International Journal of Modern Science and Technology *Vol. 1, No. 5, Aug. 2016. Page 159-163.*
http://www.ijmst.co/ *ISSN: 2456-0235*

Research Article

Interval-Valued Product Fuzzy Soft Matrices and its Application in Decision Making

S. Vijayabalaji*, N. Sathiyaseelan

*Department of Mathematics,
University College of Engineering, Panruti-60710, Tamilnadu, India.
*Corresponding author's e-mail: balaji1977harshini@gmail.com

Abstract

Matrix theory plays a significant role in decision making situation. The study of matrices in fuzzy setting has always attracted researchers to a greater extend. Fuzzy matrix is a matrix over fuzzy algebra. Soft set is another interesting theory on uncertainty. Cagman made effort in defining soft matrices and fuzzy soft matrices. Interval-valued fuzzy set is another generalization of fuzzy sets that was introduced by Zadeh. Motivated by the theory of soft sets, soft matrices and product fuzzy soft matrices our aim in this paper is to introduce the notion of interval-valued product fuzzy soft matrices as a generalization of product fuzzy soft matrices. We also provide an interesting decision theory on it.

Keywords: Fuzzy matrix; Soft set; Soft matrix; Fuzzy soft set; Fuzzy soft matrix.

Introduction

Zadeh [1,2] introduced the concept of fuzzy sets and the idea of soft computing to deal with impreciseness and uncertainty involved in all decision-making problems. In 1999, Molodstov [3] initiated a novel concept known as soft sets, a new mathematical tool to deal with uncertainties. He pointed out that the important existing theories namely fuzzy sets, intuitionistic fuzzy sets and rough sets, which can be considered as mathematical tools for dealing with uncertainties have their own difficulties. Maji and Roy [4-6] made a significant contribution in developing soft sets.

Cagman and Enginoglu [7] defined various operations on soft sets and constructed the uni-int decision making method. In [8] Cagman and Enginoglu provided a decision making algorithm using soft matrices. Aktas and Cagman [9] introduced the notion of soft groups. Ali et al [10] discussed about various operations on soft sets. Cagman et al [11] took effort in re-defining fuzzy soft sets. Jon Arockiaraj and Sathiyaseelan [12] provided an application of fuzzy soft sets for students ranking system. Thomason [13] was the first person to initiate the concept of fuzzy matrices. Vijayabalaji and Ramesh [14] introduced the notion of product soft matrices and provided a decision theory on it. Recently Vijayabalaji et al [15] generalized the product soft matrices in fuzzy setting. They also provided an example for multi-decision making using max-min decision matrix on interval-valued product fuzzy soft matrices.

Motivated by the above theories our aim in this paper introduce the notion of interval-valued product fuzzy sot matrices and to provide an algorithm for multi-decision making using min-min decision matrices on interval-valued product fuzzy soft matrices. We justify the above algorithm by means on an example.

Preliminaries

Definition 1 [14] A soft set F_A over U is a set defined by a function f_A representing a mapping $f_A: E \rightarrow P(U)$ such that $f_A=\phi$ 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 $x \in E$. A soft set over U isrepresented by a set of ordered pairs $F_A = \{(x, f_A(x)): x \in E, f_A(x) \in P(U)\}$.

Definition 2 [11] A fuzzy soft set (fs- set)Γ_A over U is a set defined by a function γ_A representing a mapping $\gamma_A : E \rightarrow F(U)$such that $\gamma_A(x) = \phi$ if x $\notin$ A. Here γ_A is called fuzzy approximation function of the f_s setΓ_A, the value γ_A(x) is a fuzzy set called x-element of thef_S set for all x $\in$ E, and $\phi$is the null fuzzy set. ThusΓ_A= $\{(x, \gamma_A(x)): x \in E, \gamma_A(x) \in F(U)\}$. The set of all fs-set over U is denoted by F_S(U).

Received: 13.08.2016; Received after Revision: 23.08.2016; Accepted: 23.08.2016; Published: 25.08.2016

Definition 3[16] For two fuzzy soft set (F, A) and (G, B) in a fuzzy soft class (U, E), We say that (F, A) is a fuzzy soft subset of (G, B) if
(i) $A \subseteq B$
(ii) for all $\varepsilon \in A$, $F(\varepsilon) \subseteq G(\varepsilon)$ and is written as $(F, A) \subseteq (G, A)$

Definition 4 [16] Union of two fuzzy soft sets (F, A) and (G, B) in a soft class is a fuzzy soft set (H, C) where $C = A \cup B$ and $\varepsilon \in C$

$$H(\varepsilon) = \begin{cases} F(\varepsilon) & \text{if } \varepsilon \in A - B \\ G(\varepsilon) & \text{if } \varepsilon \in B - A \\ F(\varepsilon) \cup G(\varepsilon) & \text{if } \varepsilon \in A \cap B \end{cases}$$

and is written as $(F, A)\ \tilde{U}\ (G, B) = (H, C)$

Definition 5 [16] Intersection of two fuzzy soft sets (F, A) and (G, B) in a soft class is a fuzzy soft set (H, C) where $C = A \cap B$ and $\varepsilon \in C$, $H(\varepsilon) = F(\varepsilon)$ or $G(\varepsilon)$ and is written as $(F, A)\ \tilde{\cap}\ (G, B) = (H, C)$

Definition 6 [11] Let $\Gamma_A \in F_S(U)$. Then a fuzzy relation form of Γ_A is defined by $\gamma_A = [(\mu_{R_A}(d, x)/(d, x) : (m, x) \in U \times E)]$, where the membership functions of μ_{R_A} is written by $\mu_{\gamma_A} : U \times E \to [0,1]$. Assume that $U = \{u_1, u_2, u_3, u_4, \dots\dots u_n\}$ $E = \{x_1, x_2, x_3, \dots\dots x_p\}$ and $A \subseteq E$, then the Γ_A can be represented by the following table.

Γ_A	x_1	x_2	...	x_p
u_1	$\mu_{\gamma_A}(u_1, x_1)$	$\mu_{\gamma_A}(u_1, x_2)$	...	$\mu_{\gamma_A}(u_1, x_p)$
u_2	$\mu_{\gamma_A}(u_2, x_1)$	$\mu_{\gamma_A}(u_2, x_2)$	...	$\mu_{\gamma_A}(u_1, x_p)$
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
u_n	$\mu_{\gamma_A}(u_n, x_1)$	$\mu_{\gamma_A}(u_n, x_2)$	...	$\mu_{\gamma_A}(u_1, x_p)$

Where $\mu_{\gamma_A}(u_i, x_i)$ is the membership function of γ_A .

If $a_{ij} = \mu_{\gamma_A}(u_i, x_i)$,then the f_s -set Γ_A is uniquely characterized by a matrix

$$[a_{ij}]_{d \times p} = \begin{pmatrix} a_{11} & a_{12} & . & . & . & a_{1p} \\ a_{21} & a_{22} & . & . & . & a_{2p} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{n1} & a_{n2} & . & . & . & a_{np} \end{pmatrix}$$

called as n×p fuzzy soft matrix (f_s) of the fuzzy soft set Γ_A over U.

Definition 7 [3] Let (F, A) and (G, B) be two fuzzy soft sets over a common universe U, Then the Cartesian product of these two fuzzy soft sets is denoted by (F, A) × (G, B) and is defined by (F, A) × (G, B) = (H , A × B), where $H(\alpha, \beta) = F(\alpha) \times G(\beta)$.

Example 8 [3] Let us consider two subsets A and B as
$A = \{x_1 = \text{expensive}; x_2 = \text{beautiful}\} \in E$ and
$B = \{x_3 = \text{branded}; x_4 = \text{cheapest}\} \in E$.
Then (F,A) describes the " attractiveness of the dress" and (G, B) describes the "cost of the dress".
Let $U = \{d_1, d_2, d_3, d_4, d_5\}$
$F(x_1) = \{0.5/d_1, 0.7/d_3, 0.4/d_4, 0.9/d_5,\}$
$F(x_2) = \{0.7/d_2, 0.8/d_3, 0.9/d_5\}$
$G(x_3) = \{0.8/d_2, 0.7/d_3\}$ and
$G(x_4) = \{1/d_2\}$.
Then we can view the fuzzy soft sets F_A and G_B as consists of the following collection of approximation:
$F_A =$
$\{(x_1, \{0.5/d_1, 0.7/d_3, 0.4/d_4, 0.9/d_5,\}), (x_2, \{0.7/d_2, 0.8/d_3, 0.9/d_5\})\}$
and
$G_B = \{(x_3, \{0.8/d_2, 0.7/d_3\}), (x_4, \{1/d_2\})\}$.
The relation form is
$R_{(H, A \times B)} = \{((x_1, x_3)\ \{(0.5/d_1, 0.8/d_2), (0.5/d_1, 0.7/d_3), (, 0.7/d_3, 0.8/d_2), (0.7/d_3, 0.7/d_3), (0.4/d_4, 0.8/d_2), (0.4/d_4, 0.7/d_3), (0.9/d_5, 0.8/d_2), (0.9/d_5, 0.7/d_3)\}), ((x_1, x_4), \{(0.5/d_1, 1/d_2), (0.7/d_2, 1/d_2), (0.4/d_4, 1/d_2), (0.9/d_5, 1/d_2)\}), ((x_2, x_3), \{(0.7/d_2, 0.8/d_2), (0.7/d_2, 0.7/d_3), (0.8/d_3, 0.8/d_2), (0.8/d_3, 0.7/d_3), (0.9/d_5, 0.8/d_2), (0.9/d_5, 0.7/d_3)\}, ((x_2, x_4), \{(0.7/d_2, 1/d_2), (0.8/d_3, 1/d_2), (0.9/d_5, 1/d_2)\})\}$.

Definition 9 [17] Let X be a set. A mapping $\bar{A}$: $X \to D[0, 1]$ is called as interval-valued fuzzy subset of X, where $\bar{A}(x) = [A^-(x), A^+(x)]$ are fuzzy subsets in X such that $A^-(x) \le A^+(x)$ for all $x \in X$.

Definition 10 [17] Let U be an initial universe, E be a set of parameters and $A \subseteq E$. Then a pair $(\overline{F_A}, E)$ is called an interval-valued fuzzy soft set over P(U) where $\overline{F_A}$ is a mapping given by $\overline{F_A}$: A → P(U).

Definition 11[18] An intuitionistic fuzzy matrix (IFM) A of order n × n is defined as $A = [x_{ij}, \langle a_{\mu_{ij}}, a_{\gamma_{ij}} \rangle]_{n\times n}$ where $a_{\mu_{ij}}$ and $a_{\gamma_{ij}}$ are called membership and non- membership values of x_{ij} in A, which maintaining the condition $0 \le a_{\mu_{ij}} + a_{\gamma_{ij}} \le 1$.

For simplicity, we write $A = [x_{ij}, a_{ij}]_{n\times n}$ or simply $[\, a_{ij}]_{n\times n}$ where $a_{ij} = \langle a_{\mu_{ij}}, a_{\gamma_{ij}} \rangle$.

Definition 12 [19] An interval valued intuitionistic fuzzy matrix (IVIFM) A of order n×n is defined as

$A = \left[x_{ij}, \langle a_{\mu_{ij}}, a_{\gamma_{ij}} \rangle\right]_{n\times n}$ where $a_{\mu_{ij}}$ and $a_{\gamma_{ij}}$ are both the subsets of [0, 1] which are denoted by $a_{\mu_{ij}} = \left[a_{\mu_{ij}L}, a_{\mu_{ij}U}\right]$ and $a_{\gamma_{ij}} = \left[a_{\gamma_{ij}L}, a_{\gamma_{ij}U}\right]$ which maintaining the condition $\left[a_{\mu_{ij}U} + a_{\gamma_{ij}U}\right] \le 1$ for $i, j = 1, 2, 3, \ldots n$.

Definition 13 [18] Let U be the universal set. Let (F, A) and (G, B) be a two fuzzy soft sets over common universe. Then the product of fuzzy soft sets is (F, A) × (G, B) = (H, A × B). We define a relation on (H, A × B) as $R_{(H,A\times B)}$ = {(h ,e) : h ∈ H(α,β) e ∈ A × B }.Now we define afunction $\mu_{R_{(H,A\times B)}}$: U × E → $\mathcal{D}$[0 ,1] by

$$\mu_{R_{(H,A\times B)}} = \begin{cases} 1, \text{if } (h, e) \in A \cap B \\ \alpha, \text{if } (h, e) \in A \;\Delta\; B \\ 0, \text{if } (h, e) \notin A \cup B \end{cases}$$

called as product fuzzy soft matrix.

Scope of the present investigation

Vijayabalaji et al, [14] took effort in generalizing fuzzy soft matrices to product fuzzy soft matrices. They also provided an algorithm for decision making using max-max decision matrix. Inspired by the interval- valued fuzzy sets and product fuzzy soft matrices, we intend to introduce the notion of interval-valued product fuzzy soft matrices as a generalization of product fuzzy soft matrices. An attempt is made to provide an algorithm for interval-valued product fuzzy soft matrices using min-min decision matrices.

Interval-valued product fuzzy soft matrices

We now introduce the notion of interval-valued product fuzzy soft matrices as follows.

Definition 14 Let (F,A) = (a_{ij}) and (G,B) = (b_{ij}) are two interval valued fuzzy soft matrices. Then (F,A) AND (G,B) is denoted by[(F,A) ∧ (G,B)] = [H, A×B] = (d_{ij}) is an interval-valued fuzzy soft matrix and defined by (f_{ij}) = min{(a_{ij}) ∩ (b_{ij})},where a_{ij} and $b_{ij} \in \mathcal{D}$[0 ,1].

Remark 15 In the above definition
$a_{ij} = [a_{ij}^-, a_{ij}^+]$ and $b_{ij} = [b_{ij}^-, b_{ij}^+]$ such that $0 \le a_{ij}^- \le a_{ij}^+ \le 1$ and $0 \le b_{ij}^- \le b_{ij}^+ \le 1$.

Example 16 Let U={ p_1, p_2, p_3, p_4, p_5 }and E={x_1, x_2, x_3,x_4}.Assume that A = { x_1, x_2, x_3} and B ={ x_2, x_3,x_4} ⊆ E.
Let (F,A) = {((x_1), {[0.5,0.8]/p_1, [0.3,0.7]/p_3, [0.3,0.4]/ p_4, [0.2,0.6]/ p_5, }) ,((x_2), {[0.7,0.8]/ [,0.5,0.9] p_3, [0.4,0.7]/p_5}), ((x_3),{[0.2,0.9]/p_4})}
(G,B)= {((x_2),{[0.8,0.9]/p_1, [0.3,0.5]/p_3, [0.6,0.8]/p_5}) ,((x_3),{ [0.2,0.6]/p_2, [0.3,0.8]/p_3}),((x_4),{[0.1, 0.7]/ p_2})}.
Hence
(F,A) ∧ (G,B) = {((x_1,x_2), {[0.5,0.8]/p_1, [0.3,0.5]/ p_3, [0.2,0.6]/p_5}), ((x_1,x_3) ,{ [0.3,0.5]/p_3}),((x_1,x_4),{ϕ}), ((x_2,x_2), {[0.3,0.5]/p_3[,0.4,0.7]/p_5}),((x_2,x_3),{ [0.2,0.6]/p_2, [0.3,0.8]/p_3}), ((x_2,x_4), {[0.1,0.7]/ p_2((x_3,x_2), {ϕ}), ((x_3,x_3) ,{ϕ}),((x_3,x_4),{ϕ}).
Hence the interval-valued fuzzy soft matrix is
(f_{ij}) =

$$\begin{pmatrix} [0.5,0.8] & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} \\ \bar{0} & \bar{0} & \bar{0} & \bar{0} & [0.2,0.6] & [0.1,0.7] & \bar{0} & \bar{0} & \bar{0} \\ [0.3,0.8] & [0.3,0.5] & \bar{0} & [0.3,0.5] & [0.3,0.8] & \bar{0} & \bar{0} & \bar{0} & \bar{0} \\ \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} \\ [0.2,0.6] & \bar{0} & \bar{0} & [0.4,0.7] & \bar{0} & \bar{0} & \bar{0} & \bar{0} & \bar{0} \end{pmatrix}$$

Definition 17 Let U be the universal set. Let (F, A) and (G, B) be a two interval-valued fuzzy soft sets over common universe. Then the product of interval-valued fuzzy soft sets is (F, A) × (G, B) = (H, A × B). We define a relation on (H, A × B) as $R_{(H,A\times B)}$ = {(h ,e) : h ∈ H(α,β) e ∈ A × B }. Now we define a function $\overline{\mu}_{R_{(H,A\times B)}}$: U × E → $\mathcal{D}$[0, 1] by

$$\overline{\mu}_{K_{(H,A\times B)}} = \begin{cases} \overline{1} & , \text{if } (h,c) \in A \cap B \\ \overline{\alpha} & , \text{if } (h,c) \in A \,\Delta\, B, \overline{\alpha} \in, (\alpha^{+} \alpha^{-}) \\ \overline{0} & , \text{if } (h,e) \notin A \cup B \end{cases}$$

called an interval-valued product fuzzy soft matrix.

Example 18 We justify above definition by means of the following example.

Consider the example 16

(F, A) ∧ (F , B) = {((x_1,x_2), {p_1,p_3,p_5}), ((x_1,x_3), {p_3}), ((x_1,x_4), { ϕ }), ((x_2,x_2),{p_3,p_5}) ((x_2,x_3), {p_2,p_3}), ((x_2,x_4), {p_2}),((x_3,x_2), { ϕ }), ((x_3,x_3) , { ϕ }),((x_3,x_4), { ϕ }}.

Then, the interval-valued product fuzzy soft matrices is $(d_{ij})_{(5\times 9)}$=

$$\begin{pmatrix} [1,1] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] \\ [0,0] & [0,0] & [0,0] & [0,0] & [1,1] & [1,1] & [0,0] & [0,0] & [0,0] \\ [1,1] & [1,1] & [0,0] & [1,1] & [1,1] & [0,0] & [0,0] & [0,0] & [0,0] \\ [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] \\ [1,1] & [0,0] & [0,0] & [1,1] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] \end{pmatrix}$$

Definition 19 The choice value of an object $d_j \in$ U is defined by d_j = min {min (d(h,e))}, where d(h,e) are the entries of d_{ij} .

Definition 20 Let U= {d_1, d_2, d_3, . . .,d_n}be an initial universe and min{min(d(h,e))} = [u_{i1}]. Then a subset of U can be obtained using [u_{i1}] in the following way.Opt$_{[u_{i1}]}$ = {u_i : u ∈ U,u_{i1} = min(0 or 1)},called an optimum set of U.

Algorithm

Assume that a set of alternative and a set of parameters are given. Now we construct a soft Min-min decision algorithm on interval-valued product fuzzy sot matrices.

Step 1: Choose feasible subsets of the set of parameters.

Step 2: Construct the interval-valued product fuzzy soft set.

Step 3: Find a interval-valued product of the product fuzzy soft matrices.

Step 4: Compute the min – min decision matrix of product.

Step 5: Conclusion.

Example 18 Consider a ball-badminton game with five players namely p_1, p_2, p_3, p_4, p_5. Let U= {p_1, p_2, p_3, p_4, p_5} be the universal set and E={x_1, x_2, x_3, x_4} be the set of parameters related to the universal set. Here x_i(i=1,2,3,4) stands for front and centre position, back position only, both front and back position only, all rounder.

Now an expert X has been invited to choose a best player in that team to lead them.

Step 1. Assume that A ={x_1, x_2, x_3} and B ={x_2, x_3,x_4}$\subseteq$E.

Step 2. Interval-valued product fuzzy soft set are Let (F,A) = {((x_1), {[0.5,0.8]/p_1, [0.3,0.7]/p_3, [0.3,0.4]/ p_4, [0.2,0.6]/ p_5, }) ,((x_2),{[0.7,0.8]/p_2[,0.5,0.9] p_3, [0.4,0.7]/p_5}), ((x_3),{[0.2,0.9]/p_4})}

(G,B)= {((x_2),{[0.8,0.9]/p_1, [0.3,0.5]/p_3, [0.6,0.8]/p_5}) ,((x_3),{[0.2,0.6]/p_2, [0.3,0.8]/p_3}),((x_4),{[0.1, 0.7]/ p_2})}.

The AND product of interval-valued fuzzy soft set is defined as

(F,A) ∧ (G,B) = {((x_1,x_2), {[0.5,0.8]/p_1, [0.3,0.5]/p_3, [0.2,0.6]/p_5}), ((x_1,x_3) ,{ [0.3,0.5]/ p_3}),((x_1,x_4),{ϕ}), ((x_2,x_2), {[0.3,0.5]/ p_3[,0.4,0.7]/p_5}),((x_2,x_3), {[0.2,0.6]/p_2, [0.3,0.8]/p_3}), ((x_2,x_4), {[0.1,0.7]/p_2},((x_3,x_2), {ϕ}),((x_3,x_3),{ϕ}),((x_3,x_4),{ϕ})}.

Step 3. Hence, the interval-valued product fuzzy soft matrix is,

(f_{ij}) =

$$\begin{pmatrix} [1,1] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] \\ [0,0] & [0,0] & [0,0] & [0,0] & [1,1] & [1,1] & [0,0] & [0,0] & [0,0] \\ [1,1] & [1,1] & [0,0] & [1,1] & [1,1] & [0,0] & [0,0] & [0,0] & [0,0] \\ [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] \\ [1,1] & [0,0] & [0,0] & [1,1] & [0,0] & [0,0] & [0,0] & [0,0] & [0,0] \end{pmatrix}$$

Step 4. min-min decision soft matrix is, min{min values in every column}=Min{{p_2, p_4},{p_1,p_2,p_3,p_4},{ p_1,p_2,p_3,p_4,p_5},{p_1,p_2,p_3},{ p_1,p_4,p_5}, { p_1,p_3,p_4,p_5},{ p_1,p_2,p_3,p_4,p_5},{ p_1,p_2,p_3,p_4,p_5},{ p_1,p_2,p_3,p_4,p_5}}=p_4.

Step 5. We find an optimum set of U according to min{min(d(h,e))} = p_4. Hence the expert chooses the optimum player as p_4.

Conclusion

A new algorithm is presented for interval-valued product fuzzy soft matrix using min-min operation. We have considered an example to choose a best player in ball badminton game by employing the above algorithm. As a future plan we try to extend this concept to cubic soft matrices and to provide a decision theory on it.

Conflict Interest

The authors declare that there is no conflict of interest regarding the publication of our paper.

Acknowledgement

The authors would like to thank the referees for their valuable comments and suggestions towards the quality improvement of the paper and to re-write it in the present form.

References

1. Zadeh LA. Fuzzy sets. Information and Control 8 (1965) 338-353.
2. Zadeh LA. The concept of a linguistic variable and its application to approximate reasoning. Information and Control 8 (1975) 199-249.
3. Molodstov DA. Soft set theory - First results. Computers and Mathematics with Applications 37 (1999) 19-31.
4. Maji PK, Biswas R, Roy AR. Soft set theory. Computers and Mathematics with Applications 45(2003) 555-562.
5. Maji PK, Roy AR. An Application of soft set in decision making problem. Computers and Mathematics with Applications. 44 (2002) 1077-1083.
6. Maji PK. Roy AR. A fuzzy soft set theoretic approach to decision making problem. Journal of computational and Applied Mathematics 203 (2007) 412-418.
7. Cagman N, Enginoglu S. Soft set theory and uni-int decision making. European Journal of Operational Research 207 (2010) 848-855.
8. Cagman N, Enginoglu S. Soft matrix theory and its decision making. Computers and Mathematics with Applications. 59 (2010) 3308-3314.
9. Aktas H, Cagman N. Soft sets and soft groups. Information Sciences 177) (2007) 2726-2735.
10. Ali MI, Feng F, Liu X, Min WK, Shabir M. On some new operations in soft set theory. Computers and Mathematics with Applications 57 (2009) 1547-1553.
11. Cagman N, Enginogul S, Citak F. Fuzzy soft set theory and its application. Iranian Journal of Fuzzy Systems 8 (2011) 137-147.
12. Jon Arockiaraj J, Sathiyaseelan N. An application of fuzzy soft set based student ranking system. International Journal of computing Algorithm 3 (2014) 745-748.
13. Thomason MG. Convergence of power of a fuzzy matrix. Journal of Mathematical Analysis and Application 57 (1977) 476-480.
14. Vijayabalaji S, Ramesh A. A new decision making theory in soft matrices. International Journal of pure and Applied Mathematics 86 (2013) 927-939.
15. Vijayabalaji S, Shyamsundar G, Ramesh A. A new decision making theory in product fuzzy soft matrices. Proceedings of the International Conference on Mathematics and its Application (2014) 578-593.
16. Maji PK, Biswas R, Roy AR. Fuzzy soft sets. Journal of Fuzzy Mathematics. 9 (2001) 589-602.
17. Mitra Basu T, Kumar Mahapatra N, Kumar Mondal S. Matrices in interval-valued fuzzy soft set theory and their application. South Asian Journal of Mathematics. 4 (2014) 1-22.
18. Pal M, Kahan SK, Shyamal AK. Intuitionistic fuzzy matrices. Notes on Intuitionistic Fuzzy Sets. 8 (2002)51-62.
19. Pal M, Kahan SK. Interval-valued intuitionistic fuzzy matrices. Notes on Intuitionistic Fuzzy Sets 11(2005) 16-27.

*****