SOLVING SEQUENCING PROBLEM ON TRIANGULAR NEUTROSOPHIC SET

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Abstract **-** In this article, we present an algorithm method for solving sequencing problem where the values are characterized by single valued triangular neutrosophic numbers. Finally a numerical example is presented to illustrate the efficiency of the proposed approach.

Keywords— Single valued triangular neutrosophic number; Score Function, sequencing problem.

I. INTRODUCTION

In 1995, the concept of the neutrosophic sets (NS for short) and neutrosophic logic were introduced by Smarandache [12, 13] in order to efficiently handle the indeterminate and inconsistent information which exist in real world. Unlike fuzzy sets which associate to each member of the set a degree of membership T and intuitionstic fussy sets which associate a degree of membership T and a degree of non-membership F, T, F € [0, 1], Neutrosophic sets characterize each member x of the set with a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$ and a falsity membership function $F_A(X)$ of which belongs to the non-standard unit interval]−0, 1+[. Thus, although in some case intuitionistic fuzzy sets consider a particular indeterminacy or hesitation margin, π =1-T - F . Neutrosophic set has the ability of handling uncertainty in a better way since in case of neutrosophic set indeterminacy is taken care of separately. Neutrosophic sets is a generalization of the theory of fuzzy set [1], intuitionistic fuzzy sets [3], interval-valued fuzzy sets and interval-valued intuitionistic fuzzy sets [2]. However, the neutrosophic theory is difficult to be directly applied in real scientific and engineering areas. To easily use it in science and engineering areas, in 2005, Wang et al. [16] proposed the concept of SVNS, which differ from neutrosophic sets only in the fact that in the former's case, the truth, indeterminacy and falsity membership functions belongs to [0, 1]. Recent research works on neutrosophic set theory and its applications in various fields are progressing rapidly [8]. Very recently Subas et al.[14] presented the concept of triangular and trapezoidal neutrosophic numbers and applied to multiple-attribute decision making problems. Then, Biswas et al. [4] presented a special case of trapezoidal neutrosophic numbers including triangular fuzzy numbers and neutrosophic set applied to multiple-attribute decision making problems by introducing the cosine similarity measure. Deli and Subas [6] presented the single valued triangular neutrosophic numbers (SVN-numbers) as a generalization of the intuitionistic triangular fuzzy numbers and proposed a methodology for solving multiple-attribute decision making problem with SVN numbers.

II. PRELIMINARIES

In this section, some basic concepts and definitions on neutrosophic sets, single valued neutrosophic sets and single valued triangular neutrosophic sets are reviewed from the literature.

Definition 2.1 [1].

Let X be a space of points (objects) with generic elements in X denoted by x; then the neutrosophic set A (NS A) is an object having the form

A = {< x: T_A (x) , I_A (x) ,F_A(x)>, x € X}, where the functions T, I, F: X→]−0,1+[define respectively the truth-membership function, an indeterminacy-membership function, and a falsity membership function of the element x € X to the set A with the condition:

−0 ≤ T_A (x) + I_A (x) +F_A(x) ≤ 3+……………… (1)

The functions T_A (x) , I_A (x) ,F_A(x) are real standard or nonstandard subsets of]−0,1+[. Since it is difficult to apply NSs to practical problems, Wang et al. [16] introduced the concept of a SVNS, which is an instance of a NS and can be used in real scientific and engineering applications.

Definition 2.2 :

Let X be a space of points (objects) with generic elements in X denoted by x. A single valued neutrosophic set A (SVNS A) is characterized by truth-membership function $T_A(x)$, an indeterminacy – membership function $I_A(x)$, and a falsity – membership function $F_A(x)$. For each point x in X $T_A(x)$, $I_A(x)$, $F_A(x) \in [0, 1]$. A SVNS A can be written as

$$A = \{< x: T_A\ (x), I_A(x), F_A(x) >, x \in X\} \qquad (2)$$

Definition 2.3 (11).

A single valued triangular neutrosophic number (SVTrN – number) $\bar{a} = <(a_1, b_1, c_1); T_a, I_a, F_{a>} >$ is a special neutrosophic set on the real number set R, whose truth membership, indeterminacy-membership, and a falsity – membership are given as follows.

$$T_a(x) = \begin{cases} (x - a_1)T_a / (b_1 - a_1) & (a_1 \le x \le b_1) \\ T_a & (x = b_1) \\ (c_1 - x)T_a / (c_1 - b_1) & (b_1 \le x \le c_1) \\ 0 & otherwise \end{cases} \qquad (3)$$

$$I_a(x) = \begin{cases} (b_1 - x + I_a(x - a_1)) \big/ (b_1 - a_1) & (a_1 \le x \le b_1) \\ I_a & (x = b_1) \\ (x - b_1 + I_a\,(c_1 - x)) \big/ (c_1 - b_1) & (b_1 \le x \le c_1) \\ 1 & otherwise \end{cases} \quad (4)$$

$$F_a(x) = \begin{cases} (b_1 - x + F_a\,(x - a_1)) \big/ (b_1 - a_1) & (a_1 \le x \le b_1) \\ F_a & (x = b_1) \\ (x - c_1 + F_a(c_1 - x)) \big/ (c_1 - b_1) & (b_1 \le x \le c_1) \\ 1 & otherwise \end{cases} \quad (5)$$

Where $0 \le T_a \le 1; 0 \le I_a \le 1; 0 \le F_a \le 1$ and $0 \le T_{a+} I_a + F_a \le 3;\ a_1 b_1 c_1 \in R$

Definition 2.4 (11).

Let $\bar{A}_1 =< (a_1, a_2, a_3); T_1, I_1, F_1 >$ and $\bar{A}_2 =< (b_1, b_2, b_3); T_2, I_2, F_2 >$ be two single valued triangular neutrosophic numbers. Then, the operations for SVTrN- numbers are defined as below;

(i) $\bar{A}_1 \oplus \bar{A}_2 =< (a_1 + b_1, a_2 + b_2, a_3 + b_3); \min(T_1, T_2), \max(I_1, I_2) \max(F_1, F_2) >$ (6)

(ii) $\bar{A}_1 \otimes \bar{A}_2 =< (a_1 b_1, a_2\, b_2, a_3\, b_3); \min(T_1, T_2), \max(I_1, I_2) > \max(F_1, F_2))$ (7)

(iii) $\lambda \bar{A}_1 =< (\lambda a_1, \lambda a_2, \lambda a_{3)};\ \min(T_1, T_2), \max(I_1, I_2) > \max(F_1, F_2) >$ (8)

A convenient method for comparing two single valued triangular neutrosophic numbers is by using of score function and accuracy function.

Definition 2.5 [11].

Let $\bar{A}_1 = < (a_1, a_2, a_3);\ T_1, I_1, F_1 >$ be a single valued triangular neutrosophic number. Then, the score function $s(\bar{A}_1)$, and accuracy function $a(\bar{A}_1)$ of a SVTrN- numbers are defined as follows:

(i) $s(\bar{A}_1) = \left(\frac{1}{12}\right) [a_1 + 2a_2 + a_3] \times [2 + T_1 - I_1 - F_1]$ (9)

(ii) $a(\bar{A}_1) = \left(\frac{1}{12}\right)[a_1 + 2a_2 + a_3] \times [2 + T_1 - I_1 + F_1]$ (10)

Definition 2.6 [11].

Let $\bar{A}_1$ and $\bar{A}_2$ be two SVTrN- numbers the ranking of $\bar{A}_1$ and $\bar{A}_2$ by score function and accuracy function are defined as follows:

(i) If $s(\bar{A}_1) \prec s(\bar{A}_2)$ then $\bar{A}_1 \prec \bar{A}_2$

(ii) If $s(\bar{A}_1) = s(\bar{A}_2)$ and if

(1) $a(\bar{A}_1) \prec a(\bar{A}_2) then\ \bar{A}_1 \prec \bar{A}_2$
(2) $a(\bar{A}_1) > a(\bar{A}_2) then\ \bar{A}_1 > \bar{A}_2$
(3) $a(\bar{A}_1) = a(\bar{A}_2) then\ \bar{A}_1 = \bar{A}_2$

Introduction to sequencing problem :

Consider a real life situation involving processing of 'j' jobs on m machines. They can be handled by a very lengthy and time consuming exercise. $(j!)^m$ different sequences would be required in such case. However, we do have a method applicable under the condition that no passing of jobs permissible and if either or both of the conditions stipulated before are satisfied.

Let there be n jobs, each of which is to be processed through K machines, say M_1, M_2, ….. M_k in the order M_1, M_2,….M_k. The list of jobs with their processing time is:

Job number :		1	2	3………………………………………n	
Processing time on machine	M_1	t_{11}	t_{12}	t_{13}………………………………	t_{1n}
	M_2	t_{21}	t_{22}	t_{23}………………………………	t_{2n}
	M3	t_{31}	t_{32}	t_{33}………………………………	t_{3n}
	.	.	.	.	.
	.	.	.	.	.
	.	.	.	.	.
	M_k	t_{k1}	t_{k2}	t_{k3}………………………………	t_{kn}

An optimum solution to this problem can be obtained. If either or both of the following conditions hold.

a) Minimum $t_{1j} \geq$ maximum t_{ij}

For i = 1,2, 3,…….k-1

Or b) Minimum $t_{kj} \geq$ maximum t_{ij}

For i = 1,2,…..k-1

Illustrative Example

Now we will solve a problem to verify the proposed approach.

1. There are 4 jobs, each of which has to go through 3 machines M_1, M_2 and M_3 in the order M_1 M_2 M_3. Find the minimum elapsed time if no passing of jobs is permitted. Also determine the idle time for each machine. Here each job has been assigned to single valued triangular neutrosophic number as follows.

Jobs / Machines	A	B	C	D
M_1	<(.1,.2,.3);(.4,.6,.7)>	<(.2,.5,.7);(.2,.3,.4)>	<(.7,.8,.9);(.3,.2,.6)>	<(.2,.7,.10); (.82,.36,.56)>
M_2	<(.1,.5,.7);(.7,.6,.8)>	<(.3,.7,.8);(.1,.4,.6)>	<(.2,.4,.5);(.6,.5,.3)>	<(.3,.4,.5); (.3,.4,.7)>
M_3	<(.2,.4,.8);(.5,.3,.1)>	<(.11,.17,.24);(.72,.018,.024)>	<(.4,.9,.11);(.46,.24,.42)>	<(.4,.11,.15); (.93,.18,.17)>

Solution

Using Score function,

The above problem transformed into

Jobs / Machines	A	B	C	D
M_1	.733	2.38	4	4.12

M_2	1.95	2.29	2.25	1.6
M_3	3.15	15.4	4.95	8.82

Minimum $M_{1j} = 2.38$, J = 1,2,…. ..4

Maximum $M_{2j} = 2.29$, J = 1,2,…….4

Minimum $M_{3j} = 3.15$, J = 1, 2,……..4

Min $M_{1j} \geq$ Max M_{2j} and

Min $M_{3j} \geq$ Max M_{2j}

The problem can be converted into that of 4 jobs and 2 machines respectively. These two fictitious machines are denoted by G and H , where each

$G = M_{1j} + M_{2j}$, J = 1, 2,……….4

and $H = M_{2j} + M_{3j}$, J = 1, 2,……….4

The equivalent problem involving 4 jobs and 2 fictitious machines G and H becomes

	A	B	C	D
G	2.68	4.67	6.25	5.72
H	5.10	17.69	7.20	10.42

By examining, we find the smallest value. It is 2.68 hour for A in first column. Then we schedule job A in the last as shown below.

G→

A			

←H

The scheduled set of processing time is:

	B	C	D
G	4.67	6.25	5.72
H	5.10	7.20	10.42

The smallest value is 4.67. it is for machine G for Job B. Then we schedule job B in second column as given below.

G→

A	B		

←H

Then the reduced set of processing time becomes:

Jobs / Machines	C	D
G	6.25	5.72
H	7.20	10.42

The smallest value is 5.72. it is for machine G for Job D. Then we schedule job D in third column as given below.

A	B	D	C

Now we can calculate the elapsed time corresponding to the optimal sequence, using the individual processing time given in the problem. The details are shown in the table below;

Machines / Jobs	M_1		M_2		M_3	
	In	Out	In	Out	In	Out
A	0	.733	.733	2.683	2.683	5.833
B	.733	3.113	3.113	5.403	5.833	21.233
D	3.113	7.233	7.233	8.833	21.233	30.053

C	7.233	11.233	11.233	13.483	30.053	35.003

Then the minimum elapsed time is 35.003 hours.

Idle time for machine M_1 = 23.77 hours

For machine M_2 = .43+1.83+2.4+21.52

= 26.913 hours

And for machine M_3 = 2.683 hours

Conclusions:

This paper introduced to solve sequencing problem for m machines and n jobs on triangular neutrosophic set i.e. under uncertainity environment. It can be used to solve the sequencing problem on triangular nuetroophic set where there are m machines and two jobs.

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