On Simplification of the Knowledge Base In the Expert System++

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ABSTRACT

In this paper, a method of simplification of the knowledge base is presented, which is based on a new concept proposed by the authors, that is, rule's Information Content Degree (ICD). The simplification is carried out among rules and rules themselves.By means of the simplification of knowledge base, the capacity of computer store can be reduced and the utility of search in AI can be increased largely. At the same time, the acquisition and representation of knowledge base is also mentioned.

KEYWORDS Decision making, Expert system, Modelling, Fuzzy system, Factors space, Set-Valued Statistics

I. INTRODUCTION

As well known as us, expert system has become one of the three main field of AI. One of the keys of expert system is the simplicity and plentifullity of its knowledge base. The plentifullity is based on the experts' knowledge and experience. But the simplicity is based on the description of the knowledge base and

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its simplification. Because there are a lot of experts' knowledge and experience for a practical problem. How to acquire, present and simplify these knowledge and experience so that the ES can solve the practical problems high speedly and high effectively?

In this paper, a method of simplification of the knowledge base is presented, which is based on a new concept proposed by the authors, that is, rule's Information Content Degree (ICD). The simplification is carried out among rules and rules themselves. By means of the simplification of knowledge base, the capacity of computer store can be reduced and the utility of search in AI can be increased largely. At the same time, the acquisition and representation of knowledge base is also mentioned.

II. Knowledge Representation and Acquisition [10]

1. Knowledge Representation

Knowledge can be described in the P.Z.Wang's factors space. A factors space[5] is a family of sets $\{Xf\}(f \in F)$ where F is a complete Boolean algebra $F=(F,\wedge,\vee,c)$ satisfying:

1) $X0=\{\phi\}$
2) If $\{ft\}$ $(t \in T)$ are independent, i.e., for any $t1,t2 \in T$, $ft1 \wedge ft2=0$, then

$$X_{\bigvee_{t\in T} ft} = \prod_{t\in T} Xft$$

where 0 and 1 are the smallest and the largest element of F respectively, and $\prod$ is Cartesian product.

Knowledge can be described as a point or a sets of points in a finite or infinite dimensional factors space. For example, suppose that the factors space is { X1,X2, ..., Xm,Y} and the

$x1, x2, \ldots, xm, y$ are the state of the factors $X1, X2, \ldots, Xm, Y$ respectively. A reasoning rule can be written as follows:

IF x1 AND x2 AND ... AND xm THEN y (1)

If these states are certain values, then the rule (1) is described as a point in the factors space. If these states are fuzzy variables, rule (1) is described as a sets of points. In this paper, if it has not especial illustration, these states are fuzzy variables. The rule (1) means reasoning from x1, x2, ... ,xm to y, denoted by <x1,x2, ... ,xm,y>. We can obtain some information from rules. But not all rules can supply useful information. So, we define rule's Information Content Degree(ICD) T as follows:

$$T=T(x1,x2, \ldots ,xm,y) \qquad (2)$$

There are two meanings included in Equ.(2), i.e., reasoning from x1, ... ,xm to y and T as its ICD. In this paper, knowledge base is consist of a series of rules as the form of Equ.(2). So, if T is obtained, the knowledge will be acquired.

2. Knowledge Acquisition in the Case of Single-factor Reasoning

For the case of single-factor reasoning, knowledge is obtained from two manners, i.e., the psychology test and the experiment. Discuss the factors X and Y, the states x $\{Ai, i \in I\}$, y $\{Bi, i \in I\}$, where $I=\{1,2, \ldots, n\}$. The ICD of the rule as the form of Equ.(3)

IF x=Ai THEN y=Bi (3)

is denoted by Tij. Tij=T(Ai,Bj).

2.1 Method acquiring knowledge from psychology-test

1) Ask every expert give the estimation of the ICD interval of Tij, for all $i \in I$, $j \in I$, which is denoted by [Ck,Dk], where k denote that the interval is given by the kth expert and [Ck,Dk]

[0,1], k=1,2, ...,K.

2) Calculate

$$a=\frac{1}{n}\sum_{k=1}^{K}\frac{Ck+Dk}{2} \qquad (4)$$

Take a as the point estimation of the ICD of Tij.

2.2 Method acquiring knowledge from experiment data

1) Calculate the frequency of <Ai,Bj>. It is denoted by Mij.

2) The estimation of Tij can be obtained from Equ.(5)

$$Tij=Mij/(\sum_{j=1}^{n} Mij) \qquad (5)$$

3. Knowledge Acquisition in the Case of Multi-factors Reasoning

For the case of multi-factors reasoning, first, determine the factors X1,X2, ... ,Xm which are correlated to the factor Y. T(xi,y) can obtained by means of methods in section 2. In this section, we discuss how to get the ICD of <x1,x2, ... ,xm,y> from T(xi,y), i=1,2,...,m.

3.1 Determine the correlated factors set

The correlated set can be directly given by the experts in the case of psychology-test. When knowledge is acquired from experimental data, the correlated factors set is obtained by means of the following correlation analysis method.

If factor X is correlated to Y, when x=Ai, the ICD which y is in a fixed state, for example y=B1, is greater than others. In other words, Ti1>>Tij, $j\neq 1$, $j,1\in I$.We define the correlation measure function as follows

$$S(x,y)=\min_{i\in I}\{\max_{j\in I} Tij\} \qquad (6)$$

If $S(x,y)\geq\delta$, X and Y is correlated in the case of δ, if

$S(x,y) < \delta$, X and Y is not correlated, where $0 \leq \delta \leq 1$. So,we get a criteria for determining the correlated factors set.

3.2 Calculate T(x1,x2, ... ,xm, y)

According to the intrinsic characteristics of thinking activities in human brain, the more the factors which is applied to reason, the greater the ICD. So we have the following formula[8]

$$T(x1,x2, \ldots ,xm,y)=1-\{[1-T(x1,y)], \ldots ,[1-t(xm,y)]\} \quad (7)$$

So we get a calculating method for the ICD of multi-factors reasoning. Then, using the methods discussing in section 2 and section 3, knowledge base can be obtained.

III. Simplification of the Knowledge Base

In section II, knowledge base is obtained, which is denoted by T=T(x1,x2,...,xm,y).There are a lot of experts' knowledge and experience for a practical problem. These knowledge and experience of experts may be repetitional and intrinsic. So, it is necessary to simplify the knowledge base. There are two cases for the simplification of the knowledge base.

1. Simplification among rules

Given rule:

if x is P then y is Q (8)

where, P(x) and Q(y) is subset(Normal or Fuzzy Set) on the Universe U and V respectively. Rule's ICD is T=T(P,Q). Universe U and V can be put into a common factors space $\{X_f\}(f \in F)$. X_f can be considered as the state sets of the elements in U and also can be considered as the cause sets of the results in V.

Definition [5] Let O be the Universe of objects concerned with a family of concepts which can be represented as Fuzzy subsets of O. Mapping r: O--->X1 is called representation of O and r(A) is called the representation of concept A in F(O). Denoted by

$$\tau(A)=\wedge\{f \mid f\in F,\ \uparrow^{1}(\downarrow_f(r(A)))=r(A)\}$$

which is called rank of concept A. Where, $\downarrow_f$ denotes project to X_f, $\uparrow^{1}$ denotes cylindric extends to X1. X1 is called whole space.

Definition 3.1: (rule's factors explanation)

Let $\{X_f\}$ ($f\in F$) be a factors space, $P\subseteq F(O1)$, $Q\subseteq F(O2)$, ri: Oi--->Xi be representation of Oi(i=1,2). We call that P implies Q denoted by P--->Q if they satisfy that

$$\uparrow^{\tau(Q)}\{\downarrow_h r1(P)\}\subseteq \downarrow_h r2(Q) \qquad (9)$$

From Definition 3.1, we know that when U is equal to V, Implication "P---->Q" is equivalent to inclusion.

Proposition 3.1:

If	P--->Q	and	$P'\subseteq P$	then	P'--->Q	(10)
If	P--->Q	and	$Q\subseteq Q'$	then	P--->Q'	(11)
If	P--->Q1	and	P--->Q2	then	$P\text{--->}Q1\cap Q2$	(12)
If	P1--->Q	and	P2--->Q	then	$P1\cup P2\text{--->}Q$	(13)

Proof: omitted.

Proposition 3.2:

Given, rule1: P1--->Q1

rule2: P2--->Q2

$T(P1,Q1)\geqslant T(P2,Q2)$ if $P1\supseteq P2$ and $Q1\subseteq Q2$.

that is, rule1's ICD is larger than rule2's.

Proof: because of $P1\supseteq P2$ and $Q1\subseteq Q2$, it is easily obtained that

$$P1\text{--->}Q1 \Longrightarrow P2\text{--->}Q2$$

and then $$P2\text{--->}Q2 \not\Longrightarrow P1\text{--->}Q1$$

from Equ.(10) and Equ.(11). Obviously, by means of the definition of the rule's ICD, we can obtained that:

$$T(P1,Q1) \geqslant T(P2,Q2)$$

Finished.

Proposition 3.3: (the method of the simplification of the knowledge base)

Given knowledge base as follows:

P1--->Q1

P2--->Q2

....

Pn--->Qn

Rule Pj--->Qj can be erased from the knowledge base, if:

$$Pi \geqslant Pj \quad \text{and} \quad Qi \subseteq Qj \quad (i \in I,\ j \in I)\ (I=1,2,...,n)$$

Proof: easily proved by means of Proposition 3.2.

Finished.

Proposition 3.4: For following knowledge base:

(X1,X2,...,Xm)--->Y

that is, $T=T(x1,x2,...,xm,y)$

Proposition 3.2 and Proposition 3.3 can be easily extended.

Proof: omitted.

2. Simplification of the rules themselves

In previous case, only simplification among rules is considered. So, the absolute value of every rule's ICD is not considered. Obviously, if the value of T of one rule is very small, this rule cannot play a part in the decision making. For example, if sun rise from west, man has a couple of eyes. In fact, this rule does not supply any information for decision making, that is, its ICD is equal to zero: T=0.

In this section, we simplify the rules whose T is very small.From Equ.(2), the method of the simplification can be described as follows:

Given ξ $(0 \leq \xi \leq 1)$, if $T(x1,x2,\ldots,xm,y) \leq \xi$, then erase this rule.

VI. Conclusion

In this paper, a method of simplification of the knowledge base is presented, which is based on the new concept---rule's ICD. By means of ICD, some problems in ES can be solved effectivelly.

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