Fuzzy knowledge searching on the basis of the traditional and-or graph search algorithm

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Abstract

Based on the fuzzy propositional logic FLCOM and fuzzy set FSCOM, we research the formal denotation, inference and computation of fuzzy knowledge. We extend the fuzzy and-or graph, turn the propositional formulas as state nodes, express the logical rules as the search space, construct and-or graph of the fuzzy propositional formula. We modify heuristic function on the basis of the traditional and-or graph search algorithm, and give out a method to process negation information in the process of reasoning, transforming the fuzzy knowledge reasoning into the state space searching problem, and using the state space searching to solve the problem of fuzzy knowledge reasoning.

Keywords: fuzzy propositional logic FLCOM, fuzzy set FSCOM, fuzzy propositional formula, negation information, state space searching

1 Introduction

With the development of information science and the further research of non classical logic, in 80's and 90's of twentieth Century, research on treatment of domestic and foreign scholars on the negative information in the field of information processing begins with new ideas and methods. Among them, the domestic famous scholar Zhu Wujia and Xiao Xian are the representative, the work of the famous scholar Gerd Wager is the most representative [1-3].

Zhu Wujia and Xiao Xian founded the formal logic system of medium logic theory in 1985 [4-5]. The negative relations in concept are divided into two types by the medium logic: contradiction and opposition, and certainly the transition state intermediate between the opposite concept, namely intermediary state [6].

In 1991, Wagner G first proposed that the database needs two kinds of negation to deal with partial information [7], and in 1994 two kinds of partial logics distinguished methods were given, and studied the two negative knowledge reasonings. Local logic mainly distinguish denotative negative information of the knowledge information: strong negation and weak negation. Local logical negation introduced two types of theories from the part of the model to represent the deletion, and processing information explicitly rejected and pseudo information [8].

In 2005, Kaneiwa K gave an extensive description logic $ALC_{\_}$, and $ALC_{\_}$ with classical negation and strong negation. Kaneiwa K believed that contradiction, opposition parties and subcontrary available predicate negation (e.g. Not Healthy) negation and the verb (such as Unhealthy) to distinguish from a possible sentence type [9]. He would improve the semantic predicate negation and negation of predicates, properly explain the combination of various classical negation and strong negation, and proved that the opposition and contradiction of $ALC_{\_}$ semantic concept were improved, and the characteristic was not all types of description logic owning. For example, building description logic ($CALC_{\_}$) with the construction of Heyting negation and strong negation would not be able to maintain this property [10-12].

In 2006, Ferré S presented a logic transformation based on modal logic AIK, and the transformation was in the concept of logic analysis LCA. This essential feature of the logic transformation is that LCA will not lose general, and distinguishes three kinds of relations in the only formal: negation, opposition and possibility [13].

In 1987, Pan Zhenghua gave a semantic interpretation of three value of medium logic [18], and proved in the interpretation that medium propositional logic (MP), medium predicate logic (MF) as well as the completeness and reliability of the extended medium propositional logic (MP^*) [14]. In 2003, Pan Zhenghua proposed and insisted that the medium logic is a kind of infinite valued logic [15], and in the infinite value semantic model of medium logic he proved the reliability and completeness of the medium proposition logic [16]. In 2007, Pan Zhenghua distinguished five different negative relationships in the conceptual level of clear knowledge and fuzzy knowledge [17]. In 2010, Pan Zhenghua gave the fuzzy set FSCOM with opposite negation, intermediary negation and contradiction negation, and different negative relation of fuzzy concepts from the set point of view characterizations was portrayed [18]. In 2012, Pan Zhenghua put forward a fuzzy propositional logic system FLCOM to differentiate contradiction, intermediary negative and opposite negation.

We distinguish three kinds of negative fuzzy logic FLCOM based on fuzzy knowledge representation to represent the state space through the reasonable extension of fuzzy and-or graph, and a three negative searching method of fuzzy knowledge reasoning method was given in the case of the FSCOM to represent and process knowledge [19-21].

2 Fuzzy knowledge representation based on FLCOM

The knowledge representation of the fuzzy logic adopts the fuzzy proposition of the fuzzy logic and 'and ($\wedge$)', 'or ($\vee$)', 'non ($\neg$)', 'implication ($\rightarrow$)', 'equivalence ($\leftrightarrow$)' logical connectives showing [22]. FLCOM on the basis of the introduction of intermediary negative word "~" and opposite negation word "$\ni$", and "$\neg$" represents the contradiction to expand the traditional logic expressions, and they will be a combination of wff more complex, in order to express the concept of facts more complex.

A fuzzy production rule with the general P ← Q, CF, τ representation. Conclusion and the premise of P, Q denote respectively, the truth degree is expressed in a fuzzy way, and CF (0<CF ≤ 1) is the confidence of the rule, and τ (0< τ ≤ 1) is a threshold [23].

3 And / or graph representation of extended fuzzy propositional formula

Definition 1 Representation of fuzzy rules:

(1) If a plurality has the same conclusion rules, and it can also be activated to perform, that is:

$$P \leftarrow Q_1, \quad CF_1$$
$$P \leftarrow Q_2, \quad CF_2$$
$$\cdots$$
$$P \leftarrow Q_k, \quad CF_k$$

Use and-or graph representation, and Q_1 , Q_2 ,... Q_k can be regarded as node P or its parent node as shown in Figure 1.

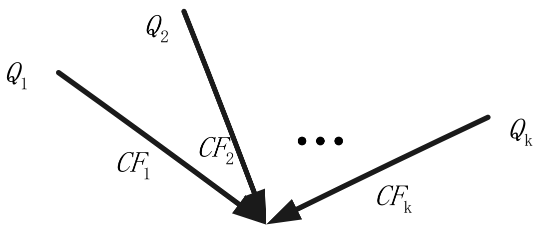

FIGURE 1 And-or graph of node P and its parent node set

(2) A condition to represent the rules can be different degrees of activation of several results, that is:

$$P_1 \leftarrow Q, \quad CF_1$$
$$P_2 \leftarrow Q, \quad CF_2$$
$$\cdots$$
$$P_k \leftarrow Q_k, \quad CF_k$$

Use and-or graph representation, and P_1 , P_2 ,... P_k is Q or sub node set as shown in Figure 2.

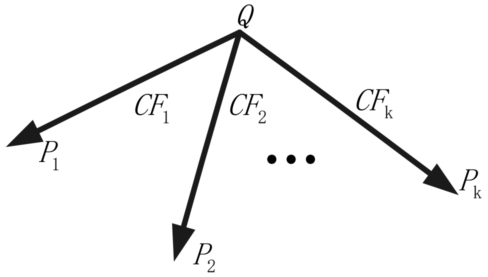

FIGURE 2 And-or graph of node Q and sub node set

(3) For the multidimensional fuzzy such as P ← Q_1 , Q_2 ,... Q_k , CF, and-or graph representation, namely Q_1 , Q_2 ,... Q_k , P and the father node set as shown in Figure 3.

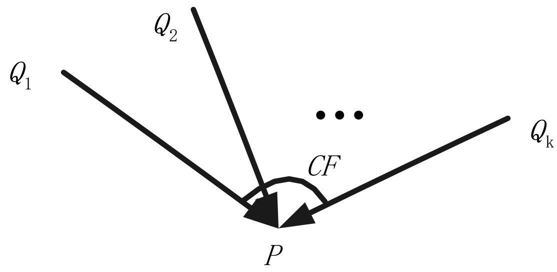

FIGURE 3 And-or graph of node P and the parent node set

(4) If the condition to represent the rules can be the same degree of activation of multiple objective, namely P_1 , P_2 ,... P_k ← Q , CF, and-or graph representation, then P_1 , P_2 ,... P_k are Q and the sub node set as shown in Figure 4.

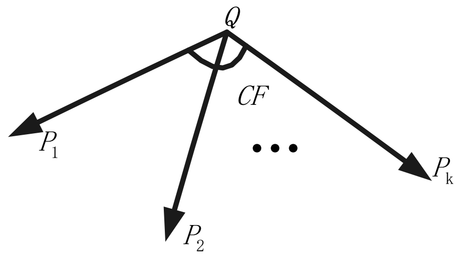

FIGURE 4 And-or graph of node Q and son sets

As shown in Figure 1, Figure 2, Figure 3 and Figure 4, in describing the fuzzy knowledge, with a correlation of arc to represent the relationship between parent and child nodes, and this relationship is the confidence of the rule. Figure 3 and Figure 4 from node P, Q are issued by the arc by a curve together and represents and node. P, Q nodes in Figure 1 and Figure 2 express or node [24].

4 State space searching of fuzzy knowledge reasoning

4.1 ALGORITHM ANALYSIS

To improve the search efficiency of the problem space needs a lot of support strategies, and these strategies are to solve problems and solutions related control knowledge, and the evaluation function reflects the control information. The general form of evaluation function is: $f(n) = g(n) + h(n)$, and $h(n)$ is the estimating cost from n to the target node, and $g(n)$ is the actual cost from the initial node to n [25]. After given a problem function definition method can have many kinds of means according to the characteristics and problems. In the fuzzy knowledge reasoning, what we want is the most likely out come, but in the traditional state space search process is looking for the shortest path to the target node. Therefore, in the search process of fuzzy knowledge reasoning can be to find the shortest path problem to find comprehensive credibility of the highest path, and it can be integrated with the reliability function to define the evaluation function.

Zadeh operators $a \wedge b = \min(a, b)$ in t- van of fuzzy 'and' operators in the fuzzy reasoning define evaluation function:

Definition 2 [45] $f(n) = g(n) \wedge h(n) = \min(g(n), h(n))$, of which, $h(n)$ is to estimate the credible degree from node n to the target, and $g(n)$ is the credibility from the initial node to node n . $h(n)$ depends on the confidence of the target node, and

$g(n)$ depends on the relational degree of node n and its parent node (set) of the arc and the confidence of the parent node (set).

In the actual search, the confidence of the initial node (set) is expressed degree of membership with initial conditions, and the correlation of the arc is the confidence of rules of inference. In fuzzy reasoning, in addition to the confidence of the inference rules, fuzzy reasoning algorithm determines the degree of confidence of the conclusion, and this paper uses CRI algorithm of Zadeh to determine the confidence degree of sub nodes in the search process [26].

If P, Q respectively are the child nodes and parent nodes, and the correlation degree of the arc of P, Q is CF (0<CF ⩽ 1) (i.e. rule confidence of P $\leftarrow Q$), then $\Psi(P)=\Psi(Q)\wedge CF$, $\Psi(P)$ and $\Psi(Q)$ respectively are the confidence of node P and node Q . In particular, for or parent node point set $Q=\{Q_1,Q_2,\cdots,Q_k\}$, $\psi(P)=\bigvee_{i=1}^{k}(\Psi(Q_i)\wedge CF_i)$; and the father node set $Q=\{Q_1,Q_2,\cdots,Q_k\}$, $\psi(P)=\bigvee_{i=1}^{k}(\Psi(Q_i)\wedge CF_i)$

Here are the fuzzy search process of reasoning.

Procedure fuzzy search

Begin

Let S represent the initial state of the node INITIAL, mark begins with an arc of S, and calculate $f(S)$.

Repeat

(1) Track this arc, and choose one on the path on the future expansion of node expansion, when expansion, if you need one or several nodes participate at the same time(i.e. with the parent node set), these nodes are added to the diagram, and the selection of the new node (node set) called NS, successor node generate NS [27].

If NS has a successor node labeled succeed, successor node for each not NS ancestor

Do Begin

Succeed is added to the chart.

If succeed has no successor node, then labeled SOLVED, the node of the confidence value is f (succeed) value.

Else calculate f (succeed).

Else Begin

f (NS) values are for the confidence of NS, and NS is labeled SOLVED.

End

The latest information is returned, node set D (initial contains only the node S), D include the marker SOLVED node, and the value of f has been the need to change back to the ancestor node.

(2) Repeat

Choose a node CS from D removed from D, and their descendants are not in D. Calculate the confidence each sub node CS, and the maximum degree of confidence in all of the sub node calculated, namely f (CS) value. Arc to the previous step confidence largest sub nodes from the start, marked as the best path begins with CS.

The best path If labeled and CS connected nodes with SOLVED markers.

Then CS is labeled SOLVED.

Else CS is marked as SOLVED or f (CS) has changed

Then return to its new status. All the ancestor of CS are added to D.

Untie D is empty;

Until S marked SOLVED succeed, else, f (S) is less than μ , failure;

End

4.2 TREATMENT OF NEGATION KNOWLEDGE

To solve the negative contains nodes in the search process. The treatment includes contrasting negation, intermediary negation and contradiction negation [28].

Each fuzzy set has its membership, we set each node of the membership degree as the node degree of confidence, in reality, the negative situation, do the following treatment: let A be the domain U of FSCOM set, for the PSI lambda $\psi_\lambda(A(x))$ for the membership of A, abbreviated $A_\lambda(x), \lambda\in\left(\frac{1}{2},1\right]$

(1) A opposition $A^{ɜ}$ membership psi lambda $\psi_\lambda(A^{ɜ}(x))=1-A_\lambda(x)$, abbreviated $A^{ɜ}(x)$

(2) A mediated negative membership psi lambda set $A^{\sim}$ $\psi_\lambda(A^{\sim}(x))$, abbreviated as $A_\lambda^{\sim}(x)$

$$A_\lambda^{\sim}(x)=\begin{cases}\frac{2\lambda-1}{\lambda-1}A_\lambda(x)+\lambda & A_\lambda(x)\in[0,1-\lambda)\\ \frac{2-2\lambda}{1-2\lambda}(1-\lambda-A_\lambda(x))+\lambda & A_\lambda(x)\in[1-\lambda,\frac{1}{2})\\ \frac{2-2\lambda}{1-2\lambda}(A_\lambda(x)-\lambda)+\lambda & A_\lambda(x)\in[\frac{1}{2},\lambda)\\ \frac{2\lambda-1}{\lambda-1}A_\lambda(x)+\lambda & A_\lambda(x)\in[\lambda,1)\\ \frac{1}{2} & A_\lambda(x)=\frac{1}{2}\end{cases}$$

(3) $A^{\neg}$ contradiction membership psi lambda set $\psi_\lambda(A^{\neg}(x))$, abbreviated as $A_\lambda^{\neg}(x)=Max(A_\lambda^{ɜ})(x),A_\lambda^{\sim}(x))$

The membership is determined according to improved FLCOM infinite value semantic interpretation. Discuss the fuzzy decision-making in the lambda value in [29] according to the value of significance, and λ value is as the threshold, and in practice the general threshold λ is greater than 0.5.

(a) when $A_\lambda(x)\in[0,1-\lambda)$, x does not belong to A, and $A_\lambda^{ɜ}(x)\in(\lambda,1]$, x fully belongs to $A^{ɜ}$, $A_\lambda^{\sim}(x)\in(1-\lambda,\lambda)$, $A_\lambda^{\sim}(x)$ decreases with $A_\lambda(x)$ increasing, x partly belongs to $A^{\sim}$.

(b) When $A_\lambda(x)\in\left[1-\lambda,\frac{1}{2}\right)$, $A_\lambda^{ɜ}(x)\in\left(\frac{1}{2},\lambda\right]$, x partly belongs to A and $A^{ɜ}$, $A_\lambda^{\sim}(x)\in(\lambda,1)$,

$A_\lambda^{\sim}(x)$ increases with $A_\lambda(x)$ increasing, x partly belongs to $A^{\sim}$.

(c) When $A_\lambda(x)\in\left(\frac{1}{2},\lambda\right]$, $A_\lambda^{ɜ}(x)\in\left[1-\lambda,\frac{1}{2}\right)$, x partly belongs to A and $A^{ɜ}$, $A_\lambda^{\sim}(x)\in(0,1-\lambda)$, $A_\lambda^{\sim}(x)$ increases with $A_\lambda(x)$ increases, x partly belongs to $A^{\sim}$.

(d) When $A_\lambda(x)\in(\lambda,1]$, x fully belongs to A, $A_\lambda^{ɜ}(x)\in[0,1-\lambda)$, x does not belong to $A^{ɜ}$, $A_\lambda^{\sim}(x)\in(1-\lambda,\lambda)$, $A_\lambda^{\sim}(x)$ decreases with $A_\lambda(x)$

increasing, x partly belongs to $A^{\sim}$.

(f) When $A_{\lambda}(x)=\frac{1}{2}$, $A_{\lambda}^{\urcorner}(x)=\frac{1}{2}$, $A_{\lambda}^{\sim}(x)=\frac{1}{2}$, x partly belongs to $A^{\sim}$, $A^{\urcorner}$ and $A^{\sim}$.

The above method is the membership of objects in practical application for opposition set, intermediary negative set and contradiction set, and the set is selected as the basis, sums up the membership degree and the threshold according to a domain object, by the above calculation method obtained membership this object belongs to its different negative set, the the method of negative information processing in the search process [30-31].

5 Application examples

Below a group of information composed of a number of rules:

(1) The middle-aged and elderly people like foods high in sodium leading to arteriosclerosis, and it has the high reliability.

(2) Eat too much sodium food leading to arteriosclerosis, and overweight people have high rates of hypertension, and it has the high reliability.

(3) Young people without family history of hypertension and the proper weight is not prone to high blood pressure.

(4) Ms. Liu is 40 years old with no family history of hypertension, it is absolutely reliable.

(5) Ms. Liu is about 1.64m and her weight is about 70kg.

5.1 FSCOM INTRODUCTION

In practical reasoning we represent the fuzzy knowledge by fuzzy set FSCOM.

The domain belongs to all people for any x belonging to the domain. Obviously ‘the elderly’, ‘youth’, ‘obese’ and ‘moderate weight’ are the fuzzy set, and the relationship among ‘the elderly’ and ‘young people’ in the concept of ‘adult’ ‘contradiction, therefore, if the fuzzy set ‘youth’ expresses with YOUNG, then fuzzy set ‘the elderly’ is represented by $YOUNG^{\neg}$, and $YOUNG^{\sim}$ expresses fuzzy set ‘middle-aged people’, and $YOUNG^{\urcorner}$ expresses fuzzy set ‘the elderly’. $YOUNG^{\sim}(x)$, $YOUNG^{\urcorner}(x)$ and $YOUNG^{\neg}(x)$ respectively express the membership for the corresponding fuzzy set x. Similarly, if the fuzzy set ‘obese’ is expressed using FAT, then the fuzzy set ‘moderate weight’ is expressed using $FAT^{\sim}$. FAT (x) and $FAT^{\sim}(x)$ respectively express the membership for the corresponding fuzzy set x. MUCHNa expresses eating foods high in sodium. ARTERIOSCLEROSIS(x) expresses x arteriosclerosis. HYPERTENSION (x) will have high blood pressure x, $HYPERTENSION^{\urcorner}(x)$ said that it would not have high blood pressure [32].

Confidence of the above rules according to the actual situation can be given that credibility language assignment. Such as ‘high reliability’ can give the confidence value 0.7, and ‘very big credibility’ can gives the confidence value 0.85, and ‘easy’ gives the confidence value 0.65, and ‘absolute confidence’ gives the confidence value 1.

Based on fuzzy set FSCOM and the fuzzy production rules, the above rules are represented as:

(1) MUCHNa(x) ← $YOUNG^{\neg}(x)$, CF=0.7;
ARTERIOSCLEROSIS(x) ← $YOUNG^{\neg}(x)$, CF=0.7.

HYPERTENSION(x) ← MUCHNa(x) ∧ ARTERIOSCLEROSIS(x) ∧ FAT(x), CF=0.85

$HYPERTENSION^{\urcorner}(x)$ ← YOUNG(x) ∧ $FAMILYHISTORY^{\urcorner}(x)$ ∧ $FAT^{\neg}(x)$, CF=0.65。

(4) AGE(Liu, 50),$FAMILYHISTORY^{\urcorner}$(Liu),CF=1

(5) HEIGHT(Liu, 164),WEIGHT(Liu, 65),CF=1.

5.2 STATE SPACE REPRESENTATION AND SEARCH

In the example 40-year-old Ms Liu belongs to ‘the elderly’ involves determining the degree of membership, for example, and ‘the youth’ generally refers to the year from 18 years old to 30 years old, and ‘the old’ generally refers to the year after the age of 60, then Ms Liu belongs to the membership of ‘young people’: $YOUNG(Liu)=\frac{d(40,60)}{d(30,60)}\approx 0.67$ belongs to the membership of ‘the old’ $YOUNG^{\urcorner}(Liu)=1-YOUNG(Liu)\approx 0.33$. And Ms Liu belonging to the membership of ‘the middle-aged’ refers to thee stablishment of a specific threshold, see article [33], here the assumption that λ =0.8, get $YOUNG^{\sim}(Liu)=\frac{2-2\lambda}{1-2\lambda}(YOUNG(Liu)-\lambda)+\lambda\approx 0.887$ by using $\frac{2-2\lambda}{1-2\lambda}(A_{\lambda}(x)-\lambda)+\lambda \quad (A_{\lambda}(x)\in(1/2,\lambda])$, so Ms Liu belongs to the membership $\psi^{\neg}(YOUNG(Liu))=Max(YOUNG^{\sim}(Liu))$, $YOUNG^{\in}(Liu)=0.887$ of ‘the elderly’. Ms. Liu belongs to ‘overweight’ or ‘moderate weight’ according to Ms. Liu's body mass index: body weight (kg) / height (m^2) to establish. Body mass index into Ms. Liu calculation is about 24.17, and it is generally believed that the ‘weight’ of the body mass index of less than 18, and ‘obese’ refers to the body of prime number greater than 28. Therefore, Ms. Liu belongs to the membership $FAT(Liu)=\frac{d(18,24.17)}{d(18,28)}=0.617$ of ‘fat obese’, still assume that $\lambda=0.8$, using the formula $\frac{2-2\lambda}{1-2\lambda}(A_{\lambda}(x)-\lambda)+\lambda \quad (A_{\lambda}(x)\in(1/2,\lambda])$ to obtain $FAT^{\sim}(Liu)=\frac{2-2\lambda}{1-2\lambda}(FAT(Liu)-\lambda)+\lambda=0.922$.

The search graph of the state space is shown in Figure 5:

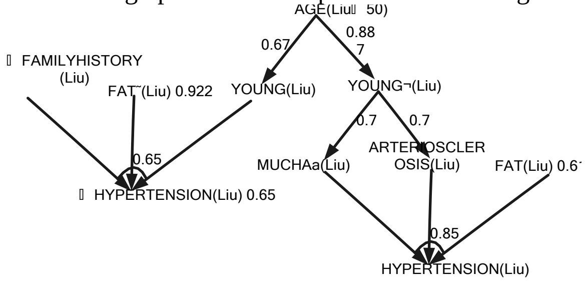

FIGURE 5 Search graph of state space about the instances

According to the algorithm and combined with Figure 5, look for the maximum path of general reliability, and the search path is as followings:

(1) AGE (Liu, 50) is the only node, and the end of the path has the highest credibility at present, and the confidence level is 1.

(2) Extended AGE (Liu, 50) gets or sub node YOUNG (Liu) and YOUNG (Liu), and the confidence is respectively 0.67 (1 ^ 0.67) and 0.887 (1 ^ 0.887), and YOUNG ¬ (Liu) node has the max confidence, so it is the most authentic path. At this time, AGE (Liu, 50) is estimated at 0.887.

(3) Extended node YOUNG ¬ (Liu) gets or sub node MUCHNa(Liu), ARTERIOSCLEROSIS (Liu), and the confidence is 0.7, and the estimated value of YOUNG ¬ (Liu) is 0.7, and the estimated value of AGE (Liu, 50) is 0.7, too. This path is still the most reliable path.

(4) Select the node MUCHNa (Liu) extension to get sub node HYPERTENSION (Liu) obtained by three and father nodes: MUCHNa (Liu), ARTERIOSCLEROSIS (Liu) and FAT (Liu), and the confidences respectively are 0.7, 0.7 and 0.617, and the related degree of the arc is 0.85, so the confidence of HYPERTENSION (Liu) is 0.617 (0.7 $\wedge$ 0.7 $\wedge$ 0.617 $\wedge$ 0.85), so the estimation of YOUNG ¬ (Liu) is 0.617, and this path is no longer the most reliable path.

(5) Therefore, the estimated value of YOUNG ¬ (Liu) is amended as 0.7, and select the extension node ARTERIOSCLEROSIS (Liu), at the same time the confidence degree of HYPERTENSION (Liu) is also is 0.617, then the estimated value of YOUNG ¬ (Liu) is 0.617 to get the estimated value of AGE (Liu,50) for 0.617, and this path is not the most reliable path.

(6) Therefore, the estimated value of AGE (Liu, 50) is amended as 0.67, and extended node is YOUNG (Liu), and the path is the most authentic path at present. The obtained child node ∍ HYPERTENSION(Liu) has three and the parent nodes: ¬ FAMILYHISTORY(Liu), FAT ˜ (Liu) and YOUNG (Liu), and the confidences respectively 1, 0.922 and 0.67, ant the the association degree of the arc is 0.65, so the obtained confidence ∍ HYPERTENSION (Liu) is 0.65 (1 ^ 0.922 ^ 0.67 ^0.65). This path is the most trusted path, so Ms. Liu will not have high blood pressure [34].

6 Conclusion

This paper describes the fuzzy knowledge based on fuzzy logic FLCOM, and the fuzzy propositional formula is looked as the state nodes to expand the fuzzy and-or graph, and the propositional calculus for reasoning about state space are described to give the method of negative information processing in a fuzzy information. Use the state space search to solve the problem of fuzzy knowledge reasoning.

References

[1] Zadeh L A 1965 Fuzzy Sets *Information and Contral* **8**(3) 338-53
[2] Zadeh L A 1975 The Concept of Linguistic variable and it's Apllication to Approximate reasoning *Information Sciences* **8** 199-249
[3] Atanassov K 1986 Intuitionistic fuzzy sets *Fuzzy Set s and Systems* **20**(1) 87-96
[4] Elkan C 1994 The paradoxical success of fuzzy logic *IEEE Expert* **9**(4) 1-14
[5] Elkan C 1994 The paradoxical controversy over fuzzy logic *IEEE Expert* **9**(4) 47-9
[6] Watkin F A 1995 False Controversy: Fuzzy and non-fuzzy faux pas *IEEE Expert* **10**(4) 4-5
[7] Wagner G 2003 Web Rules Need Two Kinds of Negation *In: F Bry, N Henze, and J Maluszynski,eds. Proc of the 1stinternational workshop on Practice of Semantic Web Reasoning. Heidelberg: Springer Verlag* 33-50
[8] Wujia Zhu, Xi'an Xiao 1988 On the Naive Mathematical Models of Mathematical System *J Math Res& Exposition* **8**(1) 139-47
[9] Wagner G 1991 A Database Needs Two Kinds of Negation *In: B.Thalbeim, J Demetrovics, H-DGerhardt,eds. Proc of 3rd Symposium on Mathematical Fundamentals of Database and Knowledge Bases Systems (MFDBS). Heidelberg: Springer-Verlag* 357-71
[10] Kaneiwa K 2005 Negations in Description Logic-Contraries, Contradictories, and Subcontraries *In: F. Dau, M.-L. Mugnier, and G. Stumme, eds. Contributions to ICCS2005. Kassel: Kassel University Press* 66–79
[11] Kaneiwa K 2007 Description Logics with Contraries, Contradictories and Subcontraries *New Generation Computing* **25**(4) 443-68
[12] Ferré S 2006 Negation, Opposition, and Possibility in Logical Concept Analysis *In: B Ganter and L Kwuida, eds. ICFCA2006,LNAI 3874. Heidelberg: Springer* 130-145
[13] Zhenghua Pan 1987 On the completeness of medium proposition logical calculus system (ML) *Proc of Int Symposium on Fuzzy Systems and knowledge Engineering. Guangzhou, China* 858-60
[14] Zhenghua Pan 1988 Construction of a model of medium logical calculus system (ML) *Proc of Workshop on knowledge-Based Systems and Models of Logical Reasoning,Cairo* 165-75
[15] Zhenghua Pan, Wujia Zhu 2003 A finite and infinite-valued model of the medium proposition logic *Proc of the Second Asian Workshop on Foundations of Software. Nanjing: Southeast University Press* 103-6
[16] Zhenghua Pan, Wujia Zhu 2004 An interpretation of infinite valued for medium proposition logical *Proc of IEEE-Third International Conference on Machine Learning and Cybernetics. Washington: IEEE Computer Society Press* 2495-9
[17] Zhenghua Pan 2013 *Three Kinds of Negation of Fuzzy Knowledge and their Base of Logic* Lecture Notes in Artificial Intelligence7996. Heidelberg: Springer Verlag 83-93
[18] Zhenghua Pan 2013 *Fuzzy Decision Making Based on Fuzzy Propositional Logic with Three Kinds of Negation* Lecture Notes in Computer Science 7995, Heidelberg: Springer Verlag 128-40
[19] Zadeh L A 1965 Fuzzy sets *Information and Control* **8**(3) 338-53
[20] Atanassov K 1986 Intutionistic fuzzy sets *Fuzzy Sets and Systems* **20**(1) 87-96
[21] Pawlak Z 1982 Rough sets *International Journal of Computer and Information Sciences* **11** 341-56
[22] Hájek P 1998 *Metamathematics of Fuzzy Logic* Kluwer Academic Publishers. Dordrech
[23] Kitainik L 1993 *Fuzzy decision procedures with binary relations* Kluwer, Dordrecht
[24] Cordon O, Herrera F, Peregrin A 1995 T-norms wersus Implication Functions as Implication Operators in Fuzzy Control *Proc.6th IFSA Congr* 501-4
[25] Cordon O, Herrera F, Peregrin A 1997 Applicability of the Fuzzy Operators in the Design of Fuzzy Logic Controllers *Fuzzy Sets and Systems* **86** 15-41
[26] Dujet C, Vincent N 1995 Force Implication: A new approach to human reasoning *Fuzzy Sets and Systems* **69** 53-63
[27] Gupta M, Qi J 1991 Theory of T-norms and Fuzzy Inference Methods *Fuzzy Sets and Systems* **40** 431-50
[28] Trillas E, Valverde L 1985 On implication and indistinguishability in the setting of fuzzy logic *In: K.Janusz and Yager R.R,eds. Management Decision Support Systems using Fuzzy Sets and Possibility Theory* 198-212
[29] Trillas E 1997 On a Mathematical Model for Indicative *FUZZIEE'97-Sixth IEEE International Conference or Fuzzy Systems* **1** 3-10
[30] Dubois D, Prade H 1991 Fuzzy Sets in approximate reasoning. Part 1:

Inference with possibility distributions *Fuzzy Sets and Systems* **4** 143-202

[31] Smets P, Magrez P 1987 Inplication in fuzzy logic *Internat. J. Approx. Reason* **1** 327-47

[32] Fodor J C, Roubens M 1994 *Fuzzy preference modeling and multicriteria decision support* Kluwer, Dordrecht 31-6

[33] Gottwal S 2001 *A trestise on many-valued logics* Research Studies Press, Baldock 53-6

[34] Shanshan Wang, Zhenghua Pan, Lei Yang 2012 *Fuzzy Decision Making Based on Fuzzy Logic with Contradictory Negation, Opposite Negation and Medium Negation* Lecture Notes in Computer Science,Springer-Verlag Berlin Heidelberg **7530** 200-8

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