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POSSIBILITY SINGLE VALUED NEUTROSOPHIC SOFT EXPERT SETS AND ITS APPLICATION IN DECISION MAKING

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Abstract - In this paper, we first introduced the concept of possibility single valued neutrosophic soft expert sets (PSVNSESs for short) which is a generalization of single valued neutrosophic soft expert sets (SVNSESs for short), possibility fuzzy soft expert sets (PFSESs) and possibility intuitionistic fuzzy soft expert sets (PIFSESs). We also define its basic operations, namely complement, union, intersection, AND and OR, and study some of their properties. Finally, an approach for solving MCDM problems is explored by applying the possibility single valued neutrosophic soft expert sets, and an example is provided to illustrate the application of the proposed method

Keywords *- Single valued neutrosophic sets, soft expert sets, possibility single valued neutrosophic soft expert sets, decision making.*

1. Introduction

In 1999, F. Smarandache [12,13,14] proposed the concept of neutrosophic set (NS for short) by adding an independent indeterminacy-membership function. The concept of neutrosophic set is a generalization of classic set, fuzzy set [40], intuitionistic fuzzy set [34] and so on. In NS, the indeterminacy is quantified explicitly and truth-membership, indeterminacy membership, and false-membership are completely independent. From scientific or engineering point of view, the neutrosophic set and set- theoretic view, operators need to be specified. Otherwise, it will be difficult to apply in the real applications. Therefore, H. Wang et al [17] defined a single valued neutrosophic set (SVNS) and then provided the set theoretic operations and various properties of single valued neutrosophic sets. The works on single valued neutrosophic set (SVNS) and their

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hybrid structure in theories and application have been progressing rapidly (e.g, [3, 4, 5, 6, 7, 8, 9, 11, 25, 26, 27, 28, 29, 30, 31, 32, 33, 41, 60, 68, 69, 70, 73, 77, 80, 81, 82, 83, 86].

In the year 1999, Molodtsov a Russian researcher [10] firstly gave the soft set theory as a general mathematical tool for dealing with uncertainty and vagueness and how soft set theory is free from the parameterization inadequacy syndrome of fuzzy set theory, rough set theory, probability theory. A soft set is in fact a set-valued map which gives an approximation description of objects under consideration based on some parameters. Then, many interesting results of soft set theory have been studied on fuzzy soft sets [45, 47, 48, 53, 54], on intuitionistic fuzzy soft set theory [49, 50, 51, 55], on possibility fuzzy soft set [45, 63], on generalized fuzzy soft sets [58], on generalized intuitionistic fuzzy soft [39], on possibility intuitionistic fuzzy soft set [42], on possibility vague soft set [35] and so on. All these research aim to solve most of our real life problems in medical sciences, engineering, management, environment and social science which involve data that are not crisp and precise. Moreover all the models created will deal only with one expert .To redefine this one expert opinion, Alkhazaleh and Salleh in 2011 [63] defined the concept of soft expert set in which the user can know the opinion of all the experts in one model and give an application of this concept in decision making problem. Also, they introduced the concept of the fuzzy soft expert set [62] as a combination between the soft experts set and the fuzzy set. Therfore, Broumi and Smarandache [85] presented the concept of iintuitionstic fuzzy soft expert set, a more general concept, which combines intuitionstic fuzzy set and soft expert set and studied its application in decision making. Later on, many researchers have worked with the concept of soft expert sets and their hybrid structures [1, 2, 15, 16, 22, 36, 37, 44, 46]. But most of these concepts cannot deal with indeterminate and inconsistent information.

Combining neutrosophic set models with other mathematical models has attracted the attention of many researchers. Maji et al. presented the concept of neutrosophic soft set [57] which is based on a combination of the neutrosophic set and soft set models. Works on neutrosophic soft set theory are progressing rapidly. Based on [57], Maji [56] introduce the concept of weighted neutrosophic soft sets which is hybridization of soft sets and weighted parameter of neutrosophic soft sets. Also, Based on Çağman [48], Karaaslan [87] redefined neutrosophic soft sets and their operations. Various kinds of extended neutrosophic soft sets such as intuitionistic neutrosophic soft set [65, 67, 76], generalized neutrosophic soft set [59, 66], interval valued neutrosophic soft set [23], neutrosophic parameterized fuzzy soft set [72], Generalized interval valued neutrosophic soft sets [75], neutrosophic soft relation [20, 21], neutrosophic soft multiset theory [24] and cyclic fuzzy neutrosophic soft group [61] were presented. The combination of neutrosophic soft sets and rough set [74, 78, 79] is another interesting topic. In this paper, our objective is to generalize the concept of single valued neutrosophic soft expert sett. In our generalization of single valued neutrosophic soft expert set , a possibility of each element in the universe is attached with the parameterization of single valued neutrosophic sets while defining a single valued neutrosophic soft expert set The new model developed is called possibility single valued neutrosophic soft expert set (PSVNSES).

The paper is structured as follows. In Section 2, we first recall the necessary background on neutrosophic sets, single valued neutrosophic sets, soft set single valued neutrosophic soft sets, possibility single valued neutrosophic soft sets, single valued neutrosophic soft expert sets, soft expert sets, fuzzy soft expert sets, possibility fuzzy soft expert sets and possibility intutionistic fuzzy soft expert sets. Section 3 reviews various proposals for the definition of possibility single valued neutrosophic soft expert sets and derive their respective properties. Section 4 presents basic operations on possibility single valued neutrosophic soft expert sets. Section 5 presents an application of this concept in solving a decision making problem. Finally, we conclude the paper.

2. Preliminaries

In this section, we will briefly recall the basic concepts of neutrosophic sets, single valued neutrosophic sets, soft set single valued neutrosophic soft sets, possibility single valued neutrosophic soft sets, soft expert sets, fuzzy soft expert sets, possibility fuzzy soft expert sets and possibility intutionistic fuzzy soft expert sets

Let U be an initial universe set of objects and E the set of parameters in relation to objects in U . Parameters are often attributes, characteristics or properties of objects. Let P (U) denote the power set of U and A ⊆ E.

2.1 Neutrosophic Set

Definition 2.1 [13] Let U be an universe of discourse then the neutrosophic set A is an object having the form A = {< x: $\mu_A(x)$, $\nu_A(x)$, $\omega_A(x)$>,x ∈ U}, where the functions $\mu_A(x)$, $\nu_A(x)$, $\omega_A(x)$: U→$]^-0,1^+[$ define respectively the degree of membership , the degree of indeterminacy, and the degree of non-membership of the element x ∈ X to the set A with the condition.

$$^-0 \leq sup\ \mu_A(x) + \sup \nu_A(x) + sup\,\omega_A(x)) \leq 3^+.$$

From philosophical point of view, the neutrosophic set takes the value from real standard or non-standard subsets of $]^-0,1^+[$. So instead of $]^-0,1^+[$ we need to take the interval [0,1] for technical applications, because $]^-0,1^+[$ will be difficult to apply in the real applications such as in scientific and engineering problems.

For two NS,

A_{NS}= {<x, $\mu_A(x)$, $\nu_A(x)$, $\omega_A(x)$ > | x ∈ X }

and

B_{NS}= {<x, $\mu_B(x)$, $\nu_B(x)$, $\omega_B(x)$ > | x ∈ X }

Then,

1. $A_{NS} \subseteq B_{NS}$ if and only if

$$\mu_A(x) \leq \mu_B(x), \nu_A(x) \geq \nu_B(x)\ , \omega_A(x) \geq \omega_B(x)\ .$$

2. $A_{NS} = B_{NS}$ if and only if ,

$\mu_A(x) = \mu_B(x)$,$\nu_A(x) = \nu_B(x)$,$\omega_A(x) = \omega_B(x)$ for any x ∈ X.

3. The complement of A_{NS} is denoted by A_{NS}^{o} and is defined by

A_{NS}^{o}= {<x, $\omega_{\mathrm{A}}(\mathrm{x}), 1-\nu_{\mathrm{A}}(\mathrm{x}), \mu_{\mathrm{A}}(\mathrm{x})$ | x ∈ X }

4. A∩B = {<x, min{$\mu_{\mathrm{A}}(\mathrm{x}), \mu_{B}(\mathrm{x})$}, max{$\nu_{\mathrm{A}}(\mathrm{x}), \nu_{B}(\mathrm{x})$}, max{$\omega_{\mathrm{A}}(\mathrm{x}), \omega_{B}(\mathrm{x})$} >:x ∈ X }

5. A∪B = {<x, max{$\mu_{\mathrm{A}}(\mathrm{x}), \mu_{B}(\mathrm{x})$},min{$\nu_{\mathrm{A}}(\mathrm{x}), \nu_{B}(\mathrm{x})$}, min{$\omega_{\mathrm{A}}(\mathrm{x}), \omega_{B}(\mathrm{x})$} >:x ∈ X }

As an illustration, let us consider the following example.

Example 2.2. Assume that the universe of discourse U={x_1,x_2,x_3,x_4}. It may be further assumed that the values of x_1, x_2, x_3 and x_4 are in [0, 1] Then, A is a neutrosophic set (NS) of U, such that,

A= {< x_1,0.4,0.6,0.5 >,< x_2, 0.3,0.4,0.7>,< x_3,0.4,0.4, 0.6] >,< x_4,0.5,0.4,0.8 >}

2.2 Soft Set

Definition 2.3. [10] Let U be an initial universe set and E be a set of parameters. Let P(U) denote the power set of U. Consider a nonempty set A, A ⊂ E. A pair (K, A) is called a soft set over U, where K is a mapping given by K : A → P(U).

As an illustration, let us consider the following example.

Example 2.4. Suppose that U is the set of houses under consideration, say U= {$h_1,h_2,...,h_5$}. Let E be the set of some attributes of such houses, say E={$e_1,e_2, ... , e_8$}, where e_1, e_2, ..., e_8 stand for the attributes "beautiful", "costly", "in the green surroundings'", "moderate", respectively.

In this case, to define a soft set means to point out expensive houses, beautiful houses, and so on. For example, the soft set (K, A) that describes the "attractiveness of the houses" in the opinion of a buyer, say Thomas, may be defined like this:

A={e_1,e_2,e_3,e_4,e_5};

K(e_1) = {h_2, h_3, h_5}, K(e_2) = {h_2, h_4}, K(e_3) = {h_1}, K(e_4) = U, K(e_5) = {h_3, h_5}.

2.3 Neutrosophic Soft Sets

Definition 2.5 [57,87] Let U be an initial universe set and $A \subset E$ be a set of parameters. Let NS(U) denotes the set of all neutrosophic subsets of U. The collection (F, A) is termed to be the neutrosophic soft set over U, where F is a mapping given by $F: A \rightarrow NS(U)$.

Example 2.6 [16] Let U be the set of houses under consideration and E is the set of parameters. Each parameter is a neutrosophic word or sentence involving neutrosophic words. Consider E ={beautiful, wooden, costly, very costly, moderate, green surroundings, in good repair, in bad repair, cheap, expensive}. In this case, to define a neutrosophic soft set means to point out beautiful houses, wooden houses, houses in the green surroundings and so on. Suppose that, there are five houses in the universe U given by $U = \{h_1, h_2, \ldots, h_5\}$ and the set of parameters

$A = \{e_1, e_2, e_3, e_4\}$,where e_1 stands for the parameter `beautiful', $e_2$ stands for the parameter `wooden', e_3 stands for the parameter `costly' and the parameter $e_4$ stands for `moderate'. Then the neutrosophic set (F, A) is defined as follows:

$$(F,A) = \left\{\begin{matrix} \left(e_1\left\{\frac{h_1}{(0.5,0.6,0.3)}, \frac{h_2}{(0.4,0.7,0.6)}, \frac{h_3}{(0.6,0.2,0.3)}, \frac{h_4}{(0.7,0.3,0.2)}, \frac{h_5}{(0.8,0.2,0.3)}\right\}\right) \\ \left(e_2\left\{\frac{h_1}{(0.6,0.3,0.5)}, \frac{h_2}{(0.7,0.4,0.3)}, \frac{h_3}{(0.8,0.1,0.2)}, \frac{h_4}{(0.7,0.1,0.3)}, \frac{h_5}{(0.8,0.3,0.6)}\right\}\right) \\ \left(e_3\left\{\frac{h_1}{(0.7,0.4,0.3)}, \frac{h_2}{(0.6,0.7,0.2)}, \frac{h_3}{(0.7,0.2,0.5)}, \frac{h_4}{(0.5,0.2,0.6)}, \frac{h_5}{(0.7,0.3,0.4)}\right\}\right) \\ \left(e_4\left\{\frac{h_1}{(0.8,0.6,0.4)}, \frac{h_2}{(0.7,0.9,0.6)}, \frac{h_3}{(0.7,0.6,0.4)}, \frac{h_4}{(0.7,0.8,0.6)}, \frac{h_5}{(0.9,0.5,0.7)}\right\}\right) \end{matrix}\right\}$$

2.4 Possibility Single Valued Neutrosophic Soft Sets

Definition 2.7 [59] Let U= $\{u_1, u_2, u_3, \ldots, u_n\}$ be a universal set of elements, E= $\{e_1, e_2, e_3, \ldots, e_m\}$ be a universal set of parameters. The pair (U, E) will be called a soft universe. Let F: E → $(I \times I \times I)^U \times I^U$ where $(I \times I \times I)^U$ is the collection of all single valued neutrosophic subset of U and I^U is the collection of all fuzzy subset of U. Let p be a fuzzy subset of E, that is p: E → I^U

And let F_p: E → $(I \times I \times I)^U \times I^U$ be a function defined as follows:

$F_p(e)$= (F(e)(x), p(e)(x)), where F(e)(x)=(μ(x), $\nu(x)$,$\omega(x)$) for x∈ U.

Then F_p is called a possibility single valued neutrosophic soft set(PSVNSS) over the soft universe (U, E).

2.5 Soft Expert Sets

Definition 2.8 [63] Let U be a universe set, E be a set of parameters and X be a set of experts (agents). Let O= {1=agree, 0=disagree} be a set of opinions. Let Z= E × X × O and A ⊆ Z

A pair (F, E) is called a soft expert set over U, where F is a mapping given by F : A → P(U) and P(U) denote the power set of U.

Definition 2.9 [63] An agree- soft expert set $(F, A)_1$ over U, is a soft expert subset of (F,A) defined as :

$$(F, A)_1 = \{F(\alpha): \alpha \in E \times X \times \{1\}\}.$$

Definition 2.10 [63] A disagree- soft expert set $(F, A)_0$ over U, is a soft expert subset of $(F$,A) defined as :

$$(F, A)_0 = \{F(\alpha): \alpha \in E \times X \times \{0\}\}.$$

2.6 Fuzzy Soft Expert Sets

Definition 2.11 [62] A pair (F, A) is called a fuzzy soft expert set over U, where F is a mapping given by F : A→ I^U,and I^U denote the set of all fuzzy subsets of U.

2.7.Possibility Fuzzy Soft Expert Sets

Definition 2.12. [44] Let U={ $u_1, u_2, u_3, \ldots, u_n$ } be a universal set of elements, E={ $e_1, e_2, e_3, \ldots, e_m$ } be a universal set of parameters, X={ $x_1, x_2, x_3, \ldots, x_i$ } be a set of experts (agents) and O = { 1=agree, 0=disagree} be a set of opinions. Let Z= { E × X × Q } and A $\subseteq$ Z. The pair (U, E) will be called a soft universe. Let F: E $\rightarrow I^U$ and μ be fuzzy subset o f E, i.e, μ :E $\rightarrow I^U$ where I^U is the collection of all fuzzy subsets of U. Let F_μ :E $\rightarrow I^U \times I^U$ be a function defined as follows:

$$F_\mu(e) = (\, F(e)(x), \mu(e)(x)), \text{ for all } x \in U.$$

Then F_μ is called a possibility fuzzy soft expert set (PFSES in short) over the soft universe (U, E)

For each parameter $e_i \in$E. $F_\mu(e_i)$ = (F(e_i)(x), $\mu(e_i)(x)$) indicates not only the degree of belongingness of the elements of U in F(e_i), but also the degree of possibility of belongingness of the elements of U in F(e_i), which is represented by $\mu(e_i)$. So we can write $F_\mu(e_i)$ as follows:

$$F_\mu(e_i)\, \{(\frac{x_i}{F(e_i)(x_i)}), \mu(e_i)(x_i)\} \text{ ,for i=1,2,3,..,n}$$

Sometimes we write F_μ as (F_μ, E) . If A ⊆ E. we can also have PFSES (F_μ, A).

2.8 Possibility Intuitionstic Fuzzy Soft expert sets

Definition 2.13 [16] Let U= { $u_1, u_2, u_3, \ldots, u_n$ } be a universal set of elements, E={ $e_1, e_2, e_3, \ldots, e_m$ } be a universal set of parameters, X={ $x_1, x_2, x_3, \ldots, x_i$ } be a set of experts (agents) and O= {1=agree, 0=disagree} be a set of opinions. Let Z= { E × X × Q } and A $\subseteq$ Z. Then the pair (U, Z) is called a soft universe. Let F: Z $\rightarrow I^U$ and λ be fuzzy subset o f Z defined as λ :Z $\rightarrow F^U$ where I^U

denotes the collection of all intuitionistic fuzzy subsets of U. Suppose F_λ :Z $\rightarrow$ I^U x F^U be a function defined as:

$$F_p(z) = (\text{ F(z)}(u_i), \lambda \text{ (z)}(u_i)), \text{ for all } u_i \in \text{U}.$$

Then $F_\lambda(z)$ is called a possibility intuitionistic fuzzy soft expert set (PIFSES in short) over the soft universe (U, Z)

For each $z_i \in$Z. $F_\lambda(z)$= (F(z_i)(u_i), λ(z_i)(u_i)) where F(z_i) represents the degree of belongingness and non-belongingness of the elements of U in F(z_i) and λ (z_i) represents the degree of possibility of such belongingness. Hence $F_\lambda(z_i)$ can be written as:

$$F_\lambda(z_i) \{ (\frac{u_i}{F(z_i)(u_i)}), \lambda(z_i)(u_i)\} \text{ ,for i=1,2,3,…n}$$

where F(z_i)(u_i) = < $\mu_{F(z_i)}(u_i)$, $\omega_{F(z_i)}(u_i)$ > with $\mu_{F(z_i)}(u_i)$ and $\omega_{F(z_i)}(u_i)$ representing the membership function and non-membership function of each of the elements $u_i \in$U respectively.

Sometimes we write F_λ as (F_λ, Z) . If A ⊆ Z. we can also have PIFSES (F_λ, A).

2.9 Single Valued Neutrosophic Soft Expert Sets

Definition 2.14 [84] Let U= = { u_1, u_2, u_3,…, u_n} be a universal set of elements, E={ e_1, e_2, e_3,…, e_m} be a universal set of parameters, X={ x_1, x_2, x_3,…, x_i} be a set of experts (agents) and O= {1=agree, 0=disagree} be a set of opinions. Let Z= { E × X × Q } and A ⊆ Z. Then the pair (U, Z) is called a soft universe. Let F: Z $\rightarrow$ SVN^U, where SVN^U denotes the collection of all single valued neutrosophic subsets of U. Suppose F :Z $\rightarrow$ SVN^U be a function defined as:

$$F(z) = \text{ F(z)}(u_i) \text{ for all } u_i \in \text{U}.$$

Then $F(z)$ is called a single valued neutrosophic soft expert set (SVNSES in short) over the soft universe (U, Z)

For each $z_i \in$ Z. $F(z)$ = F(z_i)(u_i), where F(z_i) represents the degree of belongingness, degree of indeterminacy and non-belongingness of the elements of U in F(z_i).Hence $F(z_i)$ can be written as:

$$F(z_i) \{ (\frac{u_1}{F(z_1)(u_1)}),\ldots,(\frac{u_n}{F(z_n)(u_n)}), \} \text{ ,for i=1,2,3,…n}$$

where F(z_i)(u_i) = < $\mu_{F(z_i)}(u_i)$, $\nu_{F(z_i)}(u_i)$, $\omega_{F(z_i)}(u_i)$ > with $\mu_{F(z_i)}(u_i)$, $\nu_{F(z_i)}(u_i)$ and $\omega_{F(z_i)}(u_i)$ representing the membership function, indeterminacy function and non-membership function of each of the elements $u_i \in$ U respectively.

Sometimes we write F as (F, Z) . If A ⊆ Z. we can also have SVNSES (F, A).

3. Possibility Single Valued Neutrosophic Soft Expert Sets

In this section, we generalize the possibility fuzzy soft expert sets as introduced by Alhhazaleh and Salleh [62] and possibility intuitionistic fuzzy soft expert sets as introduced by G. Selvachandran [16] to possibility single valued neutrosophic soft expert sets and give the basic properties of this concept.

Let U be universal set of elements, E be a set of parameters, X be a set of experts (agents), O= { 1=agree, 0=disagree } be a set of opinions. Let Z= E × X × O and

Definition 3.1 Let U= = { u_1, u_2, u_3,…, u_n } be a universal set of elements, E={ e_1, e_2, e_3,…, e_m } be a universal set of parameters, X={ x_1, x_2, x_3,…, x_i } be a set of experts (agents) and O= {1=agree, 0=disagree} be a set of opinions. Let Z= { E × X × Q } and A ⊆ Z. Then the pair (U, Z) is called a soft universe. Let F: Z → SVN^U and p be fuzzy subset o f Z defined as p :Z → F^U where SVN^U denotes the collection of all single valued neutrosophic subsets of U. Suppose F_p :Z → SVN^U x F^U be a function defined as:

$$F_p(z) = (\text{ F}(z)(u_i), \text{p}(z)(u_i)), \text{ for all } u_i \in \text{U}.$$

Then $F_p(z)$ is called a possibility single valued neutrosophic soft expert set (PSVNSES in short) over the soft universe (U, Z)

For each $z_i \in$ Z. $F_p(z)$= (F(z_i)(u_i), p(z_i)(u_i)) where F(z_i) represents the degree of belongingness, degree of indeterminacy and non-belongingness of the elements of U in F(z_i) and p(z_i) represents the degree of possibility of such belongingness. Hence $F_p(z_i)$ can be written as:

$$F_p(z_i)\, \{(\frac{u_i}{F(e_i)(u_i)}), \text{p}(z_i)(u_i)\}, \text{ for i=1,2,3,…}$$

where F(z_i)(u_i) = < $\mu_{F(z_i)}(u_i)$, $\nu_{F(z_i)}(u_i)$, $\omega_{F(z_i)}(u_i)$ > with $\mu_{F(z_i)}(u_i)$, $\nu_{F(z_i)}(u_i)$ and $\omega_{F(z_i)}(u_i)$ representing the membership function, indeterminacy function and non-membership function of each of the elements $u_i \in$ U respectively.

Sometimes we write F_p as (F_p, Z) . If A ⊆ Z. we can also have PSVNSES (F_p, A).

Example 3.2 Let U={u_1, u_2, u_3} be a set of elements, E={e_1, e_2} be a set of decision parameters, where e_i(i= 1, 2,3} denotes the parameters E ={e_1= beautiful, e_2= cheap} and X= {x_1, x_2} be a set of experts. Suppose that F_p:Z→ $SVN^U \times F^U$ is function defined as follows:

$$F_p(e_1, x_1, 1) = \{ (\frac{u_1}{<0.1,0.8,0.3>},0.3), (\frac{u_2}{<0.1,0.6,0.4>},0.4), (\frac{u_3}{<0.4,0.7,0.2>},0.5) \},$$

$$F_p(e_2, x_1, 1) = \{ (\frac{u_1}{<0.7,0.5,0.25>},0.6), (\frac{u_2}{<0.25,0.6,0.4>},0.8), (\frac{u_3}{<0.4,0.4,0.6>},0.7) \},$$

$$F_p(e_1, x_2, 1) = \{ (\frac{u_1}{<0.3,0.2,0.7>},0.3), (\frac{u_2}{<0.4,0.3,0.3>},0.4), (\frac{u_3}{<0.1,0.6,0.2>},0.6) \},$$

$$F_p(e_2, x_2, 1) = \{ (\frac{u_1}{<0.2,0.2,0.6>},0.5), (\frac{u_2}{<0.7,0.3,0.2>},0.8), (\frac{u_3}{<0.3,0.1,0.5>},0.1) \},$$

$$F_p(e_1, x_1, 0) = \{ (\frac{u_1}{<0.2,0.4,0.5>},0.2), (\frac{u_2}{<0.1,0.9,0.1>},0.7), (\frac{u_3}{<0.1,0.2,0.5>},0.1) \},$$

$$F_p(e_2, x_1, 0) = \{ (\frac{u_1}{<0.3,0.4,0.6>},0.4), (\frac{u_2}{<0.2,0.7,0.6>},0.6), (\frac{u_3}{<0.1,0.5,0.2>},0.1) \},$$

$$F_p(e_1, x_2, 0) = \{ (\frac{u_1}{<0.2,0.8,0.4>},0.2), (\frac{u_2}{<0.1,0.6,0.5>},0.5), (\frac{u_3}{<0.7,0.6,0.3>},0.8) \}$$

$$F_p(e_2, x_2, 0) = \{ (\frac{u_1}{<0.4,0.4,0.7>},0.2), (\frac{u_2}{<0.3,0.8,0.2>},0.6), (\frac{u_3}{<0.6,0.2,0.4>},0.5)$$

Then we can view the possibility single valued neutrosophic soft expert set (F_p, Z) as consisting of the following collection of approximations:

(F_p, Z)=

$$\{ (e_1, x_1, 1) = \{ (\frac{u_1}{<0.1,0.8,0.3>},0.3), (\frac{u_2}{<0.1,0.6,0.4>},0.4), (\frac{u_3}{<0.4,0.7,0.2>},0.5) \}\},$$

$$\{ (e_2, x_1, 1) = \{ (\frac{u_1}{<0.7,0.5,0.25>},0.6), (\frac{u_2}{<0.25,0.6,0.4>},0.8), (\frac{u_3}{<0.4,0.4,0.6>},0.7) \}\},$$

$$\{ (e_1, x_2, 1) = \{ (\frac{u_1}{<0.3,0.2,0.7>},0.3), (\frac{u_2}{<0.4,0.3,0.3>},0.4), (\frac{u_3}{<0.1,0.6,0.2>},0.6) \}\},$$

$$\{ (e_2, x_2, 1) = \{ (\frac{u_1}{<0.2,0.2,0.6>},0.5), (\frac{u_2}{<0.7,0.3,0.2>},0.8), (\frac{u_3}{<0.3,0.1,0.5>},0.1) \}\},$$

$\{ (e_1, x_1, 0) = \{ (\frac{u_1}{<0.2, 0.4, 0.5>}, 0.2), (\frac{u_2}{<0.1, 0.9, 0.1>}, 0.7), (\frac{u_3}{<0.1, 0.2, 0.5>}, 0.1) \}\}$,

$\{ (e_2, x_1, 0) = \{ (\frac{u_1}{<0.3, 0.4, 0.6>}, 0.4), (\frac{u_2}{<0.2, 0.7, 0.6>}, 0.6), (\frac{u_3}{<0.1, 0.5, 0.2>}, 0.1) \}\}$,

$\{ (e_1, x_2, 0) = \{ (\frac{u_1}{<0.2, 0.8, 0.4>}, 0.2), (\frac{u_2}{<0.1, 0.6, 0.5>}, 0.5), (\frac{u_3}{<0.7, 0.6, 0.3>}, 0.8) \}\}$,

$\{ (e_2, x_2, 0) = \{ (\frac{u_1}{<0.4, 0.4, 0.7>}, 0.2), (\frac{u_2}{<0.3, 0.8, 0.2>}, 0.6), (\frac{u_3}{<0.6, 0.2, 0.4>}, 0.5) \}\}$.

Then (F_p, Z) is a possibility single valued neutrosophic soft expert set over the soft universe (U, Z).

Definition 3.3. Let (F_p,A) and (G_q,B) be a PSVNSESs over a soft universe (U,Z). Then (F_p,A) is said to be a possibility single valued neutrosophic soft expert subset of (G_q,B) if A ⊆ B and for all $\varepsilon \in$ A, the following conditions are satisfied:

(i) $p(\varepsilon)$ is fuzzy subset of $q(\varepsilon)$
(ii) $F(\varepsilon)$ is a single valued neutrosophic subset of $G(\varepsilon)$.

This relationship is denoted as (F_p,A) ⊆ (G_q,B). In this case, (G_q,B) is called a possibility single valued neutrosophic soft expert superset (PSVNSE superset) of (F_p,A).

Definition 3.4. Let (F_p,A) and (G_q,B) be a PSVNSESs over a soft universe (U,Z). Then (F_p,A) and (G_q,B) are said to be equal if for all $\varepsilon \in$ E, the following conditions are satisfied:

(i) $p(\varepsilon)$ is equal $q(\varepsilon)$
(ii) $F(\varepsilon)$ is equal $G(\varepsilon)$

In other words, (F_p,A) = (G_q,B) if (F_p,A) is a PSVNSE subset of (G_q,B) and (G_q,B) is a PSVNSE subset of (F_p, A).

Definition 3.5. A PSVNSES (F_p,A) is said to be a null possibility single valued neutrosophic soft expert set denoted ($\widetilde{\emptyset}_p$, A) and defined as :

$$(\widetilde{\emptyset}_p, \text{A}) = (\text{F}(\alpha), \text{p}(\alpha)), \text{ where } \alpha \in \text{Z}.$$

Where F(α)= <0, 0, 1>, that is $\mu_{F(\alpha)}$=0, $\nu_{F(\alpha)}$= 0 and $\omega_{F(\alpha)}$= 1 and p(α)= 0 for all $\alpha \in$ Z

Definition 3.6. A PSVNSES (F_p,A) is said to be an absolute possibility single valued neutrosophic soft expert set denoted (F_p, A) $_{\text{abs}}$ and defined as :

$$(F_p, \text{A})_{\text{abs}} = (\text{F}(\alpha), \text{p}(\alpha)), \text{ where } \alpha \in \text{Z}.$$

Where F(α)= <1, 0, 0>, that is $\mu_{F(\alpha)}$= 1, $\nu_{F(\alpha)}$= 0 and $\omega_{F(\alpha)}$= 0 and p(α)= 1 for all $\alpha \in$ Z

Definition 3.7. Let (F_p,A) be a PSVNSES over a soft universe (U,Z). An agree-possibility single valued neutrosophic soft expert set (agree- PSVNSES) over U, denoted as $(F_p, \text{A})_1$ is a possibility single valued neutrosophic soft expert subset of (F_p,A) which is defined as :

$$(F_p, \text{A})_1 = (\text{F}(\alpha), \text{p}(\alpha)), \text{ where } \alpha \in \text{E} \times \text{X} \times \{1\}$$

Definition 3.8. Let (F_p,A) be a PSVNSES over a soft universe (U,Z). A disagree-possibility single valued neutrosophic soft expert set (disagree- PSVNSES) over U, denoted as $(F_p, \text{A})_0$ is a possibility single valued neutrosophic soft expert subset of (F_p,A) which is defined as :

$$(F_p, \text{A})_0 = (\text{F}(\alpha), \text{p}(\alpha)), \text{ where } \alpha \in \text{E} \times \text{X} \times \{0\}$$

4. Basic Operations on Possibility Single Valued Neutrosophic Soft Expert Sets.

In this section, we introduce some basic operations on PSVNSES, namely the complement, AND, OR, union and intersection of PSVNSES, derive their properties, and give some examples.

Definition 4.1 Let (F_p, A) be a PSVNSES over a soft universe (U, Z). Then the complement of (F_p, A) denoted by $(F_p, A)^c$ is defined as:

$$(F_p, A)^c = (\tilde{c}(\text{F}(\alpha)), \text{c}(\text{p}(\alpha))), \text{ for all } \alpha \in \text{U}.$$

where $\tilde{c}$ is single valued neutrosophic complement and c is a fuzzy complement.

Example 4.2 Consider the PSVNSES (F_p, Z) over a soft universe (U, Z) as given in Example 3.2. By using the basic fuzzy complement for p(α) and the single valued neutrosophic complement for F(α), we obtain $(F_p, Z)^c$ which is defined as:

$(F_p, Z)^c =$

$$\{ (e_1, x_1, 1)=\{ (\frac{u_1}{<0.3,0.8,0.1>},0.7), (\frac{u_2}{<0.4,0.6,0.1>},0.6), (\frac{u_3}{<0.2,0.7,0.4>},0.5) \}\},$$

$$\{ (e_2, x_1, 1) = \{ (\frac{u_1}{<0.25,0.5,0.7>},0.4), (\frac{u_2}{<0.4,0.6,0.25>},0.2), (\frac{u_3}{<0.6,0.4,0.4>},0.3) \}\},$$

$$\{ (e_1, x_2, 1) = \{ (\frac{u_1}{<0.7,0.2,0.3>},0.7), (\frac{u_2}{<0.3,0.3,0.4>},0.6), (\frac{u_3}{<0.2,0.6,0.1>},0.4) \}\},$$

$\{ (e_2, x_2, 1) = \{ (\frac{u_1}{<0.6,0.2,0.2>}, 0.5), (\frac{u_2}{<0.2,0.3,0.7>}, 0.2), (\frac{u_3}{<0.5,0.1,0.3>}, 0.9) \}\},$

$\{ (e_1, x_1, 0) = \{ (\frac{u_1}{<0.5,0.4,0.2>}, 0.8), (\frac{u_2}{<0.1,0.9,0.1>}, 0.3), (\frac{u_3}{<0.5,0.2,0.1>}, 0.9) \}\},$

$\{ (e_2, x_1, 0) = \{ (\frac{u_1}{<0.6,0.4,0.3>}, 0.6), (\frac{u_2}{<0.6,0.7,0.2>}, 0.4), (\frac{u_3}{<0.2,0.5,0.1>}, 0.9) \}\},$

$\{ (e_1, x_2, 0) = \{ (\frac{u_1}{<0.4,0.8,0.2>}, 0.8), (\frac{u_2}{<0.5,0.6,0.1>}, 0.5), (\frac{u_3}{<0.3,0.6,0.7>}, 0.2) \}\},$

$\{ (e_2, x_2, 0) = \{ (\frac{u_1}{<0.7,0.4,0.4>}, 0.8), (\frac{u_2}{<0.2,0.8,0.3>}, 0.4), (\frac{u_3}{<0.4,0.2,0.6>}, 0.5) \}\}.$

Proposition 4.3 If (F_p, A) is a PSVNSES over a soft universe (U,Z), Then,

$$((F_p, A)^c)^c = (F_p, A).$$

Proof. Suppose that is (F_p, A) is a PSVNSES over a soft universe (U, Z) defined as (F_p, A) = (F(e), p(e)). Now let PSVNSES $(F_p, A)^c = (G_q, B)$. Then by Definition 4.1, (G_q, B) = (G(e), q(e)) such that G(e) $= \tilde{c}$ (F(e)), and q(e) =c(p(e)).Thus it follows that:

$(G_q, B)^c = (\tilde{c}\,(G(e)), c(q(e))) = (\tilde{c}\,(\tilde{c}\,(F(e))), c(c(q(e)))) = (F(e), p(e)) = (F_p, A).$

Therefore

$((F_p, A)^c)^c = (G_q, B)^c = (F_p, A)$.Hence it is proven that $((F_p, A)^c)^c = (F_p, A)$.

Definition 4.4 Let (F_p, A) and (G_q, B) be any two PSVNSESs over a soft universe (U, Z). Then the union of (F_p, A) and (G_q, B), denoted by $(F_p, A) \tilde{\cup} (G_q, B)$ is a PSVNSES defined as $(F_p, A) \tilde{\cup} (G_q, B) = (H_r, C)$, where $C = A \cup B$ and

$$r(\alpha) = \max(p(\alpha), q(\alpha)), \text{ for all } \alpha \in C.$$

and

$$H(\alpha) = F(\alpha) \tilde{\cup} G(\alpha), \text{ for all } \alpha \in C$$

where

$$H(\alpha) = \begin{cases} F(\alpha) & \alpha \in A - B \\ G(\alpha) & \alpha \in A - B \\ s_N(F(\alpha), G(\alpha)) & \alpha \in A \cap B \end{cases}$$

where s_N is a neutrosophic co- norm.

Proposition 4.5 Let (F_p, A), (G_q, B) and (H_r, C) be any three PSVNSES over a soft universe (U, Z).Then the following properties hold true.

(i) $(F_p, \text{A}) \tilde{\cup} (G_q, \text{B}) = (G_q, \text{B}) \tilde{\cup} (F_p, \text{A})$
(ii) $(F_p, \text{A}) \tilde{\cup} ((G_q, \text{A}) \tilde{\cup} (H_r, \text{C})) = ((F_p, \text{A}) \tilde{\cup} (G_q, \text{B})) \tilde{\cup} (H_r, \text{C})$
(iii) $(F_p, \text{A}) \tilde{\cup} (F_p, \text{A}) \subseteq (F_p, \text{A})$
(iv) $(F_p, \text{A}) \tilde{\cup} (\Phi_p, A) = (\Phi_p, A)$

Proof

(i) Let $(F_p, \text{A}) \tilde{\cup} (G_q, \text{B}) = (H_r, \text{C})$. Then by definition 4.4, for all $\alpha \in \text{C}$, we have $(H_r, \text{C}) = (\text{H}(\alpha), \text{r}(\alpha))$

Where

$\text{H}(\alpha) = \text{F}(\alpha) \tilde{\cup} \text{G}(\alpha)$ and $\text{r}(\alpha) = \max(\text{p}(\alpha), \text{q}(\alpha))$. However $\text{H}(\alpha) = \text{F}(\alpha) \tilde{\cup} \text{G}(\alpha) = \text{G}(\alpha) \tilde{\cup} \text{F}(\alpha)$ since the union of these sets are commutative by definition 4.4. Also, $\text{r}(\alpha) = \max(\text{p}(\alpha), \text{q}(\alpha)) = \max(\text{q}(\alpha), \text{p}(\alpha))$. Therfore $(H_r, \text{C}) = (G_q, \text{B}) \tilde{\cup} (F_p, \text{A})$. Thus the union of two PSVNSES are commutative i.e $(F_p, \text{A}) \tilde{\cup} (G_q, \text{B}) = (G_q, \text{B}) \tilde{\cup} (F_p, \text{A})$.

(ii) The proof is similar to proof of part(i) and is therefore omitted

(iii) The proof is straightforward and is therefore omitted.

(iv) The proof is straightforward and is therefore omitted.

Definition 4.6 Let (F_p, A) and (G_q, B) be any two PSVNSES over a soft universe (U, Z). Then the intersection of (F_p, A) and (G_q, B), denoted by $(F_p, \text{A}) \tilde{\cap} (G_q, \text{B})$ is PSVNSES defined as $(F_p, \text{A}) \tilde{\cap} (G_q, \text{B}) = (H_r, \text{C})$ where $\text{C} = \text{A} \cup \text{B}$ and

$$\text{r}(\alpha) = \min(\text{p}(\alpha), \text{q}(\alpha)), \text{ for all } \alpha \in \text{C},$$

and

$$\text{H}(\alpha) = \text{F}(\alpha) \tilde{\cap} \text{G}(\alpha), \text{ for all } \alpha \in \text{C}$$

where

$$\text{H}(\alpha) = \begin{cases} \text{F}(\alpha) & \alpha \in A - B \\ \text{G}(\alpha) & \alpha \in A - B \\ \text{t}_\text{n}(F(\alpha), G(\alpha)) & \alpha \in A \cap B \end{cases}$$

where t_n is neutrosophic t-norm

Proposition 4.7 If (F_p, A), (G_q, B) and (H_r, C) are three PSVNSES over a soft universe (U, Z).Then,

(i) $(F_p, \text{A}) \tilde{\cap} (G_q, \text{B}) = (G_q, \text{B}) \tilde{\cap} (F_p, \text{A})$
(ii) $(F_p, \text{A}) \tilde{\cap} ((G_q, \text{B}) \tilde{\cap} (H_r, \text{C})) = ((F_p, \text{A}) \tilde{\cap} (G_q, \text{B})) \tilde{\cap} (H_r, \text{C})$

(iii) $(F_p, A) \tilde{\cap} (F_p, A) \subseteq (F_p, A)$

(iv) $(F_p, A) \tilde{\cap} (\Phi_p, A) = (\Phi_p, A)$

Proof

(i) The proof is similar to that of Propositio 4.5 (i) and is therefore omitted

(ii) The prof is similar to the prof of part (i) and is therefore omitted

(iii) The proof is straightforward and is therefore omitted.

(iv) The proof is straightforward and is therefore omitted.

Proposition 4.8 If (F_p, A), (G_q, B) and (H_r, C) are three PSVNSES over a soft universe (U, Z). Then,

(i) $(F_p, A) \tilde{\cup} ((G_q, B) \cap (H_r, C)) = ((F_p, A) \tilde{\cup} (G_q, B)) \tilde{\cap} ((F_p, A) \tilde{\vee} (H_r, C))$

(ii) $(F_p, A) \tilde{\cap} ((G_q, B) \tilde{\cup} (H_r, C)) = ((F_p, A) \tilde{\cap} (G_q, B)) \tilde{\cup} ((F_p, A) \tilde{\cap} (H_r, C))$

Proof. The proof is straightforward by definitions 4.4 and 4.6 and is therefore omitted.

Proposition 4.9 If (F_p, A), (G_q, B) are two PSVNSES over a soft universe (U, Z). Then,

(i) $((F_p, A) \tilde{\cup} (G_q, B))^c = (F_p, A)^c \tilde{\cap} (G_q, B)^c$.

(ii) $((F_p, A) \tilde{\cap} (G_q, B))^c = (F_p, A)^c \tilde{\cup} (G_q, B)^c$.

Proof.

(i) Suppose that (F_p, A) and(G_q, B) be PSVNSES over a soft universe (U, Z) defined as:

$(F_p, A) = (F(\alpha), p(\alpha))$, for all $\alpha \in A \subseteq Z$ and $(G_q, B) = (G(\alpha), q(\alpha))$, for all $\alpha \in B \subseteq Z$. Now , due to the commutative and associative properties of PSVNSES, it follows that: by Definition 4.10 and 4.11, it follows that:

$$
\begin{aligned}
(F_p, A)^c \tilde{\cap} (G_q, B)^c &= (F(\alpha), p(\alpha))^c \tilde{\cap} (G(\alpha), q(\alpha))^c \\
&= (\tilde{c}\,(F(\alpha)), c(p(\alpha))) \tilde{\cap} (\tilde{c}\,(G(\alpha)), c(q(\alpha))) \\
&= (\tilde{c}\,(F(\alpha)) \tilde{\cap} \tilde{c}\,(G(\alpha))), \min(c(p(\alpha)), c(q(\alpha)))) \\
&= (\tilde{c}\,(F(\alpha) \tilde{\cap} G(\alpha)), c(\max(p(\alpha), q(\alpha))) \\
&= ((F_p, A) \tilde{\cup} (G_q, B))^c .
\end{aligned}
$$

(ii) The proof is similar to the proof of part (i) and is therefore omitted

Definition 4.10 Let (F_p, A) and (G_q, B) be any two PSVNSES over a soft universe (U, Z). Then " (F_p, A) AND (G_q, B) " denoted $(F_p, A) \tilde{\wedge} (G_q, B)$ is a defined by:

$$(F_p, A) \tilde{\wedge} (G_q, B) = (H_r, A \times B)$$

Where $(H_r, A \times B) = (H(\alpha, \beta), r(\alpha, \beta))$, such that $H(\alpha, \beta) = F(\alpha) \cap G(\beta)$ and $r(\alpha, \beta) = \min$ $(p(\alpha),$

q(β)) for all $(\alpha, \beta) \in$ A × B. and ∩ represent the basic intersection.

Definition 4.11 Let (F_p, A) and (G_q, B) be any two PSVNSES over a soft universe (U, Z). Then " (F_p, A) OR (G_q, B) " denoted $(F_p, \text{A})\ \tilde{\vee}\ (G_q, \text{B})$ is a defined by:

$$(F_p, \text{A})\ \tilde{\vee}\ (G_q, \text{B}) = (H_r, \text{A} \times \text{B})$$

Where $(H_r, \text{A} \times \text{B})$ = (H(α, β), r(α, β)), such that H(α, β) = F(α) ∪ G(β) and r(α, β) = max (p(α),

q(β)) for all $(\alpha, \beta) \in$ A × B. and ∪ represent the basic union.

Proposition 4.12 If (F_p, A), (G_q, B) and (H_r, C) are three PSVNSES over a soft universe (U, Z).Then,

i. $(F_p, \text{A})\ \tilde{\wedge}\ ((G_q, \text{B})\ \tilde{\wedge}\ (H_r, \text{C})) = ((F_p, \text{A})\ \tilde{\wedge}\ (G_q, \text{B}))\ \tilde{\wedge}\ (H_r, \text{C})$
ii. $(F_p, \text{A})\ \tilde{\vee}\ ((G_q, \text{B})\ \tilde{\vee}\ (H_r, \text{C})) = ((F_p, \text{A})\ \tilde{\vee}\ (G_q, \text{B}))\ \tilde{\vee}\ (H_r, \text{C})$
iii. $(F_p, \text{A})\ \tilde{\vee}\ ((G_q, \text{B})\ \tilde{\wedge}\ (H_r, \text{C})) = ((F_p, \text{A})\ \tilde{\vee}\ (G_q, \text{B}))\ \tilde{\wedge}\ ((F_p, \text{A})\ \tilde{\vee}\ (H_r, \text{C}))$
iv. $(F_p, \text{A})\ \tilde{\wedge}\ ((G_q, \text{B})\ \tilde{\vee}\ (H_r, \text{C})) = ((F_p, \text{A})\ \tilde{\wedge}\ (G_q, \text{B}))\ \tilde{\vee}\ ((F_p, \text{A})\ \tilde{\wedge}\ (H_r, \text{C}))$

Proof. The proofs are straightforward by Definitions 4.10 and 4.11 and is therefore omitted.

<u>Note:</u> the " AND" and "OR" operations are not commutative since generally A × B ≠ B ×A.

Proposition 4.13 If (F_p, A) and (G_q, B) are two PSVNSES over a soft universe (U, Z). Then,

i. $((F_p, \text{A})\ \tilde{\wedge}\ (G_q, \text{B}))^c = (F_p, \text{A})^{\text{c}}\ \tilde{\vee}\ (G_q, \text{B})^{\text{c}}$.
ii. $((F_p, \text{A})\ \tilde{\vee}\ (G_q, \text{B}))^c = (F_p, \text{A})^{\text{c}}\ \tilde{\wedge}\ (G_q, \text{B})^{\text{c}}$.

Proof.

(i) Suppose that (F_p, A) and (G_q, B) be PSVNSES over a soft universe (U, Z) defined as:

(F_p, A) = (F(α), p(α)), for all $\alpha \in \text{A} \subseteq$ Z and (G_q, B) = (G(β), q(β)), for all $\beta \in \text{B} \subseteq$ Z. Then by Definition 4.10 and 4.11, it follows that:

$$\begin{aligned}
((F_p, \text{A})\ \tilde{\wedge}\ (G_q, \text{B}))^c &= ((F(\alpha), p(\alpha))\ \tilde{\wedge}\ (G(\beta), q(\beta)))^c \\
&= (F(\alpha)\ \cap\ G(\beta), \min(p(\alpha), q(\beta)))^c \\
&= (\ \tilde{c}\ (\text{F}(\alpha) \cap \text{G}(\beta)), \text{c}(\min(\text{p}(\alpha), \text{q}(\beta))) \\
&= (\ \tilde{c}\ (\text{F}(\alpha)) \cup \tilde{c}\ (\text{G}(\beta))), \max(\text{c}(\text{p}(\alpha)), \text{c}(\text{q}(\beta)))) \\
&= (F(\alpha), p(\alpha))^c\ \tilde{\vee}\ (G(\beta), q(\beta))^c \\
&= (F_p, \text{A})^{\text{c}}\ \tilde{\vee}\ (G_q, \text{B})^{\text{c}}.
\end{aligned}$$

(ii) the proof is similar to that of part (i) and is therefore omitted.

5. Application of Possibility Neutrosophic Soft Expert Sets in a Decision Making Problem.

In this section, we introduce a generalized algorithm which will be applied to the PNSES model introduced in Section 3 and used to solve a hypothetical decision making problem. The following example is adapted from [17] with minor changes.

Suppose that company Y is looking to hire a person to fill in the vacancy for a position in their company. Out of all the people who applied for the position, three candidates were shortlisted and these three candidates form the universe of elements, U= $\{u_1, u_2, u_3\}$ The hiring committee consists of the hiring manager, head of department and the HR director of the company and this committee is represented by the set {p, q, r }(a set of experts) while the set Q= {1=agree, 0=disagree } represents the set of opinions of the hiring committee members. The hiring committee considers a set of parameters, E={ e_1, e_2, e_3, e_4 } where the parameters e_i represent the characteristics or qualities that the candidates are assessed on, namely "relevant job experience", "excellent academic qualifications in the relevant field", "attitude and level of professionalism" and "technical knowledge" respectively. After interviewing all the three candidates and going through their certificates and other supporting documents, the hiring committee constructs the following PSVNSES.

(F_p, Z) =

$$\{(e_1, p, 1) = \{(\frac{u_1}{<0.2,0.8,0.4>},0.2),(\frac{u_2}{<0.3,0.2,0.4>},0.1),(\frac{u_3}{<0.4,0.7,0.2>},0.4)\}\},$$

$$\{(e_2, p, 1) = \{(\frac{u_1}{<0.3,0.2,0.23>},0.5),(\frac{u_2}{<0.25,0.2,0.3>},0.6),(\frac{u_3}{<0.3,0.5,0.6>},0.2)\}\},$$

$$\{(e_3, p, 1) = \{(\frac{u_1}{<0.3,0.2,0.7>},0.3),(\frac{u_2}{<0.4,0.3,0.3>},0.4),(\frac{u_3}{<0.1,0.6,0.2>},0.6)\}\},$$

$$\{(e_4, p, 1) = \{(\frac{u_1}{<0.2,0.2,0.6>},0.5),(\frac{u_2}{<0.7,0.3,0.2>},0.8),(\frac{u_3}{<0.3,0.1,0.5>},0.1)\}\},$$

$$\{(e_1, q, 1) = \{(\frac{u_1}{<0.4,0.6,0.3>},0.55),(\frac{u_2}{<0.1,0.3,0.7>},0.6),(\frac{u_3}{<0.6,0.3,0.7>},0.9)\}\},$$

$$\{(e_2, q, 1) = \{(\frac{u_1}{<0.3,0.3,0.5>},0.2),(\frac{u_2}{<0.6,0.9,0.1>},0.7),(\frac{u_3}{<0.1,0.2,0.7>},0.1)\}\},$$

$$\{(e_3, q, 1) =\{(\frac{u_1}{<0.1,0.4,0.7>},0.2),(\frac{u_2}{<0.4,0.6,0.2>},0.8),(\frac{u_3}{<0.6,0.2,0.4>},0.5)\}\}.$$

$$\{(e_4, q, 1) =\{(\frac{u_1}{<0.6,0.5,0.3>},0.1),(\frac{u_2}{<0.7,0.8,0.2>},0.6),(\frac{u_3}{<0.3,0.4,0.6>},0.7)\}\}.$$

$$\{ (e_1, r, 1) = \{ (\frac{u_1}{<0.4,0.5,0.7>},0.2), (\frac{u_2}{<0.3,0.8,0.4>},0.6), (\frac{u_3}{<0.6,0.2,0.4>},0.5) \}\}.$$

$$\{ (e_2, r, 1) = \{ (\frac{u_1}{<0.3,0.7,0.1>},0.8, (\frac{u_2}{<0.7,0.3,0.2>},0.4), (\frac{u_3}{<0.8,0.2,0.2>},0.6) \}\}.$$

$$\{ (e_3, r, 1) = \{ (\frac{u_1}{<0.6,0.5,0.2>},0.2), (\frac{u_2}{<0.5,0.1,0.6>},0.9), (\frac{u_3}{<0.3,0.2,0.1>},0.1) \}\}.$$

$$\{ (e_1, p, 0) = \{ (\frac{u_1}{<0.1,0.4,0.3>},0.2), (\frac{u_2}{<0.3,0.8,0.2>},0.6), (\frac{u_3}{<0.6,0.2,0.4>},0.5) \}\}.$$

$$\{ (e_3, p, 0) = \{ (\frac{u_1}{<0.6,0.3,0.2>},0.4), (\frac{u_2}{<0.2,0.7,0.4>},0.9), (\frac{u_3}{<0.3,0.1,0.6>},0.7) \}\}.$$

$$\{ (e_4, p, 0) = \{ (\frac{u_1}{<0.3,0.2,0.5>},0.6), (\frac{u_2}{<0.6,0.4,0.5>},0.2), (\frac{u_3}{<0.5,0.4,0.3>},0.3) \}\}.$$

$$\{ (e_1, q, 0) = \{ (\frac{u_1}{<0.2,0.4,0.7>},0.3), (\frac{u_2}{<0.1,0.9,0.2>},0.7), (\frac{u_3}{<0.1,0.2,0.5>},0.1) \}\},$$

$$\{ (e_2, q, 0) = \{ (\frac{u_1}{<0.3,0.4,0.6>},0.4), (\frac{u_2}{<0.2,0.7,0.6>},0.3), (\frac{u_3}{<0.4,0.5,0.3>},0.4) \}\},$$

$$\{ (e_3, q, 0) = \{ (\frac{u_1}{<0.2,0.8,0.4>},0.2), (\frac{u_2}{<0.1,0.2,0.5>},0.6), (\frac{u_3}{<0.7,0.6,0.3>},0.8) \}\},$$

$$\{ (e_4, q, 0) = \{ (\frac{u_1}{<0.9,0.4,0.7>},0.68), (\frac{u_2}{<0.5,0.6,0.2>},0.5), (\frac{u_3}{<0.6,0.3,0.4>},0.55) \}\}.$$

$$\{ (e_1, r, 0) = \{ (\frac{u_1}{<0.3,0.4,0.5>},0.5), (\frac{u_2}{<0.3,0.6,0.2>},0.1), (\frac{u_3}{<0.25,0.2,0.4>},0.9) \}\}.$$

$$\{ (e_2, r, 0) = \{ (\frac{u_1}{<0.4,0.6,0.7>},0.3), (\frac{u_2}{<0.6,0.4,0.2>},1), (\frac{u_3}{<0.6,0.4,0.3>},0.25) \}\}.$$

$$\{ (e_3, r, 0) = \{ (\frac{u_1}{<0.4,0.3,0.2>},0.9), (\frac{u_2}{<0.3,0.5,0.7>},0.8), (\frac{u_3}{<0.7,0.5,0.6>},0.5) \}\}.$$

Next the PSVNSES (F_p, Z) is used together with a generalized algorithm to solve the decision making problem stated at the beginning of this section. The algorithm given below is employed by the hiring committee to determine the best or most suitable candidate to be hired for the position. This algorithm is a generalization of the algorithm introduced by Alkhazaleh and Salleh (see [3]) which is used in the context of the PSVNSES model that is introduced in this paper. The generalized algorithm is as follows:

Algorithm

1. Input the PSVNSES (F_p , Z)

2. Find the values of $\mu_{F_p(z_i)}(u_i) - \nu_{F_p(z_i)}(u_i) - \omega_{F_p(z_i)}(u_i)$ for each element $u_i \in U$ where $\mu_{F_p(z_i)}(u_i)$, $\nu_{F_p(z_i)}(u_i)$ and $\omega_{F_p(z_i)}(u_i)$ are the membership function, indeterminacy function and non-membership function of each of the elements $u_i \in U$ respectively.

3. Find the highest numerical grade for the agree-PSVNSES and disagree-PSVNSES.

4. Compute the score of each element $u_i \in U$ by taking the sum of the products of the numerical grade of each element with the corresponding degree of possibility μ_i for the agree-PNSES and disagree PSVNSES, denoted by A_i and D_i respectively.

5. Find the values of the score $r_i = A_i - D_i$ for each element $u_i \in U$.

6. Determine the value of the highest score, s= $\max_{u_i} \{ r_i \}$. Then the decision is to choose element as the optimal or best solution to the problem. If there are more than one element with the highest r_i score, then any one of those elements can be chosen as the optimal solution.

Then we can conclude that the optimal choice for the hiring committee is to hire candidate u_i to fill the vacant position

Table I gives the values of $\mu_{F_p(z_i)}(u_i) - \nu_{F_p(z_i)}(u_i) - \omega_{F_p(z_i)}(u_i)$ for each element $u_i \in U$ The notation a ,b gives the values of $\mu_{F_p(z_i)}(u_i) - \nu_{F_p(z_i)}(u_i) - \omega_{F_p(z_i)}(u_i)$ and the degree of possibility of the element $\mu_i \in U$ respectively.

Table I. Values of $\mu_{F_p(z_i)}(u_i) - \nu_{F_p(z_i)}(u_i) - \omega_{F_p(z_i)}(u_i)$ for all $u_i \in U$

	u_1	u_2	u_3		u_1	u_2	u_3
$(e_1, p, 1)$	-1, 0.2	-0.3, 0.1	-0.5, 0.4	$(e_3, p, 0)$	0.1, 0.4	-0.9, 0.9	-0.4, 0.7
$(e_2, p, 1)$	-0.13, 0.5	-0.25, 0.6	-0.8, 0.2	$(e_4, p, 0)$	-0.4, 0.6	-0.3, 0.2	-0.2, 0.3
$(e_3, p, 1)$	-0.6, 0.3	-0.2, 0.4	-0.7, 0.6	$(e_1, q, 0)$	-0.9, 0.3	-1, 0.7	-0.6, 0.1
$(e_4, p, 1)$	-0.6, 0.5	0.2, 0.8	-0.3, 0.1	$(e_2, q, 0)$	-0.7, 0.4	-1.1, 0.3	-0.4, 0.4
$(e_1, q, 1)$	-0.5, 0.55	-0.9, 0.6	-0.4, 0.9	$(e_3, q, 0)$	-1, 0.2	-0.6, 0.6	-0.2, 0.8
$(e_2, q, 1)$	-0.5, 0.2	-0.4, 0.7	-0.5, 0.1	$(e_4, q, 0)$	-0.2, 0.68	-0.3,0.5	-0.1, 0.55
$(e_3, q, 1)$	-1, 0.2	-0.4, 0.8	0, 0.5	$(e_1, r, 0)$	-0.6, 0.5	-0.5, 0.1	0.35, 0.9
$(e_4,q, 1)$	-0.2, 0.1	-0.3, 0.6	-0.5,0.7	$(e_2, r, 0)$	-0.9, 0.3	0, 1	-0.1, 0.25
$(e_1, r, 1)$	-0.8, 0.2	-0.9, 0.6	0, 0.5	$(e_4, r, 0)$	-0.1, 0.9	-0.9,0.8	-0.4, 0.5
$(e_2, r, 1)$	-0.5, 0.8	0.2, 0.4	0.4, 0.6				
$(e_3, r, 1)$	-0.1, 0.2	-0.2, 0.9	0, 0.1				
$(e_1, p, 0)$	-0.6, 0.2	-0.7, 0.6	0, 0.5				

In Table II and Table III, we gives the highest numerical grade for the elements in the agree-PSVNSES and disagree PSVNSES respectively.

Table II. Numerical Grade for Agree-PSVNSES

	u_i	Highest Numeric Grade	Degree of possibility, μ_i
$(e_1, p, 1)$	u_2	-0.3	0.1
$(e_2, p, 1)$	u_1	-0.13	0.5
$(e_3, p, 1)$	u_2	-0.2	0.4
$(e_4, p, 1)$	u_2	0.2	0.8
$(e_1, q, 1)$	u_3	-0.4	0.9
$(e_2, q, 1)$	u_2	-0.4	0.7
$(e_3, q, 1)$	u_3	0	0.5
$(e_4,q, 1)$	u_1	-0. 2	0.1
$(e_1, r, 1)$	u_3	0	0.5
$(e_2, r, 1)$	u_3	0.4	0.6
$(e_3, r, 1)$	u_3	0	0.1

Score (u_1) = (-0.13 × 0.15) +(-0.2 × 0.1)
= - 0.0395

Score (u_2) = (-0.3 × 0.1) +(-0.2 × 0.4) +(-0.2 × 0.8) +(-0.4 × 0.7)
= - 0.55

Score (u_3) = (-0.4 × 0.9) +(0 × 0.5) +(0 × 0.5) +(0.4 × 0.6) +(0 × 0.1)
= - 0.12

Table III. Numerical Grade for Disagree-PSVNSES

	u_i	Highest Numeric Grade	Degree opossibility, μ_i
$(e_1, p, 0)$	u_3	0	0.5
$(e_3, p, 0)$	u_1	0.1	0.4
$(e_4, p, 0)$	u_3	-0.2	0.3
$(e_1, q, 0)$	u_3	-0.6	0.1
$(e_2, q, 0)$	u_3	-0.4	0.4
$(e_3, q, 0)$	u_3	-0.2	0.8
$(e_4, q, 0)$	u_3	-0.1	0.55
$(e_1, r, 0)$	u_3	-0.35	0.9
$(e_2, r, 0)$	u_2	0	1
$(e_4, r, 0)$	u_1	-0.1	0.9

Score (u_1) = (0.1 × 0.4) +(-0.1 × 0.9)
= - 0.05

Score (u_2) = (0 × 1)
= 0

Score (u_3) = (0 × 0.5) + (-0.2 × 0.3) +(-0.6 × 0.1) +(-0.4 × 0.4) +(-0.2 × 0.8) +(-0.1 × 0.55) +(-0.35 × 0.9) = - 0.81

Let A_i and D_i represent the score of each numerical grade for the agree-PSVNSES and disagree-PSVNSES respectively. These values are given in Table IV.

Table IV The score r_i = A_i - D_i

A_i	D_i	r_i
Score (u_1) = - 0.0395	Score (u_1) = -0.05	**0.0105**
Score (u_2) = -0.55	Score (u_2) = 0	**-0.55**
Score (u_3) = -0.12	Score (u_3) = -0.81	**0.69**

Then s= $\max_{u_i} \{ r_i \} = r_3$, the hiring committee should hire candidate u_3 to fill in the vacant position

6. Conclusion

In this paper we have introduced the concept of possibility single valued neutrosophic soft expert soft set and studied some of its properties. The complement, union, intersection, And or OR operations have been defined on the possibility single valued neutrosophic soft expert set. Finally, an application of this concept is given in solving a decision making problem. This new extension will provide a significant addition to existing theories for handling indeterminacy, and lead to potential areas of further research and pertinent applications.

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