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Fuzzy Sets and Systems 77 (1996) 265–276

FUZZY sets and systems

Evaluating weapon systems using fuzzy arithmetic operations

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Received May 1994; revised January 1995

Abstract

In this paper, we present a new method to deal with the performance evaluation of weapon systems using fuzzy arithmetic operations. An example of tactical missile systems selection is used to illustrate the performance evaluation process of weapon systems. Because the proposed methods uses simplified fuzzy arithmetic operations of fuzzy numbers rather than the complicated entropy weight calculations mentioned in [7], its execution is much faster than the one presented in [7].

Keywords: Military application; Tactical missile system; Fuzzy number; Fuzzy arithmetic operations; Analytic hierarchy process; Defuzzification

1. Introduction

Mon et al. [7] pointed out that the performance evaluation and optimal design of weapon systems are multiple criteria decision-making problems. They also pointed out that the descriptions and judgements on weapon systems are usually linguistic and fuzzy, and the traditional analytic hierarchy process method (AHP) [8, 9] has some shortcomings in evaluating weapon systems. Thus, in [7], they presented a method for evaluating weapon systems using fuzzy AHP based on entropy weight calculations [6]. Mon et al. [7], pointed out that the Satty's AHP method has the following shortcomings:

(1) The AHP method is mainly used in nearly crisp (non-fuzzy) decision applications.

(2) The AHP method creates and deals with a very unbalanced scale of judgements.

(3) The AHP method does not take into account the uncertainty associated with the mapping of one's judgement to a number.

(4) Ranking of the AHP method is rather imprecise.

(5) The subjective judgement, selection and preference of decision makers have large influene on the AHP method.

However, the entropy weight method presented by Mon et al. [7] also has the following shortcomings:

(1) The derivation of the fuzzy judgement vector is very subjectively.

(2) The entropy weight method is not efficient enough due to the fact that it uses complicated entropy weight calculations for decision making.

SSDI 0165-0114(95)00096-8

To overcome these problems, we will propose a new method for evaluating weapon systems based on [1, 5, 7] using fuzzy number arithmetic operations, where the degrees of satisfiability for each system with respect to each criteria item are ranked by integer numbers, and the summation of these rank scores denotes the degree of satisfiability of the system with respect to the criteria and is represented by a triangualar fuzzy number. Furthermore, the weight of each criteria supplied by the decision maker is also represented by triangular fuzzy numbers. Because the proposed method uses simplified fuzzy number arithmetic operations rather than the complicated entropy weight calculations mentioned in [7], its execution is much faster than the one presented in [7].

2. Fuzzy number arithmetic operations

In 1965, Zadeh presented the theory of fuzzy sets [11]. Let U be the universe of discourse, $U = \{u_1, u_2, \ldots, u_n\}$. A fuzzy set $\tilde{A}$ of U is a set of ordered pairs $\{(u_1, f_{\tilde{A}}(u_1)), (u_2, f_{\tilde{A}}(u_2)), \ldots, (u_n, f_{\tilde{A}}(u_n))\}$, where $f_{\tilde{A}}$, $f_{\tilde{A}}: U \to [0, 1]$, is the membership function of $\tilde{A}$, and $f_{\tilde{A}}(u_i)$ indicates the grade of membership of u_i in $\tilde{A}$.

Definition 2.1. A fuzzy set $\tilde{A}$ of the universe of discourse U is convex if and only if for all u_1, u_2 in U,

$$f_{\tilde{A}}(\lambda u_1 + (1 - \lambda) u_2) \geqslant \mathrm{Min}(f_{\tilde{A}}(u_1), f_{\tilde{A}}(u_2)), \tag{1}$$

where $\lambda \in [0, 1]$.

Definition 2.2. A fuzzy set $\tilde{A}$ of the universe of discourse U is called a normal fuzzy set implying that

$$\exists u_i \in U, \quad f_{\tilde{A}}(u_i) = 1. \tag{2}$$

Definition 2.3. A fuzzy number is a fuzzy subset in the universe of discourse U that is both convex and normal.

Definition 2.4. The α-cut $\tilde{A}_\alpha$ of the fuzzy set $\tilde{A}$ in the universe of discourse U is defined by

$$\tilde{A}_\alpha = \{u_i \mid f_A(u_i) \geqslant \alpha,\ u_i \in U\}, \tag{3}$$

where $\alpha \in [0, 1]$.

According to [5], a fuzzy number $\tilde{A}$ of the universe of discourse U may be charaterized by a triangular distribution function parametrized by a triplet (a, b, c) shown in Fig. 1. The membership function of the fuzzy number $\tilde{A}$ is defined as

$$f_{\tilde{A}}(u) = \begin{cases} 0, & u < a, \\ \dfrac{u-a}{b-a}, & a \leqslant u \leqslant b, \\ \dfrac{c-u}{c-b}, & b \leqslant u \leqslant c, \\ 0, & u > c. \end{cases} \tag{4}$$

Let $\tilde{A}$ and $\tilde{B}$ be two triangular fuzzy numbers parametrized by the triplet (a_1, b_1, c_1) and (a_2, b_2, c_2), respectively, where

(1) $a_1 \leqslant a_2$, $b_1 \leqslant b_2$, and $c_1 \leqslant c_2$.

(2) $c_2/c_1 \geqslant a_2/a_1$.

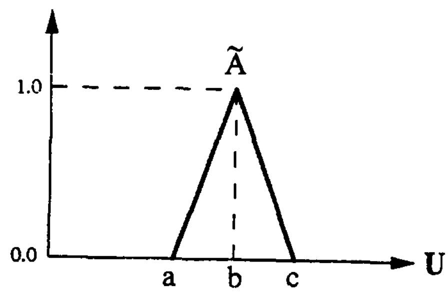

Fig. 1. A triangular fuzzy number $\tilde{A}$.

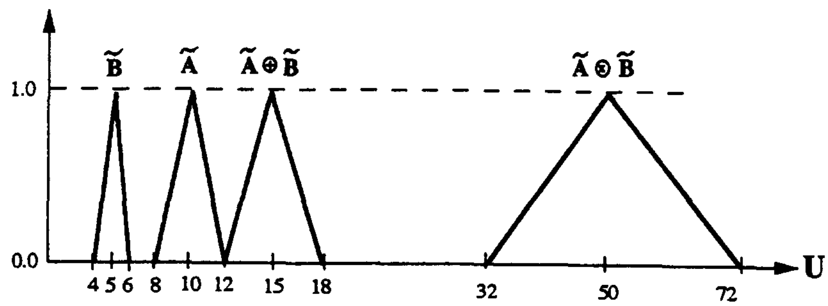

Fig. 2. Fuzzy number operations.

According to [5], the fuzzy number addition operations and the fuzzy number multiplication operations of the triangular fuzzy numbers are expressed as follows:
Fuzzy number addition $\oplus$:

$$(a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2). \tag{5}$$

Fuzzy number multiplication $\otimes$:

$$(a_1, b_1, c_1) \otimes (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2). \tag{6}$$

For example, Let $\tilde{A}$ and $\tilde{B}$ be two triangular fuzzy numbers, where $\tilde{A} = (8, 10, 12)$ and $\tilde{B} = (4, 5, 6)$. Then, based on Eqs. (5) and (6), we can get

$$\begin{aligned} \tilde{A} \oplus \tilde{B} &= (8, 10, 12) \oplus (4, 5, 6) = (12, 15, 18), \\ \tilde{A} \otimes \tilde{B} &= (8, 10, 12) \otimes (4, 5, 6) = (32, 50, 72). \end{aligned} \tag{7}$$

The results of the above fuzzy number operations are shown in Fig. 2.

A fuzzy number $\tilde{M}$ of the universe of discourse U also may be characterized by a trapezoidal distribution parametrized by a quadruple (a, b, c, d) shown in Fig. 3.

Let $\tilde{A}$ and $\tilde{B}$ be two trapezoidal fuzzy numbers, where $\tilde{A} = (a_1, b_1, c_1, d_1)$ and $\tilde{B} = (a_2, b_2, c_2, d_2)$. The fuzzy number addition operations and the fuzzy number multiplication operations of the trapezoidal fuzzy numbers $\tilde{A}$ and $\tilde{B}$ are defined by

$$\begin{aligned} \tilde{A} \oplus \tilde{B} &= (a_1, b_1, c_1, d_1) \oplus (a_2, b_2, c_2, d_2) \\ &= (a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2), \end{aligned} \tag{8}$$

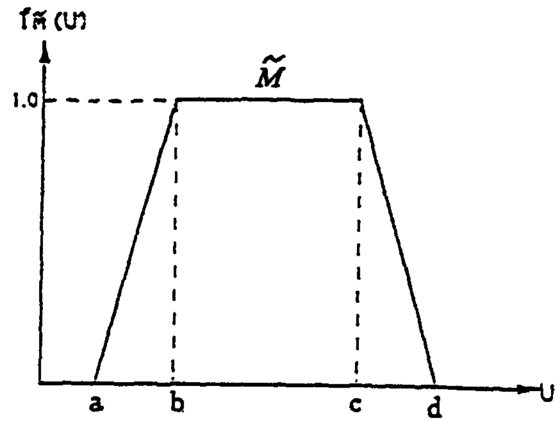

Fig. 3. A trapezoidal fuzzy number $\tilde{M}$.

$$\tilde{A} \otimes \tilde{B} = (a_1, b_1, c_1, d_1) \otimes (a_2, b_2, c_2, d_2)$$
$$= (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2, d_1 \times d_2), \tag{9}$$

It is obvious that a triangular fuzzy number parametrized by (a, b, c) is equivalent to a trapezoidal fuzzy number parameterized by (a, b, b, c). That is $(a, b, c) = (a, b, b, c)$. Thus, we can see that

$$(a_1, b_1, c_1) \oplus (a_2, b_2, c_2) \doteq (a_1, b_1, b_1, c_1) \oplus (a_2, b_2, b_2, c_2)$$
$$= (a_1 + a_2, b_1 + b_2, b_1 + b_2, c_1 + c_2)$$
$$= (a_1 + a_2, b_1 + b_2, c_1 + c_2), \tag{10}$$

$$(a_1, b_1, c_1) \otimes (a_2, b_2, c_2) = (a_1, b_1, b_1, c_1) \otimes (a_2, b_2, b_2, c_2)$$
$$= (a_1 \times a_2, b_1 \times b_2, b_1 \times b_2, c_1 \times c_2)$$
$$= (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2). \tag{11}$$

In the following, we introduce a defuzzification method of trapezoidal fuzzy numbers [5]. Consider a trapezoidal fuzzy number parametrized by a quadruple (a, b, c, d) shown in Fig. 4, where e is defuzzification value of the fuzzy number. From Fig. 4, we can see that

$$(e - b)(1) + \tfrac{1}{2}(b - a)(1) = (c - e)(1) + \tfrac{1}{2}(d - c)(1)$$
$$\Rightarrow (e - b) + \tfrac{1}{2}(b - a) = (c - e) + \tfrac{1}{2}(d - c)$$
$$\Rightarrow (e - b) - (c - e) = \tfrac{1}{2}(d - c) - \tfrac{1}{2}(b - a)$$
$$\Rightarrow 2e = \frac{d - c - b + a}{2} + b + c$$
$$\Rightarrow 2e = \frac{a + b + c + d}{2}$$
$$\Rightarrow e = \frac{a + b + c + d}{4}.$$

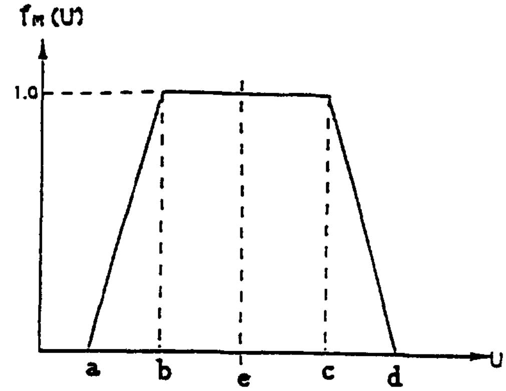

Fig. 4. Deffuzzification of a trapezoidal fuzzy number.

Thus, from the above result, we can see that the defuzzification value e of a triangular fuzzy number parametrized by (a, b, c) is equal to

$$e = \frac{a+b+c+d}{4}. \tag{13}$$

This defuzzified method will be used in Section 3.

3. Methodology and algorithm

In this section, we present an efficient algorithm for evaluating weapon systems using fuzzy arithmetic operations. Assume that there are n criteria (i.e., $C_1, C_2, \ldots, C_n$), and assume that there are m systems to be evaluated (i.e., $S_1, S_2, \ldots, S_m$). Furthermore, assume that the weights of the criteria supplied by the decision maker are represented by a weighting vector W, $W = [\tilde{W}_1, \tilde{W}_2, \ldots, \tilde{W}_m]$, where $\tilde{W}_1, \tilde{W}_2, \ldots$, and $\tilde{W}_n$ are triangular fuzzy numbers whose values may be $\tilde{0}, \tilde{1}, \tilde{2}, \ldots \tilde{9}$ defined as follows:

$$\begin{aligned} &\tilde{0} = (0,0,0), \quad \tilde{1} = (0,1,2), \quad \tilde{2} = (1,2,3), \quad \tilde{3} = (2,3,4), \quad \tilde{4} = (3,4,5), \\ &\tilde{5} = (4,5,6), \quad \tilde{6} = (5,6,7), \quad \tilde{7} = (6,7,8), \quad \tilde{8} = (7,8,9), \quad \tilde{9} = (8,9,9), \end{aligned} \tag{14}$$

$\tilde{W}_i$ denotes the weight of the criteria C_i, $1 \leqslant i \leqslant n$. The computational procedure of the decision-making methodology is now presented as follows:

Step 1: For each criteria, rank the degree of satisfiability for each system with respect to each criteria item by integer numbers $1, 2, 3, \ldots$, etc. Summarize the rank score of each system with respect to each criteria item, and represent each summarized rank score p by a triangular fuzzy number $\tilde{p}$ parametrized by a triplet $(p-1, p, p+1)$. Represent the summarized rank of each system with respect to each criteria by a fuzzy rank score matrix A,

$$A = \begin{array}{c} \\ S_1 \\ S_2 \\ \vdots \\ S_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{p}_{11} & \tilde{p}_{12} & \cdots & \tilde{p}_{1n} \\ \tilde{p}_{21} & \tilde{p}_{22} & \cdots & \tilde{p}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{p}_{m1} & \tilde{p}_{m2} & \cdots & \tilde{p}_{mn} \end{bmatrix} \end{array}, \tag{15}$$

where $\tilde{p}_{ij}$ is a triangular fuzzy number denoting the summarized rank score of system S_i with respect to criteria C_j, $1 \leqslant i \leqslant m$, and $1 \leqslant j \leqslant n$.

Step 2: Performing the following transformation operations:

$$R = A \odot W^T = \begin{bmatrix} \tilde{p}_{11} \otimes \tilde{w}_1 \oplus \tilde{p}_{12} \otimes \tilde{w}_2 \oplus \cdots \oplus \tilde{p}_{1n} \otimes \tilde{w}_n \\ \tilde{p}_{21} \otimes \tilde{w}_1 \oplus \tilde{p}_{22} \otimes \tilde{w}_2 \oplus \cdots \oplus \tilde{p}_{2n} \otimes \tilde{w}_n \\ \vdots \\ \tilde{p}_{m1} \otimes \tilde{w}_1 \oplus \tilde{p}_{m2} \otimes \tilde{w}_2 \oplus \cdots \oplus \tilde{p}_{mn} \otimes \tilde{w}_n \end{bmatrix} = \begin{bmatrix} R(1) \\ R(2) \\ \vdots \\ R(m) \end{bmatrix}, \tag{16}$$

where $\otimes$ and $\oplus$ are fuzzy number multiplication operator and fuzzy number addition operator, respectively, W^T denotes the transpose of the weighting vector W, and $R(1), R(2), \ldots, R(m)$ are triangular fuzzy numbers.

Step 3: Applying Eq. (13) to defuzzify the triangular fuzzy numbers $R(1), R(2), \ldots, R(m)$ into crisp real values $v_1, v_2, \ldots, v_m$, respectively, i.e., if $R(i) = (a_i, b_i, c_i)$, then let

$$v_i = \frac{a_i + b_i + b_i + c_i}{4}, \tag{17}$$

where $1 \leqslant i \leqslant m$. If v_j is the smallest value among $v_1, v_2, \ldots, v_m$, then system S_j is the best choice.

4. Numerical example

In this section, we use the example shown in [7] to illustrate the weapon systems evaluation process of the proposed method. Consider the tactical specification data of the three missile systems and the experts' opinions shown in Tables 1 and 2 (Data Source [7, 10]). In [7], Mon et al. established an evaluation model of the three missile systems based on Tables 1 and 2, which is shown in Fig. 5.

From Fig. 5, we can see that there are 5 criteria for evaluating the three missile systems, namely.

(1) Tactics criteria.
(2) Technology criteria.
(3) Maintenance criteria.
(4) Economy criteria.
(5) Advancement criteria.

Table 1
Tactical specification data of the three missile systems

Items	S_1	S_2	S_3
Effective range (km)	43	36	38
Flight height (m)	25	20	23
Flight velocity (M. No)	0.72	0.8	0.75
Fire rate (round/min)	0.6	0.6	0.7
Reaction time (min)	1.2	1.5	1.3
Missile scale (cm) (1 × *d*-span)	521 × 35–135	381 × 34–105	445 × 35–120
Firing accuracy (%)	67	70	63
Destruction rate (%)	84	88	86
Kill radius (%)	15	12	18
Anti-jam (%)	68	75	70
Reliability (%)	80	83	76
System cost (ten thousand)	800	755	785
System life (year)	7	5	5

Table 2
Characteristics and experts' opinions

Item	S_1	S_2	S_3
Operation condition requirement	Higher	General	General
Safety	Good	General	General
Defilade	General	Good	General
Simplicity	General	General	General
Assembility	General	General	Poor
Combat capability	Good	General	General
Material limitation	Higher	General	Higher
Mobility	Poor	Good	General
Modulation	General	Good	General
Standardization	General	General	Good

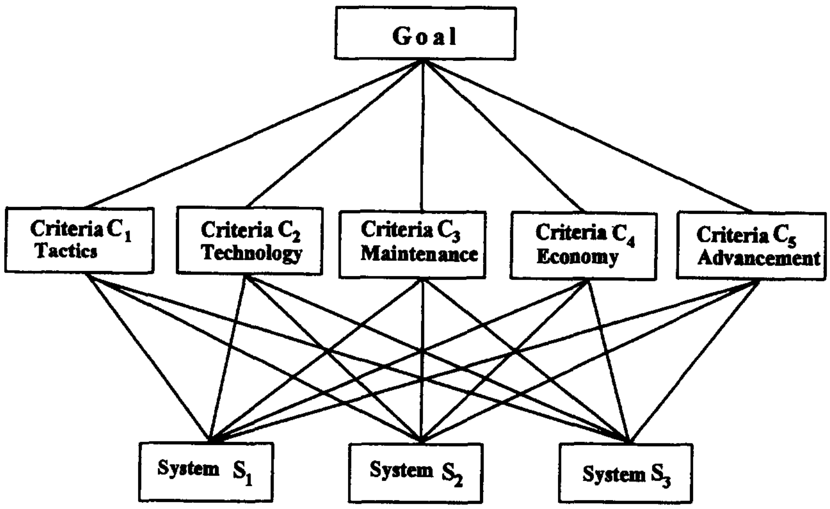

Fig. 5. Evaluation model of three tactical missile systems.

According to [7], the data shown in Tables 1 and 2 can be partitioned into 5 subtables with respect to the above 5 criteria, respectively, which are shown in Tables 3–7.

Step 1: According to the degree of satisfiability of each system with respect to each criteria item shown in Tables 3–7, we can rank the system based on our preference. Furthermore, according to the summarized rank of each system with respect to each criteria item, we can obtain the rank score of each system with respect to each criteria. The results are shown in Tables 8–12.

Thus, the fuzzy rank score matrix A can be obtained as follows:

$$A = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \end{array} \begin{array}{ccccc} \text{tactics} & \text{technology} & \text{maintenance} & \text{economy} & \text{advancement} \\ \end{array} \left[\begin{array}{ccccc} \widetilde{10} & \tilde{9} & \tilde{8} & \tilde{5} & \tilde{7} \\ \tilde{9} & \tilde{7} & \tilde{9} & \tilde{4} & \tilde{4} \\ \widetilde{12} & \tilde{8} & \widetilde{11} & \tilde{6} & \tilde{5} \end{array} \right]. \tag{18}$$

Table 3
Tactical criterial for the three tactical missile systems

Tactics criteria items	S_1	S_2	S_3
Effective range (km)	43	36	38
Flight height (m)	25	20	23
Flight velocity (M. No)	0.72	0.8	0.75
Reliability (%)	80	83	76
Firing accuracy (%)	67	70	63
Destruction rate (%)	84	88	86
Kill radius (m)	15	12	18

Table 4
Technology criteria for the three tactical missile systems

Technology criteria items	S_1	S_2	S_3
Missile scale (cm) (l × *d*-span)	521 × 35–135	381 × 34–105	445 × 35–120
Reaction time (min)	1.2	1.5	1.3
Fire rate (round/min)	0.6	0.6	0.7
Anti-jam (%)	68	75	70
Combat capability	Good	General	General

Table 5
Maintenance criteria for the three tactical missile systems

Maintenance criteria items	S_1	S_2	S_3
Operation condition requirement	Higher	General	General
Safety	Good	General	General
Defilade	General	Good	General
Simplicity	General	General	General
Assembility	General	General	Poor

Table 6
Economy criteria for the three tactical missile systems

Economy criteria items	S_1	S_2	S_3
System cost (ten thousand)	800	755	785
System life (year)	7	7	5
Material limitation	Higher	General	Higher

Step 2: If the weights of the tactics criteria, technology criteria, maintenance criteria, economy criteria, and advancement criteria supplied by the decision maker are represented by a weighting vector W,

$$\begin{array}{lccccc} & \text{tactics} & \text{technology} & \text{maintenance} & \text{economy} & \text{advancement} \\ W = [& \tilde{9} & \tilde{3} & \tilde{1} & \tilde{5} & \tilde{7} \quad], \end{array} \tag{19}$$

Table 7
Advancement criteria for the three tactical missile systems

Advancement criteria items	S_1	S_2	S_3
Modulization	General	Good	General
Mobility	Poor	Good	General
Standardization	General	General	Good

Table 8
Rank of the tactical criteria for the three tactical missile systems

Tactics criteria items	S_1	S_2	S_3
Effective range	1	2	2
Flight height	2	1	2
Flight velocity	2	1	2
Reliability	1	1	2
Firing accuracy	1	1	2
Destruction rate	2	1	1
Kill radius	1	2	1
Total rank	10	9	12

Table 9
Rank of the technology criteria for the three tactical missile systems

Technology criteria items	S_1	S_2	S_3
Missile scale	2	1	2
Reaction time	2	2	2
Fire rate	2	1	1
Anti-jam	2	1	1
Combat capability	1	2	2
Total rank	9	7	8

where $\tilde{9}$, $\tilde{3}$, $\tilde{1}$, $\tilde{5}$ and $\tilde{7}$ are triangular fuzzy numbers defined as follows:

$$\tilde{9} = (8, 9, 9), \qquad \tilde{3} = (2, 3, 4), \qquad \tilde{1} = (0, 1, 2), \qquad \tilde{5} = (4, 5, 6), \qquad \tilde{7} = (6, 7, 8), \tag{20}$$

then by performing the transformation operation $R = A \circ W^{\mathrm{T}}$, we can get the following results:

$$\begin{aligned} R(1) &= \widetilde{10} \otimes \tilde{9} \oplus \tilde{9} \otimes \tilde{3} \oplus \tilde{8} \otimes \tilde{1} \oplus \tilde{5} \otimes \tilde{5} \oplus \tilde{7} \otimes \tilde{7} \\ &= (9, 10, 11) \otimes (8, 9, 9) \oplus (8, 9, 10) \otimes (2, 3, 4) \oplus (7, 8, 9) \otimes (0, 1, 2) \oplus (4, 5, 6) \otimes (4, 5, 6) \\ &\quad \oplus (6, 7, 8) \otimes (6, 7, 8) \\ &= (72, 90, 99) \oplus (16, 27, 40) \oplus (0, 8, 18) \oplus (16, 25, 36) \oplus (36, 49, 64) \\ &= (140, 199, 257), \end{aligned} \tag{21}$$

Table 10
Rank of the maintenance criteria for the three tactical missile systems

Maintenance criteria items	S_1	S_2	S_3
Operation condition requirement	1	2	2
Safety	1	2	2
Defilade	2	1	2
Simplicity	2	2	2
Assembility	2	2	3
Total rank	8	9	11

Table 11
Rank of the economy criteria for the three tactical missile systems

Economy criteria items	S_1	S_2	S_3
System cost	2	1	2
System life	1	2	2
Material limitation	2	1	2
Total rank	5	4	6

Table 12
Rank of the advancement criteria for the three tactical missile systems

Advancement criteria items	S_1	S_2	S_3
Modulization	2	1	2
Mobility	3	1	2
Standardization	2	2	1
Total rank	7	4	5

$$\begin{aligned}
R(2) &= \tilde{9} \otimes \tilde{9} \oplus \tilde{7} \otimes \tilde{3} \oplus \tilde{9} \otimes \tilde{1} \oplus \tilde{4} \otimes \tilde{5} \oplus \tilde{4} \otimes \tilde{7} \\
&= (8,9,10) \otimes (8,9,10) \oplus (6,7,8) \otimes (2,3,4) \oplus (8,9,10) \otimes (0,1,2) \oplus (3,4,5) \otimes (4,5,6) \\
&\quad \oplus (3,4,5) \otimes (6,7,8) \\
&= (64,81,100) \oplus (12,21,32) \oplus (0,9,20) \oplus (12,20,30) \oplus (18,28,40) \\
&= (106,159,222), \qquad (22)
\end{aligned}$$

$$\begin{aligned}
R(3) &= \widetilde{12} \otimes \tilde{9} \oplus \tilde{8} \otimes \tilde{3} \oplus \widetilde{11} \otimes \tilde{1} \oplus \tilde{6} \otimes \tilde{5} \oplus \tilde{5} \otimes \tilde{7} \\
&= (11,12,13) \otimes (8,9,10) \oplus (7,8,9) \otimes (2,3,4) \oplus (10,11,12) \otimes (0,1,2) \oplus (5,6,7) \otimes (4,5,6) \\
&\quad \oplus (4,5,6) \otimes (6,7,8) \\
&= (88,108,130) \oplus (14,24,36) \oplus (0,11,24) \oplus (20,30,42) \oplus (24,35,48) \\
&= (146,208,280), \qquad (23)
\end{aligned}$$

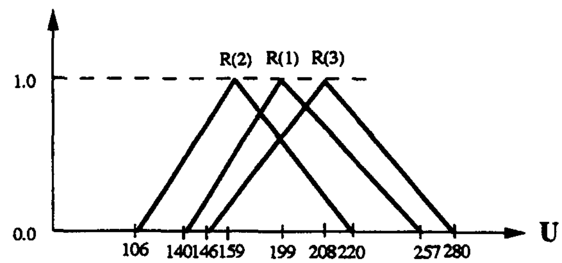

Fig. 6. Membership function curves of the triangular fuzzy numbers $R(1)$, $R(2)$, and $R(3)$.

The membership function curves of the triangular fuzzy numbers $R(1)$, $R(2)$, and $R(3)$ are shown in Fig. 6, respectively.

Step 3: By applying Eq. (13), the triangular fuzzy number $R(1) = (140, 199, 257)$ can be defuzzified into the crisp real value v_1, where

$$v_1 = \frac{140 + 199 + 199 + 257}{4} = 198.75. \tag{24}$$

By applying Eq. (13), the triangular fuzzy number $R(2) = (106, 159, 222)$ can be defuzzified into the crisp real value v_2, where

$$v_2 = \frac{106 + 159 + 159 + 222}{4} = 161.5. \tag{25}$$

By applying Eq. (13), the triangular fuzzy number $R(3) = (146, 208, 280)$ can be defuzzified into the crisp real value v_3, where

$$v_3 = \frac{146 + 208 + 208 + 280}{4} = 210.5. \tag{26}$$

Because v_2 is the smallest value among v_1, v_2, and v_3, system S_2 is the best choice. This result is coincident with the one shown in [7].

5. Conclusions

We have presented a new method for evaluating weapon systems using fuzzy arithmetic operations. We also use an example to illustrate the performance evaluation process of three tactical missile systems. From the illustrated example, we can see that the proposed method can efficiently handle the weapon system selection problems. Because the proposed method uses simplified fuzzy arithmetic operations rather than the complicated entropy weight calculations mentioned in [7], its execution is much faster than the one presented in [7].

Acknowledgements

The author wishes to thank Dr. C.H. Cheng, Department of Weapon System Engineering, National Chung Cheng Institute of Technology, for his encouragement on this work. This work was supported in part by the National Science Council, Republic of China, under Grant NSC 84-2213-E-009-100.

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