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Group Actions on Intuitionistic Fuzzy Soft G-Modules

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***Abstract*.** The main purpose of this paper is to introduce a basic version of intuitionistic fuzzy soft G-modulo theory, which extends the notion of modules by introducing some algebraic structures in soft set. Finally, we investigate some basic properties of maximal intuitionistic fuzzy soft G-modules.

Keywords: Soft set, Fuzzy soft set, soft G-module, intuitionistic fuzzy set, normal fuzzy set, maximal intuitionistic fuzzy soft G-ideal.

AMS Mathematics Subject Classification (2010): 94Dxx

1. Introduction

The notion of a fuzzy set was introduced Zadeh [24] and since then this has been applied to various algebraic structures. The idea of "an intuitionistic fuzzy set" was introduced by Atanassov [3,4] as a generalization of the notion of fuzzy set. The concept Γ- near ring, a generalization of both the concepts near ring and Γ- ring was introduced by Satyanarayana [19]. Later several author such as Booth [6] and Satyanarayana [19] studied the real theory of Γ- near rings. Later Jun.et.al [8,9,10,11] considered the fuzzification of left (respectively right) ideals of Γ- near rings. In 1999 Molodtsov [17] proposed an approach for modeling vagueness and uncertainty called soft set theory. Since its inception works on Soft set theory has been applied to many different fields, such as function smoothness, Riemann integration, Pearson integration, Measurement theory, Game theory and decision making. Maji et al. [15] defined some operations on soft sets. Aktas and Naimcagman [1] generalized soft sets by defining the concept of soft groups. After them, Sun et al [22] gave soft modules. Atagun and Sezgin [2] defined the concepts of soft sub rings of a ring, soft sub ideals of a field and soft sub modules of a module and studied their relative properties with respect to soft set operations. Atagun and Sezgin [20] defined soft N-subgroups and soft N-ideals of an N-group. Naimcagman et al. [20] introduced the concept of union substructures of an near rings and N-subgroups. In this paper, we investigate basic version of properties of maximal Intuitionistic Fuzzy Soft N-ideals and properties of maximal Intuitionistic Fuzzy Soft N-ideals.

2. Preliminaries

In this section we include some elementary aspects that are necessary for this paper, from now on we denote a Γ- near ring and N is ideal unless otherwise specified.

Definition 2.1. [15] A nonempty set R with two binary operations '+' (addition) and "." (multiplication) is called a Near-ring if it satisfies the following axioms.

(i) (R, +) is a group.
(ii) (R, .) is a semigroup.
(iii) $(x+y).\ z = x.\ z + y.z$ for all $x,y,z \in R$.

Definition 2.2. [16] A Γ- near ring is a triple (M,+, Γ) where

(i) (M,+) is a group.
(ii) Γ is a nonempty set of binary operations on M such that for $\alpha \in \Gamma$, $(M,+,\alpha)$ is a near ring.
(iii) $x\alpha(y\beta z) = (x\alpha y)\beta z$ for all $x,y,z \in M$ and $\alpha,\beta \in \Gamma$.

Definition 2.3. [16] A subset A of a Γ- near ring M is called a left (respectively right) ideal of M if

(i) (A,+) is a normal divisor of (M,+).
(ii) $U\alpha(x+V) - U\alpha V \in A$ (respectively $x\alpha U \in A$) for all $x \in A$, $\alpha \in \Gamma$ and $U,V \in M$

Definition 2.4. [8] A fuzzy set A in a Γ- near ring M is called a fuzzy left (respectively right) ideal of M if

(i) $A(x-y) \geq \min\{ A_{(x)}, A_{(y)} \}$
(ii) $A(y+x-y) \geq A_{(x)}$ for all $x, y \in M$
(iii) $A(U\alpha(x+V) - U\alpha V) \geq A_{(x)}$ for all $x, U, V \in M$ and $\alpha \in \Gamma$.

Definition 2.5. [1] Let X be an initial universal Set and E be a set of parameters. A pair (F,E) is called a soft set over X if and only if F is a mapping from E into the set of all subsets of the set that is $F:E \rightarrow p(x)$ where p(x) is the power set of X.

Definition 2.6. [15] The relative complement of the soft set F_A over U is denoted by F_A^r where $F_A^r : A \rightarrow p(U)$ is a mapping given as $F_A^r(\alpha) = U/ F_A(\alpha)$ for all $\alpha \in A$.

Definition 2.7. Let X be a non-empty fixed μ_A: $X \rightarrow [0,1]$ and ν_A: $X \rightarrow [0,1]$ denote the degree of membership of each element $x \in X$ to the set S respectively and $0 \leq \mu_A(x) + \nu_A(x) \leq 1$.

Notation: For the sake of simplicity, we shall use the symbol $A = < \mu_A, \nu_A >$ for the IFS $A = \{< x, \mu_A(x), \nu_A(x)> / x \in X\}$

Definition 2.8. Let A be an IFS in a Γ - near ring M, for each pair $<\alpha,\beta> \in [0,1]$ with $\alpha+\beta \leq 1$, the set $A_{<\alpha,\beta>} = \{ x \in X / \mu_A(x) \geq \alpha$ and $\nu_A(x) \leq \beta\}$ is called a $<\alpha,\beta>$ level subset of A.

Definition 2.9. [9] Let G be a finite group. A vector space M over a field K is called a G- module if for every g ϵ G and m ϵ M, there exists a product (called the action of G on M) m.g ϵ M satisfying the following axioms.

i) $m.1_G = m$, ∀ m ϵ M (1_G being the identity element in G)

ii) m.(g.h) = (m.g).h, ∀ m ϵ M ; g, h ϵ G

iii) $(k_1 m_1 + k_2 m_2).g = k_1(m_1.g) + k_2(m_2.g)$, ∀ k_1, k_2 ϵ K ; m_1, m_2 ϵ M; gϵ G

Example 2.1. [9] Let G = {1, -1, i, -i} and M = $\mathbb{C}^n$ (n ≥ 1). Then M is a vector space over ℂ and under the usual addition and multiplication of complex numbers, we can show that M is a G-module.

Definition 2.10. [9] Let M be a G-module. A vector subspace N of M is a G-sub module if N is also a G-module under the same action of G.

Definition 2.11. [9] Let M and M^* be G-modules. A mapping φ : M → M^* is a G-module homomorphism if

i) $\varphi(k_1.m_1 + k_2.m_2) = k_1.\varphi(m_1) + k_2\varphi(m_2)$ and,

ii) φ(m.g) = φ(m).g, ∀ k_1 , k_2 ϵ K ; m, m_1, m_2 ϵ M ; g ϵ G

Further if, φ is 1-1, then φ is an isomorphism. The G-modules M and M* are said to be isomorphic if there exists an isomorphism φ of M onto M*. Then we write M ≅ M^* .

Definition 2.12. [9] Let M be a nonzero G-module. Then M is irreducible if the only G-sub modules of M are M and {0}.Otherwise M is reducible**.**

Definition 2.13. [1] Let U be an initial Universal Set and E be a set of parameters. A pair FS(U) denotes the fuzzy power set of U and A ⊂ E. A pair (F,A) is called a fuzzy soft set over U, where F is a mapping given by F:A→p(U).

A fuzzy soft set is a parameterized family of fuzzy subsets of U.

Definition 2.14. An intutionistic fuzzy soft set A on Universe X can be defined as follows A = {< x, $\mu_A(x)$, $\nu_A(x)$> / x∈ X} where $\mu_A(x)$: X→[0,1] and $\nu_A(x)$: X→[0,1] with the property $0 \le \mu_A(x) + \nu_A(x) \le 1$, the value of $\mu_A(x)$ and $\nu_A(x)$ denote the degree of membership and non-membership of x to A, respectively.

$\prod_A(x) = 1 - \mu_A(x) - \nu_A(x)$ is called the intutionistic fuzzy soft index.

Definition 2.15. Let U be an initial Universal Set and E be a set of parameters. A pair IFS(U) denotes the intutionistic fuzzy soft set over U and A ⊂ E. A pair (F,A) is called an intutionistic fuzzy soft set over U, where F is a mapping given by F:A→IFS(U).

Definition 2.16. Let G be a group. Let M be a G-module of V and A_M be a intuitionstic fuzzy soft set over V. Then A_M is called Intuitionstic Fuzzy Soft G-module of V (IFSG-m), denoted by $A_M \lessapprox_I$ V if the following properties are satisfied

(i) $\mu(ax + by) \geq \mu(x) \cap \mu(y)$ and $\nu(ax+by) \subseteq \nu(x) \cup \nu(y)$,
(ii) $\mu(\alpha x) \geq \mu(x)$ and $\nu(\alpha x) \subseteq \nu(x)$,for all x, y$\in$ M, a,b, $\alpha \in$ F.

Example 2.2. Let G = {1,-1} , M = R^4 over R. Then M is a G-module.
Define A on M by,

$$A(x) = \begin{cases} 1, & \text{if } x_i = 0 \ \forall i. \\ 0.5, & \text{if atleast } x_i \neq 0. \end{cases}$$

where x={x_1, x_2, x_3, x_4}; $x_i \in$ R. Then A is a inuitionstic fuzzy soft G-Module

Example 2.3. Let R be the set of all integers. Then R is a ring. Take M – Γ = R. Let a,b ∈ M, α∈ Γ, Suppose a α b is the product of a,b, α∈ R, then M is a Γ – near ring.
Define an IFSS A = < $\mu_{A,}$ ν_A> in R as follows
$\mu_A(0) = 1$ and $\mu_A(\pm1) = \mu_A(\pm2) = \mu_A(\pm3) = \ldots.. = t$
And $\nu_A(0) = 1$ and $\nu_A(\pm1) = \nu_A(\pm2) = \nu_A(\pm3) = \ldots.. = s$ where $t \in (0,1)$ and $s \in (0,1)$ and $t+s \leq 1$.
By routine calculations, clearly A is an intutionistic fuzzy soft G-module of M.

Example 2.4. Consider the additive group (Z_6 , +) is a multiplication given in the following table. (Z_6 , +) is a near ring.

.	0	1	2	3	4	5
0	0	0	0	0	0	0
1	3	1	5	3	1	5
2	0	2	4	0	2	4
3	3	3	3	3	3	3
4	0	4	2	0	4	2
5	3	5	1	3	5	1

But consider the G-module , we define soft set (G,*) by G(0)={1,3,5} and G(3)={1,5}
Since G(4.(2+3) - 4.2) = G(4.5 – 4.2)= G(2-2) = G(0) = {1,3,5} $\not\subseteq$ G(3)={1,5}

3. Properties of intutionistic fuzzy soft G-modules

Proposition 3.1. Given an IFSG-m A of a Γ – near ring M. Let A* be the IFSS in M defined by $\mu_{A*}(x) = \mu_A(x)+1 - \mu_A(0)$, $\nu_{A*}(x) = \nu_A(x)+1 - \nu_A(0)$ for all $x \in M$ .Then A* is an IFSG-m of M.

Proof: For all $x \in M$ use $\mu_{A*}(x) = \mu_A(x)+1 - \mu_A(0) = 1$ and $\nu_{A*}(x) = \nu_A(x) - \nu_A(0) = 0$
We have

(i) $\mu_{A*}(ax+by) = \mu_A(ax+by)+1 - \mu_A(0)$
$\geq \min \{\mu_A(x), \mu_A(y)\}+1 - \mu_A(0)$
$= \min \{\mu_A(x)+1- \mu_A(0), \mu_A(y) + 1 - \mu_A(0)\}$
$= \min \{\mu_{A*}(x), \mu_{A*}(y)\}$ and
$\nu_{A*}(ax+by) = \nu_A(ax+by) - \nu_A(0)$
$\leq \max \{\nu_A(x), \nu_A(y)\} - \nu_A(0)$
$= \max \{\nu_A(x)- \nu_A(0), \nu_A(y) - \nu_A(0)\}$
$= \max \{\nu_{A*}(x), \nu_{A*}(y)\}$

(ii) $\mu_{A*}(\alpha x) = \mu_A(\alpha x)+1 - \mu_A(0)$

$$\geq \mu_A(x)+1 - \mu_A(0)$$
$$= \mu_{A*}(x)$$
$$\nu_{A*}(\alpha x) = \nu_A(\alpha x) - \nu_A(0)$$
$$\leq \nu_A(x) - \nu_A(0)$$
$$= \nu_{A*}(x)$$

Corollary: Let A and A* be as in Property 3.1, if there exists $x \in M$ such that $A^*(x) = 0$ then $A(x) = 0$.

Proposition 3.2. Let A be a IFSG-module of a Γ–near ring M and let $f:[0,\mu(0)] \rightarrow [0,1]$, $g:[0,\nu(0)] \rightarrow [0,1]$ are increasing functions. Then the IFS $A_f : M \rightarrow [0,1]$ defined by $\mu_{A_f} = f(\mu_A(x))$, $\nu_{A_f} = f(\nu_A(x))$ is IFSG-module of M.

Proof: Let $x,y \in M$ we have

$$\mu_{A_f}(ax+by) = f(\mu_A(ax+by))$$
$$\geq f(\min\{\mu_A(x), \mu_A(y)\})$$
$$= \min\{f(\mu_A(x)), f(\mu_A(y))\}$$
$$= \min\{\mu_{A_f}(x), \mu_{A_f}(y)\}$$
$$\nu_{A_f}(ax+by) = f(\nu_A(ax+by))$$
$$\leq f(\max\{\nu_A(x), \nu_A(y)\})$$
$$= \max\{f(\nu_A(x)), f(\nu_A(y))\}$$
$$= \max\{\nu_{A_f}(x), \nu_{A_f}(y)\}$$
$$\mu_{A_f}(\alpha x) = f(\mu_A(\alpha x)$$
$$\geq f(\mu_A(x))$$
$$= \mu_{A_f}(x)$$
$$\nu_{A_f}(\alpha x) = f(\nu_A(\alpha x)$$
$$\leq f(\nu_A(x))$$
$$= \nu_{A_f}(x)$$

Therefore A_f is an IFSG-module of M.

Note: If $f[\mu_A(0)] = 1$, then $\mu_{A_f}(0)=1$ and $f[\nu_A(x)] = 0$ and $\nu_{A_f}(x) = 0$ then A_f is normal.

Assume that $f(t) = f[\mu_A(x)] \geq \mu_A(x)$ and $f(t) = f[\nu_A(x)] \leq \nu_A(x)$ for any $x \in M$ which gives $A \subseteq A_f$.

Proposition 3.3. Let $A \in N(M)$ is a non constant maximal element of $(N(M),\subseteq)$. Then A takes only the two values (0,1) and (1,0).

Proof: Since A is normal, we have $\mu_A(0)=1$ and $\nu_A(0) = 0$, and $\mu_A(x) \neq 1$ and $\nu_A(x) \neq 0$ for some $x \in M$, we consider that $\mu_A(0)=1$ and $\nu_A(0) = 0$, If not then $\exists\, x_0 \in M$ such that $0<\mu_A(x_0)<1$ and $0<\nu_A(x_0)<1$.

Define an IFSS δ on M, by setting

$\mu_\delta(ax+by) = [\mu_A(ax+by)+ \mu_A(x_0)] / 2$ and

$\nu_\delta(ax+by) = [\nu_A(ax+by)+ \nu_A(x_0)] / 2$ for all $x \in M$

Then clearly δ is well defined and for all x, y $\in$ M

We have μ_δ (ax+by) = $[\mu_A(ax+by)+ \mu_A(x_0)] / 2$

$$\begin{aligned}
\mu_\delta(ax+by) &= [\mu_A(ax+by)+ \mu_A(x_0)] / 2\\
&\geq ½ \{ \min \{ \mu_A(x), \mu_A(y)\} + \mu_A(x_0)\}\\
&\geq \min \{ [\mu_A(x)+ \mu_A(x_0)] / 2, [\mu_A(y)+ \mu_A(x_0)] / 2 \}\\
&\geq \min \{ \mu_\delta (x), \mu_\delta (y)\}\\
\nu_\delta(ax+by) &= [\nu_A(ax+by)+ \nu_A(x_0)] / 2\\
&\leq ½ \{ \min \{ \nu_A(x), \nu_A(y)\} + \nu_A(x_0)\}\\
&\leq \min \{ [\nu_A(x)+ \nu_A(x_0)] / 2, [\nu_A(y)+ \nu_A(x_0)] / 2 \}\\
&\leq \min \{ \nu_\delta (x), \nu_\delta (y)\}\\
\mu_\delta(\alpha x) &= [\mu_A(\alpha x)+ \mu_A(x_0)] / 2\\
&\geq ½ \{ \mu_A(x)\} + \mu_A(x_0)\}\\
&= \mu_A(x)+ \mu_A(x_0) / 2\\
&= \mu_\delta(x)\\
\nu_\delta(\alpha x) &= [\nu_A (\alpha x)+ \nu_A(x_0)] / 2\\
&\leq ½ \{ \nu_A(x)+ \nu_A (x_0)\}\\
&= \nu_\delta(x)
\end{aligned}$$

Therefore δ is an IFSG-module of M.

Proposition 3.4. If $\{A_i / i\in I\}$ is a family of IFSG-module on M, then $(\wedge_{i\in I} A_i)$ IFSG-module of M.

Proof: Let $\{A_i / i\in I\}$ is a family of IFSG-module on M.

For all x, y $\in$ M, we have

$$\begin{aligned}
(\wedge_{i\in I} A_i) (ax+by) &= \inf \{ A_i(ax+by) / i\in I\}\\
&\geq \inf \{ \min \{ A_i(x), A_i(y)\} / i\in I\}\\
&= \min \{ (\wedge_{i\in I} A_i) (x), (\wedge_{i\in I} A_i) (y)\}\\
(\vee_{i\in I} A_i) (ax+by) &= \sup \{ A_i(ax+by) / i\in I\}\\
&\leq \sup \{ \max \{ A_i(x), A_i(y)\} / i\in I\}\\
&= \max \{ (\vee_{i\in I} A_i) (x), (\vee_{i\in I} A_i) (y)\}\\
(\wedge_{i\in I} A_i) (\alpha x) &= \inf \{ A_i(\alpha x) / i\in I\}\\
&\geq \inf \{ A_i(x) / i\in I\}\\
&= (\wedge_{i\in I} A_i) (x)\\
(\vee_{i\in I} A_i) (\alpha x) &= \sup \{ A_i(\alpha x) / i\in I\}\\
&\leq \sup \{ A_i(x) / i\in I\}\\
&= (\vee_{i\in I} A_i) (x)
\end{aligned}$$

Hence $(\wedge_{i\in I} A_i)$ IFSG-module of M.

Definition 3.1. An IFSG-module A of M is said to be complete if it is normal and if $\ni$ x $\in$ M such that A(x)=0.

Proposition 3.5. Let A be an IFSNG-module of M and let ω be a fixed element of M such that a fuzzy soft set A* in M by

$A^*(x) = [A(x) – A(\omega)] / [A(1) – A(\omega)]$ for all x $\in$ M then A* is an complete IFSG-module of M.

Proof: For any x,y $\in$ M, we have

$$\begin{aligned}
\mu_{A^*}(ax+by) &= [A(ax+by) - A(\omega)] / [A(1) - A(\omega)] \\
&\geq [\min\{A(x), A(y)\} - A(\omega)] / [A(1) - A(\omega)] \\
&= \min\{[A(x)-A(\omega)]/[A(1)-A(\omega)],[A(y)-A(\omega)]/[A(1)-A(\omega)]\} \\
&= \min\{A^*(x),A^*(y)\}
\end{aligned}$$

Also
$$\begin{aligned}
\nu_{A^*}(ax+by) &= [A(ax+by) - A(\omega)] / [A(1) - A(\omega)] \\
&\leq [\max\{A(x), A(y)\} - A(\omega)] / [A(1) - A(\omega)] \\
&= \max\{[A(x)-A(\omega)]/[A(1)-A(\omega)],[A(y)-A(\omega)]/[A(1)-A(\omega)]\} \\
&= \max\{A^*(x),A^*(y)\}
\end{aligned}$$

$$\begin{aligned}
\mu_{A^*}(\alpha x) &= [A(\alpha x) - A(\omega)] / [A(1) - A(\omega)] \\
&\geq [A(x) - A(\omega)] / [A(1) - A(\omega)] \\
&= A^*(x)
\end{aligned}$$

$$\begin{aligned}
\nu_{A^*}(\alpha x) &= [A(\alpha x) - A(\omega)] / [A(1) - A(\omega)] \\
&\leq [A(x) - A(\omega)] / [A(1) - A(\omega)] \\
&= A^*(x)
\end{aligned}$$

Therefore A* is a complete IFSG-module of M.

4. Conclusion

This paper summarized the basic concepts of Intuitionistic fuzzy soft-G modules. By using these concepts, we studied the algebraic structures of IFSG-module with suitable example. To extend this work one could study the property of IFS sets in other algebraic structures such as groups and fields.

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