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MAPPINGS ON NEUTROSOPHIC SOFT EXPERT SETS

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Abstract - In this paper we introduced mapping on neutrosophic soft expert sets through which we can study the images and inverse images of neutrosophic soft expert sets. Further, we investigated the basic operations and other related properties of mapping on neutrosophic soft expert sets in this paper.

***Keywords* -** Neutrosophic soft expert set, neutrosophic soft expert images, neutrosophic soft expert inverse images, mapping on neutrosophic soft expert set.

1. Introduction

Neutrosophy has been introduced by Smarandache [14, 15, 16] as a new branch of philosophy. Smarandache using this philosophy of neutrosophy to initiate neutrosophic sets and logics which is the generalization of fuzzy logic, intuitionistic fuzzy logic, paraconsistent logic etc. Fuzzy sets [42] and intuitionistic fuzzy sets [36] are characterized by membership functions, membership and non-membership functions, respectively. In some real life problems for proper description of an object in uncertain and ambiguous environment, we need to handle the indeterminate and incomplete information. Fuzzy sets and intuitionistic fuzzy sets are not able to handle the indeterminate and inconsistent information. Thus neutrosophic set (NS in short) is defined by Smarandache [15], as a new mathematical tool for dealing with problems involving incomplete, indeterminacy, inconsistent knowledge. 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 defined. Otherwise, it will be difficult to apply in the

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real applications. Therefore, H. Wang et al [19] defined a single valued neutrosophic set (SVNS) and then provided the set theoretic operations and various properties of single valued neutrosophic sets. Recent research works on neutrosophic set theory and its applications in various fields are progressing rapidly. A lot of literature can be found in this regard in [3, 6, 7, 8, 9, 10, 11, 12, 13, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 61, 62,70, 73, 76, 80, 83,84, 85, 86].

In other hand, Molodtsov [12] initiated the theory of soft set 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 a collection of approximate descriptions of an object. Later Maji et al.[58] defined several operations on soft set. Many authors [37, 41, 44, 47, 49, 50, 51, 52, 53, 54, 55, 56, 57, 60] have combined soft sets with other sets to generate hybrid structures like fuzzy soft sets, generalized fuzzy soft sets, rough soft sets, intuitionistic fuzzy soft sets, possibility fuzzy soft sets, generalized intuitionistic fuzzy softs, possibility vague soft sets and so on. All these research aim to solve most of our real life problems in medical sciences, engineering, management, environment and social sciences which involve data that are not crisp and precise. But most of these models deal with only one opinion (or) with only one expert. This causes a problem with the user when questionnaires are used for the data collection. Alkhazaleh and Salleh in 2011 [65] defined the concept of soft expert set and created a model in which the user can know the opinion of the experts in the model without any operations and give an application of this concept in decision making problem. Also, they introduced the concept of the fuzzy soft expert set [64] as a combination between the soft expert set and the fuzzy set. Based on [15], Maji [53] introduced the concept of neutrosophic soft set a more generalized concept, which is a combination of neutrosophic set and soft set and studied its properties. Various kinds of extended neutrosophic soft sets such as intuitionistic neutrosophic soft set [68, 70, 79], generalized neutrosophic soft set [61, 62], 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 studied. The combination of neutrosophic soft sets and rough sets [77, 81, 82] is another interesting topic.

Recently, Broumi and Smaranadache [88] introduced, a more generalized concept, the concept of the intuitionistic fuzzy soft expert set as a combination between the soft expert set and the intuitionistic fuzzy set. The same authors defined the concept of single valued neutrosophic soft expert set [87] and gave the application in decision making problem. The concept of single valued neutrosophic soft expert set deals with indeterminate and inconsistent data. Also, Sahin et al. [91] presented the concept of neutrosophic soft expert sets. The soft expert models are richer than soft set models since the soft set models are created with the help of one expert where as the soft expert models are made with the opinions of all experts. Later on, many researchers have worked with the concept of soft expert sets and their hybrid structures [1, 2, 17, 18, 24, 38, 39, 46, 48, 87, 91, 92].

The notion of mapping on soft classes are introduced by Kharal and Ahmad [4]. The same authors presented the concept of a mapping on classes of fuzzy soft sets [5] and studied the properties of fuzzy soft images and fuzzy soft inverse images of fuzzy soft sets, and supported them with examples and counter inconsistency in examples. In neutrosophic environment, Alkazaleh et al [67] studied the notion of mapping on neutrosophic soft classes.

Until now, there is no study on mapping on the classes of neutrosophic soft expert sets, so there is a need to develop a new mathematical tool called "Mapping on neutrosophic soft expert set".

In this paper, we introduce the notion of mapping on neutrosophic soft expert classes and study the properties of neutrosophic soft expert images and neutrosophic soft expert inverse images of neutrosophic soft expert sets. Finally, we give some illustrative examples of mapping on neutrosophic soft expert for intuition.

2. Preliminaries

In this section, we will briefly recall the basic concepts of neutrosophic sets, soft sets, neutrosophic soft sets, soft expert sets, fuzzy soft expert sets, intutionistic fuzzy soft expert sets and neutrosophic soft expert sets.

Let U be an initial universe set of objects and E is 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 [15] Let U be an universe of discourse, Then the neutrosophic set A is an object having the form $A = \{< x: T_A(x), I_A(x), F_A(x)>, x \in U\}$,where the functions $T_A(x)$, $I_A(x)$, $F_A(x) : U \to]^-0,1^+[$ define respectively the degree of membership, the degree of indeterminacy, and the degree of non-membership of the element $x \in X$ to the set A with the condition.

$$^-0 \leq sup T_A(x) + \sup I_A(x) + sup F_A(x)) \leq 3^+.$$

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,

$A_{NS} = \{<x, T_A(x), I_A(x), F_A(x)> \mid x \in X\}$

And

$B_{NS} = \{<x, T_B(x), I_B(x), F_B(x)> \mid x \in X\}$

We have,

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

$T_A(x) \leq T_B(x), I_A(x) \geq I_B(x), F_A(x) \geq F_B(x)$.

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

$\mathrm{T_A}(\mathrm{x}) = \mathrm{T_B}(\mathrm{x})$, $\mathrm{I_A}(\mathrm{x}) = \mathrm{I_B}(\mathrm{x})$, $\mathrm{F_A}(\mathrm{x}) = \mathrm{F_B}(\mathrm{x})$ for all $\mathrm{x} \in \mathrm{X}$.

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

$A_{NS}^{o} = \{<\mathrm{x}, \mathrm{F_A}(\mathrm{x}), 1 - \mathrm{T_A}(\mathrm{x}), \mathrm{T_A}(\mathrm{x}) | \mathrm{x} \in \mathrm{X}\}$

4. $\mathrm{A} \cap \mathrm{B} = \{<\mathrm{x}, \min\{\mathrm{T_A}(\mathrm{x}), \mathrm{T}_B(\mathrm{x})\}, \max\{\mathrm{I_A}(\mathrm{x}), \mathrm{I}_B(\mathrm{x})\}, \max\{\mathrm{F_A}(\mathrm{x}), \mathrm{F}_B(\mathrm{x})\}>: \mathrm{x} \in \mathrm{X}\}$

5. $\mathrm{A} \cup \mathrm{B} = \{<\mathrm{x}, \max\{\mathrm{T_A}(\mathrm{x}), \mathrm{T}(\mathrm{x})\}, \min\{\mathrm{I_A}(\mathrm{x}), \mathrm{I}_B(\mathrm{x})\}, \min\{\mathrm{F_A}(\mathrm{x}), \mathrm{F}_B(\mathrm{x})\}>: \mathrm{x} \in \mathrm{X}\}$

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 [12] 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 [59] 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 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 Ugiven 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:

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

Definition 2.7 [59] Let (H, A) and (G, B) be two NSs over the common universe U. Then the union of (H, A) and (G, B), is denoted by " (H, A)$\widetilde{\cup}$(G, B)" and is defined by(H, A) $\widetilde{\cup}$ (G, B)= (K, C), where C= A∪B and the truth-membership, indeterminacy-membership and falsity-membership of (K, C) are as follows:

$$T_{K(e)}(m)=\begin{cases} T_{H(e)}(m) \ if e \in A - B \\ T_{G(e)}(m) \ if e \in B - A \\ \max\left(T_{H(e)}, T_{G(e)}(m)\right) if e \in A \cap B \end{cases}$$

$$I_{K(e)}(m)=\begin{cases} I_{H(e)}(m) \ if e \in A - B \\ I_{G(e)}(m) \ if e \in B - A \\ \frac{\left(I_{H(e)}(m)+I_{G(e)}(m)\right)}{2} \ if e \in A \cap B \end{cases}$$

$$F_{K(e)}(m)=\begin{cases} F_{H(e)}(m) \ if e \in A - B \\ F_{G(e)}(m) \ if e \in B - A \\ \min\left(F_{H(e)}, F_{G(e)}(m)\right) if e \in A \cap B \end{cases}$$

Definition 2.8 [59] Let (H, A) and (G, B) be two NSs over the common universe U. Then the intersectionof (H, A) and (G, B), is denoted by " (H, A)$\widetilde{\cap}$(G, B)" and is defined by(H, A) $\widetilde{\cap}$ (G, B)= (K, C), where C= A ∩ B and the truth-membership, indeterminacy-membership and falsity-membership of (K, C) are as follows:

$$T_{K(e)}(m)=\begin{cases} T_{H(e)}(m)\ if e \in A-B \\ T_{G(e)}(m)\ if e \in B-A \\ \min\left(T_{H(e)}, T_{G(e)}(m)\right)\ if e \in A\cap B \end{cases}$$

$$I_{K(e)}(m)=\begin{cases} I_{H(e)}(m)\ if e \in A-B \\ I_{G(e)}(m)\ if e \in B-A \\ \frac{\left(I_{H(e)}(m)+I_{G(e)}(m)\right)}{2} if e \in A\cap B \end{cases}$$

$$F_{K(e)}(m)=\begin{cases} F_{H(e)}(m)\ if e \in A-B \\ F_{G(e)}(m)\ if e \in B-A \\ \max\left(F_{H(e)}, F_{G(e)}(m)\right)\ if e \in A\cap B \end{cases}$$

2.4. Soft expert sets

Definition 2.9 [65] 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 2.10 [65] An agree-soft expert set $(F,\mathrm{A})_1$ over U, is a soft expert subset of (F,A) defined as :

$(F,\mathrm{A})_1$ = {F(α):α ∈ E × X ×{1}}.

Definition 2.11 [65] A disagree- soft expert set $(F,\mathrm{A})_0$ over U, is a soft expert subset of (F,A) defined as :

$(F,\mathrm{A})_0$= {F(α):α ∈ E × X ×{0}}.

2.5. Fuzzy Soft expert sets

Definition 2.12 [64] 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.

2.6. Intuitionitistic Fuzzy Soft Expert sets

Definition 2.13 [88] 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 ×

$X \times Q$ } and $A \subseteq Z$. Then the pair (U, Z) is called a soft universe. Let $F: Z \rightarrow (I \times I)^U$ where $(I \times I)^U$ denotes the collection of all intuitionistic fuzzy subsets of U. Suppose $F: Z \rightarrow (I \times I)^U$ be a function defined as:

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

Then $F(z)$ is called an intuitionistic fuzzy soft expert set (IFSES 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 belongingnessand non-belongingness of the elements of U in $F(z_i)$. Hence $F(z_i)$ can be written as:

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

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 as (F, Z). If $A \subseteq Z$. we can also have IFSES (F, A).

2.7 Neutrosophic Soft Expert Sets

Definition 2.14 [89] A pair (F, A) is called a neutrosophic soft expert set over U, where F is a mapping given by

$$F : A \rightarrow P(U)$$

where P(U) denotes the power neutrosophic set of U.

3. Mapping on Neutrosophic Soft Expert Set

In this paper, we introduce the mapping on neutrosophic soft expert classes. Neutrosophic soft expert classes are collections of neutrosophic soft expert sets. We also define and study the properties of neutrosophic soft expert images and neutrosophic soft expert inverse images of neutrosophic soft expert sets, and support them with examples and theorems.

Definition 3.1 Let $(\widetilde{U,Z})$ and $(\widetilde{Y,Z'})$ be neutrosophic soft expert classes. Let r: U→Y and s: Z→ Z' be mappings.

Then a mapping $f{:}(\widetilde{U,Z}) \rightarrow (\widetilde{Y,Z'})$ is defined as follows :

For a neutrosophic soft expert set (F, A) in $(\widetilde{U,Z})$, f(F, A) is a neutrosophic soft expert set in $(\widetilde{Y,Z'})$, where

$$f(\mathrm{F, A})(\beta)(\mathrm{y}) = \begin{cases} \vee_{x\in r^{-1}(y)}(\vee_{\alpha} F(\alpha)) if \ \ r^{-1}(y) \ and \ s^{-1}(\beta)\cap A \neq \emptyset, \\ 0 \qquad\qquad\qquad\qquad\qquad\qquad otherwise \end{cases}$$

for $\beta \in$ s(Z) ⊆ Z', y ∈ Y and $\forall\alpha \in s^{-1}(\beta)\cap A$, f(F, A) is called a neutrosophic soft expert image of the neutrosophic soft expert set (F, A).

Definition 3.2 Let $(\widetilde{U,Z})$ and $(\widetilde{Y,Z'})$ be the neutrosophic soft expert classes. Let r: U→Y and s: Z→ Z' be mappings. Then a mapping f^{-1}:$(\widetilde{Y,Z'}) \to (\widetilde{U,Z})$ is defined as follows :
For a neutrosophic soft expert set (G, B) in $(\widetilde{Y,Z'})$, $f^{-1}(G,$ B) is a neutrosophic soft expert set in $(\widetilde{U,Z})$,

$$f^{-1}(G,\mathrm{B})\ (\alpha)\ (\mathrm{u}) = \begin{cases} G\big(s(\alpha)\big)\big(r(u)\big) & , if s(\alpha)\in B \\ 0 & otherwise \end{cases}$$

For $\alpha \in s^{-1}(\beta) \subseteq Z$ and u ∈ U. $f^{-1}(G,$ B) is called a neutrosophic soft expert inverse image of the neutrosophic soft expert set (F, A).

Example 3.3. Let U={u_1,u_2 , u_3}, Y={y_1,y_2,y_3} and let A ⊆ Z = {(e_1, p, 1), (e_2, p, 0), (e_3, p,1)}, and $A' \subseteq Z'$={(e_1', p',1), (e_2', p',0), (e_1', q',1)}.

Suppose that $(\widetilde{U,A})$ and $(\widetilde{Y,A'})$ are neutrosophic soft expert classes. Define r : U → Y and s: A → A' as follows :

r(u_1) = y_1, r(u_2) = y_3, r(u_3) = y_2,

s (e_1, p, 1) = (e_2', p',0) , s (e_2, p, 0) = (e_1', p',1), s (e_3, p, 1) = (e_1', q',1),

Let (F, A) and (G, A') be two neutrosophic soft experts over U and Y respectively such that.

(F, A) =

$$\left\{\left((e_1,p,1),\left\{\frac{u_1}{(0.4,0.3,0.6)},\frac{u_2}{(0.3,0.6,0.4)},\frac{u_3}{(0.3,0.5,0.5)}\right\}\right),\right.$$
$$\left((e_3,p,1),\left\{\frac{u_1}{(0.3,0.3,0.2)},\frac{u_2}{(0.5,0.4,0.4)},\frac{u_3}{(0.6,0.4,0.3)}\right\}\right),$$
$$\left.\left((e_2,p,0),\left\{\frac{u_1}{(0.5,0.6,0.3)},\frac{u_2}{(0.5,0.3,0.6)},\frac{u_3}{(0.6,0.4,0.7)}\right\}\right)\right\},$$

(G, A') =

$$\left\{\left((e_1',p',1),\left\{\frac{y_1}{(0.3,0.2,0.1)},\frac{y_2}{(0.5,0.6,0.4)},\frac{y_3}{(0.3,0.5,0.1)}\right\}\right),\right.$$
$$\left((e_1',q',1),\left\{\frac{y_1}{(0.5,0.7,0.4)},\frac{y_2}{(0.5,0.2,0.3)},\frac{y_3}{(0.6,0.5,0.1)},\right\}\right),$$
$$\left.\left((e_2',p',0),\left\{\frac{y_1}{(0.3,0.2,0.4)},\frac{y_2}{(0.1,0.7,0.5)},\frac{y_3}{(0.1,0.4,0.2)},\right\}\right)\right\}$$

Then we define the mapping from $f{:}\widetilde{(U,Z)} \to \widetilde{(Y,Z')}$ as follows :

For a neutrosophic soft expert set (F, A) in (U, Z), (f (F, A), K) is neutrosophic soft expert set in (Y, Z') where

K= s(A)={(e_1', p',1), (e_2', p',0), (e_1', q',1)} and is obtained as follows:

f (F, A) (e_1', p',1) (y_1) = $\vee_{x\in r^{-1}(y_1)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_1\}}\big(\vee_{\alpha\in\{(e_2,\mathrm{p},0),(e_3,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.5, 0.6,0.3) ∪ (0.3, 0.3,0.2)
=(0.5, 0.45, 0.2)

f (F, A) (e_1', p',1) (y_2) = $\vee_{x\in r^{-1}(y_2)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_3\}}\big(\vee_{\alpha\in\{(e_2,\mathrm{p},0),(e_3,\mathrm{p},1)\}} F(\alpha)\big)$
=(0.6, 0.4, 0.7) ∪ (0.6, 0.4, 0.3)
=(0.6, 0.4, 0.3)

f (F, A) (e_1', p',1) (y_3) = $\vee_{x\in r^{-1}(y_3)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_2\}}\big(\vee_{\alpha\in\{(e_2,\mathrm{p},0),(e_3,\mathrm{p},1)\}} F(\alpha)\big)$
=(0.5, 0.3, 0.6) ∪ (0.5, 0.4, 0.4)
=(0.5, 0.35, 0.4)

Then,

f (F, A) (e_1', p',1) = $\left\{\frac{\mathrm{y}_1}{(0.5,0.45,0.2)}, \frac{\mathrm{y}_2}{(0.6,0.4,0.3)}, \frac{\mathrm{y}_3}{(0.5,0.35,0.4)}\right\}$

f (F, A) (e_2', p',0) (y_1) = $\vee_{x\in r^{-1}(y_1)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_1\}}\big(\vee_{\alpha\in\{(e_1,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.4, 0.3, 0.6)

f (F, A) (e_2', p',0) (y_2) = $\vee_{x\in r^{-1}(y_2)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_3\}}\big(\vee_{\alpha\in\{(e_1,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.3, 0.5, 0.5)

f (F, A) (e_2', p',0) (y_3) = $\vee_{x\in r^{-1}(y_3)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_2\}}\big(\vee_{\alpha\in\{(e_1,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.3, 0.6, 0.4)

Next,

f (F, A) ((e_2', p',0)= $\left\{\frac{\mathrm{y}_1}{(0.4,0.3,0.6)}, \frac{\mathrm{y}_2}{(0.3,0.5,0.5)}, \frac{\mathrm{y}_3}{(0.3,0.6,0.4)}\right\}$

f (F, A) (e_1', q',1) (y_1) = $\vee_{x\in r^{-1}(y_1)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_1\}}\big(\vee_{\alpha\in\{(e_3,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.3, 0.3, 0.2)

f (F, A) (e_1', q',1) (y_2) = $\vee_{x\in r^{-1}(y_2)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_3\}}\big(\vee_{\alpha\in\{(e_3,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.6, 0.4, 0.3)

f (F, A) (e_1', q',1) (y_3) = $\vee_{x\in r^{-1}(y_3)}(\vee_\alpha F(\alpha))$ = $\vee_{x\in\{u_2\}}\big(\vee_{\alpha\in\{(e_3,\mathrm{p},1)\}} F(\alpha)\big)$
= (0.5, 0.4, 0.4)

Also.

f (F, A) $((e_1', q', 1) = \left\{\frac{y_1}{(0.3,0.3,0.2)}, \frac{y_2}{(0.6,0.4,0.3)}, \frac{y_3}{(0.5,0.4,0.4)}\right\}$

Hence,

$$(f\ (F,A),K)=\left\{\left((e_1',p',1),\left\{\frac{y_1}{(0.5,0.45,0.2)}, \frac{y_2}{(0.6,0.4,0.3)}, \frac{y_3}{(0.5,0.35,0.4)}\right\}\right),\right.$$
$$\left((e_2',p',0),\left\{\frac{y_1}{(0.4,0.3,0.6)}, \frac{y_2}{(0.3,0.5,0.5)}, \frac{y_3}{(0.3,0.6,0.4)}\right\}\right),$$
$$\left.\left((e_1',q',1),\left\{\frac{y_1}{(0.3,0.3,0.2)}, \frac{y_2}{(0.6,0.4,0.3)}, \frac{y_3}{(0.5,0.4,0.4)}\right\}\right)\right\}$$

Next, for the neutrosophic soft expert set inverse images, we have the following:
For a neutrosophic soft expert set (G, A') in (Y, Z'), (f^{-1} (G, A'), D) is a neutrosophic soft expert set in (U, Z), where

D= $s^{-1}(A')$= {(e_1, p, 1), (e_2, p, 0), (e_3, p,1)}, and is obtained as follows:

f^{-1} (G, B) (e_1, p, 1) $(u_1) = G(\mathrm{s}(e_1,\mathrm{p},1))(r(u_1)) = G((e_2',p',0))(y_1) = (0.3,0.2,0.4)$
f^{-1} (G, B) (e_1, p, 1) $(u_2) = G(\mathrm{s}(e_1,\mathrm{p},1))(r(u_2)) = G((e_2',p',0))(y_3) = (0.1,0.4,0.2)$
f^{-1} (G, B) (e_1, p, 1) $(u_3) = G(\mathrm{s}(e_1,\mathrm{p},1))(r(u_3)) = G((e_2',p',0))(y_2)$=(0.1, 0.7, 0.5)

Then

f^{-1} (G, B) (e_1, p, 1) = $\left\{\frac{u_1}{(0.3,0.2,0.4)}, \frac{u_2}{(0.1,0.4,0.2)}, \frac{u_3}{(0.1,0.7,0.5)}\right\}$
f^{-1} (G, B) (e_2, p, 0) $(u_1) = G(\mathrm{s}(e_2,\mathrm{p},0))(r(u_1)) = G((e_1',p',1))(y_1) = (0.3,0.2,0.1)$
f^{-1}G, B) (e_2, p, 0) $(u_2) = G(\mathrm{s}(e_2,\mathrm{p},0))(r(u_2)) = G((e_1',p',1))(y_3) = (0.3,0.5,0.1)$
f^{-1} (G, B) (e_2, p, 0) $(u_3) = G(\mathrm{s}(e_2,\mathrm{p},0))(r(u_3)) = G((e_1',p',1))(y_2)$=(0.5, 0.6, 0.4)

Then,

f^{-1} (G, B) (e_2, p, 0)= $\left\{\frac{u_1}{(0.3,0.2,0.1)}, \frac{u_2}{(0.3,0.5,0.1)}, \frac{u_3}{(0.5,0.6,0.4)}\right\}$
f^{-1} (G, B) (e_3, p,1) $(u_1) = G(s(e_3,\mathrm{p},1))(r(u_1)) = G((e_1',q',1))(y_1) = (0.5,0.7,0.4)$
f^{-1} (G, B) (e_3, p,1) $(u_2) = G(s(e_3,\mathrm{p},1))(r(u_2)) = G((e_1',q',1))(y_3) = (0.6,0.5,0.1)$
f^{-1} (G, B) (e_3, p,1) $(u_3) = G(\mathrm{s}(e_3,\mathrm{p},1))(r(u_3)) = G((e_1',q',1))(y_2)$=(0.5, 0.2, 0.3)

Then

f^{-1} (G, B) (e_3, p,1)= $\left\{\frac{u_1}{(0.5,0.7,0.4)}, \frac{u_2}{(0.6,0.5,0.1)}, \frac{u_3}{(0.5,0.2,0.4)}\right\}$

Hence

$$(f^{-1}\ (G,A'),D)=\left\{\left((e_1,\mathrm{p},1),\left\{\frac{u_1}{(0.3,0.2,0.4)}, \frac{u_2}{(0.1,0.4,0.2)}, \frac{u_3}{(0.1,0.7,0.5)}\right\}\right),\right.$$

$\left((e_2, \mathrm{p}, 0), \left\{\frac{\mathrm{u}_1}{(0.3,0.2,0.1)}, \frac{\mathrm{u}_2}{(0.3,0.5,0.1)}, \frac{\mathrm{u}_3}{(0.5,0.6,0.4)}\right\}\right),$
$\left((e_3, \mathrm{p}, 1), \left\{\frac{\mathrm{u}_1}{(0.5,0.7,0.4)}, \frac{\mathrm{u}_2}{(0.6,0.5,0.1)}, \frac{\mathrm{u}_3}{(0.5,0.2,0.4)}\right\}\right)\Big\}$

Definition 3.4 Let f: $(\widetilde{\mathrm{U}, \mathrm{Z}}) \rightarrow (\widetilde{\mathrm{Y}, \mathrm{Z}'})$ be a mapping and (F, A) and (G, B) a neutrosophic soft expert sets in $(\widetilde{\mathrm{U}, \mathrm{E}})$. Then for $\beta \in \mathrm{Z}'$, $\mathrm{y} \in \mathrm{Y}$ the union and intersection of neutrosophic soft expert images (F, A) and (G, B) are defined as follows :

$\big(f(\mathrm{F}, \mathrm{A}) \widetilde{\vee} f(\mathrm{G}, \mathrm{B})\big)(\beta)(\mathrm{y}) = f(\mathrm{F}, \mathrm{A})(\beta)(\mathrm{y}) \widetilde{\vee} f(\mathrm{G}, \mathrm{B})(\beta)(\mathrm{y}).$
$\big(f(\mathrm{F}, \mathrm{A}) \widetilde{\wedge} f(\mathrm{G}, \mathrm{B})\big)(\beta)(\mathrm{y}) = f(\mathrm{F}, \mathrm{A})(\beta)(\mathrm{y}) \widetilde{\wedge} f(\mathrm{G}, \mathrm{B})(\beta)(\mathrm{y}).$

Definition 3.5 Let f: $(\widetilde{\mathrm{U},\ \mathrm{Z}}) \rightarrow (\widetilde{\mathrm{Y},\ \mathrm{Z}'})$ be a mapping and (F, A) and (G, B) a neutrosophic soft expert sets in $(\widetilde{\mathrm{U}, \mathrm{E}})$. Then for $\alpha \in \mathrm{Z}$, $\mathrm{u} \in \mathrm{U}$, the union and intersection of neutrosophic soft expert inverse images (F, A) and (G, B) are defined as follows :

$\big(f^{-1}(\mathrm{F}, \mathrm{A}) \widetilde{\vee} f^{-1}(\mathrm{G}, \mathrm{B})\big)(\alpha)(\mathrm{u}) = f^{-1}(\mathrm{F}, \mathrm{A})(\alpha)(\mathrm{u}) \widetilde{\vee} f^{-1}(\mathrm{G}, \mathrm{B})(\alpha)(\mathrm{u}).$
$\big(f^{-1}(\mathrm{F}, \mathrm{A}) \widetilde{\wedge} f^{-1}(\mathrm{G}, \mathrm{B})\big)(\alpha)(\mathrm{u}) = f^{-1}(\mathrm{F}, \mathrm{A})(\alpha)(\mathrm{u}) \widetilde{\wedge} f^{-1}(\mathrm{G}, \mathrm{B})(\alpha)(\mathrm{u}).$

Theorem 3.6 Let f: $(\widetilde{\mathrm{U}, \mathrm{Z}}) \rightarrow (\widetilde{\mathrm{Y}, \mathrm{Z}'})$ be a mapping. Then for neutrosophic soft expert sets (F, A) and (G, B) in the neutrosophic soft expert class $(\widetilde{\mathrm{U}, \mathrm{Z}})$.

1. $f(\emptyset)=\emptyset$
2. $f(\mathrm{Z}) \subseteq \mathrm{Y}$.
3. $f\big((\mathrm{F}, \mathrm{A}) \widetilde{\vee} (\mathrm{G}, \mathrm{B})\big) = f(\mathrm{F}, \mathrm{A}) \widetilde{\vee} f(\mathrm{G}, \mathrm{B})$
4. $f\big((\mathrm{F}, \mathrm{A}) \widetilde{\wedge} (\mathrm{G}, \mathrm{B})\big) = f(F, A) \widetilde{\wedge} f(\mathrm{G}, \mathrm{B})$
5. If $(\mathrm{F}, \mathrm{A}) \subseteq (\mathrm{G}, \mathrm{B})$, then $f(\mathrm{F}, \mathrm{A}) \subseteq f(\mathrm{G}, \mathrm{B})$.

Proof: For (1) ,(2) and (5) the proof is trivial, so we just give the proof of (3) and (4).
(3). For $\beta \in \mathrm{Z}'$ and $\mathrm{y} \in \mathrm{Y}$, we want to prove that

$\big(f(\mathrm{F}, \mathrm{A}) \widetilde{\vee} f(\mathrm{G}, \mathrm{B})\big)(\beta)(\mathrm{y}) = f(\mathrm{F}, \mathrm{A})(\beta)(\mathrm{y})\ \widetilde{\vee} f(\mathrm{G}, \mathrm{B})(\beta)(\mathrm{y})$

For left hand side, consider $f\big((\mathrm{F}, \mathrm{A}) \widetilde{\vee} (\mathrm{G}, \mathrm{B})\big)(\beta)(\mathrm{y}) = f(\mathrm{H}, \mathrm{A} \cup \mathrm{B})(\beta)(\mathrm{y})$. Then

$$f(\mathrm{H}, \mathrm{A} \cup \mathrm{B})(\beta)(\mathrm{y}) = \begin{cases} \vee_{\mathrm{x} \in \mathrm{r}^{-1}(\mathrm{y})} (\vee_{\alpha} \mathrm{H}(\alpha)) & \text{if } \mathrm{r}^{-1}(\mathrm{y}) \text{and } \mathrm{s}^{-1}(\beta) \cap (\mathrm{A} \cup \mathrm{B}) \neq \emptyset, \\ 0 & \text{otherwise} \end{cases} \quad \textbf{(1,1)}$$

such that $\mathrm{H}(\alpha) = \mathrm{F}(\alpha)\ \widetilde{\cup}\ \mathrm{G}(\alpha)$ where $\widetilde{\cup}$ denotes neutrosophic union.
Considering only the non-trivial case, Then equation 1.1 becomes:

$$f(\mathrm{H}, \mathrm{A} \cup \mathrm{B})(\beta)(\mathrm{y}) = \vee_{\mathrm{x} \in \mathrm{r}^{-1}(\mathrm{y})} (\vee(\mathrm{F}(\alpha)\ \widetilde{\cup}\ \mathrm{G}(\alpha))) \quad \textbf{(1,2)}$$

For right hand side and by using definition 3.4, we have

$\left(f(\mathrm{F},\mathrm{A})\tilde{\vee}f(\mathrm{G},\mathrm{B})\right)(\beta)(\mathrm{y})=f(\mathrm{F},\mathrm{A})(\beta)(\mathrm{y})\vee f(\mathrm{G},\mathrm{B})(\beta)(\mathrm{y})$

$$=\left(\vee_{x\in r^{-1}(y)}\left(\vee_{\alpha\in s^{-1}(\beta)\cap A}\mathrm{F}(\alpha)\right)(x)\right)\vee\left(\vee_{x\in r^{-1}(y)}\left(\vee_{\forall\alpha\in s^{-1}(\beta)\cap B}\mathrm{F}(\alpha)\right)(x)\right)$$
$$=\ \vee_{x\in r^{-1}(y)}\ \ \vee_{\alpha\in s^{-1}(\beta)\cap(A\cup B)}(\mathrm{F}(\alpha)\vee\mathrm{G}(\alpha))$$
$$=\vee_{x\in r^{-1}(y)}(\vee(\mathrm{F}(\alpha)\ \tilde{\cup}\ \mathrm{G}(\alpha))) \qquad \textbf{(1,3)}$$

From equation (1.1) and (1.3) we get (3)

(4). For $\beta\in Z'$ and $y\in Y$, and using definition 3.4, we have

$f\left((\mathrm{F},\mathrm{A})\ \tilde{\wedge}\ (\mathrm{G},\mathrm{B})\right)(\beta)(\mathrm{y})$
$=f(\mathrm{H},\mathrm{A}\cup\mathrm{B})(\beta)(\mathrm{y})$
$=\vee_{x\in r^{-1}(y)}\left(\vee_{\alpha\in s^{-1}(\beta)\cap(A\cup B)}\mathrm{H}(\alpha)\right)(x)$
$=\vee_{x\in r^{-1}(y)}\left(\vee_{\alpha\in s^{-1}(\beta)\cap(A\cup B)}\mathrm{F}(\alpha)\ \tilde{\cap}\ \mathrm{G}(\alpha)\right)(x)$
$=\vee_{x\in r^{-1}(y)}\left(\vee_{\alpha\in s^{-1}(\beta)\cap(A\cup B)}\mathrm{F}(\alpha)(x)\ \tilde{\cap}\ \mathrm{G}(\alpha)(x)\right)$
$$\subseteq\left(\bigvee_{x\in r^{-1}(y)}\left(\bigvee_{\alpha\in s^{-1}(\beta)\cap A}\mathrm{F}(\alpha)\right)\right)\wedge\bigvee_{x\in r^{-1}(y)}\left(\bigvee_{\alpha\in s^{-1}(\beta)\cap B}\mathrm{G}(\alpha)\right)$$
$=f\left((\mathrm{F},\mathrm{A})(\beta)(\mathrm{y})\wedge(\mathrm{G},\mathrm{B})(\beta)(\mathrm{y})\right)$
$=\left(f(\mathrm{F},\mathrm{A})\ \tilde{\wedge}\ f(\mathrm{G},\mathrm{B})\right)(\beta)(\mathrm{y})$

This gives (4).

Theorem 3.7 Let $f^{-1}\colon(\widetilde{U,Z})\to(\widetilde{Y,Z'})$ be a an inverse mapping. Then for neutrosophic soft expert sets (F, A) and (G, B) in the neutrosophic soft expert class $(\widetilde{U,Z})$.

1. $f^{-1}(\emptyset)=\emptyset$
2. $f^{-1}(X)\subseteq X.$
3. $f^{-1}\left((\mathrm{F},\mathrm{A})\tilde{\vee}(\mathrm{G},\mathrm{B})\right)=f^{-1}(\mathrm{F},\mathrm{A})\tilde{\vee}f^{-1}(\mathrm{G},\mathrm{B})$
4. $f^{-1}\left((\mathrm{F},\mathrm{A})\ \tilde{\wedge}\ (\mathrm{G},\mathrm{B})\right)=f^{-1}(\mathrm{F},\mathrm{A})\ \tilde{\wedge}\ f^{-1}(\mathrm{G},\mathrm{B})$
5. If $(\mathrm{F},\mathrm{A})\subseteq(\mathrm{G},\mathrm{B})$, Then $f^{-1}(\mathrm{F},\mathrm{A})\subseteq f^{-1}(\mathrm{G},\mathrm{B})$.

Proof. The proof is straightforward**.**

4. Conclusion

In this paper, we studied mappings on neutrosophic soft expert classes and their basic properties. We also give some illustrative examples of mapping on neutrosophic soft expert set. We hope these fundamental results will help the researchers to enhance and promote the research on neutrosophic soft set theory.

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