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A novel lexicographical-based method for trapezoidal neutrosophic linear programming problem

Sapan Kumar Das [1,*] S. A. Edalatpanah [2] and Jatindra Kumar Dash [3]

[1] Department of Revenue, Ministry of Finance, Govt. of India. (e-mail-cool.sapankumar@gmail.com)

[2] *Department of* Applied Mathematics, Ayandegan Institute of Higher Education, Tonekabon, Iran. (saedalatpanah@gmail.com)

3 Department of Computer Science and Engineering, SRM University-AP, Amravati, India (jkdashsrm@gmail.com)

* Correspondence:Tcool.sapankumar@gmail.com, Tel: +91-9853028740

Abstract: The aim of this paper is to introduce a simplified presentation of a new computing procedure for solving trapezoidal neutrosophic linear programming (TrNLP) problem under uncertainties. Therefore, we firstly define the concept of single valued neutrosophic (SVN) numbers and ranking functions. A new strategy is planned for solving the NLP problem without any ranking function. The planned strategy is depends on multi-objective LP (MOLP) issue and lexicographic order (LO). By following the means of planned strategy, the problem is changed into crisp LP (CLP) problem. In addition to this, a theoretical analysis is provided. Numerical examples are illustrated the proposed method and the consequences are in contrast with the distinct choice methods. The outcome shows that the proposed technique defeats the deficiencies and constraints of the existing method.

Keywords: Neutrosophic trapezoidal numbers; lexicographic method; linear programming, multi-objective linear programming

1. Introduction

Over the last few decades, LP has found numerous successful applications in diverse fields, including Operation Research (O.R), manufacturing, information technology, big science data, energy optimization, and the list goes on. LP has strongly influenced the mathematicians to develop various methods to handle this.

In traditional LP, all the parameters and decision variables are expected to take on exact numerical values. In actuality circumstances, the information is conflicting and undetermined. Due to uncertainty, the decision-maker cannot generally detail the issue in an all around characterized way and careful, nor can they in every case unequivocally anticipate the result of practical choices. For Example: In India, there are three candidates A, B, and C for M.P (Member of Parliament) contested in the election. If the probability is applied for the possible outcome, then the uncertainty can be known. Suppose that A wins is 45%, then there is a chance for loosing 55% too. In case of B, we say that 33% of winning chance, it does not mean that the probability that C wins is 22%, since there may be some NOTA votes (voters reject both all candidates) or not choosing any candidate. However, there is a chance of some error when calculating the possibility. From the above real examples, one may clear that the decision-makers (voters) cannot decide the outcome of the result accurately or precisely, because all the parameters are uncertain and imprecision. Therefore, the fuzzy set principle used to be delivered to handle such type of parameters by decision-makers. Firstly, the fuzzy set was once added by means of Zadeh[31]. The idea of selection making in fuzzy surrounding was proposed by Bellman and Zadeh[32]. Numerous researchers received this idea and stretched out it to take care of the linear programming issue. This problem is called fuzzy linear programming (FLP) problem.

There are two types of problems in the LP problem under a fuzzy environment: (i) symmetric (ii) non-symmetric, which was proposed by Zimmermann [1]. Many researchers [2,9,11-18,33-34] considered the problem of FLP and proposed various methods. The conception of the practical solution and α methodical solutions of the FLP problem was proposed by Ramik [19]. Ghanbari et al. [29] introduced a technique for tackling fuzzy LP issues with crisp formulations of the fuzzy problem. Using the ranking function for tackling the FLP issue was established by Maleki et al. [20]. In the study, Mahadevi-Amiri and Nasiri [13] introduced the duality approach for solving the FLP problem. The concept of sensitivity analysis for solving the FLP problem was proposed by Ebrahimnejad [35]. Jimenez et al. [30] considered the problem of FLP using a ranking function to rank with fuzzy in objectives and to deal with inequality constraints. Wan and Dong [22] considered the possibility of LP issues having trapezoidal fuzzy numbers using multi-objective programming problems and using membership function. A new type of fuzzy symmetric trapezoidal fuzzy number was considered by Ganesan, and Veeramani [21], and the technique was solved in absence of changing to crisp LP problems. Ebrahimnejad and Tavana [4] introduce another technique for tackling FLP issues, and the authors convert the problem into a parallel crisp LP issue and the issue was solved by primal simplex method.

If the parameters, variables, and constraints are taken fuzzy numbers, then it is called fully fuzzy problems, and the linear programming is known as a fully fuzzy LP (FFLP) problem. Lotfi et al. (7) considered an FFLP problem with equality constraints and solved by using lexicographic order (Lo) for ranking symmetric triangular fuzzy numbers. A problem of FFLP with equality constraints and gives a unique solution based on ranking function was proposed by Kumar et al. [6]. Followed by the method [6], a few revisions to make the model well, when all is said in done, was proposed by Najafi and Edalatpanah [8]. In the study, Khan et al. [5] proposed a technique for solving the FFLP problem with triangular fuzzy numbers, and the authors give a solution without transforming them into a classical problem. Dehghan et al. [3] introduced some realistic technique to understand a FF linear system (FFLS) that are related to the common techniques. At that point they broadened another strategy utilizing Linear Programming (LP) for illuminating close and non-close fuzzy frameworks. Veeramani and Duraisamy [10] proposed another methodology of taking care of the FFLP issue utilizing the idea of closest symmetric triangular fuzzy number estimate with save anticipated interim. Ezati et al. [14] put in lexicographic method on fuzzy triangular numbers, and the MOLP issue acquainted another calculation with illuminate FFLP. Das et al. [25] proposed a lexicographic strategy for taking care of FFLP issues with equality and inequality constraints having trapezoidal fuzzy numbers. Das [26] proposed another method for solving the FFLP problem having triangular fuzzy numbers by using lexicographic order (Lo). Ozkok et al. [36] presented a strategy for solving the FFLP problem having mixed constraints.

Due to some drawbacks of the fuzzy set, they can handle only membership function and cannot handle other parameters of vagueness. Therefore, Atanassov [39] established the concept of intuitionistic fuzzy sets (IFS), which is a hybrid of fuzzy sets. They considered both membership and non-membership functions. Here also, some researchers focusing on the use of IFSs in the LP problem; see [53-57].

Still, in practical conditions, it is facing some difficulty in case of decision making due to incomplete information. Therefore, a new set theory was introduced, which contains incomplete, inconsistent, and indeterminate information. This tool is called the neutrosophic set (NS). Neutrosophy was presented by Smarandache [58] as another speculation of fuzzy sets and IFSs. Neutrosophy set might be described by three autonomous degrees, i.e. (i) truth-membership degree (T), (ii) indeterminacy membership degree (I), (iii) falsity membership degree (F).

Wang et al., [52] introduced a single value neutrosophic set (SVNS) problem for solving a practical problem. There are also some scholars [43-46,59] considered the problem of SVNS and applied it in practical problems like the educational and social sectors. The basic definitions and notion of neutrosophic number (NN) was introduced by Samarandache [50]. Some researchers [37,40-42] considered various problems like optimization problems and gave some strategy to solve them. Recently, Abdel-Basset et al. [38] using some ranking functions for the trapezoidal neutrosophic numbers, presented a novel technique for neutrosophic LP. Currently, a direct model for solving the LP problem having triangular neutrosophic numbers was proposed by Edalatpanah [49]. Ye et al. [51] introduced to find the optimal solution of the LP problem in NNs environment.

For the best of our mind, fewer studies have used trapezoidal neutrosophic numbers in LP problems. Recently, an exciting method was proposed by Abdel-Basset et al. [38] for solving neutrosophic LP (NLP) having parameters are represented trapezoidal neutrosophic numbers. Following the method of [38], some modifications was suggested by Singh et al. [60]. The authors have used two ranking functions for both maximization and minimization separately. Now the problem of NP is transformed into a CLP problem and solved by the simplex method.

Using a ranking function in the solution strategies is a weak spot as the use of different ranking functions in a solution method might also result in obtaining different solutions. This weak spot is an inspiration for this investigation to present a solution method that is now not based on any ranking function. For this point, the LP with trapezoidal neutrosophic parameters is converted to a MOLP in which considering all the objective functions together gives an neutrosophic objective function value. By using the LO method, the obtained multi-objective crisp linear programming is changed into single CLP problem. As a preferred position of such methodology, it offers greater flexibility to decision maker. The obtained outcomes from the computational trials of the investigation exhibit the prevalence of the proposed multi-objective optimization method comparing to these of literature.

Contribution:

The main advantage of neutrosophic set is that it's help the decision-makers making by considering truth degree, falsity degree and indeterminacy degree. Here indeterminacy degree is for the most part considered as a free factor which has a significant commitment in decision-making. Due to some uncertainty in real world problem, it is better to use TrNLP problem instead of classical LP problem. For avoiding the unrealistic modeling we used TrNLP model in practical situations. In this article, a TrLP issue is thought of, where all the coefficients are thought to be a trapezoidal neutrosophic numbers. Along these lines, we are proposing a calculation for taking care of TrNLP issue with the assistance of the newly developed LO. To best of our knowledge, it would be the first method to solve the TrNLP problem with help of LO. Thus, for the approval of created technique, direct correlation with relative strategies doesn't emerge. Another Diet outline issue is delineated to show the effectiveness and utilization of our technique, in actuality, issue.

Motivation

Neutrosophic sets plays an important role in uncertainty modeling. The development of uncertainty theory plays a fundamental role in formulation of real-life scientific mathematical model, structural modeling in engineering field, medical diagnoses problem etc. Recently, some of researchers have introduced their model to solve TrNLP problem by using ranking function. How can we implement it in a linear programming based operation research problem? Is it possible to apply in real life problem? Still there is no method for applying LO technique in TrNLP problem. From this aspect we try to extend this research article.

Novelties

In this current decade, researchers have exposed their considerations to make progress with the theories related to neutrosophic area and constantly try to endorse its sufficient scope applications in dissimilar branches of neutrosophic domain. However, justifying all the views connecting to TrNLP theory our main objective is to support the theory efficiently with these following points.

1. Introduced LO function and its efficiency.
2. Application of TrNLP problem.
3. Compared the results with previous established results.

1.1 The rest of the paper is orchestrated in the accompanying way. Some basic definitions and notations are present in Section 2. In Section 3, the general form of FFLP with new method is presented. To show the applications of the proposed method, some real life problem and comparison analysis are discussed in Section 4. In Section 5, advantages of the proposed method over some existing methods are discussed. Finally, the conclusion is been drawn in the last section.

2. Preliminaries

In this area, we present some fundamental definitions and arithmetic operations on neutrosophic sets.

Definition 1 [28]. A set $\tilde{E}_{ne}$ in the universal discourse *X, which is denoted generically by x, is said to be a neutrosophic set if* $\tilde{E}_{ne} = \{< x : [\alpha_{\tilde{E}_{ne}}(x), \beta_{\tilde{E}_{ne}}(x), \delta_{\tilde{E}_{ne}}(x)] >: x \in X\}$. *The set is characterized by a* truth-membership function i.e. degree of confidence: $\alpha_{\tilde{E}_{ne}}(x) : X \to [0,1]$, an indeterminacy membership function i.e. degree of uncertainty: $\beta_{\tilde{E}_{ne}}(x) : X \to [0,1]$ and a falsity-membership function: degree of falsity: $\delta_{\tilde{E}_{ne}}(x) : X \to [0,1]$. SVN satisfies the condition:

$$0 \le \alpha_{\tilde{E}_{ne}}(x) + \beta_{\tilde{E}_{ne}}(x) + \delta_{\tilde{E}_{ne}}(x) \le 3.$$

Definition 2 [28]. For SVNSs *A* and *B*, *A* ⊆ *B* if and only if $\alpha_{\tilde{E}_{ne}A}(x) \le \alpha_{\tilde{E}_{ne}B}(x), \beta_{\tilde{E}_{ne}A}(x) \ge \beta_{\tilde{E}_{ne}B}(x)$ *and* $\delta_{\tilde{E}_{ne}A}(x) \ge \delta_{\tilde{E}_{ne}B}(x)$ for every *x* in *X.*

Definition 3 [38]. A trapezoidal neutrosophic number (TrNNs) is denoted by $\tilde{M}_{ne} =< (p^l, q^l, r^l, s^l), (\mu, \nu, \omega) >$ whose the three membership functions for the truth, indeterminacy, and falsity of x can be defined as follows:

$$\alpha_{\tilde{M}_{ne}}(x) = \begin{cases} \dfrac{(x - p^l)}{(q^l - p^l)}\mu & p^l \le x \le q^l, \\ \mu & q^l \le x \le r^l, \\ \dfrac{(s^l - x)}{(s^l - r^l)}\mu & r^l \le x \le s^l, \\ 0 & \textit{otherwise.} \end{cases}$$

$$\beta_{\tilde{M}_{ne}}(x)=\begin{cases}\dfrac{\left(q^{l}-x\right)}{\left(q^{l}-p^{l}\right)}\nu, & \mathrm{p}^{l}\le x\le q^{l},\\ \nu, & \mathrm{q}^{l}\le x\le r^{l},\\ \dfrac{\left(s^{l}-x\right)}{\left(s^{l}-r^{l}\right)}\nu, & \mathrm{r}^{l}\le x\le s^{l},\\ 1, & otherwise.\end{cases}$$

$$\delta_{\tilde{M}_{ne}}(x)=\begin{cases}\dfrac{\left(q^{l}-x\right)}{\left(q^{l}-p^{l}\right)}\omega, & \mathrm{p}^{l}\le x\le q^{l},\\ \omega, & \mathrm{q}^{l}\le x\le r^{l},\\ \dfrac{\left(s^{l}-x\right)}{\left(s^{l}-r^{l}\right)}\omega, & r^{l}\le x\le s^{l},\\ 1, & otherwise.\end{cases}$$

Where, $0\le\alpha_{\tilde{E}_{ne}}(x)+\beta_{\tilde{E}_{ne}}(x)+\delta_{\tilde{E}_{ne}}(x)\le 3, x\in\tilde{M}_{ne}$. Additionally, when $p^{l}\ge 0,\ \tilde{M}_{ne}$ is called a nonnegative TrNN. Similarly, when $p^{l}<0,\ \tilde{M}_{ne}$ becomes a negative TrNN.

Definition 4 [38]. Suppose $\tilde{M}_{ne}=<(p_1^a,q_1^a,r_1^a,s_1^a),(\mu_1,\nu_1,\omega_1)>$ and $\tilde{N}_{ne}=<(p_2^a,q_2^a,r_2^a,s_2^a),(\mu_2,\nu_2,\omega_2)>$ be two TNNs. Then the arithmetic relations are defined as:

$$(i)\tilde{M}_{ne}\oplus\tilde{N}_{ne}=<(p_1^a+p_2^a,q_1^a+q_2^a,r_1^a+r_2^a,s_1^a+s_2^a),(\mu_1\wedge\mu_2,\nu_1\vee\nu_2,\omega_1\vee\omega_2)>$$
$$(ii)\tilde{M}_{ne}-\tilde{N}_{ne}=<(p_1^a-s_2^a,q_1^a-r_2^a,r_1^a-q_2^a,s_1^a-p_2^a),(\mu_1\wedge\mu_2,\nu_1\vee\nu_2,\omega_1\vee\omega_2)>$$
$$(iii)\tilde{M}_{ne}\otimes\tilde{N}_{ne}=<(p_1^ap_2^a,q_1^aq_2^a,r_1^ar_2^a,s_1^as_2^a),(\mu_1\wedge\mu_2,\nu_1\vee\nu_2,\omega_1\vee\omega_2)>,\ \ if\ p_1^a>0,q_1^a>0,$$

$$(iv)\lambda\tilde{M}_{ne}=\begin{cases}<(\lambda p_1^a,\lambda q_1^a,\lambda r_1^a,\lambda s_1^a),(\mu_1,\nu_1,\omega_1)>, & if\ \ \lambda>0\\ <(\lambda s_1^a,\lambda r_1^a,\lambda q_1^a,\lambda p_1^a),(\mu_1,\nu_1,\omega_1)>, & if\ \ \lambda<0\end{cases}$$

$$(v)\frac{\tilde{M}_{ne}}{\tilde{N}_{ne}}=\begin{cases}<(\dfrac{p_1^a}{s_2^a},\dfrac{q_1^a}{r_2^a},\dfrac{r_1^a}{q_2^a},\dfrac{s_1^a}{p_2^a});(\mu_1\wedge\mu_2,\nu_1\vee\nu_2,\omega_1\vee\omega_2)>if\ (s_1^a>0,s_2^a>0)\\ <(\dfrac{s_1^a}{s_2^a},\dfrac{r_1^a}{r_2^a},\dfrac{q_1^a}{q_2^a},\dfrac{p_1^a}{p_2^a});(\mu_1\wedge\mu_2,\nu_1\vee\nu_2,\omega_1\vee\omega_2)>if\ (s_1^a<0,s_2^a>0)\\ <(\dfrac{s_1^a}{p_2^a},\dfrac{r_1^a}{q_2^a},\dfrac{q_1^a}{r_2^a},\dfrac{p_1^a}{s_2^a});(\mu_1\wedge\mu_2,\nu_1\vee\nu_2,\omega_1\vee\omega_2)>if\ (s_1^a<0,s_2^a<0)\end{cases}$$

Definition 5. [38] A ranking function of neutrosophic numbers is a function $R:N(R)\to R,$ where $N(R)$ is a set of neutrosophic numbers characterized on set of real numbers, which convert each neutrosophic number into the real line.

Let $\tilde{M}_{ne} = <(p_1^a, q_1^a, r_1^a, s_1^a), (\mu_1, \nu_1, \omega_1)>$ and $\tilde{N}_{ne} = <(p_2^a, q_2^a, r_2^a, s_2^a), (\mu_2, \nu_2, \omega_2)>$ be two trapezoidal neutrosophic numbers (TrNN), at that point:

1. If $R(\tilde{M}_{ne}) > R(\tilde{N}_{ne})$ then $\tilde{M}_{ne} > \tilde{N}_{ne}$.
2. If $R(\tilde{M}_{ne}) < R(\tilde{N}_{ne})$ then $\tilde{M}_{ne} < \tilde{N}_{ne}$.
3. If $R(\tilde{M}_{ne}) = R(\tilde{N}_{ne})$ then $\tilde{M}_{ne} = \tilde{N}_{ne}$.

Definition 6 Let $\tilde{M}_{ne} = <(p_1^a, q_1^a, r_1^a, s_1^a), (\mu_1, \nu_1, \omega_1)>$ and $\tilde{N}_{ne} = <(p_2^a, q_2^a, r_2^a, s_2^a), (\mu_2, \nu_2, \omega_2)>$ be any two neutrosophic trapezoidal numbers, then $p_1^a = p_2^a$, $q_1^a = q_2^a$, $r_1^a = r_2^a$, $s_1^a = s_2^a$, $\mu_1 = \mu_2, \nu_1 = \nu_2$, and $\omega_1 = \omega_2$.

3. Proposed method

Consider the standard form of neutrosophic linear programming (NLP) problem with *m* constraints and *n* variables having all coefficients and resources are represented trapezoidal neutrosophic numbers as follows:

$$\begin{aligned} &\text{maximize (minimize) } (\tilde{c}^t y) \\ &\text{s.t} \\ &\qquad \tilde{D}y \le \tilde{h}, \\ &\qquad\ y \ge 0. \end{aligned} \qquad (1.1)$$

After all $\tilde{D} = \left[d_{ij}\right]_{m\times n}$ is the coefficient matrix, $\tilde{h} = \left[\tilde{h}_1, \tilde{h}_2, \tilde{h}_3, \ldots, \tilde{h}_m\right]^t$ is the trapezoidal neutrosophic available resource vector, $\tilde{c} = \left[\tilde{c}_1, \tilde{c}_2, \tilde{c}_3, \ldots, \tilde{c}_n\right]^t$ is the target coefficient and y is the selection variable vector.

Let $\tilde{r}, y^*$ be a possible location and an actual most effective answer of issue (1.1), individually. In the event that there exist an $y' \in \tilde{r}$ so as to fulfils the constraint $Dy \le h$, then, $\tilde{\mathbf{c}}^{\mathbf{T}} y' \ge \tilde{\mathbf{c}}^{\mathbf{T}} y^*$,then y' is also an novel optimal solution of problem (1.1) and is called an substitute exact optimal solution.

The objective function of model (1.1) is a TrNN as $\tilde{z}=\left(\left(\mathbf{c}_1^l\right)^T y,\left(\mathbf{c}_2^l\right)^T y,\left(\mathbf{c}_3^l\right)^T y,\left(\mathbf{c}_4^l\right)^T y;\mu_1 y,v_1 y,\omega_1 y\right)$. This objective function should be maximized as a TrNN. The constraints of model (1.1) is a TrNN consider as: $\tilde{D}=(d_1^l,d_2^l,d_3^l,d_4^l;\mu_d,v_d,\omega_d),\tilde{h}=(h_1^l,h_2^l,h_3^l,h_4^l;\mu_h,v_h,\omega_h)$.

The steps of the proposed method are as follows:

Step 1: By utilizing definition 3 and 4, the issue (1.1) might be composed as by the accompanying multi-objective structure for example

maximize (minimize) $\{(c_1^l)^t y,(c_2^l)^t y,(c_3^l)^t y,(c_4^l)^t y;(\mu_1)y,(v_1)y,(\omega_1 y)\}$ **(2.2)**

s.t

$$\{(d_1^l)y,(d_2^l)y,(d_3^l)y,(d_4^l)y;(\mu_d)y,(v_d)y,(\omega_d)y\}\le\{(h_1^l)y,(h_2^l)y,(h_3^l)y,(h_4^l)y;(\mu_h)y,(v_h)y,(\omega_h)y\}$$

$$y\ge 0.$$

Step-2. Now the issue (2.2) is changed into the accompanying MOLP issue:

$$\min imize\ (\max imize)\ Z_1=\left(\mathbf{c}_2^l\right)^T y-\left(\mathbf{c}_1^l\right)^T y$$

$$\max imize\ (\min imize)\ Z_2=\left(\mathbf{c}_2^l\right)^T y$$

$$\max imize(\min imize)\ Z_3=\frac{1}{2}\left(\left(\mathbf{c}_2^l\right)^T y+\left(\mathbf{c}_3^l\right)^T y\right)$$

$$\max imize(\min imize)\ Z_4=\left(\mathbf{c}_4^l\right)^T y-\left(\mathbf{c}_3^l\right)^T y$$

$$\max imize\ (\min imize)\ Z_5=\left(\mu_1\right)y+\left(\omega_1\right)y$$

$$\max imize\ (\min imize)\ Z_6=\left(v_1\right)y$$

$$\min imize\ (\max imize)\ Z_7=\left(\omega_1\right)y-\left(\mu_1\right)y$$

Subject to (3.3)

$$d_1^l y\le h_1^l$$

$$d_1^l y\le h_2^l$$

$$d_3^l y\le h_3^l$$

$$d_4^l y \le h_4^l$$

$$\mu_d y \le \mu_h$$

$$v_d y \le v_h$$

$$\omega_d y \le \omega_h$$
$$y \ge \mathbf{0}.$$

Step-3. Presently the issue (3.3) is likewise a MOLP issue. In objective functions, the lexicographic technique will be utilized to get lexicographic optimal solution of issue (3.3), we have:

$$\min imize\ (\max imize)\, Z_1 = \left(\mathbf{c}_2^l\right)^T y - \left(\mathbf{c}_1^l\right)^T y \qquad (4.4)$$

Subject to

$$d_1^l y \le h_1^l$$

$$d_1^l y \le h_2^l$$

$$d_3^l y \le h_3^l$$

$$d_4^l y \le h_4^l$$

$$\mu_d y \le \mu_h$$

$$v_d y \le v_h$$

$$\omega_d y \le \omega_h$$
$$y \ge \mathbf{0}.$$

If (4.4) has a special best solution, at that point it is an ideal arrangement of (2.2). Else ourselves continue to following pace.

Step-4. Tackle the accompanying issue above ideal arrangement that is discovered in step-3 as succeed:

$$\max imize\ (\min imize)\, Z_2 = \left(\mathbf{c}_2^l\right)^T y \qquad (5.5)$$

Subject to

$$\left(\mathbf{c}_2^l\right)^T y - \left(\mathbf{c}_1^l\right)^T y = J$$

all constraints of problem (4.4).

Where J is the optimal value of the Problem (4.4). In the event that (5.5) has a novel optimal result, at that point it is an ideal result of (2.2) and stop. In any case go to the following step.

Step-5. Tackle the accompanying issue above the ideal results that are observed in step-4 as succeed:

$$\max imize\,(\min imize)\,\frac{1}{2}((c_2^l)^t y + (c_3^l)^t y) \tag{6.6}$$

Subject to

$$(c_2^l)^t y = K$$

$$\left(\mathbf{c}_2^l\right)^T y - \left(\mathbf{c}_1^l\right)^T y = J$$

all constraints of problem (4.4).

where K is the optimal value of the problem (5.5). If (6.6) has a novel optimal solution, at that point it is an ideal result of (2.2) and stop. In any case go to the following step.

Step-6. Tackle the accompanying issue above the ideal results that are resolved in step-5 as succeed:

$$\max imize\,(\min imize)\,(c_4^l)^T y - (c_3^l)^T y \tag{7.7}$$

Subject to

$$\frac{1}{2}((c_2^l)^t y + (c_3^l)^t y) = L$$

$$(c_2^l)^t y = K$$

$$\left(\mathbf{c}_2^l\right)^T y - \left(\mathbf{c}_1^l\right)^T y = J$$

$$all\ constra\text{int}\,s\ of\ \ problem\,(4.4).$$

where L is the optimal value of the problem (6.6). If (7.7) has a novel optimal solution, at that point it is an ideal result of (2.2) and end. Else go to following step.

Step-7. Tackle the accompanying issue above the ideal results that are resolved in step-6 as succeed:

$$\max imize(\min imize)\,(\mu_1)y+(\omega_1)y \qquad (8.8)$$

Subject to

$$(c_4^l)^T y-(c_3^l)^T y=M$$
$$\frac{1}{2}((c_2^l)^t y+(c_3^l)^t y)=L$$
$$(c_2^l)^t y=K$$
$$\left(\mathbf{c}_2^l\right)^T y-\left(\mathbf{c}_1^l\right)^T y=J$$
$$all\; constra\operatorname{int}s\; of\;\; problem\,(4.4).$$

where M is the optimal value of issue (7.7). If (8.8) has novel optimal solution, at that point it is ideal result of (2.2) and end. In any case go to following step.

Step-8. Tackle the accompanying issue above the ideal solutions that are resolved in step-7 as succeed:

$$\max imize(\min imize)\,(\nu \qquad (9.9)$$

Subject to

$$(\mu_1)y+(\omega_1)y=N$$
$$(c_4^l)^T y-(c_3^l)^T y=M$$
$$\frac{1}{2}((c_2^l)^t y+(c_3^l)^t y)=L$$
$$(c_2^l)^t y=K$$
$$\left(\mathbf{c}_2^l\right)^T y-\left(\mathbf{c}_1^l\right)^T \mathbf{x}=J$$
$$all\; constra\operatorname{int}s\; of\;\; problem\,(4.4).$$

where N is the optimal value of issue (8.8). If (9.9) has a novel optimal solution, at that point it is an ideal result of (2.2) and end. In other case go to the following step.

Step-9. Tackle the accompanying issue above the ideal solutions that are resolved in step-8 as succeed:

$$\min imize(\max imize)\,(\omega_1)y-(\mu_1)y \qquad (10.10)$$

Subject to

$$(v_1)y = O$$
$$(\mu_1)y + (\omega_1)y = N$$
$$(c_4^l)^T y - (c_3^l)^T y = M$$
$$\frac{1}{2}((c_2^l)^t y + (c_3^l)^t y) = L$$
$$(c_2^l)^t y = K$$
$$\left(\mathbf{c}_2^l\right)^T y - \left(\mathbf{c}_1^l\right)^T y = J$$
$$all\, constra\operatorname{int} s\, of\ \ problem\,(4.4).$$

where O is the ideal value of issue (9.9).

In Step-9, we get an precise ideal solution which is equal to the issue (2.2).

The stream outline depicts the technique of the proposed strategy as appeared in Fig. 1.

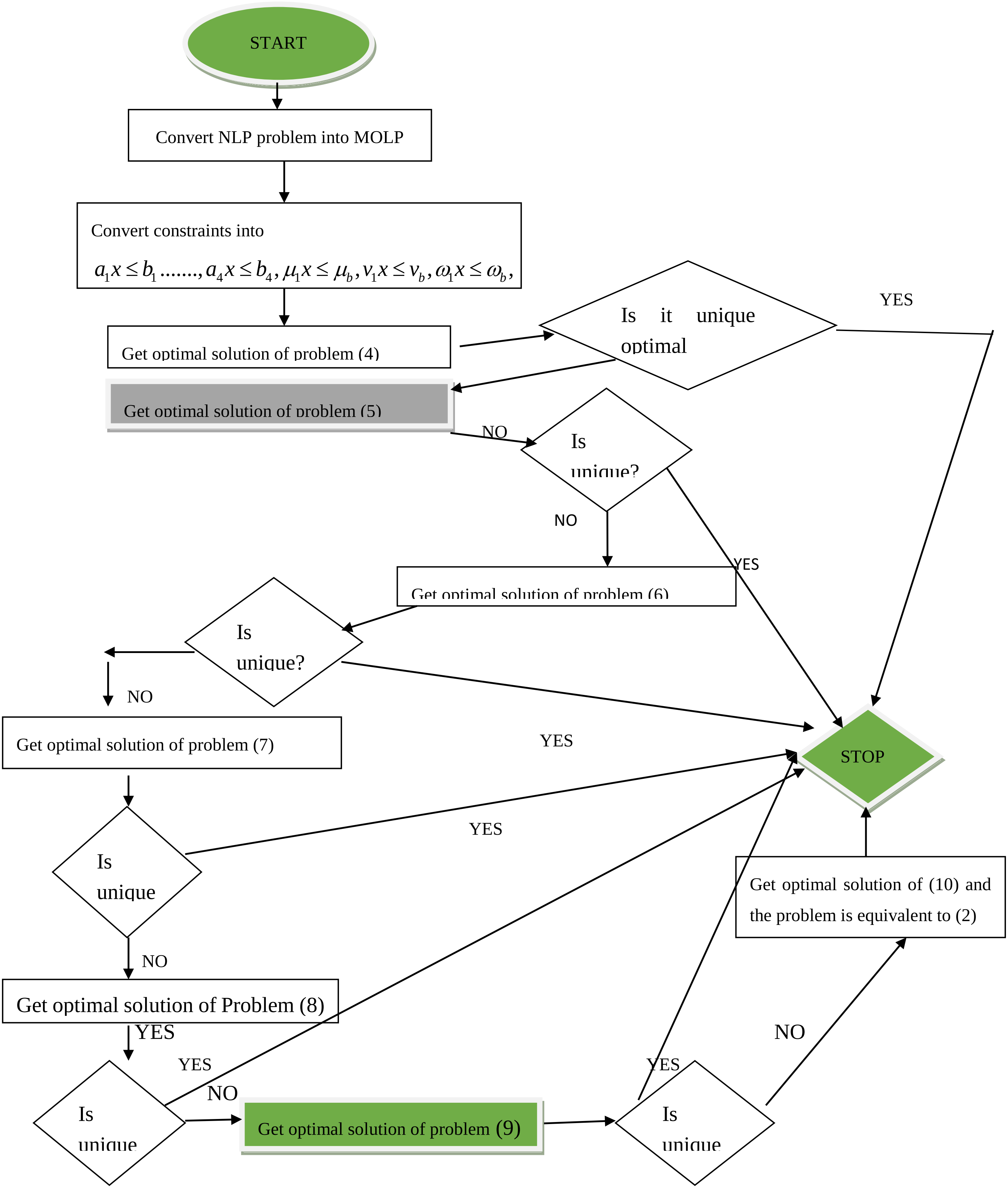

Fig-1. Flowchart depicting the proposed solution method

4. Numerical example

In this area, to demonstrate the pertinence and efficiency of our proposed model of NLP problems, we tackled the issue where the decision-makers always think the truth degree, indeterminacy, and falsity degree. Here the managers not fixed the conformation degree, and the confirmation degree may change as per real-life situation.

Example-1:

The information gathered from a proprietor of a provincial Electrical Cable maker (information is furnished with a legitimate understanding that the title of the organization won't occur unveiled) arranged with Bhubaneswar do appeared in desk-1.

An Electrical Cable maker makes two sorts of cable p1 and p2. These cable comprises of Metal and Plastic (R1, R2) utilized in per unit of cable. The accessibility of cables relies upon its creation however creation relies upon men, machine and so forth of cables are not known precisely because of electricity-failure, employment extra effort, surprising disappointments during instrument and so on. The shipping value of every day provide Metal with Plastic isn't familiar precisely because of varieties in paces of fuel, traffic issues and so on. In this way, all the parameters of the creation organization are unsure amounts with faltering. As per old incident of the proprietor the day by day provides of load is spoken to trapezoidal neutrosophic numbers in desk-1. The normal expense of per meter of p1 and p2 are (1,3,4,7;.8,0.2,0.4) and (4,6,8,10;0.9,0.3,0.5) units, individually. The most extreme every day supplies metals R1 and R2 are around (10,15,20,25;0.6,0.0,0.5) and (10,20,25,300.9,0.45,0.3) units individually. The maker needs to know so as to maximize the expense of Metal and Plastic what number of meters of Cables P1 and p2 he should deliver every day?

Table-1: The statistics of day to day provides of Metal along with Plastic

	Outcomes

Load	Metal (p1)	Plastic (p2)
R1	(2,4,6,8;0.8,0.2,0.4)	(3,5,9,12,0.7,0.2,0.1)
R2	(4,7,10,13;0.7,0.4,0.2)	(3,6,9,14;0.8,0.5,0.3)

Now the issue might be rewritten as

$$\max Z = (1,3,4,7;0.8,0.2,0.4)x_1 + (4,6,8,10;0.9,0.3,0.5)x_2$$
$$s.t.$$
$$(2,4,6,8;0.6,0.1,0.3)x_1 + (3,5,9,12;0.7,0.2,0.1)x_2 \leq (10,15,20,25;0.6,0.0,0.5)$$
$$(4,7,10,13;0.7,0.4,0.2)x_1 + (3,6,9,14;0.8,0.5,0.3)x_2 \leq (10,20,25,3;0.9,0.45,0.3)$$
$$x_1, x_2 \geq 0.$$

By sing Step-1, the problem may be rewritten as;

$$\max Z = (x_1, 3x_1, 4x_1, 7x_1; 0.8x_1, 0.2x_1, 0.4x_1) + (4x_2, 6x_2, 8x_2, 10x_2; 0.9x_2, 0.3x_2, 0.5x_2)$$
$$s.t.$$
$$(2x_1, 4x_1, 6x_1, 8x_1; 0.6x_1, 0.1x_1, 0.3x_1) + (3x_2, 5x_2, 9x_2, 12x_2; 0.7x_2, 0.2x_2, 0.1x_2)x_2$$
$$\leq (10,15,20,25;0.6,0.0,0.5)$$
$$(4x_1, 7x_1, 10x_1, 13x_1; 0.7x_1, 0.4x_1, 0.2x_1) + (3x_2, 6x_2, 9x_2, 14x_2; 0.8x_2, 0.5x_2, 0.3x_2)$$
$$\leq (10,20,25,30;0.9,0.45,0.3)$$
$$x_1, x_2 \geq 0.$$

Found on Step-2, the above model may be changed into MOLP model

$$\begin{aligned}
&\min Z_1 = 2x_1 + 2x_2 \\
&\max Z_2 = 3x_1 + 6x_2 \\
&\max Z_3 = 5.5x_1 + 9x_2 \\
&\max Z_4 = 3x_1 + 2x_2 \\
&\max Z_5 = 0.8x_1 \\
&\max Z_6 = 0.8x_1 - 0.4x_2 \\
&\min Z_7 = 0.8x_1 + 0.4x_2 \\
&s.t. \\
&\quad 2x_1 + 3x_2 \le 10 \\
&\quad 4x_1 + 5x_2 \le 15 \\
&\quad 6x_1 + 9x_2 \le 20 \\
&\quad 8x_1 + 25x_2 \le 25 \\
&\quad 0.6x_1 \le 0.6 \\
&\quad 0.2x_2 \le 0 \\
&\quad 0.3x_1 \le 0.5 \\
&\quad 4x_1 + 3x_2 \le 10 \\
&\quad 7x_1 + 6x_2 \le 20 \\
&\quad 10x_1 + 9x_2 \le 25 \\
&\quad 13x_1 + 14x_2 \le 30 \\
&\quad 0.7x_1 \le 0.9 \\
&\quad 0.5x_2 \le 0.45 \\
&\quad 0.3x_2 \le 0.3 \\
&\quad x_1, x_2 \ge 0.
\end{aligned} \tag{11}$$

Using step3 to Step-9, the ideal answer of the problem is done as follows:

As a multi-objective formulation, the model (11) was solved by the proposed solution approach (steps 3-9). The obtained results are as : $x_1 = 1.25, x_2 = 0$ and the objective solution is: $Z = 3$.

The below table express the quality phase of our proposed method is that it off ers new perfect cost regards as differentiated and the present existing system. This is showed up in Table 2(Numerical assessment with existing procedures) exc lusively.

Table-2. Comparison of the proposed method with existing methods [38]

Approach	Optimal solution	Crisp objective value	Neutrosophic optimal value
Proposed Method	$x_1 = 1.25, x_2 = 0$	$Z = 3$	(1.25,3.75,5,8.75;0.8,0.2,0.4)
Existing Method [38]	$x_1 = 1.523, x_2 = 0$	$Z = 2.75$	(1.523,4.569,6.092,10.661;1,0,0)

Example-2

In this section, we consider the symmetric trapezoidal numbers in form of $(a^l, a^u, \alpha, \alpha)$. Where $(a^l, a^u, \alpha, \alpha)$ represented the lower, upper bound and first, second median value of trapezoidal number respectively. Additionally, here we consider the confirmation degree is (1,0,0). We shows the applicability of our proposed method, we consider the problem of Das et al. [25], Ganesan and Veeramani [21].

$$\begin{aligned}
&\max Z = (13,15,2,2)x_1 + (12,14,3,3)x_2 + (15,17,2,2)x_3 \\
&s.t. \\
&\quad (11,13,2,2)x_1 + (12,14,1,1)x_2 + (11,13,2,2)x_3 \le (475,505,6,6) \\
&\quad (12,16,1,1)x_1 + (12,14,1,1)x_3 \le (460,480,8,8) \\
&\quad (11,13,2,2)x_1 + (14,16,3,3)x_2 \le (465,495,5,5) \\
&\quad x_1, x_2, x_3 \ge 0.
\end{aligned}$$

By using our proposed method (Steps 1 to 9), we get the results of Table-3.

Table-3. Comparison of the proposed method with existing methods [21,25,38]

Approach	Optimal solution	Crisp objective value	Neutrosophic optimal value
Proposed Method	$x_1 = 0, x_2 = 4.44, x_3 = 37.29$	$Z = 838.21$	(612.63,696.09,87.9,87.9;1,0,0)
Existing Method	$x_1 = 0, x_2 = 4.11, x_3 = 37.38$	$Z = 825.71$	(610.02,693,87.09,87.09;1,0,0)

[38]			
Existing method [25]	$x_1 = 0, x_2 = 4.23, x_3 = 34.28$	$Z = 622.97$	(564.96,680.98,80.98,80.98)

4. Result Analysis

At first, we examined the example-1, we compare our result with existing method Abdel-Basset[38], we conclude that,

1. In our method, the objective values equal to 3 and the existing method [38], the optimal value s 2.75. As the problem is maximization, therefore, our problem is better than the other method.
2. In our method, we do not use the slack variables in constraints. However, the existing method the authors have used the slack variables and solved in the simplex method.

For example-2, we consider the problem which was proposed by Das et al. [25] on the trapezoidal fuzzy number and Abdel-basset [38], and we compare it with our proposed method having trapezoidal neutrosophic numbers.

3. From table-3, it is clear that our objective values is maximized and equal to 838.21 as the problem is maximized given. In our comparison, neutrosophic is better handling than fuzzy in real-life situations.
4. In our lexicographic method is better than the ranking function of Abdel-Basset [38] method.The results are supported by the fact that the existing method [38] use a single ranking function, in this case the optimization criterion, whi ch can not guarantee the feasibility of the solution. However, proposed me thod in this paper is more concentrate regarding the indeterminacy and co nvert to MOLP problem by utilizing the LO.
5. In the existing method [38], the authors considered two types of ranking functions for handling different types of NLP problems. However, in our proposed method, we

propose only one type of method called the lexicographic method and that method can handle any type of NLP problem.

From the above Table-2 and Table-3, one can conclude that the optimum value of NLP problem is higher side of the present methods. Therefore, we can conclude that our proposed algorithm is a new way to handle the problem and its more effective.

All the problems are solved by LINGO version 18.0. Therefore, from the above real-life problem and the above discussion, we can conclude that our proposed m ethod ismore robust than the method proposed in [21,25,38].

4.1 Advantages and limitations of the proposed method

Here, in this paper, we proposed a new technique for trapezoidal neutrosophic fuzzy numbers based on lexicographic technique orders and the significant advantages of the proposed measure are given as follows.

- Trapezoidal fuzzy neutrosophic number is a simple design of arithmetic operations and easy and perceptive interpretation as well. Therefore the proposed measure is an easy and effective one under neutrosophic environment.
- Lexicographic Orders can be estimated with simple algorithm and significant level of accuracy can be acquired as well.
- While taking the inequality constraints convert to equality constraints we used LO technique instead of any slack variables.
- Also it can be applied in location planning, operations management, Neutrosophic Statistics,clustering, medical diagnosis, Optimization and image processing to get more accurate results without any computational complexity.

Limitations

- While used LO technique to convert multi-objective LP problem the numbers of constraints are bigger than original LP problem.
- Very slow response while applied in linear fractional problem and quadratic programming problem.

5.Conclusion

In a real-world environment, we handle imprecise, vague, and insufficient information by using the neutrosophic set. In this paper, we considered an NLP problem having trapezoidal neutrosophic numbers and transformed it into a MOLP problem. Based on the LO method, we solve the MOLP problem corresponding to the linear programming problem. It is believed that our method for the solution of NLP problem in the application of practical issue along with the simple issue might be adopted by scholars who are working in this field. Meantime, a numerical example was provided to show the efficiency of the proposed method and illustrate the solution process. The new model not only richens uncertain linear programming methods but also provides a new effective way for handling indeterminate optimization problems. Further, comparative analysis has been done with the existing methods to show the potential of the proposed LO method and various forms of trapezoidal fuzzy neutrosophic number have been listed and shown the uniqueness of the proposed tabular representation. Furthermore, advantages of the proposed measure are given. In future, the present work may be extended to other special types of neutrosophic set like pentagonal neutrosophic set, neutrosophic rough set, interval valued neutrosophic set and plithogeneic environments.

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