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TRANSLATIONS OF INTUITIONISTIC FUZZY SUBALGEBRAS IN BF-ALGEBRAS

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ABSTRACT. This research article explores on, the concepts of IFT to IFS in BF-algebras. The phenomenon of IF-extensions and IF-multiplications of IFS is proposed and several related properties are investigated. In this paper, the interaction between IFTs and IF-extensions of IFSs are investigated.

1. INTRODUCTION AND PRELIMINARIES

Iseki et al. proposed two classes of abstract algebras BCI-algebras and BCK-algebras [3]. It is evident that the class of BCK-algebras is a proper subclass of the class of BCI-Algebras. H.S. Kim et al. [24] proposed a new notion known as a B-algebras, which is a simplification of BCK-algebra. Walendziak [1] defined BF-algebras. In 1965, the notion of fuzzy sets, an extraordinary idea in mathematics, was proposed by Zadeh [25]. Saeid and Rezvani [2] proposed BF-subalgebras based on the above concepts. Atanassov [21,22] was the first researcher who introduced the new idea of "IF-set", which is depicted as generalized idea of fuzzy set. Satyanarayana et al. [4,6-8]. Proposed fuzzy BF-subalgebras and IFS. Fuzzy Translation of BCK/BCI-algebras, worked out by many researchers such as Lee and Jun [23]. Further some more researchers

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used the concept of fuzzy and fuzzy functions on time scales [9-20]. The aim of this article is applying the notion of the IFTs, IF-extensions and IF-multiplications of IFSs in BF-algebras are investigated.

Definition 1.1. *[1] A BF-algebra is a non-empty set Y with a constant 0 and a binary operation satisfying the following axioms:*

(i) $\alpha_1 * \alpha_1 = 0$,

(ii) $\alpha_1 * 0 = \alpha_1$,

(iii) $0 * (\alpha_1 * \alpha_2) = \alpha_2 * \alpha_1$ *for all* α_1,$\alpha_2 \in \mathrm{Y}$.

X is considered a BF-algebra in the following conversation.

Example 1. *[6]* R *=The set of real numbers and* $\mathrm{A} = (\mathrm{R}, *, 0)$ *be an Algebra given by*

$$\alpha_1 * \alpha_2 = \begin{cases} \alpha, & \text{if} \alpha_2 = 0, \\ \alpha_2, & \text{if} \alpha_1 = 0, \\ 0, & \text{otherwise} \end{cases}$$

Then A will become a BF-algebra.

Example 2. *[5] The set* $X = \{0, p, q, s, t\}$, $*$ *is given by the Table:1 is a BF-Algebra*

TABLE 1

*	0	p	q	s	t
0	0	t	s	q	p
p	p	0	t	s	q
q	q	p	0	t	s
s	s	q	p	0	t
t	t	s	q	p	0

Definition 1.2. *[1]* $I \subseteq Y$ *is know to be subalgebra of* Y*, if*

(i) $0 \in I$,

(ii) $\mathrm{y}_1 \in \mathrm{I}$ *and* $\mathrm{y}_2 \in \mathrm{I} \Rightarrow \mathrm{y}_1 * \mathrm{y}_2 \in \mathrm{I}$.

Definition 1.3. *An IF-set* $\mathrm{A} = (\mathrm{X}, \mathrm{R}_\mathrm{A}, \mathrm{J}_\mathrm{A})$ *is supposed to be IFSs of X if*

(i) $\mathrm{R}_\mathrm{A}(\mathrm{x}_1 * \mathrm{x}_2) \geq \min\{\mathrm{R}_\mathrm{A}(\mathrm{x}_1), \mathrm{R}_\mathrm{A}(\mathrm{x}_2)\}$

(ii) $\mathrm{J}_\mathrm{A}(\mathrm{x}_1 * \mathrm{x}_2) \leq \max\{\mathrm{J}_\mathrm{A}(\mathrm{x}_1), \mathrm{J}_\mathrm{A}(\mathrm{x}_2)\}$

for all $\mathrm{x}_1, \mathrm{x}_2 \in X$.

2. TRANSLATIONS OF IFSS IN BF-ALGEBRAS

The following discussion is on the notation of IFT on X. It evident that, X stands a BF-algebra, and for any IF-set $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ of X, $\mathrm{T} = 1 - \sup\{\mathrm{R_A}(\mathrm{x_1}) : \mathrm{x_1} \in \mathrm{X}\} = 1 - \inf\{\mathrm{J_A}(\mathrm{x_1}) : \mathrm{x_1} \in \mathrm{X}\}$.

Definition 2.1. $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is an IF-subset of* X. *Let*$\alpha \in [0, \mathrm{T}]$. *An object having the form* $A_\alpha^T = ((R_A)_\alpha^T, (J_A)_\alpha^T)$ *is called IF-*α*-translation of A if* $(R_A)_\alpha^T(x_1) = R_A(x_1) + \alpha$ *and* $(J_A)_\alpha^T(x_1) = J_A(x_1) - \alpha$ *for all* $x_1 \in X$.

Definition 2.2. *Let* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *be an IF-Subset of X and let* $\alpha \in [0, 1]$. *An object having the form* $A_\alpha^m = ((R_A)_\alpha^m, (J_A)_\alpha^m)$ *is called an IF-*α*-multiplication of A if* $(R_A)_\alpha^m(x_1) = \alpha.R_A(x_1)$ *and* $(J_A)_\alpha^m(x_1) = \alpha.J_A(x_1)$ *for all* $x_1 \in X$. *For any IF-set* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *of* X*, , an IF-0-multiplication* $A_0^m = ((R_A)_0^m, (J_A)_0^m)$ *of* A *is an IFS of* X.

Example 3. *Consider the BF-algebra* $X = \{0, p, q, s, t\}$ *in Example 2. Define a IF-subset* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *of* X *by*

$$R_A(r) = \begin{cases} 0.4; r \neq q \\ 0.1; r = q \end{cases} \quad \textit{and} \quad J_A(r) = \begin{cases} 0.4; r \neq q \\ 0.7; r = q \end{cases},$$

then $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is IFS of* X. *Here* $T = 1 - \sup\{R_A(r) : r \in X\} = 1 - 0.4 = 0.6 = 1 - \inf\{J_A(r) : r \in X\} = 1 - 0.4 = 0.6$. *Choose* $\alpha = 0.3 \in [0, \mathrm{T}]$ *and* $\beta = 0.2 \in [0, 1]$. *Then the mapping* $(R_A)_{0.3}^T : X \to [0, 1]$ $(J_A)_{0.3}^T : X \to [0, 1]$ *are defined by*

$$(R_A)_{0.3}^T(r) = \begin{cases} 0.4 + 0.3 = 0.7; r \neq q \\ 0.1 + 0.3 = 0.4; r = q \end{cases}$$

and

$$(J_A)_{0.3}^T(r) = \begin{cases} 0.4 - 0.3 = 0.1; r \neq q \\ 0.7 - 0.3 = 0.4; r = q \end{cases},$$

which satisfies $A_{0.3}^T = ((R_A)_{0.3}^T, (J_A)_{0.3}^T) = (R_A(r) + 0.3, J_A(r) - 0.3)$ *for all* $r \in X$ *is IF-0.3-Translation.*

The mappings $(R_A)_{0.2}^m : X \to [0, 1]$ *and* $(J_A)_{0.2}^m : X \to [0, 1]$ *are defined by*

$$(\mathrm{R_A})_{0.2}^{\mathrm{m}}(\mathrm{r}) = \begin{cases} (0.4)(0.2) = 0.08; \mathrm{r} \neq q \\ (0.1)(0.2) = 0.02; \mathrm{r} = \mathrm{q} \end{cases}$$

and

$$(J_{\mathrm{A}})^{\mathrm{m}}_{0.2}(\mathrm{r}) = \begin{cases} (0.4)(0.2) = 0.08; \mathrm{r} \neq \mathrm{q} \\ (0.7)(0.2) = 0.14; \mathrm{r} = \mathrm{q} \end{cases},$$

which satisfies $(\mathrm{R_A})^{\mathrm{m}}_{0.2}(\mathrm{r}) = 0.2.\mathrm{R_A}$ $(\mathrm{J_A})^{\mathrm{m}}_{0.2}(\mathrm{r}) = 0.2.\mathrm{J_A}$ *for allis IF-0.2-multiplication.*

Theorem 2.1. *For all IFS* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *of* $X \wedge \alpha \in [0, \mathrm{T}]$ *the 'IF-α-translation'.* $A^T_\alpha = ((R_A)^T_\alpha, (J_A)^T_\alpha)$ *of*$\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is a IFS of* X.

Proof. Let $\mathrm{r}, \mathrm{s} \in \mathrm{X}$ and $\alpha \in [0, \mathrm{T}]$. Then $R_A(r * s) \geq \min\{R_A(r), R_A(s)\}$. Now,

$$(R_A)^T_\alpha(r * s) = R_A(r * s) + \alpha \geq \min\{R_A(r), R_A(s)\} + \alpha$$
$$= \min\{R_A(r) + \alpha, R_A(s) + \alpha\} = \min\{(R_A)^T_\alpha(r), (R_A)^T_\alpha(s)\}$$

and

$$(J_A)^T_\alpha(r * s) = J_A(r * s) - \alpha \leq \max\{J_A(r), J_A(s)\} - \alpha$$
$$= \max\{J_A(r) - \alpha, J_A(s) - \alpha\} = \max\{(J_A)^T_\alpha(r), (J_A)^T_\alpha(s)\}.$$

Hence the theorem follows. □

Theorem 2.2. *For all IF-subset* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$*of* X. $\wedge\ \alpha \in [0, \mathrm{T}]$ *if the IF-α - Translation* $A^T_\alpha = ((R_A)^T_\alpha, (J_A)^T_\alpha)$ *of* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is a IFS of* X *then* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is IFS of* X.

Proof. Suppose that $A^T_\alpha = ((R_A)^T_\alpha, (J_A)^T_\alpha)$ is an IFSs of X and $\alpha \in [0, \mathrm{T}]$. Let $r, s \in X$, we have

$$\mathrm{R_A}(r * s) + \alpha = (\mathrm{R_A})^{\mathrm{T}}_\alpha(r * s) \geq \min\{(\mathrm{R_A})^{\mathrm{T}}_\alpha(r), (\mathrm{R_A})^{\mathrm{T}}_\alpha(s)\}$$
$$=\min\{\mathrm{R_A}(r) + \alpha, \mathrm{R_A}(s) + \alpha\} = \min\{\mathrm{R_A}(r), \mathrm{R_A}(s)\} + \alpha$$

and

$$J_{\mathrm{A}}(r * s) - \alpha = (J_{\mathrm{A}})^{\mathrm{T}}_\alpha(r * s) \leq \max\{(J_{\mathrm{A}})^{\mathrm{T}}_\alpha(r), (J_{\mathrm{A}})^{\mathrm{T}}_\alpha(s)\}$$
$$=\max\{\mathrm{J_A}(r), \mathrm{J_A}(s)\} - \alpha = \max\{J_{\mathrm{A}}(r) - \alpha, J_{\mathrm{A}}(s) - \alpha\},$$

which implies that $\mathrm{R_A}(r * s) \geq \min\{\mathrm{R_A}(r), \mathrm{R_A}(s)\}$ and $\mathrm{J_A}(r * s) \leq \max\{\mathrm{J_A}(r), \mathrm{J_A}(s)\}$ for all r,$s \in \mathrm{X}$. Hence $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ is IFS of X. □

Theorem 2.3. $(A_1)^T_\alpha$ *and* $(A_2)^T_\alpha$ *are two IFS of* $X \Rightarrow (A_1 \cap A_2)^T_\alpha$*is also a IFS of* X.

Proof. $(A_1)^T_\alpha$ and $(A_2)^T_\alpha$ are two IFS of X. Then

$$(R_{A_1 \cap A_2})^T_\alpha(x_1 * x_2) = \min\{(R_{A_1})^T_\alpha(x_1 * x_2), (R_{A_2})^T_\alpha(x_1 * x_2)\}$$
$$= \min\{(R_{A_1})(x_1 * x_2) + \alpha, (R_{A_2})(x_1 * x_2) + \alpha\}$$

$$\geq \min\{\min\{R_{A_1}(x_1), R_{A_1}(x_2)\} + \alpha, \min\{R_{A_2}(x_1), R_{A_2}(x_2)\} + \alpha\}$$
$$= \min\{\min\{R_{A_1}(x_1) + \alpha, R_{A_1}(x_2) + \alpha\}, \min\{R_{A_2}(x_1) + \alpha, R_{A_2}(x_2) + \alpha\}\}$$
$$= \min\{\min\{(R_{A_1})^T_\alpha(x_1), (R_{A_1})^T_\alpha(x_2)\}, \min\{(R_{A_2})^T_\alpha(x_1), (R_{A_2})^T_\alpha(x_2)\}\}$$
$$= \min\{\min\{(R_{A_1})^T_\alpha(x_1), (R_{A_2})^T_\alpha(x_1)\}, \min\{(R_{A_1})^T_\alpha(x_2), (R_{A_2})^T_\alpha(x_2)\}\}$$
$$= \min\{(R_{A_1\cap A_2})^T_\alpha(x_1), (R_{A_1\cap A_2})^T_\alpha(x_2)\}$$
$$(R_{A_1\cap A_2})^T_\alpha(x_1 * x_2) \geq \min\{(R_{A_1\cap A_2})^T_\alpha(x_1), (R_{A_1\cap A_2})^T_\alpha(x_2)\}$$
$$(J_{A_1\cap A_2})^T_\alpha(x_1 * x_2) = \max\{(J_{A_1})^T_\alpha(x_1 * x_2), (J_{A_2})^T_\alpha(x_1 * x_2)\}$$
$$= \max\{(J_{A_1})(x_1 * x_2) - \alpha, (J_{A_2})(x_1 * x_2) - \alpha\}$$
$$\leq \max\{\max\{J_{A_1}(x_1), J_{A_1}(x_2)\} - \alpha, \max\{J_{A_2}(x_1), J_{A_2}(x_2)\} - \alpha\}$$
$$= \max\{\max\{J_{A_1}(x_1) - \alpha, J_{A_1}(x_2) - \alpha\}, \max\{J_{A_2}(x_1) - \alpha, J_{A_2}(x_2) - \alpha\}\}$$
$$= \max\{\max\{(J_{A_1})^T_\alpha(x_1), (J_{A_1})^T_\alpha(x_2)\}, \max\{(J_{A_2})^T_\alpha(x_1), (J_{A_2})^T_\alpha(x_2)\}\}$$
$$= \max\{\max\{(J_{A_1})^T_\alpha(x_1), (J_{A_2})^T_\alpha(x_1)\}, \max\{(J_{A_1})^T_\alpha(x_2), (J_{A_2})^T_\alpha(x_2)\}\}$$
$$= \max\{(J_{A_1\cap A_2})^T_\alpha(x_1), (J_{A_1\cap A_2})^T_\alpha(x_2)\}$$
$$(J_{A_1\cap A_2})^T_\alpha(x_1 * x_2) \leq \max\{(J_{A_1\cap A_2})^T_\alpha(x_1), (J_{A_1\cap A_2})^T_\alpha(x_2)\}$$

Hence $(A_1 \cap A_2)^T_\alpha$is a IFS of X. □

Theorem 2.4. *Let* $\{A_i/i = 1, 2, 3, \ldots\}$ *be a family of IFS of* X*. Then* $(\cap \mathrm{A_i})^{\mathrm{T}}_\alpha$ *is also a IFS of* X*, where* $(\cap \mathrm{A_i})^{\mathrm{T}}_\alpha = \min\{(\mathrm{A_i})^T_\alpha(x)\}$.

Theorem 2.5. *For any IFS* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *of X.*α *is an element in* $[0, 1]$*, the IF-*α *-multiplication.*$A^m_\alpha = ((R_A)^m_\alpha, (J_A)^m_\alpha)$ *of* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is an IFS of* X.

Proof. Let $\mathrm{r}, s \in \mathrm{X}\ \&\alpha \in [0, 1]$. Then $R_A(r * s) \geq \min\{R_A(r), R_A(s)\}$. Now

$$(R_A)^m_\alpha(r * s) = \alpha.R_A(r * s) \geq \alpha.\min\{R_A(r), R_A(s)\}$$
$$= \min\{\alpha.R_A(r), \alpha.R_A(s)\} = \min\{(R_A)^m_\alpha(r), (R_A)^m_\alpha(s)\}, (J_A)^m_\alpha(r * s)$$
$$= \alpha.J_A(r * s) \leq \alpha.\max\{J_A(r), J_A(s)\} = \max\{\alpha.J_A(r), \alpha.J_A(s)\}$$
$$= \max\{(J_A)^m_\alpha(r), (J_A)^m_\alpha(s)\}.$$

Hence the theorem follows. □

Theorem 2.6. *For any IF-subset* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *of* X *and* $\alpha \in [0, 1]$*, if the IF-*α*-multiplication* $A^m_\alpha = ((R_A)^m_\alpha, (J_A)^m_\alpha)$ *of* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is an of* X *then* $\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ *is IFS of* X.

Proof. Assume $A_\alpha^m = ((\mu_A)_\alpha^m, (\lambda_A)_\alpha^m)$ is an IFS of X where $\alpha \in [0, \mathrm{T}]$, $x_1, x_2 \in X$. One can have

$$\begin{aligned}
&\alpha.\mathrm{R_A}(x_1 * x_2) = (\mathrm{R_A})_\alpha^{\mathrm{m}}(x_1 * x_2) \geq \min\{(\mathrm{R_A})_\alpha^{\mathrm{m}}(\mathrm{x_1}), (\mathrm{R_A})_\alpha^{\mathrm{m}}(x_2)\}\\
&=\min\{\alpha.\mathrm{R_A}(\mathrm{x_1}), \alpha.\mathrm{R_A}(x_2)\} = \alpha.\min\{\mathrm{R_A}(\mathrm{x_1}), \mathrm{R_A}(x_2)\}, \alpha.J_{\mathrm{A}}(x_1 * x_2)\\
&=(J_{\mathrm{A}})_\alpha^{\mathrm{m}}(x_1 * x_2) \leq \max\{(J_{\mathrm{A}})_\alpha^{\mathrm{m}}(\mathrm{x_1}), (J_{\mathrm{A}})_\alpha^{\mathrm{m}}(x_2)\}\\
&=\max\{\alpha.J_{\mathrm{A}}(\mathrm{x_1}), \alpha.J_{\mathrm{A}}(x_2)\} = \alpha.\max\{\mathrm{J_A}(\mathrm{x_1}), \mathrm{J_A}(x_2)\},
\end{aligned}$$

which implies that $\mathrm{R_A}(x_1 * x_2) \geq \min\{\mathrm{R_A}(\mathrm{x_1}), \mathrm{R_A}(x_2)\}$ and $\mathrm{J_A}(x_1 * x_2) \leq \max\{\mathrm{J_A}(\mathrm{x_1}), \mathrm{J_A}(x_2)\}$ for all $x_1, x_2 \in X$ since $\alpha \neq 0$. Hence$\mathrm{A} = (\mathrm{R_A}, \mathrm{J_A})$ is IFSs of X. □

Theorem 2.7. *$(A_1)_\alpha^m$ and $(A_2)_\alpha^m$ be two IFS of $X \Rightarrow (A_1 \cap A_2)_\alpha^m$ is also IFS of X.*

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