Intuitionistic fuzzy parametrized soft set theory and its decision making

Irfan Deli[a,*], Naim Çağman[b]

[a] *Department of Mathematics, Faculty of Arts and Sciences, 7 Aralık University , 79000 Kilis, Turkey*

[b] *Department of Mathematics, Faculty of Arts and Sciences, Gaziosmanpaşa University 60250 Tokat, Turkey*

Abstract

In this work, we first define intuitionistic fuzzy parametrized soft sets (intuitionistic FP-soft sets) and study some of their properties. We then introduce an adjustable approaches to intuitionistic FP-soft sets based decision making. We also give an example which shows that they can be successfully applied to problems that contain uncertainties.

Keywords: Soft sets, fuzzy sets, FP-soft sets, intuitionistic FP-soft sets, soft level sets, decision making.

1. Introduction

Many fields deal with the uncertain data which may not be successfully modeled by the classical mathematics, probability theory, fuzzy sets [33], rough sets [30], and other mathematical tools. In 1999, Molodtsov [28] proposed a completely new approach so-called *soft set theory* that is more universal for modeling vagueness and uncertainty.

After definitions of the operations of soft sets [3, 11, 26, 32], the properties and applications on the soft set theory have been studied increasingly (e.g. [3, 7, 9]). The algebraic structure of soft set theory has also been studied increasingly (e.g. [1, 2, 5, 13, 17, 18, 19, 20, 31]). In recent years, many interesting applications of soft set theory have been expanded by embedding

*Corresponding author

Email addresses: irfandeli@kilis.edu.tr (Irfan Deli), ncagman@gop.edu.tr (Naim Çağman)

the ideas of fuzzy sets (e.g. [4, 6, 10, 14, 20, 22, 25, 27]), rough sets (e.g. [4, 15, 16]) and intuitionistic fuzzy sets (e.g. [23, 24, 29])

Çağman *et al.*[8] defined FP-soft sets and constructed an FP-soft set decision making method. In this paper, we first define intuitionistic fuzzy parametrized soft sets (intuitionistic FP-soft sets), and study their operations and properties. We then introduce a decision making method based on intuitionistic FP-soft sets. This method is more practical and can be successfully applied to many problems that contain uncertainties.

2. Preliminary

In this section, we present the basic definitions of soft set theory [28], fuzzy set theory [33], intuitionistic fuzzy set theory [12] and FP-soft set theory [8] that are useful for subsequent discussions.

Definition 1. *Let U be an initial universe, $P(U)$ be the power set of U, E is a set of parameters and $A \subseteq E$. Then, a soft set F_A over U is defined as follows:*

$$F_A = \{(x, f_A(x)) : x \in E\}$$

where $f_A : E \to P(U)$ such that $f_A(x) = \emptyset$ if $x \notin A$.

*Here, f_A is called approximate function of the soft set F_A, and the value $f_A(x)$ is a set called x-*element *of the soft set for all $x \in E$. It is worth noting that the sets $f_A(x)$ may be arbitrary.*

Definition 2. *Let U be a universe. Then a fuzzy set X over U is a function defined as follows:*

$$X = \{(\mu_X(u)/u) : u \in U\}$$

where $\mu_X : U \to [0.1]$

Here, μ_X called membership function of X, and the value $\mu_X(u)$ is called the grade of membership of $u \in U$. The value represents the degree of u belonging to the fuzzy set X.

Definition 3. *Let E be a universe. An intuitionistic fuzzy set A on E can be defined as follows:*

$$A = \{< x, \mu_A(x), \gamma_A(x) >: \ x \in E\}$$

where, $\mu_A : E \to [0,1]$ and $\gamma_A : E \to [0,1]$ such that $0 \leq \mu_A(x) + \gamma_A(x) \leq 1$ for any $x \in E$.

Here, $\mu_A(x)$ and $\gamma_A(x)$ is the degree of membership and degree of non-membership of the element x, respectively.

If A and B are two intuitionistic fuzzy sets on E, then

i. $A \subset B$ if and only if $\mu_A(x) \leq \mu_B(x)$ and $\gamma_A(x) \geq \gamma_B(x)$ for $\forall x \in E$

ii. $A = B$ if and only if $\mu_A(x) = \mu_B(x)$ and $\gamma_A(x) = \gamma_B(x)$ $\forall x \in E$

iii. $A^c = \{< x, \gamma_A(x), \mu_A(x) >: \ x \in E\}$

iv. $A \cup B = \{< x, max(\mu_A(x), \mu_B(x)), min(\gamma_A(x), \gamma_B(x) >: \ x \in E\}$,

v. $A \cap B = \{< x, min(\mu_A(x), \mu_B(x)), max(\gamma_A(x), \gamma_B(x) >: \ x \in E\}$,

vi. $A + B = \{< x, \mu_X(x) + \mu_Y(x) - \mu_X(x)\mu_Y(x), \gamma_X(x)\gamma_Y(x) >: \ x \in E\}$,

vii. $A \cdot B = \{< x, \mu_A(x)\mu_B(x), \gamma_A(x) + \gamma_B(x) - \gamma_A(x)\gamma_B(x) >: \ x \in E\}$.

Definition 4. *Let U be an initial universe, $P(U)$ be the power set of U, E be a set of all parameters and X be a fuzzy set over E. Then a FP-soft set (f_X, E) on the universe U is defined as follows:*

$$(f_X, E) = \{(\mu_X(x)/x, f_X(x)) : x \in E\}$$

where $\mu_X : E \to [0.1]$ and $f_X : E \to P(U)$ such that $f_X(x) = \emptyset$ if $\mu_X(x) = 0$.

Here f_X called approximate function and μ_X called membership function of FP-soft sets.

3. Intuitionistic FP-soft sets

In this section, we define intuitionistic fuzzy parametrized soft sets (intuitionistic FP-soft sets) and their operations.

Definition 5. *Let U be an initial universe, $P(U)$ be the power set of U, E be a set of all parameters and K be an intuitionistic fuzzy set over E. An intuitionistic FP-soft sets $\amalg_K$ over U is defined as follows:*

$$\amalg_K = \left\{(< x, \alpha_K(x), \beta_K(x) >, f_K(x)) : x \in E\right\}$$

where $\alpha_K : E \to [0.1]$, $\beta_K : E \to [0.1]$ and $f_K : E \to P(U)$ with the property $f_K(x) = \emptyset$ if $\alpha_K(x) = 0$ and $\beta_K(x) = 1$.

Here, the function α_K and β_K called membership function and non-membership of intuitionistic FP-soft set, respectively. The value $\alpha_K(x)$ and $\beta_K(x)$ is the degree of importance and unimportant of the parameter x.

Obviously, each ordinary FP-soft set can be written as

$$\Pi_K = \Big\{(< x, \alpha_K(x), 1 - \alpha_K(x) >, f_K(x)) : x \in E\Big\}$$

Note that the sets of all intuitionistic FP-soft sets over U will be denoted by $IFPS(U)$.

Definition 6. *Let $\Pi_K \in IFPS(U)$. If $\alpha_K(x) = 0$ and $\beta_K(x) = 1$ for all $x \in E$, then Π_K is called a empty intuitionistic FP-soft sets, denoted by Π_Φ.*

Definition 7. *Let $\Pi_K \in IFPS(U)$. If $\alpha_K(x) = 1$, $\beta_K(x) = 0$ and $f_K(x) = U$ for all $x \in E$, then Π_K is called universal intuitionistic FP-soft set, denoted by $\Pi_{\tilde{E}}$.*

Example 1. *Assume that $U = \{u_1, u_2, u_3, u_4, u_5\}$ is a universal set and $E = \{x_1, x_2, x_3, x_4\}$ is a set of parameters. If*

$$K = \{< x_2, 0.2, 0.5 >, < x_3, 0.5, 0.5 >, < x_4, 0.6, 0.3 >\}$$

and

$$f_K(x_2) = \{u_2, u_4\}, f_K(x_3) = \emptyset, f_K(x_4) = U$$

then an intuitionistic FP-soft set Π_K is written by

$$\Pi_K = \{(< x_2, 0.2, 0.5 >, \{u_2, u_4\}), (< x_3, 0.5, 0.5 >, \emptyset), (< x_4, 0.6, 0.3 >, U)\}$$

If $L = \{< x_1, 0, 1 >, < x_2, 0, 1 >, < x_3, 0, 1 >, < x_4, 0, 1 >\}$, then the intuitionistic FP-soft set Π_L is an empty intuitionistic FP soft set.

If $M = \{< x_1, 1, 0 >, < x_2, 1, 0 >, < x_3, 1, 0 >, < x_4, 1, 0 >\}$ and $f_M(x_1) = U$, $f_M(x_2) = U$, $f_M(x_3) = U$ and $f_M(x_4) = U$, then the intuitionistic FP-soft set Π_M is a universal intuitionistic FP-soft set.

Definition 8. *$\Pi_K, \Pi_L \in IFPS(U)$. Then Π_K is a intuitionistic FP-soft subset of Π_L, denoted by $\Pi_K \widetilde{\subseteq} \Pi_L$, if and only if $\alpha_K(x) \leq \alpha_L(x)$, $\beta_K(x) \geq \beta_L(x)$ and $f_K(x) \subseteq f_L(x)$ for all $x \in E$.*

Remark 1. *$\Pi_K \widetilde{\subseteq} \Pi_L$ does not imply that every element of Π_K is an element of Π_L as in the definition of classical subset. For example, assume that $U = \{u_1, u_2, u_3, u_4\}$ is a universal set of objects and $E = \{x_1, x_2, x_3\}$ is a set of all parameters. If $K = \{< x_1, 0.4, 0.6 >\}$ and $L = \{< x_1, 0.5, 0.5 >, < x_3, 0.4, 0.5 >\}$, and $\Pi_K = \{(< x_1, 0.4, 0.6 >, \{u_2, u_4\})\}$, $\Pi_L = \{(<$*

$x_1, 0.5, 0.5>, \{u_2, u_3, u_4\}), (< x_3, 0.4, 0.5 >, \{u_1, u_5\})\}$, *then for all* $x \in E$, $\alpha_K(x) \leq \alpha_L(x)$, $\beta_K(x) \geq \beta_L(x)$ *and* $\amalg_K\ (x) \subseteq \amalg_L(x)$ *is valid. Hence* $\amalg_K \tilde{\subseteq} \amalg_L$. *It is clear that* $(< x_1, 0.4, 0.6 >, \{u_2, u_4\}) \in \amalg_K$ *but* $(< x_1, 0.4, 0.6 >$ $, \{u_2, u_4\}) \notin \amalg_L$.

Proposition 1. *Let* $\amalg_K, \amalg_L \in IFPS(U)$. *Then*

i. $\amalg_K \tilde{\subseteq} \amalg_{\tilde{E}}$

ii. $\amalg_\Phi \tilde{\subseteq} \amalg_K$

iii. $\amalg_K \tilde{\subseteq} \amalg_K$

Definition 9. $\amalg_K, \amalg_L \in IFPS(U)$. *Then* $\amalg_K$ *and* $\amalg_L$ *are intuitionistic FP-soft-equal, written by* $\amalg_K = \amalg_L$, *if and only if* $\alpha_K(x) = \alpha_L(x)$, $\beta_K(x) = \beta_L(x)$ *and* $f_K(x) = f_L(x)$ *for all* $x \in E$.

Proposition 2. *Let* $\amalg_K, \amalg_L, \amalg_M \in IFPS(U)$. *Then*

i. $\amalg_K = \amalg_L$ *and* $\amalg_L = \amalg_M \Leftrightarrow \amalg_K = \amalg_M$

ii. $\amalg_K \tilde{\subseteq} \amalg_L$ *and* $\amalg_L \tilde{\subseteq} \amalg_K \Leftrightarrow \amalg_K = \amalg_L$

iii. $\amalg_K \tilde{\subseteq} \amalg_L$ *and* $\amalg_L \tilde{\subseteq} \amalg_M \Rightarrow \amalg_K \tilde{\subseteq} \amalg_M$

Definition 10. $\amalg_K \in IFPS(U)$. *Then complement of* $\amalg_K$, *denoted by* $\amalg_K^c$, *is a intuitionistic FP-soft set defined by*

$$\amalg_K^c = \Big\{(< x, \beta_K(x), \alpha_K(x) >, f_{K^c}(x)) : x \in K\Big\}$$

where $f_{K^c}(x) = U \setminus f_K(x)$.

Proposition 3. *Let* $\amalg_K \in IFPS(U)$. *Then*

i. $(\amalg_K^c)^c = \amalg_K$

ii. $\amalg_\Phi^c = \amalg_{\tilde{E}}$

iii. $\amalg_{\tilde{E}}^c = \amalg_\Phi$

Definition 11. $\Pi_K, \Pi_L \in IFPS(U)$. *Then union of* Π_K *and* Π_L*, denoted by* $\Pi_K \tilde{\cup} \Pi_L$*, is defined by*

$$\Pi_K \tilde{\cup} \Pi_L = \Big\{ (< x, max(\alpha_K(x), \alpha_L(x)), min(\beta_K(x), \beta_L(x)) >, f_{K\tilde{\cup}L}(x)) : x \in E \Big\}$$

where $f_{K\tilde{\cup}L}(x) = f_K(x) \cup f_L(x)$.

Proposition 4. *Let* $\Pi_K, \Pi_L, \Pi_M \in IFPS(U)$. *Then*

i. $\Pi_K \tilde{\cup} \Pi_K = \Pi_K$

ii. $\Pi_K \tilde{\cup} \Pi_\Phi = \Pi_K$

iii. $\Pi_K \tilde{\cup} \Pi_{\tilde{E}} = \Pi_{\tilde{E}}$

iv. $\Pi_K \tilde{\cup} \Pi_L = \Pi_L \tilde{\cup} \Pi_K$

v. $(\Pi_K \tilde{\cup} \Pi_L) \tilde{\cup} \Pi_M = \Pi_K \tilde{\cup} (\Pi_L \tilde{\cup} \Pi_M)$

Definition 12. $\Pi_K, \Pi_L \in IFPS(U)$. *Then intersection of* Π_K *and* Π_L*, denoted by* $\Pi_K \tilde{\cap} \Pi_L$*, is a intuitionistic FP-soft sets defined by*

$$\Pi_K \tilde{\cap} \Pi_L = \Big\{ < x, min(\alpha_K(x), \alpha_L(x)), max(\beta_K(x), \beta_L(x) >, f_{K\tilde{\cap}L}(x)) : x \in E \Big\}$$

where $f_{K\tilde{\cap}L}(x) = f_K(x) \cap f_L(x)$.

Proposition 5. *Let* $\Pi_K, \Pi_L, \Pi_M \in IFPS(U)$. *Then*

i. $\Pi_K \tilde{\cap} \Pi_K = \Pi_K$

ii. $\Pi_K \tilde{\cap} \Pi_\Phi = \Pi_\Phi$

iii. $\Pi_K \tilde{\cap} \Pi_{\tilde{E}} = \Pi_K$

iv. $\Pi_K \tilde{\cap} \Pi_L = \Pi_L \tilde{\cap} \Pi_K$

v. $(\Pi_K \tilde{\cap} \Pi_L) \tilde{\cap} \Pi_M = \Pi_K \tilde{\cap} (\Pi_L \tilde{\cap} \Pi_M)$

Remark 2. *Let* $\Pi_K \in IFPS(U)$. *If* $\Pi_K \neq \Pi_\Phi$ *or* $\Pi_K \neq \Pi_{\tilde{E}}$, *then* $\Pi_K \tilde{\cup} \Pi_K^c \neq \Pi_{\tilde{E}}$ *and* $\Pi_K \tilde{\cap} \Pi_K^c \neq \Pi_\Phi$.

Proposition 6. *Let* $\Pi_K, \Pi_L, \Pi_M \in IFPS(U)$. *Then* *i.* $\amalg_K \widetilde{\cup} (\amalg_L \widetilde{\cap} \amalg_M) = (\amalg_K \widetilde{\cup} \amalg_L) \widetilde{\cap} (\amalg_K \widetilde{\cup} \amalg_M)$

ii. $\amalg_K \widetilde{\cap} (\amalg_L \widetilde{\cup} \amalg_M) = (\amalg_K \widetilde{\cap} \amalg_L) \widetilde{\cup} (\amalg_K \widetilde{\cap} \amalg_M)$

Proposition 7. *Let $\amalg_K, \amalg_L IFPS(U)$. Then following DeMorgans types of results are true.*

i. $(\amalg_K \widetilde{\cup} \amalg_L)^c = \amalg_K^c \widetilde{\cap} \amalg_L^c$

ii. $(\amalg_K \widetilde{\cap} \amalg_L)^c = \amalg_K^c \widetilde{\cup} \amalg_L^c$

Definition 13. $\amalg_K, \amalg_L \in IFPS(U)$. *Then OR-sum of $\amalg_K$ and $\amalg_L$, denoted by $\amalg_K \vee^+ \amalg_L$, is defined by*

$$\amalg_K \vee^+ \amalg_L(x) = \\ \Big\{(< x, \alpha_K(x) + \alpha_L(x) - \alpha_K(x)\alpha_L(x), \beta_K(x)\beta_L(x) >, f_{K\widetilde{\cup}L}(x)) : x \in E\Big\}$$

where $f_{K\widetilde{\cup}L}(x) = f_K(x) \cup f_L(x)$.

Definition 14. $\amalg_K, \amalg_L \in IFPS(U)$. *Then AND-sum of $\amalg_K$ and $\amalg_L$, denoted by $\amalg_K \wedge^+ \amalg_L$, is defined by*

$$\amalg_K \wedge^+ \amalg_L(x) = \\ \Big\{(< x, \alpha_K(x) + \alpha_L(x) - \alpha_K(x)\alpha_L(x), \beta_K(x)\beta_L(x) >, f_{K\widetilde{\cap}L}(x)) : x \in E\Big\}$$

where $f_{K\widetilde{\cap}L}(x) = f_K(x) \cap f_L(x)$.

Proposition 8. *Let $\amalg_K, \amalg_L, \amalg_M \in IFPS(U)$. Then*

i. $\amalg_K \vee^+ \amalg_\Phi = \amalg_K$

ii. $\amalg_K \vee^+ \amalg_{\tilde{E}} = \amalg_{\tilde{E}}$

iii. $\amalg_K \vee^+ \amalg_L = \amalg_L \vee^+ \amalg_K$

iv. $\amalg_K \wedge^+ \amalg_L = \amalg_L \wedge^+ \amalg_K$

v. $(\amalg_K \vee^+ \amalg_L) \vee^+ \amalg_M = \amalg_K \vee^+ (\amalg_L \vee^+ \amalg_M)$

vi. $(\amalg_K \wedge^+ \amalg_L) \wedge^+ \amalg_M = \amalg_K \wedge^+ (\amalg_L \wedge^+ \amalg_M)$

Definition 15. $\amalg_K, \amalg_L \in IFPS(U)$. *Then OR-product* $\amalg_K$ *and* $\amalg_L$*, denoted by* $\amalg_K \vee^{\times} \amalg_L$*, is defined by*

$$\amalg_K \vee^{\times} \amalg_L(x) = \\ \Big\{ < x, \alpha_K(x)\alpha_L(x), \beta_K(x) + \beta_L(x) - \beta_K(x)\beta_L(x) >, f_{K\tilde{\cup}L}(x)) : x \in E \Big\}$$

where $f_{K\tilde{\cup}L}(x) = f_K(x) \cup f_L(x)$.

Definition 16. $\amalg_K, \amalg_L \in IFPS(U)$. *Then AND-product* $\amalg_K$ *and* $\amalg_L$*, denoted by* $\amalg_K \wedge^{\times} \amalg_L$*, is defined by*

$$\amalg_K \wedge^{\times} \amalg_L(x) = \\ \Big\{ < x, \alpha_K(x)\alpha_L(x), \beta_K(x) + \beta_L(x) - \beta_K(x)\beta_L(x) >, f_{K\tilde{\cap}L}(x)) : x \in E \Big\}$$

where $f_{K\tilde{\cap}L}(x) = f_K(x) \cap f_L(x)$.

Proposition 9. *Let* $\amalg_K, \amalg_L, \amalg_M \in IFPS(U)$. *Then*

i. $\amalg_K \wedge^{\times} \amalg_{\Phi} = \amalg_{\Phi}$

ii. $\amalg_K \wedge^{\times} \amalg_{\tilde{E}} = \amalg_K$

iii. $\amalg_K \wedge^{\times} \amalg_L = \amalg_L \wedge^{\times} \amalg_K$

iv. $\amalg_K \vee^{\times} \amalg_L = \amalg_L \vee^{\times} \amalg_K$

v. $(\amalg_K \wedge^{\times} \amalg_L) \wedge^{\times} \amalg_M = \amalg_K \wedge^{\times} (\amalg_L \wedge^{\times} \amalg_M)$

vi. $(\amalg_K \vee^{\times} \amalg_L) \vee^{\times} \amalg_M = \amalg_K \vee^{\times} (\amalg_L \vee^{\times} \amalg_M)$

4. Intuitionistic FP-soft decision making method

In this section, we have defined a reduced intuitionistic fuzzy set of an intuitionistic FP-soft set, that produce an intuitionistic fuzzy set from an intuitionistic FP-soft set. We then have defined a reduced fuzzy set of an intuitionistic fuzzy set, that produce a fuzzy set from an intuitionistic fuzzy set. These sets present an adjustable approach to intuitionistic FP-soft sets based decision making problems.

Definition 17. *Let* Π_K *be an intuitionistic FP-soft set. Then, a reduced intuitionistic fuzzy set of* Π_K*, denoted by* K_{rif}*, defined as follows*

$$K_{rif} = \Big\{ < u, \alpha_{K_{rif}}(u), \beta_{K_{rif}}(u) >: u \in U \Big\}$$

where

$$\alpha_{K_{rif}} : U \to [0,1], \;\; \alpha_{K_{rif}}(u) = \frac{1}{|U|} \sum_{x \in E, u \in U} \alpha_K(x) \chi_{f_K(x)}(u)$$

$$\beta_{K_{rif}} : U \to [0,1], \;\; \beta_{K_{rif}}(u) = \frac{1}{|U|} \sum_{x \in E, u \in U} \beta_K(x) \chi_{f_K(x)}(u)$$

where

$$\chi_{f_K(x)}(u) = \begin{cases} 1, & u \in f_K(x) \\ 0, & u \notin f_K(x) \end{cases}$$

Here, $\alpha_{K_{rif}}$ *and* $\beta_{K_{rif}}$ *are called reduced-set operators of* K_{rif}*. It is clear that* K_{rif} *is an intuitionistic fuzzy set over* U*.*

Definition 18. $\Pi_K \in IFPS(U)$ *and* K_{rif} *be reduced intuitionistic fuzzy set of* Π_K*. Then, a reduced fuzzy set of* K_{rif} *is a fuzzy set over* U*, denoted by* K_{rf}*, defined as follows*

$$K_{rf} = \Big\{ \mu_{K_{rf}}(u)/u : u \in U \Big\}$$

where

$$\mu_{K_{rf}} : U \to [0,1], \;\; \mu_{K_{rf}}(u) = \alpha_{K_{rif}}(u)(1 - \beta_{K_{rif}}(u))$$

Now, we construct an intuitionistic FP-soft decision making method by the following algorithm to produce a decision fuzzy set from a crisp set of the alternatives.

According to the problem, decision maker;

i. constructs a feasible intuitionistic fuzzy subsets K over the parameters set E,

ii. constructs an intuitionistic FP-soft set Π_K over the alternatives set U,

iii. computes the reduced intuitionistic fuzzy set K_{rif} of Π_K,

iv. computes the reduced fuzzy set K_{rf} of K_{rif},

v. chooses the element of K_{rf} that has maximum membership degree.

Now, we can give an example for the intuitionistic FP-soft decision making method. Some of it is quoted from example in [11].

Example 2. *Assume that a company wants to fill a position. There are 5 candidates who fill in a form in order to apply formally for the position. There is a decision maker (DM), that is from the department of human resources. He want to interview the candidates, but it is very difficult to make it all of them. Therefore, by using the intuitionistic FP-soft decision making method, the number of candidates are reduced to a suitable one. Assume that the set of candidates $U = \{u_1, u_2, u_3, u_4, u_5\}$ which may be characterized by a set of parameters $E = \{a_1, a_2, a_3, a_4\}$. For $i = 1, 2, 3, 4$ the parameters a_i stand for experience, computer knowledge, training and young age, respectively. Now, we can apply the method as follows:*

Step *i.* *Assume that DM constructs a feasible intuitionistic fuzzy subsets K over the parameters set E as follows;*

$$K = \{< x_1, 0.7, 0.3 >, < x_2, 0.2, 0.5 >, < x_3, 0.5, 0.5 >, < x_4, 0.6, 0.3 >\}$$

Step *ii.* *DM constructs an intuitionistic FP-soft set Π_K over the alternatives set U as follows;*

$$\Pi_K = \Big\{(< x_1, 0.7, 0.3 >, \{u_1, u_2, u_4\}), (< x_2, 0.2, 0.5 >, U), (< x_3, 0.5, 0.5 >, \{u_1, u_2, u_4\}), (< x_4, 0.6, 0.3 >, \{u_2, u_3\})\Big\}$$

Step *iii.* *DM computes the reduced intuitionistic fuzzy set K_{rif} of Π_K as follows;*

$$K_{rif} = \Big\{(< u_1, 0.28, 0.26 >, < u_2, 0.40, 0.32 >, < u_3, 0.16, 0.16 >, < u_4, 0.28, 0.32 >, < u_5, 0.04, 0.10 > \Big\}$$

Step *iv.* *DM computes the reduced fuzzy set K_{rf} of K_{rif} as follows;*

$$K_{rf} = \Big\{0.2072/u_1, 0.2720/u_2, 0.1344/u_3, 0.1904/u_4, 0.0360/u_5\Big\}$$

Step *v*. *Finally, DM chooses u_2 for the position from K_{rf} since it has the maximum degree 0.2720 among the others.*

Note that this decision making method can be applied for group decision making easily with help of the Definition 13, Definition 14 Definition 15 and Definition 16.

5. Conclusion

In this paper, we first defined intuitionistic FP-soft sets and their operations. We then presented the decision making method on the intuitionistic FP-soft set theory. Finally, we provided an example that demonstrated that the decision making method can successfully work. It can be applied to problems of many fields that contain uncertainty such as computer science, game theory, and so on.

References

[1] U. Acar, F. Koyuncu and B. Tanay, Soft sets and soft rings, Computers and Mathematics with Applications, 59 (2010) 3458-3463.

[2] H. Aktaş and N. Çağman, Soft sets and soft groups, Information Sciences, 177 (2007) 2726-2735.

[3] M.I. Ali, F. Feng, X. Liu, W.K. Min and M. Shabir, On some new operations in soft set theory, Computers and Mathematics with Applications, 57 (2009) 1547-1553.

[4] M.I. Ali, A note on soft sets,rough soft sets and fuzzy soft sets, Applied Soft Computing, 11 (2011) 3329-3332.

[5] A.O. Atagün and A. Sezgin, Soft substructures of rings, fields and modules, Computers and Mathematics with Applications, 61 (2011) 592-601.

[6] A. Aygünoglu, H. Aygün, Introduction to fuzzy soft groups, Computers and Mathematics with Applications, 58 (2009) 1279-1286.

[7] N. Çağman, S. Karataş and S. Enginoğlu, Soft Topology, Computers and Mathematics with Applications, 62 (2011) 351 - 358.

[8] N. Çağman, F. Erdoğan and S. Enginoğlu, FP-soft set theory and its applications, Annals of Fuzzy Mathematics and informatics, 2/2 (2011) 219-226.

[9] N. Çağman and S. Enginoğlu, Soft matrices and its decision makings, Computers and Mathematics with Applications, 59 (2010) 3308-3314.

[10] N. Çağman, F. Erdoğan and S. Enginoğlu, Fuzzy parameterized fuzzy soft set theory and its applications, Turkish Journal of Fuzzy Systems, 1/1, (2010) 21-35.

[11] N. Çağman and S. Enginoğlu, Soft set theory and uni-int decision making, European Journal of Operational Research, 207 (2010) 848-855.

[12] K. Atanassov, Intuitionistic fuzzy sets, Fuzzy Sets and Systems, 20 (1986) 87-96.

[13] F. Feng, Y. B. Jun and X. Zhao, Soft semirings, Computers and Mathematics with Applications, 56/10 (2008) 2621-2628.

[14] F. Feng, Y. B. Jun, X. Liu, L. Li, An adjustable approach to fuzzy soft sets based decision making, Journal of Computational and Applied Mathematics, 234 (2010) 10-20.

[15] F. Feng, X. Liu , V. L. Fotea, Y. B. Jun, Soft sets and soft rough sets, Information Sciences 181 (2011) 1125–1137.

[16] F. Feng, C. Li, B. Davvaz, M. Irfan Ali, Soft sets combined with fuzzy sets and rough sets: a tentative approach, Soft Computing 14 (2010) 899–911.

[17] Y. B.Jun, K. J. Lee and A. Khan, Soft ordered semigroups, Mathematical Logic Quarterly, 56 (1) (2010) 42-50.

[18] Y.B. Jun, Soft BCK/BCI-algebras, Computers and Mathematics with Applications, 56 (2008) 1408-1413.

[19] Y.B. Jun and C. H. Park, Applications of soft sets in ideal theory of BCK/BCI-algebras, Information Sciences, 178 (2008) 2466-2475.

[20] J. Zhan and Y.B. Jun, Soft BL-algebras based on fuzzy sets, Computers and Mathematics with Applications, 59 (2010) 2037-2046.

[21] Y. Jiang, Y. Tang, Q. Chen, An adjustable approach to intuitionistic fuzzy soft sets based decision making, Applied Mathematical Modelling, 35 (2011) 824836.

[22] A.R. Roy, P.K. Maji, A fuzzy soft set theoretic approach to decision making problems. Journal of Computational and Applied Mathematics, 203 (2007) 412-418.

[23] P.K. Maji,A.R. Roy, R. Biswas, On Intuitionistic Fuzzy Soft Sets. The Journal of Fuzzy Mathematics, 12(3) (2004) 669-683.

[24] P.K. Maji, R.Biswas A.R. Roy, Intuitionistic Fuzzy Soft Sets. The Journal of Fuzzy Mathematics, 9(3) (2001) 677-692.

[25] P.K. Maji, R. Biswas and A.R. Roy, Fuzzy soft sets, Journal of Fuzzy Mathematics, 9(3) (2001) 589-602.

[26] P.K. Maji, R. Bismas and A.R. Roy, Soft set theory, Computers and Mathematics with Applications, 45 (2003) 555-562.

[27] P. Majumdar, S. K. Samanta, Generalised fuzzy soft sets, Computers and Mathematics with Applications, 59 (2010) 1425-1432.

[28] D.A. Molodtsov, Soft set theory-first results, Computers and Mathematics with Applications, 37 (1999) 19-31.

[29] A. Mukherjee, S.B. Chakraborty, On intuitionistic fuzzy soft relations. Bulletin of Kerala Mathematics Association, 5 (1) (2008) 35-42.

[30] Z. Pawlak, Rough sets, International Journal of Information and Computer Sciences, 11 (1982) 341-356.

[31] C.H. Park, Y.B. Jun, and M.A. Öztürk, Soft WS-algebras, Commun. Korean Math. Soc. 23/3 (2008) 313-324.

[32] A. Sezgin and A.O. Atagün, On operations of soft sets, Computers and Mathematics with Applications, 61/5 (2011) 1457-1467.

[33] L.A. Zadeh, Fuzzy Sets, Inform. and Control, 8 (1965) 338-353.