http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (19): 5022-5026, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.5022.5026

Uncertainty Network Reasoning Research Based on the Expert System of BAYES Rule

Chen Guo, Ming Huang and Xu Liang
Software Technology Institute, Dalian Jiaotong University, Dalian, China

Abstract: This study proposed a new algorithm based on BAYES rule, after deeply researching the reasoning methods which related with uncertainty problems of expert system. This algorithm introduced the thought of credibility, by establishing inference network model, started from the known observed evidences to forward reasoning and eventually got the probability of the impact of evidence on object conclusion. And it also greatly reduces the probability of which uncertainty faction caused object conclusion distortion. The reasoning result showed it works well and meet expectation.

Key words: BAYES rule, expert system, inference network, uncertainty

INTRODUCTION

The probabilistic reasoning method always be used to evaluate in a variety of specialist areas (Wang, 2008). In the condition of less information, the result of reasoning can be got by taking some methods which use part of evidences. Sometimes, the given evidence is stronger than the proposed conclusions and sometimes not. But whether it is strong or weak, human experts always hope to find the subjective information about relationship between evidence and conclusion by using known evidences (Zhang, 2007). These information are usually used for calculating and reasoning in the form of probability. Users by providing the uncertainty problems' probability which might be related with conclusion to reason the probability of this evidence to a unknown conclusion. It makes system could easily reason the uncertainty dependency by using probability and estimate the probability of evidence effect to conclusion. Then the maximum likelihood of deduction result will be obverse, the uncertainty problem researching will turn into solving the certain problems.

BAYES RULE IN UNCERTAINTY RESEARCHING

The core of expert system is to complete reasoning calculation (Bian, 2010). And the main task of reasoning calculation is adopting some effective measures or tactics to reason and suppose for hypothesis reasoning. In the process of reasoning, Using the method of probability is an effective solution (Wang, 2006).

By BAYES rule we could know when known P is true and already known P and Q have some kind of connection, hope by using P, the probability of Q can be calculated (Johnson and Kelafunuo, 1989). Importance of BAYES rule is mainly showed in:(1)For P and Q, generally have prior probability of possible reasoning assumption;(2)In the condition of evidence P constrained by assumption Q, the relational knowledge between P and Q represent by p(P??Q) is valid. Then by using BAYES rule, we can deduce that when P is true, the posterior similarity equation of Q is $O(Q|P) = \lambda O(Q)$, the similarity degree:

$$\lambda = \frac{p(P\,|\,Q)}{p(P\,|\sim Q)}$$

Event discrepancy:

$$O(Q) = \frac{p(Q)}{p(\sim Q)} = \frac{p(Q)}{1-p(Q)}$$

prior probability:

$$p(Q) = \frac{O(Q)}{1+O(Q)}$$

Similarly, when P is false, the posterior similarity equation of Q is $O(Q|\sim P) = \bar{\lambda} O(Q)$.

- λ reflects the support degree of P to Q.λ is greater, p(Q|P) is greater and p(Q|P) becomes greater also, means the support of P to Q is stronger. When $\lambda\to\infty$, $O(Q|P)\to\infty$, deduces P(Q|P), means the existence of P made Q be true; when $\lambda = 1$, means P and Q are independent; when $\lambda>1$, the existence of P made the existence possibility of Q is falling down; when $\lambda = 0$, means the existence of P made Q be false

Corresponding Author: Chen Guo, Software Technology Institute, Dalian Jiaotong University, Dalian, China

- λ reflects the support degree of ~P to Q. λ is greater, the more P supports Q. When $\bar{\lambda} \to \infty$, then ~P→true, Q→true; when $\bar{\lambda} = 1$, means ~P and Q are independent; when $\bar{\lambda} < 1$, the existence of ~P made the existence possibility of Q is falling down; when $\lambda = 0$, O(Q|~P) = 0, means P does not exist, made Q be false

ESTABLISH THE INFERENCE NETWORK MODEL BASED ON BAYES RULE

As shown in Fig. 1, in the system based on rules, experts' knowledge are given in the form of rule (Chen, 2011). All the rules all have the statement in form of IF P THEN Q. In the statement, P represents the antecedent of rule, Q represents conclusion (Yang *et al*., 2007). In this study's reasoning model, there are parameters λ and $\bar{\lambda}$ existed between P and Q, so the abstraction of this rule can be expressed in $P \xrightarrow{(\lambda,\bar{\lambda})} Q$. Otherwise, for the single independent reasoning probability P, the connection probability is given by its product of individual probability. It exists $p(P_1 \wedge P_2 \wedge \ldots \wedge P_i) = \min(P_1, P_2 \ldots, P_i)$, I = 1, 2…n and $p(P_1 \vee P_2 \vee \ldots \vee P_i)$, i = 1, 2,… n; so, using this rule also can get p(~P) = 1-p(P). This shows that the establishment of inference network is forward reasoning by initial antecedent. It means users only need to provide the probability of initial antecedent.

INTRODUCE THE EXTENDING ALGORITHM OF BAYES RULES

For solving the uncertainty effect of prior probability to object assertion, according to the known initial antecedent to forward reasoning, establish a inference network model with connect with initial antecedent. And introduce the BAYES rule reasoning algorithm based on confidence to calculate the probability credibility of the whole network antecedent to the final object assertion; the planned reasoning result is hoping to observe the whole process of reasoning that the object conclusion credibility degree affected by uncertainty.

In the expert system, domain experts give 3 parameters for each of rules, there are λ, $\bar{\lambda}$ and O(Q). There exists following known form of rule: $P \xrightarrow{O(Q),\,\lambda,\,\bar{\lambda}} Q$ According to the rule, deduced:

$$\begin{cases} p(Q \mid P) = \dfrac{\lambda p(Q)}{1+(\lambda-1)p(Q)} \\ p(Q \mid \sim P) = \dfrac{\bar{\lambda} p(Q)}{1+(\bar{\lambda}-1)p(Q)} \end{cases}$$

from this we can directly determine the posterior probability of Q. But in the practical case, object assertion always associated with relevant multi-statements. And every statement has it own associated statements, so only

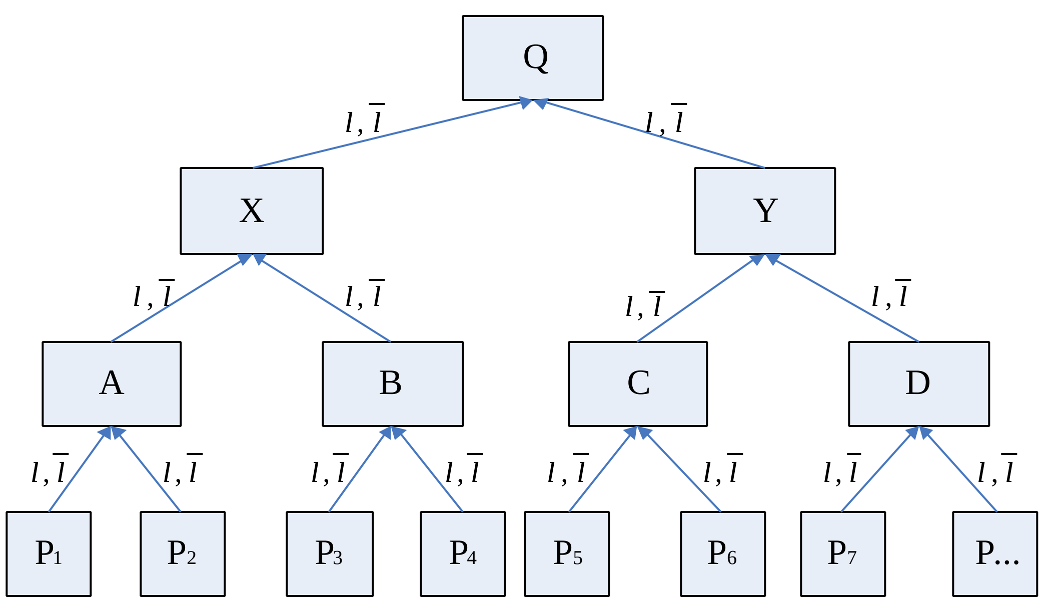

Fig. 1: Inference network model

using the above equation can not solve the problem. We analyze the situation in the practical case and step by step to reasoning, extended the set which including multiple initial antecedents by that equation, the equation of obtained reasoning object assertion's posterior probability is:

$$O(Q\mid P_1',\cdots,P_n')=\frac{O(Q\mid P_1')}{O(Q)}\cdot\frac{O(Q\mid P_2')}{O(Q)}\cdots\frac{O(Q\mid P_n')}{O(Q)}O(Q)\qquad(1)$$

Solving Eq. 1, the thought of credibility need to be introduced, means product degree of confidence to P on the premise of observational P_i'. It is denoted as $C(P|P')$ and degree of confidence between [-5, 5] (Li, 1991); When $C(P|P') = -5$, means P is false, it is equivalent to $p(P|P') = 0$; When $C(P|P') = 5$, means P is existed, it is equivalent to $p(P|P') = 1$; When $C(P|P') = 0$, means observational p and P' are independent, it is equivalent to $p(P|P') = (P)$. When $C(P|P')$ is given, if existed $p(P)>C(P|P')\le 1$ or $0\le p(P|P')\le p(P)$, $p(Q|P')$'s posterior probability equation can be calculated as:

$$p(Q\mid P')=\begin{cases}p(Q\mid\sim P)+[p(Q)-p(Q\mid\sim P)][\frac{1}{5}C(P\mid P')+1], & \text{when}\ \ C(P\mid P')\le 0\\ p(Q)+[p(Q|p)-p(Q)]\times\frac{1}{5}C(P\mid P'), & \text{when}\ \ C(P\mid P')>0\end{cases}\qquad(2)$$

If existed, $p(P|P')$ is another value (not 1, 0, p(Q)), $p(P|P')$'s posterior probability equation can be calculated as:

$$p(Q\mid P')=\begin{cases}p(Q\mid\sim P)+\frac{p(Q)-p(Q\mid\sim P)}{p(P)}p(P\mid P')\le 0 & \text{when}\ \ 0\le p(P\mid P')<p(P)\\ p(Q)+\frac{p(Q\mid P)-p(Q)}{1-p(P)}[p(P\mid P')-p(P)] & \text{when}\ \ p(P)\le p(P\mid P')\le 1\end{cases}\qquad(3)$$

INSTANCE DESCRIPTION

Parameter description: Suppose exists known inference network model in Fig. 2.

Parameters relates with the rules which set according to the reasoning model (Table 1 and 2):

Detail reasoning process:

- From the parameter list can see:

$$P(X)=\frac{O(X)}{1+O(X)}=\frac{0.1}{1+0.1}\approx 0.09$$

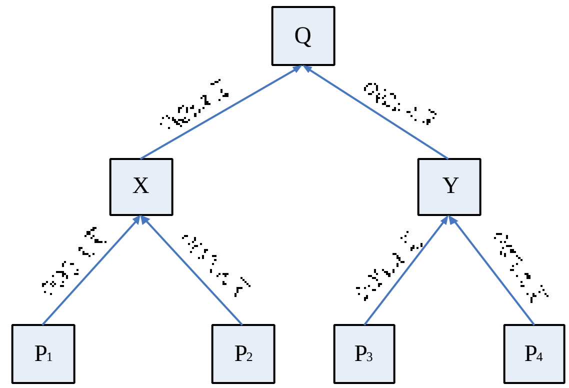

Fig. 2: Case model

Table 1: Parameter list

	O(M)	λ	$\bar{\lambda}$
R_1	0.10	15	0.00001
R_2	0.10	20	0.00001
R_3	0.02	85	0.01000
R_4	0.15	500	0.00001
R_5	0.15	8	0.00002
R_6	0.02	40	0.00030

Table 2: Parameter list of rules and evidences

Rule	Description of rule	Evidence	Evidence credibility
R_1	$P_1\rightarrow X$	P_1'	3
R_2	$P_2\rightarrow X$	P_2'	1
R_3	$X\rightarrow Q$	P_3'	-2
R_4	$P_3\rightarrow X$	P_4'	-3
R_5	$P_4\rightarrow X$		
R_6	$Y\rightarrow Q$		

$$P(X|P_1)=\frac{O(X|P_1)}{1+O(X|P_1)}=\frac{\lambda_1 O(X)}{1+\lambda_1 O(X)}=\frac{15\times 0.1}{1+15\times 0.1}=0.6$$

and because the degree of known evidence's credibility $C(P_1|P_1') = 3>0$, by Eq. 2 we can determine:

$$P(X|P_2')=p(X)+[P(X|P_2)-p(X)]\times\frac{1}{5}\times C(P_2|P_2')$$

$$O(X|P_1')=\frac{p(X|P_1')}{1-p(X|P_1')}=\frac{0.396}{1-0.396}=0.65563$$

- Because $C(P_2|P_2') = 1>0$, by Eq. 2 we can determine:

$$P(X|P_2')=p(X)+[P(X|P_2)-p(X)]\times\frac{1}{5}\times C(P_2|P_2')$$

In above:

$$P(X)=\frac{O(X)}{1+O(X)}=\frac{0.1}{1+0.1}\approx 0.09$$

$$P(X|P_2)=\frac{O(X|P_2)}{1+O(X|P_2)}=\frac{\lambda_2 O(X)}{1+\lambda_2 O(X)}=\frac{20\times 0.1}{1+20\times 0.1}\approx 0.67$$

So:

$$P(X|P_2')=0.09+(0.67-0.09)\times 0.2\times 1=0.206$$

$$O(X|P_2')=\frac{p(X|P_2')}{1-p(X|P_2')}=\frac{0.206}{1-0.206}=0.25945$$

By Eq. 1 we can know the synthetic effect of P_1' and P_2' to X, the posterior probability of $p(X|P_1', P_2')$ is:

$$O(X|P_1',P_2')=\frac{O(X|P_1')}{O(X)}\times\frac{O(X|P_2')}{O(X)}\times O(X)=\frac{0.65563}{0.1}\times\frac{0.25945}{0.1}\times 0.1\approx 1.7$$

And because:

$$O(X|P_1', P_2') = 1.7>OX = 0.1$$

Then:

$$p(X|P_1',P_2')=\frac{O(X|P_1',P_2')}{1+O(X|P_1',P_2')}=\frac{1.7}{1+1.7}=0.62963>P(X)=0.09$$

By using Eq. 3 we can determine:

$$p(Q|P_1',P_2')=p(Q)+\frac{p(Q|A)-p(Q)}{1-p(X)}\times[p(X|P_1',P_2')-p(X)]$$

In above:

$$p(Q)=\frac{O(Q)}{1+O(Q)}=\frac{0.01}{1+0.01}=0.0099$$

$$p(Q|X)=\frac{\lambda_{R3}\times O(Q)}{1+\lambda_{R3}\times O(Q)}=\frac{85\times 0.01}{1+85\times 0.01}=0.45946$$

So:

$$p(Q|P_1',P_2')=0.0099+\frac{0.45946-0.0099}{1-0.09}\times(0.62963-0.09)=0.27649$$

$$O(Q|P_1',P_2')=\frac{p(Q|P_1',P_2')}{1-p(Q|P_1',P_2')}=\frac{0.27649}{1-0.27649}=0.38215$$

- Because $C(P3|P_3') = -2<0$, By using Eq. 2 we can determine:

$$P(Y|P_3')=P(Y|\sim P_3)+[p(Y)-P(Y|\sim P_3)]\times[\frac{C(P_3|P_3')}{5}+1]$$

In above:

$$P(Y|\sim P_3)=\frac{O(Y|\sim P_3)}{1+O(Y|\sim P_3)}=\frac{\bar{\lambda}_{R4}\times O(Y)}{1+\bar{\lambda}_{R4}\times O(Y)}=\frac{0.00001\times 0.15}{1+0.00001\times 0.15}\approx 1.5\times 10^{-6}$$

$$P(Y)=\frac{O(Y)}{1+O(Y)}=\frac{0.15}{1+0.15}\approx 0.13$$

So:

$$P(Y|P_3')=1.5\times 10^{-6}+[0.13-1.5\times 10^{-6}]\times[\frac{-2}{5}+1]\approx 0.078$$

$$O(Y|P_3')=\frac{p(Y|P_3')}{1-p(Y|P_3')}=\frac{0.078}{1-0.078}=0.0846$$

- Because $C(P4|P_4') = -3<0$, By using Eq. 2 we can determine:

$$P(Y|P_4')=P(Y|\sim P_4)+[p(Y)-P(Y|\sim P_4)]\times[\frac{C(P_4|P_4')}{5}+1]$$

In above:

$$P(Y|\sim P_4)=\frac{O(Y|\sim P_4)}{1+O(Y|\sim P_4)}=\frac{\bar{\lambda}_{R5}\times O(Y)}{1+\bar{\lambda}_{R5}\times O(Y)}=\frac{0.00002\times 0.15}{1+0.00002\times 0.15}\approx 3.0\times 10^{-6}$$

$$P(Y)=\frac{O(Y)}{1+O(Y)}=\frac{0.15}{1+0.15}\approx 0.13$$

So:

$$P(Y|P_4')=3.0\times 10^{-6}+[0.13-3.0\times 10^{-6}]\times[\frac{-3}{5}+1]\approx 0.052$$

$$O(Y|P_4')=\frac{p(Y|P_4')}{1-p(Y|P_4')}=\frac{0.052}{1-0.052}\approx 0.0549$$

Then:

$$O(Y|P_3',P_4')=\frac{O(Y|P_3')}{O(Y)}\times\frac{O(Y|P_4')}{O(Y)}\times O(Y)=\frac{0.0846}{0.15}\times\frac{0.0549}{0.15}\times 0.15\approx 0.031$$

and because:

$$O(Y|P_3^{'},P_4^{'}) = 0.031 < O(Y) = 0.15$$

got $P(Y|P_3', P_4') < p(Y)$, By using Eq. 3 we can determine:

$$p(Q|P_3^{'},P_4^{'}) = p(Q|\sim Y) + \frac{p(Q) - p(Q|\sim Y)}{p(Y)} \times p(Y|P_3^{'},P_4^{'})$$

In above:

$$p(Q|\sim Y) = \frac{O(Q|\sim Y)}{1 + O(Q|\sim Y)} = \frac{\bar{\lambda}_{R6} \times O(Q)}{1 + \bar{\lambda}_{R6} \times O(Q)}$$
$$= \frac{0.0003 \times 0.01}{1 + 0.0003 \times 0.01} \approx 3.0 \times 10^{-6}$$

$$p(Q) = \frac{O(Q)}{1 + O(Q)} = \frac{0.01}{1 + 0.01} = 0.0099$$

So:

$$p(Y|P_3^{'},P_4^{'}) = \frac{O(Y|P_3^{'},P_4^{'})}{1 + O(Y|P_3^{'},P_4^{'})} = \frac{0.031}{1 + 0.031} \approx 0.03$$

$$p(Q|P_3^{'},P_4^{'}) = 3.0 \times 10^{-6} + \frac{0.0099 - 3.0 \times 10^{-6}}{0.13} \times 0.03 \approx 0.00228$$

$$O(Q|P_3^{'},P_4^{'}) = \frac{p(Q|P_3^{'},P_4^{'})}{1 - p(Q|P_3^{'},P_4^{'})} = \frac{0.00228}{1 - 0.00228} = 0.00229$$

By above calculation we can arrive the conclusion:

$$O(Q|P_1^{'},P_2^{'},P_3^{'},P_4^{'}) = \frac{O(Q|P_1^{'},P_2^{'})}{O(Q)} \times \frac{O(Q|P_3^{'},P_4^{'})}{O(Q)} \times$$
$$O(Q)\frac{0.38215}{0.01} \times \frac{0.00229}{0.01} \times 0.01 \approx 0.088$$

$O(Q|P_1', P_2', P_3', P_4')$ is the synthetically credibility of object assertion Q which using the observed evidences of antecedent of rule (P_1', P_2', P_3', P_4') to reason by reasoning network. The object's credibility degree proved, in the uncertainty reasoning process, the adopted algorithm can ensure the accurate judgment of the effect of antecedent evidences (P_1', P_2', P_3', P_4') to object assertion result. The result of calculation proved the effect index for object assertion is 0.088. It has stronger effect and works well.

CONCLUSION

This study regards BAYES rule as researching object and introduces uncertainty reasoning method which based on BAYES rule in detail. And based on BAYES rule theory, by studying extending research and introducing relative algorithm, obtained the effect probability of observational evidence to object conclusion. Instance reasoning proved, the extending algorithm based on BAYES rule can greatly solve the effect of observational evidence to object conclusion. And the result of calculation proved it works well and yielded the expected result.

REFERENCES

Bian, S.H., 2010. Research and application of uncertainty reasoning in expert system. Maser's Thesis, Anhui University.

Chen, X.Y., 2011. Study and realization of uncertain reasoning machine base on expert system. Manuf. Autom., 33: 78-81.

Johnson, L. and E.T. Kelafunuo, 1989. Expert System Technical Guide. World Publishing Co., USA., pp: 31-32.

Li, F., 1991. Uncertainty in Artificial Intelligence. Meteorological Press, China, pp: 85-90.

Wang, K.J., 2008. Geometric characteristics based on data and statistical learning probabilistic reasoning research. Ph.D. Thesis, Xi'an University of Electronic Science and Technology

Wang, Y.N., 2006. Expert system inference mechanism and application. Master's Thesis, WuHan Polytechnic University.

Yang, X., D.Q. Zhu and Q.B. Sang, 2007. Research and prospect of expert system. Applic. Res. Comput., 24: 4-9.

Zhang, J., 2007. Conflicting evidence theory and application of evidence handling. Master's Thesis, NanChang University, China.