On Neutro Quadruple Groups

Florentin Smarandache
Department of Mathematics and Science, University of New Mexico, Gallup, NM 87301, USA
Akbar Rezaei*
Department of Mathematics, Payame Noor University, P. O. Box 19395-3697, Tehran, Iran
Adesina Abdul Akeem Agboola
Department of Mathematics, College of Physical Sciences, Director ICTREC, Federal University of Agriculture, PMB 2240, Abeokuta, Ogun State, Nigeria
Young Bae Jun
Gyeongsang National University, South Korea
Rajab Ali Borzooei
Department of Mathematics, Shahid Beheshti University, Tehran, Iran
Bijan Davvaz
Department of Mathematics, Yazd University, Yazd, Iran
Arsham Borumand Saeid
Department of Pure Mathematics, Faculty of Mathematics and Computer, Shahid Bahonar University of Kerman, Kerman, Iran
Mohammad Akram
University of the Punjab, New Campus, Lahore, Pakistan
Mohammad Hamidi and Saeed Mirvakili
Department of Mathematics, Payame Noor University, P. O. Box 19395-3697, Tehran, Iran

Abstract. As generalizations and alternatives of classical algebraic structures there have been introduced in 2019 the Neutro Algebraic Structures (or Neutro Algebras) and Anti Algebraic structures (or Anti Algebras). Unlike the classical algebraic structures, where all operations are well-defined and all axioms are totally true, in Neutro Algebras and Anti Algebras the operations may be partially well-defined and the axioms partially true or respectively totally outer-defined and the axioms totally false. These Neutro Algebras and Anti Algebras form a new field of research, which is inspired from our real world. In this paper, we study neutrosophic quadruple algebraic structures and Neutro Quadruple Algebraic Structures. Neutro Quadruple Group is studied in particular and several examples are provided. It is shown that $(NQ(\mathbb{Z}), \div)$ is a Neutro Quadruple Group. Substructures of Neutro Quadruple Groups are also presented with examples.

Keywords: Neutrosophic quadruple number, Neutro Quadruple Group, Neutro Quadruple Subgroup.

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*Presenter

1. Introduction

It was started from Paradoxism, then to Neutrosophy, and afterwards to Neutrosophic Set and Neutrosophic Algebraic Structures. Paradoxism [10] is an international movement in science and culture, founded by Smarandache in 1980s, based on excessive use of antitheses, oxymoron, contradictions, and paradoxes. During the three decades (1980-2020) hundreds of authors from tens of countries around the globe contributed papers to 15 international paradoxist anthologies. In 1995, Smarandache extended the paradoxism (based on opposites) to a new branch of philosophy called neutrosophy (based on opposites and their neutrals), that gave birth to many scientific branches, such as: neutrosophic logic, neutrosophic set, neutrosophic probability and statistics, neutrosophic algebraic structures, and so on with multiple applications in engineering, computer science, administrative work, medical research etc. Neutrosophy is an extension of Yin-Yang Ancient Chinese Philosophy and of course of Dialectics. From Classical Algebraic Structures to Neutro Algebraic Structures and Anti Algebraic Structures. In 2019 Smarandache [8] generalized the classical glgebraic structures to Neutro Algebraic Structures (or Neutro Algebras) whose operations and axioms are partially true, partially indeterminate, and partially false as extensions of Partial Algebra, and to Anti Algebraic Structures (or AntiAlgebra) whose operations and axioms are totally false. "Algebra" can be: groupoid, semigroup, monoid, group, commutative group, ring, field, vector space, BCK-Algebra, BCI-Algebra, K-algebra, BE-algebra, etc. (See [1]-[7]).

In the present paper, we study neutrosophic quadruple algebraic structures and Neutro Quadruple Algebraic Structures. Neutro Quadruple Group is studied in particular and several examples are provided. It is shown that $(NQ(\mathbb{Z}), \div)$ is a Neutro Quadruple Group. Substructures of Neutro Quadruple Groups are also presented with examples.

The sets of natural/integer/rational/real/complex numbers are respectively denoted by $\mathbb{N} \subseteq \mathbb{Z} \subseteq \mathbb{Q} \subseteq \mathbb{R} \subseteq \mathbb{C}$.

The Neutrosophic Quadruple Numbers and the Absorbance Law were introduced by Smarandache in 2015 [9]; they have the general form:
$N = a + bT + cI + dF$, where a, b, c, d may be numbers of any type (natural, integer, rational, irrational, real, complex, etc.), where "a" is the known part of the neutrosophic quadruple number N, while "$bT + cI + dF$" is the unknown part of the neutrosophic quadruple number N; then the unknown part is split into three subparts: degree of confidence (T), degree of indeterminacy of confidence (non-confidence) (I), and degree of non-confidence (F). N is a four-dimensional vector that can also be written as: $N = (a, b, c, d)$.

There are transcendental, irrational etc. numbers that are not well known, they are only partially known and partially unknown, they may have infinitely many decimals. Not even the most modern supercomputers can compute more than a few thousands decimals, but the infinitely many left decimals still remain unknown. Therefore, such numbers are very little known (because only a finite number of decimals are known), and infinitely unknown (because an infinite number of decimals are unknown). Take for example: $\sqrt{2} = 1.4142\ldots$.

2. Arithmetic Operations on the Neutrosophic Set of Quadruple Numbers

DEFINITION 2.1. A neutrosophic set of quadruple numbers denoted by $NQ(X)$ is a set defined by

$$NQ(X) = \{(a, bT, cI, dF) : a, b, c, d \in \mathbb{R} \text{ or } \mathbb{C}\},$$

where T, I, F have their usual neutrosophic logic meanings.

DEFINITION 2.2. A neutrosophic quadruple number is a number of the form $(a, bT, cI, dF) \in NQ(X)$. For any neutrosophic quadruple number (a, bT, cI, dF) representing any entity which may be a number, an idea, an object, etc, a is called the known part and (bT, cI, dF) is called the unknown part. Two neutrosophic quadruple numbers $x = (a, bT, cI, dF)$ and $y = (e, fT, gI, hF)$ are said to be equal written $x = y$ if and only if $a = e, b = f, c = g, d = h$.

Multiplication of two neutrosophic quadruple numbers cannot be carried out like multiplication of two real or complex numbers. In order to multiply two neutrosophic quadruple numbers $a = (a_1, a_2T, a_3I, a_4F), b = (b_1, b_2T, b_3I, b_4F) \in NQ(X)$, the prevalence order of $\{T, I, F\}$ is required.

Two neutrosophic quadruple numbers $m = (a_1, b_1T, c_1I, d_1F)$ and $n = (a_2, b_2T, c_2I, d_2F)$ cannot be divided as we do for real and complex numbers. Since the literal neutrosophic components T, I and F are not invertible, the inversion of a neutrosophic quadruple number or the division of a neutrosophic quadruple number by another neutrosophic quadruple number must be carried out a systematic way. Suppose we are to evaluate m/n. Then we must look for a neutrosophic quadruple number $p = (x, yT, zI, wF)$ equivalent to m/n. In this way, we write

$$\begin{aligned} m/n &= p \\ \Rightarrow \frac{(a_1, b_1T, c_1I, d_1F)}{(a_2, b_2T, c_2I, d_2F)} &= (x, yT, zI, wF) \\ \Leftrightarrow (a_2, b_2T, c_2I, d_2F)(x, yT, zI, wF) &\equiv (a_1, b_1T, c_1I, d_1F). \end{aligned} \tag{1}$$

Assuming the prevalence order $T \succ I \succ F$ and from the equality of two neutrosophic quadruple numbers, we obtain from Eq. (1)

$$\begin{aligned} a_2x &= a_1, \\ b_2x + (a_2 + b_2 + c_2 + d_2)y + b_2z + b_2w &= b_1, \\ c_2x + (a_2 + c_2 + d_2)z + c_2w &= c_1, \\ d_2x + (a_2 + d_2)w &= d_1, \end{aligned}$$

a system of linear equations in unknowns x, y, z and w. By similarly assuming the prevalence order $T \prec I \prec F$, we obtain from Eq. (1)

$$\begin{aligned} a_2x &= a_1, \\ b_2x + (a_2 + b_2)y &= b_1, \\ c_2x + c_2y + (a_2 + b_2 + c_2)z &= c_1, \\ d_2x + d_2y + d_2z + (a_2 + b_2 + c_2 + d_2)w &= d_1, \end{aligned}$$

a system of linear equations in unknowns x, y, z and w.

3. Neutrosophic Quadruple Algebraic Structures, Neutrosophic Quadruple Algebraic Hyper Structures and Neutro Quadruple Algebraic Structures

3.1. Neutrosophic Quadruple Algebraic Structures and Neutrosophic Quadruple Algebraic Hyper Structures. Let $NQ(X)$ be a neutrosophic quadruple set and let $* : NQ(X) \times NQ(X) \rightarrow NQ(X)$ be a classical binary operation on $NQ(X)$. The couple $(NQ(X), *)$ is called a neutrosophic quadruple algebraic structure. The structure $(NQ(X), *)$ is named according to the classical laws and axioms satisfied or obeyed by $*$.

If $* : NQ(X) \times NQ(X) \rightarrow \mathbb{P}(NQ(X))$ is the classical hyper operation on $NQ(X)$. Then the couple $(NQ(X), *)$ is called a neutrosophic quadruple hyper algebraic structure; and the hyper structure $(NQ(X), *)$ is named according to the classical laws and axioms satisfied by $*$.

3.2. Neutro Quadruple Algebraic Structures. In this section unless otherwise stated, the optimistic prevalence order $T \succ I \succ F$ will be assumed.

Definition 3.1. Let $NQ(G)$ be a nonempty set and let $* : NQ(G) \times NQ(G) \rightarrow NQ(G)$ be a binary operation on $NQ(G)$. The couple $(NQ(G), *)$ is called a neutrosophic quadruple group if the following conditions hold:

(QG1) $x * y \in G \; \forall x, y \in NQ(G)$ [closure law].
(QG2) $x * (y * z) = (x * y) * z \; \forall x, y, z \in G$ [axiom of associativity].
(QG3) There exists $e \in NQ(G)$ such that $x * e = e * x = x \; \forall x \in NQ(G)$ [axiom of existence of neutral element].
(QG4) There exists $y \in NQ(G)$ such that $x * y = y * x = e \; \forall x \in NQ(G)$ [axiom of existence of inverse element], where e is the neutral element of $NQ(G)$.
If in addition $\forall x, y \in NQ(G)$, we have
(QG5) $x * y = y * x$, then $(NQ(G), *)$ is called a commutative neutrosophic quadruple group.

Definition 3.2. [Neutro Sophication of the law and axioms of the neutrosophic quadruple]

(NQ(G)1) There exist some duplets $(x, y), (u, v), (p, q), \in NQ(G)$ such that $x*y \in G$ (inner-defined with degree of truth T) and [$u * v$ = indeterminate (with degree of indeterminacy I) or $p * q \notin NQ(G)$ (outer-defined/falsehood with degree of falsehood F)] [Neutro Closure Law].
(NQ(G)2) There exist some triplets $(x, y, z), (p, q, r), (u, v, w) \in NQ(G)$ such that $x * (y * z) = (x * y) * z$ (inner-defined with degree of truth T) and [[$p * (q * r)$]or [$(p * q) * r$] = indeterminate (with degree of indeterminacy I) or $u * (v * w) \neq (u * v) * w$ (outer-defined/falsehood with degree of falsehood F)] [NeutroAxiom of associativity (Neutro Associativity)].
(NQ(G)3) There exists an element $e \in NQ(G)$ such that $x * e = e * x = x$ (inner-defined with degree of truth T) and [[$x * e$]or[$e * x$] = indeterminate (with degree of indeterminacy I) or $x * e \neq x \neq e * x$ (outer-defined/falsehood with degree of falsehood F)] for at least one $x \in NQ(G)$ [Neutro Axiom of existence of neutral element (Neutro Neutral Element)].

(NQ(G)4) There exists an element $u \in NQ(G)$ such that $x * u = u * x = e$ (inner-defined with degree of truth T) and $[[x*u]\text{or}[u*x)] =$ indeterminate (with degree of indeterminacy I) or $x * u \neq e \neq u * x$ (outer-defined/falsehood with degre of falsehood F)] for at least one $x \in G$ [Neutro Axiom of existence of inverse element (Neutro Inverse Element)], where e is a Neutro Neutral Element in $NQ(G)$.

(NQ(G)5) There exist some duplets $(x, y), (u, v), (p, q) \in NQ(G)$ such that $x * y = y * x$ (inner-defined with degree of truth T) and $[[u * v]\text{or}[v * u] =$ indeterminate (with degree of indeterminacy I) or $p * q \neq q * p$ (outer-defined/falsehood with degree of falsehood F)] [Neutro Axiom of commutativity (Neutro Commutativity)].

Definition 3.3. A Neutro Quadruple Group $NQ(G)$ is an alternative to the neutrosophic quadruple group $Q(G)$ that has at least one NeutroLaw or at least one of $\{NQ(G)1, NQ(G)2, NQ(G)3, NQ(G)4\}$ with no Anti Law or Anti Axiom.

Definition 3.4. A Neutro Commutative Quadruple Group $NQ(G)$ is an alternative to the commutative neutrosophic quadruple group $Q(G)$ that has at least one Neutro Law or at least one of $\{NQ(G)1, NQ(G)2, NQ(G)3, NQ(G)4\}$ and $NQ(G)5$ with no Anti Law or Anti Axiom.

NeutroClosure of $\div$ over $NQ(\mathbb{Z})$

For the degree of truth, let $a = (0, 0T, I, 0F) \in NQ(\mathbb{Z})$. Then

$$a \div a = \frac{(0, 0T, I, 0F)}{(0, 0T, I, 0F)} = (1 - k_1 - k_2, 0T, k_1 I, k_2 F) \in NQ(\mathbb{Z}), k_1, k_2 \in \mathbb{Z}.$$

For the degree of indeterminacy, let $a = (4, 5T, -2I, -7F), b = (0, -6T, I, 3F) \in NQ(\mathbb{Z})$. Then

$$a \div b = \frac{(4, 5T, -2I, -7F)}{(0, -6T, I, 3F)} = \left(\frac{4}{0}, ?T, ?I, ?F\right) \notin NQ(\mathbb{Z}).$$

For the degree of falsehood, let $a = (0, 0T, 0I, F), b = (0, 0T, 0I, 2F) \in NQ(\mathbb{Z})$. Then

$$a \div b = \frac{(0, 0T, 0I, F)}{(0, 0T, 0I, 2F)} = \left(\frac{1}{2} - k, 0T, 0I, kF\right) \notin NQ(\mathbb{Z}), k \in \mathbb{Z}.$$

Neutro Associativity of $\div$ over $NQ(\mathbb{Z})$

For the degree of truth, let $a = (6, 6T, 6I, 6F), b = (2, 2T, 2I, 2F)$, $c = (-1, 0T, 0I, 0F) \in NQ(\mathbb{Z})$. Then

$$\begin{aligned} a \div (b \div c) &= (6, 6T, 6I, 6F) \div ((2, 2T, 2I, 2F) \div (-1, 0T, 0I, 0F)) \\ &= (6, 6T, 6I, 6F) \div (-2, 0T, 0I, 0F) \\ &= (-3, 0T, 0I, 0F). \\ (a \div b) \div c &= ((6, 6T, 6I, 6F) \div (2, 2T, 2I, 2F)) \div (-1, 0T, 0I, 0F) \\ &= (3, 0T, 0I, 0F) \div (-1, 0T, 0I, 0F) \\ &= (-3, 0T, 0I, 0F). \end{aligned}$$

For the degree of indeterminacy, let $a = (4, -T, 2I, -7F), b = (0, T, 0I, -8F)$, $c = (0, 0T, 9I, -F) \in NQ(\mathbb{Z})$. Then

$$\begin{aligned} a \div (b \div c) &= (4, -T, 2I, -7F) \div ((0, T, 0I, -8F) \div (0, 0T, 9I, -F)) \\ &= (4, -T, 2I, -7F) \div \left(8 - k, \frac{1}{8}T, -9I, kF\right), k \in \mathbb{Z} \\ &= (?, ?T, ?I, ?F). \\ (a \div b) \div c &= ((4, -T, 2I, -7F) \div (0, T, 0I, -8F)) \div (0, 0T, 9I, -F) \\ &= \left(\frac{4}{0}, ?T, ?I, ?F\right) \div (0, 0T, 9I, -F) \\ &= (?, ?T, ?I, ?F). \end{aligned}$$

For the degree of falsehood, let $a = (0, 5T, 0I, 0F), b = (0, T, 0I, 0F)$, $c = (5, 0T, 0I, 0F) \in NQ(\mathbb{Z})$. Then

$$\begin{aligned} a \div (b \div c) &= (0, 5T, 0I, 0F) \div ((0, T, 0I, 0F) \div (5, 0T, 0I, 0F)) \\ &= (0, 5T, 0I, 0F) \div \left(0, \frac{1}{5}T, 0I, 0F\right) \\ &= (25 - k_1 - k_2 - k_3, k_1T, k_2I, k_3F) \in NQ(\mathbb{Z}), k_1, k_2, k_3 \in \mathbb{Z}. \\ (a \div b) \div c &= ((0, 5T, 0I, 0F) \div (0, T, 0I, 0F)) \div (5, 0T, 0I, 0F) \\ &= (5 - k_1 - k_2 - k_3, k_1T, k_2I, k_3F) \div (5, 0T, 0I, 0F), k_1, k_2, k_3 \in \mathbb{Z} \\ &= \left(\frac{1}{5}(5 - k_1 - k_2 - k_3), \frac{1}{5}k_1T, \frac{1}{5}k_2I, \frac{1}{5}k_3F\right) \notin NQ(\mathbb{Z}). \end{aligned}$$

Existence of Neutro Unitary Element and Neutro Inverse Element in $NQ(\mathbb{Z})$ w.r.t. $\div$

Let $a = (0, T, 0I, 0F), b = (0, 0T, I, 0F), c = (0, 0T, 0I, F) \in NQ(\mathbb{Z})$. Then

$$(2)\, a \div a = \frac{(0, T, 0I, 0F)}{(0, T, 0I, 0F)} = (1 - k_1 - k_2 - k_3, k_1T, k_2I, k_3F), k_1, k_2, k_3 \in \mathbb{Z}.$$

$$(3)\, b \div b = \frac{(0, 0T, I, 0F)}{(0, 0T, I, 0F)} = (1 - k_1 - k_2, 0T, k_1I, k_2F), k_1, k_2 \in \mathbb{Z}.$$

$$(4)\, c \div c = \frac{(0, 0T, 0I, F)}{(0, 0T, 0I, F)} = (1 - k, 0T, 0I, kF), k \in \mathbb{Z}.$$

$$(5)\, a \div b = \frac{(0, T, 0I, 0F)}{(0, 0T, I, 0F)} = (-(k_1 + k_2), T, k_1I, k_2F), k_1, k_2 \in \mathbb{Z}.$$

$$(6)\, b \div a = \frac{(0, 0T, I, 0F)}{(0, T, 0I, 0F)} = (-(k_1 + k_2 + k_3), k_1T, k_2I, k_3F), k_1, k_2, k_3 \in \mathbb{Z}.$$

For the degree of truth, putting $k_1 = 1, k_2 = k_3 = 0$ in Eq. (2), $k_1 = 1, k_2 = 0$ in Eq. (3) and $k = 1$ in Eq. (4) we will obtain $a \div a = a, b \div b = b$ and $c \div c = c$. These show that a, b, c are respectively Neutro Unitary Elements and Neutro Inverse Elements in $NQ(\mathbb{Z})$.

For the degree of falsehood, putting $k_1 \neq 1, k_2 \neq k_3 \neq 0$ in Eq. (2), $k_1 \neq 1, k_2 \neq 0$ in Eq. (3) and $k \neq 1$ in Eq. (4) we will obtain $a \div a \neq a, b \div b \neq b$ and $c \div c \neq c$. These show that a, b, c are respectively not Neutro Unitary Elements and Neutro Inverse Elements in $NQ(\mathbb{Z})$.

Neutro Commtativity of $\div$ over $NQ(\mathbb{Z})$

For the degree of truth, putting $k_1 = 1, k_2 = k_3 = 0$ in Eq. (2), $k_1 = 1, k_2 = 0$ in Eq. (3) and $k = 1$ in Eq. (4) we will obtain $a \div a = a, b \div b = b$ and $c \div c = c$. These show the commutativity of $\div$ wrt a, b and c $NQ(\mathbb{Z})$.

For the degree of falsehood, putting $k_1 = k_2 = k_3 = 1$ in Eq. (5) and Eq. (6), we will obtain $a \div b = (-2, T, I, F)$ and $b \div a = (-3, T, I, F) \neq a \div b$. Hence, $\div$ is Neutro Commutative in $NQ(\mathbb{Z})$.

Definition 3.5. Let $(NQ(G), *)$ be a neutrosophic quadruple group. A nonempty subset $NQ(H)$ of $NQ(G)$ is called a Neutro Quadruple Subgroup of $NQ(G)$ if $NQ(H), *)$ is a neutrosophic quadruple group of the same type as $(NQ(G), *)$.

Example 3.6.

i) For $n = 2, 3, 4, \ldots$ $(NQ(n\mathbb{Z}), -)$ is a Neutro Quadruple Subgroup of $(NQ(\mathbb{Z}), -)$.
ii) For $n = 2, 3, 4, \ldots$ $(NQ(n\mathbb{Z}), \times)$ is a Neutro Quadruple Subgroup of $(NQ(\mathbb{Z}), \times)$.

Example 3.7.

i) Let $NQ(H) = \{(a, bT, cI, dF) : a, b, c, d \in \{1, 2, 3\}\}$ be a subset of the Neutro Quadruple Group $(NQ(\mathbb{Z}_4), -)$. Then $(NQ(H), -)$ is a Neutro Quadruple Subgroup of $(NQ(\mathbb{Z}_4), -)$.
ii) Let $NQ(K) = \{(w, xT, yI, zF) : a, b, c, d \in \{1, 3, 5\}\}$ be a subset of the Neutro Quadruple Group $(NQ(\mathbb{Z}_6), \times)$. Then $(NQ(H), \times)$ is a Neutro Quadruple Subgroup of $(NQ(\mathbb{Z}_6), \times)$.

4. Conclusion

We have in this paper studied neutrosophic quadruple algebraic structures and Neutro Quadruple Algebraic Structures. Neutro Quadruple Group was studied in particular and several examples were provided. It was shown that $(NQ(\mathbb{Z}), \div)$ is a Neutro Quadruple Group. Substructures of Neutro Quadruple Groups were also presented with examples.

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References

1. A. A. A. Agboola, M. A. Ibrahim and E. O. Adeleke, *Elementary examination of NeutroAlgebras and AntiAlgebras viz-a-viz the classical number systems,* Int. J. Neutrosophic Sci. **4** (1) (2020) 16–19.
2. M. Akram and K. -P. Shum, *A survey on single-valued neutrosophic K-algebras*, J. Math. Res. Appl. **40** (3) (2020). DOI: 10.3770/j.issn:2095-2651.2020.03.000
3. M. Al-Tahan and B. Davvaz, *On some properties of neutrosophic quadruple Hv-rings*, Neutrosophic Sets Sys. **36** (2020) 256–270.
4. R. A. Borzooei, M. Mohseni Takallo, F. Smarandache and Y. B. Jun, *Positive implicative BMBJ-neutrosophic ideals in BCK-algebras*, Neutrosophic Sets Sys. **23** (2018) 126–141.

5. M. Hamidi and F. Smarandache, *Neutro-BCK-Algebra*, Int. J. Neutrosophic Sci. **8** (2020) 110–117.
6. Y. B. Jun, S. Z. Song, F. Smarandache and H. Bordbar, *Neutrosophic Quadruple BCK/BCI-Algebras*, Axioms **7** (41) (2018). DOI:10.3390/axioms7020041.
7. A. Rezaei and F. Smarandache, *On Neutro-BE-Algebras and Anti-BE-Algebras*, Int. J. Neutrosophic Sci. **4** (2020) 8–15.
8. F. Smarandache, *Introduction to NeutroAlgebraic structures and AntiAlgebraic structures, in advances of standard and nonstandard neutrosophic theories,* Pons Publishing House Brussels, Belgium, Chapter 6, pages 240–265, 2019.
9. F. Smarandache, *Neutrosophic quadruple numbers, refined neutrosophic quadruple numbers, absorbance law, and the multiplication of neutrosophic quadruple numbers*, Neutrosophic Sets Sys. **10** (2015) 96–98.
10. UNM, *Paradoxism, the last vanguard of second millennium*, http://fs.unm.edu/a/paradoxism.htm.

E-mail: smarand@unm.edu
E-mail: rezaei@pnu.ac.ir
E-mail: agboolaaaa@funaab.edu.ng
E-mail: skywine@gmail.com
E-mail: borzooei@sbu.ac.ir
E-mail: davvaz@yazd.ac.ir
E-mail: arsham@uk.ac.ir
E-mail: m.akram@pucit.edu.pk
E-mail: m.hamidi@pnu.ac.ir
E-mail: saeed_mirvakili@pnu.ac.ir