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A NOTES ON MULTI (T,S)-INTUITIONISTIC FUZZY SUBFIELD OF A FIELD

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Abstract. In this paper, we made an attempt to study the algebraic nature of a (T,S)intuitionistic fuzzy subfield of a field.
Keywords: (T,S)**- norm,** (T,S)**-intuitionistic fuzzy subfield.**

1. Introduction

After the introduction of fuzzy sets by L.A. Zadeh [24], several researchers explored on the generalization of the concept of fuzzy sets. The concept of intuitionistic fuzzy subset was introduced by K.T. Atanassov [4], as a generalization of the notion of fuzzy set. Azriel Rosenfeld [6] defined a fuzzy groups. The notion of fuzzy subgroups, anti-fuzzy subgroups, fuzzy fields and fuzzy linear spaces was introduced by Biswas. R [8]. In this paper, we introduce the some theorems in (T,S)-intuitionistic fuzzy subfield of a field.

2. Preliminaries

Definition 2.1.
A (T,S)-norm is a binary operations $T: [0,1] \times [0,1] \rightarrow [0,1]$ and$S : [0,1] \times [0,1] \rightarrow [0,1]$ satisfying the following requirements;

(i) $T(0,x) = 0, T(1,x) = x$ (boundary condition)

(ii) $T(x,y) = T(y,x)$ (commutativity)

(iii) $T(x,T(y,z)) = T(T(x,y),z)$ (associativity)

(iv) if $x \leq y$ and $w \leq z$, then $T(x,w) \leq T(y,z)$ (monotonicity).

(v) $S(0,x) = x, S(1,x) = 1$ (boundary condition)

(vi) $S(x,y) = S(y,x)$ (commutativity)

(vii) $S(x,S(y,z)) = S(S(x,y),z)$ (associativity)

(viii) if $x \leq y$ and $w \leq z$, then $S(x,w) \leq S(y,z)$ (monotonicity).

Definition 2.2. [24]

Let X be a non-empty set. A fuzzy subset A of X is a function $A : X \to [0,1]$.

Definition 2.3.

A **multi fuzzy subset** A of a set X is defined as an object of the form $A = \{hx, A_1(x), A_2(x), A_3(x), \cdots, A_n(x)i/x \in X\}$, where $A_i : X \to [0,1]$ for all i. It is denoted as $A = hA_1, A_2, A_3, \cdots, A_n i$.

Definition 2.4. [2]

An **intuitionistic fuzzy subset (IFS)** A of a set X is defined as an object of the form $A = \{hx, \mu_A(x), \nu_A(x)i/x \in X\}$, where $\mu_A : X \to [0,1]$ and $\nu_A : X \to [0,1]$ define the degree of membership and the degree of non-membership of the element x in X respectively and for every x in X satisfying $0 \leq \mu_A(x) + \nu_A(x) \leq 1$.

Definition 2.5.

A **multi intuitionistic fuzzy subset (MIFS)** A of a set X is defined as an object of the form$A = \{hx, \mu_A(x), \nu_A(x)i/x \in X\}$, where $\mu_A(x) = (\mu_{A1}(x), \mu_{A2}(x), \cdots, \mu_{An}(x)), \mu_{Ai} : X \to [0,1]$ for all i and $\nu_A(x) = (\nu_{A1}(x), \nu_{A2}(x), \cdots, \nu_{An}(x)), \nu_{Ai} : X \to [0,1]$ for all i, define the degrees of membership and the degrees of non-membership of the element x in X respectively and for every x in X satisfying $0 \leq \mu_{Ai}(x) + \nu_{Ai}(x) \leq 1$ for all i.

Definition 2.6.

Let $(F,+,\cdot)$ be a field. An intuitionistic multi fuzzy subset A of F is said to be a **multi** (T,S)**-intuitionistic fuzzy subfield** of F if the following conditions are satisfied:

(i) $\mu_{Ai}(x+y) \geq T(\mu_{Ai}(x), \mu_{Ai}(y))$, for all x,yin F,

(ii) $\mu_{Ai}(-x) \geq \mu_{Ai}(x)$, for all x in F,

(iii) $\mu_{Ai}(xy) \geq T(\mu_{Ai}(x), \mu_{Ai}(y))$, for all x,yin F,

(iv) $\mu_{Ai}(x^{-1}) \geq \mu_{Ai}(x)$, for all x 6= 0 in F,

(v) $\nu_{Ai}(x+y) \leq S(\nu_{Ai}(x), \nu_{Ai}(y))$, for all x,yin F,

(vi) $\nu_{Ai}(-x) \leq \nu_{Ai}(x)$, for all x in F,

(vii) $\nu_{Ai}(xy) \leq S(\nu_{Ai}(x), \nu_{Ai}(y))$, for all x,yin F,

(viii) $\nu_{Ai}(x^{-1}) \leq \nu_{Ai}(x)$, for all x = 06 in F and for all i.

Example 2.7. Consider the field $Z_5 = \{0,1,2,3,4\}$ with addition modulo 5 and multiplication modulo 5 operations. Then $A = \{$h0,(0.7,0.6,0.5),(0.1,0.2,0.3)i, h1,(0.6,0.5,0.4),(0.2,0.4,0.4)i, h2,(0.6,0.5,0.4),(0.2,0.4,0.4)i, h3,(0.6,0.5,0.4),(0.2,0.4,0.4)i, h4,(0.6,0.5,0.4),(0.2,0.4,0.4)i$\}$ is a (T,S)-intuitionistic multi fuzzy subfield of Z_5.

3. Properties

Theorem 3.1.

If A and B are any two (T,S)-intuitionistic fuzzy subfields of a field $(F,+,\cdot)$, then their intersection $A \cap B$ is an (T,S)-intuitionistic fuzzy subfield of F.

Proof: Let x and y belong to F and let $C = A \cap B$.

Now: $\mu_C(x-y) = \min\{\mu_{Ai}(x-y), \mu_{Bi}(x-y)\}$

$$\geq \min\{T(\mu_{A_i}(x),\mu_{A_i}(y)),T(\mu_{B_i}(x),\mu_{B_i}(y))\}$$
$$\geq T(\min\{\mu_{A_i}(x),\mu_{B_i}(x)\},\min\{\mu_{A_i}(y),\mu_{B_i}(y)\})$$
$$= T(\mu_C(x),\mu_C(y)).$$

Therefore, $\mu_C(x-y) \geq T(\mu_C(x),\mu_C(y))$ for all x,y in F and

$$\mu_C(xy^{-1}) = \min\{\mu_{A_i}(xy^{-1}),\mu_{B_i}(xy^{-1})\}$$
$$\geq \min\{T(\mu_{A_i}(x),\mu_{A_i}(y)),T(\mu_{B_i}(x),\mu_{B_i}(y))\}$$
$$\geq T(\min\{\mu_{A_i}(x),\mu_{B_i}(x)\},\min\{\mu_{A_i}(y),\mu_{B_i}(y)\})$$
$$= T(\mu_C(x),\mu_C(y)).$$

Therefore, $\mu_C(xy^{-1}) \geq T(\mu_C(x),\mu_C(y))$ for all x and $y \neq 0$ in F.

Also
$$\nu_C(x-y) = \max\{\nu_{A_i}(x-y),\nu_{B_i}(x-y)\}$$
$$\leq \max\{S(\nu_{A_i}(x),\nu_{A_i}(y)),S(\nu_{B_i}(x),\nu_{B_i}(y))\}$$
$$\leq S(\max\{\nu_{A_i}(x),\nu_{B_i}(x)\},\max\{\nu_{A_i}(y),\nu_{B_i}(y)\})$$
$$= S(\nu_C(x),\nu_C(y)).$$

Therefore, $\nu_C(x-y) \leq S(\nu_C(x),\nu_C(y))$ for all x and y in F and

$$\nu_C(xy^{-1}) = \max\{\nu_{A_i}(xy^{-1}),\nu_{B_i}(xy^{-1})\}$$
$$\leq \max\{S(\nu_{A_i}(x),\nu_{A_i}(y)),S(\nu_{B_i}(x),\nu_{B_i}(y))\}$$
$$\leq S(\max\{\nu_{A_i}(x),\nu_{B_i}(x)\},\max\{\nu_{A_i}(y),\nu_{B_i}(y)\})$$
$$= S(\nu_C(x),\nu_C(y)).$$

Therefore $\nu_C(xy^{-1}) \leq S(\nu_C(x),\nu_C(y))$ for all x and $y \neq 0$ in F.

Hence $A \cap B$ is an (T,S)-intuitionistic fuzzy subfield of a field F.

Theorem 3.2.

The intersection of a family of (T,S)-intuitionistic fuzzy subfields of a field $(F,+,\cdot)$ is an (T,S)-intuitionistic fuzzy subfield of F.

Proof: Let $\{A_i\}_{i\in I}$ be a family of (T,S)-intuitionistic fuzzy subfields of a field F and $A = \bigcap A_{i}, i\in I$ where $\mu_{A_i}(x) = \inf \mu_{A_i}(x)$ and $\nu_{A_i}(x) = \sup \nu_{A_i}$. Then for x and y belongs to F, then

$$\mu_{A_i}(x-y) = \inf_{i\in I} \mu_{A_i}(x-y)$$
$$\geq \inf_{i\in I} T(\mu_{A_i}(x),\mu_{A_i}(y))$$
$$\geq T(\inf_{i\in I}(\mu_{A_i}(x)),\inf_{i\in I}(\mu_{A_i}(y)))$$
$$= T(\mu_{A_i}(x),\mu_{A_i}(y))$$

Therefore, $\mu_{A_i}(x-y) \geq T(\mu_{A_i}(x),\mu_{A_i}(y))$ for all x and y in F and

$$\mu_{A_i}(xy^{-1}) = \inf_{i\in I} \mu_{A_i}(xy^{-1})$$
$$\geq \inf_{i\in I} T(\mu_{A_i}(x),\mu_{A_i}(y))$$
$$\geq T(\inf_{i\in I}(\mu_{A_i}(x),\inf_{i\in I}(\mu_{A_i}(y)))$$
$$= T(\mu_{A_i}(x),\mu_{A_i}(y)).$$

Therefore, $\mu_{A_i}(xy^{-1}) \geq T(\mu_{A_i}(x),\mu_{A_i}(y))$ for all x and $y \neq 0$ in F.

Also,
$$\nu_{A_i}(x-y) = \sup_{i\in I} \nu_{A_i}(x-y)$$
$$\leq \sup_{i\in I} S(\nu_{A_i}(x),\nu_{A_i}(y))$$
$$\leq S(\sup_{i\in I}(\nu_{A_i}(X)),\sup_{i\in I} \nu_{A_i}(y))$$
$$= S(\nu_{A_i}(x),\nu_{A_i}(y)).$$

Therefore, $\nu_{A_i}(x-y) \leq S(\nu_{A_i}(x), \nu_{A_i}(y))$ for all x and y in F and

$$\nu_{A_i}(xy^{-1}) = \sup_{i \in I} \nu_{A_i}(xy^{-1})$$
$$\leq \sup_{i \in I} S(\nu_{A_i}(x), \nu_{A_i}(y))$$
$$\leq S(\sup_{i \in I}(\nu_{A_i}(x)), \sup_{i \in I}(\nu_{A_i}(y)))$$
$$= S(\nu_{A_i}(x), \nu_{A_i}(y)).$$

Therefore $\nu_{A_i}(xy^{-1}) \leq S(\nu_{A_i}(x), \nu_{A_i}(y))$ for all x and y 6= 0 in F.

Hence the intersection of a family of (T,S)-intuitionistic fuzzy subfields of a field F is a (T,S) intuitionistic fuzzy subfield of F.

Theorem 3.3.

If A is a multi (T,S)-intuitionistic fuzzy subfield of a field $(F,+,\cdot)$, then *2A*is a multi (T,S)-intuitionistic fuzzy subfield of F.

Proof: Let A be a multi (T,S)-intuitionistic fuzzy subfield of a field F.
Consider $A = \{$h$x, \mu_{A_i}(x), \nu_{A_i}(x)i\}$, for all x in F and then*2A* $= B = \{$h$x, \mu_{B_i}(x), \nu_{B_i}(x)i\}$, where $\mu_{B_i}(x) = {}_{A_i}(x), \nu_{B_i}(x) = 1 - \mu_{A_i}(x)$. Clearly $\mu_{B_i}(x-y) \geq T(\mu_{B_i}(x), \mu_{B_i}(y))$, for all x and y in F and $\mu_{B_i}(xy^{-1}) \geq T(\mu_{B_i}(x), \mu_{B_i}(y))$ for all x and y 6= 0 in F. Since A is a multi (T,S)-intuitionistic fuzzy subfield of F, then $\mu_{A_i}(x-y) \geq T(\mu_{A_i}(x), \mu_{A_i}(y))$ for all x and y in F, which implies that:

$$1 - \nu_{B_i}(x-y) \geq T((1-\nu_{B_i}(x)), (1-\nu_{B_i}(y)))$$

which implies that: $\nu_{B_i}(x-y) \leq 1 - T((1-\nu_{B_i}(x)), (1-\nu_{B_i}(y))) = S(\nu_{B_i}(x), \nu_{B_i}(y))$.
Therefore, $\nu_{B_i}(x-y) \leq S(\nu_{B_i}(x), \nu_{B_i}(y))$ for all x and y in F and $\mu_{A_i}(xy^{-1}) \geq T(\mu_{A_i}(x), \mu_{A_i}(y))$ for all x and y 6= 0 in F, which implies that:

$$1 - \nu_{B_i}(xy^{-1}) \geq T((1-\nu_{B_i}(x)), (1-\nu_{B_i}(y)))$$

which implies that $\nu_{B_i}(xy^{-1}) \leq 1 - T((1-\nu_{B_i}(x)), (1-\nu_{B_i}(y))) = S(\nu_{B_i}(x), \nu_{B_i}(y))$.
Therefore, $\nu_{B_i}(xy^{-1}) \leq S(\nu_{B_i}(x), \nu_{B_i}(y))$ for all x and y 6= 0 in F.
Hence $B = 2A$ is a multi (T,S)-intuitionistic fuzzy subfield of a field F.

Theorem 3.4.

If A is a multi (T,S)-intuitionistic fuzzy subfield of a field $(F,+,\cdot)$, then $\diamond A$.

Proof: Let A be a multi (T,S)-intuitionistic fuzzy subfield of a field F.That is $A = \{$h$x, \mu_{A_i}(x), \nu_{A_i}(x)i\}$, for all x in F. Le t$\diamond A = B = \{\langle x, \mu_{B_i}(x), \nu_{B_i}(x)\rangle\}$, where $\mu_{B_i}(x) = 1 - \nu_{A_i}(x), \nu_{B_i}(x) = \nu_{A_i}(x)$.
Clearly $\nu_{B_i}(x-y) \leq S(\nu_{B_i}(x), \nu_{B_i}(y))$, for all x and y in F and $\nu_{B_i}(xy^{-1}) \leq S(\nu_{B_i}(x), \nu_{B_i}(y))$ for all x and y 6= 0 in F. Since A is a multi (T,S)-intuitionistic fuzzy subfield of F, then $\nu_{A_i}(x-y) \leq S(\nu_{A_i}(x), \nu_{A_i}(y))$ for all x and y in F which implies that $\mu_{B_i}(x-y) \geq 1 - S((1-\mu_{B_i}(x)), (1-\mu_{B_i}(y))) = T(\mu_{B_i}(x), \mu_{B_i}(y))$. Therefore, $\mu_{B_i}(x-y) \geq T(\mu_{B_i}(x), \mu_{B_i}(y))$ for all x and y in F and $\nu_{A_i}(xy^{-1}) \leq S(\nu_{A_i}(x), \nu_{A_i}(y))$ for all x and y 6= 0 in F,
which implies that $1 - \mu_{B_i}(xy^{-1}) \leq S((1-\mu_{B_i}(x)), (1-\mu_{B_i}(y)))$
which implies that $\mu_{B_i}(xy^{-1}) \geq 1 - S((1-\mu_{B_i}(x)), (1-\mu_{B_i}(y))) = T(\mu_{B_i}(x), \mu_{B_i}(y))$.
Therefore $\mu_{B_i}(xy^{-1}) \geq T(\mu_{B_i}(x), \mu_{B_i}(y))$ for all x and y 6= 0 in F.
Hence $B = \diamond A$ is a multi (T,S)-intuitionistic fuzzy subfield of a field F.

Theorem 3.5.

If A and B are multi (T,S)-intuitionistic fuzzy subfields of the fields G and H respectively, then $A \times B$ is an multi (T,S)-intuitionistic fuzzy subfield of $G \times H$.

Proof: Let A and B be multi (T,S)-intuitionistic fuzzy subfields of the fields G and H respectively.
Let x_1 and x_2 be in G,y_1 and y_2 be in H. Then (x_1,y_1) and (x_2,y_2) are in $G \times H$. Now,

$$\mu_{A_i \times B_i}[(x_1,y_1) - (x_2,y_2)] = \mu_{A_i \times B_i}(x_1 - x_2, y_1 - y_2)$$
$$= \min\{\mu_{A_i}(x_1 - x_2), \mu_{B_i}(y_1 - y_2)\}$$

$$\geq \min\{T(\mu_{A_i}(x_1),\mu_{A_i}(x_2)),T(\mu_{B_i}(y_1),\mu_{B_i}(y_2))\}$$
$$\geq T(\min(\mu_{A_i}(x_1),\mu_{B_i}(y_1)),\min(\mu_{A_i}(x_2),\mu_{B_i}(y_2)))$$
$$= T(\mu_{A_i\times B_i}(x_1,y_1),\mu_{A_i\times B_i}(x_2,y_2)).$$

Therefore,

$\mu_{A_i\times B_i}[(x_1,y_1)-(x_2,y_2)] \geq T(\mu_{A_i\times B_i}(x_1,y_1),\mu_{A_i\times B_i}(x_2,y_2))$, for all x_1 and x_2 in G and y_1 and y_2 in H.

Now, $\mu_{A_i\times B_i}[(x1,y1)(x2,y2)-1] = \mu_{A_i\times B_i}(x1x-21,y1y2-1)$

$$= \min\{\mu_{A_i}(x1x-21),\mu_{B_i}(y1y2-1)\}$$
$$\geq \min\{T(\mu_{A_i}(x_1),\mu_{A_i}(x_2)),T(\mu_{B_i}(y_1),\mu_{B_i}(y_2))\}$$
$$\geq T(\min(\mu_{A_i}(x_1),\mu_{B_i}(y_1)),\min(\mu_{A_i}(x_2),\mu_{B_i}(y2)))$$
$$= T(\mu_{A_i\times B_i}(x_1,y_1),\mu_{A_i\times B_i}(x_2,y_2)).$$

Therefore, $\mu_{A_i\times B_i}[(x_1,y_1)(x_2,y_2)^{-1}] \geq T(\mu_{A_i\times B_i}(x_1,y_1),\mu_{A_i\times B_i}(x_2,y_2))$, for all x_1 and $x_2 = 06$ in G and y_1 and y_2 $6= 0^0$ in H and, $\nu_{A_i\times B_i}[(x1,y1) -(x2,y2)] = \nu_{A_i\times B_i}(x1 -x2,y1 -y2)$

$$= \max\{\nu_{A_i}(x_1 -x_2),\nu_{B_i}(y_1 -y_2)\}$$
$$\leq \max\{S(\nu_{A_i}(x_1),\nu_{A_i}(x_2)),S(\nu_{B_i}(y_1),\nu_{B_i}(y_2))\}$$
$$\leq S(\max(\nu_{A_i}(x_1),\nu_{B_i}(y_1)),\max(\nu_{A_i}(x_2),\nu_{B_i}(y_2)))$$
$$= S(\nu_{A_i\times B_i}(x1,y1),\nu_{A_i\times B_i}(x2,y2)).$$

Therefore, $\nu_{A_i\times B_i}[(x_1,y_1) -(x_2,y_2)] \leq S(\nu_{A_i\times B_i}(x_1,y_1),\nu_{A_i\times B_i}(x_2,y_2))$, for all x_1 and x_2 in G and y_1 and y_2 in H and $\nu_{A_i\times B_i}[(x1,y1)(x2,y2)-1] = \nu_{A_i\times B_i}(x1x-21,y1y2-1)$

$$= \max\{\nu_{A_i}(x1x-21),\nu_{B_i}(y1y2-1)\}$$
$$\leq \max\{S(\nu_{A_i}(x_1),\nu_{A_i}(x_2)),S(\nu_{B_i}(y_1),\nu_{B_i}(y_2))\}$$
$$\leq S(\max(\nu_{A_i}(x_1),\nu_{B_i}(y_1)),\max(\nu_{A_i}(x_2),\nu_{B_i}(y2)))$$
$$= S(\nu_{A_i\times B_i}(x1,y1),\nu_{A_i\times B_i}(x2,y2)).$$

Therefore, $\nu_{A_i\times B_i}[(x_1,y_1)(x_2,y_2)^{-1}] \leq S(\nu_{A_i\times B_i}(x_1,y_1),\nu_{A_i\times B_i}(x_2,y_2))$, for all x_1 and $x_2 = 06$ in G and y_1 and y_2 $6= 0^0$ in H.

Hence $A \times B$ is an multi (T,S)-intuitionistic fuzzy subfield of $G \times H$.

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