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Linear neutrosophic pentadecagonal fuzzy number with symmetry in solving fuzzy environmental problems

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ABSTRACT

In this paper, we deal with the new concept of linear Pentadecagonal neutrosophic fuzzy number with symmetry. Neutrosophic number are extensively used by researchers where unclear, uncertain information appear, so this paper focus on its properties using alpha cut method. We had applied it in a real life problem and found the result using the assignment problem. So alpha cut method is introduced.

1. Introduction

In real life Assignment problem is one of the most popular method in operation research due to its versatile application. It helps us to set us free from difficulty that we face in assigning to when uncertainty, imprecise, incomplete, inconsistent information arises in a philosophical view point, there emerge the neutrosophic set which leads to the integral part of the framework. There arise many practical problem in engineering application wherein, this neutrosophic pentadecagonal fuzzy number helps in solving it. Here, we carry out the NPDFN for real life application where the information provided is incomplete about the parameter used. We have developed then neutrosophic pentadecagonal fuzzy number and its graphical representation. Thus, developed the score and accuracy function for NPDFN which converts into crisp value for the optimization problem like transportation, assignment problems. The membership values of truth, hesitation and falsity quantities are independent and dependent of each other cases are formulated and applied in transportation problem Table 1.

2. Basic definitions

2.1. Definition (Fuzzy neutrosophic Set)

A fuzzy neutrosophic set A on the universe of discourse X is defined as $A = \{x, \omega_A(x), \mu_A(x), \vartheta_A(x) : x\epsilon X\}$where $\omega, \mu, \vartheta : X \rightarrow [0,1]$ and $0 \leq \omega_A(x) + \mu_A(x) + \vartheta_A(x) \leq 3$,where $\omega_A(x)$is a membership function, $\mu_A(x)$ is indeterministic function and $\vartheta_A(x)$ is non-deterministic function.

2.2. Definition (Pentadecagonal neutrosophic fuzzy number)

A Neutrosophic Pentadecagonal fuzzy number NPDFN $\widehat{NP_d} = \left(\left(\breve{B}_1, \breve{B}_2, \breve{B}_3, \breve{B}\breve{B}_4, \breve{B}_5, \breve{B}_6, \breve{B}_7, \breve{B}_8, \breve{B}_9, \breve{B}_{10}, \breve{B}_{11}, \breve{B}_{12}, \breve{B}_{13}, \breve{B}_{14}, \breve{B}_{15} \right); \omega, \mu, \vartheta \right)$ on a real line $\mathbb{R}$, whose truth membership, in determinancy membership and falsity membership function is defined by

2.2.1. Linear generalized Pentadecagonal neutrosophic number

2.2.1.1. Single-valued neutrosophic set. If $\times$ is a single-valued independent variable, then a neutrosophic set is said to be single-valued neutrosophic set if $\bar{\tilde{SVNFN}} = \{ \left(x; \left[\aleph_{\bar{\tilde{SVNFN}}}(x), \beth_{\bar{\tilde{SVNFN}}}(x), \vartheta_{\bar{\tilde{SVNFN}}}(x) \right] \right) : x\epsilon X \}$ where $\aleph_{\bar{\tilde{SVNFN}}}(x), \beth_{\bar{\tilde{SVNFN}}}(x)and\vartheta_{\bar{\tilde{SVNFN}}}(x)$ is the truth, in determinacy and falsity memberships function respectively. If there exist three points τ_0, τ_1, τ_2 for

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Table 1
Crisp Assignment value using Score and Accuracy Function.

	O	P	Q	R
S	52	70	75	63
T	65	67	80	53
U	62	78	79	61
V	80	82	87	58

which $\aleph_{\tilde{\tilde{SVNFN}}}(\tau_0) = 1, \beth_{\tilde{\tilde{SVNFN}}}(\tau_1) = 1$ and $\vartheta_{\tilde{\tilde{SVNFN}}}(\tau_2) = 1$, then $\tilde{\tilde{SVNFN}}$ is called as neutro-normal.

$\tilde{\tilde{SVNFN}}$ is said to be neutro-convex if $\tilde{\tilde{SVNFN}}$ is a subset of a real line by which it satisfies the following conditions:

a. $\aleph_{\tilde{\tilde{SVNFN}}}(\delta \mathrm{d}_1 + (1-\delta)\mathrm{d}_2) \geq \min(\aleph_{\tilde{\tilde{SVNFN}}}(\mathrm{d}_1), \aleph_{\tilde{\tilde{SVNFN}}}(\mathrm{d}_2))$
b. $\beth_{\tilde{\tilde{SVNFN}}}(\tau_1) = (\delta \mathrm{d}_1 + (1-\delta)\mathrm{d}_2) \leq \min(\beth_{\tilde{\tilde{SVNFN}}}(\mathrm{d}_1), \beth_{\tilde{\tilde{SVNFN}}}(\mathrm{d}_2))$
c. $\vartheta_{\tilde{\tilde{SVNFN}}}(\tau_1) = (\delta \mathrm{d}_1 + (1-\delta)\mathrm{d}_2) \leq \min(\vartheta_{\tilde{\tilde{SVNFN}}}(\mathrm{d}_1), \vartheta_{\tilde{\tilde{SVNFN}}}(\mathrm{d}_2))$

Where d_1 and $d_2 \in \mathbb{R}$ and $\delta \epsilon [0,1]$

Pentadecagonal Single Type Neutrosophic Number of Specification 1: When the quantity of the truth, hesitation and falsity are independent to each other.

A Single-valued Neutrosophic Pentadecagonal fuzzy number SVNPDFN- $\bar{B}_{\widehat{SNP_d}} = \left(\left(\breve{B}_1, \breve{B}_2, \breve{B}_3, \breve{B}_4, \breve{B}_5, \breve{B}_6, \breve{B}_7, \breve{B}_8, \breve{B}_9, \breve{B}_{10}, \breve{B}_{11}, \breve{B}_{12}, \breve{B}_{13}, \breve{B}_{14}, \breve{B}_{15}\right); \omega, \mu, \vartheta\right)$ on a real line $\mathbb{R}$, whose truth membership, indeterminancy membership and falsity membership function is defined by A Pentadecagonal 0.

$$\mathbb{T}_{B^-_{\widehat{SNP_d}}}(\boldsymbol{x}) = \begin{cases} 0, x < \breve{B}_1 \\ \boldsymbol{\tau}_1\left(\frac{x-\breve{B}_1}{\breve{B}_2-\breve{B}_1}\right), \breve{B}_1 \leq \boldsymbol{x} \leq \breve{B}_2 \\ \boldsymbol{\tau}_1, \breve{B}_2 \leq \boldsymbol{x} \leq \breve{B}_3 \\ \boldsymbol{\tau}_1 + (\boldsymbol{\tau}_2 - \boldsymbol{\tau}_1)\left(\frac{x-\breve{B}_3}{\breve{B}_4-\breve{B}_3}\right), \breve{B}_3 \leq x \leq \breve{B}_4 \\ \boldsymbol{\tau}_2, \breve{B}_4 \leq x \leq \breve{B}_5 \\ \boldsymbol{\tau}_2 + (\boldsymbol{\tau}_3 - \boldsymbol{\tau}_2)\left(\frac{x-\breve{B}_5}{\breve{B}_6-\breve{B}_5}\right), \breve{B}_5 \leq x \leq \breve{B}_6 \\ \boldsymbol{\tau}_3, \breve{B}_6 \leq x \leq \breve{B}_7 \\ \boldsymbol{\tau}_3 + (1 - \boldsymbol{\tau}_3)\left(\frac{x-\breve{B}_7}{\breve{B}_8-\breve{B}_7}\right), \breve{B}_7 \leq x \leq \breve{B}_8 \\ 1, x = \breve{B}_8 \\ \boldsymbol{\tau}_3 + (\boldsymbol{\tau}_3 - 1)\left(\frac{x-\breve{B}_8}{\breve{B}_9-\breve{B}_8}\right), \breve{B}_8 \leq x \leq \breve{B}_9 \\ \boldsymbol{\tau}_3, \breve{B}_9 \leq x \leq \breve{B}_{10} \\ \boldsymbol{\tau}_2 + (\boldsymbol{\tau}_2 - \boldsymbol{\tau}_3)\left(\frac{x-\breve{B}_{10}}{\breve{B}_{11}-\breve{B}_{10}}\right), \breve{B}_{10} \leq \boldsymbol{x} \leq \breve{B}_{11} \\ \boldsymbol{\tau}_2, \breve{B}_{11} \leq \boldsymbol{x} \leq \breve{B}_{12} \\ \boldsymbol{\tau}_1 + (\boldsymbol{\tau}_1 - \boldsymbol{\tau}_2)\left(\frac{x-\breve{B}_{12}}{\breve{B}_{13}-\breve{B}_{12}}\right), \breve{B}_{12} \leq \boldsymbol{x} \leq \breve{B}_{13} \\ \boldsymbol{\tau}_1, \breve{B}_{13} \leq \boldsymbol{x} \leq \breve{B}_{14} \\ \boldsymbol{\tau}_1\left(\frac{x-\breve{B}_{14}}{\breve{B}_{15}-\breve{B}_{14}}\right), \breve{B}_{14} \leq \boldsymbol{x} \leq \breve{B}_{15} \\ 0, \boldsymbol{x} > \breve{B}_{15} \end{cases}$$

$$\mathbb{I}_{B^-_{\widehat{SNP_d}}}(\boldsymbol{x}) = \begin{cases} 1 + (\boldsymbol{\tau}_3 - 1)\left(\frac{x-\breve{B}_1{}^1}{\breve{B}_2{}^1-\breve{B}_1{}^1}\right), \breve{B}_1{}^1 \leq \boldsymbol{x} \leq \breve{B}_2{}^1 \\ \boldsymbol{\tau}_3, \breve{B}_2{}^1 \leq \boldsymbol{x} \leq \breve{B}_3{}^1 \\ \boldsymbol{\tau}_3 + (\boldsymbol{\tau}_2 - \boldsymbol{\tau}_3)\left(\frac{x-\breve{B}_3{}^1}{\breve{B}_4{}^1-\breve{B}_3{}^1}\right), \breve{B}_3{}^1 \leq x \leq \breve{B}_4{}^1 \\ \boldsymbol{\tau}_2, \breve{B}_4{}^1 \leq x \leq \breve{B}_5{}^1 \\ \boldsymbol{\tau}_2 + (\boldsymbol{\tau}_1 - \boldsymbol{\tau}_2)\left(\frac{x-\breve{B}_5{}^1}{\breve{B}_6{}^1-\breve{B}_5{}^1}\right), \breve{B}_5{}^1 \leq x \leq \breve{B}_6{}^1 \\ \boldsymbol{\tau}_1, \breve{B}_6{}^1 \leq x \leq \breve{B}_7{}^1 \\ \boldsymbol{\tau}_1 - \boldsymbol{\tau}_1\left(\frac{x-\breve{B}_7{}^1}{\breve{B}_8{}^1-\breve{B}_7{}^1}\right), \breve{B}_7{}^1 \leq x \leq \breve{B}_8{}^1 \\ 0, x = \breve{B}_8{}^1 \\ \boldsymbol{\tau}_1 + \boldsymbol{\tau}_1\left(\frac{x-\breve{B}_8{}^1}{\breve{B}_9{}^1-\breve{B}_8{}^1}\right), \breve{B}_8{}^1 \leq x \leq \breve{B}_9{}^1 \\ \boldsymbol{\tau}_1, \breve{B}_9{}^1 \leq x \leq \breve{B}_{10}{}^1 \\ \boldsymbol{\tau}_2 + (\boldsymbol{\tau}_2 - \boldsymbol{\tau}_1)\left(\frac{x-\breve{B}_{10}{}^1}{\breve{B}_{11}{}^1-\breve{B}_{10}{}^1}\right), \breve{B}_{10}{}^1 \leq \boldsymbol{x} \leq \breve{B}_{11}{}^1 \\ \boldsymbol{\tau}_2, \breve{B}_{11}{}^1 \leq \boldsymbol{x} \leq \breve{B}_{12}{}^1 \\ \boldsymbol{\tau}_3 + (\boldsymbol{\tau}_3 - \boldsymbol{\tau}_2)\left(\frac{x-\breve{B}_{12}{}^1}{\breve{B}_{13}{}^1-\breve{B}_{12}{}^1}\right), \breve{B}_{12}{}^1 \leq \boldsymbol{x} \leq \breve{B}_{13}{}^1 \\ \boldsymbol{\tau}_3, \breve{B}_{13}{}^1 \leq \boldsymbol{x} \leq \breve{B}_{14}{}^1 \\ 1 + (1 - \boldsymbol{\tau}_3)\left(\frac{x-\breve{B}_{14}{}^1}{\breve{B}_{15}{}^1-\breve{B}_{14}{}^1}\right), \breve{B}_{14}{}^1 \leq \boldsymbol{x} \leq \breve{B}_{15}{}^1 \\ 1, \boldsymbol{x} < \breve{B}_1{}^1, \boldsymbol{x} > \breve{B}_{15}{}^1 \end{cases}$$

$$0 < \tau_1 < \boldsymbol{\tau}_2 < \boldsymbol{\tau}_3 < 1$$

$$\mathbb{F}_{B^-_{\widehat{SNP_d}}}(\boldsymbol{x}) = \begin{cases} 1 + (\boldsymbol{\tau}_3 - 1)\left(\frac{x-\breve{B}_1{}^2}{\breve{B}_2{}^2-\breve{B}_1{}^2}\right), \breve{B}_1{}^2 \leq \boldsymbol{x} \leq \breve{B}_2{}^2 \\ \boldsymbol{\tau}_3, \breve{B}_2{}^2 \leq \boldsymbol{x} \leq \breve{B}_3{}^2 \\ \boldsymbol{\tau}_3 + (\boldsymbol{\tau}_2 - \boldsymbol{\tau}_3)\left(\frac{x-\breve{B}_3{}^2}{\breve{B}_4{}^2-\breve{B}_3{}^2}\right), \breve{B}_3{}^2 \leq x \leq \breve{B}_4{}^2 \\ \boldsymbol{\tau}_2, \breve{B}_4{}^2 \leq x \leq \breve{B}_5{}^2 \\ \boldsymbol{\tau}_2 + (\boldsymbol{\tau}_1 - \boldsymbol{\tau}_2)\left(\frac{x-\breve{B}_5{}^2}{\breve{B}_6{}^2-\breve{B}_5{}^2}\right), \breve{B}_5{}^2 \leq x \leq \breve{B}_6{}^2 \\ \boldsymbol{\tau}_1, \breve{B}_6{}^2 \leq x \leq \breve{B}_7{}^2 \\ \boldsymbol{\tau}_1 + (o - \boldsymbol{\tau}_1)\left(\frac{x-\breve{B}_7{}^2}{\breve{B}_8{}^2-\breve{B}_7{}^2}\right), \breve{B}_7{}^2 \leq x \leq \breve{B}_8{}^2 \\ 0, x = \breve{B}_8{}^2 \\ \boldsymbol{\tau}_1\left(\frac{x-B\breve{B}_8{}^2}{\breve{B}_9{}^2-\breve{B}_8{}^2}\right), \breve{B}_8{}^2 \leq x \leq \breve{B}_9{}^2 \\ \boldsymbol{\tau}_1, \breve{B}_9{}^2 \leq x \leq \breve{B}_{10}{}^2 \\ \boldsymbol{\tau}_1 + (\boldsymbol{\tau}_2 - \boldsymbol{\tau}_1)\left(\frac{x-\breve{B}_{10}{}^2}{\breve{B}_{11}{}^2-\breve{B}_{10}{}^2}\right), \breve{B}_{10}{}^2 \leq \boldsymbol{x} \leq \breve{B}_{11}{}^2 \\ \boldsymbol{\tau}_2, \breve{B}_{11}{}^2 \leq \boldsymbol{x} \leq \breve{B}_{12}{}^2 \\ \boldsymbol{\tau}_2 + (\boldsymbol{\tau}_3 - \boldsymbol{\tau}_2)\left(\frac{x-\breve{B}_{12}{}^2}{\breve{B}_{13}{}^2-\breve{B}_{12}{}^2}\right), \breve{B}_{12}{}^2 \leq \boldsymbol{x} \leq \breve{B}_{13}{}^2 \\ \boldsymbol{\tau}_3, \breve{B}_{13}{}^2 \leq \boldsymbol{x} \leq \breve{B}_{14}{}^2 \\ \boldsymbol{\tau}_3 + (1 - \boldsymbol{\tau}_3)\left(\frac{x-\breve{B}_{14}{}^2}{\breve{B}_{15}{}^2-\breve{B}_{14}{}^2}\right), \breve{B}_{14}{}^2 \leq \boldsymbol{x} \leq \breve{B}_{15}{}^2 \\ 1, \boldsymbol{x} < \breve{B}_1{}^2, \boldsymbol{x} > \breve{B}_{15}{}^2 \end{cases}$$

Where $0 < \tau_1 < \tau_2 < \tau_3 < 1;$ $0 \le \mathbb{T}_{\bar{B}_{\widehat{SNP_d}}}(\boldsymbol{x}) \le \mathbb{I}_{\bar{B}_{\widehat{SNP_d}}}(\boldsymbol{x}) \le \mathbb{F}_{\bar{B}_{\widehat{SNP_d}}}(\boldsymbol{x}) \le 3+; \boldsymbol{x} \in \bar{B}_{\widehat{SNP_d}}$

Fig. 1 Shows Linear Single-valued Neutrosophic Symmetric Pentadecagonal Fuzzy Number (LSNSP$_d$FN) Pentadecagonal

Single Type Neutrosophic Number A Single-valued Neutrosophic Pentadecagonal fuzzy number SVNPDFN $\bar{B}_{\widehat{SNP_d}} = \left(\left(\breve{B}_1, \breve{B}_2, \breve{B}_3, \breve{B}_4, \breve{B}_5, \breve{B}_6, \breve{B}_7, \breve{B}_8, \breve{B}_9, \breve{B}_{10}, \breve{B}_{11}, \breve{B}_{12}, \breve{B}_{13}, \breve{B}_{14}, \breve{B}_{15}\right); \omega, \mu, \vartheta\right)$ on a real line $\mathbb{R}$, whose truth membership, indeterminancy membership and falsity membership function is defined by:

where

Where$0 \le \mathbb{T}\boldsymbol{\mu}_{\widehat{NP_d}}(\boldsymbol{x}) \le \mathbb{I}\boldsymbol{\mu}_{\widehat{NP_d}}(\boldsymbol{x}) \le \mathbb{F}\boldsymbol{\mu}_{\widehat{NP_d}}(\boldsymbol{x}) \le 2+; \boldsymbol{x} \in \boldsymbol{\mu}_{\widehat{NP_d}}$

The parametric form is given by:

Where,

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d1}}}}(\boldsymbol{\omega}) = \breve{B}_1 + \frac{\boldsymbol{\omega}}{\boldsymbol{j}}\left(\breve{B}_2 - \breve{B}_1\right) for \omega \epsilon [0, \boldsymbol{j}] \mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d14}}}}(\boldsymbol{\omega}) = \breve{B}_{14} - \frac{\boldsymbol{\omega}}{\boldsymbol{j}}\left(\breve{B}_{15} - \breve{B}_{14}\right) for \omega \epsilon [0, \boldsymbol{j}]$$

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d2}}}}(\boldsymbol{\omega}) = \breve{B}_2 + \frac{\boldsymbol{\omega} - \boldsymbol{j}}{\boldsymbol{k} - \boldsymbol{j}}\left(\breve{B}_3 - \breve{B}_2\right) for \omega \epsilon [\boldsymbol{j}, \boldsymbol{k}] \mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d13}}}}(\boldsymbol{\omega}) = \breve{B}_{13} - \frac{\boldsymbol{\omega} - \boldsymbol{j}}{\boldsymbol{k} - \boldsymbol{j}}\left(\breve{B}_{14} - \breve{B}_{13}\right) for \omega \epsilon [\boldsymbol{j}, \boldsymbol{k}]$$

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d3}}}}(\boldsymbol{\omega}) = \breve{B}_3 + \frac{\boldsymbol{\omega} - \boldsymbol{k}}{\boldsymbol{l} - \boldsymbol{k}}\left(\breve{B}_4 - \breve{B}_3\right) for \omega \epsilon [\boldsymbol{k}, \boldsymbol{l}] \mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d12}}}}(\boldsymbol{\omega}) = \breve{B}_{12} - \frac{\boldsymbol{\omega} - \boldsymbol{k}}{\boldsymbol{l} - \boldsymbol{k}}\left(\breve{B}_{13} - \breve{B}_{12}\right) for \omega \epsilon [\boldsymbol{k}, \boldsymbol{l}]$$

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d4}}}}(\boldsymbol{\omega}) = \breve{B}_4 + \frac{\boldsymbol{\omega} - \boldsymbol{l}}{\boldsymbol{m} - \boldsymbol{l}}\left(\breve{B}_5 - \breve{B}_4\right) for \omega \epsilon [\boldsymbol{l}, m] \mathbb{T}\boldsymbol{\mu}_{\widehat{NP_{d11}}}(\boldsymbol{\omega}) = \breve{B}_{11} - \frac{\boldsymbol{\omega} - \boldsymbol{l}}{\boldsymbol{m} - \boldsymbol{l}}\left(\breve{B}_{12} - \breve{B}_{11}\right) for \omega \epsilon [\boldsymbol{l}, m]$$

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d5}}}}(\omega) = \breve{B}_5 + \frac{\omega - m}{n - m}\left(\breve{B}_6 - \breve{B}_5\right) for \omega \epsilon [m, n] \mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d10}}}}(\boldsymbol{\omega}) = \breve{B}_{10} - \frac{\omega - m}{n - m}\left(\breve{B}_{11} - \breve{B}_{10}\right) for \omega \epsilon [m, n]$$

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d6}}}}(\boldsymbol{\omega}) = \breve{B}_6 + \frac{\boldsymbol{\omega} - \boldsymbol{n}}{\boldsymbol{o} - \boldsymbol{n}}\left(\breve{B}_7 - \breve{B}_6\right) for \omega \epsilon [\boldsymbol{n}, \boldsymbol{o}] \mathbb{T}\boldsymbol{\mu}_{\widehat{NP_{d9}}}(\boldsymbol{\omega}) = \breve{B}_9 - \frac{\boldsymbol{\omega} - \boldsymbol{n}}{\boldsymbol{o} - \boldsymbol{n}}\left(\breve{B}_{10} - \breve{B}_9\right) for \omega \epsilon [\boldsymbol{n}, \boldsymbol{o}]$$

$$\mathbb{T}_{\boldsymbol{\mu}_{\widehat{NP_{d7}}}}(\boldsymbol{\omega}) = \breve{B}_7 + \frac{\boldsymbol{\omega} - \boldsymbol{o}}{1 - o}\left(\breve{B}_8 - \breve{B}_7\right) for \omega \epsilon [\boldsymbol{o}, 1] \mathbb{T}\boldsymbol{\mu}_{\widehat{NP_{d8}}}(\boldsymbol{\omega}) = \breve{B}_8 - \frac{\boldsymbol{\omega} - \boldsymbol{o}}{1 - o}\left(\breve{B}_9 - \breve{B}_8\right) for \omega \epsilon [\boldsymbol{o}, 1]$$

$$\text{Where}, 0 < \omega \le 1, \Delta_{\widehat{NP_d}} < \mu \le 1, \Phi_{\widehat{NP_d}} < \vartheta \le 1, 0 < \mu + \vartheta \le 1 + and 0 < \omega + \mu + \vartheta \le 2+$$

3. Proposed score and accuracy function

Score function and accuracy function of a pentagonal neutrosophic number is fully depend on the value of truth membership indicator degree, falsity membership indicator degree and hesitation membership indicator degree. The need of score and accuracy function is to compare or convert a pentadecagonal neu- trosophic fuzzy number into a crisp number. In this section we will proposed a score function as follows.

For any Pentagonal Single typed Neutrosophic Number (PTGNEU):

$$\bar{B}_{\widehat{SNP_d}} = \left(\left(\breve{B}_1, \breve{B}_2, \breve{B}_3, \breve{B}_4, \breve{B}_5, \breve{B}_6, \breve{B}_7, \breve{B}_8, \breve{B}_9, \breve{B}_{10}, \breve{B}_{11}, \breve{B}_{12}, \breve{B}_{13}, \breve{B}_{14}, \breve{B}_{15}\right); \omega, \mu, \vartheta\right)$$

We consider the beneficiary degree of truth indicator part as $= \left(\frac{\breve{B}_1 + \breve{B}_2 + \breve{B}_3 + \breve{B}_4 + \breve{B}_5 + \breve{B}_6 + \breve{B}_7 + \breve{B}_8 + \breve{B}_9 + \breve{B}_{10} + \breve{B}_{11} + \breve{B}_{12} + \breve{B}_{13} + \breve{B}_{14} + \breve{B}_{15}}{15}\right)$

hesitation degree of indeterminacy indicator as $= \left(\frac{\breve{b}_1 + \breve{b}_2 + \breve{b}_3 + \breve{b}_4 + \breve{b}_5 + \breve{b}_6 + \breve{b}_7 + \breve{b}_8 + \breve{b}_9 + \breve{b}_{10} + \breve{b}_{11} + \breve{b}_{12} + \breve{b}_{13} + \breve{b}_{14} + \breve{b}_{15}}{15}\right)$

Non– beneficiary degree of falsity indicator part $= \left(\frac{\breve{f}_1 + \breve{f}_2 + \breve{f}_3 + \breve{f}_4 + \breve{f}_5 + \breve{f}_6 + \breve{f}_7 + \breve{f}_8 + \breve{f}_9 + \breve{f}_{10} + \breve{f}_{11} + \breve{f}_{12} + \breve{f}_{13} + \breve{f}_{14} + \breve{f}_{15}}{15}\right)$

The score function is given by $\bar{SFB}_{\widehat{SNP_d}} = \frac{1}{3}\left(2 + \frac{\breve{B}_1 + \breve{B}_2 + \breve{B}_3 + \breve{B}_4 + \breve{B}_5 + \breve{B}_6 + \breve{B}_7 + \breve{B}_8 + \breve{B}_9 + \breve{B}_{10} + \breve{B}_{11} + \breve{B}_{12} + \breve{B}_{13} + \breve{B}_{14} + \breve{B}_{15}}{15} - \frac{\breve{b}_1 + \breve{b}_2 + \breve{b}_3 + \breve{b}_4 + \breve{b}_5 + \breve{b}_6 + \breve{b}_7 + \breve{b}_8 + \breve{b}_9 + \breve{b}_{10} + \breve{b}_{11} + \breve{b}_{12} + \breve{b}_{13} + \breve{b}_{14} + \breve{b}_{15}}{15} - \frac{\breve{f}_1 + \breve{f}_2 + \breve{f}_3 + \breve{f}_4 + \breve{f}_5 + \breve{f}_6 + \breve{f}_7 + \breve{f}_8 + \breve{f}_9 + \breve{f}_{10} + \breve{f}_{11} + \breve{f}_{12} + \breve{f}_{13} + \breve{f}_{14} + \breve{f}_{15}}{15}\right)$

$\bar{SFB}_{\widehat{SNP_d}} \epsilon [0, 1]$

The accuracy function is given by $\bar{AFB}_{\widehat{SNP_d}} = \frac{1}{3}\left(\frac{\breve{B}_1 + \breve{B}_2 + \breve{B}_3 + \breve{B}_4 + \breve{B}_5 + \breve{B}_6 + \breve{B}_7 + \breve{B}_8 + \breve{B}_9 + \breve{B}_{10} + \breve{B}_{11} + \breve{B}_{12} + \breve{B}_{13} + \breve{B}_{14} + \breve{B}_{15}}{15} - \frac{\breve{f}_1 + \breve{f}_2 + \breve{f}_3 + \breve{f}_4 + \breve{f}_5 + \breve{f}_6 + \breve{f}_7 + \breve{f}_8 + \breve{f}_9 + \breve{f}_{10} + \breve{f}_{11} + \breve{f}_{12} + \breve{f}_{13} + \breve{f}_{14} + \breve{f}_{15}}{15}\right)$

Where $\bar{AFB}_{\widehat{SNP_d}} \epsilon [-1, 1]$

3.1. Application in neutrosophic transportation environment

We consider PDN environment for a assignment problem, in which there are "A" resources and "R" destinations. Choose a minimum cost and starting from "A"th source and it will go to "R"th section of uncertainty, hesitation in assignment problem.

Proposed Algorithm to find out the optimal solution:

'To solve an assignment problem in neutrosophic environment the following algorithm has to be followed.

Step 1. Form a neutrosophic pentadecagonal fuzzy cost matrix $[\tilde{a}ij]$ (say) whose each entry is SVPd N number.

Step 2. Find out the least cost in each row from ρ-weighted value functions using a pre-assigned ρ and subtract that least cost from all costs in respective row. Proceed the fact in each column also.

Step 3. Mark those cells where subtraction results are equivalent to $V\rho(0\sim)$.

Step 4. Draw the least number of horizontal and vertical lines to cover all the marked cells of present matrix.

Step 5. If the number of lines drawn is equal to the order of matrix, optimality arises. Then go to Step 6, otherwise go to Step 8.

Step 6. Specify a number of marked cells equal to the order of matrix such that each column and each row contains exactly one marked cell.

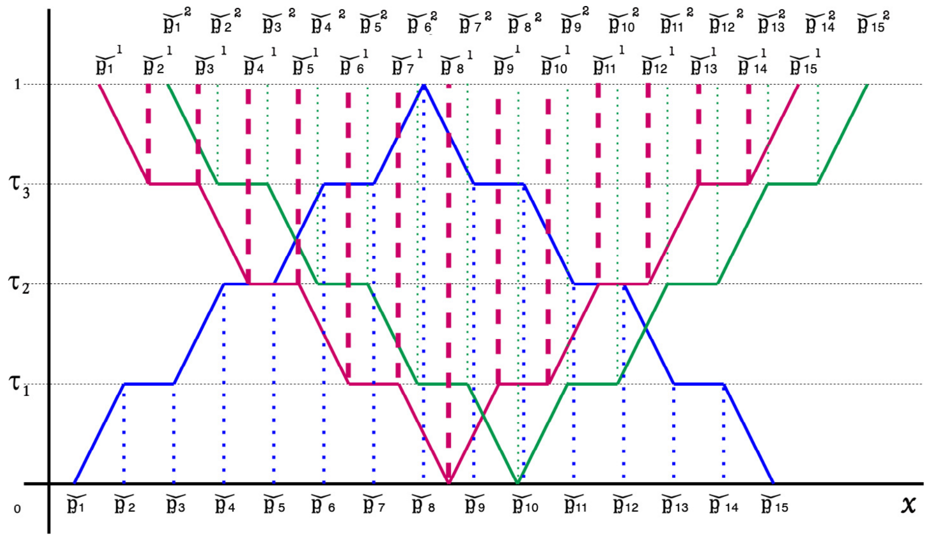

Fig. 1. Linear Single-valued Neutrosophic Symmetric Pentadecagonal Fuzzy Number (LSNSP$_d$FN).

Step 7. Add the costs of neutrosophic cost matrix $[\tilde{a}ij]$ corresponding to the position of specified marked cells and calculate the ρ-weighted value function of that sum. This gives the optimal numeric value for the pre-assigned ρ.

Step 8. Find the smallest SVPdN-number among the uncovered SVPdN-numbers left after drawing the lines as in Step 4 using ρ-weighted value function for the pre-assigned ρ. Subtract it from all uncovered SVTrN numbers of the present matrix and add it with the SVPdN-number lying at the intersection of horizontal and vertical lines. Keep intact all remaining SVT'

Example

A firm employs typists basis for their daily work on hourly rate. The five typist are employed on speed and their charges are different. The typist was paid on hourly basis even if they work for some time. We set up the assignment tableau for this problem to determine the least cost allocation for the following data.

	O	P	Q	R
S	(10, 14, 17, 17, 19, 22, 24, 27, 35, 47, 70, 85, 89, 91, 95;2, 2, 2, 3, 4, 5, 5, 7, 11, 11, 12, 12, 15, 17, 17;0, 1, 1, 1, 1, 3, 3, 5, 5, 7, 8, 8, 8, 8, 8)	(1, 15, 20, 20, 23, 23, 25, 25, 30, 49, 79, 80, 81, 100, 139;0, 1, 10, 10, 10, 15, 15, 15, 20, 20, 20, 27, 27, 30, 30;0, 0, 0, 0, 10, 10, 10, 12, 14, 20, 34, 37, 42, 42)	(45.5, 97.5, 130, 130, 149.5, 149.5, 162.5, 162.5, 195, 318.5, 513.5, 520, 526.5, 650, 903.5;7, 43, 65, 65, 65, 97.5, 97.5, 97.5, 130, 130, 130, 175.5, 175.5, 195, 195;10, 20, 20, 25, 25, 50, 65, 65, 78, 91, 130, 221, 240.5, 273, 273)	(3, 4, 8, 7.9, 7.8, 10, 14, 14, 14.5, 15, 17, 21, 27, 38, 39;1, 2, 2, 2.2, 2.5, 3, 3, 3, 3.7, 4, 4.7, 4.7, 4.7, 5, 5;0, 0.2, 0.2, 0.2, 0.3, 0.3, 0.7, 1, 1, 1, 1.2, 1.3, 1.4, 1.4, 1.4)
T	(0, 0, 0, 2, 4, 8, 8, 8, 14, 14, 16, 18, 18, 18, 25;0, 0.2, 0.2, 0.3, 0.3, 0.4, 0.4, 0.7, 1, 1.3, 1.3, 1.5, 1.5, 1.7, 1.7;0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0.1, 0.3, 0.5, 1, 1)	(3, 7, 8, 8, 9, 9, 10, 10, 12, 15, 15, 17, 20, 28, 37;1, 2.5, 2.5, 2.5, 2.5, 3, 3, 3, 3, 4, 4.7, 4.7, 4.7, 4.7, 4.7;0, 0, 0, 0, 0.3, 0.3, 0, 1, 1, 1, 1.2, 1.3, 1.4, 1.4, 1.4)	(2.4, 7, 7, 7, 7, 8, 9, 9, 9, 12, 12, 13, 14, 14, 14;1, 1.5, 1.7, 1.7, 1, 1.9, 1.9, 1.9, 2, 2.1, 2.1, 2.1, 3, 3, 3;0, 0, 0, 0, 0, 0, 1, 1.7, 1.7, 1.7, 1.8, 1.8, 1.8, 2, 2.1)	(0, 1, 1.3, 1.5, 1.7, 1.7, 3, 3.2, 3.5, 3.5, 6, 7, 7, 9, 12;0, 0, 0.3, 0.3, 0.3, 0.3, 1, 1, 1, 1, 1.2, 1.3, 2, 2.4, 3;0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1)
U	(25, 35, 42.5, 42.5, 47.5, 55, 60, 67.5, 87.5, 117.5, 175, 212.5, 222.5, 227.5, 237.5;5, 5, 5, 7.5, 10, 12.5, 12.5, 17.5, 27.5, 27.5, 30, 30, 37.5, 42.5, 42.5;0, 2.5, 2.5, 2.5, 2.5, 7.5, 7.5, 12.5, 12.5, 17.5, 20, 20, 20, 20, 20)	(2, 2.5, 2.5, 2.7, 2.8, 2.9, 3.4, 7, 11, 14, 14.5, 17, 19, 25, 34;0.7, 2, 2.5, 2.5, 2.7, 3, 3, 3, 3, 3, 5, 7, 10, 17, 19;0, 0, 0, 0.3, 0.3, 0, 1, 1, 1, 1, 7, 8, 10, 14)	(0, 1.5, 3, 7, 10, 14, 14, 14, 15, 15, 17, 17, 21, 24, 25;0, 7, 7, 7, 7, 7, 8, 9, 9, 9, 10, 10.5, 12, 12.5, 12.5;0, 0, 0, 0, 0, 0, 3, 3.3, 3.7, 4, 7, 7, 7, 8, 8)	(2, 5, 7, 12, 14, 17, 19, 21, 24, 27, 28, 29, 29, 30, 30;0, 0.5, 0.5, 0.5, 0.7, 1, 1.7, 1.7, 2, 2, 3, 5, , 12, 15;0, 0, 0, 0, 0, 0, 0, 0, 1.2, 1.2, 1.5, 3, 4, 5, 5)
Demand	10	12	11	8

We convert the neutrosophic Pentadecagonal Fuzzy number into a crisp value by score and accuracy function.

By solving, we therefore we get the solution as:

S → O, T → P, U → Q, V → R. The optimal solution using pentadecagonal neutrosophic salesman problem is given by 227.

4. Conclusion

Thus linear and non-linear Neutrosophic Pentadecagonal fuzzy number membership function with symmetry concepts are explained. We have solved using travelling salesman problem. Thus the result is found for better mechanism to obtain travelling salesman problem. The linear single-valued Neutrosophic Pentadecagonal Fuzzy number with symmetry is explained with graphical representation and arithmetic operations for better results. The spectacular study for Pentadecagonal Neutrosophic Fuzzy Number PDNFN was explored with parameters in optimization techniques. Thus it helps in solving where we have a neutrosophic parameter. We can also find the optimal solution using branch and bound method.

CRediT authorship contribution statement

N. Ruth Naveena: Conceptualization, Methodology. **A. Rajkumar:** Data curation, Investigation. **S. Shalini:** Formal analysis, Supervision, Validation, Writing - original draft. **Chirag Goyal:** Resources, Visualization, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Further Reading

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