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Education Sector Assessment Using Linguistic Quadripartitioned Single-Valued Neutrosophic Soft Sets

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Abstract

Recent time uncertainty analysis and its characterization become more complex due to dark data sets. It became more crucial in the case of the education sector where large number of dark data set generated related to measuring student performance. This becomes more complex while dealing with linguistic information and its significance in case of student performance measurement. One of the reason is that these types of data is based on human quantum Turiyam consciousness and some time in unconsciousness way. To deal with these types of dark data generated in unconscious way this paper try to introduce the linguistic Quadripartitioned single-valued neutrosophic set (LQSVNS). It defines each object of the universe by four independent linguistic variables known as truth, contradiction, unknown, and false linguistic variables. Same time some operations and properties based on LQSVNNs are extensively studied in this paper using a combination of soft set (SS) known as the linguistic Quadripartitioned single-valued

neutrosophic soft set (LQSVNSS). Moreover, a distance similarity measured-based model under the LQSVNSSs is investigated with an illustrative example of the education sector.

Keywords: Big data; Four Valued Data; Linguistic Quadripartitioned single-valued neutrosophic set; Quadripartitioned single-valued neutrosophic set; Turiyam set

1. Introduction

The last decade most of the researchers paid attention towards computing with words and its vagueness. To deal with this problem the algebra of Fuzzy Set (FS) (Zadeh, 1965) is introduced with the aid of the truth-grade function (μ) and its membership value defined in $[0,1]$. Atanassov et al. (Atanassov & Stoeva, 1986) initiated an intuitionistic fuzzy set (IFS) to represent the acceptance and the rejection part via dependent true and false membership values μ and ν respectively via inequality $0 \leq \mu + \nu \leq 1$. The problem arises with IFS also in case $\mu + \nu > 1$ or they are independent of each other. To solve this issue, Pythagorean fuzzy sets (PFSs) (Yager, 2013), q-rung orthopair fuzzy sets (q-ROFSs) (Yager, 2016) are introduced. In a PFS and a q-ROFS the true (μ) and false (ν) membership grades of a particular element are restricted with conditions $0 \leq \mu^2 + \nu^2 \leq 1$ and $0 \leq \mu^q + \nu^q \leq 1$ respectively with its various applications (Garg, 2016; Thao, 2020; Xiao & Ding, 2019; Ejegwa, 2020).

The problem arises when the hesitant part of IFS become independent of true and false membership values. To deal with this type of indeterminacy Single-valued Neutrosophic set (SVNS) introduced Smarandache (Smarandache, 2005; Wang, Smarandache, Zhang & Sunderraman, 2010). It is applied in various fields (Broumi et al. 2023; Caballero & Broumi 2023; Sivasankar & Broumi 2023). The other way to make a decision through the application of NST. One is to use neutrosophic rough sets (Broumi et al., 2014; Salama & Broumi, 2014) and the other is to use aggregation operators. To extend neutrosophic set to MCDA problems, Bao and Yang (2017) proposed a model integrating single valued neutrosophic refined sets with rough sets while Bo et al. (2018) utilized multi-granulation neutrosophic rough sets. Moreover, many mixed models with NST have been proposed, such as n-dimension single valued neutrosophic refined rough sets (Yang et al., 2017; Zhao & Zhang, 2018a) and hesitant neutrosophic rough sets (Zhao & Zhang, 2018b, 2020). In addition, there is a combined ITARA with TOPSIS-AL approach based neutrosophic sets for risk assessment of university sustainability（Lin & Lo, 2023). The problem arises while dealing with contradictory, unknown, ambiguous, or computing its complement as discussed by Belnap (Belnap Jr, 1977). It can be useful to encounter contradictory facts, human super consciousness, and solve various machine intelligence problems based on human cognitive intelligence. Due to this, the SVNS is extended as Quadripartitioned single-valued neutrosophic set (QSVNS) (Chatterjee et al. 2016 a, b). It can represent the dependent data set and its membership via n-valued refined neutrosophic set (Smarandache, 2013) which give several authors to study QSVNS (Roy, Lee, Pal & Samanta, 2020; Mohanasundari & Mohana, 2020; Mohan & Krishnaswamy, 2020a; Sinha & Majumdar, 2020) and its hybrid model (Mohan & Krishnaswamy, 2020b; Kamaci, 2021; Sinha, Majumdar & Broumi, 2022). It becomes more useful when soft set (SS) (Molodtsov, 1999) theory is connected with this logic. The reason is soft set offers a more general framework to present uncertainty without any restriction. The hybridization with soft set utilizes in many areas such as decision-making problems (Maji, Roy & Biswas, 2002; Kong, Wang & Wu, 2011), medical diagnosis

(Muthukumar & Krishnan, 2016; Xiao, 2018), etc. Moreover, a combination of SS and QSVNS provides a new theoretical concept known as quadripartitioned single-valued neutrosophic soft set (QSVNSS) that can be viewed as a special type of quadripartitioned neutrosophic soft set (QNSS) (Radha, Mary & Smarandache, 2021). This set is utilized successfully in case of uncertainty measurement in interval-valued possibility QSVNSS (Chatterjee et al. 2016b), and topological space based on QNSS (Kumar & Mary, 2021). This current paper focused on Quadripartitioned single-valued neutrosophic soft set (LQSVNSS) for dealing with the qualitative data.

However, dealing with qualitative data required human consciousness for the precise representation of contradictory events. Sometimes it can be represented via linguistic variables in the case of known objects or dependent variables. For example, small, very small, almost small, not small, quite small, not very small, etc. The linguistic setting is a very popular and interesting topic to measure the uncertainty that arises due to human thoughts. In the research article (Zadeh, 1975), Zadeh first introduced the concept of linguistic variables in approximate reasoning. According to him, a linguistic variable is characterized by a quintuple$(\Im, \mathbb{T}(\Im), \mathcal{U}, \mathcal{G}, \mathcal{M})$, where $\Im$ is a variable, $\mathbb{T}(\Im)$ is the term set of $\Im$, $\mathcal{U}$ is a set of the universe, $\mathcal{G}$ is a rule that generates $\mathbb{T}(\Im)$, and $\mathcal{M}$is a semantic rule associated with a linguistic value. Liu et al. (liu & Zhang, 2010) utilized the risk-based linguistic variable in MADM. Herrera et al. (Herrera & Herrera-Viedma, 2000) presented a linguistic decision analysis to solve the decision problem. Xu (Xu, 2004) proposed the linguistic aggregate operators for group decision-making. A fuzzy set-based linguistic value is proposed in (Dohnal, 1983; Bonissone, 1980). Zhang (Zhang, 2014) introduced the linguistic intuitionistic fuzzy set (LIFS) that is characterized by linguistic membership and non-membership degrees. Garg et al. (Garg & Kumar, 2018) presented some aggregate operators on LIFSs in GDM. He also presented the linguistic Pythagorean fuzzy set (LPFS) (Garg, 2018) to address uncertain linguistic information in a better way. Also, q-rung orthopair fuzzy sets are based on linguistic information studied in (Lin, Li & Chen, 2020; Akram, Naz, Edalatpanah & Mehreen, 2021; Liu & Liu, 2019; Wang, Ju & Liu, 2019). The fusion of neutrosophic set and its hybrids with linguistic set resulted in linguistic neutrosophic sets (LNSs) in MCDM (Li, Zhang & Wang, 2017), interval complex neutrosophic sets under linguistic information (Dat, Thong, Ali, Smarandache, Abdel-Basset & Long, 2019), multi-objective linguistic neutrosophic matrix games (Bhaumik, Roy & Weber, 2021). Kamaci (Kamaci, 2021) initiate the linguistic single-valued neutrosophic soft set (LSVNS) and proposed a game theory model via the TOPSIS technique.

Some other methods are proposed for dealing the human cognition (Singh, 2021) in case of unknown or undefined impossible objects using human quantum Turiyam cognition (Singh, 2022a). It represents the qualitative data based on four dimensions whereas the fourth dimension is represented by Human Turiyam consciousness. It is independent of true, false, uncertain, or contradictory membership values of the given event (Singh, 2022b). It is based on time-based measurement, human superconsciousness, or quantum cognition distinct from any of the available set as discussed in Singh (2023c). It represents the error measured in dark data sets due to human consciousness rather than unconsciousness value of Quadripartitioned set. It can be represented via the Turiyam matrix (Ani, Mashadi & Gemawati, 2023) for precise analysis of knowledge-processing tasks based on the Turiyam relation (Ganati, Srinivasa Rao Repalle & Ashebo, 2023) and its graph (Ganati, Srinivasa, Ashebo & Amini, 2023). It gives a way to represent the data set based on human quantum cognition (Singh, 2023a,b,c) for dealing the self-driving cars (Said et al., 2022), robotics (Silva, 2022) or mathematical exploration in school teaching (Singh 2023b). The problem arises when data sets and their uncertainty are represented without human cognition beyond the three polar spaces (Singh, 2023c; Siraj, Naeem & Said, 2023; Naeem & Divvaz, 2023; Naeem, Riaz & Karaaslan, 2021; Naeem, Riaz & Afzal, 2019; Siraj, Fatima, Afzal, Naeem & Karaaslan, 2022). It requires a new set theory for dealing the qualitative data sets contain static uncertainty rather than involvement of human consciousness (Singh 2023b). To achieve this goal, the current paper focused on dealing with uncertainty in known qualitative data and its refinement using linguistic single-valued neutrosophic soft set (LSVNS) rather than human consciousness.

Table 1 gives an overview and distinction among each of the available approaches.

Other parts of the paper are organized as follows: Section 2 provides a brief background about the mathematical concepts. Section 3 provides the basis of weighted aggregation for the proposed method and its illustration. In Section 4, LQSVNSSs and their properties are executed. Application of the present study is briefly discussed in Section 5. Section 6 contains the conclusion followed by acknowledgment and references.

2. Basic Mathematical Concepts

In this section, some basic concepts are reviewed to ease the discussion in the subsequent sections:

2.1 Linguistic Term Set (LTS)

Definition 2.1 (Zadeh, 1975) Let $\mathfrak{S} = \{\mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_2, \ldots, \mathfrak{s}_{\wp}\}$ be a finite linguistic term set with cardinality $\wp + 1$ where $\wp$ is a positive integer. Also, we consider $\mathfrak{s}_{\mathfrak{m}}$ as a possible value of a linguistic variable. Then the LTS must satisfy the following properties:

(i) $\mathfrak{s}_{\mathfrak{m}} \geq \mathfrak{s}_{\mathfrak{n}\ if\ \mathfrak{m} \geq \mathfrak{n}\ and}\ \mathfrak{s}_{\mathfrak{m}} \leq \mathfrak{s}_{\mathfrak{n}\ if\ \mathfrak{m} \leq \mathfrak{n}}$ (Order relation)

(ii) $neg\,(\mathfrak{s}_{\mathfrak{m}}) = \mathfrak{s}_{\mathfrak{n}}$ where $\mathfrak{m} + \mathfrak{n} = \wp$ (negation)

This concept is based on discrete LTS. To extend this concept to continuous LTS, see the next definition.

Definition 2.2 (Xu, 2004) Let $\mathfrak{S} = \{\mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_2, \ldots, \mathfrak{s}_{\wp}\}$ be a finite linguistic term set with cardinality $\wp + 1$ where $\wp$ is a positive integer. Then, $\mathfrak{S}_{[0,\wp]} = \{\mathfrak{s}_{\mathfrak{m}} : \mathfrak{s}_0 \leq \mathfrak{s}_{\mathfrak{m}} \leq \mathfrak{s}_{\wp,\, \mathfrak{m} \in [0,\wp]}\}$ is said to be a continuous LTS for $\mathfrak{S}$.

2.2 Single-Valued Neutrosophic Set (SVNS)

Definition 2.3 (Smarandache, 2005) A single-valued neutrosophic set (SVNS) $\mathcal{H}$ over $\mathcal{L}$ is defined as

$\mathcal{H} = \{(\ell_i, < \mu_{\mathcal{H}(\ell_i)}, \vartheta_{\mathcal{H}(\ell_i)}, \nu_{\mathcal{H}(\ell_i)} >) : \ell_i \in \mathcal{L}\}$ where $\mu_{\mathcal{H}(\ell_i)}, \vartheta_{\mathcal{H}(\ell_i)}, \nu_{\mathcal{H}(\ell_i)} \in [0,1]$ represent the degrees of truth, indeterminacy, and falsity memberships respectively with $0 \leq \mu_{\mathcal{H}(\ell_i)} + \vartheta_{\mathcal{H}(\ell_i)} + \nu_{\mathcal{H}(\ell_i)} \leq 3$.

2.3 Linguistic Single-Valued Neutrosophic Set (LSVNS)

Definition 2.4 (Li, Zhang & Wang, 2017) Let $\mathfrak{S} = \{\mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_2, \ldots, \mathfrak{s}_{\wp}\}$ be a finite linguistic term set with cardinality $\wp + 1$ where $\wp$ is a positive integer and $\mathfrak{S}_{[0,\wp]} = \{\mathfrak{s}_{\mathfrak{m}} : \mathfrak{s}_0 \leq \mathfrak{s}_{\mathfrak{m}} \leq \mathfrak{s}_{\wp,\, \mathfrak{m} \in [0,\wp]}\}$. Then a LSVNS $\mathcal{g}$ in $\mathcal{L}$ is defined as

$g = \{(\ell_i, < g_{s_\mu}(\ell_i), g_{s_\vartheta}(\ell_i), g_{s_\nu}(\ell_i) >): \ell_i \in \mathcal{L}\}$ where $g_{s_\mu}(\ell_i), g_{s_\vartheta}(\ell_i), g_{s_\nu}(\ell_i) \in \mathfrak{S}_{[0,p]}$ denote the linguistic truth, indeterminacy, and falsity degrees of $\ell_i \in \mathcal{L}$ respectively such that $0 \leq \mu, \vartheta, \nu \leq p$ and $0 \leq \mu + \vartheta + \nu \leq 3p$.

2.4 Quadripartitioned Single-Valued Neutrosophic Set (QSVNSS)

Definition 2.5 (Chatterjee et al. 2016 a,b) A QSVNS $\mathcal{Q}$ in $\mathcal{L}$ is defined as $\mathcal{Q} = \{(\ell_i, < \mu_{\mathcal{Q}(\ell_i)}, \xi_{\mathcal{Q}(\ell_i)}, \zeta_{\mathcal{H}(\ell_i)}, \nu_{\mathcal{Q}(\ell_i)} >): \ell_i \in \mathcal{L}\}$ where $\mu_{\mathcal{Q}(\ell_i)}, \xi_{\mathcal{Q}(\ell_i)}, \zeta_{\mathcal{H}(\ell_i)}, \nu_{\mathcal{Q}(\ell_i)} \in [0,1]$ denote the truth, contradiction, unknown, and falsity membership grades respectively with $0 \leq \mu_{\mathcal{Q}(\ell_i)} + \xi_{\mathcal{Q}(\ell_i)} + \zeta_{\mathcal{H}(\ell_i)} + \nu_{\mathcal{Q}(\ell_i)} \leq 4$. It is distinct from Turiyam where each parameter is independent and the last dimension is based on human Turiyam consciousness. It means Turiyam contains two truth values rather than one in QSVNSS. Same time the Liberal values in Turiyam are independent from true false or uncertainty whereas in Quadripartitioned Single-Valued Neutrosophic not the same. In this case, this set theory is helpful in some cases where human quantum cognition is not required. We required membership value in a partition way for dealing with the contradiction among the opinion.

2.5 Quadripartitioned Single-Valued Neutrosophic Soft Set (QSVNSS)

Definition 2.6 (Radha, Mary & Smarandache, 2021) Let $\mathcal{L}$ be an initial universe and $\mathcal{E}$ be a set of parameters where $\mathring{A}(\neq \varphi) \subseteq \mathcal{E}$. Let $\wp(\mathcal{L})$ signifies the collection of all Quadripartitioned single-valued neutrosophic sets of $\mathcal{L}$. Then the pair $(\mathcal{F}, \mathring{A})$ is considered as a QSVNSS over $\mathcal{L}$ where $\mathcal{F}: \mathring{A} \rightarrow \wp(\mathcal{L})$.

3. Linguistic Quadripartitioned Single-Valued Neutrosophic Set (LQSVNS)

In this section dealing of linguistic variables which are qualitative is discussed via LQSVNS. Same time different aggregate operators and distance measures associated with LQSVNS is also introduced in this section for dealing the linguistic static uncertainty arises unconsciously.

Definition 3.1 Let $\mathfrak{S} = \{\mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_2, \ldots, \mathfrak{s}_{\wp}\}$ be a continuous finite linguistic term set with cardinality $\wp + 1$ where $\wp$ is a positive integer and $\mathfrak{S}_{[0,\wp]} = \{\mathfrak{s}_{\mathfrak{m}} : \mathfrak{s}_0 \leq \mathfrak{s}_{\mathfrak{m}} \leq \mathfrak{s}_{\wp},\ \mathfrak{m} \in [0, \wp]\}$.

Then a LQSVNS $\eth$ in $\mathcal{L}$ is defined as

$\eth = \{(\ell_i, < \eth_{\mathfrak{s}_{\mu}}(\ell_i), \eth_{\mathfrak{s}_{\xi}}(\ell_i), \eth_{\mathfrak{s}_{\zeta}}(\ell_i), \eth_{\mathfrak{s}_{\nu}}(\ell_i) >) : \ell_i \in \mathcal{L}\}$ where $\eth_{\mathfrak{s}_{\mu}}(\ell_i), \eth_{\mathfrak{s}_{\xi}}(\ell_i), \eth_{\mathfrak{s}_{\zeta}}(\ell_i), \eth_{\mathfrak{s}_{\nu}}(\ell_i)$ $\in \mathfrak{S}_{[0,\wp]}$ denote the linguistic truth, contradiction, uncertain, and falsity degrees of $\ell_i \in \mathcal{L}$ respectively such that $0 \leq \mu, \xi, \zeta, \nu \leq \wp$ and $0 \leq \mu + \xi + \zeta + \nu \leq 4\wp$.

In short, $\eth = < \eth_{\mathfrak{s}_{\mu}}, \eth_{\mathfrak{s}_{\xi}}, \eth_{\mathfrak{s}_{\zeta}}, \eth_{\mathfrak{s}_{\nu}} >$ denote the linguistic Quadripartitioned single-valued neutrosophic number (LQSVNN). Moreover, the set of all LQSVNNs on $\mathfrak{S}$ is denoted by $\aleph_{[0,\wp]} = \{< \eth_{\mathfrak{s}_{\mu}}, \eth_{\mathfrak{s}_{\xi}}, \eth_{\mathfrak{s}_{\zeta}}, \eth_{\mathfrak{s}_{\nu}} > : \eth_{\mathfrak{s}_{\mu}}, \eth_{\mathfrak{s}_{\xi}}, \eth_{\mathfrak{s}_{\zeta}}, \eth_{\mathfrak{s}_{\nu}} \in \mathfrak{S}_{[0,\wp]}\}$.

Example 3.2 Let $\mathcal{L} = \{\ell_1, \ell_2, \ell_3, \ell_4, \ell_5\}$ be a set of alternatives and

$\mathfrak{S} =$
$\{\mathfrak{s}_{0=very\ sensitive\ (VS)}, \mathfrak{s}_{1=quite\ sensitive\ (QS)}, \mathfrak{s}_{2=high\ sensitive\ (HS)}, \mathfrak{s}_{3=very\ high\ sensitive\ (VHS)}, \mathfrak{s}_{4=medium(M)}, \mathfrak{s}_{5=low(L}$
$\}$ be a LTS.

If we consider the following

$\eth = \{(\ell_1, < \mathfrak{s}_1, \mathfrak{s}_2, \mathfrak{s}_0, \mathfrak{s}_1 >), (\ell_2, < \mathfrak{s}_0, \mathfrak{s}_0, \mathfrak{s}_4, \mathfrak{s}_1 >), (\ell_3, < \mathfrak{s}_1, \mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_3 >), (\ell_4, < \mathfrak{s}_2, \mathfrak{s}_3, \mathfrak{s}_3, \mathfrak{s}_4 >), (\ell_5, < \mathfrak{s}_5, \mathfrak{s}_0, \mathfrak{s}_3, \mathfrak{s}_3 >)\}$

Then $\eth$ denotes the LQSVNS over $\mathcal{L}$.

Definition 3.3 Let $\eth =< \eth_{\mathfrak{s}_{\mu'}}, \eth_{\mathfrak{s}_{\xi'}}, \eth_{\mathfrak{s}_{\zeta'}}, \eth_{\mathfrak{s}_{\nu'}} > \in \aleph_{[0,\wp]}$ be a LQSVNN. Then the score function associated to $\eth$ is defined as

$$\mho(\eth) = \frac{\eth_{\mathfrak{s}_{\mu'}} + \eth_{\mathfrak{s}_{\xi'}} - \eth_{\mathfrak{s}_{\zeta'}} - \eth_{\mathfrak{s}_{\nu'}}}{2} \text{ Or } \frac{\mu+\xi-\zeta-\nu}{2} \in [-\wp, \wp] \qquad (1)$$

Definition 3.4 Let $\eth =< \eth_{\mathfrak{s}_{\mu'}}, \eth_{\mathfrak{s}_{\xi'}}, \eth_{\mathfrak{s}_{\zeta'}}, \eth_{\mathfrak{s}_{\nu'}} > \in \aleph_{[0,\wp]}$ be a LQSVNN. Then the accuracy function associated to $\eth$ is defined as

$$\mathfrak{H}(\eth) = \frac{\eth_{\mathfrak{s}_{\mu'}} + \eth_{\mathfrak{s}_{\xi'}} + \eth_{\mathfrak{s}_{\zeta'}} + \eth_{\mathfrak{s}_{\nu'}}}{4} \text{ Or } \frac{\mu+\xi+\zeta+\nu}{4} \in [0, \wp] \qquad (2)$$

Definition 3.5 Let $\eth_{1=} < \eth_{\mathfrak{s}_{\mu'_1}}, \eth_{\mathfrak{s}_{\xi'_1}}, \eth_{\mathfrak{s}_{\zeta'_1}}, \eth_{\mathfrak{s}_{\nu'_1}} >$ and $\eth_{2=} < \eth_{\mathfrak{s}_{\mu'_2}}, \eth_{\mathfrak{s}_{\xi'_2}}, \eth_{\mathfrak{s}_{\zeta'_2}}, \eth_{\mathfrak{s}_{\nu'_2}} >$ be two LQSVNNs. Based on the score and accuracy function (see Definition 3.3 & 3.4), to compare these two LQSVNNs, we define the following:

$a)$ if $\mho(\eth_1) > \mho(\eth_2)$ $then$ $\eth_1 \succ \eth_2$ i.e. $\eth_1$is more preferable than $\eth_2$

$b)$ if $\mho(\eth_1) = \mho(\eth_2)$ $then$

$i)$ for $\mathfrak{H}(\eth_1) = \mathfrak{H}(\eth_2)$, $\eth_1 = \eth_2$

$ii)$ for $\mathfrak{H}(\eth_1) > H(\eth_2)$, $\eth_1 \succ \eth_2$

Example 3.6 Let $\mathfrak{S} = \{\mathfrak{s}_{\mathfrak{m}} : \mathfrak{s}_0 \le \mathfrak{s}_{\mathfrak{m}} \le \mathfrak{s}_7, \mathfrak{m} \in [0,7]\}$ be a LTS. Also, we consider $\eth_{1=<} \mathfrak{s}_1, \mathfrak{s}_3, \mathfrak{s}_4, \mathfrak{s}_5 >, \eth_{2=<} \mathfrak{s}_0, \mathfrak{s}_4, \mathfrak{s}_2, \mathfrak{s}_3 >, \eth_{3=<} \mathfrak{s}_3, \mathfrak{s}_5, \mathfrak{s}_4, \mathfrak{s}_2 >, and$ $\eth_{4=<} \mathfrak{s}_7, \mathfrak{s}_6, \mathfrak{s}_2, \mathfrak{s}_3 >$ be LQSVNNs derived from$\mathfrak{S}$. By using equation (1), we obtain the following

$\mho(\eth_1) = \frac{1+3-4-5}{2}$=-2.5, $\mho(\eth_2) = \frac{0+4-2-3}{2}$=-0.5, $\mho(\eth_3) = \frac{3+5-4-2}{2}$=1, $\mho(\eth_4) = \frac{7+6-2-3}{2}$=4

Thus, we rank the numbers as $\eth_4 \succ \eth_3 \succ \eth_2 \succ \eth_1$

3.1 Operational Laws on LQSVNNs

Definition 3.7 Let $ð_{1=} < ð_{s_{\mu'_1}}, ð_{s_{\xi'_1}}, ð_{s_{\zeta'_1}}, ð_{s_{\nu'_1}} >$ and $ð_{2=} < ð_{s_{\mu'_2}}, ð_{s_{\xi'_2}}, ð_{s_{\zeta'_2}}, ð_{s_{\nu'_2}} >$ be two LQSVNNs. Then we have the following laws:

a) $ð_1 \Cup ð_{2=}$<max $(ð_{s_{\mu'_1}}, ð_{s_{\mu'_2}})$, max $(ð_{s_{\xi'_1}}, ð_{s_{\xi'_2}})$, min $(ð_{s_{\zeta'_1}}, ð_{s_{\zeta'_2}})$, min $(ð_{s_{\nu'_1}}, ð_{s_{\nu'_2}}) >$

$$=< ð_{max(s_{\mu_1}, s_{\mu_2})}, ð_{max(s_{\xi_1}, s_{\xi_2})}, ð_{min(s_{\zeta_1}, s_{\zeta_2})}, ð_{min(s_{\nu_1}, s_{\nu_2})} >$$

b) $ð_1 \Cap ð_{2=}$<min $(ð_{s_{\mu'_1}}, ð_{s_{\mu'_2}})$, min $(ð_{s_{\xi'_1}}, ð_{s_{\xi'_2}})$, max $(ð_{s_{\zeta'_1}}, ð_{s_{\zeta'_2}})$, max $(ð_{s_{\nu'_1}}, ð_{s_{\nu'_2}}) >$

$$=< ð_{min(s_{\mu_1}, s_{\mu_2})}, ð_{min(s_{\xi_1}, s_{\xi_2})}, ð_{max(s_{\zeta_1}, s_{\zeta_2})}, ð_{max(s_{\nu_1}, s_{\nu_2})} >$$

$c)\ ð_1 \succcurlyeq ð_2 \Rightarrow ð_{s_{\mu'_1}} \geq ð_{s_{\mu'_2}}, ð_{s_{\xi'_1}} \geq ð_{s_{\xi'_2}}, ð_{s_{\zeta'_1}} \leq ð_{s_{\zeta'_2}}, ð_{s_{\nu'_1}} \leq ð_{s_{\nu'_2}}$

$d)\ ð_1 = ð_2 \Rightarrow ð_{s_{\mu'_1}} = ð_{s_{\mu'_2}}, ð_{s_{\xi'_1}} = ð_{s_{\xi'_2}}, ð_{s_{\zeta'_1}} = ð_{s_{\zeta'_2}}, ð_{s_{\nu'_1}} = ð_{s_{\nu'_2}}$

$e)\ ð_1^{\ c} =< ð_{s_{\nu'_1}}, ð_{s_{\zeta'_1}}, ð_{s_{\xi'_1}}, ð_{s_{\mu'_1}} >$ where $ð_1^{\ c}$indicates the complement of $ð_1$.

Theorem 3.8 If $ð_{1=} < ð_{s_{\mu'_1}}, ð_{s_{\xi'_1}}, ð_{s_{\zeta'_1}}, ð_{s_{\nu'_1}} >$ and $ð_{2=} < ð_{s_{\mu'_2}}, ð_{s_{\xi'_2}}, ð_{s_{\zeta'_2}}, ð_{s_{\nu'_2}} >$ be in $\aleph_{[0,\wp]}$ then

1. $(ð_1 \Cup ð_2)^c = ð_1^{\ c} \Cap ð_2^{\ c}$

2. $(ð_1 \Cap ð_2)^c = ð_1^{\ c} \Cup ð_2^{\ c}$

Proof: Considering the Definition 3.7 (a) and (b), we can easily obtain the results.

Definition 3.9 Let $ð =< ð_{s_{\mu'}}, ð_{s_{\xi'}}, ð_{s_{\zeta'}}, ð_{s_{\nu'}} >$, $ð_{1} = < ð_{s_{\mu'_1}}, ð_{s_{\xi'_1}}, ð_{s_{\zeta'_1}}, ð_{s_{\nu'_1}} >$ and $ð_{2} = < ð_{s_{\mu'_2}}, ð_{s_{\xi'_2}}, ð_{s_{\zeta'_2}}, ð_{s_{\nu'_2}} >$ be three LQSVNNs in $\aleph_{[0,p]}$, and $\varrho > 0$. Then the following operational laws are defined in the following:

$a)\ ð_1 \oplus ð_2 = < ð_{s_{\mu'_1}+s_{\mu'_2}-\frac{s_{\mu'_1}s_{\mu'_2}}{p}}, ð_{s_{\xi'_1}+s_{\xi'_2}-\frac{s_{\xi'_1}s_{\xi'_2}}{p}}, ð_{\frac{s_{\zeta'_1}s_{\zeta'_2}}{p}}, ð_{\frac{s_{\nu'_1}s_{\nu'_2}}{p}} >$

$b)\ ð_1 \otimes ð_2 = < ð_{\frac{s_{\mu'_1}s_{\mu'_2}}{p}}, ð_{\frac{s_{\xi'_1}s_{\xi'_2}}{p}}, ð_{s_{\zeta'_1}+s_{\zeta'_2}-\frac{s_{\zeta'_1}s_{\zeta'_2}}{p}}, ð_{s_{\nu'_1}+s_{\nu'_2}-\frac{s_{\nu'_1}s_{\nu'_2}}{p}} >$

$c)\ \varrho ð =< ð_{p-p\left(1-\frac{s_{\mu'}}{p}\right)^{\varrho}}, ð_{p-p\left(1-\frac{s_{\xi'}}{p}\right)^{\varrho}}, ð_{p\left(\frac{s_{\zeta'}}{p}\right)^{\varrho}}, ð_{p\left(\frac{s_{\nu'}}{p}\right)^{\varrho}} >$

$d)\ ð^{\varrho} =< ð_{p\left(\frac{s_{\mu'}}{p}\right)^{\varrho}}, ð_{p\left(\frac{s_{\xi'}}{p}\right)^{\varrho}}, ð_{p-p\left(1-\frac{s_{\zeta'}}{p}\right)^{\varrho}}, ð_{p-p\left(1-\frac{s_{\nu'}}{p}\right)^{\varrho}} >$

Example 3.10

Let

$\mathfrak{S} = \{s_0 = flop(F), s_1 = average(A), s_2 = below\ average(BA), s_3 = above\ average(AA), s_4 = hit(H), s_5 = semi\ hit(SMH), s_6 = super\ hit(SPH), s_7 = blockbuster(BBH), s_8 = disaster(D)\}$

be a LTS. Let $ð_{1} = < s_1, s_5, s_6, s_3 >$ and $ð_2 = < s_3, s_0, s_2, s_5 >$ be two LQSVNNs obtained from $\mathfrak{S}$ and $\varrho = 0.6$. Then by using Definition 3.8, we obtain the following:

1. $ð_1 \oplus ð_2 = < ð_{1+3-\frac{1.3}{8}}, ð_{5+0}, ð_{\frac{6.2}{8}}, ð_{\frac{3.5}{8}} > = < ð_{3.625}, s_5, ð_{1.5}, ð_{1.87} >$

2. $ð_1 \otimes ð_2 = < ð_{\frac{1.3}{8}}, ð_{0}, ð_{6+2-\frac{6.2}{8}}, ð_{3+5-\frac{3.5}{8}} > = < ð_{0.375}, s_0, ð_{6.5}, ð_{6.125} >$

3. $\varrho ð_1 =< ð_{8-8\left(1-\frac{1}{8}\right)^{0.6}}, ð_{8-8\left(1-\frac{5}{8}\right)^{0.6}}, ð_{8\left(\frac{6}{8}\right)^{0.6}}, ð_{8\left(\frac{3}{8}\right)^{0.6}} > = < ð_{0.615}, ð_{3.55}, ð_{6.73}, ð_{4.441} >$

4. $ð_2^{\varrho} =< ð_{8\left(\frac{3}{8}\right)^{0.6}}, ð_{8\left(\frac{0}{8}\right)^{0.6}}, ð_{8-8\left(1-\frac{2}{8}\right)^{0.6}}, ð_{8-8\left(1-\frac{5}{8}\right)^{0.6}} > = < ð_{4.441}, s_0, ð_{1.268}, ð_{3.558} >$

3.2 Weighted Aggregation Operators of LQSVNNs

Definition 3.11 Let $\eth_{j} = \langle \eth_{s_{\mu'_{j}}}, \eth_{s_{\xi'_{j}}}, \eth_{s_{\zeta'_{j}}}, \eth_{s_{v'_{j}}} \rangle \in \aleph_{[0,\wp]}$ $(j = 1,2,\ldots,k)$ be a class of LQSVNNs, and $\mathfrak{W}_{j} \in [0,1]$ denotes the weight of $\eth_{j}$ satisfying $\sum_{j=1}^{k} \mathfrak{W}_{j} = 1$. Then the linguistic Quadripartitioned single-valued weighted average aggregation (LQSVNWAA) operator is defined as

$$LQSVNWAA(\eth_1, \eth_2, \eth_3, \ldots\ldots, \eth_k) = \sum_{j=1}^{k} \mathfrak{W}_{j}\, \eth_{j}$$

$$= \langle \eth_{\wp - \wp \prod_{j=1}^{k}\left(1 - \frac{s_{\mu'_{j}}}{\wp}\right)^{\mathfrak{w}_{j}}}, \eth_{\wp - \wp \prod_{j=1}^{k}\left(1 - \frac{s_{\xi'_{j}}}{\wp}\right)^{\mathfrak{w}_{j}}}, \eth_{\wp \prod_{j=1}^{k}\left(\frac{s_{\zeta'_{j}}}{\wp}\right)^{\mathfrak{w}_{j}}}, \eth_{\wp \prod_{j=1}^{k}\left(\frac{s_{v'_{j}}}{\wp}\right)^{\mathfrak{w}_{j}}} \rangle \qquad (3)$$

The LQSVNWAA operator satisfies the following properties:

(i) Idempotency: Let $\eth_{j} = \langle \eth_{s_{\mu'_{j}}}, \eth_{s_{\xi'_{j}}}, \eth_{s_{\zeta'_{j}}}, \eth_{s_{v'_{j}}} \rangle \in \aleph_{[0,\wp]}$ $(j = 1,2,\ldots,k)$ be a collection of LQSVNNs where $\eth_1 = \eth_2 = \eth_3 = \ldots\ldots\ldots = \eth_k = \eth$ (say), then $LQSVNWAA(\eth_1, \eth_2, \eth_3, \ldots\ldots, \eth_k) = \eth$.

(ii) Monotonicity: Let $\eth_{j} = \langle \eth_{s_{\mu'_{j}}}, \eth_{s_{\xi'_{j}}}, \eth_{s_{\zeta'_{j}}}, \eth_{s_{v'_{j}}} \rangle \in \aleph_{[0,\wp]}$ $(j = 1,2,\ldots,k)$ be a collection of LQSVNNs. If $\eth_{j} \leq \eth_{j}^{*}$ $for\ j = 1,2,\ldots,k$, then $LQSVNWAA(\eth_1, \eth_2, \eth_3, \ldots\ldots, \eth_k) \leq LQSVNWAA(\eth_1^{*}, \eth_2^{*}, \eth_3^{*}, \ldots\ldots, \eth_k^{*})$

(iii) Boundedness: Let $\eth_{j} = \langle \eth_{s_{\mu'_{j}}}, \eth_{s_{\xi'_{j}}}, \eth_{s_{\zeta'_{j}}}, \eth_{s_{v'_{j}}} \rangle \in \aleph_{[0,\wp]}$ $(j = 1,2,\ldots,k)$ be a collection of LQSVNNs. If there exists $\lambda^{-} = \langle min_{j}(\eth_{s_{\mu'_{j}}}), min_{j}(\eth_{s_{\xi'_{j}}}), max_{j}(\eth_{s_{\zeta'_{j}}}), max_{j}(\eth_{s_{v'_{j}}}) \rangle$ and $\lambda^{+} = \langle max_{j}(\eth_{s_{\mu'_{j}}}), max_{j}(\eth_{s_{\xi'_{j}}}), min_{j}(\eth_{s_{\zeta'_{j}}}), min_{j}(\eth_{s_{v'_{j}}}) \rangle$ then $\lambda^{-} \leq LQSVNWAA(\eth_1, \eth_2, \eth_3, \ldots\ldots, \eth_k) \leq \lambda^{+}$.

Definition 3.12 Let $\eth_{j} = \langle \eth_{s_{\mu'_{j}}}, \eth_{s_{\xi'_{j}}}, \eth_{s_{\zeta'_{j}}}, \eth_{s_{v'_{j}}} \rangle \in \aleph_{[0,\wp]}$ $(j = 1,2,\ldots,k)$ be a class of LQSVNNs, and $\mathfrak{W}_{j} \in [0,1]$ denotes the weight of $\eth_{j}$ satisfying $\sum_{j=1}^{k} \mathfrak{W}_{j} = 1$. Then the linguistic Quadripartitioned single-valued weighted geometric aggregation (LQSVNWGA) operator is defined as

$$LQSVNWAA(\eth_1, \eth_2, \eth_3, \ldots\ldots, \eth_k) = \prod_{j=1}^{k} \eth_j^{\mathfrak{m}_j}$$

$$= < \eth_{p \prod_{j=1}^{k}\left(\frac{s_{\mu'_j}}{p}\right)^{\mathfrak{m}_j}}, \eth_{p \prod_{j=1}^{k}\left(\frac{s_{\xi'_j}}{p}\right)^{\mathfrak{m}_j}}, \eth_{p - p \prod_{j=1}^{k}\left(1-\frac{s_{\zeta'_j}}{p}\right)^{\mathfrak{m}_j}}, \eth_{p - p \prod_{j=1}^{k}\left(1-\frac{s_{\nu'_j}}{p}\right)^{\mathfrak{m}_j}} > \qquad (4)$$

The way we have defined the properties of the LQSVNWAA operator, in a similar way we can define the properties of the LQSVNWAA operator, so it is not repeated here.

3.3 Distance measures between two linguistic Quadripartitioned single-valued neutrosophic numbers

Definition 3.13 For any two LQSVNNs $\eth_1 = < \eth_{s_{\mu'_1}}, \eth_{s_{\xi'_1}}, \eth_{s_{\zeta'_1}}, \eth_{s_{\nu'_1}} >$ and $\eth_2 = < \eth_{s_{\mu'_2}}, \eth_{s_{\xi'_2}}, \eth_{s_{\zeta'_2}}, \eth_{s_{\nu'_2}} >$ the Hamming distance between them is defined as

$$\mathcal{X}_{\mathfrak{h}}(\eth_1, \eth_2) = \frac{\left|\eth_{s_{\mu'_1}} - \eth_{s_{\mu'_2}}\right| + \left|\eth_{s_{\xi'_1}} - \eth_{s_{\xi'_2}}\right| + \left|\eth_{s_{\zeta'_1}} - \eth_{s_{\zeta'_2}}\right| + \left|\eth_{s_{\nu'_1}} - \eth_{s_{\nu'_2}}\right|}{4} \qquad (5)$$

Example 3.14 Let $\eth_1 = <s_2, s_0, s_3, s_2>$ and $\eth_2 = <s_3, s_5, s_2, s_3>$ be two LQSVNNs obtained from $\aleph_{[0,5]}$. Then we obtain their Hamming distance in the following way

$$\mathcal{X}_{\mathfrak{h}}(\eth_1, \eth_2) = \frac{|2-3|+|0-5|+|3-2|+|2-3|}{4} = 2$$

Proposition 3.15 The Hamming distance between two LQSVNNs $\eth_1$ and $\eth_2 \in \aleph_{[0,p]}$ is denoted by $\mathcal{X}_{\mathfrak{h}}(\eth_1, \eth_2)$ and it satisfies the following properties:

1. $0 \leq \mathcal{X}_{\mathfrak{h}}(\eth_1, \eth_2) \leq p$

2. $ð_1 = ð_2 \Leftrightarrow Ӿ_{ɧ}(ð_1, ð_2) = 0$

3. $Ӿ_{ɧ}(ð_1, ð_2) = Ӿ_{ɧ}(ð_2, ð_1)$

4. $If\, ð_1 \leq ð_2 \leq ð_3 \; for \; ð_3 \in \aleph_{[0,\wp]} \; then \; Ӿ_{ɧ}(ð_1, ð_2) \leq Ӿ_{ɧ}(ð_1, ð_3)$ and $Ӿ_{ɧ}(ð_2, ð_3) \leq Ӿ_{ɧ}(ð_1, ð_3)$.

Proof.

1. We have

$0 \leq \left|ð_{s_{\mu'_1}} - ð_{s_{\mu'_2}}\right| \leq \wp, \; 0 \leq \left|ð_{s_{\xi'_1}} - ð_{s_{\xi'_2}}\right| \leq \wp, \; 0 \leq \left|ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_2}}\right| \leq \wp, and \; 0 \leq \left|ð_{s_{\nu'_1}} - ð_{s_{\nu'_2}}\right| \leq \wp.$

Thus, $0 \leq Ӿ_{ɧ}(ð_1, ð_2) \leq \wp$.

2. If $ð_1 = ð_2$ then it is obvious that

$\left|ð_{s_{\mu'_1}} - ð_{s_{\mu'_2}}\right| = \left|ð_{s_{\xi'_1}} - ð_{s_{\xi'_2}}\right| = \left|ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_2}}\right| = \left|ð_{s_{\nu'_1}} - ð_{s_{\nu'_2}}\right| = 0$

Which implies $Ӿ_{ɧ}(ð_1, ð_2) = 0$.

On the other hand $Ӿ_{ɧ}(ð_1, ð_2) = 0 \Rightarrow ð_{s_{\mu'_1}} = ð_{s_{\mu'_2}}, ð_{s_{\xi'_1}} = ð_{s_{\xi'_2}}, ð_{s_{\zeta'_1}} = ð_{s_{\zeta'_2}}$, and $ð_{s_{\nu'_1}} = ð_{s_{\nu'_2}}$ i.e $ð_1 = ð_2$.

Thus, $ð_1 = ð_2 \Leftrightarrow Ӿ_{ɧ}(ð_1, ð_2) = 0$

3. $Ӿ_{ɧ}(ð_1, ð_2) = \frac{\left|ð_{s_{\mu'_1}} - ð_{s_{\mu'_2}}\right| + \left|ð_{s_{\xi'_1}} - ð_{s_{\xi'_2}}\right| + \left|ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_2}}\right| + \left|ð_{s_{\nu'_1}} - ð_{s_{\nu'_2}}\right|}{4}$

$= \frac{\left|ð_{s_{\mu'_2}} - ð_{s_{\mu'_1}}\right| + \left|ð_{s_{\xi'_2}} - ð_{s_{\xi'_1}}\right| + \left|ð_{s_{\zeta'_2}} - ð_{s_{\zeta'_1}}\right| + \left|ð_{s_{\nu'_2}} - ð_{s_{\nu'_1}}\right|}{4} = Ӿ_{ɧ}(ð_2, ð_1)$

4. Let $ð_1 = \langle ð_{s_{\mu'_1}}, ð_{s_{\xi'_1}}, ð_{s_{\zeta'_1}}, ð_{s_{\nu'_1}} \rangle$, $ð_2 = \langle ð_{s_{\mu'_2}}, ð_{s_{\xi'_2}}, ð_{s_{\zeta'_2}}, ð_{s_{\nu'_2}} \rangle$, and $ð_3 = \langle ð_{s_{\mu'_3}}, ð_{s_{\xi'_3}}, ð_{s_{\zeta'_3}}, ð_{s_{\nu'_3}} \rangle$

It is given that $ð_1 \leq ð_2 \leq ð_3$ which implies $ð_{s_{\mu'_1}} \leq ð_{s_{\mu'_2}} \leq ð_{s_{\mu'_3}}$, $ð_{s_{\xi'_1}} \leq ð_{s_{\xi'_2}} \leq ð_{s_{\xi'_3}}$, $ð_{s_{\zeta'_1}} \geq ð_{s_{\zeta'_2}} \geq ð_{s_{\zeta'_3}}$, and $ð_{s_{\nu'_1}} \geq ð_{s_{\nu'_2}} \geq ð_{s_{\nu'_3}}$.

Now,

$Ӿ_{ђ}(ð_1, ð_3)$- $Ӿ_{ђ}(ð_1, ð_2)$=

$$\frac{\left|ð_{s_{\mu'_1}} - ð_{s_{\mu'_3}}\right| + \left|ð_{s_{\xi'_1}} - ð_{s_{\xi'_3}}\right| + \left|ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_3}}\right| + \left|ð_{s_{\nu'_1}} - ð_{s_{\nu'_3}}\right|}{4} - \frac{\left|ð_{s_{\mu'_1}} - ð_{s_{\mu'_2}}\right| + \left|ð_{s_{\xi'_1}} - ð_{s_{\xi'_2}}\right| + \left|ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_2}}\right| + \left|ð_{s_{\nu'_1}} - ð_{s_{\nu'_2}}\right|}{4}$$

$$= \frac{ð_{s_{\mu'_3}} - ð_{s_{\mu'_1}} + ð_{s_{\xi'_3}} - ð_{s_{\xi'_1}} + ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_3}} + ð_{s_{\nu'_1}} - ð_{s_{\nu'_3}}}{4} - \frac{ð_{s_{\mu'_2}} - ð_{s_{\mu'_1}} + ð_{s_{\xi'_2}} - ð_{s_{\xi'_1}} + ð_{s_{\zeta'_1}} - ð_{s_{\zeta'_2}} + ð_{s_{\nu'_1}} - ð_{s_{\nu'_2}}}{4}$$

$$= \frac{ð_{s_{\mu'_3}} - ð_{s_{\mu'_2}} + ð_{s_{\xi'_3}} - ð_{s_{\xi'_2}} + ð_{s_{\zeta'_2}} - ð_{s_{\zeta'_3}} + ð_{s_{\nu'_2}} - ð_{s_{\nu'_3}}}{4} \geq 0$$

Therefore, $Ӿ_{ђ}(ð_1, ð_2) \leq Ӿ_{ђ}(ð_1, ð_3)$.

Similarly, we can prove that $Ӿ_{ђ}(ð_2, ð_3) \leq Ӿ_{ђ}(ð_1, ð_3)$.

4. Linguistic Quadripartitioned Single-Valued Neutrosophic Soft Sets (LQSVNSSs) and their Properties:

In this part, we first give the notion of LQSVNSSs and then study their various properties and operations on them.

Definition 4.1 Let Á be a set of alternatives, Ç be a set of criteria, and $\mathfrak{S} = \{\mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_2, \ldots, \mathfrak{s}_{p}\}$ be a continuous finite linguistic term set with cardinality $p + 1$. Then, a LQSVNSS defined on Á under Ç be denoted and defined as

$\Upsilon_{Ç} = \{(\varepsilon_{j}, \pi_{Ç(\varepsilon_{j})}) : \varepsilon_{j \in Ç}, \pi_{Ç(\varepsilon_{j})} \in \Lambda^{Á}_{[0,\wp]}\}$ where $\pi_{Ç} : Ç \rightarrow \Lambda^{Á}_{[0,\wp]}$. Furthermore, we represent it in the following manner:

$$\Upsilon_{Ç} = \{(\varepsilon_{j}, \{(a_{i}, < \mathfrak{s}_{\mu_{ij}}, \mathfrak{s}_{\xi_{ij}}, \mathfrak{s}_{\zeta_{ij}}, \mathfrak{s}_{\nu_{ij}} >)\}) : \varepsilon_{j \in Ç}, a_{i \in Á}, < \mathfrak{s}_{\mu_{ij}}, \mathfrak{s}_{\xi_{ij}}, \mathfrak{s}_{\zeta_{ij}}, \mathfrak{s}_{\nu_{ij}} > \in \Lambda_{[0,\wp]}\}$$

For simplicity, the set of all LQSVNSSs on Á under the criteria set $Ç$ and $\mathfrak{S} = \{\mathfrak{s}_0, \mathfrak{s}_1, \mathfrak{s}_2, \dots, \mathfrak{s}_{\wp}\}$ is denoted by $\Lambda^{Á/Ç}_{[0,\wp]}$.

Example 4.2 Let us assume that $P = \{p_1, p_2, p_3, p_4, p_5\}$ is a set of people whose sputum being collected by a primary health center for diagnostic purposes whenever the given set of persons have the symptoms represented by the set $S = \{s_1 = cough, s_2 = chest\ pain, s_3 = fever, s_4 = breathing\ difficulty\}$.

The linguistic term set is

$$L = \{l_0 = frequently, l_1 = always, l_2 = never, l_3 = severe, l_4 = more\ than\ one\ week, l_5 = last\ for\ 6\ days\}$$

.The qualitative measurement of expert is represented by the following LQSVNSS:

$\Upsilon =$

$$\{(s_1, \{(p_1, < l_1, l_2, l_3, l_1 >), (p_2, < l_0, l_4, l_3, l_5 >), (p_3, < l_1, l_1, l_3, l_4 >), (p_4, < l_1, l_0, l_2, l_1 >), (p_5, < l_5, l_5, l_2, l_3 >)\}), (s_2, \{(p_1, < l_1, l_0, l_4, l_2 >), (p_2, < l_2, l_2, l_3, l_4 >), (p_3, < l_3, l_0, l_2, l_4 >), (p_4, < l_2, l_2, l_2, l_3 >), (p_5, < l_5, l_2, l_2, l_1 >)\}), (s_3, \{(p_1, < l_1, l_0, l_2, l_2 >), (p_2, < l_4, l_2, l_3, l_5 >), (p_3, < l_1, l_2, l_3, l_3 >), (p_4, < l_0, l_0, l_0, l_5 >), (p_5, < l_4, l_4, l_2, l_1 >)\}), (s_4, \{(p_1, < l_5, l_4, l_3, l_1 >), (p_2, < l_2, l_2, l_4, l_0 >), (p_3, < l_1, l_2, l_0, l_3 >), (p_4, < l_3, l_3, l_4, l_5 >), (p_5, < l_4, l_4, l_3, l_5 >)\})\}$$

For a better understanding the above LQSVNS set can be represented in the following matrix form given in Table 2 below:

Definition 4.3 Let $\Upsilon^1, \Upsilon^2 \in \Lambda^{Á/Ç}_{[0,\wp]}$, then Υ^1 is an LQSVNS subset of Υ^2 if $\Lambda^1_{ij} \leq \Lambda^2_{ij}$ for all $i \in \{1, 2, \dots, p\}$ and $j \in \{1, 2, \dots, q\}$ and it is denoted by $\Upsilon^1 \hat{\sqsubseteq} \Upsilon^2$.

Note: For all $i \in \{1,2,\ldots,p\}$ *and* $j \in \{1,2,\ldots,q\}$ if $\Lambda^1_{ij} = \Lambda^2_{ij}$ then equality holds.

Proposition 4.4 Let $\Upsilon^1, \Upsilon^2, \Upsilon^3 \in \Lambda^{\acute{A}/\varsigma}_{[0,\wp]}$, then we have the following:

(i) $\Upsilon^1 \hat{\subseteq} \Upsilon^2$ and $\Upsilon^2 \hat{\subseteq} \Upsilon^1 \Leftrightarrow \Upsilon^1 = \Upsilon^2$

(ii) $\Upsilon^1 \hat{\subseteq} \Upsilon^2$ and $\Upsilon^2 \hat{\subseteq} \Upsilon^3 \Rightarrow \Upsilon^1 \hat{\subseteq} \Upsilon^3$

Proof. The proofs are straight forward.

Definition 4.5 Let $\Upsilon_{\varsigma} = \{(\varepsilon_j, \pi_{\varsigma(\varepsilon_j)}) : \varepsilon_j \in \varsigma, \pi_{\varsigma(\varepsilon_j)} \in \Lambda^{\acute{A}}_{[0,\wp]}\}$ be a LQSVNSS. Then its complement is denoted and defined by $\widetilde{\Upsilon_{\varsigma}} = \{(\varepsilon_j, \widetilde{\pi_{\varsigma(\varepsilon_j)}}) : \varepsilon_j \in \varsigma, \widetilde{\pi_{\varsigma(\varepsilon_j)}} \in \Lambda^{\acute{A}}_{[0,\wp]}\} = \{(\varepsilon_j, \{(a_i, \widetilde{\pi_{ij}})\}) : \varepsilon_j \in \varsigma, \widetilde{\pi_{ij}} \in \Lambda_{[0,\wp]}\}$.

Definition 4.6 Let Υ_{ς}^1 and Υ_{ς}^2 be two LQSVNSSs. Then their intersection is denoted and defined by

$$\Upsilon_{\varsigma}^1 \hat{\cap} \Upsilon_{\varsigma}^2 = \{(\varepsilon_j, \pi^{\cap}_{\varsigma}(\varepsilon_j)) : \varepsilon_j \in \varsigma, \pi^{\cap}_{\varsigma}(\varepsilon_j) \in \Lambda^{\acute{A}}_{[0,\wp]}\}$$

$$= \{(\varepsilon_j, \{(a_i, \pi^{\cap}_{ij})\}) : \varepsilon_j \in \varsigma, \pi^{\cap}_{ij} \in \Lambda_{[0,\wp]}\}$$

where $\pi^{\cap}_{ij} = \Upsilon_{ij}^1 \cap \Upsilon_{ij}^2$ for i=1,2,…,n and j=1,2,….,m.

Definition 4.7 Let Υ_{ς}^1 and Υ_{ς}^2 be two LQSVNSSs. Then their union is denoted and defined by

$$\Upsilon_{\varsigma}^1 \hat{\cup} \Upsilon_{\varsigma}^2 = \{(\varepsilon_j, \pi^{\cup}_{\varsigma}(\varepsilon_j)) : \varepsilon_j \in \varsigma, \pi^{\cup}_{\varsigma}(\varepsilon_j) \in \Lambda^{\acute{A}}_{[0,\wp]}\}$$

$$= \{(\varepsilon_j, \{(a_i, \pi^{\cup}_{ij})\}) : \varepsilon_j \in \varsigma, \pi^{\cup}_{ij} \in \Lambda_{[0,\wp]}\}$$

where $\pi^{\cup}_{ij} = \Upsilon_{ij}^1 \cup \Upsilon_{ij}^2$ for i=1,2,…,n and j=1,2,….,m.

5. Applications:

In this section one of the examples of Linguistic Quadripartitioned Single-Valued Neutrosophic Soft Set for various applications is briefly discussed. It is well known that this set is independent of human quantum Turiyam cognition (Singh 2023c). It represents Linguistics and its indeterminacy in four ways as static uncertainty rather than dynamic or involvement of Human consciousness. Let us suppose a problem related to India where some of the students demand teaching in the local language. To solve this issue feedback data is collected. Some of the students agreed for teaching in the local language $\mu_{Q(e_i)}, \in [0,1]$ denote the truth. Some of the nearby or other state students contradict the statement that why the local language of my state is near hence my state language should be considered $\xi_{Q(e_i)}, \in [0,1]$. Some of the students from outside India $\zeta_{\mathcal{H}(e_i)} \in [0,1]$ who came for a degree wanted to take a degree in any language or were unaware about an issue can be represented via an uncertain degree. The last is educated or intellectual students disagree that teaching locally is harmful to the career. We should go for a global language. It can be represented as falsity membership grades. These types of data sets can be analyzed using the Linguistic Quadripartitioned Single-Valued Neutrosophic Soft Set. Table 3 represents the Tabular representation where x represents the number of students (x_n) and y represents the number of subjects (y_m) and the Quadripartitioned Single-Valued Neutrosophic $(< l_1, l_2, l_3, l_1 >)$relations show their feedback for teaching in a local language, its contradiction or uncertainty or rejection. Everyone independently gave their feedback. It will help to analyze the influence of local language in the university, diversity in the university, weak or strong student percentages in the university as well as acceptance of other languages. For more details see Table 3

We can also compute the Hamming distance to analyze the similarity among feedback of two departments and their students. In this way, the proposed method helps deal with these types of data sets where contradiction exists between two or more opinions beyond the true or false, or uncertainty. However, to explore the unknown or impossible data that teaching in a multilingual system requires human quantum Turiyam cognition as discussed by Singh (2023c). The authors will try to focus on exploring this area with an illustrative example.

6. Conclusions:

This paper focused on dealing with the uncertainty in qualitative data which are known. To deal with uncertainty in these types of data a Linguistic Quadripartitioned Single-Valued Neutrosophic Soft Sets (LQSVNSSs) and its weighted aggregation operator are introduced. The paper introduces some of the basic concepts and examples for dealing with the education sector data. Shortly, the authors will focus on introducing other metrics for dealing with these types of data using four-valued logic.

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	Fuzzy set	Intuitionistic fuzzy set	Neutrosophic set	Turiyam set	Quadripartitioned
Data	Uncertain	Vague	Indeterminacy	Unknown or impossible	Uncertain and indeterminant
Membership-values	Single-valuesfor true (*t*) and false (*f*)	Dependent values for true (*t*) and false (*f*)	Independent values for true (*t*), false (*f*) and indeterminacy (*i*)	Independent and dependent values for true (*t*), false (*f*), uncertain (*i*) and liberation (*l*).	Independent and dependent values for true (*t*), false (*f*), uncertain(*i*), incompleteness (*l*).
Range	[0, 1]	Dependent: [0, 1]	Independent case:$^{-}[-3, 3]^{+}$ or Dependent case: $^{-}[0, 1]^{+}$	Independent case:$^{-}[-4, 4]^{+}$ or Dependent case: $^{-}[0, 1]^{+}$	Independent case:$^{-}[-4, 4]^{+}$ or Dependent case: $^{-}[0, 1]^{+}$
Undefined objects	No	No	No	Yes	No
Dynamic attribute	No	No	No	Yes	No
Consciousness utilized	No	No	No	Yes	No
Expert to expert	Same representation	Same Representation	Same representation	Varies from expert to expert based on their consciousness	Same representation
Application	Natural Language processing	Pattern recognition	Image Processing, feedback	Robotics, Self-driving cars, cognitive science	Qualitative data measurement

Table 1: The distinction among fuzzy, intuitionistic, neutrosophic, Turiyam and Quadripartitioned

	S_1	S_2	S_3	S_4
p_1	$< l_1, l_2, l_3, l_1 >$	$< l_1, l_0, l_4, l_2 >$	$< l_1, l_0, l_2, l_2 >$	$< l_5, l_4, l_3, l_1 >$
p_2	$< l_0, l_4, l_3, l_5 >$	$< l_2, l_2, l_3, l_4 >$	$< l_4, l_2, l_3, l_5 >$	$< l_2, l_2, l_4, l_0 >$
p_3	$< l_1, l_1, l_3, l_4 >$	$< l_3, l_0, l_2, l_4 >$	$< l_1, l_2, l_3, l_3 >$	$< l_1, l_2, l_0, l_3 >$
p_4	$< l_1, l_0, l_2, l_1 >$	$< l_2, l_2, l_2, l_3 >$	$< l_0, l_0, l_0, l_5 >$	$< l_3, l_3, l_4, l_5 >$
p_5	$< l_5, l_5, l_2, l_3 >$	$< l_5, l_2, l_2, l_1 >$	$< l_4, l_4, l_2, l_1 >$	$< l_4, l_4, l_3, l_5 >$

Table 2: Tabular representation of an LQSVNSS

	y_1	y_2	y_3	...	y_m
x_1	$< l_1, l_2, l_3, l_1 >$	$< l_1, l_0, l_4, l_2 >$	$< l_1, l_0, l_2, l_2 >$	$\cdots$	$< l_5, l_4, l_3, l_1 >$
x_2	$< l_0, l_4, l_3, l_5 >$	$< l_2, l_2, l_3, l_4 >$	$< l_4, l_2, l_3, l_5 >$	$\ldots$	$< l_2, l_2, l_4, l_0 >$
x_3	$< l_1, l_1, l_3, l_4 >$	$< l_3, l_0, l_2, l_4 >$	$< l_1, l_2, l_3, l_3 >$	$\ldots$	$< l_1, l_2, l_0, l_3 >$
x_4	$< l_1, l_0, l_2, l_1 >$	$< l_2, l_2, l_2, l_3 >$	$< l_0, l_0, l_0, l_5 >$	$\ldots$	$< l_3, l_3, l_4, l_5 >$
………					
x_n	$< l_5, l_5, l_2, l_3 >$	$< l_5, l_2, l_2, l_1 >$	$< l_4, l_4, l_2, l_1 >$	$\ldots$	$< l_4, l_4, l_3, l_5 >$

Table 3: Tabular representation of an LQSVNSS for teaching in Local Language