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A New Neutrosophic Algebraic Structures

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Abstract: A new approach of neutrosophic algebraic structure is discussed in the work, which will open the door in front of researchers to new research about neutrosophic algebraic structure. In this work, we define new neutrosophic groupoid (semigroup, monoid) and new neutrosophic subgroupoid (subsemigroup, submonoid) in a new way which is more natural than the previous versions and we discuss some properties of these new neutrosophic concepts. Also, we discuss the relationship of new neutrosophic algebraic structures with other classical neutrosophic algebraic structure and prove some results. Finally, we introduced a new NeutroGroupoid and new NeutroSemiGroup.

Keywords: neutrosophic algebraic structure, new neutrosophic groupoid, new neutrosophic semigroup, new neutrosophic monoid, new NeutroGroupoid, new NeutroSemiGroup

1. Introduction

A new branch of philosophy, "neutrosophic" (Smarandache, 1999), takes place in many sciences, especially in algebra and topology (Al-Omeri, 2016; Al-Omeri & Jafari, 2019; Das et al., 2021; Gunuuz Aras et al., 2019; Jayaparthasarathy et al., 2019; Salama, 2015; Salama & Alblowi, 2012; Suresh & Palaniammal, 2020). Recently, neutrosophic sets have applications in the medical field (Abdel-Basset et al., 2019a; Abdel-Basset et al., 2019b).

Then many researchers generalizations the neutrosophic topological space to neutrosophic bi-topological space see (Al-Hamido, 2018; Gowri & Rajayal, 2017; Ozturk & Ozkan, 2019) via neutrosophic sets which is more generalized than fuzzy set and classical sets.

In recent years, Agboola et al. (2011) and Agboola et al. (2012) studied many neutrosophic algebraic concepts such as "neutrosophic group" and "neutrosophic ring" and presented refined neutrosophic groups.

Also, Sumathi and Arockiarani (2016) defined the concept of "neutrosophic topological groups."

After this study, Al-Hamido (2021) studied neutrosophic bi-topological groups and investigated its basic properties.

Smarandache (2019) generalized "Algebraic Structures" to "NeutroAlgebraic Structures" (whose "axioms" and "operations" are partially true, partially indeterminate, and partially false). Also, in 2020, he continued to develop them (Smarandache, 2020).

The old idea of introducing neutrosophic algebraic structure is by adding indeterminacy I to the elements of set G where $(G,*)$ is any algebraic structures such as groupoid or group or semigroup, which means if $(G,*)$ is any algebraic structures (groupoid or group or semigroup, etc.), then $(G(I) = \langle G \cup I \rangle, *)$ is neutrosophic algebraic structures (groupoid or group or semigroup, etc.).

So, in this work, many properties which hold in the classical algebraic structures do not hold in the neutrosophic algebraic structures, for example, the neutrosophic group is not a group, the same holds for ring, module, ideals, and victor space.

The neutrosophic groupoid is not a groupoid and also has many properties which hold in the classical groupoid and that does not hold in the neutrosophic groupoid theory. So, we think about defining a new neutrosophic groupoid (a new neutrosophic semigroup, a new neutrosophic monoid) which is different from the neutrosophic groupoid (a new neutrosophic semigroup, a new neutrosophic monoid).

In this work, we introduced and studied "a new neutrosophic groupoid" and "a new neutrosophic subgroupoid" for the first time. Also, we studied a new neutrosophic semigroup, a new neutrosophic subsemigroup, and a new neutrosophic monoid, for the first time. This new neutrosophic algebraic structures open the door to re-defining many neutrosophic algebraic structures. Moreover, we studied the properties of this new neutrosophic algebraic structure. Finally, the relations among new neutrosophic algebraic structure and algebraic structure are introduced. Moreover, we introduced a new NeutroGroupoid and a new NeutroSemiGroup.

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2. Preliminaries

Remark 2.1: The symbol (I) is an indeterminate and where (I) is such that $I^2 = I$.

Definition 2.2. (Ozturk & Ozkan, 2019): Let $(\dot{G}, \#)$ be any groupoid, the "neutrosophic groupoid" which is generated by I and $\dot{G}$ under # denoted by $N(\dot{G})=\{\langle \dot{G} \cup I \rangle, \#\}$.

Definition 2.3. (Agboola et al., 2012): The operation is well defined for some elements [degree of truth T], indeterminate for other elements [degree of indeterminacy I], and outer-defined for the other elements [degree of falsehood F], where $(T; I; F)$ is different from (1, 0, 0) and from (0, 0, 1) (this is a NeutroOperation). Neutrosophically, we write NeutroOperation $(T; I; F)$.

3. New Neutrosophic Group

In this part, we introduced new neutrosophic groupoid and new neutrosophic subgroupoid and studied its basic properties.

Theorem 3.1: If $(G,*)$ be a groupoid, $G(I) = \{a + bI{:}a, b \in G\}$, and "$\breve{*}$" is a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I), \breve{*})$ is a groupoid, we called it new neutrosophic groupoid.

Proof: $\forall\ (\alpha + \beta I), (\gamma + \delta I) \in G(I)$ *then* $(\alpha + \beta I)\breve{*}\ (\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \in G(I)$ implies that G is closed under $\breve{*}$.

Definition 3.2: If $(G,*)$ be a groupoid, $G(I)=\{ (\alpha + \beta I){:}\, \alpha, \beta \in G\}$, and "$\breve{*}$" is a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall \alpha, \beta, \gamma, \delta \in G.$$

Then: $(G(I), \breve{*})$ is a new neutrosophic groupoid.

Example 3.3: Let $\breve{R} = R\text{-}\{0\}$ then $(\breve{R},.)$ be an group, $G(I) = \{(\alpha + \beta I){:}\, \alpha, \beta \in \breve{R}\}$, and "$\breve{*}$" is a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha.\gamma) + (\beta.\delta)I \quad \forall \alpha, \beta, \gamma, \delta \in \breve{R}$$

Then: $(\breve{R}(I), \breve{*})$ is a new neutrosophic groupoid.

Remark 3.4: We now know that a neutrosophic groupoid is not a groupoid, but new neutrosophic groupoid is a groupoid.

Definition 3.5: Suppose that $(G(I), \breve{*})$ be a new neutrosophic groupoid then:

If $\breve{*}$ be a "commutative binary operation" in $G(I)$ then:

$(G(I), \breve{*})$ is called a commutative new neutrosophic groupoid.

-When $(G,*)$ be a "commutative groupoid," what about $(G(I), \breve{*})$. The following remark answers.

Remark 3.6: Let $(G,*)$ be a "commutative groupoid," then $(G(I), \breve{*})$ is a "commutative new neutrosophic groupoid."

Proof: Since $(G,*)$ be a commutative groupoid, "$\breve{*}$" be a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in \breve{R}$$

Then: $(G(I), \breve{*})$ is a commutative new neutrosophic groupoid, because

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I = (\gamma * \alpha) + (\delta * \beta)I$$
$$= (\gamma + \delta I) * (\overbrace{\alpha + \beta I})\forall \alpha, \beta, \gamma, \delta \in \breve{R}$$

Definition 3.7: A subset $(M, \breve{*})$ of a new neutrosophic groupoid $(G(I), \breve{*})$ is called a "new neutrosophic subgroupoid" in $G(I)$ if $(M, \breve{*})$ is also a "new neutrosophic groupoid."

Theorem 3.8: Let $(N,*)$ be subgroupoid of $(G,*)$ then:

A subset $(N(I), \breve{*})$ is called a new neutrosophic subgroupoid in $(G(I), \breve{*})$.

Proof: Since $(N, *)$ is a subgroupoid of $(G, *)$ then $(N, *)$ is also a groupoid, therefore $(N(I), \breve{*})$ is new neutrosophic groupoid, so $(N(I), \breve{*})$ is a new neutrosophic subgroupoid of $(G(I), \breve{*})$.

Theorem 3.9: If $(N, *)$ is a subgroupoid of $(M, *)$ and $(M, *)$ is "a subgroupoid" in $(G, *)$ then: $(N(I), \breve{*})$ is a new neutrosophic subgroupoid in $(G(I), \breve{*})$.

Proof: Since $(N, *)$ is a subgroupoid in $(M, *)$ and $(M, *)$ is a subgroupoid of $(G, *)$ then: $(N, *)$ is "a subgroupoid" of $(G, *)$. Therefore, $(N(I), \breve{*})$ is a new neutrosophic subgroupoid of $(G(I), \breve{*})$.

Theorem 3.10: If $(N(I), \breve{*})$ is "a new neutrosophic subgroupoid" in $(M(I), \breve{*})$ and $(M(I), \breve{*})$ is "a new neutrosophic subgroupoid" in $(G(I), \breve{*})$, then: $(N(I), \breve{*})$ is "a new neutrosophic subgroupoid" in $(G(I), \breve{*})$.

Proof: Follow from Theorem 3.9.

Definition 3.11: A new neutrosophic groupoid $G(I)$ has an "identity Element" $(e + eI)$ in $G(I)$ if

$$(\alpha + \beta I)\breve{*}(e + eI) = (e + eI)\breve{*}(\alpha + \beta I) = (\alpha + \beta I)\ ; \quad \alpha + \beta I \in G(I).$$

Definition 3.12: If G be a nonempty set, $*{:}\ G \times G \to G$ be a" binary NeutroOperation" in G. Then $(G,*)$ is called a NeutroGroupoid.

Definition 3.13: If $(G,*)$ be a NeutroGroupoid, $G(I)=\{\alpha + \beta I{:}\alpha, \beta \in G\}$, and "$\breve{*}$" be a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I), \breve{*})$ is a new NeutroGroupoid.

Example 3.14: Let $(G,+)$; $G = \{1,0,-1\}$ be a Neutro Groupoid, since:

the law + is Neutro-well-defined, that is,

- partially true, because $\exists$ ($a = 1$, $b =$ -1$\in G$) such that ($a + b \in G$); degree of truth $T > 0$.
- degree of "indeterminacy" ($I = 0$) since no indeterminacy exists.
- and partially false, because $\exists$ ($a =$ -1, $b =$ -1$\in G$) such that ($a + b =$ -2$\notin G$); so degree of "falsehood" ($F > 0$).

Let $G(I)=\{\alpha + \beta I{:}\, \alpha, \beta \in G\}$, and "$\breve{*}$" is "a binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I), \breve{*})$ is "a new NeutroGroupoid."

4. A New Neutrosophic Semigroup:

Theorem 4.1: Let (G,*) be an "semigroup," $G(I)$ = {$\alpha + \beta I$: $\alpha, \beta \in G$}, and "$\check{*}$" is a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\check{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I), \check{*})$ is a semigroup, we called it a new neutrosophic semigroup.

Proof:
(i) $\forall\ (\alpha + \beta I)\check{*}(\gamma + \delta I) \in G(I)$ then $(\alpha + \beta I)\check{*}(\gamma + \delta I) = (\alpha * \gamma) +$ $(\beta * \delta)\ I\ \forall\ \alpha, \beta, \gamma, \delta \in G$ implies that G is closed under $\check{*}$.
(ii) $\forall\ (\alpha + \beta I), (\gamma + \delta I),\ (e + fI) \in G(I)$ then $[(\alpha + \beta I)$ $\check{*}(\gamma + \delta I)]\check{*}\ (e + fI) = [(\alpha * \gamma) + (\beta * \delta)I\,]\check{*}(e + fI) =$ $[(\alpha * \gamma) * e] + [(\beta * \delta) * f]I$ (since * such that associative law)
$= [\alpha * (\gamma * e)] + [\beta * (\delta * f)]I = (a + bI)\check{*}[(c * e) + (d * f)I]$
$= (\alpha + \beta I)\check{*}[(\gamma + \delta I)\check{*}(e + fI)]$ (associative law).

By (i) and (ii), $(G(I),\ \check{*})$ is a semigroup, we called it new neutrosophic semigroup.

Definition 4.2: Let (G,*) be an "semigroup," $G(I)$ = {$\alpha + \beta I$: α, $\beta \in G$}, and "$\check{*}$" be a binary operation in $G(I)$ defined as follows:

$$(\alpha + \beta I)\check{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I\ \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I),\ \check{*})$ is a semigroup, we called it a new neutrosophic semigroup.

Example 4.3: Let (G,+); G={1,0,-1} be an "semigroup," $G(I)$={$a + bI$: $a,b \in R$}, and "$\check{*}$" be a "binary operation" in $G(I)$ defined as follows:

$$(\alpha + \beta I)\check{*}(\gamma + \delta I) = (\alpha + \gamma) + (\beta + \delta)I\ \forall\ \alpha,\ \beta, \gamma, \delta \in R$$

Then: $(G(I),\ \check{*})$ is a new neutrosophic semigroup.

Definition 4.4: Let $(G(I),\ \check{*})$ be a "new neutrosophic semigroup," then if $\check{*}$ be a "commutative binary operation" in $G(I)$ then:

$(G(I),\ \check{*})$ is said to be "commutative new neutrosophic semigroup."

-If (G,*) be a "commutative semigroup", what about $(G(I),\ \check{*})$. The following remark answers.

Remark 4.5: If (G,*) be a "commutative semigroup", then $(G(I),\ \check{*})$ is a "commutative new neutrosophic semigroup."

Proof: Since (G,*) be a "commutative semigroup," "$\check{*}$" be a "binary operation" on $G(I)$ defined as follows:

$$(\alpha + \beta I)\check{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I\ \forall\, \alpha, \beta, \gamma, \delta\ \in \check{R}$$

Then: $(G(I),\ \check{*})$ is a commutative new neutrosophic semigroup, because

$$(\alpha + \beta I)\check{*}(\gamma + \delta I) = (\alpha * \gamma) + (\beta * \delta)I = (\gamma * \delta) + (\delta * \beta)I$$
$$= (\gamma + \delta I)\check{*}(\alpha + \beta I)\ \forall\ \alpha, \beta, \gamma, \delta \in \check{R}$$

Definition 4.6:

A subset $(M,\ \check{*})$ of a new neutrosophic semigroup $(G(I),\ \check{*})$ is called "a new neutrosophic subsemigroup" in $G(I)$ if $(M,\ \check{*})$ is also "a new neutrosophic semigroup."

Theorem 4.7: If $(N,\ *)$ is subsemigroup of $(G, *)$ then:
A subset $(N(I),\ \check{*})$ is called "a new neutrosophic subsemigroup" in $(G(I),\ \check{*})$.

Proof: Since $(N,\ *)$ is subsemigroup of $(G, *)$, then $(N,\ *)$ is also semigroup, therefore $(N(I),\ \check{*})$ is new neutrosophic semigroup, so $(N(I),\ \check{*})$ is a new neutrosophic subsemigroup of $(G(I),\ \check{*})$.

- Now we defined the notion of "neutrosophic monoid."

Definition 4.8: A new neutrosophic semigroup $(G(I),\ \check{*})$ which has an element (e+eI) in $G(I)$ such that

$$(\alpha + \beta I)\check{*}(e + eI) = (e + eI)\check{*}(\alpha + \beta I) = (\alpha + \beta I); \alpha + \beta I \in G(I),$$

is called as "a new neutrosophic monoid."

Theorem 4.9: If $(G, *)$ be a monoid, then:
a subset $(G(I),\ \check{*})$ is "a new neutrosophic monoid."

Proof:. If $(G, *)$ be a "monoid", then $(G, *)$ is a semigroup and has an element e in G such that $\alpha * e = e * \alpha = \alpha$ *for all* $\alpha \in G$. Therefore, $(G(I),\ \check{*})$ is a new neutrosophic semigroup which has an element $e + eI$ in $G(I)$ such that

$$(\alpha + \beta I)\check{*}(e + eI) = (\alpha * e) + (\beta * e)I = \alpha + \beta I \ldots (i)$$

$$(e + eI)\check{*}(\alpha + \beta I) = (e * \alpha) + (e * \beta)I = \alpha + \beta I \ldots (ii)$$

By (i) and (ii), we have $(\alpha + \beta I)\check{*}(e + eI) = (e + eI)\check{*}\ (\alpha + \beta I) =$ $\alpha + \beta I$ for all $\alpha + \beta I \in G(I)$, therefore $(G(I),\ \check{*})$ is "a new neutrosophic monoid."

Definition 4.10: If $G(I)$ be "a new neutrosophic groupoid" (or a new neutrosophic semigroup or a new neutrosophic monoid). The center of a new neutrosophic groupoid (or a new neutrosophic semigroup or a new neutrosophic monoid) N-$C(G)$ = {$x + yI \in G(I)$: $(\alpha + \beta I)\check{*}(x + yI) = (x + yI)\check{*}(\alpha + \beta I)$ for all $\alpha + \beta I \in G(I)$}.

Theorem 4.11: Let $(G, *)$ be a groupoid (or a semigroup or a monoid), $C(G)$ = {$x \in G$: $a * x = x * a$ for all a$\in G$} and $(G(I),\ \check{*})$ be a new neutrosophic groupoid (or a new neutrosophic semigroup or a new neutrosophic monoid). The center of the a new neutrosophic groupoid (or a new neutrosophic semigroup or a new neutrosophic monoid) N-C (G) = {$x + yI \in G(I)$: $x, y \in$ C(G)}.

Proof: Let $(G, *)$ be a groupoid (or a semigroup or a monoid), $C(G) = \{x \in G: \alpha * x = x * \alpha \ \forall \alpha \in G\}$.

$\forall \ x,y \in C(G), \ (\alpha + \beta I)\breve{*}(x + yI) = (a * x) + (b * y)I$ $(since\ x, y \in C(G)\ ) = (x * a) + (y * b)I = (x + yI)\breve{*}(\alpha + \beta I)$; $\forall \alpha + \beta I \in G(I)$

Therefore, $N\text{-}C\ (G) = \{x + yI \in G(I): x, y \in C(G)\}$.

Theorem 4.12: If $(G(I), \breve{*})$ be "a commutative new neutrosophic groupoid" (or a new neutrosophic semigroup or a new neutrosophic monoid). The center of the "a new neutrosophic groupoid" (or a new neutrosophic semigroup or a new neutrosophic monoid) N-C $(G) = \{G(I)\}$.

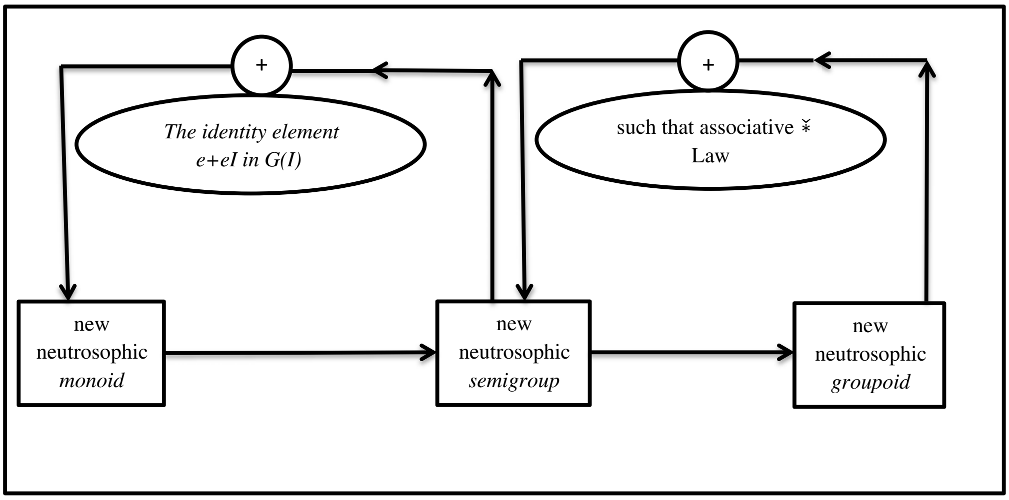
Proof: Since $(G(I), \breve{*})$ be "a commutative new neutrosophic groupoid" (or a new neutrosophic semigroup or a new neutrosophic monoid) then

$$\forall x + yI \in G(I)(\alpha + \beta I)\breve{*}(x + yI) = (x + yI)\breve{*}(\alpha + \beta I) \ \forall \alpha + \beta I \in G(I)$$

Therefore, $N\text{-}C\ (G) = \{G(I)\}$.

Remark 4.13: Figure 1 shows the relations among new neutrosophic algebraic structures

Figure 1
The relations among new neutrosophic algebraic structures



Definition 4.14: Let $G \neq \phi$ be a set, $*$: $G \times G \rightarrow G$ be a "binary NeutroOperation" or a "binary Operation" on G. Then $(G,*)$ is called a "NeutroSemiGroup" if the following condition is satisfied:

$*$is NeutroAssociative that is, $\exists$ (ξ,ζ,χ) $\in G$ such that
ξ $*$(ζ $*$χ) = (ξ $*$ζ)$*$χ and $\exists$ (ą,ĕ,ķ) $\in G$ such that
ą $*$(ĕ $*$ ķ) $\neq$ (ą $*$ ĕ)$*$ ķ.

Definition 4.15: Let $(G,*)$ be a "NeutroSemiGroup," $G(I) = \{\alpha + \beta I: \alpha, \beta \in G\}$, and "$\breve{*}$" be a binary operation on $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(c + dI) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I), \breve{*})$ is a new NeutroSemiGroup.

Example 3.16: Let $G = \{1,2,3\}$ and $*$ defined on G as follows: $1 * 1 = 1$, $1 * 2 = 3$, $1 * 3 = 1$, $2 * 1 = 1$, $2 * 2 = 2$, $2 * 3 = 1$ and $3 * 1 = 2$, $3 * 2 = 3$, $3 * 3 = 1$, $(G,*)$ be a "NeutroSemiGroup," since: the associativity law is a NeutroAssociativity, that is,

- partially true, because ∃ξ = 1, χ=2, ĕ =3∈G such that (ξ$*$χ)$*$ĕ =3 $*$ 3 = 1=ξ$*$(χ$*$ ĕ)=1 $*$ 1 = 1; the degree of "truth" $T > 0$.
- degree of "indeterminacy" $I = 0$ since no "indeterminacy" exists.
- and partially false, because ∃ξ = 3, χ=3, ĕ =3∈G such that (ξ$*$χ)$*$ĕ =1 $*$ 3 = 1≠ ξ$*$(χ$*$ ĕ)=3 $*$ 1 = 2; so degree of "falsehood" $F > 0$.

Let $G(I)$={a+bI:a,b∈G}, and "$\breve{*}$" be a "binary operation" on $G(I)$ defined as follows:

$$(\alpha + \beta I)\breve{*}(c + dI) = (\alpha * \gamma) + (\beta * \delta)I \quad \forall\, \alpha, \beta, \gamma, \delta \in G$$

Then: $(G(I), \breve{*})$ is a "new neutroSemiGroup".

5. Conclusion

In this work, we have defined "new neutrosophic structures" as "new neutrosophic groupoid" (semigroup, monoid) and new neutrosophic subgroupoid (subsemigroup, submonoid) in a new way. Finally, new neutrosophic structure is the first step for a new neutrosophic algebraic structure.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

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