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REVIEW ARTICLE

SOFT INTERSECTION-SYMMETRIC DIFFERENCE PRODUCT OF GROUPS

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ABSTRACT

Soft set theory constitutes a mathematically robust and structurally versatile formalism for modeling real-world systems characterized by epistemic uncertainty, vagueness, and parameter-contingent variability—ubiquitous features across decision theory, engineering, economics, and information sciences. At the core of this framework lies a spectrum of algebraic operations and binary product constructions that endow the soft set universe with a rich internal structure, capable of encapsulating intricate interdependencies among parameters. In this context, we introduce and investigate a novel product of soft sets, termed the soft intersection–symmetric difference product, formulated specifically for soft sets whose parameter domains are structured as groups. This product is rigorously defined and analyzed within an axiomatic framework that ensures compatibility with generalized soft subsethood and equality relations. The structural analysis of the soft intersection–symmetric difference product includes the examination of essential algebraic properties—such as closure, associativity, commutativity, and idempotency. In addition, the interplay between this product and pre-existing soft products, is explored to regarding the subsets. Theoretical investigations reveal that the operation not only respects the algebraic architecture of the underlying group-parameterized domain but also induces a cohesive and well-behaved algebraic system on the collection of soft sets. This analytical framework yields two central algebraic insights: (i) the internal algebraic cohesion of soft set theory is significantly enhanced by embedding the newly defined product into a logically sound and operation-preserving environment; and (ii) the product itself possesses the formal potential to serve as a foundational construct for a generalized soft group theory, wherein soft sets over group-parameter spaces mimic the axiomatic behavior of classical group-theoretic constructs through suitably defined soft operations. Given that the maturation of soft algebraic systems is contingent upon the rigorous formulation of operations satisfying structurally meaningful axioms, the contributions of this study represent a notable advancement in the algebraic consolidation of soft set theory. Beyond theoretical enrichment, the proposed operation offers tangible utility in the construction of abstract algebra-based soft computational models, with applications spanning multi-criteria decision-making, algebraically-driven classification mechanisms, and uncertainty-aware data analysis governed by group-parametrized semantic domains. Thus, the framework established herein not only extends the theoretical boundaries of soft algebra but also fortifies its role as a foundational tool in both pure and applied mathematical discourse

KEYWORDS

Soft sets; Soft subsets; Soft equalities; Soft intersection-symmetric difference product.

1. INTRODUCTION

A vast array of advanced mathematical frameworks has been devised to represent and analyze systems permeated by uncertainty, vagueness, and indeterminacy—phenomena that frequently emerge in engineering, economics, social sciences, and medical diagnostics. Despite the conceptual sophistication of such paradigms, including fuzzy set theory and probabilistic models, critical epistemological and algebraic limitations persist. Fuzzy set theory, as pioneered hinges on subjectively chosen membership functions, while probabilistic approaches presuppose the availability of repeatable events and known distributional profiles—assumptions which are often untenable in real-world contexts governed by epistemic ambiguity (Zadeh, 1965). In a groundbreaking contribution, circumvented these structural constraints by formulating soft set theory as a mathematically elastic yet axiomatically minimalistic framework that models uncertainty relative to parameter sets, rather than probabilistic or membership-theoretic axioms (Molodtsov, 1999).

The initial formalism of soft sets has undergone systematic algebraic refinement since 2003. Foundational operations such as union, intersection, and AND/OR-products were introduced, while recontextualized these operations through information-theoretic lenses, rendering them compatible with relational and multivalued contexts (Maji et al., 2003; Pei et al., 2005). This study, extended the operational schema by defining restricted and extended variants, enhancing the algebraic granularity of soft systems (Ali et al., 2009). Subsequent research—including the works of further deepened the algebraic infrastructure of soft set theory, resolving semantic ambiguities and introducing a spectrum of new product operations and generalized equalities (Yang, 2008; Feng et al., 2010; Jiang et al., 2010; Ali et al., 2011;

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Jiang et al., 2010; Ali et al., 2011; Neog and Sut, 2011; Fu, 2011; Ge and Yang, 2011; Singh and Onyeozili, 2012a–d; Zhu and Wen, 2013; Onyeozili and Gwary, 2014; Sen, 2014). Recent developments have significantly enriched the algebraic foundations of soft set theory through the introduction of a wide array of novel operations, each rigorously analyzed within formal algebraic frameworks. Noteworthy contributions in this regard include the works of whose investigations have collectively established a robust and extensible algebraic landscape for the continued advancement of soft set theory (Eren and Çalışıcı, 2019; Stojanović, 2021; Sezgin et al., 2023a, 2023b; Sezgin and Dağtoros, 2023; Sezgin and Demirci, 2023; Sezgin and Çalışıcı, 2024; Sezgin and Yavuz, 2023a, 2023b; 2024; Sezgin and Çağman, 2024, 2025; Sezgin and Sarıalioğlu, 2024a, 2024b; Sezgin and Şenyiğit, 2025).

The algebraic formalization of soft equality and soft inclusion has evolved into a cornerstone of modern soft algebra. The classical notion of soft subsets proposed was generalized and developed soft congruence relations that embedded equivalence structures into the soft set universe (Maji et al., 2003; Pei and Miao, 2005; Feng et al., 2010; Qin and Hong, 2010). This study, advanced the algebraic semantics by introducing J-soft equalities and new distributive frameworks, and revealed profound algebraic divergence in their definition of L-soft subsets and L-equalities, wherein traditional distributive identities fail to hold universally (Çağman andi Enginoğlu, 2010; Liu et al., 2012). These foundational results were extended by who rigorously categorized soft subset types and established associativity, commutativity, and distributivity criteria under L-equality, proving that certain classes of quotient soft algebras admit commutative semigroup structures (Feng et al., 2013). In addition, the interplay between this product and pre-existing soft products, is explored to regarding the subsets. Further generalizations—such as g-soft, gf-soft, and T-soft equalities—have been developed within lattice-enriched frameworks by marking a paradigm shift toward lattice-theoretic and congruence-based perspectives (Abbas et al., 2014, 2017; Alshami, 2019; Alshami et al., 2020).

In a pivotal intervention, reconstructed the definitional foundations of soft set operations to rectify inconsistencies in the original formulation, thereby enabling a robust algebraic treatment (Çağman andi Enginoğlu, 2010). Parallel developments have focused on soft products over algebraic domains. The soft intersection–union product has been extended to rings, semigroups and groups, yielding structurally consistent notions of soft union rings, semigroups, and groups (Sezer, 2012; Sezgin, 2016; Muştuoğlu et al., 2016). Conversely, the soft union–intersection product has been investigated in group-theoretic, semigroup-theoretic, and ring-theoretic contexts, with algebraic properties contingent on the behavior of identity and inverse elements in the parameter set (Kaygısız, 2012; Sezer et al., 2015; Sezgin et al., 2017).

In response to these advances, the present study proposes a novel product of soft sets—the soft intersection–symmetric difference product—formulated over soft sets whose parameter domains are endowed with group structure. This operation is subjected to a comprehensive algebraic examination, emphasizing its compatibility with generalized soft inclusion and equality relations. The structural analysis of the soft intersection–symmetric difference product includes the examination of essential algebraic properties—such as closure, associativity, distributivity (both left and right), and compatibility with identity and absorbing elements. Moreover, the proposed operation is subjected to a comprehensive comparative assessment against previously formulated soft products within the structured hierarchy of soft subset classifications, providing enhanced theoretical clarity regarding their respective expressive strengths and algebraic coherence. In parallel, a rigorous examination of the product's interaction with both the null and absolute soft sets is undertaken to further articulate its foundational structural properties. Our results demonstrate that the proposed product adheres to desirable axiomatic criteria, while introducing a structurally coherent mechanism for combining soft information across parametric group domains. The product facilitates a natural extension of classical algebraic concepts to the soft domain, allowing the construction of soft analogues of group-theoretic entities, and laying the groundwork for a new mathematical branch—soft group theory—defined through rigorously axiomatized binary operations. The remainder of this manuscript is structured as follows: Section 2 revisits foundational definitions and formal preliminaries. Section 3 introduces the soft intersection–symmetric difference product and develops its algebraic theory in detail. Section 4 synthesizes the primary results and delineates directions for future research aimed at expanding the algebraic universe of soft sets and exploring their applications in abstract algebra and uncertainty modeling.

2. Preliminaries

This section presents a rigorous and methodical re-evaluation of the foundational definitions and algebraic underpinnings that serve as the formal substrate for the theoretical constructs elaborated in the subsequent discourse. While the original conception of soft set theory was introduced as a parameterized generalization for modeling uncertainty, its formal definitional schema and operational calculus were substantially restructured in the influential reformulation (Molodtsov, 1999; Çağman andi Enginoğlu, 2010). Their axiomatic revision endowed the theory with heightened structural coherence and broadened its applicability across diverse algebraic and decision-theoretic settings. The present investigation adopts this refined formalism as the axiomatic foundation upon which all further constructions are based. Accordingly, every algebraic development, operational specification, and theoretical generalization in the forthcoming sections is rigorously articulated within this enhanced framework, ensuring both internal consistency and formal adherence to contemporary standards in soft algebraic systems.

Definition 2.1. (Çağman and Enginoğlu, 2010) Let E be a parameter set, U be a universal set, $P(U)$ be the power set of U, and $\mathcal{H} \subseteq E$. Then, the soft set $f_{\mathcal{H}}$ over U is a function such that $f_{\mathcal{H}}: E \to P(U)$, where for all $w \notin \mathcal{H}$, $f_{\mathcal{H}}(w) = \emptyset$. That is,

$$f_{\mathcal{H}} = \{(w, f_{\mathcal{H}}(w)) : w \in E\}$$

From now on, the soft set over U is abbreviated by $\mathcal{SS}$.

Definition 2.2. (Çağman andi Enginoğlu, 2010) Let $f_{\mathcal{H}}$ be an $\mathcal{SS}$. If $f_{\mathcal{H}}(w) = \emptyset$ for all $w \in E$, then $f_{\mathcal{H}}$ is called a null $\mathcal{SS}$ and indicated by $\emptyset_E$, and if $f_{\mathcal{H}}(w) = U$, for all $w \in E$, then $f_{\mathcal{H}}$ is called an absolute $\mathcal{SS}$ and indicated by U_E.

Definition 2.3. (Çağman andi Enginoğlu, 2010) Let $f_{\mathcal{H}}$ be a soft set over U. Then, the complement of $f_{\mathcal{H}}$ denoted by ${f_{\mathcal{H}}}^{c}$, is defined by the soft set ${f_{\mathcal{H}}}^{c}: E \to P(U)$ such that ${f_{\mathcal{H}}}^{c}(e) = U \setminus f_{\mathcal{H}}(e) = (f_{\mathcal{H}}(e))'$, for all $e \in E$.

Definition 2.4. (Çağman andi Enginoğlu, 2010) Let $f_{\mathcal{H}}$ and $g_{\aleph}$ be two $\mathcal{SS}$s. Then, the difference of $f_{\mathcal{H}}$ and $g_{\aleph}$ is the $\mathcal{SS}$ $f_{\mathcal{H}} \tilde{\setminus} g_{\aleph}$, where $(f_{\mathcal{H}} \tilde{\setminus} g_{\aleph})(w) = f_{\mathcal{H}}(w) \setminus g_{\aleph}(w)$, for all $w \in E$.

Definition 2.5. (Çağman andi Enginoğlu, 2010) Let $f_{\mathcal{H}}$ and $g_{\aleph}$ be two $\mathcal{SS}$s. If $f_{\mathcal{H}}(w) \subseteq g_{\aleph}(w)$, for all $w \in E$, then $f_{\mathcal{H}}$ is a soft subset of $g_{\aleph}$ and indicated by $f_{\mathcal{H}} \tilde{\subseteq} g_{\aleph}$. If $f_{\mathcal{H}}(w) = g_{\aleph}(w)$, for all $w \in E$, then $f_{\mathcal{H}}$ is called soft equal to $g_{\aleph}$, and denoted by $f_{\mathcal{H}} = g_{\aleph}$.

Definition 2.6. (Sezgin et al., 2025b) Let f_K and $g_{\aleph}$ be two $\mathcal{SS}$s. Then, f_K is called a soft S-subset of $g_{\aleph}$, denoted by $f_K \tilde{\subseteq}_S g_{\aleph}$ if for all $w \in E$, $f_K(w) = \mathcal{M}$ and $g_{\aleph}(w) = \mathcal{D}$, where $\mathcal{M}$ and $\mathcal{D}$ are two fixed sets and $\mathcal{M} \subseteq \mathcal{D}$. Moreover, two SSs f_K and $g_{\aleph}$ are said to be soft S-equal, denoted by $f_K =_S g_{\aleph}$, if $f_K \tilde{\subseteq}_S g_{\aleph}$ and $g_{\aleph} \tilde{\subseteq}_S f_K$.

It is obvious that if $f_K =_S g_{\aleph}$, then f_K and $g_{\aleph}$ are the same constant functions, that is, for all $w \in E$, $f_K(w) = g_{\aleph}(w) = \mathcal{M}$, where $\mathcal{M}$ is a fixed set.

Definition 2.7. (Sezgin et al., 2025b) Let f_K and $g_{\aleph}$ be two $\mathcal{SS}$s. Then, f_K is called a soft A-subset of $g_{\aleph}$, denoted by $f_K \tilde{\subseteq}_A g_{\aleph}$, if, for each $a, b \in E$, $f_K(a) \subseteq g_{\aleph}(b)$.

Definition 2.8. (Sezgin et al., 2025b) Let f_K and $g_{\aleph}$ be two $\mathcal{SS}$s. Then, f_K is called a soft S-complement of $g_{\aleph}$, denoted by $f_K =_S (g_{\aleph})^c$, if, for all $w \in E$, $f_K(w) = \mathcal{M}$ and $g_{\aleph}(w) = \mathcal{D}$, where $\mathcal{M}$ and $\mathcal{D}$ are two fixed sets and $\mathcal{M} = \mathcal{D}'$.

From now on, let G be a group, and $S_G(U)$ denotes the collection of all $\mathcal{SS}$s over U, whose parameter sets are G; that is, each element of $S_G(U)$ is an $\mathcal{SS}$ parameterized by G.

Definition 2.9. (Sezgin and Ay, 2025) Let f_G and g_G be two $\mathcal{SS}$s. Then, the intersection-difference product $f_G \otimes_{i/d} g_G$ is defined by

$$(f_G \otimes_{i/d} g_G)(x) = \bigcap_{x=yz} \left(f_G(y) \setminus g_G(z)\right), \qquad y, z \in G$$

for all $x \in G$.

For additional information on SSs, we refer to (Aktas and Çağman, 2007; Alcantud et al., 2024; Ali et al., 2015; Ali et al., 2022; Atagün et al., 2019; Atagün and Sezer, 2015; Atagün and Sezgin, 2017; Atagün and Sezgin, 2018; Atagün and Sezgin, 2022; Feng et al., 2008; Gulistan and Shahzad, 2014; Gulistan et al., 2018; Jana et al., 2019; Karaaslan, 2019; Khan et al., 2017; Mahmood et al., 2015; Mahmood et al., 2018; Manikantan et al., 2023; Memiş, 2022; Özlü and Sezgin, 2020; Riaz et al., 2023; Sezer and

Atagün, 2016; Sezer et al., 2017; Sezer et al., 2013; Sezer et al., 2014; Sezgin and İlgin, 2024; Sezgin et al., 2022; Sezgin and Onur, 2024; Sezgin et al., 2024; Sezgin and Orbay, 2022; Sezgin et al., 2019; Sun et al., 2008; Tunçay and Sezgin, 2016; Ullah et al., 2018; Sezgin et al., 2024a, 2024b).

3. Soft Intersection–Symmetric Difference Product Of Groups

In this section, we introduce a novel product off soft sets, termed the soft intersection–symmetric difference product, defined over parameter setss endowed with group structures. We undertake a thorough algebraic analysis aimed at rigorously characterizing the operation's fundamental structural attributes. Special attention is devoted to elucidating the interplay between this product and various generalized soft equality relations, alongside the hierarchical classification of soft subsets under diverse inclusion frameworks. To bridge abstract theory with concrete insight, the exposition incorporates a curated collection of illustrative examples that demonstrate the operational dynamics and algebraic subtleties inherent to the product. Additionally, we explore the relation between the proposed product and some other certainn soft products with respect to the soft subsets, thereby clarifying its algebraic compatibility within the existing operational landscape. This examination effectively highlighs the proposed soft product's structural coherence and potential for integration into more comprehensive soft algebraic systems.

Definition 3.1:

Let f_G and g_G be two SSs. Then, the soft intersection-symmetric difference product $f_G \otimes_{i/s} g_G$ is defined by

$$(f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} \left(f_G(y) \Delta g_G(z)\right), \qquad y, z \in G$$

for all $x \in G$.

Note here that since G is a group, there always exist $y, z \in G$ such that $x = yz$, for all $x \in G$. Let the order of the group G be n, that is, $|G| = n$. Then, it is obvious that there exist n different combinations of writing styles for each $x \in G$ such that $x = yz$, where $y, z \in G$.

Note 3.2: The soft intersection-symmetric difference product is well-defined in $S_G(U)$. In fact, let $f_G, g_G, m_G, k_G \in S_G(U)$ such that $(f_G, g_G) = (m_G, k_G)$. Then, $f_G = m_G$ and $g_G = k_G$, implying that $f_G(x) = m_G(x)$ and $g_G(x) = k_G(x)$, for all $x \in G$. Thereby, for all $x \in G$,

$$\begin{aligned}(f_G \otimes_{i/s} g_G)(x) &= \bigcap_{x=yz} \left(f_G(y) \Delta g_G(z)\right) \\ &= \bigcap_{x=yz} \left(m_G(y) \Delta k_G(z)\right) \\ &= (m_G \otimes_{i/s} k_G)(x)\end{aligned}$$

Hence, $f_G \otimes_{i/s} g_G = m_G \otimes_{i/s} k_G$.

Example 3.3: Consider the group $G = \{\rho, \tau\}$ with the following operation:

$\cdot$	ρ	τ
ρ	ρ	τ
τ	τ	ρ

Let f_G and g_G be two SSs over $U = D_2 = \{< x, y >: x^2 = y^2 = e, xy = yx\} = \{e, x, y, yx\}$ as follows:

$f_G = \{(\rho, \{e, x\}), (\tau, \{x, yx\})\}$ and $g_G = \{(\rho, \{x, y\}), (\tau, \{e, x, yx\})\}$

Since $\rho = \rho\rho = \tau\tau$, $(f_G \otimes_{i/s} g_G)(\rho) = (f_G(\rho) \Delta g_G(\rho)) \cap (f_G(\tau) \Delta g_G(\tau)) = \{e\}$, and since $\tau = \rho\tau = \tau\rho$, $(f_G \otimes_{i/s} g_G)(\tau) = (f_G(\rho) \Delta g_G(\tau)) \cap (f_G(\tau) \Delta g_G(\rho)) = \{yx\}$ is obtained. Hence,

$f_G \otimes_{i/s} g_G = \{(\rho, \{e\}), (\tau, \{yx\})\}$

Proposition 3.4:

The set $S_G(U)$ is closed under the soft intersection-symmetric difference product. That is, if f_G and g_G are two SSs, then so is $f_G \otimes_{i/s} g_G$.

PROOF. It is obvious that the soft intersection-symmetric difference product is a binary operation in $S_G(U)$. Thereby, $S_G(U)$ is closed under the soft intersection-symmetric difference product. □

Proposition 3.5:

The soft intersection-symmetric difference product is not associative in $S_G(U)$.

PROOF. Consider the group G and the SSs f_G and g_G in Example 3.3, and let $h_G = \{(\rho, \{yx\}), (\tau, \{e, x, y\})\}$ be an SS over $U = \{e, x, y, yx\}$.

Since $f_G \otimes_{i/s} g_G = \{(\rho, \{e\}), (\tau, \{yx\})\}$, then

$(f_G \otimes_{i/s} g_G) \otimes_{i/s} h_G = \{(\rho, \{e, yx\}), (\tau, \emptyset)\}$

Moreover, since $g_G \otimes_{i/s} h_G = \{(\rho, \{y, yx\}), (\tau, \{e\})\}$, then

$f_G \otimes_{i/s} (g_G \otimes_{i/s} h_G) = \{(\rho, \{e, x, yx\}), (\tau, \{x\})\}$

Thereby, $(f_G \otimes_{i/s} g_G) \otimes_{i/s} h_G \neq f_G \otimes_{i/s} (g_G \otimes_{i/s} h_G)$. □

Proposition 3.6:

The soft intersection-union product is not commutative in $S_G(U)$. However, if G is an abelian group, then the intersection-union product is commutative in $S_G(U)$.

PROOF. Let f_G, g_G be two SSs and G be an abelian group. Then, for all $x \in G$,

$$\begin{aligned}(f_G \otimes_{i/s} g_G)(x) &= \bigcap_{x=yz} \left(f_G(y) \Delta g_G(z)\right) \\ &= \bigcap_{x=zy} \left(g_G(z) \Delta f_G(y)\right) \\ &= (g_G \otimes_{i/s} f_G)(x)\end{aligned}$$

implying that $f_G \otimes_{i/s} g_G = g_G \otimes_{i/s} f_G$. □

Proposition 3.7:

The soft intersection-symmetric difference product is not idempotent in $S_G(U)$.

PROOF. Consider the SS f_G in Example 3.3. Then,

$f_G \otimes_{i/s} f_G = \{(\rho, \emptyset), (\tau, \emptyset)\}$

implying that $f_G \otimes_{i/s} f_G \neq f_G$. □

Proposition 3.8:

Let f_G be a constant SS. Then, $f_G \otimes_{i/s} f_G = \emptyset_G$.

PROOF. Let f_G be a constant SS such that, for all $x \in G$, $f_G(x) = A$, where A is a fixed set. Hence, for all $x \in G$,

$$(f_G \otimes_{i/s} f_G)(x) = \bigcap_{x=yz} \left(f_G(y) \Delta f_G(z)\right) = \emptyset_G(x)$$

Thereby, $f_G \otimes_{i/s} f_G = \emptyset_G$. □

Remark 3.9:

Let $S_G{}^*(U)$ be the collection of all constant SSs. Then, the soft intersection-symmetric difference product is not idempotent in $S_G{}^*(U)$ either.

Proposition 3.10:

Let f_G be a constant SS. Then, $f_G \otimes_{i/s} \emptyset_G = \emptyset_G \otimes_{i/s} f_G = f_G$.

PROOF. Let f_G be a constant SS such that, for all $x \in G$, $f_G(x) = A$, where A is a fixed set. Hence, for all $x \in G$,

$$(f_G \otimes_{i/s} \emptyset_G)(x) = \bigcap_{x=yz} \left(f_G(y) \Delta \emptyset_G(z)\right) = \bigcap_{x=yz} \left(f_G(y) \Delta \emptyset\right) = f_G(x)$$

Thereby, $f_G \otimes_{u/s} \emptyset_G = f_G$. Similarly, for all $x \in G$,

$(\emptyset_G \otimes_{i/s} f_G)(x) = \bigcap_{x=yz} (\emptyset_G(y) \Delta f_G(z)) = \bigcap_{x=yz} (\emptyset \Delta f_G(z)) = f_G(x)$

Thereby, $\emptyset_G \otimes_{i/s} f_G = f_G$.

Remark 3.11:

$\emptyset_G$ is the identity element of the soft intersction-symmetric difference product in $S_G{}^*(U)$. Besides, the inverse of each element is itself in $S_G{}^*(U)$ with respect to the soft intersction-symmetric difference product by Proposition 3.8.

Proposition 3.12:

Let f_G be a constant SS. Then, $f_G \otimes_{i/s} U_G = U_G \otimes_{i/s} f_G = f_G{}^c$.

PROOF. Let f_G be a constant SS such that, for all $x \in G$, $f_G(x) = A$, where A is a fixed set. Hence, for all $x \in G$,

$$(f_G \otimes_{i/s} U_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta U_G(z)) = \bigcap_{x=yz} (f_G(y) \Delta U) = f_G{}^c(x)$$

Thereby, $f_G \otimes_{u/s} U_G = f_G{}^c$. Similarly, for all $x \in G$,

$$(U_G \otimes_{i/s} f_G)(x) = \bigcap_{x=yz} (U_G(y) \Delta f_G(z)) = \bigcap_{x=yz} (U \Delta f_G(z)) = f_G{}^c(x)$$

Thereby, $U_G \otimes_{i/s} f_G = f_G{}^c$.

Proposition 3.13:

Let f_G be a constant SS. Then, $f_G \otimes_{i/s} f_G{}^c = f_G{}^c \otimes_{i/s} f_G = U_G$.

PROOF. Let f_G be a constant SS such that, for all $x \in G$, $f_G(x) = A$, where A is a fixed set. Hence, for all $x \in G$,

$$(f_G \otimes_{i/s} f_G{}^c)(x) = \bigcap_{x=yz} (f_G(y) \Delta f_G{}^c(z)) = U = U_G(x)$$

Thereby, $f_G \otimes_{i/s} f_G{}^c = U_G$. Similarly, for all $x \in G$,

$$(f_G{}^c \otimes_{i/s} f_G)(x) = \bigcap_{x=yz} (f_G{}^c(y) \Delta f_G(z)) = U = U_G(x)$$

Thus, $f_G{}^c \otimes_{i/s} f_G = U_G$.□

Theorem 3.14:

Let f_G and g_G be two SSs. Then, $f_G \otimes_{i/s} g_G = U_G$ if only if $f_G =_S (g_G)^c$.

PROOF. Let $f_G =_S (g_G)^c$. Then, for all $x \in G$, $f_G(x) = A$ and $g_G(x) = B$, where A and B are two fixed sets and $A = B'$. Hence, for all $x \in G$,

$$(f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) = U = U_G(x)$$

Thereby, $f_G \otimes_{i/s} g_G = U_G$.

Conversely, suppose that $f_G \otimes_{i/s} g_G = U_G$. That is, $(f_G \otimes_{i/s} g_G)(x) = U_G(x)$, for each $x \in G$. Then, for all $x \in G$,

$$U_G(x) = (f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) = U$$

This implies that $f_G(y) \Delta g_G(z) = U$, for all $y, z \in G$. Thus, $f_G =_S (g_G)^c$. □

Proposition 3.15:

Let f_G and g_G be two SSs. Then, $(f_G \otimes_{i/s} g_G)^c = f_G \otimes_{u/s'} g_G$.

PROOF. Let f_G and g_G be two SSs. Then, for all $x \in G$,

$$(f_G \otimes_{i/s} g_G)^c(x) = \left(\bigcap_{x=yz} (f_G(y) \Delta g_G(z))\right)'$$

$$= \bigcup_{x=yz} (f_G(y) \Delta g_G(z))'$$

$$= \bigcup_{x=yz} (f_G(y) \amalg g_G(z))$$

$$= (f_G \otimes_{u/s'} g_G)^c(x)$$

Thus, $(f_G \otimes_{i/s} g_G) = f_G \otimes_{u/s'} g_G$. For more on the symmetric difference complement ($\amalg$) operation, we refer to (Ay and Sezgin, 2025).

Proposition 3.16:

Let f_G and g_G be two SSs. If $g_G \subseteq_A f_G$, then $f_G \otimes_{i/s} g_G = f_G \otimes_{i/d} g_G$.

PROOF. Let f_G and g_G be two SSs such that $g_G \subseteq_A f_G$. Then, for each $x, y \in G$, $g_G(x) \subseteq f_G(y)$. Thus, for all $x \in G$,

$$(f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) = \bigcap_{x=yz} (f_G(y) \setminus g_G(z)) = (f_G \otimes_{i/d} g_G)(x)$$

Thus, $f_G \otimes_{i/s} g_G = f_G \otimes_{i/d} g_G$.

Remark 3.17:

Let f_G and g_G be two SSs. If If $g_G \subseteq_s f_G$, then $f_G \otimes_{i/s} g_G = f_G \tilde{\setminus} g_G$.

Proposition 3.18:

Let f_G and g_G be two SSs. Then, $f_G \otimes_{i/s} g_G \tilde{\subseteq} f_G \otimes_{u/s} g_G$.

PROOF. Let f_G and g_G be two SSs. Then, for all $x \in G$,

$$(f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta g_G(z))$$

$$\subseteq \bigcup_{x=yz} (f_G(y) \Delta g_G(z))$$

$$= (f_G \otimes_{u/s} g_G)(x)$$

Thus, $f_G \otimes_{i/s} g_G \tilde{\subseteq} f_G \otimes_{u/s} g_G$. □

Proposition 3.19:

Let f_G and g_G be two SSs. If one of the following assertions is satisfied, then $f_G \otimes_{i/s} g_G = f_G \otimes_{u/s} g_G$:

i. $f_G \tilde{\subseteq}_S g_G$

ii. $g_G \tilde{\subseteq}_S f_G$

iii. $f_G =_S (g_G)^c$

PROOF. Let f_G and g_G be two SSs.

i. Let $f_G \tilde{\subseteq}_S g_G$. Hence, for all $x \in G$, $f_G(x) = A$ and $g_G(x) = B$, where A and B are two fixed sets and $A \subseteq B$. Then, for all $x \in G$,

$$(f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta g_G(z))$$

$$= \bigcup_{x=yz} (f_G(y) \Delta g_G(z))$$

$$= (f_G \otimes_{u/s} g_G)(x)$$

Thereby, $f_G \otimes_{i/s} g_G = f_G \otimes_{u/s} g_G$.

ii. Let $g_G \tilde{\subseteq}_S f_G$. Hence, for all $x \in G$, $f_G(x) = A$ and $g_G(x) = B$, where A and B are two fixed sets and $B \subseteq A$. Then, for all $x \in G$,

$$(f_G \otimes_{i/s} g_G)(x) = \bigcap_{x=yz} (f_G(y) \Delta g_G(z))$$

$$= \bigcup_{x=yz} (f_G(y) \Delta g_G(z))$$

$$= (f_G \otimes_{u/s} g_G)(x)$$

Thereby, $f_G \otimes_{i/s} g_G = f_G \otimes_{u/s} g_G$.

iii. Let $f_G =_S (g_G)^c$. Then, for all $x \in G$, $f_G(x) = A$ and $g_G(x) = B$, where A and B are two fixed sets and $A = B'$. Hence, for all $x \in G$,

$$\begin{aligned}(f_G \otimes_{i/s} g_G)(x) &= \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) \\ &= U \\ &= \bigcup_{x=yz} (f_G(y) \Delta g_G(z)) \\ &= (f_G \otimes_{u/s} g_G)(x)\end{aligned}$$

Thereby, $f_G \otimes_{i/s} g_G = f_G \otimes_{u/s} g_G$. □

Proposition 3.20:

Let f_G and g_G be two SSs. Then, $f_G \otimes_{i/s} g_G \,\tilde{\subseteq}\, f_G \otimes_{i/u} g_G$.

PROOF. Let f_G and g_G be two SSs. Then, for all $x \in G$,

$$\begin{aligned}(f_G \otimes_{i/s} g_G)(x) &= \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) \\ &\subseteq \bigcap_{x=yz} (f_G(y) \cup g_G(z)) \\ &= (f_G \otimes_{i/u} g_G)(x)\end{aligned}$$

Thus, $f_G \otimes_{i/s} g_G \,\tilde{\subseteq}\, f_G \otimes_{i/u} g_G$. □

Proposition 3.21:

Let f_G and g_G be two SSs. If one of the following assertions is satisfied, then $f_G \otimes_{i/s} g_G = f_G \otimes_{i/u} g_G$:

i. $f_G = \emptyset_G$ or $g_G = \emptyset_G$

ii. $f_G =_S (g_G)^c$

PROOF. Let f_G and g_G be two SSs.

i. Without loss of generality, let $f_G = \emptyset_G$. Then, for all $x \in G$, $f_G(x) = \emptyset$. Thus, for all $x \in G$,

$$\begin{aligned}(f_G \otimes_{i/s} g_G)(x) &= \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) \\ &= \bigcap_{x=yz} (f_G(y) \cup g_G(z)) \\ &= (f_G \otimes_{i/u} g_G)(x)\end{aligned}$$

Thereby, $f_G \otimes_{i/s} g_G = f_G \otimes_{i/u} g_G$.

ii. Let $f_G =_S (g_G)^c$. Then, for all $x \in G$, $f_G(x) = A$ and $g_G(x) = B$, where A and B are two fixed sets and $A = B'$. Hence, for all $x \in G$,

$$\begin{aligned}(f_G \otimes_{i/s} g_G)(x) &= \bigcap_{x=yz} (f_G(y) \Delta g_G(z)) \\ &= U \\ &= \bigcap_{x=yz} (f_G(y) \cup g_G(z)) \\ &= (f_G \otimes_{i/u} g_G)(x)\end{aligned}$$

Thereby, $f_G \otimes_{i/s} g_G = f_G \otimes_{i/u} g_G$. □

4. Conclusion

This study initiates with the formal definition of a novel product of soft sets, referred to as the soft intersection–symmetric difference product, constructed over a parameter domain equipped with a group-theoretic structure. Anchored in this foundational formulation, we conduct a rigorous algebraic investigation of the operation, with particular focus on its behavior under various taxonomies of soft subsethood and its compatibility with generalized soft equality relations. Furthermore, the proposed operation undergoes an in-depth comparative analysis with earlier soft product constructions within the hierarchical taxonomy of soft subset classifications, thereby yielding refined theoretical insights into their respective representational capacities and algebraic congruence. Concurrently, a meticulous structural investigation into the product's behavior with respect to both the null and absolute soft sets further elucidates its foundational role within the broader algebraic framework.The systematic development and examination of such operations within an axiomatized algebraic framework constitute a cornerstone of abstract algebra, wherein structural validation through properties such as closure, associativity, commutativity, idempotenncy, and the existence (or nonexistence) of identity, inverse, and absorbing elements is essential for the formal classification of the induced algebraic system within the established algebraic hierarchy.The algebraic regularities and structural phenomena uncovered through this analysis not only consolidate the internal logical coherence of the framework but also affirm the product's capacity to generalize classical algebraic constructs, thereby extending the expressive reach of soft algebraic systems. From a theoretical standpoint, the framework articulated herein addresses critical gaps in the existing body of literature and provides a robust foundation for the formal emergence of a new line of inquiry: soft group theory, grounded in the structural behavior of the proposed operation. Future explorations may aim to synthesize further algebraic operations within soft environments and refine generalized soft equality notions, ultimately broadening the theoretical landscape and enhancing the methodological applicability of soft set theory in algebraic modeling, computational structures, and decision-theoretic analysis under uncertainty.

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References

Abbas, M., Ali, B., and Romaguera, S., 2014. On generalized soft equality and soft lattice structure. Filomat, 28(6), Pp. 1191–1203.

Abbas, M., Ali, M. I., and Romaguera, S., 2017. Generalized operations in soft set theory via relaxed conditions on parameters. Filomat, 31(19), Pp. 5955–5964.

Aktas, H., and Çağman, N., 2007. Soft sets and soft groups. Information Sciences, 177(13), Pp. 2726–2735.

Ali, M. I., Feng, F., Liu, X., Min, W. K., and Shabir, M., 2009. On some new operations in soft set theory. Computers and Mathematics with Applications, 57(9), Pp. 1547–1553.

Ali, M. I., Mahmood, M., Rehman, M. U., and Aslam, M. F., 2015. On lattice ordered soft sets. Applied Soft Computing, 36, Pp. 499–505.

Ali, B., Saleem, N., Sundus, N., Khaleeq, S., Saeed, M., and George, R., 2022. A contribution to the theory of soft sets via generalized relaxed operations. Mathematics, 10(15), Pp. 26–36.

Ali, M. I., Shabir, M., and Naz, M., 2011. Algebraic structures of soft sets associated with new operations. Computers and Mathematics with Applications, 61(9), Pp. 2647–2654.

Al Shami, T. M., 2019. Investigation and corrigendum to some results related to g soft equality and gf soft equality relations. Filomat, 33(11), Pp. 3375–3383.

Alshami, T., and El Shafei, M., 2020. T soft equality relation. Turkish Journal of Mathematics, 44(4), Pp. 1427–1441.

Atagün, A. O., Kamacı, H., Taştekin, İ., and Sezgin, A., 2019. P properties in near rings. Journal of Mathematical and Fundamental Sciences, 51(2), Pp. 152–167.

Atagün, A. O. and Sezer, A. S. 2015. Soft sets, soft semimodules and soft substructures of semimodules. Mathematical Sciences Letters, 4(3), Pp. 235-242.

Atagün, A. O., and Sezgin, A., 2017. Int soft substructures of groups and semirings with applications. Applied Mathematics and Information Sciences, 11(1), Pp. 105–113.

Atagün, A. O., and Sezgin, A., 2018. A new view to near ring theory: Soft near rings. South East Asian Journal of Mathematics and Mathematical Sciences, 14(3), Pp. 1–14.

Ay, Z., and Sezgin, A., 2025, Soft union-symmetric difference complement product of groups, Natural Sciences and Engineering Bulletin, in press.

Çağman, N., and Enginoğlu, S., 2010. Soft set theory and uni int decision making. European Journal of Operational Research, 207(2), Pp. 848–855.

Eren, Ö. F., and Çalışıcı, H., 2019. On some operations of soft sets. The

Fourth International Conference on Computational Mathematics and Engineering Sciences.

Feng, F., and Li, Y., 2013. Soft subsets and soft product operations. Information Sciences, 232(20), Pp. 44–57.

Feng, F., Li, Y. M., Davvaz, B., and Ali, M. I., 2010. Soft sets combined with fuzzy sets and rough sets: A tentative approach. Soft Computing, 14, Pp. 899–911.

Feng, F., Jun, Y. B., and Zhao, X., 2008. Soft semirings. Computers and Mathematics with Applications, 56(10), Pp. 2621–2628.

Fu, L., 2011. Notes on soft set operations. ARPN Journal of Systems and Software, 1, Pp. 205–208.

Ge, X., and Yang, S., 2011. Investigations on some operations of soft sets. World Academy of Science, Engineering and Technology, 75, Pp. 1113–1116.

Gulistan, M., and Shahzad, M., 2014. On soft KU algebras. Journal of Algebra, Number Theory: Advances and Applications, 11(1), Pp. 1–20.

Gulistan, M., Feng, F., Khan, M., and Sezgin, A., 2018. Characterizations of right weakly regular semigroups in terms of generalized cubic soft sets. Mathematics, 6, 293.

Jana, C., Pal, M., Karaaslan, F., and Sezgin, A., 2019. (α, β) soft intersectional rings and ideals with their applications. New Mathematics and Natural Computation, 15(2), Pp. 333–350.

Jiang, Y., Tang, Y., Chen, Q., Wang, J., and Tang, S., 2010. Extending soft sets with description logics. Computers and Mathematics with Applications, 59(6), Pp. 2087–2096.

Jun, Y. B., and Yang, X., 2011. A note on the paper combination of interval valued fuzzy set and soft set. Computers and Mathematics with Applications, 61(5), Pp. 1468–1470.

Karaaslan, F., 2019. Some properties of AG* groupoids and AG bands under SI product operation. Journal of Intelligent and Fuzzy Systems, 36(1), Pp. 231–239.

Kaygisiz, K., 2012. On soft int groups. Annals of Fuzzy Mathematics and Informatics, 4(2), Pp. 363–375.

Khan, M., Ilyas, F., Gulistan, M., and Anis, S., 2015. A study of soft AG groupoids. Annals of Fuzzy Mathematics and Informatics, 9(4), Pp. 621–638.

Khan, A., Izhar, I., and Sezgin, A., 2017. Characterizations of Abel Grassmann's groupoids by the properties of their double framed soft ideals. International Journal of Analysis and Applications, 15(1), Pp. 62–74.

Liu, X., Feng, F., and Jun, Y. B., 2012. A note on generalized soft equal relations. Computers and Mathematics with Applications, 64(4), Pp. 572–578.

Maji, P. K., Biswas, R., and Roy, A. R., 2003. Soft set theory. Computers and Mathematics with Applications, 45(1), Pp. 555–562.

Mahmood, T., Waqas, A., and Rana, M. A., 2015. Soft intersectional ideals in ternary semiring. Science International, 27(5), Pp. 3929–3934.

Mahmood, T., Rehman, Z. U., and Sezgin, A., 2018. Lattice ordered soft near rings. Korean Journal of Mathematics, 26(3), Pp. 503–517.

Manikantan, T., Ramasany, P., and Sezgin, A., 2023. Soft quasi ideals of soft near rings. Sigma Journal of Engineering and Natural Science, 41(3), Pp. 565–574.

Memiş, S., 2022. Another view on picture fuzzy soft sets and their product operations with soft decision making. Journal of New Theory, 38, Pp. 1–13.

Molodtsov, D., 1999. Soft set theory. Computers and Mathematics with Applications, 37(1), Pp. 19–31.

Muştuoğlu, E., Sezgin, A., and Türk, Z. K., 2016. Some characterizations on soft uni groups and normal soft uni groups. International Journal of Computer Applications, 155(10), Pp. 1–8.

Neog, I. J., and Sut, D. K., 2011. A new approach to the theory of softset. International Journal of Computer Applications, 32(2), Pp. 1–6.

Onyeozili, I. A., and Gwary, T. M., 2014. A study of the fundamentals of soft set theory. International Journal of Scientific and Technology Research, 3(4), Pp. 132–143.

Özlü, Ş., and Sezgin, A., 2020. Soft covered ideals in semigroups. Acta Universitatis Sapientiae Mathematica, 12(2), Pp. 317–346.

Pei, D., and Miao, D., 2005. From soft sets to information systems. In X. Hu et al. (Eds.), Proceedings of Granular Computing (Vol. 2, pp. 617–621). IEEE.

Riaz, M., Hashmi, M. R., Karaaslan, F., Sezgin, A., Shamiri, M. M. A. A., and Khalaf, M. M., 2023. Emerging trends in social networking systems and generation gap with neutrosophic crisp soft mapping. CMES–Computer Modeling in Engineering and Sciences, 136(2), Pp. 1759–1783.

Qin, K., and Hong, Z., 2010. On soft equality. Journal of Computational and Applied Mathematics, 234(5), Pp. 1347–1355.

Sen, J., 2014. On algebraic structure of soft sets. Annals of Fuzzy Mathematics and Informatics, 7(6), Pp. 1013–1020.

Sezer, A. S., 2012. A new view to ring theory via soft union rings, ideals and bi ideals. Knowledge Based Systems, 36, Pp. 300–314.

Sezer, A. S., and Atagün, A. O., 2016. A new kind of vector space: Soft vector space. Southeast Asian Bulletin of Mathematics, 40(5), Pp. 753–770.

Sezer, A., Atagün, A. O., and Çağman, N., 2017. N group SI action and its applications to N group theory. Fasciculi Mathematici, 52, Pp. 139–153.

Sezer, A., Atagün, A. O., and Çağman, N., 2013. A new view to N group theory: Soft N groups. Fasciculi Mathematici, 51, Pp. 123–140.

Sezer, A. S., Çağman, N., Atagün, A. O., Ali, M. I., and Türkmen, E., 2015. Soft intersection semigroups, ideals and bi ideals; A new application on semigroup theory I. Filomat, 29(5), Pp. 917–946.

Sezer, A. S., Çağman, N., and Atagün, A. O., 2014. Soft intersection interior ideals, quasi ideals and generalized bi ideals; A new approach to semigroup theory II. Journal of Multiple Valued Logic and Soft Computing, 23(1–2), Pp. 161–207.

Sezgin, A., 2016. A new approach to semigroup theory I: Soft union semigroups, ideals and bi ideals. Algebra Letters, 2016(3), Pp. 1–46.

Sezgin, A., and İlgin, A., 2024. Soft intersection almost subsemigroups of semigroups. International Journal of Mathematics and Physics, 15(1), Pp. 13–20.

Sezgin, A., Atagün, A. O., and Çağman, N., 2025a. A complete study on and product of soft sets. Sigma Journal of Engineering and Natural Sciences, 43(1), Pp. 1–14.

Sezgin, A., Atagün, A. O., Çağman, N., and Demir, H., 2022. On near rings with soft union ideals and applications. New Mathematics and Natural Computation, 18(2), Pp. 495–511.

Sezgin, A., and Ay, Z., 2025. Soft intersection-difference product of groups. Uncertainty Discourse and Applications, 2(1), Pp. 45-58.

Sezgin, A., Aybek, F., and Atagün, A. O., 2023a. A new soft set operation: Complementary soft binary piecewise intersection operation. Black Sea Journal of Engineering and Science, 6(4), Pp. 330–346.

Sezgin, A., Aybek, F., and Güngör, N. B., 2023b. A new soft set operation: Complementary soft binary piecewise union operation. Acta Informatica Malaysia, 7(1), Pp. 38–53.

Sezgin, A., and Çağman, N., 2024. A new soft set operation: Complementary soft binary piecewise difference operation. Osmaniye Korkut Ata University Journal of the Institute of Science and Technology, 7(1), Pp. 1–37.

Sezgin, A., and Çağman, N., 2025. An extensive study on restricted and extended symmetric difference operations of soft sets. Utilitas Mathematica. (in press).

Sezgin, A., Çağman, N., and Atagün, A. O., 2017. A completely new view to soft intersection rings via soft uni int product. Applied Soft Computing, 54, Pp. 366–392.

Sezgin, A., Çağman, N., Atagün, A. O., and Aybek, F., 2023c. Complemental binary operations of sets and their application to group theory. Matrix Science Mathematic, 7(2), Pp. 99–106.

Sezgin, A., and Çalışıcı, H., 2024. A comprehensive study on soft binary piecewise difference operation. Eskişehir Teknik Üniversitesi Bilim ve Teknoloji Dergisi B Teorik Bilimler, 12(1), Pp. 1–23.

Sezgin, A., and Dagtoros, K., 2023. Complementary soft binary piecewise symmetric difference operation: A novel soft set operation. Scientific Journal of Mehmet Akif Ersoy University, 6(2), Pp. 31–45.

Sezgin, A., and Demirci, A. M., 2023. A new soft set operation: Complementary soft binary piecewise star operation. Ikonion Journal of Mathematics, 5(2), Pp. 24–52.

Sezgin, A., Durak, İ., and Ay, Z., 2025b. Some new classifications of soft subsets and soft equalities with soft symmetric difference difference product of groups. Journal of Amasya University the Institute of Sciences and Technology, Amesia, 6(1), Pp. 16-32.

Sezgin, A., and Onur, B., 2024a. Soft intersection almost bi ideals of semigroups. Systemic Analytics, 2(1), Pp. 95–105.

Sezgin, A., Onur, B., and İlgin, A., 2024. Soft intersection almost tri ideals of semigroups. SciNexuses, 1, Pp. 126–138.

Sezgin, A., and Orbay, M., 2022. Analysis of semigroups with soft intersection ideals. Acta Universitatis Sapientiae, Mathematica, 14(2), Pp. 166–210.

Sezgin, A., and Sarıalioğlu, M., 2024a. A new soft set operation: Complementary soft binary piecewise theta operation. Journal of Kadirli Faculty of Applied Sciences, 4(2), Pp. 325–357.

Sezgin, A., and Sarıalioğlu, M., 2024b. Complementary extended gamma operation: A new soft set operation. Natural and Applied Sciences Journal, 7(1), Pp. 15–44.

Sezgin, A., Shahzad, A., and Mehmood, A., 2019. A new operation on soft sets: Extended difference of soft sets. Journal of New Theory, 27, Pp. 33–42.

Sezgin, A., and Şenyiğit, E., 2025. A new product for soft sets with its decision making: Soft star product. Big Data and Computing Visions, 5(1), Pp. 52–73.

Sezgin, A., and Yavuz, E., 2023a. A new soft set operation: Soft binary piecewise symmetric difference operation. Necmettin Erbakan University Journal of Science and Engineering, 5(2), Pp. 150–168.

Sezgin, A., and Yavuz, E., 2023b. A new soft set operation: Complementary soft binary piecewise lambda operation. Sinop University Journal of Natural Sciences, 8(2), Pp. 101–133.

Sezgin, A, Yavuz, E, and Özlü, Ş. 2024b. Insight into soft binary piecewise lambda operation: a new operation for soft sets. Journal of Umm Al-qura University for Applied Sciences, https://doi.org/10.1007/s43994-024-00187-1, in press.

Singh, D., and Onyeozili, I. A., 2012a. Notes on soft matrices operations. ARPN Journal of Science and Technology, 2(9), Pp. 861–869.

Singh, D., and Onyeozili, I. A., 2012b. On some new properties on soft set operations. International Journal of Computer Applications, 59(4), Pp. 39–44.

Singh, D., and Onyeozili, I. A., 2012c. Some results on distributive and absorption properties on soft operations. IOSR Journal of Mathematics (IOSR JM), 4(2), Pp. 18–30.

Singh, D., and Onyeozili, I. A., 2012d. Some conceptual misunderstanding of the fundamentals of soft set theory. ARPN Journal of Systems and Software, 2(9), Pp. 251–254.

Stojanovic, N. S., 2021. A new operation on soft sets: Extended symmetric difference of soft sets. Military Technical Courier, 69(4), Pp. 779–791.

Tunçay, M., and Sezgin, A., 2016. Soft union ring and its applications to ring theory. International Journal of Computer Applications, 151(9), Pp. 7–13.

Ullah, A., Karaaslan, F., and Ahmad, I., 2018. Soft uni abel grassmann's groups. European Journal of Pure and Applied Mathematics, 11(2), Pp. 517–536.

Yang, C. F., 2008. A note on: Soft set theory. Computers and Mathematics with Applications, 56(7), Pp. 1899–1900.

Zadeh, L. A., 1965. Fuzzy sets. Information and Control, 8(3), Pp. 338–353.

Zhu, P., and Wen, Q., 2013. Operations on soft sets revisited. Journal of Applied Mathematics, 2013, Article ID 105752, 7 pages.