NEW INTERVAL VALUE INTUITIONISTIC FUZZY SETS

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Abstract

In this paper, a generalized interval value intuitionistic fuzzy set (GIVIFS$_B$) is proposed. It is showed that Atanassov’s interval value intuitionistic fuzzy set is a special case of this new one. Further, some important notions and basic algebraic properties of GIVIFS$_B$ are discussed.

1. Introduction

Zadeh’s fuzzy sets [33] characterized only by membership function, where the values membership function are numbers belong to $[0, 1]$. Zadeh [32] and Turksen [26] introduced the concept of interval valued fuzzy subsets (IVFS), where the values of the membership functions are intervals of numbers instead of the numbers. Later on, Atanassov [5] introduced some operations over interval-valued fuzzy set.

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Atanassov [3] introduced the concept of intuitionistic fuzzy sets (IFSs), which is a generalization of fuzzy subsets and defines new operations on IFSs. In this extension, IFSs are defined using degree of membership belong to \([0, 1]\) and a degree of non-membership belong to \([0, 1]\), under the constraint that the sum of two degrees does not exceeds one. Following the definition IFS, Atanassov and Gargov [4] introduced interval valued intuitionistic fuzzy sets (IVIFS), which is a generalization of the IFS. The fundamental characteristic of the IVIFSs is that the values of its membership function and non membership function are intervals at \([0, 1]\) rather than exact numbers. The IVIFSs has been studied and applied in a variety of fields as pattern recognition, medical diagnosis, decision making, data mining, conflict analysis algebra and so on.

Xu [27, 28] developed some arithmetic aggregation operators and some geometric aggregation operators of IVIFS, to be used in decision making. Ahn et al. [2] IVIFS theory has been applied to make a diagnosis of headache as a new approach on decision support practice in medicine. Ye [30] and Jing and Min [20] studied the entropy of the interval-valued intuitionistic fuzzy sets and its applications. Hu and Li [18] investigate the relationship between entropy and similarity of interval valued intuitionistic fuzzy sets.

Bustince and Burillo [12], Hong [19] and Zeng and Wang [34] introduced the concepts of correlation and correlation coefficient of interval-valued intuitionistic fuzzy sets. Park et al. [24] extend three methods for measuring distances between IVFSs to IVIFSs. Xu [29] introduced some relations and operations of interval-valued intuitionistic fuzzy numbers and define some types of interval-valued intuitionistic fuzzy matrices for group decision making. Bhowmik and Pal [10, 11] defined generalized interval-valued intuitionistic fuzzy set (GIVIFS) and presented various properties of it. Zhenhua et al. [35] introduced generalized interval-valued intuitionistic fuzzy sets with parameters. Chen et al. [13], Yue [31] and Li [14, 15, 16] presented methods for Multicriteria fuzzy decision making based on IVIFS. Mondal and Samanta [23] studied the topological properties and the category of
topological spaces of IVIFSs. Adak and Bhowmik [1] defined interval cut-set of interval-valued intuitionistic fuzzy sets. Mishra and Pal [22] product of interval valued intuitionistic fuzzy graph. Baloui and Nadaraja [9] introduced a generalization of the IFS. In this paper, the main objective is introduce a new generalized of interval value intuitionistic fuzzy sets and also define some operations and their properties.

2. Preliminaries

In this section, we give some definition. Let $X$ be a non-empty set.

**Definition 2.1** (Atanassov [3]). An IFS $A$ in $X$ is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X \}$, where the functions $\mu_A : X \rightarrow [0, 1]$ and $\nu_A : X \rightarrow [0, 1]$ denote the degree of membership and non-membership functions of $A$, respectively, and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ for each $x \in X$.

**Definition 2.2** (Atanassov and Gargov [4]). Interval value intuitionistic fuzzy sets (IVIFS) $A$ in $X$, is defined as an object of the form $A = \{\langle x, M_A(x), N_A(x) \rangle : x \in X \}$, where the functions $M_A(x) : X \rightarrow [I]$ and $N_A(x) : X \rightarrow [I]$, denote the degree of membership and degree of non membership functions of $A$, respectively, where $M_A(x) = [M_{AL}(x), M_{AU}(x)]$, $N_A(x) = [N_{AL}(x), N_{AU}(x)]$, $0 \leq M_{AU}(x) + N_{AU}(x) \leq 1$ for each $x \in X$.

**Definition 2.3** (Baloui Jamkhaneh and Nadarajah [9]). Generalized intuitionistic fuzzy sets (GIFS$_B$) $A$ in $X$, is defined as an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x) \rangle : x \in X \}$, where the functions $\mu_A : X \rightarrow [0, 1]$ and $\nu_A : X \rightarrow [0, 1]$, denote the degree of membership and degree of non membership functions of $A$, respectively, and $0 \leq \mu_A(x)^\delta + \nu_A(x)^\delta \leq 1$ for each $x \in X$ and $\delta = n$ or $\frac{1}{n}$, $n = 1, 2, \ldots, N$. 
Definition 2.4. Let \([I]\) be the set of all closed subintervals of the interval \([0,1]\) and \(M_A(x) = [M_{AL}(x), M_{AU}(x)] \in [I]\) and \(N_A(x) = [N_{AL}(x), N_{AU}(x)] \in [I]\), then \(N_A(x) \leq M_A(x)\) if and only if \(N_{AL}(x) \leq M_{AL}(x)\) and \(N_{AU}(x) \leq M_{AU}(x)\).

Definition 2.5. Let \([I]\) be the set of all closed subintervals of the interval \([0,1]\) and \(M_A(x) = [M_{AL}(x), M_{AU}(x)] \in [I]\), \(f : [0,1] \rightarrow [0,1]\), then \(f(M_A(x)) = [f(M_{AL}(x)), f(M_{AU}(x))].\)

3. Generalized Interval Value Intuitionistic Fuzzy Sets

Definition 3.1. Let \(X\) be a non empty set. Generalized interval value intuitionistic fuzzy sets (GIVIFS\(_B\)) \(A\) in \(X\), is defined as an object of the form \(A = \{(x, M_A(x), N_A(x))|x \in X\}\), where the functions \(M_A(x) : X \rightarrow [I]\) and \(N_A(x) : X \rightarrow [I]\), denote the degree of membership and degree of non membership of \(A\), respectively, and \(M_A(x) = [M_{AL}(x), M_{AU}(x)], N_A(x) = [N_{AL}(x), N_{AU}(x)]\), where \(0 \leq M_{AU}(x) + N_{AU}(x) \leq 1\), for each \(x \in X\) and \(\delta = n \) or \(\frac{1}{n}, n = 1, 2, ..., N\). The collection of all \(GIVIFS_B(\delta)\) is denoted by \(GIVIFS_B(\delta, X)\).

Remark 3.1. It is obvious that for all real numbers \(\alpha, \beta \in [0,1]\).

(i) If \(0 \leq \alpha + \beta \leq 1\) and \(\delta \geq 1\), then we have \(0 \leq \alpha^\delta + \beta^\delta \leq 1\), with this consideration if \(A \in IVIFS\), then \(A \in GIVIFS_B\).

(ii) If \(0 \leq \alpha^\delta + \beta^\delta \leq 1\) and \(\delta \leq 1\), then \(0 \leq \alpha + \beta \leq 1\), with this consideration if \(A \in GIVIFS_B\), then \(A \in IVIFS\).

(iii) If \(\delta_1 \leq \delta_2\), then \(\alpha^{\delta_2} \leq \alpha^{\delta_1}\) and \(\beta^{\delta_2} \leq \beta^{\delta_1}\). It follows that \(GIVIFS_B(\delta_1) \subset GIVIFS_B(\delta_2)\).
**Definition 3.2.** Let $X$ be a non-empty set. Let $A$ and $B$ be two $GIVIFS_{B^g}$ such that

\[
A = \{ (x, M_A(x), N_A(x)) : x \in X \},
\]
\[
B = \{ (x, M_B(x), N_B(x)) : x \in X \},
\]
\[
M_A(x) = [M_{AL}(x), M_{AU}(x)], \quad N_A(x) = [N_{AL}(x), N_{AU}(x)],
\]
\[
M_B(x) = [M_{BL}(x), M_{BU}(x)], \quad N_B(x) = [N_{BL}(x), N_{BU}(x)],
\]

define the following relations and operations on $A$ and $B$:

(i) $A \subseteq B$ if and only if $M_A(x) \leq M_B(x)$ and $N_A(x) \geq N_B(x)$, $\forall x \in X$,

(ii) $A = B$ if and only if $M_A(x) = M_B(x)$ and $N_A(x) = N_B(x)$, $\forall x \in X$,

(iii) $A \cup B = \{ (x, \max(M_{AL}(x), M_{BL}(x)), \max(M_{AU}(x), M_{BU}(x)))$
\[
\quad [ \min(N_{AL}(x), N_{BL}(x)), \min(N_{AU}(x), N_{BU}(x))] : x \in X \},
\]

(iv) $A \cap B = \{ (x, \min(M_{AL}(x), M_{BL}(x)), \min(M_{AU}(x), M_{BU}(x)))$
\[
\quad [ \max(N_{AL}(x), N_{BL}(x)), \max(N_{AU}(x), N_{BU}(x))] : x \in X \},
\]

(v) $A + B = \{ (x, \left[ M_{AL}(x)^\delta + M_{BL}(x)^\delta - M_{AL}(x)^\delta M_{BL}(x)^\delta, M_{AU}(x)^\delta \right.$
\[
\quad + M_{BU}(x)^\delta - M_{AU}(x)^\delta M_{BU}(x)^\delta ], [N_{AL}(x)^\delta, N_{BL}(x)^\delta]$,
\[
N_{AU}(x)^\delta \cdot N_{BU}(x)^\delta \} : x \in X \},
\]

therefore,

\[
2A = \{ (x, \left[ 1 - (1 - M_{AL}(x)^\delta)^2, 1 - (1 - M_{AU}(x)^\delta)^2 \right] ; [N_{AL}(x)^{2\delta}, N_{AU}(x)^{2\delta}] : x \in X \},
\]

and

\[
nA = \{ (x, \left[ 1 - (1 - M_{AL}(x)^\delta)^n, 1 - (1 - M_{AU}(x)^\delta)^n \right] ; [N_{AL}(x)^{n\delta}, N_{AU}(x)^{n\delta}] : x \in X \},
\]
(vi)

\[ A.B = \{ (x, [M_{AL}(x)^\delta \cdot M_{BL}(x)^\delta, M_{AU}(x)^\delta \cdot M_{BU}(x)^\delta], [N_{AL}(x)^\delta + N_{BL}(x)^\delta]
\] 

\[ - N_{AL}(x)^\delta N_{BL}(x)^\delta, N_{AU}(x)^\delta + N_{BU}(x)^\delta - N_{AU}(x)^\delta N_{BU}(x)^\delta) : x \in X \} \]

therefore,

\[ A^2 = \]

\[ \{ (x, [M_{AL}(x)^{2\delta}, M_{AU}(x)^{2\delta}], [1 - (1 - N_{AL}(x)^\delta)^2, 1 - (1 - N_{AU}(x)^\delta)^2] : x \in X \} \]

and

\[ A^n = \]

\[ \{ (x, [M_{AL}(x)^{n\delta}, M_{AU}(x)^{n\delta}], [1 - (1 - N_{AL}(x)^\delta)^n, 1 - (1 - N_{AU}(x)^\delta)^n] : x \in X \} \]

(vii) \[ \overline{A} = \{ (x, N_A(x), M_A(x)) : x \in X \} \]

**Proposition 3.1.** Let \( A, B, C \in GIVIFS_B \), we have

(i) \[ \overline{\overline{A}} = A \]

(ii) \[ \overline{A \cup B} = \overline{A} \cap \overline{B} \]

(iii) \[ \overline{A \cap B} = \overline{A} \cup \overline{B} \]

(iv) \[ A \subset B, B \subset C \Rightarrow A \subset C \]

**Proof.** Proof is obvious.

**Proposition 3.2.** Let \( A, B \in GIVIFS_B \), we have

(i) \[ A \cup B \in GIVIFS_B \]

(ii) \[ A \cap B \in GIVIFS_B \]

(iii) \[ \delta \geq 1 \Rightarrow A + B \in GIVIFS_B \]

\[ \delta < 1 \Rightarrow A + B \in IVIFS \]
(iv) \( \delta \geq 1 \Rightarrow A \cdot B \in GIVIFS_B \),
\( \delta < 1 \Rightarrow A \cdot B \in IVIFS \),

**Proof.** (i) Let \( \max(M_{AU}(x), M_{BU}(x)) = M_{AU}(x) \), since \( \min(N_{AU}(x), N_{BU}(x)) \leq N_{AU}(x) \), we have

\[
0 \leq M_{(A \cup B)U}(x) \delta + N_{(A \cup B)U}(x) \delta,
\]

\[
= (\max(M_{AU}(x), M_{BU}(x))) \delta + (\min(N_{AU}(x), N_{BU}(x))) \delta,
\]

\[
= M_{AU}(x) \delta + (\min(N_{AU}(x), N_{BU}(x))) \delta,
\]

\[
\leq M_{AU}(x) \delta + N_{AU}(x) \delta \leq 1.
\]

If \( \max(M_{AU}(x), M_{BU}(x)) = M_{BU}(x) \), since \( \min(N_{AU}(x), N_{BU}(x)) \leq N_{BU}(x) \), we have

\[
0 \leq M_{(A \cup B)U}(x) \delta + N_{(A \cup B)U}(x) \delta
\]

\[
= (\max(M_{AU}(x), M_{BU}(x))) \delta + (\min(N_{AU}(x), N_{BU}(x))) \delta
\]

\[
= M_{BU}(x) \delta + (\min(N_{AU}(x), N_{BU}(x))) \delta
\]

\[
\leq M_{BU}(x) \delta + N_{BU}(x) \delta \leq 1.
\]

The proof is completed. Proof of (ii) is similar (i).

(iii) We know

\[
A + B = \{(x, [M_{AL}(x) \delta + M_{BL}(x) \delta - M_{AL}(x) \delta M_{BL}(x) \delta, M_{AU}(x) \delta
\]

\[
+ M_{BU}(x) \delta - M_{AU}(x) \delta M_{BU}(x) \delta], [N_{AL}(x) \delta \cdot N_{BL}(x) \delta,
\]

\[
N_{AU}(x) \delta \cdot N_{BU}(x) \delta] : x \in X\},
\]
then

\[ M_{(A+B)U}(x)^\delta + N_{(A+B)U}(x)^\delta \]

\[ = (M_{AU}(x)^\delta + M_{BU}(x)^\delta - M_{AU}(x)^\delta M_{BU}(x)^\delta )^\delta + (N_{AU}(x)^\delta .N_{BU}(x)^\delta )^\delta \]

\[ = (M_{AU}(x)^\delta (1 - M_{BU}(x)^\delta ) + M_{BU}(x)^\delta )^\delta + (N_{AU}(x)^\delta .N_{BU}(x)^\delta )^\delta \geq 0, \]

and

\[ M_{(A+B)\{U\}x^\delta + N_{(A+B)\{U\}x^\delta} \]

\[ = (M_{AU}(x)^\delta + M_{BU}(x)^\delta - M_{AU}(x)^\delta M_{BU}(x)^\delta )^\delta + (N_{AU}(x)^\delta .N_{BU}(x)^\delta )^\delta \]

\[ \leq \left( (1 - N_{AU}(x)^\delta ) + (1 - N_{BU}(x)^\delta ) - (1 - N_{AU}(x)^\delta )^{-1}(1 - N_{BU}(x)^\delta )^{-1} \right)^\delta \]

\[ + (N_{AU}(x)^\delta .N_{BU}(x)^\delta )^\delta \]

\[ = \left( 1 - N_{AU}(x)^\delta .N_{BU}(x)^\delta \right)^\delta + (N_{AU}(x)^\delta .N_{BU}(x)^\delta )^\delta \]

\[ = (1 - u)^\delta + u^\delta, \quad u = N_{AU}(x)^\delta .N_{BU}(x)^\delta . \]

If \( \delta \geq 1 \), then \( (1 - u)^\delta + u^\delta \geq 1 \), hence \( A + B \in IVIFS_B \). If \( \delta < 1 \), then \( (1 - u)^\delta + u^\delta \leq 1 \), if and only if \( N_{AU}(x) = 0 \) or \( N_{BU}(x) = 0 \). But for any \( \delta \), we have

\[ M_{(A+B)\{U\}x}(x)^\delta + N_{(A+B)\{U\}x}(x) \]

\[ = (M_{AU}(x)^\delta + M_{BU}(x)^\delta - M_{AU}(x)^\delta M_{BU}(x)^\delta ) + (N_{AU}(x)^\delta .N_{BU}(x)^\delta ) \]

\[ \leq (M_{AU}(x)^\delta + M_{BU}(x)^\delta - M_{AU}(x)^\delta M_{BU}(x)^\delta ) \]

\[ + (1 - M_{AU}(x)^\delta ).(1 - M_{BU}(x)^\delta ) = 1, \]

hence \( A + B \in IVIFS \).

Proof of (iv) is similar (iii).
Proposition 3.3. For every GIVIFS$_B$ $A$, we have

(i) $m \geq n \rightarrow A^m \subset A^n$,

(ii) $m \geq n \rightarrow nA \subset mA$,

(iii) $A^n = \overline{nA}$,

where $m$ and $n$ are both positive number.

Proof. (i)

$A^n = \{(x, [M_{AL}(x)^{\overline{m}}, M_{AU}(x)^{\overline{m}}], [1 - (1 - N_{AL}(x)^{\overline{m}})^n, 1 - (1 - N_{AU}(x)^{\overline{m}})^n]) : x \in X\}$,

$A^m = \{(x, [M_{AL}(x)^{\overline{m}}, M_{AU}(x)^{\overline{m}}], [1 - (1 - N_{AL}(x)^{\overline{m}})^m, 1 - (1 - N_{AU}(x)^{\overline{m}})^m]) : x \in X\}$.

Since $m \geq n$, then $M_{AU}(x)^{\overline{m}} \geq M_{AU}(x)^{\overline{m}}$, $M_{AL}(x)^{\overline{m}} \geq M_{AL}(x)^{\overline{m}}$ hence $M_{A^n}(x) \geq M_{A^m}(x)$. Also since $N_{AL}(x) \leq 1, N_{AU}(x) \leq 1$, then

$(1 - N_{AU}(x)^{\overline{m}})^n \leq (1 - N_{AU}(x)^{\overline{m}})^n, (1 - N_{AL}(x)^{\overline{m}})^m \leq (1 - N_{AL}(x)^{\overline{m}})^n$ hence

$1 - (1 - N_{AU}(x)^{\overline{m}})^n \leq 1 - (1 - N_{AU}(x)^{\overline{m}})^n, 1 - (1 - N_{AL}(x)^{\overline{m}})^m \leq 1 - (1 - N_{AL}(x)^{\overline{m}})^n$, hence $N_{A^n}(x) \leq N_{A^m}(x)$.

Proof is complete. Proof of (ii) is similar (i). Proof of (iii) is clearly.

Proposition 3.4. Let $A$, $B \in$ GIVIFS$_B$, we have

(i) $A \subset B \rightarrow nA \subset nB$,

(ii) $A \subset B \rightarrow A^n \subset B^n$,

(iii) $(A \cup B)^n = A^n \cup B^n$,

(iv) $(A \cap B)^n = A^n \cap B^n$,

(v) $n(A \cup B) = nA \cup nB$,

(vi) $n(A \cap B) = nA \cap nB$. 
Proof. (i) Since $A \subset B$, then $M_A(x) \leq M_B(x)$ hence

$$M_A(x)^\delta \leq M_B(x)^\delta \Rightarrow 1 - M_B(x)^\delta \leq 1 - M_A(x)^\delta \Rightarrow (1 - M_B(x)^\delta)^n \leq (1 - M_A(x)^\delta)^n,$$

finally,

$$1 - (1 - M_A(x)^\delta)^n \leq 1 - (1 - M_B(x)^\delta)^n \Rightarrow M_{nA}(x) \leq M_{nB}(x).$$

Also since $A \subset B$, then $N_B(x) \leq N_A(x)$ hence

$$N_B(x)^{n\delta} \leq N_A(x)^{n\delta} \Rightarrow N_{nB}(x) \leq N_{nA}(x),$$

proof is complete.

(ii)

$$A \subset B \Rightarrow \overline{B} \subset \overline{A} \Rightarrow n\overline{B} \subset n\overline{A} \Rightarrow \overline{n\overline{A}} \subset \overline{n\overline{B}} \Rightarrow A^n \subset B^n.$$ 

(iii)

$$(A \cup B)^n = \{ x, \big[ \max(M_{AL}(x), M_{BL}(x))^{n\delta}, (\max(M_{AU}(x), M_{BU}(x))^{n\delta} \big],
\langle 1 - (1 - \min(N_{AL}(x), N_{BL}(x))^{\delta})^n, 1 - \left(1 - \min(N_{AU}(x), N_{BU}(x))^{\delta}\right)^n \rangle : x \in X \}

=\{ x, [\max(M_{AL}(x)^{n\delta}, M_{BL}(x)^{n\delta}), \max(M_{AU}(x)^{n\delta}, M_{BU}(x)^{n\delta})],
[1 - (1 - \min(N_{AL}(x)^{\delta}, N_{BL}(x)^{\delta}))^n, 1 - (1 - \min(N_{AU}(x)^{\delta}, N_{BU}(x)^{\delta}))^n] : x \in X \}

=\{ x, [\max(M_{AL}(x)^{n\delta}, M_{BL}(x)^{n\delta}), \max(M_{AU}(x)^{n\delta}, M_{BU}(x)^{n\delta})],
[1 - (\max(1 - N_{AL}(x)^{\delta}, 1 - N_{BL}(x)^{\delta})^n, 1 - (\max(1 - N_{AU}(x)^{\delta}, 1 - N_{BU}(x)^{\delta})^n) \rangle : x \in X \}$$
\[
\begin{align*}
&= \{(x, [\max(M_{AL}(x)^{\delta}, M_{BL}(x)^{\delta}), \max(M_{AU}(x)^{\delta}, M_{BU}(x)^{\delta})], \\
&\quad \min(1 - (1 - N_{AL}(x)^{\delta})^n, 1 - (1 - N_{BL}(x)^{\delta})^n), \\
&\quad \min(1 - (1 - N_{AU}(x)^{\delta})^n, 1 - (1 - N_{BU}(x)^{\delta})^n)) : x \in X}\} \\
&= A^n \cup B^n.
\end{align*}
\]

Proof (iv) is similar (iii).

(v)

\[
n(A \cup B)
\]

\[
= \{(x, \left[1 - (1 - \max(M_{AL}(x), M_{BL}(x)^{\delta}))^n, 1 - (1 - \max(M_{AU}(x), M_{BU}(x)^{\delta}))^n\right], \\
\quad \min(N_{AL}(x), N_{BL}(x))^{n\delta}, \min(N_{AU}(x), N_{BU}(x))^{n\delta}) : x \in X\}
\]

\[
= \{(x, [1 - (1 - \max(M_{AL}(x)^{\delta}, M_{BL}(x)^{\delta}))^n], \\
\quad (1 - (1 - \max(M_{AU}(x)^{\delta}, M_{BU}(x)^{\delta}))^n], \\
\quad \min(N_{AL}(x), N_{BL}(x))^{n\delta}, \min(N_{AU}(x), N_{BU}(x))^{n\delta}) : x \in X\}
\]

\[
= \{(x, [1 - \min((1 - M_{AL}(x)^{\delta})^n, (1 - M_{BL}(x)^{\delta})^n), \\
\quad 1 - \min((1 - M_{AU}(x)^{\delta})^n, (1 - M_{BU}(x)^{\delta})^n]) \\
\quad \min(N_{AL}(x), N_{BL}(x))^{n\delta}, \min(N_{AU}(x), N_{BU}(x))^{n\delta}) : x \in X\}
\]

\[
= \{(x, [\max(1 - (1 - M_{AL}(x)^{\delta})^n, 1 - (1 - M_{BL}(x)^{\delta})^n], \\
\quad \max(1 - (1 - M_{AU}(x)^{\delta})^n, 1 - (1 - M_{BU}(x)^{\delta})^n], [\min(N_{AL}(x), \\
\quad N_{BL}(x))^{n\delta}, \min(N_{AU}(x), N_{BU}(x))^{n\delta}) : x \in X\}
\]

\[
= nA \cup nB.
\]

Proof (vi) is similar (v).
5. Conclusion

We have introduced Baloui’s generalized interval value intuitionistic fuzzy set (GIVIFS$_B$) as an extension to the interval value intuitionistic fuzzy set. The basic algebraic properties on GIVIFS$_B$ are also presented. Some operations on GIVIFS$_B$ are defined and their relationship are proved. GIVIFS$_B$ is more comprehensive and practical than IVIFS in coping with fuzziness and uncertainty. A list of open problems is as follows: definition of generalized interval value intuitionistic fuzzy number and norms, distances, metrics, metric space, similarity measures, new operators and etc over GIVIFS$_B$ and study their properties.

References


