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A Conflict Treatment Algorithm for Certainty Rule-based Knowledge

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Abstract

The rule-based knowledge expert system has traditionally emphasized the verification of structural errors in the rule base. For conflicting rules, designated rules are usually followed to implement prioritized. However, there exist no proper methods by which to resolve conflicts, inconsistencies in values. The citation of erroneous knowledge can lead to mistakes in reaching decisions.

According to the group decision idea, this study proposes an algorithm that is provided to use a “reliability factor” to refer to the reliability level of the knowledge item with a conflict or inconsistency in value. Most users, 94% report perplexity at the moment that conflicting rules are cited. Moreover, 92% of users hold that the algorithm is helpful to knowledge application and as aid to the decision-making process.

1. Introduction

A rule-based knowledge expert system is a rule base formed after the combination of facts obtained by the experts familiar with all realms and rules. However, there is always a possibility of conflicts in the experience of experts engaged in diversified fields.

Verification of the rule base concentrates on detecting structural errors resulting from interaction between rules. Structural errors may influence the consistency of rule inference through redundancy, inconsistency, incompleteness and circularity [2]. To define terms, structural errors include redundancy, inconsistency, incompleteness and circularity of the rule.

The currently prevailing method of treating conflict between rules is to implement prioritized by following designated rules. However, there exist no proper methods to resolve conflicts or inconsistencies in value.

Inconsistency is likely to result in the incomplete fulfillment of the benefits intended to be derived from the knowledge application. On the other hand, citation of erroneous knowledge will lead to mistakes in making a final decision. To obtain more benefits from knowledge management applications, it is a necessity to confirm the existence and reliability of cited knowledge.

Employing a group decision idea, the current study attempts to provide a certainty rule-based knowledge conflict treatment algorithm. In the algorithm, the term “reliability factor” refers to the reliability of the knowledge in which there is a conflict or inconsistency in value. For conflicting knowledge, knowledge of higher reliability can be chosen and extensively applied to treatment of all certainty rule-based conflicting knowledge. In this way, mistaken decisions can be effectively prevented.

2. Literature Review

Suwa et al. put forward a set of verification checkers to detect conflicting, overlapping and inclusive rules [4]. Cragun et al. proposed a decision table base processor to cut and rank the main table into several sub-tables to check whether errors exist [1].

The high-order Petri Nets, together with graph and mathematical theory, can be used to represent the system by observing the serial and forecasting the transfer network model [5]. As for the conflicting rules, they will be often treated in chronological order by the designated rules. However, there is no appropriate method of treating the conflict between rules, inconsistency in corresponding value between rules.

3. Certainty Rule-based Knowledge Conflict Treatment Algorithm

According to the group decision idea and weighted average theory, this study proposes the “reliability factor” refers to the reliability level of the knowledge
in conflict or having inconsistent value, and constructs the Certainty Rule-based Knowledge Conflict Treatment Algorithm (CRKCTA).

3.1 Reliability factor theory

In this paper, the “Reliability Factor” (RF) refers to the reliability of each rule in regard to the conflicting nature of those rules. For example, if three experts suggest three different treatments to the same problems shown in Fig. 1, the final treatment is chosen to be the central area comprised of the unanimous conclusions of the three experts. In other words, the intersection of three experts is used as the final treatment. A scheme of data selection which is executed in this way can produce results that are approved by all three experts and therefore can be deemed as the most reliable.

![Fig. 1. The concept of treating disputes and conflicts through a group decision.](image)

For the knowledge sets with incongruent corresponding values, the way to represent the reliability factor is put forward an accurate indicator of reliability.

**Definition 1:** The reliability factor of knowledge with the same antecedent or consequent: \(0 \leq RF \leq 1\)

\[
RF = \frac{RA_i}{RA} \quad (1)
\]

**RA** = The number of rules with the same antecedent and corresponding consequent in the \(i^{th}\) interval.

\[
RF = \frac{RC_i}{RC} \quad (2)
\]

**RC** = The number of rules with the same consequent and corresponding antecedent in the \(i^{th}\) interval.

According to Eq. (1) and Eq. (2), both bounded intervals and unbounded intervals are included in the distribution interval of the antecedent or consequent of the knowledge set which is conflicting or inconsistent in the corresponding value. Considering that the distribution interval of a rule may have several different reliability factors, we shall discuss the ways to calculate the reliability factor of the rule in the following paragraphs:

1. When the distribution interval of the antecedent or consequent value of a rule is a bounded interval

Suppose the rule has three different but constant reliability factors, \(RF_1\), \(RF_2\) and \(RF_3\) and their corresponding constant linear lengths are \(L_1\), \(L_2\) and \(L_3\) respectively, as shown in Fig. 2. In accordance with a weighted average theory, the RF for the rule can be determined by Eq. (3). If there is a corresponding RF of a fixed point in an interval but the point has no length, then the RF for the point cannot be calculated through Eq. (3); rather it just represents the RF for the value of the point. Eq. (3) will be rewritten into the universal representation, as in Eq. (4).

![Fig. 2. When the distribution interval of the antecedent or consequent value is a bounded interval](image)

\[
RF = \frac{L_1 \cdot RF_1 + L_2 \cdot RF_2 + L_3 \cdot RF_3}{L_1 + L_2 + L_3} \quad (3)
\]

\[
RF = \frac{\sum_{i=1}^{m} RF_i \cdot L_i}{\sum_{i=1}^{m} L_i} \quad (4)
\]

**RF:** the reliability factor of the \(i^{th}\) interval of the antecedent or consequent value

\(L_i\): the linear length of the \(i^{th}\) interval of the antecedent or consequent value

\(m\): the total number of the distribution intervals of the antecedent or consequent values

2. When the distribution interval of the antecedent or consequent value of a rule is an unbounded interval or two unbounded intervals

(a) Suppose the rule has three different but constant reliability factors, \(RF_1\), \(RF_2\) and \(RF_3\) and their corresponding linear lengths are \(L_1\), \(L_2\) and \(x\) respectively, as shown in Fig. 3, wherein \(L_1\) and \(L_2\) are constants while \(x\) is a variable. Through Eq. (4), the RF for the rule can be calculated, as in Eq. (5).

\[
RF = \frac{RF_1 \cdot L_1 + RF_2 \cdot L_2 + RF_3 \cdot \lim_{x \to \infty} x}{L_1 + L_2 + \lim_{x \to \infty} x} = RF_x \quad (5)
\]

The RF that represents the reliability factor of the rule is approximate to the \(RF_x\) of an indefinite long interval in the interval.
The distribution interval in a rule may have various kinds of reliability factors, and distribution intervals of different types as well. In addition, there is a need to correct the reliability factors under circumstances where operators such as AND or OR are used. The RFs will be specified individually as follows:

Definition 2:
\[
V_{\text{max}} : \text{the maximal value of the antecedent or consequent of the knowledge set} \\
V_{\text{min}} : \text{the minimal value of the antecedent or consequent of the knowledge set} \\
r : \text{the distribution interval of the previous values of antecedent or consequent of the knowledge set, namely,} \\
r = V_{\text{max}} - V_{\text{min}} \\
\text{max: namely, max} = V_{\text{max}} + r \\
\text{min: namely, min} = V_{\text{min}} - r.
\]

Based on these definitions, the maximal possible distribution interval of the value of antecedents or consequents of a rule can be shown in Fig. 5.

(3) When the distribution interval of the antecedent or consequent value of a rule extends both in positive and negative directions and becomes a bounded interval, Suppose a rule has three different but constant reliability factors \(RF_1, RF_2\), and \(RF_3\) and their corresponding linear lengths are \(L_1\), \(x\) and \(y\) respectively, as is shown in Fig. 4, wherein \(L_2\) is a constant while \(x\) and \(y\) are variables. Through Eq. (4), the RF for the rule can be calculated, as in Eq. (6).

\[
RF = \left(\frac{RF_1 \cdot L_1 + RF_3 \cdot \lim_{x \to +\infty} x + RF_2 \cdot \lim_{y \to +\infty} y}{L_1 + \lim_{x \to +\infty} x + \lim_{y \to +\infty} y}\right) = \frac{RF_1 + RF_3}{2}
\]  

(6)

The RF that represents the rule is approximate to the mean value of the reliability factors of two indefinitely long intervals in the interval.

It can be seen from Eq. (5) and Eq. (6) that when the distribution interval of the antecedent or consequent value of a rule has an unbounded interval, then the reliability factors of other intervals of limited length in the rule are absorbed into the reliability factors of the indefinitely long intervals. The complete failure to actualize the effect will reduce the precision of the RF for the rule, so it is a necessity to fill up the inadequacy.

The main purpose of treating knowledge sets containing conflicts or inconsistency in corresponding values is to choose the rule of the highest reliability derived from the knowledge set. The reliability factor is represented by the relative comparison. Thereby the length of extension in the unbounded interval is restricted and the unbounded interval in which the antecedent or consequent value of a rule is distributed is corrected into two bounded intervals which extend themselves in one direction or both positive and negative directions. Although the extension length is restricted, the reliable factor for the indefinitely long interval will exert the greatest influence over the reliable factor for the rule.
R2: IF a1, THEN (V = V1 OR V = V2)

The RF of R1: RF = min[RF1, RF2] (8)
The RF of R2: RF = max[RF1, RF2] (9)

Example: The following six rules are ones with the same antecedent; the consequents are different in value and include logic operator AND and OR.
R3: IF a1, THEN V > 42.
R4: IF a1, THEN 30 < V ≤ 50.
R5: IF a1, THEN (V < 20 AND V > 70).
R6: IF a1, THEN V < 60.
R7: IF a1, THEN V = 50.
R8: IF a1, THEN (V = 48 OR V > 56).

The distribution interval of the consequent values of these six rules with the same antecedent is an unbounded interval, in which V_{max} = 70 and V_{min} = 20, r = 50, max = 120, min = -30 as in Fig. 7. The RFs for six rules are calculated as follows:
R3: IF a1, THEN V > 42 (RF = 0.466)
R4: IF a1, THEN 30 < V ≤ 50 (RF = 0.44)
R5: IF a1, THEN (V < 20 AND V > 70) (RF = 0.415)
R6: IF a1, THEN V < 60 (RF = 0.336)
R7: IF a1, THEN V = 50 (RF = 0.667)
R8: IF a1, THEN (V = 48 OR V > 56) (RF = 0.667)

3.2 Certainty Rule-based Knowledge Conflict Treatment Algorithm

This method is termed as “Certainty Rule-based Knowledge Conflict Treatment Algorithm” (CRKCTA), and is described as follows.

Input:
ASM, CSM // (Antecedent Similarity Matrix, ASM) and (Consequent Similarity Matrix, CSM) [3]
Output:
RF // the reliability factor of conflicting rules

Step 1: Select the knowledge sets with conflicting rules in accordance with the ASM and CSM
Step 2: Calculate the reliability factor (RF) for each conflicting rule among the conflicting rule sets.
Step 3: Output RF for each conflicting rule.

Step 4: END

4. Conclusion

The study came up with two conclusions based on the aforementioned analysis:
(1) The study provided the Certainty Rule-based Knowledge Conflict Treatment Algorithm using the “reliability factor,” which refers to the reliability level of the knowledge with conflicts or inconsistency in value. This tool can effectively prevent or minimize mistakes in making decisions.
(2) The questionnaire revealed that 94% of users admitted it was perplexing to cite conflicting 92% of them held that the definite RF for conflicting rules was helpful to knowledge applications and auxiliary decision making; and 90% thought the provision of additional relevant and auxiliary information was needed when they were treating conflicting rules.

5. References