good weight. This feature is absent in the systems with fuzzy max-min inferences. We have built rule patterns for the diagnosis of about 50 disease syndromes and their treatment by Herbs and Acupuncture with the cooperation of practitioners of Oriental Traditional Medicine in Viet Nam. Some examples of databases and the rules for disease syndrome differentiation and treatment by herbal medicine and Acupuncture are shown. Finally, some conclusions and future works are given.

Keywords. Disease syndromes, traditional Vietnamese medicine, fuzzy max-min inference, Abelian group, CADIAG-2.

1. INTRODUCTION

Viet Nam medicine consists of two medicines: Western and traditional Vietnamese medicine, which belongs to traditional Oriental medicine. Traditional Vietnamese medicine is an Oriental medicine practiced by Vietnamese people for thousands of years. It is influenced by traditional Chinese medicine. Nowadays, traditional Vietnamese medicine is viral in Viet Nam, i.e., in every hospital, there is usually a traditional medicine department together with other departments of Western medicine to examine and treat patients. It is applied in the diagnosis of disease syndromes of patients and in guiding disease prevention and treatment.

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Traditional Vietnamese medicine is based on the philosophy of Yin and Yang, the five elements, energy, blood, and body fluid. To treat a disease syndrome, we make a balance between Yang and Yin. People in Viet Nam are often attracted to traditional Vietnamese medicine because they perfect natural and nondrug therapy options. Others seek out traditional Vietnamese medicine when mainstream medicine has been unsatisfactory in resolving their health problems. A few people avoid mainstream physicians altogether because they object to taking pharmaceutical drugs or undergoing invasive procedures, such as surgery or radiation therapy. Traditional Vietnamese medicine generally views health, disease, and the body differently. The overall emphasis is on prevention, often through re-establishing the individual's connection with natural rhythms, lifestyles, and foods. Traditional Vietnamese medicine offers additional treatment options to individuals with chronic health problems for which mainstream medicine presently offers no utterly satisfactory treatment. It may also benefit the many people who are bothered by multiple nagging or annoying symptoms - tiredness, vague aches and pains, sensitivity to temperature extremes, frequent viral infections, and so on - and have been told by their doctors, after careful testing and examination, that they do not have any underlying disease. Traditional Vietnamese medicine consists of syndrome differentiation and treatment (drug and nondrug therapy). The diagnosis of traditional Vietnamese medicine depends on four methods, namely:

- Inspection.
- Auscultation and olfaction.
- Interrogation.
- Pulse examination and palpation.

As the pathogenesis is convinced, the prescription can be given by non-drugs such as herbs, acupuncture, acupressure, moxibustions, etc. [1–4]. We observe that the fuzzy systems in medicine using the max-min inference are simple and (often) give reasonable (acceptable) results, but the operation max (which composes contributions in max-min inference) is idempotent, i.e. $\max x, x = x$ for all x. In this case, the fuzzy systems based on the max-min inference are not thinking close to the medical doctors, especially, to the traditional physicians in diagnosis and treatment. To overcome this problem, we propose a novel approach to model the diagnosis of disease syndromes and treatment of traditional Vietnamese medicine. We apply a MYCIN-like systems approach [5,6] to represent the knowledge and inference of the system of diagnosis of disease syndromes and treatment of traditional Vietnamese medicine. To summarize, the main contributions of this paper are:

- Proposing a novel model of diagnosis and treatment of traditional Vietnamese medicine based on MYCIN-like systems approach.
- Presenting a knowledge representation including a combination of proposition and negated propositions.
- Applying Abelian group operations to combine the contributions of confirmed conclusions and excluded conclusions of the rules having the same conclusions.
- Comparing the inference of our model with the fuzzy max-min inference so that our model can have very similar rules whose contributions sum up to a higher weight. It lacks fuzzy max-min inferences.
- In the proposed model, a rule with a negative weight may diminish an effect of a rule with a good weight. This feature is absent in the systems with fuzzy max-min inferences.

The organization of this paper is as follows: Section 2 reviews some related works. Section 3 proposes a model of diagnosis of disease syndromes and treatment of traditional Vietnamese Medicine. Section 4 presents a comparison of the inference of our model with the fuzzy max-min inference of the existing models. Some conclusions and future works are given in Section 5.

2. RELATED WORKS

To model intelligent systems of Diagnosis and Treatment of Traditional Vietnamese Medicine, previous works have presented several ideas for applying fuzzy logic and fuzzy expert systems [7,8] to improve the diagnostic accuracy of systems for diagnosis in medicine. In [9], the authors develop a model of CADIAG-2, a computer-assisted medical diagnostic system using fuzzy subsets. The knowledge base of the system consists of IF-THEN rules as symptom-disease relationships with two weights of occurrence and confirmability, which are documented by medical experts. The diagnostic process provides confirmed and excluded diagnoses as well as diagnostic hypotheses based on fuzzy max-min inferences. In recent years in [10], the authors propose a model of a Fuzzy System for the Diagnosis of Disease Syndromes in Traditional Vietnamese Medicine, Combining Positive and Negative Rules. The knowledge base of the system consists of fuzzy positive rules (for confirmation of the conclusion of the rules) and negative rules (for exclusion of the conclusion of the rules). The inference engine applies a fuzzy max-min inference which makes a decision from the facts and rules contained in the knowledge base of the system. In [11], the authors conducted research on the correlation measure of the double hierarchy hesitant fuzzy linguistic term set (DHHFLTS). Based on the equivalent transformation functions of the double hierarchy hesitant fuzzy linguistic element (DHHFLE), they propose the mean and hesitancy degree of DHHFLEs and the mean and variance of DHHFLTSs. Then, this paper proposes the hesitancy degree-based correlation and correlation coefficient of DHHFLTSs. In addition, on the one hand, considering that hesitation is a key feature of the DHHFLTS, this paper gives the upper and lower bounds of the above correlation coefficient. On the other hand, taking into account the weighting factors in the actual problem, the weighted correlation coefficient, and the ordered weighted correlation measure are proposed. Then, a general framework for applying the correlation measures is proposed in this paper using to multi-attribute decision-making problems.

3. A MODEL OF DIAGNOSIS OF DISEASE SYNDROMES AND TREATMENT OF TRADITIONAL VIETNAMESE MEDICINE

3.1. A model of diagnosis of disease syndromes

In this section, we develop a model of diagnosis of disease syndromes of traditional Vietnamese medicine. For knowledge representation, a combination of symptoms and diseases is considered as well. The compositional inference rule of medical diagnosis is used as an inference engine. Let us define some notations as follows:

- Let $S = \{S_1, S_2, ..., S_m\}$ denote the set of symptoms. Symptom $S_i (i = 1, .., m)$ takes values $\mu_{R_{PS}}(P_q, S_i)$ in $[-1, 1]$. The value $\mu_{R_{PS}}(P_q, S_i)$ indicates the degree to which a patient exhibits symptoms S_i where $\mu_{R_{PS}}(P_q, S_i) = 1$ means symptom S_i surely present for a patient P_q, $\mu_{R_{PS}}(P_q, S_i) = -1$ means symptom S_i surely absent for the patient P_q, $0 < \mu_{R_{PS}}(P_q, S_i) < 1$ means symptom S_i present for a patient P_q to some degree, $0 < \mu_{R_{PS}}(P_q, S_i) < -1$ means symptom S_i absent for patient P_q with some degree and the value $\mu_{R_{PS}}(P_q, S_i) = 0$ meaning "no preference" that symptom S_i is "unknown" about presence or absence for a patient P_q.

- Let $E = \{E_1, E_2, ..., E_n\}$ denote the set of all elementary conjunctions of some symptoms, i.e. the conjunction of some symptoms and some other negated symptoms (e.g., S_1, and $\neg S_2$, $\& S_3$ mean symptom S_1 is present, S_2 absent, and S_3 present), which take values $\mu_{R_{P\_E}}(P_q, E_h)$, where each value of $\mu_{R_{P\_E}}(P_q, E_h)$ is a value of the conjunction $E_h (h = 1, .., n)$, and $\mu_{R_{P\_E}}(P_q, E_h)$ gets value in $[-1, 1]$.
- Let $SYND = \{SYND_1, SYND_2, ..., SYND_g\}$ denote the set of disease syndromes, where $SYND_k$ $(k = 1, .., g)$ takes value $\mu^c_{R_{P\_SYND}}(P_q, SYND_k)$, which confirms the belief degree of $SYND_k$ of the patient P_q from observed symptoms defined by questionnaire q and takes value in $[-1, 1]$, which can be represented in Figure 1.

'no preference'
('certainly no') -1 ________________ 0 ________________ 1 ('certainly yes')

Figure 1: The representation of the degree $\mu^c_{R_{P\_SYND}}(P_q, SYND_k)$ in $[-1, 1]$

The relationships between entities in traditional Vietnamese medicine are as follows.

For diagnosis of disease syndromes, we have the following relations:

The form of rules: $E_h \rightarrow SYND_k(\mu^c_{R_{E\_SYND}}(E_h, SYND_k))$, where E_h is a symptom or elementary conjunction of symptom S_i in the form of E_h=$S_1, ..., \neg S_m$, for each $i, i = 1, \ldots, m$; $SYND_k$ is a disease syndrome; The values $\mu^c_{R_{S\_SYND}}(E_h, SYND_k)$ indicate degrees in which the present symptoms or the elementary conjunction of symptoms E_h confirm the pathogenesis labeled with disease syndrome $SYND_k$.

The knowledge propagation of the system for disease symptom diagnosis is described as follows:

The global weight of a diagnosis of a disease syndrome $SYND_k$ is given by a questionnaire q, and the contribution of a rule R given q is defined as follows:

Step 1: A user assigns weights $\mu_{R_{P\_S}}(P_q, S_i) = q(S_i)$ to symptoms, if S_i is a question.

Step 2: Calculate the conjunction in the rule's premise E_h by formulas:

$\mu_{R_{P\_E}}(P_q, A \ \& \ B) = CONJ(\mu_{R_{P\_E}}(A), \mu_{R_{P\_E}}(B))$, where $CONJ(x, y) = \min(x, y)$,

$\mu_{R_{P\_E}}(P_q, \neg A) = NEG(\mu_{R_{P\_E}}(P_q, A))$, where $NEG(x) = -x$.

Step 3: Calculation of the contribution of a rule R given q by the formula

$\mu^c_{R_{P\_SYND}}(P_q, E_h \rightarrow SYND_k) = CTR(\mu_{R_{P\_E}}(P_q, E_h), \mu^c_{R_{S\_SYND}}(E_h, SYND_k))$.

(the contribution of a rule R is computed from the weight of the rule and the global weight of its antecedent E using CTR), where

- $CTR(\mu_{R_{P\_E}}(P_q, E_h), \mu^c_{R_{S\_SYND}}(E_h, SYND_k)) = 0$, if $\mu_{R_{P\_E}}(P_q, E_h) \leq 0$.
- $CTR(\mu_{R_{P\_E}}(P_q, E_h), \mu^c_{R_{S\_SYND}}(E_h, SYND_k))$
  $= \min(\mu_{R_{P\_E}}(P_q, E_h), \mu^c_{R_{S\_SYND}}(E_h, SYND_k))$,
  if $\mu_{R_{P\_E}}(P_q, E_h), \ \mu^c_{R_{S\_SYND}}(E_h, SYND_k) \geq 0$.

- $CTR(\mu_{R_{P\_E}}(P_q, E_h), \mu^c_{R_{S\_SYND}}(E_h, SYND_k))$
  $= -\min(\mu_{R_{P\_E}}(P_q, E_h), -\mu^c_{R_{S\_SYND}}(E_h, SYND_k))$,
  if $\mu_{R_{P\_E}}(P_q, E_h) > 0,\ \mu^c_{R_{S\_SYND}}(E_h, SYND_k) < 0$.

Step 4: Calculate all contributions of the rules $R_1, ..., R_n$ if the same conclusion $SYND_k$ given q by the formula $\mu^c_{R_{P\_SYND}}(P_q, SYND_k) = \mu^c_{R_{P\_SYND}}(P_q, R_1) \oplus .... \oplus \mu^c_{R_{P\_SYND}}(P_q, R_n)$, where $SYND_k$ is a propositional variable and $R_1, ..., R_n$ are all rules in the rule base θ whose succedent is $SYND_k$).

The group operation $\oplus$ is computed by the following formulas

$$\begin{aligned} X \oplus Y &= X + Y - X^*Y & \text{for } X, Y \geq 0,\\ X \oplus Y &= X + Y + X^*Y & \text{for } X, Y \leq 0,\\ X \oplus Y &= (X + Y)/(1 - \min(|X|, |Y|) & \text{for } X^*Y \leq 0. \end{aligned} \quad (1)$$

We assume that the ordered set weights $\mu^c_{R_{P\_SYND}}(P_q, SYND_k)$ are in $[-1, 1]$.

More precisely, for the diagnosis of disease syndromes, the meanings of the degree of $\mu^c_{R_{P\_SYND}}(P_q, SYND_k)$ are as follows:

- $\mu^c_{R_{P\_SYND}}(P_q, SYND_k) = 1$ means Absolutely Confirmation of the conclusion $SYND_k$;

- $0.6 \leq \mu^c_{R_{P\_SYND}}(P_q, SYND_k) < 1$ means Almost Confirmation of the conclusion $SYND_k$;
- $\varepsilon \leq \mu^c_{R_{P\_SYND}}(P_q, SYND_k) < 0.6$ means Possible Confirmation of the conclusion $SYND_k$;
- $-\varepsilon < \mu^c_{R_{P\_SYND}}(P_q, SYND_k) < \varepsilon$ means "unknown" about Confirmation of conclusion of $SYND_k$;
- $-0.6 < \mu^c_{R_{P\_SYND}}(P_q, SYND_k) \leq -\varepsilon$ means Possible Exclusion of conclusion of $SYND_k$;
- $-1 < \mu^c_{R_{P\_SYND}}(P_q, SYND_k) \leq -0.6$ means Almost Exclusion of conclusion $SYND_k$;

- $\mu^c_{R_{P\_SYND}}(P_q, SYND_k) = -1$ means Absolutely Exclusion of conclusion $SYND_k$;

where ε is a heuristic value and in our case $\varepsilon = 0.01$.
The system will list all conclusions of syndromes $SYND_k$with their degrees of belief. The final diagnosis result is a maximum of all degrees of all conclusions of syndromes $SYND_k$. Based on this result of disease syndrome diagnosis, traditional medical doctors can select the correct treatment for the patient. We assume that only the values of the conclusions of syndromes $SYND_k$ bigger than ε are chosen for treatment.

3.2. A model of treatment of disease syndromes by traditional Vietnamese medicine

3.2.1. A model of treatment of disease syndromes by herbal plants

- Let $HERB = \{HERB_1, HERB_2, ..., HERB_d\}$ denote the set of treatments $HERB_f$, $(k = 1, ..., d)$ which take values $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$, where the value $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$

confirms the belief degree of $HERB_f$ by patient P_q from the received disease syndromes and $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$ gets value in $[-1, 1]$.

- Let $E_{SYND\_S} = \{E_{SYND\_S_1}, E_{SYND\_S_1}, ...E_{SYND\_So}\}$ denote the set of all elementary conjunctions of one disease syndrome and some symptoms, i.e. a conjunction of one disease syndrome, some symptoms, and some other negated symptoms $E_{SYND\_S_p}(p = 1, \ldots, o)$, (e.g., $SYND_k, S_1, \&\neg S_2, \&S_3$ means 'disease syndrome $SYND_k$ is confirmed, the symptom S_1 is present, S_2 absent, and S_3 present), which take values $\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p})$, where each value of $\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p})$ is a value of the conjunction $E_{SYND\_S_p}$ and $E_{SYND\_S_p}$ takes value in $[-1, 1]$.

In conjunction $E_{SYND\_S_p}$, additional symptoms "help" the system choose an optimal therapy among Oriental remedies such as herbs and acupuncture. In fact, acupuncture is helpful for treating pain, stress, and paralysis. On the other hand, herbal medicine is suitable for treating chronic diseases. For example, if a patient has a "Headache caused by the cold wind" syndrome without any "additional symptoms," then he/she can choose one of the therapies as Herbs or Acupuncture. If this patient has a "Headache caused by the cold wind" syndrome and an additional symptom such as facial paralysis, the recommendation of treatment by acupuncture is suggested.

For the treatment of disease syndromes by herbal remedies, we have the following relations:

The form of rules: $E_{SYND\_S_p} \rightarrow HERB_f(\mu^c_{R_{SYND\_HERB}}(SYND_k, HERB_f))$, where $E_{SYND\_S_p}$ is a disease syndrome, $(k = 1, .., g)$.

The value of $\mu^c_{R_{SYND\_HERB}}(SYND_k, HERB_f)$ indicates the degree to which the present syndrome confirms the treatment by herbal plants $HERB_f$.

The knowledge propagation of the system for treatment by herbal plants is described as follows:

The weight of treatment by the herbal plant $HERB_f$ is given by a questionnaire q, and the contribution of a rule R given q is defined as follows:

Step 1: Our system automatically assigns the received weight of the value $\mu^c_{R_{P\_SYND}}(P_q, SYND_k)$ to the disease syndrome $SYND_k$ (because when the system infers the conclusion $SYND_k$, we assume that the patient gets the disease syndrome $SYND_k$ and this disease needs to be treated by any Oriental remedies), then the user assigns weights $\mu_{R_{P\_S}}(P_q, S_i)$ to additional symptoms if any.

Step 2: Calculate the conjunction in the rule's premise $E_{SYND\_S_h}$ by formulas

$$\mu_{R_{P\_E_{SYND\_S}}}(P_q, A \ \& \ B) = CONJ(\mu_{R_{P\_E_{SYND\_S}}}(A), \mu_{R_{P\_E_{SYND\_S}}}(B)),$$

where $CONJ(x, y) = \min(x, y)$.

$$\mu_{R_{P\_E_{SYND\_S}}}(P_q, \neg A) = NEG(\mu_{R_{P\_E_{SYND\_S}}}(P_q, A)),$$

where $NEG(x) = -x$.

Step 3: Calculate the contribution of a rule R given q by the formula

$$\mu^c_{R_{P\_HERB}}(P_q, HERB_f) = CTR(\mu_{R_{P\_HERB}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{SYND\_S\_HERB}}(E_{SYND\_S_p}, HERB_f))$$

(the contribution of a rule R is computed from the weight of the rule and the global weight of its antecedent E using CTR), where

$$CTR(\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{S\_SYND}}(E_{SYND\_S_p}, HERB_f)) = 0,$$

if $\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}) \leq 0$.

$$CTR(\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{S\_SYND}}(E_{SYND\_S_p}, HERB_f)) = \min(\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{S\_SYND}}(E_{SYND\_S_p}, HERB_f)),$$

if $\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{S\_SYND}}(E_{SYND\_S_p}, HERB_f) \geq 0$.

$$CTR(\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{S\_SYND}}(E_{SYND\_S_p}, HERB_f)) = -\min(\mu_{R_{P\_E_{SYND\_S}}}(P_q, E_{SYND\_S_p}), \mu^c_{R_{S\_SYND}}(E_{SYND\_S_p}, HERB_f)),$$

propositional variable and $R_1....R_n$ are all rules in the rule base θ whose succedent is $HERB_f$.

Step 4: Calculate all contributions of all rule$R_1, ...R_n$ with the same conclusion $HERB_f$ given q by the formula

$\mu^c_{R_{P\_HERB}}(P_q, HERB_f) = \mu^c_{R_{P\_HERB}}(P_q, R_1) \oplus .... \oplus \mu^c_{R_{P\_HERB}}(P_q, R_n)$, where $HERB_f$ is a propositional variable and $R_1....R_n$ are all rules in the rule base θ whose succedent is $HERB_f$.

More precisely, for treatment by herbal plants:

- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f) = 1$ means Absolutely Confirmation of treatment $HERB_f$.
- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$ such that $0.6 \leq \mu^c_{R_{P\_HERB}}(P_q, HERB_f) < 1$ means Almost Confirmation of treatment $HERB_f$.
- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$ such that $\varepsilon \leq \mu^c_{R_{P\_HERB}}(P_q, HERB_f) < 0.6$ means Possible Confirmation of treatment $HERB_f$.
- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$ such that $-\varepsilon < \mu^c_{R_{P\_HERB}}(P_q, HERB_f) < \varepsilon$ means "unknown" about Confirmation of treatment $HERB_f$.
- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$ such that $-0.6 < \mu^c_{R_{P\_HERB}}(P_q, HERB_f) =\leq -\varepsilon$ means Possible Exclusion of treatment $HERB_f$.
- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f)$ such that $-1 < \mu^c_{R_{P\_HERB}}(P_q, HERB_f) =\leq -0.6$ means Almost Exclusion of treatment $HERB_f$.
- Degree $\mu^c_{R_{P\_HERB}}(P_q, HERB_f) = -1$ means Absolutely Exclusion of treatment $HERB_f$,

where ε is a heuristic value and, in our case $\varepsilon = 0.01$.

3.2.2. A model of treatment of disease syndromes by acupuncture

- Let $ACU = \{ACU_1, ACU_2, ..., ACU_j\}$ denote the set of treatments $ACU_s(k = 1, ..., j)$ which take values $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$, where the value of $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ confirms the belief degree of ACU_k by patient P_q from the received disease syndromes and $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ takes value in $[-1, 1]$.

For the treatment of disease syndromes by acupuncture, we have the following relation:
The form of rules: $E_{SYND\_S_p} \to ACU_k(\mu^c_{R_{P\_ACU}}(P_q, ACU_s))$, where $E_{SYND\_S_p}$ is a disease syndrome $(k = 1, .., g)$. The values of $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ indicate the degrees to which the present syndrome confirms the treatment by acupuncture ACU_s.

Similarly, we can calculate the weight of treatment by acupuncture ACU_s given by a questionnaire q and the contribution of a rule R given q.

More precisely, the treatment by acupuncture is as follows:

- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s) = 1$ means Absolutely Confirmation of treatment of acupuncture ACU_s.
- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ such that $0.6 \le \mu^c_{R_{P\_ACU}}(P_q, ACU_s) < 1$ means Almost Confirmation of treatment of acupuncture ACU_s.
- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ such that $\varepsilon \le \mu^c_{R_{P\_ACU}}(P_q, ACU_s) < 0.6$ means Possible Confirmation of treatment of acupuncture ACU_s.
- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ such that $-\varepsilon < \mu^c_{R_{P\_ACU}}(P_q, ACU_s) < \varepsilon$ means "unknown" about Confirmation of treatment of acupuncture ACU_s.
- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ such that $-0.6 < \mu^c_{R_{P\_ACU}}(P_q, ACU_s) \le -\varepsilon$ means Possible Exclusion of treatment of acupuncture ACU_s.
- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s)$ such that $-1 < \mu^c_{R_{P\_ACU}}(P_q, ACU_s) \le -0.6$ means Almost Exclusion of treatment of acupuncture ACU_s.
- Degree $\mu^c_{R_{P\_ACU}}(P_q, ACU_s) = -1$ means Absolutely Exclusion of treatment of acupuncture ACU_s.

where ε is a heuristic value and in our case $\varepsilon = 0.01$.

4. A COMPARISON OF THE INFERENCE OF OUR MODEL WITH THE FUZZY MAX-MIN INFERENCES

4.1. Our model can have very similar rules whose contributions sum up to high weight

The model of diagnosis and treatment of traditional Vietnamese medicine based on MYCIN-like systems' approach can have very similar rules whose contributions sum up to high weight. On the other hand, the fuzzy max-min inferences as in CADIAG-2 do not pay attention to several independent rules confirming the same diagnosis with equal weight, it just gives you the common weight as a result.

Let us illustrate this with examples concerning CADIAG-2 's max-min inference.
Example 1: Let us have a knowledge base including three rules as follow:
Rule 1: IF stuffy nose with nasal discharge, THEN Influenza is caused by Wind-Cold Syndrome
WITH ($c_1 = 0.6$)
Rule 2: IF slight aversion to cold, THEN Influenza is caused by Wind - Heat Syndrome
WITH ($c_2 = 0.6$)
Rule 3: IF Thirst THEN Influenza is caused by Wind - Heat Syndrome
WITH ($c_3 = 0.6$)
(Here, the parameter c_1 represents a degree of Confirmation of the symptom "stuffy nose with nasal discharge" for disease syndrome "Influenza is caused by Wind-Cold Syndrome" and the parameters c_2, c_3 represent degrees of Confirmation of the symptom "slight aversion to cold" and "Thirst" for disease syndrome "Influenza is caused by Wind - Heat Syndrome", while the parameter o_i (frequency of occurrence of symptoms with their diseases) is not considered.

Let the patient P_q has symptoms of "stuffy nose with nasal discharge", "slight aversion to cold" and "Thirst" with the same degree, e.g., 1. We have

$$\mu_{R_{PS}}(P_q, \text{stuffy nose with nasal discharge}) = \mu_{R_{PS}}(P_q, \text{slight aversion to cold}) = \mu_{R_{PS}}(P_q, \text{Thirst}) = 1.$$

In this case, CADIAG-2 generates the following hypotheses:
From Rule 1, we get

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza is caused by Wind-Cold Syndrome}) = \min(1, 0.6)) = 0.6,$$

which means the disease "Influenza is caused by Wind - Cold Syndrome" with a degree of 0.6.
From Rule 2 and Rule 3, we get the contribution of Rule 2 and Rule 3 for the same conclusion "Influenza caused by Wind-Heat Syndrome" as follows

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza caused by Wind-Heat Syndrome}) = \max\{\mu^c_{R_{P\_SYND}}(P_q, Rule_2), \mu^c_{R_{P\_SYND}}(P_q, Rule_3)\} = \max\{0.6, 0.6\} = 0.6.$$

This means the value of the disease "Influenza is caused by Wind - Heat Syndrome" with a degree of 0.6.
CADIAG-2 concludes that both diagnoses, "Influenza is caused by Wind - Cold Syndrome" and "Influenza is caused by Wind-Heat Syndrome" with the same degree of 0.6 (the operation max is idempotent).

Now, we apply the model of Diagnosis of Disease Syndromes of traditional Vietnamese medicine described above for Example 1; in this case, the model generates the following hypotheses:
From Rule 1: we get

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza is caused by Wind-Cold Syndrome}) = \min\{1, 0.6\} = 0.6,$$

which means the disease "Influenza is caused by Wind - Cold Syndrome" with a degree of 0.6.
From Rule 2 and Rule 3, in a similar way, we get

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza caused by Wind-Heat Syndrome}) = \mu^c_{R_{P\_SYND}}(P_q, Rule_2) + \mu^c_{R_{P\_SYND}}(P_q, Rule_3) - \mu^c_{R_{P\_SYND}}(P_q, Rule_2) * \mu^c_{R_{P\_SYND}}(P_q, Rule_3) = 0.6 + 0.6 - 0.36 = 0.84,$$

which means the value of the disease "Influenza is caused by Wind - Heat Syndrome" with

a degree 0.84.
Our model concludes with the diagnosis “Influenza is caused by Wind - Cold Syndrome” with a degree of 0.6 and the diagnosis “Influenza is caused by Wind-Heat Syndrome” with a degree of 0.84.
Observation: From the point of view of traditional medicine practitioners, the diagnosis “Influenza is caused by Wind-Heat Syndrome” with a degree of 0.84 of our model is more reasonable than the diagnosis “Influenza is caused by Wind-Heat Syndrome” with a degree of 0.6 of CADIAG-2 because the contribution of two rules with same (or similar) degrees should be bigger than the contribution of one rules with the same degrees.

4.2. In our model, a rule with a negative weight may diminish an effect of a rule with a good weight

This feature is absent in the systems with fuzzy max-min inferences and CADIAG-2’s max-min inference (which is one of its weaknesses).
Let us illustrate this in the following example concerning our model.
Example 2: Let us have a knowledge base including the following three rules:
Rule 1: IF stuffy nose with nasal discharge, THEN Influenza is caused by Wind - Cold Syndrome
WITH ($c_1 = 0.5$).
Rule 2: IF slight aversion to cold, THEN Influenza is caused by Wind - Heat Syndrome
WITH ($c_2 = 0.5$).
Rule 3: IF Thirst THEN Influenza is caused by Wind - Heat Syndrome
WITH ($c_3 = -0.4$).
Now, we apply our model in Subsection 2.1 for Example 2; in this case, the model generates the following hypotheses:
From Rule 1, we get

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza is caused by Wind-Cold Syndrome}) = \min\{1, 0.5\} = 0.5,$$

which means Rule 1 concludes that the disease “Influenza is caused by Wind - Cold Syndrome” with a degree of 0.5.
From Rule 2, we get

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza is caused by Wind- Heat Syndrome}) = \min\{1, 0.5\} = 0.5,$$

which means Rule 2 concludes that the disease “Influenza is caused by Wind-Heat Syndrome” with a degree of 0.5.
From Rule 3, we get

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza is caused by Wind-Heat Syndrome}) = \min\{1, -0.4\} = -0.4,$$

which means the disease “Influenza is caused by Wind-Heat Syndrome” with a degree of -0.4.
Now, we calculate the contribution of Rule 2 and Rule 3 as follows.
From Rule 2 and Rule 3, we get

$$\begin{aligned}
&\mu^c_{R_{P_SYND}}(P_q, \text{Influenza is caused by Wind-Heat Syndrome})\\
&= \mu^c_{R_{P_SYND}}(P_q, Rule_1) + \mu^c_{R_{P_SYND}}(P_q, Rule_2) - \mu^c_{R_{P_SYND}}(P_q, Rule_1) * \mu^c_{R_{P_SYND}}(P_q, Rule_2)\\
&= 0.5 + (-0.4) - (0.5 * (-0.4)) = 0.1 + 0.2 = 0.3,
\end{aligned}$$

that means the disease “Influenza is caused by Wind - Heat Syndrome” with a degree of 0.3.

$$\mu^c_{R_{P\_SYND}}(P_q, \text{Influenza is caused by Wind-Heat Syndrome})$$
$$= \mu^c_{R_{P\_SYND}}(P_q, Rule_1) + \mu^c_{R_{P\_SYND}}(P_q, Rule_2) - \mu^c_{R_{P\_SYND}}(P_q, Rule_1) * \mu^c_{R_{P\_SYND}}(P_q, Rule_2)$$
$$= 0.5 + (-0.4) - (0.5 * (-0.4)) = 0.1 + 0.2 = 0.3,$$

that means the disease "Influenza is caused by Wind - Heat Syndrome" with a degree of 0.3.

Our model concludes with the diagnosis "Influenza is caused by Wind-Cold Syndrome" with a degree of 0.5 and the diagnosis "Influenza is caused by Wind-Heat Syndrome" with a degree of 0.3.

Observation: The weight of Rule 3 for confirmation of the conclusion takes the negative value of -0.4. This rule with the negative weight of -0.4 diminished the effect of Rule 2 with a good weight of 0.3 is a result of the combination of Rule 2 and Rule 3.

5. CONCLUSIONS

In this paper, we have presented a model of disease syndrome diagnosis and treatment of traditional Vietnamese medicine based on an MYCIN-like system approach. We have also presented a knowledge representation including a combination of proposition and negated propositions and an inference engine applying Abelian group operations to combine the contributions of confirmed conclusions and excluded conclusions of the rules having the same conclusions. We have shown the advantages of our model in comparison with the fuzzy max-min inferences so that our model can have very similar rules whose contributions sum up to a higher weight. It lacks fuzzy max-min inferences. On the other hand, in our model, a rule with a negative weight may diminish an effect of a rule with a good weight. This feature is absent in the systems with fuzzy max-min inferences. We have built rule patterns for the diagnosis of about 50 disease syndromes and its treatment by Herbs, and Acupuncture described in [1, 2, 4] with the cooperation of practitioners of Oriental Traditional Medicine in Vietnam. Some examples of databases and the rules for disease syndrome differentiation and treatment by Herbal medicine and Acupuncture are shown in Appendixes.

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