Proceedings of the 2013 International Conference on Machine Learning and Cybernetics, Tianjin, 14-17 July, 2013

A NOVEL APPROACH TO EVIDENCE COMBINATION IN BATTLEFIELD SITUATION ASSESSMENT USING DEZERT-SMARANDACHE THEORY

HUIMIN CHAI

School of Computer Science and Technology, Xidian University, Xi'an, China

Abstract:

Situation assessment, which belongs to high level information fusion, plays an important role in military decision-making systems. In order to combine the fuzzy evidence in situation assessment, a novel approach based on Dezert-Smarandache theory(DSmT) is described in this paper. The model of fuzzy synthetic judgement is constructed to estimate the intension of force group. The characteristics of force group, including the speed, the distance and the direction, are mapped into fuzzy sets and taken as the inputs of the model. Then the results of estimation between two consecutive time moments are combined based on DSmT. Finally, a simple application is illustrated and the comparison between DSmT and Dempster-Shafer theory is given.

Keywords

Situation assessment; DSmT; Fuzzy synthetic judgement

1. Introduction

Situation assessment belongings to high-level information fusion, and its goals include identifying the meaningful events and activities, deriving higher order relations among objects and inferring the intension. In the Joint Development Laboratory(JDL) fusion model, situation assessment is defined at the level 2 data fusion, accepts the results from level 1 data fusion and provides an accurate and timely picture of the battlefield situation[1].

Today, the modern battlefield is characterized by an overwhelming volume of information collected from a vast networked array of increasingly more sophisticated sensors and technologically equipped troops[2,3]. There remains a significant need for higher level information fusion such as those required for battlefield situation assessment. The information of battlefield situation assessment has the characteristics of fuzziness, uncertainty and inconsistency. It will greatly affect the decision making in situation assessment systems if the evidence information cannot be effectively combined.

Dempster-Shafer theory(DST, DS theory) of evidence[4] is a mainstream theory for information fusion and it can be used to model and combine with uncertain information in decision-making support systems[5,6]. However, the DS theory cannot combine the highly conflicting evidences[7,8]. The counterintuitive results of applying Dempster's combination rule to conflicting beliefs will be obtained. In order to resolve the problem, alternative combination rules have been explored to recommend where there is the mass of the conflicting belief from the two sources. The three well-known alternatives include: Smets's unnormalized combination rule[9], Dubois and Prade's disjunctive combination rule[10], and Yager's combination rule[11]. The three alternatives listed above re-distribute the mass of the combined belief assigned to the empty set(the false assumption) in a flexible way. These alternative combination rules can adapt to the conflicting evidence, but not resolve the problem from the nature of conflicting evidence.

The Dezert-Smarandache theory (DSmT) is proposed by Dr. Jean Dezert in the year of 2002[12] and developed with Prof. Florentin Smarandache[13]. Compared with DS theory, the Dezert-Smarandache theory assures a particular framework where the frame of discernment is exhaustive but not necessarily exclusive. And it can deals with imprecise, uncertain or paradoxical data. In the paper, the Dezert-Smarandache theory is used to fuse the fuzzy evidence in the battlefield situation assessment.

The rest of the paper is organized as follows. In Section 2, the problem on estimation of target intension is discussed. In Section 3, we review the basic definitions in DS theory. In Section 4, the definitions in DSmT are introduced, including DSm rule of combination. In Section 5, the model of fuzzy synthetic judgement is constructed and the process of utilizing the DSmT is described. In Section 6, a simple application is illustrated and the fused results are compared between DS theory and DSmT. Section 7 concludes the main contribution of the paper and presents the prospect for future work.

2. Statement of the Problem

It is very important for situation assessment to obtain the result with high confidence by fusing a large volume of information received from level 1 fusion and the other

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intelligence reports. However, there remains a difficult problem that how to fuse the high level information for situation assessment. In the paper, our efforts are to estimate the force group intension according to the group characteristics. Now suppose that several force groups are classified at time *T*. The set S_t is used to represent the force groups as:

$$S_t = \{g_1, g_2, ..., g_n\}$$

where g_i denotes the i-th group in the current battlefield.

The attribute vector for the i-th force group contains the speed, the position, the direction. It can be defined as

$$G(i) = (L, S, D)$$

where L represents the estimated x, y and z locations: (x, y, z), S represents its speed and D denotes the direction of force group.

Our goal is to estimate and predict the possible intension of force group in the current battlefield by analyzing the attributes of force group. The process of estimating the force group intension is shown in the following.

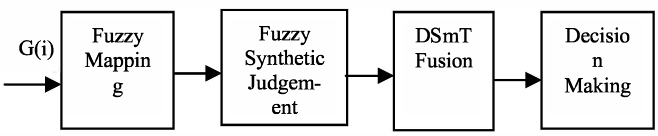

Figure 1. The process of force group intension estimating

In Fig.1, the attribute vector for force group *G(i)* is mapped into fuzzy sets according to fuzzification method and the model based on fuzzy synthetic judgement is utilized to estimate the intension of force group. Then, the results of estimation between two consecutive time moments are fused based on DSmT and the decision making is done.

3. Basics of the Dempster-Shafer theory

A few concepts commonly used in the Dempster-Shafer theory of evidence are reviewed. The Dempster-Shafer theory considers a discrete and finite frame of discernment based on a set of exhaustive and exclusive elementary elements. Let Ω be a finite set called the frame of discernment.

Definition 1. [14] A basic belief assignment(bba) is a mapping m: $2^{\Omega} \to [0,1]$ that satisfies $\sum_{A \subseteq \Omega} m(A) = 1$.

In Shafer's original definition which he called the basic probability assignment, condition $m(\varnothing) = 0$ is required in Definition 1. Recently, some of the papers on Dempster-Shafer theory, especially since the establishment of the Transferable Belief Model(TBM)[15], condition $m(\varnothing) = 0$ is often omitted.

Definition 2. The belief function from a bba *m* is defined as $bel: 2^{\Omega} \to [0,1]$,

$$bel(A) = \sum_{B \in 2^{\Omega}, B \subseteq A} m(B)$$

and the plausibility function is defined as :

$$pl(A) = \sum_{B \in 2^{\Omega}, B \cap A \neq \phi} m(B) = 1 - bel(\overline{A})$$

when $m(A) > 0$, A is called a focal element of the belief function.

Definition 3. Let m_1 and m_2 be two bbas defined on frame Ω which are derived from two distinct sources. By Dempster's rule of combination, the combined bba is $m_{\oplus} = m_1 \oplus m_2$ where $\oplus$ denotes the operator of combination. Then

$$\begin{cases} m(\varnothing) = 0 \\ m_{\oplus}(A) = \dfrac{\sum_{\substack{X,Y \subseteq \Omega \\ X \cap Y = A}} m_1(X) m_2(Y)}{1 - \sum_{\substack{X,Y \subseteq \Omega \\ X \cap Y = \varnothing}} m_1(X) m_2(Y)} \quad (\forall (A \neq \varnothing) \in 2^{\Theta}) \end{cases} \qquad (1)$$

when $\sum_{\substack{X,Y \subseteq \Omega \\ X \cap Y = \varnothing}} m_1(X) m_2(Y)$ is not equal to "1".

Two beliefs from different evidence sources are in conflict in the context of Dempster-Shafer theory as one source strongly supports one hypothesis and the other strongly supports another hypothesis. In DS theory, a conflict between two beliefs from different sources can be represented as:

$$K_{12} = \sum_{\substack{X,Y \subseteq \Omega \\ X \cap Y = \varnothing}} m_1(X) m_2(Y) \qquad (2)$$

If the two beliefs are in conflict, the value of K_{12} will be very large. So far, in Dempster-Shafer theory, the value of K_{12} can be commonly taken as the quantitative measure of the conflict. The two beliefs are totally in conflict as $K_{12} = 1$ and the Dempster's rule of combination cannot be applied.

4. Dezert-Smarandache Theory

In some practical fusion applications, the fusion results lead to an unreasonable conclusion or cannot provide a reliable results at all as two pieces of evidence are in high conflict. To overcome the limitations of DS theory, a new theory of plausible and paradoxical reasoning, Dezert-Smarandache theory has been developed. In general, DSm theory can be considered as a generalization of the DS theory.

In the Dezert-Smarandache theory, the possibility for paradoxes(partial overlapping) between elements of the frame of discernment is allowed. Consequently, the imprecise or vague concepts can be described by the elements of the frame of discernment in DSm theory. On the other hand, the frame is usually interpreted differently by the distinct sources of evidences or experts. Some subjectivity on the information provided by a source of evidence is almost unavoidable. It will lead to the conflict between the different sources of evidences. The Dezert-Smarandache theory can deal with the conflicting evidences from different sources.

The Dezert-Smarandache theory can be considered as a general and direct extension of probability theory and the DST in the following sense. Let $\Omega = \{\theta_1, \theta_2\}$ be the simplest frame of discernment involving only two elements.

- under the condition of a finite frame of discernment based on a set of exhaustive and exclusive elements, the probability theory deals with basic probability assignments $m(\bullet) \in [0,1]$ as follows: $m(\theta_1) + m(\theta_2) = 1$;
- under the same condition, the DST deals with bba $m(\bullet) \in [0,1]$ such that: $m(\theta_1) + m(\theta_2) + m(\theta_1 \cup \theta_2) = 1$
- under the condition of exhaustivity, the DSmT theory deals with new bba $m(\bullet) \in [0,1]$ in the following: $m(\theta_1) + m(\theta_2) + m(\theta_1 \cup \theta_2) + m(\theta_1 \cap \theta_2) = 1$.

a) Hyper-Powerset

The concept of hyper-powerset is the important basis of the Dezert-Smarandache theory. Suppose $\Omega = \{\theta_1, \theta_2, \ldots \theta_n\}$ be a set of n elements which cannot be precisely defined and separated. The hyper-powerset, denoted as D^Ω, is defined as the set of all composite propositions built from elements of Ω with the operators $\cup$ and $\cap$.

(1) $\varnothing, \theta_1, \theta_2, \ldots, \theta_n \in D^\Omega$

(2) If $A, B \in D^\Omega$, then $A \cap B \in D^\Omega$ and $A \cup B \in D^\Omega$

(3) No other elements belong to D^Ω, except those obtained by using rules (1) or (2).

The cardinality of D^Ω is majored by 2^{2^n} when $Card(\Omega) = |\Omega| = n$. The generation of hyper-powerset D^Ω is closely related with the famous Dedekind's problem on enumerating the set of monotone Boolean functions.

From a general frame of discernment Ω, a mapping $m(\bullet): D^\Omega \to [0,1]$ is defined as follows:

$$m(\varnothing) = 0, \sum_{A \in D^\Omega} m(A) = 1$$

And $m(\bullet)$ is called generalized basic belief assignment(gbba). The belief and plausibility functions are defined in almost the same way as in the Dempster-Shafer theory:

$$bel(A) = \sum_{B \in D^\Omega, B \subseteq A} m(B)$$

$$pl(A) = \sum_{B \in D^\Omega, B \cap A \neq \phi} m(B) = 1 - bel(\overline{A})$$

b) DSm Classic Rule of Combination

The two gbbas $m_1(\bullet)$ and $m_2(\bullet)$ defined on frame Ω which are derived from the two distinct evidence sources. The DSm classic(DSmC) rule of combination $m_{\mu^f}(\Omega) \equiv m(\bullet) = [m_1 \oplus m_2](\bullet)$ is given by[16]:

$$\forall C \in D^\Omega, m_{\mu^f}(\Omega)(C) \equiv m(C) = \sum_{X_1, X_2 \in D^\Omega, X_1 \cap X_2 = C} m_1(X_1) m_2(X_2) \tag{3}$$

Since D^Ω is closed under the operators $\cup$ and $\cap$, this new rule of combination guarantees that $m(\bullet): D^\Omega \to [0,1]$ is a proper generalized basic belief assignment.

The DSmC rule of combination is commutative and associative. The classic DSm rule of combination is used in free DSm model in which there is not constraint condition. It can be utilized to fuse uncertain or paradoxical sources of evidences. The fusion process based on the DSmC rule can deal with the conflict between different pieces of evidence.

c) DSm Hybrid Rule of Combination

However, some constraint conditions may be considered in the process of information fusion. If there is some constraint conditions, instead of DSm classic rule, the DSm hybrid(DSmH) rule of combination should be utilized that is shown in the following:

$$
\begin{aligned}
& m_{\mu}(\Omega)(C) \equiv \varnothing(C)[S_1(C) + S_2(C) + S_3(C)] \\
& S_1(C) = \sum_{X_1, X_2 \in D^{\Omega}, X_1 \cap X_2 = C} m_1(X_1) m_2(X_2) \\
& S_2(C) = \sum_{\substack{X_1, X_2 \in \varnothing \\ [(u(X_1) \cup u(X_2)) = C] \vee [(u(X_1) \cup u(X_2) \in \varnothing) \wedge (C = I_t)]}} m_1(X_1) m_2(X_2) \\
& S_3(C) = \sum_{\substack{X_1, X_2 \in D^{\Omega} \\ (X_1 \cup X_2) = C \\ X_1 \cup X_2 \in \varnothing}} m_1(X_1) m_2(X_2)
\end{aligned} \tag{4}
$$

where $\varnothing = \{\Phi, \varnothing_{\mu}\}$ is the constrain condition set that includes absolute empty condition Φ and relative empty condition $\varnothing_{\mu}$, and $I_t = \theta_1 \cup \theta_2 \cup \ldots \cup \theta_n$. $\varnothing(C)$ is nonempty characteristic function. If $C \in \varnothing$, the value of $\varnothing(C)$ is '0', else is '1'.

5. Estimation of Force Group Intension

a) Model of Fuzzy Synthetic Judgement

In order to estimate the force group intension, the model of fuzzy synthetic judgement is to be defined and will be consistent with the changes of force group characteristics in consecutive time moments $T = T_1, T_2, \ldots, T_n$. The characteristics of force group, including the speed, the distance and the direction angle, are the inputs of the model.

In the paper, the attacking intension is discussed, which is used to estimate the possibility for the force group to attack our target. There are three states to be estimated that include *Big*, *Medium* and *Small*, which respectively denote the possibility of the intension of attacking our target is big, medium or small. Obviously, the three states are not precise and the union set of the two adjacent states is not empty. For example, $Small \cap Medium \neq \varnothing$.

The model based on fuzzy synthetic judgement can be represented as the triple:

$$M = (U, V, \tilde{R}) \tag{5}$$

where $U = \{u_1 = speed, u_2 = distance, u_3 = angle\}$ is the set of judgement factors. $V = \{v_1 = small, v_2 = medium, v_3 = big\}$ denotes the set of estimation levels. $\tilde{R}$ is the judgement matrix that is composed of judgement result of each factor, which can be represented as the following:

$$\tilde{R} = \begin{matrix} speed \\ distance \\ angle \end{matrix} \overset{\begin{matrix} small & medium & big \end{matrix}}{\begin{bmatrix} r_{11}, & r_{12}, & r_{13} \\ r_{21}, & r_{22}, & r_{23} \\ r_{31}, & r_{32}, & r_{33} \end{bmatrix}} \tag{6}$$

$\tilde{A} = (a_1, a_2, a_3) = (0.25, 0.35, 0.4)$ is the weight vector that represents the importance for each judgement factor. The Mamdani inference algorithm is utilized in the process of estimation, then the judgement result $\tilde{B} = (b_1, b_2, b_3)$ of the model can be computed in the following:

$$\tilde{B} = \tilde{A} \circ \tilde{R} = \vee_{1 \le i \le 3, 1 \le j \le 3} (\mathrm{a}_i \wedge \mathrm{r}_{ij}) \tag{7}$$

From the result of fuzzy synthetic judgement, the possibility of attacking intension of force group can be obtained in form of the vector: $\tilde{B} = \{b_1(small), b_2(medium), b_3(big)\}$.

b) Fuzzification of Force Group Attributes

In the process of utilzing the attacking model based on fuzzy synthetic judgement, each judgement factor should be effectively measured under the estimation levels: $V = \{v_1 = small, v_2 = medium, v_3 = big\}$. In the paper, the fuzzification method is used to map the attributes of force group into fuzzy sets. There are three attributes that need to be fuzzified, including: the speed of force group, the distance between the force group and our target and the angle between the direction from the current position of the group to our target and the speed vector of the group.

For the force group speed, the fuzzy set is defined as $\mu_S = \{small, medium, big\}$. It denote that the estimation level of attacking our target is small, medium or big. The membership function of fuzzy set μ_S is defined by

$$\mu_{S(small)}(x) = \begin{cases} 1 & x \le v_1 \\ (v_2 - x)/(v_2 - v_1) & v_1 < x \le v_2 \\ 0 & x > v_2 \end{cases} \tag{8}$$

$$\mu_{S(med)}(x) = \begin{cases} 0 & x \le v_2 - v_p \\ (x - v_2 + v_p)/v_p & v_2 - v_p < x \le v_2 \\ (v_2 + v_p - x)/v_p & v_2 < x \le v_2 + v_p \\ 0 & x > v_2 + v_p \end{cases} \tag{9}$$

$$\mu_{S(big)}(x)=\begin{cases}0 & x\le v_2\\ (x-v_2)/(v_3-v_2) & v_2<x\le v_3\\ 1 & x>v_3\end{cases} \quad (10)$$

The member function of fuzzy set μ_S is belonging to triangular distribution, which is illustrated in Fig.2. According to expert knowledge, the parameters of μ_S for air force group can be set as: $v_1 = 0.5Ma$, $v_2 = 1.5Ma$, $v_3 = 2.5Ma$, $v_p = 1Ma$.

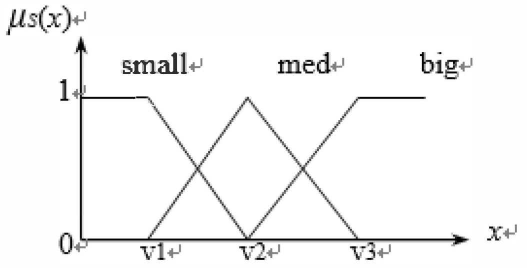

Figure.2 The membership function of fuzzy set μ_S

For the judgement factor of the distance between the estimating force group and our target, it can be computed as:

$$\|G_i - Target\| = \sqrt{(\overline{x}_i - x_{Target})^2 + (\overline{y}_i - y_{Target})^2 + (\overline{z}_i - z_{Target})^2} \quad (11)$$

where $(\overline{x}_i, \overline{y}_i, \overline{z}_i)$ and $(x_{Target}, y_{Target}, z_{Target})$ respectively denote the position of group G_i and our Target. In order to evaluate the posibility of attacking our target for the factor of distance, the corresponding fuzzy set $\mu_D = \{small, medium, big\}$ is defined. The membership function of fuzzy set μ_D is also belonging to the triangular distribution that is shown in Fig.3.

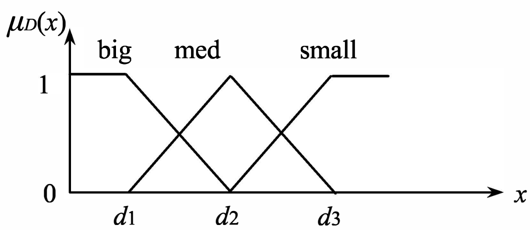

Figure.3 The membership function of fuzzy set μ_D

For air force group, the parameters of μ_D can be set as: $d_1 = 30km$, $d_2 = 150km$, $d_3 = 270km$.

For the judgement factor of the angle, it represents the angle difference between the force group speed vector and the direction from the current position of the group to our target, which is illustrated in Fig.4.

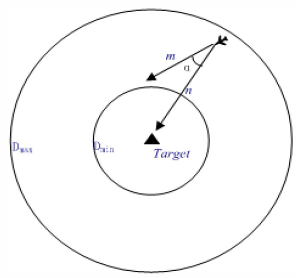

Figure.4. The diagram of the judgement factor of the angle

In Fig.4, the triangle mark and the airplane mark respectively denote our target and the force group, $\vec{m}$ denotes the vector of the force group speed, $\vec{n}$ represents the direction vector from the group to our target and α is the angle between $\vec{m}$ and $\vec{n}$.

Suppose $\vec{m} = (m_x, m_y, m_z)$ and $\vec{n} = (n_x, n_y, n_z)$, the angle α can be computed as the following:

$$\alpha = \cos^{-1}\frac{m_x \times n_x + m_y \times n_y}{\sqrt{(m_x^2 + m_y^2)(n_x^2 + n_y^2)}} \quad (12)$$

Obviously, α is the angle difference between $\vec{m}$ and $\vec{n}$ in XOY plane.

For the evaluation of the angle α under the estimation levels $\{small, medium, big\}$, the corresponding fuzzy set $\mu_\alpha = \{small, medium, big\}$ is defined. The membership function of fuzzy set μ_α is belonging to the triangular distribution that is shown in Fig.5.

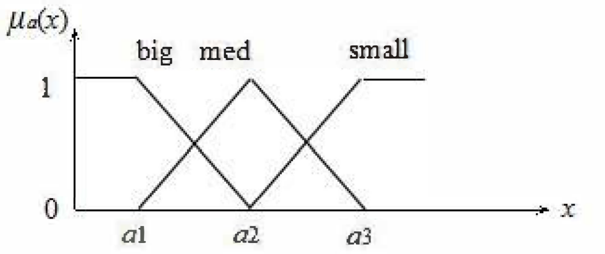

Figure.5 The membership function of fuzzy set μ_D

In Fig.5, for the airplane group, the parameters of μ_a can be set as: $\alpha_1 = \pi/6$, $\alpha_2 = 7\pi/18$, $\alpha_3 = 11\pi/18$.

c) Assessment Updating using DSmT

In order to be assured of awareness about the tendencies of force group intension, the results of fuzzy synthetic judgement in the attacking model are fused. Because the states of estimation results(that are small, medium and big) are fuzzy and not exclusive, Dezert-Smarandache theory is available to fuse information here for the estimation result updating. For there is constrain condition $\mu_f = (small \cap big \equiv \varnothing)$, the DSm hybrid(DSmH) rule of combination is employed to combine two results of intension estimation between two consecutive time moments T_{i-1} and T_i.

As mentioned above, D^Ω is closed under operators $\cup, \cap$ and a mapping $m(\bullet): D^\Omega \to [0,1]$ should be guaranteed. Consequently, it is necessary to transform the results of fuzzy synthetic judgement into mass function. In the paper, it is realized through the normalization with respect to the unity interval. According to the result of fuzzy reference, the normalization is made to obtain gbba in DSm theory:

$$m(Small) = \frac{b_1(Small)}{b_1(Small) + b_2(Medium) + b_3(Big)}$$
$$m(Medium) = \frac{b_2(Medium)}{b_1(Small) + b_2(Medium) + b_3(Big)} \quad (13)$$
$$m(Big) = \frac{b_3(Big)}{b_1(Small) + b_2(Medium) + b_3(Big)}$$

Let $\Omega = \{Small, Medium, Big\}$, the estimation of force group intension at time T_i is updated from two gbbas that are respectively at time T_{i-1} and T_i : $m_{Ti-1}(\bullet)$ and $m_{Ti}(\bullet)$ by the DSmH rule of combination. While using the DSmH rule of combination, the constraint condition is μ_f=(small $\cap$ big $\equiv \varnothing$). According to equation(4), the estimation of force group intension can be updated.

In our case, the frame of discernment $\Omega = \{Small, Medium, Big\}$ is not exclusive. The paradoxical estimations $Small \cap Medium$ and $Medium \cap Big$ can be taken into account in the process of combining two results of intension. For example, $Small \cap Medium$ relates to the case when the moving force group arrives at an intermediate region and it is hard to estimate the group intension is small or medium. The union of element on frame Ω (for example, $Small \cup Big$) is considered as the unknown state of force group estimation.

6. Experiments and Results

This section presents a simple application in which the intension of force group is estimated in situation assessment system. Let's consider the following scenario: the enemy attempt to attack our target and send out some aircrafts to access to our base. Based on the results of force group classification, the enemy aircrafts can be classified into three force groups: Cluster1,Cluster2 and Cluster3, which is shown in the following.

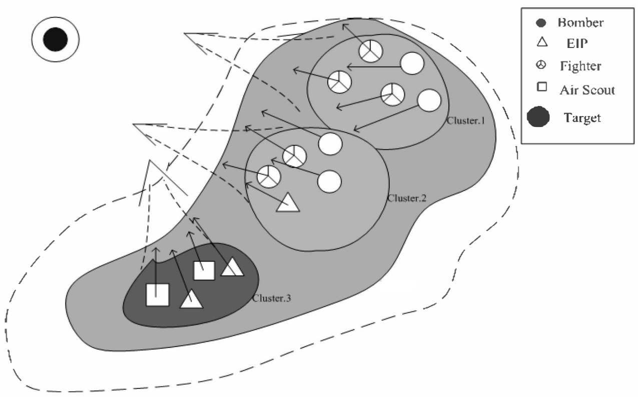

Figure.6 The diagram of battlefield situation assessment

For force group Cluster1, the attributes of the speed, the distance and the angle collected at four consecutive time moments are given in Table1.

Table.1 The Attributes of force group Cluster1

Time	Speed(Ma)	Distance(Km)	Angle(Degree)
T1	0.61	201.5	95.0
T2	0.78	172.4	67.3
T3	1.17	128.5	64.7
T4	1.78	72.6	47.2

Based on the fuzzy algorithm in Section 5.2, the attributes of force group Cluster1 is mapped into the fuzzy vector: $(small, medium, big)$. The results of the fuzzification of speed, distance and angle are shown in Table2. For example, the speed of force group Cluster1 is fuzzified as: $(small = 0.89, medium = 0.11, big = 0)$.

Table.2 The results of fuzzification for group attribute

Time	Speed	Distance	Angle
T1	(0.89,0.11,0)	(0.43,0.57,0)	(0.38,0.62,0)
T2	(0.72,0.28,0)	(0.19,0.81,0)	(0,0.93,0.07)
T3	(0.33,0.67,0)	(0,0.82,0.18)	(0,0.87,0.13)
T4	(0,0.72,0.28)	(0,0.35,0.65)	(0,0.43,0.57)

Then, the model of fuzzy synthetic judgement defined in Section 5.1 is used to assess the possibility for the force group Cluster1 attacking our target. Furthermore, the estimation results of group Cluster1 are normalized for four moments, which is given in Table3.

Table.3 The results of fuzzy synthetic judgement

Time	Small	Medium	Big
T1	0.49	0.51	0
T2	0.35	0.56	0.09
T3	0.30	0.48	0.22
T4	0	0.5	0.5

Nextly, the the DSm hybrid(DSmH) rule of combination and Dempster's rule respectively are used to combine the results of estimated intension between two consecutive time moments T_{i-1} and T_i. The results of combination are give in Table.4.

Table.4 The results of combination by DST and DSmH

Time		Small	Small∩Medium	Medium	Medium ∩Big	Big	Small ∪ Big
T1+T2	DST	0.38		0.62		0	
	DSmH	0.17	0.45	0.29	0.05	0	0.04
T2+T3	DST	0.27		0.68		0.05	
	DSmH	0.11	0.33	0.27	0.17	0.02	0.10
T3+T4	DST	0		0.69		0.31	
	DSmH	0	0.15	0.24	0.35	0.11	0.15

As shown in Table.4, according to Dempster's rule of combination in DS theory, the fused estimation results include *Small, Medium* and *Big*. For DSm hybrid rule of combination, the fused results include $Small, Small \cap Big, Medium, Medium \cap Big, Big, Small \cup Big$. $Small \cup Big$ denotes the estimation of force group intension is unknown. From the result of combination, it is illustrated that DSm theory can contribute to a better understanding of force group motion and intension.

In order to compare the DS theory with the DSm theory, three figures are given in the following, in which the result before combination, the combination results by Dempster's rule and DSm hybrid rule are respectively shown.

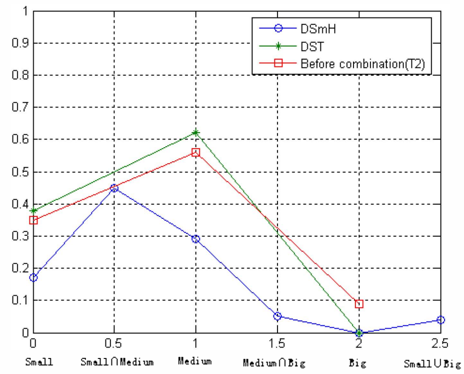

Figure.7 The combination result with time moment T1 and T2

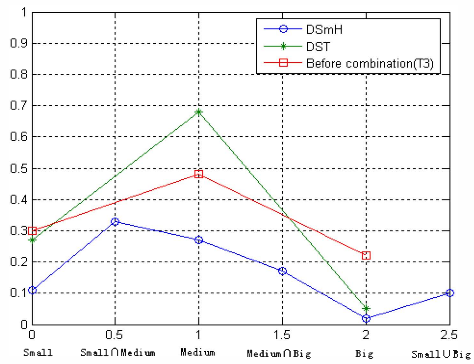

Figure.8 The combination result with time moment T2 and T3

In Fig.7 and Fig.8, compared with Dempster's rule, the combination results by DSm hybrid rule have the better understanding for force group estimated intension for two result states $Small \cap Big, Medium \cap Big$ are added. In contrast to DS theory, DSm theory can deal with imprecise concept and fuse fuzzy data set.

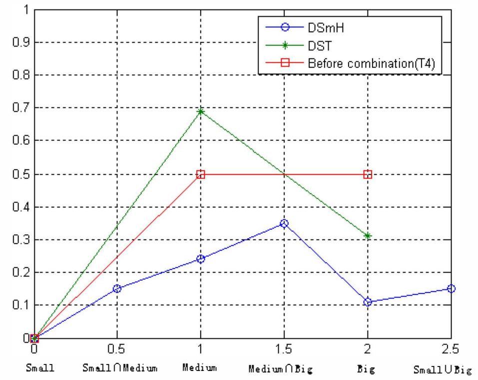

Figure.9 The combination result with time moment T3 and T4

DSm hybrid rule can deal with the conflict more effectively than Dempster's rule. The conflict between two consecutive moment results is transferred to the unknown estimation state $Small \cup Big$ by DSm hybrid rule. In Fig.9, the maximum value of combination result is $Medium \cap Big$ by DSm hybrid rule and the maximum value of combination result is *Medium* by Dempster's rule. Before combination, the force group attacking intension is *Medium* or *Big*. It shows that the result of DSm hybrid rule is more reasonable than that of Dempster's rule.

7. Conclusion

A good understanding of force group intension is important for battlefield situation assessment. In the paper, a approach based on Dezert-Smarandache theory(DSmT) is discussed to solve the fusion of imprecise and fuzzy information in situation assessment. Compared with the DS theory, DSmT can deal with the fuzzy evidence more effectively. The model of fuzzy synthetic judgement is constructed to estimate the intension of force group. In the future work, the fusion of different type of information by DSmT, such that intelligence report, terrain data and sensors data, would be studied.

Acknowledgements

The research is supported by the Fundamental Research Funds for the Central Universities(No.KS0510030005) and the National Natural Science funds(No.61070143).

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