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Some Results On Fuzzy δ - Semi Precontinuous Mappings

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Abstract: *The purpose of this paper is to investigate some basic properties of "δ - semi preopen sets" in fuzzy topological spaces. Also the aim of this paper is to introduce and investigate the concept of "fuzzy δ - semi precontinuous mappings" in fuzzy topological spaces. Some of their characterization theorems and basic properties in fuzzy topological spaces are also to be investigated. Also the properties of these mappings with other known fuzzy mappings would be compared.*
Key words: *Fuzzy topological space, fuzzy δ - preopen set, fuzzy δ - semi preopen set, fuzzy δ - semi precontinuous mapping.*
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I. Introduction

The concept of fuzzy sets was introduced by Prof. L. A. Zadeh [14]. The researchers realized the potentiality of introduced notion of fuzzy sets and successfully applied it for investigations in all the branches of science and technology. C. L. Chang [4] introduced the notion of fuzzy topology. The concepts of fuzzy semi preopen set and fuzzy semi precontinuity in fuzzy topological spaces were introduced by S. S. Thakur and S. Singh [12]. The concept of fuzzy δ - continuous mappings in fuzzy setting was introduced by Ganguly and Saha [8]. Also Debnath [5] introduced the concept of fuzzy δ - semi continuous mappings in fuzzy topological spaces. Recently the notion of fuzzy sets and fuzzy topology have been applied by Dhar [6, 7]. In section III of this paper, the different properties of fuzzy δ - preopen sets and fuzzy δ - semi preopen sets would be studied. In section IV, the concept of fuzzy δ - semi precontinuous mappings and some of their characterization theorems and basic properties would be introduced and investigated in fuzzy topological spaces.

II. Preliminaries

Throughout this section, some of the known results and definitions are to be mentioned for ready references.

Definition 2.1. [14] Let X be a crisp set and A and B be two fuzzy subsets of X with membership functions μ_A and μ_B respectively. Then

(a) A is equal to B, i.e., A = B if and only if $\mu_A(x) = \mu_B(x)$, for all $x \in X$,
(b) A is called a subset of B if and only if $\mu_A(x) \le \mu_B(x)$, for all $x \in X$,
(c) the Union of two fuzzy sets A and B is denoted by $A \vee B$ and its membership function is given by $\mu_{A\vee B} = \max(\mu_A, \mu_B)$,
(d) the Intersection of two fuzzy sets A and B is denoted by $A \wedge B$ and its membership function is given by $\mu_{A\wedge B} = \min(\mu_A, \mu_B)$,
(e) the Complement of a fuzzy set A is defined as the negation of the specified membership function. Symbolically it can be written as $\mu^c{}_A = 1 - \mu_A$.

Definition 2.2. [11] A fuzzy point x_p in X is a fuzzy set in X defined by

$$x_p(y) = p\ (0 < p \le 1), \text{ for } y = x$$
$$= 0 \quad , \text{ for } y \ne x\ (y \in X),$$

x and p are respectively the support and the value of x_p.

A fuzzy point x_p is said to belong to a fuzzy set A of X if and only if $p \le A(x)$. A fuzzy set A in X is the union of all fuzzy points which belong to A.

Definition 2.3. A fuzzy subset A of a fuzzy topological space (X, τ) is said to be

(a) [1] fuzzy semiopen if $A \le cl(int(A))$,
(b) [2] fuzzy preopen if $A \le int(cl(A))$,
(c) [12] fuzzy semi preopen if $A \le cl(int(cl(A)))$,

(d) [8] fuzzy δ - closed if and only if A = δcl(A) and the complement of fuzzy δ - closed set is called fuzzy δ - open,
(e) [9] fuzzy δ - semiopen if A ≤ cl(δint(A)).

Definition 2.4. A fuzzy subset A in a fuzzy topological space X is called
(a) [11] quasi - coincident (q - coincident, for short) with a fuzzy subset B, denoted by AqB, if and only if ∃ x∈X such that A(x) + B(x) >1,
(b) [11] q - coincident with a fuzzy point x_p (where x is the support, p is the value of the point & 0<p≤1) if and only if p + A(x) >1,
(c) [11] q - neighbourhood (q - nbd, for short) of fuzzy point x_p if and only if there exists a fuzzy open set B such that x_pqB≤A.

Definition 2.5. Let f : (X, τ) → (Y, σ) be a mapping from a fuzzy topological space (X, τ) to another fuzzy topological space (Y, σ). Then f is called
(a) [4] fuzzy continuous if $f^{-1}(B)$ is a fuzzy open set in X for any fuzzy open set B in Y,
(b) [12] fuzzy semi precontinuous if the inverse image of each fuzzy open set of Y is a fuzzy semi preopen set in X,
(c) [5] fuzzy δ - semi continuous if $f^{-1}(B)$ is a fuzzy δ - semi open set in X for every fuzzy open set B of Y.

Definition 2.6. [10] A fuzzy set A of a fuzzy topological space (X, τ) is called fuzzy *δ* - semi preneighbourhood (respectively fuzzy δ - semi pre q - neighbourhood) of a fuzzy point x_p if there exists a fuzzy δ - semi preopen set U such that x_p∈U≤A (respectively x_pqU≤A).
The set of all fuzzy δ - semi pre neighbourds of a fuzzy point x_p in a fuzzy topological space (X, τ) is denoted by ξ(x_p) and the set of all fuzzy δ - semi pre q - nbds of a fuzzy point x_p in a fuzzy topological space (X, τ) is denoted by η(x_p).

III. Fuzzy δ - preopen and fuzzy δ - semi preopen sets

M. Caldas et al. [3] introduced fuzzy δ - preopen set and S. S. Thakur and R. K. Khare [13] introduced fuzzy δ - semi preopen set. In this section, some more concepts about these sets are to be investigated in fuzzy setting.

Definition 3.1. Let A be a fuzzy set of a fuzzy topological space (X, τ). Then A is called:
(a) [3] fuzzy δ - preopen if A ≤ int(δcl(A)),
(b) [13] fuzzy δ - semi preopen if A ≤ δcl(intδcl(A)), equivalently, if there exists a fuzzy δ - preopen set B such that B ≤ A ≤ δcl(B). The set of all fuzzy δ - preopen (respectively δ - semi preopen) sets on X is denoted by δpo(X) (respectively δspo(X)).

Remark 3.2. Every fuzzy δ - semi preopen set is fuzzy semi preopen set but the converse is not true.
Example 3.3. Let X = {a, b} and A, B, C are fuzzy sets defined as follows:
A(a) = 0.4, A(b) = 0.5
B(a) = 0.6, B(b) = 0.7
C(a) = 0.3, C(b) = 0.2

Let τ = {0, 1, A} be a fuzzy topology on X. Then B is fuzzy semi preopen but not fuzzy δ - semi preopen.

Remark 3.4. It is clear from [12, Remarks 2.2] and Remark 3.3., the following diagram of implications is true.

fuzzy semiopen
Fuzzy open ⇨ fuzzy α-open ⇗ ⇘ fuzzy δ - semi preopen ⇗ fuzzy semi preopen
fuzzy preopen

Theorem 3.5.
(a) The union of any collection of fuzzy δ - semi preopen sets in a fuzzy topological space (X, τ) is also fuzzy δ - semi preopen,
(b) the intersection of any collection of fuzzy δ - semi preclosed sets in a fuzzy topological space (X, τ) is also fuzzy δ - semi preclosed.

Proof .

(a) Let (A_i : i ∈ J) be a collection of fuzzy δ - semi preopen sets of a fuzzy topological space (X, τ). Then $A_i \le \delta cl(int\delta cl(A_i))$ for each i and by lemma 3.1 of [1], we have $\vee A_i \le \vee \delta cl(int\delta cl(A_i)) \le \delta cl(int\delta cl(\vee A_i))$.
This shows that $\vee A_i$ is a fuzzy δ - semi preopen set.
Thus, the union of any collection of fuzzy δ - semi preopen sets is a fuzzy δ - semi preopen set.
(b) Let (A_i : i ∈ J) be a collection of fuzzy δ - semi preopen sets of a fuzzy topological space (X, τ).
Then by (a), $\vee A_i$ is a fuzzy δ - semi preopen set.
Therefore, $(\vee A_i)^c$ is a fuzzy δ - semi preclosed set.
Thus, $\wedge (A_i)^c$ is a fuzzy δ - semi preclosed set.
But $(A_i)^c$ is a fuzzy δ - semi preclosed set, as A_i is a fuzzy δ - semi preopen set.
Thus, the intersection of any collection of fuzzy δ - semi preclosed sets is a fuzzy δ - semi preclosed set.

Theorem 3.6. Let A and B be two fuzzy sets in a fuzzy topological space X. Then
(a) δspcl(A) ≤cl(A)
(b) δspcl(A) is a fuzzy δ - semi preclosed set
(c) A∈ δspc(X) ⇔ A= δspcl(A)
(d) A ≤ B⇒ δspcl(A) ≤ δspcl(B)
(e) int(A) ≤ δspint(A)
(f) δspint(A) is fuzzy δ - semi preopen set
(g) A∈ δspo(X) ⇔ A= δspint(A)
(h) A ≤ B⇒ δspint(A) ≤ δspint(B)
(i) 1 - δspcl(A) = δspint(1 - A).

Theorem 3.7. A fuzzy point x_p ∈ δpcl(A) if and only if A∧B ≠ 0, for each fuzzy δ - preopen set B containing x_p.
Proof. Suppose there exists a fuzzy δ - preopen set B containing x_p such that A∧B = 0. Then A≤1 – B and 1 – B is fuzzy δ – preclosed set. Since δpcl(A) ≤(1 – B), x_p ∉ δpcl(A), which is a contradiction. Conversely, suppose that x_p ∉ δpcl(A). Put B = 1 - δpcl(A). Then B is a fuzzy δ – preopen set containing x_p and A∧B = 0, which is a contradiction. Hence x_p ∉ δpcl(A).

Theorem 3.8. A fuzzy set A ∈ δspo(X) if and only if for every fuzzy point x_p ∈ A, there exists a fuzzy set B ∈ δspo(X) such that x_p q B ≤ A.
Proof. If A ∈ δspo(X), then we may take B = A, for every x_p ∈ A.
Conversely, we have

$$A = \vee \{x_p\} \le \vee B \le A, \text{ for every } x_p \in A.$$

The result now follows from the fact that any union of fuzzy δ - semi preopen sets is fuzzy δ - semi preopen.

Theorem 3.9. A fuzzy set A ∈ δspo(X) if and only if for every fuzzy point x_p ∈ A, A is a fuzzy δ - semi pre nbd of x_p.
Proof . Obvious.

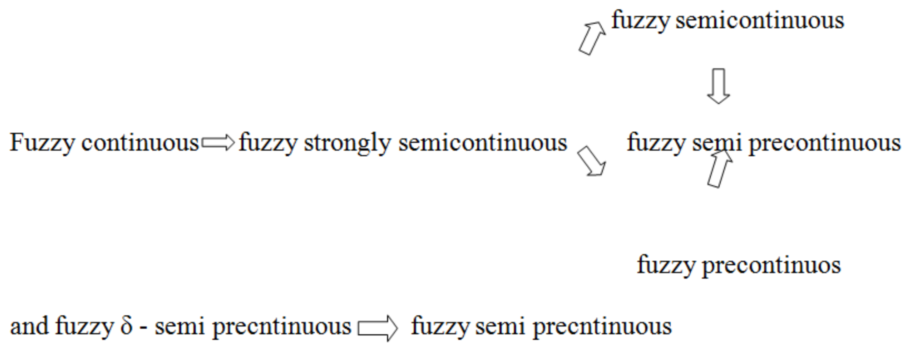
Theorem 3.10. Let X be a fuzzy topological space.
(a) If A≤ B≤cl(A) and A∈ δspo(X), then B∈ δspo(X).
(b) If int(C)≤ D≤C and C∈ δspc(X), then B∈ δspc(X).
Proof. (a) Let B_1∈ δpo(X) such that B_1≤ A≤cl(B_1). Clearly B_1≤ B and A≤cl(B_1) implies that cl(A)≤cl(B_1). Consequently, B_1≤ B≤cl(B_1). Hence B∈ δspo(X).
(b) Follows from (a).

IV. Fuzzy δ - semi precontinuous mappings

S. S. Thakur and R. K. Khare [13] introduced the concept of fuzzy semi δ - precontinuous mappings. In this section, the concept of fuzzy δ - semi precontinuous mappings with the help of fuzzy open and fuzzy δ - semi preopen sets is to be introduced. Some of their basic properties are also to be studied in fuzzy topological spaces.
Definition 4.1. A mapping f : (X, τ) → (Y, σ) from a fuzzy topological space (X, τ) to another fuzzy topological space (Y, σ) is called fuzzy δ - semi precontinuous if $f^{-1}(B)$ ∈ δspo(X) for each fuzzy open set B of Y.
Remark 4.2. Every fuzzy δ - semi precontinuous mapping is fuzzy semi precontinuous but the converse may be true.
Example 4.3. Let X = {a, b}, Y = {x, y} and A, B and C be fuzzy sets defined as follows :
A(a) = 0.6, A(b) = 0.2

B(a) = 0.6, B(b) = 0.1
C(a) = 0.6, C(b) = 0.3
Let $\tau_1 = \{0, 1, A, B\}$ and $\tau_2 = \{0, 1, C\}$. Then the mapping $f : (X, \tau_1) \to (Y, \tau_2)$ defined by f(a) = x, f(b) = y is fuzzy semi precontinuous, but not fuzzy δ - semi precontinuous.

Remark 4.4. It is clear from [12, Remarks 3.2] and Remark 4.2., the following diagram of implications is true.



Theorem 4.5. Let $f : (X, \tau) \to (Y, \sigma)$ be a mapping from a fuzzy topological space (X, τ) to another fuzzy topological space (Y, σ). Then the following statements are equivalent :

(a) f is fuzzy δ - semi precontinuous.
(b) For every fuzzy closed set B in Y, there is a fuzzy set $f^{-1}(B) \in \delta spc(X)$.
(c) For every fuzzy point x_p in X and every fuzzy open set B in Y such that $f(x_p) \in B$, there is a fuzzy set $A \in \delta spo(X)$ such that $x_p \in A$ and $f(A) \le B$.
(d) For every fuzzy point x_p in X and every fuzzy nbd A of $f(x_p)$, there is a fuzzy nbd $f^{-1}(A) \in \xi(x_p)$.
(e) For every fuzzy point x_p in X and every fuzzy nbd A of $f(x_p)$, there is a fuzzy nbd $B \in \xi(x_p)$ such that $f(B) \le A$.
(f) For every fuzzy point x_p in X and every fuzzy open set A such that $f(x_p)qA$, there is a fuzzy $B \in \delta spo(X)$ such that $x_p\, qB$ and $f(B) \le A$.
(g) For every fuzzy point x_p in X and every fuzzy q - neighbourhood A of $f(x_p)$, $f^{-1}(A)$ is a fuzzy δ - semi pre q - neighbourhood of x_p.
(h) For every fuzzy point x_p in X and every fuzzy q - neighbourhood A of $f(x_p)$, there is a fuzzy δ - semi pre q - neighbourhood B of x_p such that $f(B) \le A$.
(i) $f(\delta spcl(A)) \le cl(f(A))$, for every fuzzy set A of X.
(j) $\delta spcl(f^{-1}(B)) \le f^{-1}(cl(f(B))$, for every fuzzy set B of Y.
(k) $f^{-1}(int(B)) \le \delta spint(f^{-1}(B))$, for every fuzzy set B of Y.

Proof.
(a) ⇒ (b). Let B be a fuzzy closed set in Y, then $1_Y - B$ is a fuzzy open set in Y. By (a), $f^{-1}(1_Y - B) = 1_Y - f^{-1}(B) \in \delta spo(X)$. Hence $f^{-1}(B)$ is fuzzy δ - semi preclosed in X, i.e., $f^{-1}(B) \in \delta spc(X)$.
(b) ⇒ (a). Let B be any fuzzy open set in Y, then $1_Y - B$ is fuzzy closed set in Y. Now, by (b), $f^{-1}(1_Y - B) = 1_Y - f^{-1}(B) \in \delta spc(X)$. Hence $f^{-1}(B)$ is fuzzy δ - semi preopen set in X, i.e., $f^{-1}(B) \in \delta spo(X)$. Hence f is fuzzy δ - semi precontinuous.
(a) ⇒ (c). Let x_p be a fuzzy point of X and B be a fuzzy open set in Y such that $f(x_p) \in B$. Put $A = f^{-1}(B)$. Then by (a), $A \in \delta spo(X)$ such that $x_p \in A$ and $f(A) \le B$.
(c) ⇒ (a). Let B be any fuzzy open set in Y and $x_p \in f^{-1}(B)$. Then $f(x_p) \in B$. Now by (c), there is a fuzzy set $A \in \delta spo(X)$ such that $x_p \in A$ and $f(A) \le B$. Then $x_p \in A \le f^{-1}(B)$. Hence by theorem 3.10., $f^{-1}(B) \in \delta spo(X)$. Thus f is fuzzy δ - semi precontinuous.
(a) ⇒ (d). Let x_p be a fuzzy point of X and A be a fuzzy nbd of $f(x_p)$. Then there is a fuzzy open set B such that $f(x_p) \in B \le A$. Now by (a), $f^{-1}(B) \in \delta spo(X)$ and $x_p \in f^{-1}(B) \le f^{-1}(A)$. Thus $f^{-1}(A)$ is a fuzzy δ - semi pre nbd of x_p in X, i.e., $f^{-1}(A) \in \xi(x_p)$.
(d) ⇒ (e). Let x_p be a fuzzy point of X and A be a fuzzy nbd of $f(x_p)$. Then by (d), $B = f^{-1}(A)$ is a fuzzy δ - semi pre nbd of x_p, i.e., $f^{-1}(A) \in \xi(x_p)$ and $f(B) = f(f^{-1}(A)) \le A$.

(e) ⇒ (c). Let x_p be a fuzzy point of X and B be a fuzzy open set in Y such that $f(x_p) \in B$. Then B is a fuzzy nbd of $f(x_p)$. So by (e), there is a fuzzy nbd $A \in \xi(x_p)$ such that $x_p \in A$ and $f(A) \leq B$. Hence there is a fuzzy set $C \in \delta spo(X)$ such that $x_p \in C \leq A$ and so $f(C) \leq f(A) \leq B$.
(a) ⇒ (f). Let x_p be a fuzzy point of X and A be a fuzzy open set in Y such that $f(x_p)qA$. Let $B = f^{-1}(A)$. Then $B \in \delta spo(X)$ such that $x_p\, qB$ and $f(B) = f(f^{-1}(A)) \leq A$.
(f) ⇒ (a). Let A be a fuzzy open set in Y and $x_p \in f^{-1}(A)$. Clearly $f(x_p) \in A$. Choose the fuzzy point x_p^c as $x_p^c(x) = 1 - x_p$. Then $f(x_p)qA$. Thus by (f), there exists a fuzzy set $B \in \delta spo(X)$ such that $x_p^c qB$ and $f(B) \leq A$. Now $x_p^c qB \Rightarrow x_p^c + B(x) = 1 - p + B(x) > 1 \Rightarrow B(x) > p \Rightarrow x_p \in B$. Thus $x_p \in B \leq f^{-1}(A)$. Hence by Theorem 3.10., $f^{-1}(B) \in \delta spo(X)$.
(f) ⇒ (g). Let x_p be a fuzzy point of X and A be a q - neighbourhood of $f(x_p)$. Then there is a fuzzy open set A_1 in Y such that $f(x_p)A_1 \leq A$. By hypothesis there is a fuzzy set $B \in \delta spo(X)$ such that $x_p\, qB$ and $f(B) \leq A$. Thus $x_p\, qB \leq f^{-1}(A_1) \leq f^{-1}(A)$. Hence $f^{-1}(A)$ is a fuzzy δ - semi pre q - neighbourhood of x_p.
(g) ⇒ (h). Let x_p be a fuzzy point of X and A be a fuzzy q - neighbourhood of $f(x_p)$. Then $B = f^{-1}(A)$ is a fuzzy δ - semi pre q - neighbourhood of x_p and $f(B) = f(f^{-1}(A)) \leq A$.
(h) ⇒ (f). Let x_p be a fuzzy point of X and A be a fuzzy open set such that $f(x_p)qA$. Then A is a fuzzy q - neighbourhood of $f(x_p)$. So there is a fuzzy δ - semi pre q - neighbourhood C of x_p such that $f(C) \leq A$. Now C being a fuzzy δ - semi pre q - neighbourhood of x_p, there exists $B \in \delta spo(X)$ such that $x_p qB \leq C$. Hence $x_p qB$ and $f(B) \leq f(C) \leq A$.
(b) ⇔ (i). Obvious.
(i) ⇔ (j). Obvious.
(a) ⇔ (k). Obvious.

Theorem 4.6. If (X, τ_1), (Y, τ_2) and (Z, τ_3) are three fuzzy topological spaces and $f : (X, \tau_1) \rightarrow (Y, \tau_2)$ is a fuzzy δ - semi precontupus mapping and $g : (Y, \tau_2) \rightarrow (Z, \tau_3)$ is a fuzzy continuous mapping, then $gof : (X, \tau_1) \rightarrow (Z, \tau_3)$ is a fuzzy δ - semi precontinuous mapping.
Proof. Let C be an arbitrary fuzzy open set of Z. As g is fuzzy continuous, so $g^{-1}(C)$ is fuzzy open set of Y. Since $g^{-1}(C)$ is fuzzy open set of Y and f is fuzzy δ - semi precntinuous mapping, so $f^{-1}(g^{-1}(C))$ is fuzzy δ - semi preopen set of X. But $f^{-1}(g^{-1}(C)) = (gof)^{-1}(C)$. Therefore for each fuzzy open set of Z, $(gof)^{-1}(C)$ is fuzzy δ - semi preopen set of X. This shows that $gof: X \rightarrow Z$ is a fuzzy δ - semi precontinuous mapping.

Theorem 4.7. Let (X, τ) and (Y, σ) be fuzzy topological spaces such that X is product related to Y and $f : (X, \tau) \rightarrow (Y, \sigma)$ be a mapping. Then, if the graph mapping $g : (X, \tau) \rightarrow (X \times Y, \theta)$ of f defined by $g(x) = (x, f(x))$ is fuzzy δ - semi precontinuous, then f is also fuzzy δ - semi precontinuous.
Proof. Let A be any fuzzy open set in Y. Then by lemma 2.4. of [1] $f^{-1}(A) = 1_x \wedge f^{-1}(A) = g^{-1}(1_x \times A)$. Now if B is fuzzy open in Y, then $1_x \times B$ is fuzzy open in $X \times Y$. Again, $g^{-1}(1_x \times A)$ is fuzzy δ - semi preopen as g is fuzzy δ - semi precontinuous mapping. Consequently, $f^{-1}(A)$ is fuzzy δ - semi preopen set in X. Hence f is fuzzy δ - semi precontinuous mapping.

References

[1] K. K. Azad: On fuzzy semicontinuity, fuzzy almost continuity and fuzzy weakly continuity, J.Math. Anal.Appl. 82(1981), 14 - 32.
[2] A. S. Bin Shahana, On fuzzy strong semicontinuity and fuzzy precontinuity, Fuzzy Sets and Systems 44 (1991) 303 - 308.
[3] M. Caldas, S. Jafari, R. K. Saraf, Fuzzy (δ, P) - T_1 Topological spaces, J. Tri. Math. Soc. 9 (2008) 1- 4.
[4] C. L. Chang, Fuzzy topological spaces, J. Math. Anal. Appl. 24 (1968) 182-190.
[5] S. Debnath, Fuzzy δ - semi continuous functions, Acta Ciencia Indica, Vol.XXXIV, M, No. 2 (2008) 697 - 703.
[6] R. Dhar, On δ - lower semi precontinuous functions, Int. J. of mathematics trends and technology 47(3) (2017) 36 - 39.
[7] R. Dhar, Results on fuzzy δ - semi preseparated sets and fuzzy semi δ - preseparation axioms, CiiT Int. J. of fuzzy systems 9(8) (2017) 159-159.[10]
[8] S. Ganguly, S. Saha, A note on δ - continuity and δ - connected sets in fuzzy set theory, Simon Stevin 62 (1988) 127 - 141.
[9] A. Mukherjee, S. Debnath, On δ - semiopen sets in Fuzzy Setting, J. Tri. Math. Soc. 8 (2006) 51-54.
[10] A. Mukherjee, R. Dhar, On weakly fuzzy δ - semi precontinuous mappings and weakly fuzzy δ - semi preirresolute mappings, The Journal of Fuzzy Mathematics 18(1) (2010) 209 - 216.
[11] P. M. Pu and Y. M. Liu, Fuzzy topology I. Neighbourhood structure of a fuzzy point and Moore - Smith convergence, J. Math. Anal. Appl. 76 (1980) 571 - 599.
[12] S. S. Thakur, S. S. Singh, On fuzzy semi preopen sets and fuzzy semi precontinuity, Fuzzy Sets and Systems 98 (1998) 383 - 391.
[13] S. S. Thakur, R. K. Khare, Fuzzy semi δ - preopen sets and fuzzy semi δ - pre continuous mappings, Universitatea din Bacau studii si cerceturi Strintitice Seria Mathematica 14 (2004) 201 - 211.
[14] L. A. Zadeh, Fuzzy sets, Information and Control 8 (1965) 338 - 353.

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