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Neutrosophic *d*-Filter of *d*-Algebra

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Abstract

In this article, an attempt has been made to introduce the concept of Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter of *d*-Algebra by generalizing the notion of Intuitionistic Fuzzy *d*-Filter of *d*-Algebra. Besides, we establish different properties of them. Further, we study several relations on this notion from the point of view of Neutrosophic *d*-Algebra.

Keywords: Neutrosophic Set; Neutrosophic *d*-Algebra; Neutrosophic *d*-Filter; Neutrosophic Prime *d*-Filter.
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1. Introduction

In the year 1965, Zadeh [1] grounded the notions of the Fuzzy Set theory. In the year 1966, Iseki [2] grounded an algebraic relation with propositional calculus. Afterward, the concepts of *BCK* and *BCI* algebra are introduced by Imai and Iseki [3] in the year 1966. In the year 1986, Atanassov [4] introduced notions of the Intuitionistic Fuzzy Set, which is the natural generalization of fuzzy set theory. Thereafter, Negger and Kim [5] presented the idea of *d*-Algebra as an extension of *BCK* algebra in the year 1999. In the year 2000, Neggers et al. [6] introduced and studied *d*-Fuzzy Functions via *d*-Algebra. Thereafter, Negger et al. [7] introduced and studied the theory of ideal in *d*-Algebra. The concept of the Neutrosophic Set was grounded by Smarandache [8] in the year 2005. Thereafter, Neutrosophic Set and its extensions have been applied in theoretical research [9-22] as well as practical research [23-29]. Jun et al. [30] applied the notion of Intuitionistic Fuzzy Set on *d*-Algebra, and grounded the idea of Intuitionistic Fuzzy *d*-Algebra in the year 2006. In the year 2007, Allen et al. [31] studied companion *d*-Algebra. In the year 2017, Abdullah and Hassan [32] presented the concept of Fuzzy Filter Spectrum of *d*-Algebra. Later on, Hasan [33] introduced the notion of Intuitionistic Fuzzy *d*-Filter by the year 2020. In the year 2021, Das et al. [8] introduced and studied the notions of Neutrosophic *d*-Ideal of *d*-Algebra, which are very useful generalizations of Intuitionistic Fuzzy *d*-Algebra. Thereafter, Das et al. [34] studied the notions of Pentapartitioned Neutrosophic *Q*-Ideals of *Q*-Algebra. In this paper, we introduce the notion of Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter of *d*-Algebra with several interesting properties. Besides, we study some relations on Neutrosophic *d*-Algebra.

Research Gap

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Jun et al. [30] and Hasan [33] presented the notion of Intuitionistic Fuzzy *d*-Algebra and Intuitionistic Fuzzy *d*-Filter respectively by generalizing the notion of Fuzzy *d*-Algebra and Fuzzy *d*-Filter. But, no investigation on Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter of *d*-Algebra has been reported in the recent literature. So, it is necessary to study the concept of Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter of *d*-Algebra.

Motivation

To fill the research gap, we introduce the notion of Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter of *d*-Algebra.

2. Preliminaries

In this section, we give some basic definitions and results on *d*-Algebra, *d*-Filter, Fuzzy *d*-Algebra, Fuzzy *d*-Filter, Intuitionistic Fuzzy *d*-Algebra, Intuitionistic Fuzzy *d*-Filter, Neutrosophic Set and Neutrosophic *d*-Ideal.

Definition 2.1:[5]. Assume that X be a fixed set. Then, X with a constant 0 and a binary operation "$\ast$" is called a *d*-Algebra if the following axioms hold:

(i) $a \ast a = 0$ for all $a \in X$;

(ii) $0 \ast a = 0$ for all $a \in X$;

(iii) $a \ast b = 0$ and $b \ast a = 0 \Rightarrow a = b$ for all $a, b \in X$.

We will refer to $a \ast b$ by ab and $a \leq b$ if and only if $ab = 0$. Further, b(ba) is denoted by $(a \wedge b)$.

Definition 2.2:[5]. A *d*-Algebra X is said to be commutative if and only if $a(ab) = b(ba)$ for all $a, b \in X$.

Definition 2.3:[5]. A *d*-Algebra X is called bounded if there is an element $e \in X$ such that $a \leq e$, for all $a \in X$, i.e., $ae = 0$ for all $a \in X$. In a bounded *d*-Algebra, we denote "ea" by "a^*" for all $a \in X$.

Remark 2.1: The operator "$\ast$" is similar to the complement.

Definition 2.4:[5]. A *d*-Algebra X is called a d^S-Algebra if the following conditions hold:

(i) $a0 = a$ for all $a \in X$;

(ii) $(ab)c = (ac)b$ for all $a, b, c \in X$.

Proposition 2.1:[5]. In a bounded commutative d^S-Algebra, the following properties hold:

(i) $(a^*)^* = a$ for all $a \in X$;

(ii) $(a \wedge b)^* = a^* \vee b^*$ and $(a \vee b)^* = a^* \wedge b^*$ for all $a, b \in X$;

(iii) $a^* b^* = ba$ for all $a, b \in X$;

(iv) $(a \vee b)^* \leq b^*$ for all $a, b \in X$;

(v) $a \vee 0 = a$ and $a \vee e = e$, $\forall a \in X$.

Proposition 2.2:[5]. In a bounded d^S-Algebra X, the following properties hold:

(i) $(ab) \leq a$ for all $a, b \in X$;

(ii) $a \leq b \Rightarrow b^* \leq a^*$ for all $a, b \in X$;

(iii) $a(ab) \leq b$ for all $a, b \in X$.

Definition 2.5:[5]. A fixed sub-set F of a bounded *d*-Algebra X is called a *d*-Filter of X if the following conditions hold:

(i) $e \in F$;

(ii) $(a^*b^*)^* \in F$, and $b \in F \Rightarrow a \in F$ for all a, b∈X.

Definition 2.6:[34]. A proper *d*-Filter F of a *d*-Algebra X is called a prime *d*-Filter if $a \wedge b \in F \Rightarrow a \in F$ or $b \in F$, for all a, b∈X.

Definition 2.7:[1]. A Fuzzy Set R over a fixed set X is defined by $R=\{(a, T_R(a)): a \in X\}$, where $T_R(a)$ ($\in[0,1]$) is the membership value of a∈X towards R.

Definition 2.8:[32]. Let $Y=\{(c,T_Y(c)):c \in X\}$ be a Fuzzy Set over a *d*-Algebra X. Then, Y is called a Fuzzy *d*-Algebra if $T_Y(cd) \geq \min\{T_Y(c), T_Y(d)\}$, for all c, d∈X.

Definition 2.9:[32]. A Fuzzy Fet $Y=\{(c,T_Y(c)):c \in X\}$ is called a Fuzzy *d*-Filter of a *d*-Algebra *X* if the following holds:
(*i*) $T_Y(e) \geq T_Y(c)$, for all c∈*X*,
(*ii*) $T_Y(c) \geq \min\{T_Y((c^*d^*)^*), T_Y(d)\}$, for all c, d∈*X*.

Definition 2.10:[32]. A Fuzzy *d*-Filter $Y=\{(c,T_Y(c)):c \in X\}$ of a *d*-Algebra is called a Fuzzy Prime *d*-Algebra if and only if $T_Y(c \wedge d) \leq \max\{T_Y(c), T_Y(d)\}$, for all c, d∈*X*.

Definition 2.11:[4]. An Intuitionistic Fuzzy Set D over a fixed set X is defined by $D=\{(a, T_D(a), F_D(a)): a \in X\}$, where $T_R(a)$, $F_D(a)$ ($\in[0,1]$) is the membership and non-membership values of a∈X towards R.

Definition 2.12:[4]. Assume that $f:X \rightarrow Y$ be a one to one and onto mapping. If $D=\{(a, T_D(a), F_D(a)): a \in Y\}$ be an Intuitionistic Fuzzy Set over *Y*, then $f^{-1}(D)$ is the Intuitionistic Fuzzy Set over *X* defined by:
$f^{-1}(D)=\{(a, f^{-1}(T_D(a)), f^{-1}(F_D(a))): a \in X\}$
Further, if $D=\{(a, T_D(a), F_D(a)):a \in X\}$ be an Intuitionistic Fuzzy Set over *X*, then f(D) is an Intuitionistic Fuzzy Set over *Y* defined by
$f(D)=\{(a, f_{sup}(T_D(a)), f_{inf}(F_D(a))):a \in Y\}$,
where $f_{sup}(T_D(a)) = \begin{cases} \sup_{b \in f^{-1}(a)} T_D(b) \text{ if } f^{-1}(a) \neq \emptyset \\ 0 \quad \text{otherwise} \end{cases}$,
and $f_{inf}(F_D(a)) = \begin{cases} \inf_{b \in f^{-1}(a)} F_D(b) \text{ if } f^{-1}(a) \neq \emptyset \\ 0 \quad \text{otherwise} \end{cases}$, for each a∈*Y*.

Definition 2.13:[30]. Let $Y=\{(c,T_Y(c),F_Y(c)): c \in X\}$ be an Intuitionistic Fuzzy Set over a d-Algebra X. Then, Y is called an Intuitionistic Fuzzy *d*-Algebra if it satisfies the followings:
(i) $T_Y(cd) \geq \min\{T_Y(c), T_Y(d)\}$, for all c, d∈X;
(ii) $F_Y(cd) \leq \max\{F_Y(c), F_Y(d)\}$, for all c, d∈X.

Definition 2.14:[33]. An Intuitionistic Fuzzy Set $Y=\{(c,T_Y(c),F_Y(c)): c \in X\}$ over a *d*-Algebra (X, *****) is said to be an Intuitionistic Fuzzy *d*-Filter (IF-*d*-Filter) of X, if the following holds:
(i) $T_Y(e) \geq T_Y(c)$, $F_Y(e) \leq F_Y(c)$, for all c∈X;
(ii) $T_Y(c) \geq \min\{T_Y((c^*d^*)^*), T_Y(d)\}$, $F_Y(c) \leq \max\{F_Y((c^*d^*)^*), F_Y(d)\}$, for all c, d∈X.

Definition 2.15:[33]. An IF-*d*-Filter $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c \in X\}$ of a *d*-Algebra X is called an Intuitionistic Fuzzy Prime *d*-Filter (IF-P-*d*-Filter) of X if the following conditions hold:
(i) $T_Y(a \wedge b) \leq \max\{T_Y(a), T_Y(b)\}$, for all a, b∈X;
(ii) $F_Y(a \wedge b) \geq \min\{F_Y(a), F_Y(b)\}$, for all a, b∈X.

Proposition 2.3:[33]. Assume that $Y=\{(c,T_Y(c),F_Y(c)): c\in X\}$ be an IF-*d*-Filter of a bounded commutative d^S-Algebra X. Then, the followings hold:
(i) $a^* \leq b^* \Rightarrow T_Y(a) \geq T_Y(b)$ and $F_Y(a) \geq F_Y(b)$, for all a, b$\in$X;
(ii) $b \leq a \Rightarrow T_Y(b) \leq T_Y(a)$ and $F_Y(b) \leq F_Y(a)$, for all a, b$\in$X.

Definition 2.16:[35]. An Neutrosophic Set over a universal set X is defined as follows:
$H=\{(y,T_H(y),I_H(y),F_H(y)): y\in X\}$,
where $T_H(y)$, $I_H(y)$ and $F_H(y)$ ($\in[0,1]$) are the truth, indeterminacy and false membership values of y, and so $0 \leq T_H(y) + I_H(y) + F_H(y) \leq 3$, for all y$\in$X.

Definition 2.17:[35]. Suppose that $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an Neutrosophic Set over a *d*-Algebra X. Then, A is called an Neutrosophic *d*-Algebra (N-*d*-Algebra) if the following condition satisfies:
(i) $T_Y(c*d)\geq \min\{T_Y(c), T_Y(d)\}$, for all c, d$\in$X;
(ii) $I_Y(c*d)\leq \max\{I_Y(c), I_Y(d)\}$, for all c, d$\in$X;
(iii) $F_Y(c*d)\leq \max\{F_Y(c), F_Y(d)\}$, for all c, d$\in$X.

3. Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter

In this section, we procure the concept of Neutrosophic *d*-Filter (N-*d*-Filter) and Neutrosophic Prime *d*-Filter of *d*-Algebra as an extension of Intuitionistic Fuzzy *d*-Filter of *d*-Algebra. Further, some of the theorems and properties of this concept have been established.

Definition 3.1: An Neutrosophic Set $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ over X is called an N-*d*-Filter if the following conditions hold:
(i) $T_Y(e) \geq T_Y(c)$, $I_Y(e) \leq I_Y(c)$, $F_Y(e) \leq F_Y(c)$, for all c$\in$X;
(ii) $T_Y(c) \geq \min\{T_Y((c^*d^*)^*), T_Y(d)\}$,
$I_Y(c) \leq \max\{I_Y((c^*d^*)^*), I_Y(d)\}$,
and $F_Y(c) \leq \max\{F_Y((c^*d^*)^*), F_Y(d)\}$, for all c, d$\in$X.
Here, e is the boundary element of X.

Theorem 3.1: Let $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-*d*-Filter of a bounded commutative d^S-Algebra X. Then,
(i) $c^* \leq d^* \Rightarrow T_Y(c) \geq T_Y(d)$, $I_Y(c) \geq I_Y(d)$ and $F_Y(c) \geq F_Y(d)$, for all c, d$\in$X;
(ii) $d \leq c \Rightarrow T_Y(d) \leq T_Y(c)$, $I_Y(d) \leq I_Y(c)$ and $F_Y(d) \leq F_Y(c)$, for all c, d$\in$X.

Proof. (i) since $c^* \leq d^*$, so $(c^*d^*)^* = e$.
Now, $T_Y(c) \geq \min\{T_Y((c^*d^*)^*), T_Y(d)\}= \min\{T_Y(e), T_Y(d)\}= T_Y(d)$, for all c, d$\in X$.
$I_Y(c) \leq \max\{I_Y((c^*d^*)^*), I_Y(d)\}= \max \{I_Y(e), I_Y(d)\}= I_Y(d)$, for all c, d$\in X$.
and $F_Y(c) \leq \max\{F_Y((c^*d^*)^*), F_Y(d)\}= \max \{F_Y(e), F_Y(d)\}= F_Y(d)$, for all c, d$\in X$.
(ii) Since $d \leq c$, so $dc = 0$. By a known result, we have $c^*d^* = dc$ that means $c^* \leq d^*$. By (i), we have, $T_Y(c) \geq T_Y(d)$, $I_Y(c) \leq I_Y(d)$, and $F_Y(c) \leq F_Y(d)$.

Theorem 3.2: Let $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-*d*-Filter of a *d*-Algebra X.
Then, (i) $T_Y(e) \geq T_Y(c)$, $I_Y(e) \leq I_Y(c)$, $F_Y(e) \leq F_Y(c)$, for all c$\in$X;
(ii) $T_Y(d) \geq \min\{T_Y(cd)^*, T_Y(c)\}$, $I_Y(d) \leq \max \{I_Y(cd)^*, I_Y(c)\}$, $F_Y(d) \leq \max \{F_Y(cd)^*, F_Y(c)\}$, for all c, d$\in$X.

Proof. Suppose that $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-*d*-Filter of a *d*-Algebra X. By Definition 3.1**,** the proof of (i) holds easily.
Now, $T_Y((c^*d^*)^*) = T_Y((d^*c^*)^*)$, $I_Y((c^*d^*)^*) = I_Y((d^*c^*)^*)$, and $F_Y((c^*d^*)^*) = F_Y((d^*c^*)^*)$.
Therefore, $T_Y(d) \geq \min\{T_Y((c^*d^*)^*), T_Y(c)\}= \min\{T_Y((d^*c^*)^*), T_Y(c)\}$,
$I_Y(d) \leq \max\{I_Y((c^*d^*)^*), I_Y(c)\}= \max\{I_Y((d^*c^*)^*), I_Y(c)\}$,
and $F_Y(d) \leq \max\{F_Y((c^*d^*)^*), F_Y(c)\}= \max\{F_Y((d^*c^*)^*), F_Y(c)\}$.

Theorem 3.3: An Neutrosophic Set $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ over a bounded commutative d^S-Algebra X is called a N-*d*-Filter if and only if $(m^* n^*) b^* = 0 \Rightarrow T_Y(m) \geq \min\{T_Y(n), T_Y(b)\}$, $I_Y(m) \geq \min\{I_Y(n), I_Y(b)\}$, $F_Y(m) \geq \min\{F_Y(n), F_Y(b)\}$, for all m, n, b$\in$X.

Proof. Let $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-*d*-Filter of a bounded commutative d^S-Algebra X. Assume that $(m^* n^*) b^* = 0$, then $(m^* n^*)^{**} \leq b^*$. By Proposition 2.2, we have $T_Y(b) \leq T_Y((m^*n^*)^*)$, $I_Y(b) \geq I_Y((m^*n^*)^*)$ and $F_Y(b) \geq F_Y((m^*n^*)^*)$. Then, we will get $T_Y(m) \geq \min\{T_Y((m^*n^*)^*), T_Y(m)\} \geq \min\{T_Y(b), T_Y(n)\}$, $I_Y(m) \leq \max\{I_Y((m^*n^*)^*), I_Y(n)\} \leq \max\{I_Y(b), I_Y(n)\}$, and $F_Y(m) \leq \max\{F_Y((m^*n^*)^*), F_Y(n)\} \leq \max\{F_Y(b),F_Y(n)\}$.
Conversely, let $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an Neutrosophic Set satisfies that $(m^*n^*)b^*= 0$ implies $T_Y(m) \geq \min\{T_Y(n), T_Y(b)\}$, $I_Y(m) \leq \max\{I_Y(n), I_Y(b)\}$ and $F_Y(m) \leq \max\{F_Y(n), F_Y(b)\}$, for all m, n, b$\in$X.
Since, $(e^*n^*)n^* = (0n^*) n^* = 0$, it is follow that
$T_Y(b) \geq \min\{T_Y(n), T_Y(n)\} = T_Y(n)$,
$I_Y(b) \leq \max\{I_Y(n), I_Y(n)\} = I_Y(n)$,
and $F_Y(b) \leq \max\{F_Y(n), F_Y(n)\} = F_Y(n)$.
Now, since X is a d^S-Algebra, so $m(mn)n = 0$, for all m, n$\in$X.
This implies, $[m^*(m^*n^*)^{**}]n^* = 0$. Therefore, we have
$T_Y(n) \geq \min\{T_Y((m^*n^*)^*), T_Y(n)\}$, $I_Y(b) \leq \max\{I_Y((m^*n^*)^*), I_Y(n)\}$, and $F_Y(b) \leq \max\{F_Y((m^*n^*)^*), F_Y(n)\}$.
Hence, $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-*d*-Filter.

Theorem 3.4: Let $\{Y_i: i\in\Delta\}$ be a family of N-*d*-Filters of a *d*-Algebra X. Then, their intersection $\cap Y_i = \{(c, \wedge \mathbf{T}_{\mathbf{Y_i}}(c), \vee \mathbf{I}_{\mathbf{Y_i}}(c), \vee \mathbf{F}_{\mathbf{Y_i}}(c)): c\in X\}$ is also an N-*d*-Filter of X.

Proof. Assume that $\{Y_i: i\in\Delta\}$ be a family of N-*d*-Filter of a *d*-Algebra X. It is known that, $\mathbf{T}_{\mathbf{Y_i}}(e) \geq \mathbf{T}_{\mathbf{Y_i}}(c)$, $\mathbf{I}_{\mathbf{Y_i}}(e) \leq \mathbf{I}_{\mathbf{Y_i}}(c)$ and $\mathbf{F}_{\mathbf{Y_i}}(e) \leq \mathbf{F}_{\mathbf{Y_i}}(c)$, for all c$\in$X (for all i$\in\Delta$). Now, we have $\wedge\mathbf{T}_{\mathbf{Y_i}}(e) \geq \wedge\mathbf{T}_{\mathbf{Y_i}}(a)$, $\vee\mathbf{I}_{\mathbf{Y_i}}(e) \leq \vee\mathbf{I}_{\mathbf{Y_i}}(a)$, and $\vee\mathbf{F}_{\mathbf{Y_i}}(e) \leq \vee\mathbf{F}_{\mathbf{Y_i}}(a)$. Since $\mathbf{T}_{\mathbf{Y_i}}(c) \geq \min\{\mathbf{T}_{\mathbf{Y_i}}((c^*d^*)^*), \mathbf{T}_{\mathbf{Y_i}}(d)\}$, $\mathbf{I}_{\mathbf{Y_i}}(c) \leq \max\{\mathbf{I}_{\mathbf{Y_i}}((c^*d^*)^*), \mathbf{I}_{\mathbf{Y_i}}(d)\}$, and $\mathbf{F}_{\mathbf{Y_i}}(c) \leq \max\{\mathbf{F}_{\mathbf{Y_i}}((c^*d^*)^*), \mathbf{F}_{\mathbf{Y_i}}(d)\}$, for all c, d$\in$X (for all i$\in\Delta$). Therefore, $\wedge\mathbf{T}_{\mathbf{Y_i}}(c) \geq \wedge\{\min\{\mathbf{T}_{\mathbf{Y_i}}((c^*d^*)^*), \mathbf{T}_{\mathbf{Y_i}}(d)\}\}$
$= \{\min\{\wedge\mathbf{T}_{\mathbf{Y_i}}((c^*d^*)^*), \wedge\mathbf{T}_{\mathbf{Y_i}}(d)\}$, for all c, d$\in$X ($\forall i\in\Delta$).
$\vee\mathbf{I}_{\mathbf{Y_i}}(c) \leq \vee\{\max\{\mathbf{I}_{\mathbf{Y_i}}((c^*d^*)^*), \mathbf{I}_{\mathbf{Y_i}}(d)\}\}= \{\min\{\vee\mathbf{I}_{\mathbf{Y_i}}((c^*d^*)^*), \vee\mathbf{I}_{\mathbf{Y_i}}(d)\}\}$, for all c, d$\in$X ($\forall i\in\Delta$).
and $\vee\mathbf{F}_{\mathbf{Y_i}}(c) \leq \vee\{\max\{\mathbf{F}_{\mathbf{Y_i}}((c^*d^*)^*), \mathbf{F}_{\mathbf{Y_i}}(d)\}\}= \{\min\{\vee\mathbf{F}_{\mathbf{Y_i}}((c^*d^*)^*), \vee\mathbf{F}_{\mathbf{Y_i}}(d)\}\}$, for all c, d$\in$X ($\forall i\in\Delta$). Hence, $\cap Y_i = \{(c, \wedge\mathbf{T}_{\mathbf{Y_i}}(c), \vee\mathbf{I}_{\mathbf{Y_i}}(c), \vee\mathbf{F}_{\mathbf{Y_i}}(c)): c\in X\}$ is also an N-d-Filter of X.

Lemma 3.1: An Neutrosophic Set $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-*d*-Filter of X if and only if $T_Y=\{(c,T_Y(c)): c\in X\}$, $\bar{\mathbf{I}}_Y=\{(c, 1-I_Y(c)): c\in X\}$, and $\bar{\mathbf{F}}_Y=\{(c, 1-F_Y(c)): c\in X\}$ are F-*d*-Filters of X.

Proof. Suppose that $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-*d*-Filter of a *d*-Algebra X. Then, by Definition 3.1 and Definition 2.3, it is clear that T_Y is a Fuzzy *d*-Filter of X.
Now, for all a, b∈X, we have $\bar{\mathbf{I}}_Y(e)=1-I_Y(e)\geq 1-I_Y(a)=\bar{\mathbf{I}}_Y(a)$
and $\bar{\mathbf{I}}_Y(a)=1-I_Y(a)\geq 1-\max\{I_Y((a^*b^*)^*), I_Y(b)\}=\min\{1-I_Y((a^*b^*)^*), 1-I_Y(b)\}$
$=\min\{\bar{\mathbf{I}}_Y((a^*b^*)^*), \bar{\mathbf{I}}_Y(b)\}$.
Hence, $\bar{\mathbf{I}}_Y$ is a Fuzzy *d*-Filter of X. Further, $\bar{\mathbf{F}}_Y(e)=1-F_Y(e)\geq 1-F_Y(a)=\bar{\mathbf{F}}_Y(a)$
and $\bar{\mathbf{F}}_Y(a)=1-F_Y(a)\geq 1-\max\{F_Y((a^*b^*)^*), F_Y(b)\}=\min\{1-F_Y((a^*b^*)^*), 1-F_Y(b)\}$
$=\min\{\bar{\mathbf{F}}_Y((a^*b^*)^*), \bar{\mathbf{F}}_Y(b)\}$.
Hence, $\bar{\mathbf{F}}_Y$ is a Fuzzy *d*-Filter of X.
Conversely, let $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an Neutrosophic Set over a *d*-Algebra X such that $T_Y=\{(c,T_Y(c)): c\in X\}$, $\bar{\mathbf{I}}_Y=\{(c, 1-I_Y(c)): c\in X\}$ and $\bar{\mathbf{F}}_Y=\{(c, 1-F_Y(c)): c\in X\}$ are F-*d*-Filters of X.
Now, for all a, b∈X, we havebT$_Y(e)\geq T_Y(a)$;
$T_Y(a)\geq\min\{T_Y((a^*b^*)^*), T_Y(b)\}$; $\bar{\mathbf{I}}_Y(e)=1-I_Y(e)\geq 1-I_Y(a)=\bar{\mathbf{I}}_Y(a)\Rightarrow\bar{\mathbf{I}}_Y(e)\geq\bar{\mathbf{I}}_Y(a)$;
$\bar{\mathbf{I}}_Y(a)=1-I_Y(a)=\bar{\mathbf{I}}_Y(a)\geq\min\{\bar{\mathbf{I}}_Y((a^*b^*)^*), \bar{\mathbf{I}}_Y(b)\}=\min\{1-I_Y((a^*b^*)^*), 1-I_Y(b)\}$
$=1-\max\{I_Y((a^*b^*)^*), I_Y(b)\}\Rightarrow\bar{\mathbf{I}}_Y(a)\geq 1-\max\{I_Y((a^*b^*)^*), I_Y(b)\}$;
$\bar{\mathbf{F}}_Y(e)=1-F_Y(e)\geq 1-F_Y(a)=\bar{\mathbf{F}}_Y(a)\Rightarrow\bar{\mathbf{F}}_Y(e)\geq\bar{\mathbf{F}}_Y(a)$;
$\bar{\mathbf{F}}_Y(a)=1-F_Y(a)=\bar{\mathbf{F}}_Y(a)\geq\min\{\bar{\mathbf{F}}_Y((a^*b^*)^*), \bar{\mathbf{F}}_Y(b)\}=\min\{1-F_Y((a^*b^*)^*), 1-F_Y(b)\}$
$=1-\max\{F_Y((a^*b^*)^*), F_Y(b)\}\Rightarrow\bar{\mathbf{F}}_Y(a)\geq 1-\max\{F_Y((a^*b^*)^*), F_Y(b)\}$;
Hence, $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-*d*-Filter of X.

Theorem 3.5: Let f:X→Y be a homomorphism from a *d*-Algebra X to another *d*-Algebra Y. If $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ is an N-*d*-Filter of Y, then, $f^{-1}(N)$ is also an N-*d*-Filter of X.

Proof. Let f:X→Y be a homomorphism from a *d*-Algebra X to another *d*-Algebra Y. Suppose that $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ be an N-*d*-Filter of Y. Now, for any a∈X, we have $T_N(\mathbf{é})\leq T_N(\mathbf{á})$, $I_N(\mathbf{é})\leq I_N(\mathbf{á})$, and $F_N(\mathbf{é})\leq F_N(\mathbf{á})$. Let **é** = f(e) and **á** = f(a).
We have,
$\mathbf{T}_{\mathbf{f^{-1}(N)}}(e)=T_N(f(e))\leq T_N(f(a))=\mathbf{T}_{\mathbf{f^{-1}(N)}}(a)$;
$\mathbf{I}_{\mathbf{f^{-1}(N)}}(e)=I_N(f(e))=I_N(\mathbf{é})\geq I_N(\mathbf{á})=I_N(f(a))=\mathbf{I}_{\mathbf{f^{-1}(N)}}(a)$;
and $\mathbf{F}_{\mathbf{f^{-1}(N)}}(e)=F_N(f(e))=F_N(\mathbf{é})\geq F_N(\mathbf{á})=F_N(f(a))=\mathbf{F}_{\mathbf{f^{-1}(N)}}(a)$.
Now,
$\min\{\mathbf{T}_{\mathbf{f^{-1}(N)}}((a*b*)^*), \mathbf{T}_{\mathbf{f^{-1}(N)}}(b)\}=\min\{T_N(f((a*b*)^*), T_N(f(b))\}\leq T_N(f(a))=\mathbf{T}_{\mathbf{f^{-1}(N)}}(a)$;
$\max\{\mathbf{I}_{\mathbf{f^{-1}(N)}}((a*b*)^*), \mathbf{I}_{\mathbf{f^{-1}(N)}}(b)\}=\min\{I_N(f((a*b*)^*), I_N(f(b))\}\leq I_N(f(a))=\mathbf{I}_{\mathbf{f^{-1}(N)}}(a)$;
and $\max\{\mathbf{F}_{\mathbf{f^{-1}(N)}}((a*b*)^*), \mathbf{F}_{\mathbf{f^{-1}(N)}}(b)\}=\min\{F_N(f((a*b*)^*), F_N(f(b))\}\leq F_N(f(a))=\mathbf{F}_{\mathbf{f^{-1}(N)}}(a)$.

Theorem 3.6: Let f:X→Y be an epimorphism from a *d*-Algebra X to another *d*-Algebra Y. Let $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ be an Neutrosophic Set over Y. If $f^{-1}(N)=\{(c, \mathbf{T}_{\mathbf{f^{-1}(N)}}(c), \mathbf{I}_{\mathbf{f^{-1}(N)}}(c), \mathbf{F}_{\mathbf{f^{-1}(N)}}(c)): c\in X\}$ is an N-*d*-Filter of X, then $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ is an N-*d*-Filter of Y.

Proof. For any a, b∈Y such that f(c) = a, f(d) = b and f(**é**) = e such that **é** and e are the bounded element in X and Y respectively.
Now, we have
$T_N(e)=T_N(f(\mathbf{é}))=\mathbf{T}_{\mathbf{f^{-1}(N)}}(\mathbf{é})\geq\mathbf{T}_{\mathbf{f^{-1}(N)}}(c)=T_N(f(c))=T_N(a)$;
$I_N(e)=I_N(f(\mathbf{é}))=\mathbf{I}_{\mathbf{f^{-1}(N)}}(\mathbf{é})\leq\mathbf{I}_{\mathbf{f^{-1}(N)}}(c)=I_N(f(c))=I_N(a)$;

and $F_N(e) = F_N(f(\acute{e})) = \mathbf{F}_{f^{-1}(N)}(\acute{e}) \leq \mathbf{F}_{f^{-1}(N)}(c) = F_N(f(c)) = F_N(a)$.
Now, $T_N(a)= T_N(f(c))= \mathbf{T}_{f^{-1}(N)}(c) \geq \min\{\mathbf{T}_{f^{-1}(N)}((c*d*)^*), \mathbf{T}_{f^{-1}(N)}(d)\}= \min\{T_N(f(c*d*)^*), T_N(d)\}= \min\{T_N(f(a*b*)^*), T_N(b)\}$;
$I_N(a)= I_N(f(c))= \mathbf{I}_{f^{-1}(N)}(c) \leq \max\{\mathbf{I}_{f^{-1}(N)}((c*d*)^*), \mathbf{I}_{f^{-1}(N)}(d)\}= \max\{I_N(f(c*d*)^*), I_N(f(d))\}$
$= \max\{I_N((a*b*)^*), I_N(b)\}$ and $F_N(a)= F_N(f(c))= \mathbf{F}_{f^{-1}(N)}(c) \leq \max\{\mathbf{F}_{f^{-1}(N)}((c*d*)^*), \mathbf{F}_{f^{-1}(N)}(d)\}= \max\{F_N(f(c*d*)^*), F_N(f(d))\}= \max\{F_N((a*b*)^*), F_N(b)\}$.
Therefore, $f^{-1}(N)$ is an N-*d*-Filter of X.

Definition 3.2: An N-*d*-Filter $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ of a *d*-Algebra X is called an Neutrosophic Prime *d*-Filter (N-P-*d*-Filter) of X if the following conditions hold:
(i) $T_Y(a \wedge b) \leq \max\{T_Y(a), T_Y(b)\}$, for all a, b∈X;
(ii) $I_Y(a \wedge b) \geq \min\{I_Y(a), I_Y(b)\}$, for all a, b∈X;
(ii) $F_Y(a \wedge b) \geq \min\{F_Y(a), F_Y(b)\}$, for all a, b∈X.

Theorem 3.7: Let $\{N_i, i\in\Delta\}$ be the family of N-P-*d*-Filters of *X*. Then, $\cap N_i=\{(c, \wedge T_{N_i}(a), \vee I_{N_i}(c), \vee F_{N_i}(c)): c\in X\}$ is also an N-P-*d*-Filter of *X*.

Proof. Assume that $\{N_i: i\in I\}$ be a collection of N-P-*d*-Filters of *X*. By a known theorem, we have $\cap N_i$ is an N-*d*-Filter of *X*. It is known that, $T_{N_i}(a\wedge b) \leq \max\{T_{N_i}(a), T_{N_i}(b)\}$, $I_{N_i}(a\wedge b) \geq \min\{I_{N_i}(a), I_{N_i}(b)\}$ and $F_{N_i}(a\wedge b) \geq \min\{F_{N_i}(a), F_{N_i}(b)\}$, $\forall$ a, b∈*X* (i∈Δ). Now,
$\wedge_{i\in I}T_{N_i}(a\wedge b) \leq \wedge_{i\in I}\{\max\{T_{N_i}(a), T_{N_i}(b)\}\} \leq \{\max\{\wedge_{i\in I}\alpha_{F_i}(a), \wedge_{i\in I}\alpha_{F_i}(b)\}\}$;
$\vee_{i\in I}F_{N_i}(a\vee b) \geq \vee_{i\in I}\{\min\{F_{N_i}(a), F_{N_i}(b)\}\} \geq \{\min\{\vee_{i\in I}F_{N_i}(a), \vee_{i\in I}F_{N_i}(b)\}\}$,
and $\vee_{i\in I}F_{N_i}(a\vee b) \geq \vee_{i\in I}\{\min\{F_{N_i}(a), F_{N_i}(b)\}\} \geq \{\min\{\vee_{i\in I}F_{N_i}(a), \vee_{i\in I}F_{N_i}(b)\}\}$,
Therefore, the intersection $\cap N_i =\{(a, \wedge T_{N_i}(a), \vee I_{N_i}(a), \vee F_{N_i}(a)): a\in X\}$ is an N-P-*d*-Filter.

Theorem 3.8: An Neutrosophic Set $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-P-*d*-Filter of X if and only if $T_Y=\{(c, T_Y(c)): c\in X\}$, $\bar{I}_Y=\{(c, 1-I_Y(c)): c\in X\}$ and $\bar{F}_Y=\{(c, 1-F_Y(c)): c\in X\}$ are F-P-*d*-Filters of X.

Proof. Suppose that $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-P-*d*-Filter of *X*. Therefore, $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-*d*-Filter of *X*. Since $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-*d*-Filter, so $T_Y=\{(c, T_Y(c)): c\in X\}$, $\bar{I}_Y=\{(c, 1-I_Y(c)): c\in X\}$, and $\bar{F}_Y=\{(c, 1-F_Y(c)): c\in X\}$ are Fuzzy *d*-Filter of *X*.
Now, we have
$T_Y(a \wedge b) \leq \max\{T_Y(a), T_Y(b)\}$, for all a, b∈*X*.
$I_Y(a \wedge b) \geq \min\{I_Y(a), I_Y(b)\}$, for all a, b∈*X*.
and $F_Y(a \wedge b) \geq \min\{F_Y(a), F_Y(b)\}$, for all a, b∈*X*.
Now, $\bar{I}_Y(a \wedge b) = 1-I_Y(a \wedge b) \leq 1 - \min\{I_Y(a), I_Y(b)\}= \max\{1 - I_Y(a), 1 - I_Y(b)\}$
$= \max\{\bar{I}_Y(a), \bar{I}_Y(b)\}$, for all a, b∈*X*;
and $\bar{F}_Y(a \wedge b) = 1-F_Y(a \wedge b) \leq 1 - \min\{F_Y(a), F_Y(b)\}= \max\{1 - F_Y(a), 1 - F_Y(b)\}$
$= \max\{\bar{F}_Y(a), \bar{F}_Y(b)\}$, for all a, b∈*X*.
Therefore, $T_Y=\{(c, T_Y(c)): c\in X\}$, $\bar{I}_Y=\{(c, 1-I_Y(c)): c\in X\}$, and $\bar{F}_Y=\{(c, 1-F_Y(c)): c\in X\}$ are F-P-*d*-Filters of X.
Theorem 3.9:

If an Neutrosophic Set $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ is an N-P-*d*-Filter of *X*, then the sets $U(T_Y, p)=\{c: T_Y(c)\geq p\}$, $L(I_Y, q)=\{c: I_Y(c)\leq q\}$, and $L(F_Y, q)=\{c: F_Y(c)\leq q\}$ are Prime *d*-Filters of *X*, for all $p, q\in[0, 1]$.

Proof. Suppose that $Y=\{(c,T_Y(c),I_Y(c),F_Y(c)): c\in X\}$ be an N-P-*d*-Filter of a *d*-Algebra *X*. Therefore, *Y* is an N-*d*-Filter. Let us consider three sets $U(T_Y, p)=\{c: T_Y(c)\geq p\}$, $L(I_Y, p)=\{c: I_Y(c)\leq p\}$, and $L(F_Y, p)=\{c: F_Y(c)\leq p\}$, for any $p, q\in[0, 1]$.
By Theorem 3.8, $U(T_Y, p)$ is *d*-Filter.
Let $a, b\in X$ such that $a\wedge b\in U(T_Y, p)$. Therefore, $T_Y(a\wedge b)\geq p$.
It is known that, $T_Y(a\wedge b)\leq \max\{T_Y(a), T_Y(b)\}\Rightarrow \max\{T_Y(a), T_Y(b)\}\geq T_Y(a\wedge b)\geq p$
$\Rightarrow T_Y(a)\geq p$ or $T_Y(b)\geq p \Rightarrow a\in U(T_Y, p)$ or $b\in U(T_Y, p)$
Hence, the set $U(T_Y, p)=\{c: T_Y(c)\geq p\}$ is a Prime *d*-Filter of *X* for any $p\in[0, 1]$.
Similarly, it can be shown that the sets $L(I_Y, p)=\{c: I_Y(c)\leq p\}$ and $L(F_Y, p)=\{c: F_Y(c)\leq p\}$ are the Prime *d*-Filters of *X* for any $p\in[0, 1]$.

Definition 3.3: Let $f:X\rightarrow Y$ be a one to one and onto mapping. If $D=\{(a, T_D(a), I_D(a), F_D(a)): a\in Y\}$ be an Neutrosophic Set over *Y*, then $f^{-1}(D)$ is the Neutrosophic Set over *X* defined by:
$f^{-1}(D)=\{(a, f^{-1}(T_D(a)), f^{-1}(I_D(a)), f^{-1}(F_D(a))): a\in X\}$
Further, if $D=\{(a, T_D(a), I_D(a), F_D(a)): a\in X\}$ be an Neutrosophic Set over *X*, then $f(D)$ is an Neutrosophic Set over *Y* defined by
$f(D)=\{(a, f_{sup}(T_D(a)), f_{inf}(I_D(a)), f_{inf}(F_D(a))): a\in Y\}$,

where $$f_{sup}(T_D(a))=\begin{cases}\sup_{b\in f^{-1}(a)} T_D(b) & \text{if } f^{-1}(a)\neq\emptyset\\ 0 & \text{otherwise}\end{cases},$$ for each $a\in Y$,

$$f_{inf}(I_D(a))=\begin{cases}\inf_{b\in f^{-1}(a)} I_D(b) & \text{if } f^{-1}(a)\neq\emptyset\\ 0 & \text{otherwise}\end{cases},$$ for each $a\in Y$,

and $$f_{inf}(F_D(a))=\begin{cases}\inf_{b\in f^{-1}(a)} F_D(b) & \text{if } f^{-1}(a)\neq\emptyset\\ 0 & \text{otherwise}\end{cases},$$ for each $a\in Y$.

Theorem 3.10: Let $f: X\rightarrow Y$ be an epimorphism from a *d*-Algebra *X* to another *d*-Algebra *Y*. Assume that $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ be an Neutrosophic Set over a *d*-Algebra *Y*. If $f^{-1}(N)=\{(c, T_{f^{-1}(N)}(c), I_{f^{-1}(N)}(c), F_{f^{-1}(N)}(c)): c\in X\}$ is an N-P-*d*-Filter of *X*, then $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ is also an N-P-*d*-Filter of Y.

Proof. Since $f^{-1}(N)=\{(c, T_{f^{-1}(N)}(c), I_{f^{-1}(N)}(c), F_{f^{-1}(N)}(c)): c\in X\}$ is an N-P-*d*-Filter of *X*, so $f^{-1}(N)$ is a N-*d*-Filter of *X*. By Theorem 3.6, $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ is a N-*d*-Filter of *Y*. Now, let $a, b\in X$. Then, $f(c)=a$, $f(d)=b$, for some $c, d\in X$.
Now, $T_N(a\wedge b)=T_N(f(c)\wedge f(d))=T_N(f(c\wedge d))=T_{f^{-1}(N)}(c\wedge d)\leq \max\{T_{f^{-1}(N)}(c), T_{f^{-1}(N)}(d)\}$
$=\max\{T_N(f(c)), T_N(f(d))\}=\{T_N(a), T_N(b)\}$.
$I_N(a\wedge b)=I_N(f(c)\wedge f(d))=I_N(f(c\wedge d))=I_{f^{-1}(F)}(c\wedge d)\geq \min\{I_{f^{-1}(N)}(c), I_{f^{-1}(N)}(d)\}$
$=\min\{I_N(f(c)), I_N(f(d))\}=\{I_N(a), I_N(b)\}$.
and $F_N(a\wedge b)=F_N(f(c)\wedge f(d))$
$=F_N(f(c\wedge d))=F_{f^{-1}(F)}(c\wedge d)\geq \min\{F_{f^{-1}(N)}(c), F_{f^{-1}(N)}(d)\}=\min\{F_N(f(c)), F_N(f(d))\}$
$=\{F_N(a), F_N(b)\}$. Hence, $N=\{(c, T_N(c), I_N(c), F_N(c)): c\in Y\}$ is an N-P-d-Filter of *X*.

5. Conclusions

In this article, we have grounded the notion of Neutrosophic *d*-Filter and Neutrosophic Prime *d*-Filter of *d*-Algebra. Besides, we have also established a few interesting results on them via *d*-Algebra. Further, it is hoped that the concept of Neutrosophic *d*-Filter and Neutrosophic

Prime *d*-Filter of *d*-Algebra can also be used in the area of Bipolar Neutrosophic Set [27], Quadripartitioned Neutrosophic Set [23], Bipolar Quadripartitioned Neutrosophic Set [21], Pentapartitioned Neutrosophic Set [19], Bipolar Pentapartitioned Neutrosophic Set [24], etc.

Conflict of Interest

The authors declare that they have no conflict of interest.

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