Comparison of Typical DS Conflict Evidence Improved Algorithms

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Abstract: Aiming at there will generate a counter-intuitive conclusion when DS evidence theory handle the highly conflict evidence information, some of the existing methods of improvement do not solve these problems well, and there is no unified, widely accepted scheme in the academia. Therefore, several typical improved algorithms are introduced in this paper, and an example is given to show which method is more reasonable, and the effect to handle conflict evidence is better. The results of the paper can provide the ideas for the further research to solve the conflict of evidence.

1 INTRODUCTION

Dempster-Shafer (DS) theory of evidence was first proposed by Dempster in 1967 in studying the multi-valued mapping issues (Dempster, 1967). Shafer further developed it into a systematic theory of uncertain reasoning in Shafer (1976). DS evidence theory is a common and efficient method used to handle uncertain information. After Jeff Barnett introduced the name "Dempster-Shafer" in 1981, the theory quickly acquired textbook status in artificial intelligence (Barnett, 1981). The theory is used in many branches of technology. Articles on the theory and its applications appear in a remarkable number of journals and recurring conferences. Books on the theory continue to appear.

However, in some special situations, especially when dealing with combination of the conflicting evidences, Dempster's combination rule may produce the counter-intuitive result. As an inherent problem, the rule is incapable of managing the high conflicts from various information sources at the step of normalization and may generate counter-intuitive results as first highlighted by Zadeh (1986). In the actual data processing, the situation of evidence conflict is often encountered, so it is necessary to try to avoid the errors caused by the combination of conflicting evidence, otherwise unpredictable consequences can be caused. Therefore, it is an important research topic in this field to study the method of combination of conflicting evidence. By studying the improved

methods, they can be divided into two main categories: One methodology is to modify Dempster's combination rule, which had more satisfactory behaviour compared with Dempster's combination rule. The representative method is Yager's method(Yager, 1983). This method can be also divided into two kinds, which are completely reliable evidence and incompletely reliable evidence. In the case of incomplete reliable evidence, the main issue is how to allocate the conflict, including conflict will be assigned to a subset of what proportion. The unified belief function method represented by Lefevre (2002) is essentially the process of redistributing global conflicts. The above methods, they are based on the closed framework, when the recognition framework is not complete, can not effectively deal with the conflict. Smets (1990) believes that in an unknown environment could not get a poor and complete recognition framework, he put forward the concept of the open framework, the transferable belief model, will be part of the conflict assignment to the empty set. The literature (Yager, 1987; Dubois, 1998) presented the combination method in the open recognition framework. But these methods only for the group with the rest of the empty set reliability value for processing, not considered in BBA generation will be set into the system. On this basis, Deng Yong (2004) systematically put forward the generalized evidence theory. Scholars who put forward this method believe that the cause of high conflict evidence combination failure is due to some defects

of the Dempster's combination rules. However, when Dempster's combination rules are modified, some new rules will usually lose the advantage of meeting commutative law and associative law at the same time.

The other methodology is to pre-process evidence, without changing the Dempster's combination rule. The idea is that the modified combination rule is not a good solution to the conflict of evidence fusion, but some of the advantages of evidence theory cannot be preserved, so using the modified data model, fusion method retains the combination rule to solve the conflict of evidence. This method is mainly divided into the weighted average discount method and evidence. Modify the model proposed by Murphy(2000) is simple average of evidence, weighted average method is more classic, but did not consider the different between evidence. Jousselme(2003) proposed a function of distance between evidences, measure the relevance of evidence. Deng Yong (2011) proposed an effective method for the combination of conflict evidence based on the distance between the evidence put forward by Jousselme. In addition, Paper (Yao, 2012) According to the correlation between evidence, redistribute BPA. The evidence discount model was first proposed by Shafer, take the evidence on the discount factor and endow the remaining credibility with the complete set. Due to the discount method, the remaining reliability of the discount is allocated to the whole set, which increases the uncertainty. When the credibility of the evidence source is low or the credibility information is not available, the conflict problem cannot be well handled. The scholars who are in favour of this kind of methodology believe that the high conflict is due to the unreliable evidence rather than Dempster's rule itself.

In this paper, we refer to the research at home and abroad, and introduce the research status of conflict evidence, several typical improved algorithms are introduced in this paper, and an example is given to show which method is more reasonable, and the effect to handle conflict evidence is better. The conclusions of the paper provides new content and consumption services for further study of evidence theory, and enhances the ability of reasoning decision-making by using conflicting evidence.

2 DS EVIDENCE THEORY AND ITS DEFICIENCY

In this section, the basic concepts and shortcomings of DS evidence theory are introduced.

2.1 DS evidence theory

In theory of evidence, all of the objects of the study are called the frame of discernment, here are some basic concepts.

Definition 1: Let Θ be the frame of discernment, Θ is incompatible focal element. A basic probability assignment (BPA) is a function m mapping from 2^{Θ} to [0, 1], which satisfies the following conditions

$$m(\phi) = 0 \tag{1}$$

$$\sum_{A \subset \Theta} m(A) = 1 \tag{2}$$

Definition 2: Suppose $m_1, m_2, \ldots, m_n$ be n BPAs on Θ, then the Dempster's combination rule can be defined as:

$$m(A) = \begin{cases} 0 & A = \phi \\ \dfrac{\sum\limits_{A_i \cap B_j = A} m_1(A_i) m_2(B_j)}{1 - K} & A \neq \phi \end{cases} \tag{3}$$

Where $K = \sum\limits_{A_i \cap B_j = \phi} m_1(A_i) m_2(B_j)$ $(0 < K < 1)$ is the conflict coefficient reflecting the degree of conflict between the two sources of evidence.

2.2 The deficiency of DS evidence theory

When the conflict of evidence is small, the DS combination rule of evidence theory can centrally set the credibility of evidence to a higher certainty. But in larger evidence conflict or completely opposite, because the DS theory discarded all the conflicts and lost its fusion ability, the combination conclusion was often contrary to the actual situation. The following examples are illustrated.

Example 1. Consider $\Theta = \{A, B, C\}$ and two experts opinions given by m1(A) =0.9, m1(B) = 0, m1(C) = 0.1, and m2(A) =0, m2(B) = 0.9, m2(C) = 0.1.

According to the results of combination, we can get table 1.

Table 1: combination results of DS theory.

m 2	m 1		
	A (0.9)	B (0)	C (0.1)
A (0)	A(0)	$\varnothing$(0)	$\varnothing$(0)
B (0.9)	$\varnothing$(0.81)	B(0)	$\varnothing$(0.09)
C (0.1)	$\varnothing$(0.09)	$\varnothing$(0)	C (0.01)

It can be seen that K＝0.09+0.81+0.09=0.99. evidence m1 and m2 are highly conflicting, highly supported by A and B, respectively. However, the BBA resulting in the combination using Dempster's rule is :

m (A)=(0)/(1-K)=0；

m(B)=(0)/(1-K)=0;

m (C)=(0.001)/(1-K)=1．

It is the counter-intuitive result that m(C) = 1.. The combination is failed.

Example2. Consider $\Theta = \{A, B\}$

m1:　　　　m1(A) =0　　　m1(B) = 1
m2:　　　　m2(A) =1　　　m2(B) = 0

According to the rules of combination of DS theory: K=1*1+0*0=1. It shows that evidence is completely conflicting, because the composite denominator is zero at this time, and the DS theory can not fuse the data. The DS evidence theory is invalid and can not make any decisions based on the known evidence. When only consider the non inclusiveness between the evidence, in the normalization process, DS evidence theory discards all information, and can not get ideal fusion results.

3 TYPICAL IMPROVED METHODS

The DS evidence theory has been developed over four decades and blossomed in various fields, but the evidence of conflict still cannot be combined well. The problem enlightened by the now famous Zadeh's example is the repartition of the global conflict. To solve this problem, many scholars have proposed a variety of improved methods. There has been no uniform and widespread solution so far. Here we introduce two classic improved algorithms.

3.1 Yager's method

Yager (1983) proposed a modified method which assigned the conflicting mass assignments to the unknown state. The idea is that the paradox is due to fusion of conflict evidence deduction of the fused

empty part of the reliability, the remaining reliability was normalized to produce, so we need to modify the rules of combination. The improved combination formula is as follows:

$$m(A) = \sum_{B \cap C = A} m_1(B)m_2(C) \qquad (4)$$

$$m(\Theta) = m_1(\Theta)m_2(\Theta) + \sum_{B \cap C \neq \phi} m_1(B)m_2(C) \qquad (5)$$

3.2 Murphy's method

In document [18], Murphy proposes a fast convergence method. When there are N evidence in the system, the Murphy rule first calculates all the evidence's average value of the propositional support in the recognition framework, then uses DS merging rules to iterate N-1times.

$$\overline{m}(X) = \frac{1}{N} \sum_{i=1}^{N} m_i(X) \qquad \forall X \in \Theta \qquad (6)$$

$$m(A) = \frac{\sum_{B \bigcap C} \overline{m}(B)\overline{m}(C)}{1 - \overline{k}} \qquad (7)$$

$$\overline{k} = \sum_{B \bigcap C = \varnothing} \overline{m}(B)\overline{m}(C) \qquad (8)$$

4 COMPARISON STUDIES OF MAIN METHODS

In this section, some numerical examples with conflicting BOEs are given to demonstrate the effectiveness of the different method by comparing with Dempster's rule, Yager's method and Marphy's method.

Example3. Consider $\Theta = \{A, B, C\}$

m1(A)=0.5　m1(B)=0.2　m1(C)=0.3
m2(A)=0　　m2(B)=0.9　m2(C)=0.1
m3(A)=0.6　m3(B)=0.1　m3(C)=0.3

According to the combination rules, results are shown in table 2 and table 3.

Table 2: comparison of combined results of improved algorithm 1.

m1、m2	A	B	C	Θ
DS	0	0.8571	0.1429	0
Yager's	0	0.18	0.03	0.79
Murphy's	0.1543	0.7469	0.0988	0

Table 3: comparison of combined results of improved algorithm 2.

m1、m2、m3	A	B	C	Θ
DS	0	0.666	0.3334	0
Yager's	0	0.018	0.009	0.973
Murphy's	0.3912	0.5079	0.0988	0

As seen from Table 2 and Table 3, classic DS combination rule of evidence theory for highly conflict evidence cannot be fused because m2(A)=0, it totally negate evidence A, even if there is a lot of evidence support evidence A, its fusion results always show m2(A)=0. Yager's method is similar to the combination rule of the classic DS evidence theory, it can not solve the above problems effectively, and is too conservative. The scope of the unknown area is expanding. Although there are many evidences, it can not get the ideal conclusion and cannot make decisions based on it. Murphy's method is only a simple mean of evidence, and does not take into account the compatibility between evidence and conflict. But the effect to handle conflict evidence is better than that of the two methods mentioned above. It is proved by the examples that Murphy's method can effectively compensate for the shortcomings of DS evidence theory and Yager's method, and it can get a more ideal conclusion. However, due to the objectivity of conflict, the conflict of evidence theory has not yet been solved thoroughly, so it needs further study.

5 CONCLUSIONS

Through the comparison of the examples above, compared to the modified combination rule, the way to modify the body of evidence is more effectively. Because the modification of rules often destroys the exchange rules of the Dempster's rule, combining the excellent properties of law. In fact, if the evidence conflict between sensor failure or sensor report is not accurate, it is not reasonable to blame

the combination rule directly. Therefore the solution of the DS conflict evidence should pay attention to pre-process evidence, which may result in better results.

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