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A New Approach to Interval-Valued Fuzzy Soft Set and its Application in Group Decision Making

Sooraj.T.R[1], R K Mohanty[2] and B.K.Tripathy [3]
[1] VIT University/SCSE, Vellore, India
Email: soorajtr19@gmail.com
[2-3] VIT University/SCSE, Vellore, India
Email: [2]rkmohanty@gmail.com, [3]tripathybk@vit.ac.in

***Abstract*—Molodtsov introduced soft set theory in 1999 to handle uncertainty. In this paper we define membership function and some operations of interval valued intuitionistic fuzzy soft set (IVFSS). We also provide an application of IVFSSs in group decision making which substantially improve and is more realistic than the algorithm proposed earlier.**

***Index Terms*— soft sets, fuzzy soft sets, interval valued fuzzy soft sets and group decision making.**

I. INTRODUCTION

Zadeh [7] initiated the concept of fuzzy sets in 1965 which is considered as generalization of classical or crisp sets. In 1999, Molodtsov [6] introduced the concepts of soft sets, which is parameterized family of subsets defined over a universe and a set of parameters as a model to capture uncertainty and vagueness in data. Many new operations on soft sets were introduced by Maji et al [9, 10] in a later paper. Maji et al. [8] put forward the concept of fuzzy soft sets (FSS), which is a hybrid model of fuzzy sets and soft sets. Membership function plays an important role in fuzzy set theory. Tripathy et al [1] defined soft sets through their characteristic functions. This approach has been highly authentic and helpful in defining the basic operations of soft sets. Similarly, it is expected that defining membership function for FSSs will systematize many operations defined upon them as done in [8]. Extending this approach further, we introduce the membership functions for IVFSS in this paper. Many of Soft set theory have been discussed by Molodtsov in [4]. Maji et.al discussed an application of soft sets in decision making problems [9]. This study was further extended to the context of FSSs by Tripathy et al in [2], where they identified some drawbacks in [9] and took care of these drawbacks while introducing an algorithm for decision making. Many applications of soft set models are discussed in [4, 5,11]. In this paper, we have carried this study further by using IVFSS in handling the problem of multi-criteria decision making. It has been widely known that the concept of IVFSS introduced by Yang [12] which is more realistic model of uncertainty than the fuzzy set. In this paper, we follow the definition of soft set due to Tripathy et al [1] in defining IVFSS and redefine their union, intersection, complement and some other operations on them. The major contribution in this paper is introducing a group decision making algorithm which uses IVFSS and we illustrate the suitability of this algorithm in real life situations. Also, it generalizes the algorithm introduced in [9] while keeping the authenticity intact.

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II DEFINITIONS AND NOTIONS

A soft universe (U, E) is a combination of a universe U and a set of parameters E. By P(U) and I(U) we denote the set of all subsets of U and the set of all fuzzy subsets of U respectively.

Definition 2.1 (Soft Set): We denote a soft set over (U, E) by (F, E), where

$$F : E \to P(U) \tag{2.1}$$

Definition 2.2 (FSS): We denote a FSS over (U, E) by (F, E) where

$$F : E \to I(U) \tag{2.2}$$

Definition 2.3 (IVFS): An IVFS X on a universe U is a mapping such that

$$X : U \to Int([0,1]) \tag{2.3}$$

Where *Int*([0,1]) stands for the set of all closed subintervals [0,1], the set of all IVFSs on U is denoted by P(U). Suppose that $X \in P(U), \forall x \in U, \mu_X(x) = [\mu_X^-(x), \mu_X^+(x)]$ is called the degree of membership of an element x to X. $\mu_X^-(x)$ and $\mu_X^+(x)$ are referred to as the lower and upper degrees of membership x to X where $0 \le \mu_X^-(x) \le \mu_X^+(x) \le 1$.

III INTERVAL-VALUED FUZZY SOFT SETS

In this section, we discuss membership function and some operations of IVFSS. Let *(F, E)* be an IVFSS over *(U, E)*. Then the set of parametric membership functions $\mu_{(F,E)} = \left\{ \mu_{(F,E)}^a \mid a \in E \right\}$ of *(F, E)* is defined as follows:

Definition 3.1: For any $\forall a \in E$, we define the membership function as follows.

$$\mu_{(F,E)}^a(\mathrm{x}) = \alpha,\ \alpha \in [0,1] \tag{3.1}$$

For any two IVFSSs (F, E) and (G, E) over the universe U, the following operations are defined.

Definition 3.2: The union of *(F, E)* and *(G, E)* is the IVFSS *(H, E)* and $\forall a \in E$ and $\forall x \in U$, we have

$$\begin{aligned}(F,E)\bigcup(G,E)(x) &= \max[\mu_{(F,E)}^a(x), \mu_{(G,E)}^a(x)] \\ &= [\max(\mu_{(F,E)}^{a-}(x), \mu_{(G,E)}^{a-}(x)), \max(\mu_{(F,E)}^{a+}(x), \mu_{(G,E)}^{a+}(x))]\end{aligned} \tag{3.2}$$

Definition 3.3: Intersection of *(F, E)* and *(G, E)* is the IVFSS *(H, E)* and $\forall a \in E$ and $\forall x \in U$, we have

$$\begin{aligned}(F,E)\bigcap(G,E)(x) &= \min[\mu_{(F,E)}^a(x), \mu_{(G,E)}^a(x)] \\ &= [\min(\mu_{(F,E)}^{a-}(x), \mu_{(G,E)}^{a-}(x)), \min(\mu_{(F,E)}^{a+}(x), \mu_{(F,E)}^{a+}(x))]\end{aligned} \tag{3.3}$$

Definition 3.4: *(F, E)* is said to be interval valued fuzzy soft subset of *(G, E)*, $(F,E) \subseteq (G,E)$ and $\forall a \in E$, $\forall x \in U$,

$$\begin{gathered}\mu_{(F,E)}^{a+}(x) \le \mu_{(G,E)}^{a+}(x) \\ and \\ \mu_{(F,E)}^{a-}(x) \le \mu_{(G,E)}^{a-}(x)\end{gathered} \tag{3.4}$$

Definition 3.5: We say that *(F, E)* is equal to *(G, E)* written as *(F, E) = (G, E)* and $\forall x \in U$,

$$\begin{gathered}\mu_{(F,E)}^{a+}(x) = \mu_{(G,E)}^{a+}(x) \\ and \\ \mu_{(F,E)}^{a-}(x) = \mu_{(G,E)}^{a-}(x)\end{gathered} \tag{3.5}$$

Definition 3.6: The complement *(H, E)* of *(G, E)* in *(F, E)* as $\forall a \in E$ and $\forall x \in U$.

$$\mu_{(H,E)}^{a+}(x) = \max\left\{0, \mu_{(F,E)}^{a+}(x) - \mu_{(G,E)}^{a+}(x)\right\}$$

$$and$$

$$\mu_{(H,E)}^{a-}(x) = \max\left\{0, \mu_{(F,E)}^{a-}(x) - \mu_{(G,E)}^{a-}(x)\right\}$$

IV APPLICATION OF IVFSS IN GROUP DECISION MAKING

Many applications of soft sets are discussed in [6]. In [8] Maji et.al has given an application of FSSs in a decision making system. But the algorithm given in that paper has some issues. The issues of decision making application are discussed in [2]. And Tripathy et.al provided suitable solution for the problems addressed in [2] and also introduced the concept of negative and positive parameters in [2, 3].

Consider the case of an interview conducted by an organization, where interview performance of each candidate is analyzed by a panel of judges. Here, we assign some parameters to evaluate the performance of each candidate. Some parameters are communication skills, personality, reactivity etc.

Let U be a set of candidates is given by U={ c_1,c_2,c_3,c_4,c_5,c_6} and E be the parameter set given by E={knowledge, communication, behaviour, presentation, extracurricular activities}. Consider a IVFSS *(U, E)* which describes the 'performance of a candidate '.

The table 4.1 shows the IVFSS of candidate performance. In the case of IVFSS, we need to consider three cases.

(i) Pessimistic
(ii) Optimistic
(iii)Neutral

Neutral values are obtained by taking the average of pessimistic values and optimistic values.

$$neutral\ value = \frac{pesimistic + optimistic}{2} \tag{4.1}$$

Most of the real-life decision making problems cannot be effectively resolved by a single decision maker. Depends on the uncertainty and the amount of knowledge available, it is not easy to take a suitable decision for a single decision maker. So, it is needed to gather multiple decision makers with different knowledge structures and experience to conduct a group decision making (GDM). Here we discuss an application of group decision making in fuzzy soft sets.

Algorithm

1. Input the priority given by the panel (J_1, J_2, J_3,…, J_n) for each parameter, where 'n' is the number of judges.
2. For each judge J_i (i =1, 2, 3, ..., n) repeat the following steps.
   a. Input the IVFSS (U, E) provided by Judge J_i and arrange it in tabular form. Extract the pessimistic, optimistic and neutral values from the IVFSS and perform the following operations for all these cases.
   b. Multiply the priority values with the corresponding parameter values to get the priority table.
   c. Compute the row sum of each row in the priority table.
   d. Construct the respective comparison tables by finding the entries as differences of each row sum in priority tables with those of all other rows.
   e. Compute the row sum for each row in the comparison table to get the score.
   f. Construct the decision table by taking the row sums in the comparison table. Assign rankings to each candidate for pessimistic, optimistic and neutral values.
3. Create rank table based on the results obtained from the above step which contains rankings provided by all the judges for pessimistic, optimistic and neutral cases.
4. Calculate the normalized score of each candidate in the rank table by using the following equation.

$$\text{Normalized Score} = \frac{2*(|c|*|k|*|j| - \sum_{i=1,x\in K}^{i=|j|} RC_{ix})}{|k|*|j|*|c|*(|c|-1)}, \tag{4.2}$$

where |c| is the number of candidates, K={optimistic, pessimistic , neutral}. So, K=3 and |j| is the number of judges.

5. The candidate with higher normalized score value is the best choice.

Assume that 'n' candidates are applying for a job in an organization. From these n candidates, the organization filters out many candidates based on some criteria (For eg: Those who got more than 60% are eligible to attend the interview). The candidates, who passed the elimination criteria, will be eligible to attend the interview. The interview performance of each selected candidate is analyzed by a panel of different judges. Here, the panel assigns some parameters to evaluate the performance of each candidate. Some parameters are communication skills, personality, reactivity etc.

Let U be a set of candidates is given by U={ c_1,c_2,c_3,c_4,c_5,c_6} and E be the parameter set given by E={knowledge, communication, behaviour, presentation, extracurricular activities}. Consider a fuzzy soft set (U, E) which describes the 'performance of a candidate '. Consider J_1, J_2 and J_3 are the judges who analyze the performance of the candidates and each judge is assigning a rank to each candidate according to his/her performance. The panel of judges assigns priority values to the parameters and based upon the impact of the parameters, they assign rankings to each parameter. This is shown in the following table 4.1.

TABLE 4.1 PARAMETER RANK TABLE

	e_1	e_2	e_3	e_4	e_5
priority	0.4	0.3	-0.15	0.05	0.1
parameter rank	1	2	3	5	4

The parameter values assigned by each judge to the candidate depend upon the performance of the candidate in the interview. The interval valued fuzzy soft set for the candidates from the judge J_1 is shown in Table 4.2.

TABLE 4.2 TABULAR REPRESENTATION OF IVFSS OF JUDGE J_1

U	e_1	e_2	e_3	e_4	e_5
c_1	0.2-0.4	0.3-0.5	0.8-0.9	0.4-0.7	0.6-0.9
c_2	0.4-0.8	0.6-0.9	0.2-0.5	0.7-1	0.5-0.6
c_3	0.5-0.8	0.7-0.9	0.7-0.8	0.8-1	0.5-0.7
c_4	0.6-0.8	0.5-0.9	0.8-1	0.5-0.9	0.7-0.8
c_5	0.1-0.4	0.9-1	0.3-0.6	0.1-0.5	0.8-1
c_6	0.9-1	0.5-0.7	0.1-0.3	0.2-0.4	0.3-0.7

The priority for parameters e_1, e_2, e_3, e_4 and e_5 is given by the judge panel as 0.4, 0.3, -0.15, 0.05 and 0.1. Here, the parameter 'e_3' is a negative parameter. Parameters are classified into positive parameter and negative parameter. The concept of negative parameter was introduced by Tripathy [2]. In the case of pessimistic decision making, we consider the lower membership value of each parameter and in the case of optimistic decision making we need to take the highest membership value of each parameter and in the case of neutral decision making we need to take average of both pessimistic and optimistic values. First, we are considering the pessimistic case. The values of the pessimistic case are shown in the following table.

TABLE 4.3 PESSIMISTIC VALUES OF J_1

U	e_1	e_2	e_3	e_4	e_5
c_1	0.2	0.3	0.8	0.4	0.6
c_2	0.4	0.6	0.2	0.7	0.5
c_3	0.5	0.7	0.7	0.8	0.5
c_4	0.6	0.5	0.8	0.5	0.7
c_5	0.1	0.9	0.3	0.1	0.8
c_6	0.9	0.5	0.1	0.2	0.3

Here, the panel is assigning some priority to the parameters. The priorities for the parameters e_1, e_2, e_3, e_4 and e_5 are 0.4, 0.3, -0.15, 0.05, 0.1. With the help of this priority values, we can create priority table as shown in table.

TABLE 4.4 PRIORITY TABLE FOR PESSIMISTIC VALUES OF J_1

	e_1	e_2	e_3	e_4	e_5
c_1	0.08	0.09	-0.12	0.02	0.06
c_2	0.16	0.18	-0.03	0.035	0.05
c_3	0.2	0.21	-0.105	0.04	0.05
c_4	0.24	0.15	-0.12	0.025	0.07
c_5	0.04	0.27	-0.045	0.005	0.08
c_6	0.36	0.15	-0.015	0.01	0.03

The comparison table is formed by finding the entries as differences of each row sum with those of all other rows, which is shown in table.

TABLE 4.5: COMPARISON TABLE FOR PESSIMISTIC CASE OF JUDGE J_1

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.265	-0.265	-0.235	-0.22	-0.405	-1.39	6
c_2	0.265	0	0	0.03	0.045	-0.14	0.2	3
c_3	0.265	0	0	0.03	0.045	-0.14	0.2	2
c_4	0.235	-0.03	-0.03	0	0.015	-0.17	0.02	4
c_5	0.22	-0.045	-0.045	-0.015	0	-0.185	-0.07	5
c_6	0.405	0.14	0.14	0.17	0.185	0	1.04	1

Similarly, we need to find the comparison table for optimistic and neutral cases. The comparison table for optimistic decision making is given below.

TABLE 4.6: COMPARISON TABLE FOR OPTIMISTIC CASE OF JUDGE J_1

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.325	-0.29	-0.265	-0.195	-0.355	-1.43	6
c_2	0.325	0	0.035	0.06	0.13	-0.03	0.52	2
c_3	0.29	-0.035	0	0.025	0.095	-0.065	0.31	3
c_4	0.265	-0.06	-0.025	0	0.07	-0.09	0.16	4
c_5	0.195	-0.13	-0.095	-0.07	0	-0.16	-0.26	5
c_6	0.355	0.03	0.065	0.09	0.16	0	0.7	1

TABLE 4.7: COMPARISON TABLE FOR NEUTRAL CASE OF JUDGE J_1

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.295	-0.2775	-0.25	-0.2075	-0.38	-1.41	5
c_2	0.295	0	0.0175	0.045	0.0875	-0.085	0.36	2
c_3	0.2775	-0.0175	0	0.0275	0.07	-0.1025	0.255	3
c_4	0.25	-0.045	-0.0275	0	0.0425	-0.13	0.09	4
c_5	0.2075	-0.0875	-0.07	-0.0425	0	-0.1725	-0.165	6
c_6	0.38	0.085	0.1025	0.13	0.1725	0	0.87	1

The following table indicates the IVFSS "performance of candidate" given by judge J_2.

TABLE 4.8 IVFSS GIVEN BY JUDGE J_2

U	e1	e2	e3	e4	e5
c1	0.1-.3	0.4-.5	0.7-.9	0.5-.8	0.6-.8
c2	0.3-.6	0.6-.9	0.3-.5	0.8-.9	0.4-.7
c3	0.4-.7	0.5-.7	0.5-.7	0.7-1	0.3-.6
c4	0.7-.8	0.6-.9	0.8-.9	0.5-.8	0.8-1
c5	0.2-.4	0.8-1	0.2-.5	0.3-.5	0.7-.9
c6	0.7-.9	0.5-.8	0.2-.4	0.1-.3	0.2-.5

Similarly, we find the comparison table for pessimistic, optimistic and neutral cases of Judge J_2 is shown in table 4.9, 4.10 and 4.11

TABLE 4.9 COMPARISON TABLE FOR PESSIMISTIC OF JUDGE J_2

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.195	-0.16	-0.305	-0.235	-0.285	-1.18	6
c_2	0.195	0	0.035	-0.11	-0.04	-0.09	-0.01	4
c_3	0.16	-0.035	0	-0.145	-0.075	-0.125	-0.22	5
c_4	0.305	0.11	0.145	0	0.07	0.02	0.65	1
c_5	0.235	0.04	0.075	-0.07	0	-0.05	0.23	3
c_6	0.285	0.09	0.125	-0.02	0.05	0	0.53	2

TABLE 4.10 COMPARISON TABLE FOR OPTIMISTIC CASE OF JUDGE J_2

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.295	-0.24	-0.34	-0.245	-0.35	-1.47	6
c_2	0.295	0	0.055	-0.045	0.05	-0.055	0.3	3
c_3	0.24	-0.055	0	-0.1	-0.005	-0.11	-0.03	5
c_4	0.34	0.045	0.1	0	0.095	-0.01	0.57	2
c_5	0.245	-0.05	0.005	-0.095	0	-0.105	0	4
c_6	0.35	0.055	0.11	0.01	0.105	0	0.63	1

TABLE 4.11 COMPARISON TABLE FOR NEUTRAL CASE OF JUDGE J_2

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.245	-0.2	-0.3225	-0.24	-0.3175	-1.325	6
c_2	0.245	0	0.045	-0.0775	0.005	-0.0725	0.145	3
c_3	0.2	-0.245	0	-0.1225	-0.04	-0.1175	-0.325	5
c_4	0.3225	0.0775	0.1225	0	0.0825	0.005	0.61	1
c_5	0.24	-0.005	0.04	-0.0825	0	-0.0775	0.115	4
c_6	0.3175	0.0725	0.1175	-0.005	-0.0775	0	0.425	2

The IVFSS (U, E), given by judge J3 is shown in table 4.12

TABLE 4.12 IVFSS GIVEN BY JUDGE J_3

	e1	e2	e3	e4	e5
c1	0.3-.4	0.2-.7	0.6-.9	0.2-.5	0.4-.8
c2	0.3-.5	0.5-.9	0.1-.3	0.6-.9	0.3-.5
c3	0.3-.6	0.5-.7	0.8-1	0.9-1	0.3-.7
c4	0.6-.9	0.3-.7	0.7-.9	0.3-.7	0.6-.9
c5	0.1-.4	0.7-1	0.3-.7	0.2-.6	0.5-.7
c6	0.6-1	0.3-.9	0.3-.5	0.2-.5	0.1-.6

Similarly, we find out comparison table for pessimistic case of judge J_3 as follows.

TABLE 4.13 COMPARISON TABLE FOR PESSIMISTIC CASE OF JUDGE J_3

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.175	-0.085	-0.16	-0.125	-0.165	-0.71	6
c_2	0.175	0	0.09	0.015	0.05	0.01	0.34	1
c_3	0.085	-0.09	0	-0.075	0.035	-0.08	-0.125	5
c_4	0.16	-0.015	0.075	0	0.035	-0.005	0.25	3
c_5	0.125	-0.05	-0.035	-0.035	0	-0.04	-0.035	4
c_6	0.165	-0.01	0.08	0.005	0.04	0	0.28	2

TABLE 4.14 COMPARISON TABLE FOR OPTIMISTIC CASE OF JUDGE J_3

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.18	-0.08	-0.22	-0.115	-0.34	-0.935	6
c_2	0.18	0	0.1	-0.04	0.065	-0.16	0.145	3
c_3	0.08	-0.1	0	-0.14	-0.035	-0.26	-0.455	5
c_4	0.22	0.04	0.14	0	0.105	-0.12	0.385	2
c_5	0.115	-0.065	0.035	-0.105	0	-0.225	-0.245	4
c_6	0.34	0.16	0.26	0.12	0.225	0	1.105	1

TABLE 4.15 COMPARISON TABLE FOR NEUTRAL CASE OF JUDGE J_3

	c_1	c_2	c_3	c_4	c_5	c_6	Row sum	Rank
c_1	0	-0.1775	-0.0825	-0.19	-0.12	-0.2525	-0.8225	6
c_2	0.1775	0	0.095	-0.0125	0.0575	-0.075	0.2425	3
c_3	0.0825	0.095	0	-0.1075	-0.0375	-0.17	-0.1375	5
c_4	0.19	0.0125	0.1075	0	0.07	-0.0625	0.3175	2
c_5	0.12	-0.0575	0.0375	-0.07	0	-0.1325	-0.1025	4
c_6	0.2525	0.075	0.17	0.0625	0.1325	0	0.6925	1

The following table shows the ranking summary of all the judges for pessimistic, optimistic and neutral cases. The normalized score can be obtained by using the equation (4.2).
The final decision is taken with the help of normalized score. The candidate who is having more value in the normalized score is the best choice. From this table 3.14, we can see c6 is the best candidate. The choice of candidates is in the order of c_6, c_4, c_2, c_3, c_5 and c_1.

TABLE 4.16 RANK MATRIX

	J_1			J_2			J_3			**Normalized Score**	**Final Rank**
	P	O	N	P	O	N	P	O	N		
c_1	6	6	5	6	6	6	6	6	6	0.007407	6
c_2	3	2	2	4	3	3	1	3	3	0.222222	3
c_3	2	3	3	5	5	5	5	5	5	0.118519	4
c_4	4	4	4	1	2	1	3	2	2	0.22963	2
c_5	5	5	6	3	4	4	4	4	4	0.111111	5
c_6	1	1	1	2	1	2	2	1	1	0.311111	1

V. CONCLUSIONS

The definition of soft set using the characteristic function approach was provided by Tripathy et al recently, which besides being able to take care of several definitions of operations on soft sets could make the proofs of properties very elegant. For IVFSSs no such approach was in existence. In this paper we define membership function for IVFSSs which extends the notion of characteristic function introduced by Tripathy et.al in 2015. We also propose an application of IVFSSs in group decision making, so that the decision making becomes more efficient and realistic.

REFERENCES

[1] B.K Tripathy, Arun K.R, “A New Approach to Soft Sets, Soft Multisets and Their Properties”, International Journal of Reasoning-based Intelligent Systems, Vol. 7, no. 3/4, 2015, pp.244-253.

[2] B.K Tripathy, T.R Sooraj, and R K Mohanty, “A new approach to fuzzy soft set and its application in decision making”, accepted in ICCIDM 2015.

[3] B.K Tripathy., R K Mohanty , Sooraj T.R and K.R. Arun, “A New Approach to Intuitionistic Fuzzy Soft Set Theory and its Application in Decision Making”, Proceeding of ICICT 2015, 9-10th oct, Udaipur (2015).

[4] B.K Tripathy, Sooraj.T.R, and R K Mohanty, “A new approach to Interval valued fuzzy soft sets and its application in decision making”, accepted in ICCI 2015, RANCHI

[5] B.K Tripathy., R K Mohanty, Sooraj.T.R, “On intuitionistic fuzzy soft sets and their application in decision making”, accepted in ICSNCS-2016, New Delhi.

[6] D. Molodtsov, “Soft Set Theory - First Results”, Computers and Mathematics with Applications, 37 (1999) pp.19-31

[7] L.A Zadeh, “Fuzzy sets”, Information and Control, 8 (1965) pp.338-353

[8] P.K Maji, R. Biswas and A.R Roy, “Fuzzy Soft Sets”, Journal of Fuzzy Mathematics, 9(3), (2001) pp.589-602

[9] P.K Maji, R. Biswas and A.R Roy, “An Application of Soft Sets in a Decision Making Problem”, Computers and Mathematics with Applications, 44 (2002) pp.1007-1083

[10] P.K Maji, R. Biswas and A.R Roy, “Soft Set Theory”, Computers and Mathematics with Applications, 45 (2003) pp.555-562

[11] Sooraj.T.R, RK Mohanty, B.K Tripathy, “ Fuzzy Soft Set Theory and its Application in Group Decision Making”, accepted in ICACCT-2015, PANIPATT.

[12] X.B. Yang, T.Y. Lin, J.Y. Yang, Y. Li and D. Yu, “Combination of interval-valued fuzzy set and soft set”, Computers & Mathematics with Applications 58 (3)(2009) 521-527