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Near Soft Topological Groups Based on Near Soft Element

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Abstract. In this article, we introduce the concept of the near soft element and define the near soft group using near soft element with binary operation in the whole set non-empty near soft elements of a dedicated near soft set. In addition, the concepts of topology and continuity of the near soft group are mentioned. The concept of near soft topological group was created with the help of continuous transformations defined on the near soft group. Finally, an example is given for the concept of near soft topological group.

1. Introduction

The concept of near sets Peters [1, 2] and the concept of soft theory is given by Molodtsov [3]. It was later examined by many scientists with [3–11]. The binary soft element definition given by Wardowski [12] is operating on all non-empty soft elements of a dedicated soft set. Next, J.Ghosh [13, 14] defines the soft groupoid according to the soft elements set. Many other researchers have created the topological version of soft set theory and soft algebra. Following these articles, Wardowski [12] gave his ideas about soft topological groups with the help of soft elements. Starting from this definition, scientists studied the soft transformation and continuity of soft mapping [15]. on the other hand Feng and Li [5] came up with the notion of rough soft sets by combining soft sets with rough sets. Similar algebraic studies have been done on rough sets. Later, Tasbozan et al. [16–18] combined the near-set approach with the soft-set. Also, the concept of the near soft set was presented. Next, the concept of a near soft element is defined and the near soft groupoid is defined using a near soft element by binary operation on the set of all nonempty near soft elements of a dedicated near soft set [19].

In this study, first a near soft group definition was made, then a topology structure was created on this near soft group, and the concept of a near soft topological group was defined with the help of the topology defined on this near soft group and continuous mapping. In addition, examples were given for the new concepts defined.

2. Preliminary

In this part, the notions of near approximation(NA), nearness approximation space (NAS) and other definitions of this concept are given. Then we define a binary composition on near soft sets and this form is called near soft group over near soft set.

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Definition 2.1. *[18, 20] Let* $(\mathcal{O}, \mathcal{F}, \sim_{Br}, N_r, \upsilon_{N_r})$ *be a NAS and* $\sigma = (F, B)$ *be a soft set over* $\mathcal{O}$.

$$N_r*((F,B)) = (N_r*(F(k) = \cup\{x \in \mathcal{O} : [x]_{Br} \subseteq F(k)\}, B))$$

and

$$N_r^*((F,B)) = (N_r^*(F(k) = \cup\{x \in \mathcal{O} : [x]_{Br} \cap F(k) \neq \emptyset\}, B))$$

are lower and upper near approximation operators. The SS $N_r((F,B))$ *with* $Bnd_{N_r(B)}((F,B)) \geqslant 0$ *called a near soft set(NSS).*

The collection of all NSS on $\mathcal{O}$ will be denoted $NSS(\mathcal{O})$.

Definition 2.2. *[18] Let* $\mathcal{O}$ *be an universe set, E be the parameters and* $B \subseteq E$. *For NSS* (F, B) *over* $\mathcal{O}$, *the set*

$$Supp(F,B) = \{\phi \in B : F(\phi) \neq \emptyset\}$$

is called the support of the NSS (F, B).

1. *A NSS* (F, B) *is called non-null NSS (with respect to the parameters of B) if* $Supp(F, B) \neq \emptyset$. *Otherwise* (F, B) *is called null NSS.*
2. *A near soft set* (F, B) *is called full null NSS if* $Supp(F, B) = B$. *A collection of all full NSS on* $\mathcal{O}$ *will be denoted by* $NS_f(\mathcal{O})$.

Definition 2.3. *[21] Let* $\mathcal{O}$ *be an initial set, E be the parameters and* $B \subseteq E$ *and* $(F, B) \in NSS(\mathcal{O})$. *We say that* $(\phi, \{x_k\})$ *is a nonempty near soft element (NSE) of* (F, B) *if* $\phi \in B$ *and* $x_k \in F(\phi)$. *The pair* $(\phi, \emptyset)$, *where* $\phi \in B$ *is an empty NSE of* (F, B).*Then* $(\phi, \{x_k\}) = \{x_k\}_\phi$ *is a NSE of* (F, B) *and denoted by* F_B.

3. Near Soft Group

Definition 3.1. *[19] Let* $(\mathcal{F}, \circ)$ *and* $(\mathcal{O}, *)$ *be two groupoids and* $B \subseteq \mathcal{F}$. *Also let* $(F, B) \in NS_f(\mathcal{O})$, $\forall\ \phi \in B, \ni \exists$ *nonempty NSE of* (F, B). *We define a binary composition* $*$ *on* (F, B) *by*

$$(\phi_i, \{x_a\}) * (\phi_j, \{x_b\}) = (\phi_i \circ \phi_j, \{x_a * x_b\})$$

for all $(\phi_i, \{x_a\}), (\phi_j, \{x_b\}) \in (F, B)$. (F, B) *is said to be closed under the binary composition* $*$ *if and only if* $(\phi_i \circ \phi_j, \{x_a * x_b\}) \in (F, B)$, $\phi_i \circ \phi_j \in B$ *and* $x_a * x_b \in F(\phi_i \circ \phi_j)$ *for all* $(\phi_i, \{x_a\}), (\phi_j, \{x_b\}) \in (F, B)$. *Then* $(F_B, *)$ *is a near soft groupoid* (NSG) *over* $(F, \mathcal{O})$.

Theorem 3.2. *[19] Let* $(F, B) \in NS_f(\mathcal{O})$, *then* $((F, B), *)$ *forms a NSG over* $(F, \mathcal{O})$ *if and only if*

1. B is a subgroupoid of F, i.e., $\phi_i \circ \phi_j \in B$ for all $\phi_i, \phi_j \in B$,
2. for $\phi_i, \phi_j \in B$, $x_a \in F(\phi_i)$, $x_b \in F(\phi_j)$ then $x_a * x_b \in F(\phi_i \circ \phi_j)$.

Definition 3.3. *[19] Let* $(F_B, *)$ *be a NSG over* $(F, \mathcal{O})$. *Then* $*$ *binary composition said to be*

1. commutative if $(\phi_i, \{x_a\}) * (\phi_j, \{x_b\}) = (\phi_j, \{x_b\}) * (\phi_i, \{x_a\})$,
2. associative if
$$[(\phi_i, \{x_a\}) * (\phi_j, \{x_b\})] * (\phi_k, \{x_c\}) = (\phi_i, \{x_a\}) * [(\phi_j, \{x_b\}) * (\phi_k, \{x_c\})]$$
for all $(\phi_i, \{x_a\}), (\phi_j, \{x_b\}), (\phi_k, \{x_c\}) \in F_B$.

Definition 3.4. *A* (NSE) $(\phi, \{x\}) \in F_B$ *is a near soft identity element in a NSG* $(F_B, *)$ *if for all* $(\phi_i, \{x_a\}) \in F_B$

$$(\phi, \{x\}) * (\phi_i, \{x_a\}) = (\phi_i, \{x_a\}) = (\phi_i, \{x_a\}) * (\phi, \{x\}).$$

Definition 3.5. *Let $(F_B, *)$ be a NSG with near soft identity element $(\phi, \{x\})$. A NSE $(\phi_i, \{x_a\}) \in F_B$ is an invertible if there exists a (NSE) $(\phi_i', \{x_a'\}) \in F_B$ such that*

$$(\phi_i, \{x_a\}) * (\phi_i', \{x_a'\}) = (\phi, \{x\}) = (\phi_i', \{x_a'\}) * (\phi_i, \{x_a\})$$

Then $(\phi_i', \{x_a'\})$ is a near soft inverse of $(\phi_i, \{x_a\})$ and denoted by $(\phi_i, \{x_a\})^{-1}$.

Definition 3.6. *Let $B \subseteq \mathcal{F}$ and $(F, B) \in NS(O)$. We say that $(\phi, \{x\})$ is a nonempty NSE of (F, B)if $\phi \in B$ and $x \in F(\phi)$. The pair $(\phi, \emptyset)$, where $\phi \in \mathcal{F}$, is called an empty NSE of (F, B).*

Definition 3.7. *Let $(\mathcal{F}, \circ)$ and $(O, *)$ be two groups, $A, B \subseteq \mathcal{F}$ and $(F, B) \in NS(O)$. (NSG) $(F_B, *)$ is a near soft group (NSGp) over $(O, \mathcal{F})$ if,*

1. $*$ is associative,
2. there exist a *NSE* $(\phi, \{x\})$ such that

$$(\phi, \{x\}) * (\phi_i, \{x_a\}) = (\phi_i, \{x_a\}) = (\phi_i, \{x_a\}) * (\phi, \{x\})$$

   for all $(\phi_i, \{x_a\}) \in (F, B)$,
3. for each $(\phi_i, \{x_a\}) \in (F, B)$ there exist a *NSE* $(\phi_i', \{x_a\}')$ such that

$$(\phi_i, \{x_a\}) * (\phi_i', \{x_a\}') = (\phi, \{x\}) = (\phi_i', \{x_a\}') * (\phi_i, \{x_a\}).$$

Example 3.8. *Let $(O, *)$ be a group with $*$ operation being multiplication modula 8 on the set $\{1, 3, 5, 7\}$ and $(B, \circ)$ be a group with $\circ$ operation. The composition table of $\circ$ on B is given by Table 1.*

Table 1: The composition table of $\circ$ on B.

$\circ$	ϕ_1	ϕ_2
ϕ_1	ϕ_1	ϕ_2
ϕ_2	ϕ_2	ϕ_1

and define the (NSS) $\sigma = (F, B) = \{(\phi_1, \{1, 3\}), (\phi_2, \{5, 7\})\}$. For $r = 1$

$$\begin{aligned} [1]_{\phi_1} &= \{1, 3, 7\}, [5]_{\phi_1} = \{5\} \\ [1]_{\phi_2} &= \{1, 3\}, [5]_{\phi_2} = \{5, 7\} \end{aligned}$$

$N_*(\sigma) = \{(\phi_2, \{5, 7\})\}, N^*(\sigma) = \{(\phi_1, \{1, 3\}), (\phi_2, \{5, 7\})\}, Bnd(\sigma) \geq 0.$

For $r = 2$; $N_*(\sigma) = \{(\phi_1, \{1, 3\}), (\phi_2, \{5, 7\})\} = N^*(\sigma), Bnd(\sigma) \geq 0$. Then σ is a *NSS*. Hence all the *NSE* of σ are;

$$F_{B.} = (\phi_1, \{1\}), (\phi_1, \{3\}), (\phi_2, \{5\}), (\phi_2, \{7\}).$$

The table of operation $*$ on $F_{B.}$ is given in Table 2.

Table 2: The table of operation $*$ on $F_{B.}$.

$*$	$(\phi_1, \{1\})$	$(\phi_1, \{3\})$	$(\phi_2, \{5\})$	$(\phi_2, \{7\})$
$(\phi_1, \{1\})$	$(\phi_1, \{1\})$	$(\phi_1, \{3\})$	$(\phi_2, \{5\})$	$(\phi_2, \{7\})$
$(\phi_1, \{3\})$	$(\phi_1, \{3\})$	$(\phi_1, \{1\})$	$(\phi_2, \{7\})$	$(\phi_2, \{5\})$
$(\phi_2, \{5\})$	$(\phi_2, \{5\})$	$(\phi_2, \{7\})$	$(\phi_1, \{1\})$	$(\phi_1, \{3\})$
$(\phi_2, \{7\})$	$(\phi_2, \{7\})$	$(\phi_2, \{5\})$	$(\phi_1, \{3\})$	$(\phi_1, \{1\})$

$(F_{B.}, *)$ is commutative *NSGp* with near soft identity $(\phi_1, \{1\})$.

Definition 3.9. *Suppose that* $(\mathcal{O}, B)$ *is a group then* $(F, B) \in NS(\mathcal{O})$ *is called a NSGp (resp. near normal soft group) over* $(\mathcal{O}, B) \Leftrightarrow (F(\phi), B)$ *is a subgroup (resp. normal subgroup) of* $(\mathcal{O}, B)$, $\forall \phi \in B$.

Definition 3.10. *Suppose that* (F, B) *is a NSGp over* $(\mathcal{O}, B)$. *Then* $(G, A) \in NS(\mathcal{O})$ *is called a near soft subgroup* $(NSsGp)$ *(resp. near soft normal subgroup* $(NSNsGp)$ *of* (F, B) *if and only if* $A \subseteq B$ *and* $(G(\phi), A)$ *is a subgroup (resp. a normal subgroup) of* $(F(\phi), B)$, $\forall \phi \in B$.

Definition 3.11. *Let* (F_B*) *be a NSGp over* $(\mathcal{O}, \mathcal{F})$ *and* (G, A) *be* $(NSsGp)$ *of* (F, B). *If for all* $(\phi_j, \{x_b\}) \in (F, B)$

$$(\phi_i, \{x_a\}) * (G, A) * (\phi_i, \{x_a\})^{-1} = (G, A)$$

then (G, A)*is called NSNsGp of* (F, B).

Definition 3.12. *Let* (F, B) *be a NSS over* $\mathcal{O}$ *and* τ *be the collection of NSs of* $\mathcal{O}$, *if if the following are provided*

i) $(\emptyset, B), (\mathcal{O}, B) \in \tau$

ii) $(F_1, B), (F_2, B) \in \tau$ then $(F_1, B) \cap (F_2, B) \in \tau$

iii) $(F_i, B), \forall \phi \in B$ then $\bigcup_i (F_i, B) \in \tau$

Then $(\mathcal{O}, \tau, B)$ is a near soft topological space($NSTS$) [18].

Definition 3.13. $(\mathcal{O}, \tau, B)$ *be a NSTS and* $G \subseteq \mathcal{O}$. *The near soft topology* (NST) *on* (G, B) *induced by the NST* τ *is the family* τ_G *of the near soft subsets of G of the form* $\tau_G = \{V \cap G : V \in \tau\}$. *Thus* (G, τ_G, B) *is a near soft topological subspace of* $(\mathcal{O}, \tau, B)$.

Definition 3.14. $NS(\mathcal{O}, B)$ *denotes the family of all NSS over* $(\mathcal{O}, B)$.*Let* $(F, A), (G, C) \in NS(\mathcal{O}, B), A, C \subseteq B$. *the near soft cartesian product of* $(F, A), (G, C)$ *denoted by* $(F, A) \times (G, C)$ *is a NSS on* $(\mathcal{O}, B) \times (\mathcal{O}, B)$ *such that* $(F, A) \times (G, C) = \{((\phi_1, \phi_2), F(\phi_1) \times G(\phi_2)) : \phi_1, \phi_2 \in B\}$

Definition 3.15. *Let* $(\mathcal{O}, \tau, B)$ *be a NSTS over* $\mathcal{O}$. *A, NSS* (F, B) *in* $(\mathcal{O}, \tau, B)$ *is called a near soft neighbourhood of the NSP* $(x_e, B) \in (F, B)$ *if there exists a NSOS* (G, B) *such that* $(x_e, B) \in (G, B) \subset (F, B)$.

Definition 3.16. *Let* $(F, A), (G, C) \in NS(\mathcal{O}, B)$ *and* $f : (F, A) \to (G, C)$ *a near soft mapping NSM then the following hold:*

1. *The image of* $X \subseteq F$ *under* (NSM) f *is the near soft set of the form* $(f(X), C) = (\cup_{\alpha \in X} f(\alpha), C)$ *and for each NSM* $(f(\emptyset), B) = (\emptyset, B)$.
2. *The invese of* $Y \subseteq G$ *under NSM* f *is the NSS of the form* $(f^{-1}(Y), A) = (\cup\{\{\alpha\} : \alpha \in (F, A), f(\alpha) \in (Y, C)\}, B)$.

Definition 3.17. *Let* $(F, \tau, B), (G, \upsilon, B)$ *be a NSTS and* $f : (F, B) \to (G, B)$ *be a NSM. If for each* $V \in \upsilon, f^{-1}(V) \in \tau$ *then* f *is a near soft continuous mapping and denoted by NSCM.*

Definition 3.18. *Let* $(\mathcal{O}_1, \tau, B)$ *and* $(\mathcal{O}_2, \tau, B)$ *be two NSTS.* $f : (\mathcal{O}_1, \tau, B) \to (\mathcal{O}_2, \tau, B)$ *be a mapping. For each near soft neighbourhood* (H, B) *of* $(f(x)_\phi, B)$, *if there exists a near soft neighbourhood* $f((F, B)) \subset (H, B)$ *then* f *is a NSCM* (x_ϕ, B). *If* f *is* $(NSCM)$ *for all* (x_ϕ, B), *then* f *is a NSCM.*

Definition 3.19. *Let* $(\mathcal{O}_1, \tau, B)$ *and* $(\mathcal{O}_2, \tau, B)$ *be two NSTS.* $f : \mathcal{O}_1 \to \mathcal{O}_2$ *be a mapping.* $\mathcal{O}_1$ *is near soft homeomorphic to* $\mathcal{O}_2$ *if* f *is a bijection, NSC and* f^{-1} *is a near soft homeomorfizm.*

Example 3.20. *Let $\sigma = (F, B)$ be a NSS given in example 10. Then all near soft subsets of $\sigma = (F, B)$ are;*

$$\begin{aligned}
(F_1, B) &= \{(\phi_1, \{1, 3\})\} \\
(F_2, B) &= \{(\phi_2, \{5, 7\})\} \\
(F_3, B) &= \{(\phi_1, \{1, 3\}), (\phi_2, \{5\})\} \\
(F_4, B) &= \{(\phi_1, \{1, 3\}), (\phi_2, \{7\})\} \\
(F_5, B) &= \{(\phi_1, \{1\}), (\phi_2, \{5, 7\})\} \\
(F_6, B) &= \{(\phi_1, \{3\}), (\phi_2, \{5, 7\})\} \\
(F_7, B) &= \{(\phi_1, \{1, 3\}), (\phi_2, \{5, 7\})\} \\
&\dots
\end{aligned}$$

$\tau = \{(F_1, B), (F_2, B), (F_7, B), (\emptyset, B)\}$ is a NST on (F, B). $(F_{B.}, *)$ is a NSGp with a topology τ. Then $\imath : F_{B.} \to F_{B.}$ which defined by

$$\begin{aligned}
\imath((\phi_i, \{x_a\})) &= ((\phi_i, \{x_a\}))^{-1} \\
\imath((\phi_1, \{1\})) &= ((\phi_1, \{1\}))^{-1} = (\phi_1, \{1\}) \\
\imath((\phi_1, \{3\})) &= ((\phi_1, \{3\}))^{-1} = (\phi_1, \{3\}) \\
\imath((\phi_2, \{5\})) &= ((\phi_2, \{5\}))^{-1} = (\phi_2, \{5\}) \\
\imath((\phi_2, \{7\})) &= ((\phi_2, \{7\}))^{-1} = (\phi_2, \{7\})
\end{aligned}$$

is continuous.

Definition 3.21. *Let (O, τ) be a NSTS of NSE and $(\phi_j, \{x_a\}) \in F_B$. If $(\phi_j, \{x_a\}) \in H_C \subseteq G_A$ is an open set then a near soft subset G_A of F_B is a near soft neighborhood of NSE $(\phi_j, \{x_a\})$. The collection of all near soft neighborhoods of the NSE $(\phi_j, \{x_a\})$ is denoted $N_{(\phi_j, \{x_a\})}$.*

Definition 3.22. *Let (O_F, τ) be a NSTS over (F, B).A NSS $(G, A) \subseteq (F, B)$ is near soft open $\Leftrightarrow$ for each NSE $\gamma \in (G, A)$ there exist a NSS $(H, C) \in \tau$ such that $\gamma \in (H, C) \subseteq (G, A)$.*

Definition 3.23. *Let (O_F, τ_1) and (O_G, τ_2) be a NSTS over (F, B) and (G, B) respectively and $\lambda = \{O_F \times O_G : F \in \tau_1$ and $G \in \tau_2\}$. The collection τ of all arbitrary union of elements of λ is a near soft product topology over $O_F \times O_G$.*

4. Near Soft Topological Group Based on Near Soft Element

Definition 4.1. *A near soft group $(F_B, *)$ with a topology τ on F_B is called a near soft semi- topological group (NSsTGp) if for each near soft neighborhood F_A of $(\phi_i, \{x_a\}) * (\phi_i', \{x_a\}')$, there exists a near soft neighborhood F_C of $(\phi_i, \{x_a\})$ and a near soft neighborhood F_D of $(\phi_i', \{x_a\}')$ such that $F_C * F_D \subseteq F_A$.*

Example 4.2. *Let $\sigma = (F, B)$ be a NSs given in example 10. $\tau = \{(F_1, B), (F_2, B), (F_7, B), (\emptyset, B)\}$ is a NSTS where*

$$\begin{aligned}
(F_1, B) &= \{(\phi_1, \{1, 3\})\} \\
(F_2, B) &= \{(\phi_2, \{5, 7\})\}
\end{aligned}$$

.Then $(F_{B.}, *, \tau)$ is a NSsTGp.

Definition 4.3. *A near soft group $(F_B, *)$ with a topology τ on F_B is a near soft topological group (NSTGp) if the following hold:*

1. $f : F_B \times F_B \to F_B$ which defined by

$$f((\phi_i, \{x_a\}), (\phi_i', \{x_a\}')) = (\phi_i, \{x_a\}) * (\phi_i', \{x_a\}')$$

is continuous with respect to a product topollogy on $F_B \times F_B$.

2. $\imath : F_B \to F_B$ which defined by $\imath((\phi_i, \{x_a\})) = ((\phi_i, \{x_a\}))^{-1}$ is continuous.

Definition 4.4. *Let τ be a topology defined on a additive group G. Let (F, B) be a non-null near soft set defined over G. Then, the triplet (F, B, τ) is a NSTGp over G if*
i. $F(\phi)$ is a subgroup of G for all $\phi \in B$
ii. the mapping $(x_1, x_2) \to x_1 - x_2$ of the topological space $F(\phi) \times F(\phi)$ onto $F(\phi)$ is continuous for all $\phi \in B$.

Definition 4.5. *Suppose that O is an additive group and τ be a near soft topology it. Then the NSTS (O, τ, B) is called a NSTGp if the mapping $(x_1, x_2) \to x_1 - x_2$ is a NSCM from $(O \times O, \tau \times \tau)$ to (O, τ, B).*

Example 4.6. *Let $\sigma = (F, B)$ be a NSS given in example 10. $\tau = \{(F_1, B), (F_2, B), (F_7, B), (\emptyset, B)\}$ is a near soft topology on (F, B). $(F_{B.}, *)$ is a NSGp with a topology τ. $(F_{B.}, *, \tau)$ is a NSTGp;*

1. $f : F_B \times F_B \to F_B$ which defined by

$$f((\phi_i, \{x_a\}), (\phi_i', \{x_a\}')) = (\phi_i, \{x_a\}) * (\phi_i', \{x_a\}')$$

is continuous with respect to a product topollogy on $F_B \times F_B$.

2. $\imath : F_B \to F_B$ which defined by $\imath((\phi_i, \{x_a\})) = ((\phi_i, \{x_a\}))^{-1}$ is continuous from example 25.

5. Conclusion

Soft set theory and near set theory, which have been successfully studied by many researchers to date, have a very good resource for applications. To contribute to the applications in this article, we introduce near soft topological groups with the help of the near soft element. These results provide an environment for studying applications on Near soft topological algebraic structures.

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