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R-Generalized Fuzzy Closed Sets with Respect to an Ideal in Fuzzy Topological Spaces

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Abstract

The work in this paper is a generalization The concept of r-generalized fuzzy closed sets in fuzzy topological spaces was introduced by Kim. In this paper, we introduce and study the concept of r-generalized fuzzy closed sets with respect to an ideal in an ideal fuzzy topological space in Sostak sense.

Keywords: R-generalized fuzzy closed sets; Rv-generalized fuzzy closed sets with respect to an ideal in an ideal fuzzy topological space in Sostak sense

Introduction

Ŝostak introduce the fundamental concept of fuzzy topological structure as an extension of both crisp topology and Chang's fuzzy topology [1], in the sense that not only the object was fuzzified, but also the axiomatic. Chattopdhyay et al. [2,3] have redefined the similar concept. In El-Naschie [4-14] and Kim and Ko [15] gave a similar definition namely "Smooth fuzzy topology". We must point out that [16-19]; the concept of fuzzy topological spaces has been a significant concept in string theory and E-infinity theory pertaining to quantum particular physics ever since El-Naschie ([4-14]). After that several authors [20,21] have introduced the smooth definition and studied smooth fuzzy idea topological spaces being unaware of Ŝostak works.

Throughout this paper, let X be a nonempty set I=[0;1] and I_0=(0;1]: For α∈I; $\overline{\alpha}(x)=\alpha$ for all x∈ X: The family of all fuzzy sets on X denoted by I^X : For two fuzzy sets we write $\lambda_{q\mu}$ to mean that is quasi-coincident (q-coincident, for short) with μ, i.e., there exists at least one point x∈X such that λ(x) + μ(x)>1: Negation of such a statement is denoted as $\lambda_{\overline{q}\mu}$:

Definition 1.1

A mapping τ: I^X→I is called a fuzzy topology on X if it satisfies the following conditions [17]:

$$\tau(\overline{0})=\tau(\overline{1})=\overline{1}$$

$$\tau(\vee_{i\in\Gamma}\mu_i)\geq\wedge_{i\in\Gamma}\tau(\mu_i), for\ any\ \{\mu_i\}_{i\in\Gamma}\in I^X$$

$$\tau(\mu_1\wedge\mu_2)\geq\tau(\mu_1)\wedge\tau(\mu_2)\ for\ any\ \mu_1,\mu_2\in I^X$$

The pair $(X;\tau)$ is called a fuzzy topological space (for short, fts).

Definition 1.2

Let (X,τ) be a fts, λ, μ∈I^X and r∈I_0 .

A fuzzy set λ is called r-generalized fuzzy closed (for short, r-gfc) if C_γ (λ;γ)whenever λ≤μ and $\tau(\mu)\geq\gamma$

A fuzzy set λ is called r-generalized fuzzy closed (for short, r-gfc) if $I_\tau(\lambda;\gamma)\geq\mu$ whenever $\lambda\geq\mu$ and $\tau(\overline{1}-\mu)\geq\gamma$

Definition 1.3

A mapping **I** : I^X→I is called fuzzy ideal on X if :

(I_1) I(0)=1; **I**(1)=0:

(I_2) If λ≤μ; then I(λ)≥I(λ); for each λ∈I^X :

(I_3) For each λ; μ∈I^X ; **I**(λvμ)≥ **I**(λ)∧ **I**(μ)[finite additivity].

Lemma 1.1.

Let (X,τ,I) be a fits. The simplest fuzzy ideal on X are I^0,I^1 : I^X→I where

$$I^0(\lambda)=\begin{cases}1, & if\ \lambda=\underline{0}\\ 0, & \text{otherwise,}\end{cases}\qquad I^1(\lambda)=\begin{cases}0, & \text{if } \lambda=\underline{1}\\ 1, & \text{otherwise}\end{cases}.$$

If we take I=I^0, for each A∈I^X we have A^*_r=C_τ(A,r).

If we take I=I^1, for each A∈Θ'we have $A^*_r=\underline{0}$, where, $\underline{1}\notin\Theta'$ be a subset of I^X [4-14].

Definition 1.4

Let (X,τ,I) be a fuzzy ideal topological space[16]. Let μ, λ∈I^X, the r-fuzzy open local function μ^*_r of μ is the union of all fuzzy points x_t such that if ρ∈Q(x_t,γ) and I(λ) ≥ r then there is at least one y∈X for which ρ(y)+ μ(y)−1>λ(y).

Theorem 1.1

Let (X,τ) be a fts. Then for each r∈I_0, λ ∈ I^X we define an operator C_τ : I^X ×I_0 → I^X as follows:

$$C_\tau(\lambda,\gamma)=\wedge\{\mu\in I^x:\lambda\leq\mu,\tau(\overline{1}-\mu)\geq\gamma\}$$

For λ, μ∈I^X and r, s∈I_0, the operator C_τ satisfies the following conditions:

$$C\tau(\overline{0},\gamma)=\overline{0}$$

$$\lambda\leq C\tau(\lambda,\gamma)$$

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$$C\tau(\lambda,\gamma)\vee C\tau(\mu,\gamma)=C\tau(\lambda\vee\mu,\gamma)$$
$$C\tau(\lambda,\gamma)\vee C\tau(\lambda,s)\ \textit{if}\ \gamma\le s$$
$$C\tau(C\tau(\lambda,\gamma),\gamma)=C\tau(\lambda,\gamma)$$

Theorem 1.2

Let (X,τ) be a fts. Then for each $r \in I_0$, $\lambda \in I^X$ we define an operator $I\tau : I^X \times I_0 \to I^X$ as follows [18]:

$$I\tau((\lambda,\gamma)=\vee\{\mu\in I^x:\lambda\ge\mu,\tau(\mu)\ge\gamma\}$$

For $\lambda,\mu \in I^X$ and $r,s \in I_0$, the operator I_τ satisfies the following conditions:

$$I_\tau((\overline{1}-\lambda,\gamma)=\overline{1}-C_\tau(\lambda,\gamma\}\ \textit{and}\ C_\tau(\overline{1}-\lambda,\gamma)=\overline{1}-I_\tau(\lambda,\gamma)$$
$$I_\tau(\overline{1},\gamma)=\overline{1}.$$
$$\lambda\ge I_\tau(\lambda,\gamma)$$
$$I_\tau(\lambda,\gamma)\wedge I_\tau\{\mu,\gamma\}=I_\tau(\lambda\wedge\mu,\gamma)$$
$$I_\tau(\lambda,\gamma)\wedge I_\tau\{\lambda,s\}\ \text{if}\ \gamma\ge\text{s}.$$
$$I_\tau(I_\tau(\lambda,\gamma),\gamma)=I_\tau\{\lambda,\gamma\}$$

r-generalized fuzzy closed sets with respect to an ideal

Definition 2.1

Let (X,τ,**I**) be fuzzy ideal topological space, $\mu \in I^X$ and $r \in I_0$. A fuzzy set μ is called r-generalized fuzzy closed with respect to an ideal **I** (briefly, r-gfIc) if $\mathbf{I}(C_\tau(\mu,\gamma)\backslash\lambda) \ge \gamma$, whenever $\mu \le \lambda$ and $\tau(\lambda) \ge r$.

Lemma 2.2

Every r-gfc set is r-gfIc.

Proof

Let $\mu\le\lambda$ and $\tau(\lambda) \ge r$. Since μ is r-gfc set, then $C\tau(\mu,\gamma)\le\lambda$, this implies that $C\tau(\mu,\gamma)\overline{q}\underline{1}-\lambda$, implies $C_\tau(\mu,r)(x)+(\underline{1}-\lambda)(x)\le 1$, then $C_\tau(\mu,\gamma)(x)-\lambda(x) \le 0$. Thus, $\mathbf{I}(C_\tau(\mu,r)\backslash\lambda) \ge \gamma$ [16-19].

Example

The converse Lemma 2.2 is not true. Let X={a,b} be a set.

$\mu_1(a)=0.4$, $\mu_1(b)=0.5$; $\mu_2(a)=0.4$ $\mu_2(b)=0.6$; $\mu_1(a)=0.3$, $\mu_1(b)=0.5$.

We define fuzzy topology and fuzzy ideal τ, $I : I^X \to I$ as follows

$$\tau(\lambda)=\begin{cases}1, \text{ if } \lambda=\underline{1},\underline{0}\\ \frac{1}{2},\text{if } \lambda=\mu_1,\\ \frac{1}{2},\text{if } \lambda=\mu_2\\ 0, \text{ otherwise}\end{cases}\quad \mathbb{J}(\lambda)=\begin{cases}1, \text{ if } \lambda=\underline{0}\\ \frac{1}{2},\text{if } \lambda=\underline{0}.5\\ \frac{1}{2},\text{if } \underline{0}<\lambda<\underline{0}.5\\ 0, \text{ otherwise}\end{cases}$$

Then μ is r-gfIc set because,

$$\mu\le\mu_1,\tau(\mu_1)\ge\frac{1}{2}C_\tau\left(\mu,\frac{1}{2}\right)=\underline{1}-\mu_1\backslash\mu_1=a_{0.3}.$$

Theorem 2.1

Let (X,τ,**I**) be an fuzzy ideal topological space, $\mu,\lambda \in I^X$ and $r \in I_0$. If μ and λ are r-gfIc sets, then $\mu\vee\lambda$ is r-gfIc.

Proof

Suppose μ and λ are r-gfIc sets. If $\mu\vee\lambda \le \rho$ and $\tau(\rho) \ge \gamma$, then $\mu \le \rho$ and $\lambda \le \rho$. By assumption, $I(C_\tau(\mu,\gamma)\backslash\rho) \ge \gamma$ and $I(C_\tau(\lambda,\gamma)\backslash\rho) \ge \gamma$ and hence

$\mathbf{I}(C_\tau(\mu\vee\lambda,\gamma)\backslash\rho=C\tau(\mu,\gamma)\backslash\rho\vee C\tau(\lambda,\gamma)\backslash\rho) \ge \gamma$.

Therefore, $\mu\vee\lambda$ is r-gfIc.

Remark

The intersection of two r-gfIc sets need not be an r-gfIc set as shown by the following example.

Example

The converse Lemma 2.2 is not true. Let X={a,b} be a set.

$\mu_1(a)=0.4$, $\mu_1(b)=0.5$; $\mu_2(a)=0.4$ $\mu_2(b)=0.6$; $\mu_1(a)=0.3$, $\mu_1(b)=0.5$.

We define fuzzy topology and fuzzy ideal τ,**I** : $I^X \to I$ as follows:

$$\tau(\lambda)=\begin{cases}1, \text{ if } \lambda=\underline{1},\underline{0}\\ \frac{1}{2},\text{if } \lambda=\mu_1,\\ \frac{1}{2},\text{if } \lambda=\mu_2\\ 0, \text{ otherwise}\end{cases}\quad \mathbb{J}(\lambda)=\begin{cases}1, \text{ if } \lambda=\underline{0}\\ \frac{1}{2},\text{if } \lambda=\underline{0}.5\\ \frac{1}{2},\text{if } \underline{0}<\lambda<\underline{0}.5\\ 0, \text{ otherwise}\end{cases}$$

Then μ is r-gfIc set because,

$$\mu\le\mu_1,\tau(\mu_1)\ge\frac{1}{2}C_\tau\left(\mu,\frac{1}{2}\right)=\underline{1}-\mu_1\backslash\mu_1=a_{0.3}$$

Therefore,

$$\mathbf{I}\left(C\tau\left(\mu,\ \frac{1}{2}\right)\backslash\mu_1\right)\ \ge\ \frac{1}{2}.$$

But μ is not r-gfc set because

$$\mu\le\mu_1,\tau(\mu_1)\ge\frac{1}{2}C_\tau\left(\mu,\frac{1}{2}\right)=\underline{1}-\mu_1\not\le\mu_1$$

Theorem 2.2

Let (X,τ,**I**) be an fuzzy ideal topological space, $\mu,\lambda\in I^X$ and $\gamma\in I_0$. If μ is r-gfIc set and $\mu \le \lambda \le C_\tau(\mu,\gamma)$, then λ are r-gfIc.

Proof

Let μ is r-gfIc set and $\mu \le \lambda \le C_\tau(\mu,\gamma)$. Suppose $\lambda \le \rho$ and $\tau(\rho) \ge \gamma$. Then $\mu \le \rho$. Since μ is r-gfIc, we have $I(C_\tau(\mu,\gamma)\backslash\rho) \ge \gamma$. Now $\lambda \le C_\tau(\mu,\gamma)$ implies that

$C_\tau(\lambda,\gamma)\backslash\rho \le C_\tau(\mu,\gamma)\backslash\rho$,

and hence, $I(C_\tau(\lambda,\gamma)\backslash\rho) \ge r$. Therefore, λ is r-gfIc set [20,21].

Definition 2.2

Let (X,τ,**I**) be fuzzy ideal topological space, $\mu\in I^X$ and $\gamma\in I_0$. A fuzzy set μ is called r-fuzzy generalized open with respect to an ideal I (briefly, r-gfIo) if $\underline{1}-\mu$ is r-gfIc set.

Theorem 2.3

Let (X,τ,**I**) be an fuzzy ideal topological space, $\mu,\lambda,\rho\in I^X$ and $\gamma\in I_0$. If μ is r-gfIo sets if and only if $\lambda\backslash\rho \le Int\tau(\mu,r)$ for some $\mathbf{I}(\rho) \ge r$, whenever $\lambda \le \mu$ and $\tau(\underline{1}-\lambda)\ \ge\gamma$.

Proof

Suppose that μ is r-gfIo sets. Suppose $\lambda \le \mu$ and $\tau(\underline{1}-\lambda)\ \ge\ \gamma$. We have $\underline{1}-\lambda\ \ge\ \underline{1}-\mu$. By assumption,

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$C_\tau\left(\underline{1}-\mu,\gamma\right)\leq \underline{1}\vee\rho$

For some $\mathbf{I}(\rho) \geq \gamma$. This implies

$\underline{1}-\left((\underline{1}-\lambda)\vee\rho\right)\leq \underline{1}-C_\tau\left(\underline{1}-\mu\right)$

and hence, $\lambda\backslash\rho \leq Int_\tau(\mu,\gamma)$.

Conversely, assume that $\lambda \leq \mu$ and $\tau(1-\lambda) \geq \gamma$ imply $\lambda\backslash\rho \leq Int_\tau(\mu,\gamma)$ for some $I(\rho) \geq \gamma$. Consider $\tau(\omega) \geq \gamma$ such that $\underline{1}-\mu \leq \omega$. Then $\underline{1}-\omega \leq \mu$. By assumption,

$\underline{1}-\omega\backslash\rho\leq Int_\tau\left(\mu,\gamma\right)=\underline{1}-C_\tau\left(\underline{1}-\mu,\gamma\right)$

for some $\mathbf{I}(\rho) \geq\gamma$. This gives that $\underline{1}-(\omega\vee\rho)\leq\underline{1}-C_\tau\left(\underline{1}-\mu,\gamma\right)$. Therefore, $C_\tau\left(\underline{1}-\mu,\gamma\right)\leq\omega\vee\rho$ for some $I(\rho)\geq\gamma$. This show that $\mathbf{I}\left(C_\tau(\underline{1}-\mu,\gamma)\backslash\omega\right)\geq\gamma$. Hence, $\underline{1}-\mu$ is r-gfIc set.

Recall that the sets μ and λ are fuzzy separated if $C_\tau\left(\mu,\gamma\right)\overline{q}\lambda$ and $\mu\overline{q}C_\tau(\lambda,\gamma)$.

Theorem 2.4

Let $(X,\tau,\mathbf{I})$ be an fuzzy ideal topological space, $\mu, \lambda, \in I^X$ and $r\in I_0$. If μ and λ are fuzzy separated and r-gfIo sets, then $\mu\vee\lambda$ is r-gfIo.

Proof

Suppose μ and λ are fuzzy separated and r-gfIo sets and $\rho \leq \mu \vee \lambda$, and $\tau(\underline{1}-\rho)\geq\gamma$. Then $\rho\wedge C_\tau(\mu,\gamma) \leq \mu$ and $\rho\wedge C\tau(\lambda,\gamma) \leq \lambda$. By assumption,

$\rho\wedge C_\tau(\mu,\gamma)\backslash\nu_1 \leq Int_\tau(\mu,\gamma)$, $\rho\wedge C_\tau(\lambda,\gamma)\backslash\nu_2 \leq Int_\tau(\lambda,\gamma)$,

for some $\mathbf{I}(\nu_1,\nu_2) \geq \gamma$. This means $\mathbf{I}(\rho\wedge C_\tau(\mu,\gamma)\backslash Int_\tau(\mu,\gamma)) \geq \gamma$, and $I(\rho\wedge C_\tau(\lambda,\gamma)\backslash Int_\tau(\lambda,\gamma)) \geq \gamma$. Thus, $\mathbf{I}(\rho\wedge C_\tau(\mu,\gamma)\backslash Int_\tau(\mu,\gamma))\vee(\rho\wedge C_\tau(\lambda,\gamma)\backslash Int_\tau(\lambda,\gamma)) \geq \gamma$.

Therefore,

$I(\rho\wedge(C_\tau(\mu,\gamma)\vee C_\tau(\lambda,\gamma))\backslash(Int_\tau(\mu,\gamma)\vee Int_\tau(\lambda,\gamma))) \geq \gamma$

But $\rho=\rho\wedge(\mu\vee\lambda) \leq \rho\wedge(C_\tau(\mu\vee\lambda,\gamma))$, and we have

$I(\rho\backslash Int_\tau(\mu\vee\lambda,\gamma) \leq (\rho\wedge C_\tau(\mu\vee\lambda,\gamma))\backslash Int_\tau(\mu\vee\lambda,\gamma) \leq (\rho\wedge C_\tau(\mu\vee\lambda,\gamma))\backslash(Int_\tau(\mu,\gamma)\vee Int_\tau(\lambda,\gamma))) \geq \gamma$.

Hence, $\rho\backslash\nu \leq Int_\tau(\mu\vee\lambda,\gamma)$ for some $I(\nu) \geq \gamma$. This proves that $\mu\vee\lambda$ is r-gfIo.

Corollary 1.1

Let $(X,\tau,\mathbf{I})$ be an fuzzy ideal topological space, $\mu, \lambda,\in I^X$ and $r\in I_0$. If μ and λ are r-gfIo sets, $\underline{1}-\mu$ *and* $\underline{1}-\lambda$ are fuzzy separated. Then $\mu\wedge\lambda$ is r-gfIc.

Proof

Obvious.

Corollary 1.2

Let $(X,\tau,\mathbf{I})$ be an fuzzy ideal topological space, $\mu, \lambda, \mathbf{I}^X$ and $r\in I_0$. If μ and λ are r-gfIo sets, then $\mu\wedge\lambda$ is r-gfIo.

Proof:

Obvious.

Theorem 2.5

Let $(X,\tau,\mathbf{I})$ be an fuzzy ideal topological space, $\mu, \lambda, \in I^X$ and $r\in I_0$. If and $\mu \leq \lambda$, and μ r-gfIo relative to λ and λ is r-gfIo relative to X, then μ r-gfIo relative to X.

Proof

Suppose that $\mu \leq \lambda$, μ is r-gfIo relative to λ and λ is r-gfIo relative to X. Let $\rho \leq \mu$ and $\tau(\underline{1}-\rho)\geq\gamma$. Since μ is r-gfIo relative to λ. By Theorem 2.5. $\rho\backslash\nu_1 \leq Int_\lambda(\mu,\gamma)$ for some $I_\lambda(\nu_1) \geq r$. This implies that there exists $\tau(\omega_1) \geq \gamma$ such that

$\rho\backslash\nu_1 \leq \omega_1\wedge\lambda \leq \mu$,

for some $\mathbf{I}_\lambda(\nu_1) \geq \lambda$. Let $\rho \leq \lambda$ and $\tau(\underline{1}-\rho)\geq\gamma$. Since λ is r-gfIo, we have

$\rho\backslash\nu_2 \leq Int_\tau(\lambda,\gamma)$

for some $I(\nu_2) \geq \gamma$. This implies that there exists $\tau(\omega_2) \geq r$ such that

$\rho\backslash\nu_2 \leq \omega_2 \leq \lambda$,

for some $I(\nu_2) \geq \gamma$. Now

$\rho\backslash(\nu_1\vee\nu_2)=(\rho\backslash\nu_1)\wedge(\rho\backslash\nu_2) \leq \omega_1\wedge\omega_2 \leq \omega_1\wedge\lambda \leq \mu$.

This implies that $\rho\backslash(\nu_1\vee\nu_2) \leq Int\lambda(\mu,\gamma)$ for some $I(\nu_1\vee\nu_2) \geq\gamma$.

Thus, μ r-gfIo relative to X.

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