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Journal of Vibration Engineering

ISSN:1004-4523

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OnSomeClosedSetsInFuzzyMinimalIdealSpaces

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Abstract: The purpose of this paper is to introduce fuzzy minimal ideal topologicalspacesandfuzzyminimalidealgeneralizedclosed setsinfuzzyminimaltopologicalspaces andtoinvestigatetherelationshipsbetweenfuzzyminimalspacesandfuzzyminimalidealspaces.

Keywords: Fuzzy ideal topological spaces, Fuzzy I_g- closed sets, Fuzzy minimal idealspace,Fuzzy minimal idealgeneralized closed setsetc.

Introduction

In 1945, R. Vaidyanathaswamy[7] introduced the concept of ideal topological spaces.Hayashi[4]definedthelocalfunctionandstudiedsometopologicalpropertiesusinglocalfunction in ideal topological spaces in 1964.Since then many mathematicians studied varioustopological concepts in ideal topological spaces.After the introduction of fuzzy sets by Zadeh[5]in 1965 and fuzzy topology by Chang[2] in 1968, severalmathematicians[10, 3, 6] studied thegeneralization of fuzzysets and fuzzy ideal topological spaces.In this sequence Noiri andPopa[11] have created and developed the theory of minimal structure in general topology. As ageneralizationofthefuzzydomain,Brescan[6]introducedtheconceptoffuzzyminimalstructure. This paper explores the fuzzy minimalideal topological spacesand its generalizationinfuzzy ideal topologicalspaces.

Preliminary

Let X be a nonempty set. A family $r$of fuzzy sets of X is called a fuzzytopology on X if the null fuzzy set 0 and the whole fuzzy set 1 belongs to$r$and$r$is closedwith respect to any union and finite intersection[5].If $r$is a fuzzy topology on X, then the pair(X , r)iscalleda fuzzy topological space [5] and the members of $r$are called fuzzy opensets and their complements are called fuzzy closed sets. The closure of a fuzzy set $A$of Xdenoted by (A) , is theintersection of all fuzzy closed sets which contains A.Theinteriorofafuzzyset$A$ofX denotedby$Ikt(A)$ is the union of all fuzzy sets of X containedin A. A fuzzy set Ainfuzzy topologicalspace(X,r)issaidtobequasi-coincidentwithafuzzyset$B$denotedby
AqB,if there existsa point$x \in$ X such that $A(x)+B(x)>1$[9] . A fuzzy set Vinafuzzy topological space(X, r) is called a Q- neighborhood of a fuzzy point$x_\beta$ifthere existsafuzzyopenset$U$ofXsuchthat$x_\beta q U \leq V$[3] .

Definition2.1: A nonemptycollection offuzzysets Iofaset Xsatisfyingtheconditions

(i) if$A \in I$and$B \leq A$,then$B \in I$(heredity) ,

(ii) if $A \in I$and $B \in I$then $A \cup B \in I$(finite additivity)is called a fuzzy ideal on X .Thetriplex (X, r, I)denotes a fuzzy ideal topologicalspacewith a fuzzy ideal $I$and fuzzytopology$r$[5,9] .

Definition2.2: Thelocal function forafuzzyset AofXwith respect to$r$and$I$denotedby $A^*(r,I)$ (brieflyA^*)inafuzzy ideal topological space(X,r,I)isthe union of all fuzzypoints$x_\beta$such that if UisaQ-neighbourhoodof$x_\beta$and $E \in I$thenfor atleast one point $y \in$Xfor which$U(y) + A(y) - 1 > E(y)$[9].

Definition2.3: The Closureof a fuzzy set Adenotedby$Cl^*(A)$in(X,r,I)defined as $Cl^*(A) = A \cup A^*$[9].

Ina fuzzy ideal topological space (X, r, I) ,the collection $r^*(I)$ means anextension offuzzy topological space than $r$via fuzzy ideal which is constructed by considering theClass$\beta = \{U - E : U \in r, E \in I\}$asabase[9].

Definition 2.4: Afuzzy set$A$of a fuzzy ideal topological space (X, r, I) is called fuzzy I_g -closed if$A^* \leq U$, whenever $A \leq U$and $U$is fuzzy open. AndA is calledcalled fuzzy I_g –open ifitscomplementisfuzzyI_g–closed[10].

Remark 2.5: Every fuzzy g-closed (resp. fuzzy $*$-closed) set is fuzzy I_g –closed and every fuzzy g-open(resp. fuzzy $*$-open) set is fuzzy I_g –open. Examples can be easily constructed to show that the conversemay not betrue[10].

Remark2.6: Ina fuzzyidealtopologicalspace (X,r,I),I isfuzzyI_g-closedfor everyI∈I [10].

Lemma2.7:$A \leq B \Leftrightarrow \rceil(A q 1 - B)$,foreverypairoffuzzysets$A$and BofX[11].

Definition2.8: Let F(X) be a class of fuzzy subsets of a non empty set X. A subclass $F_m$of F(X) iscalled fuzzy minimal structure on X (or a F_m-structure) if $0 \in F_m$, $1 \in F_m$. The pair (X, F_m) is called fuzzyminimalspaceoraF_m-space.Afuzzyset$A$iscalledF_m-opensetif$A \in F_m$,if$A^c \in F_m$then$A$iscalled F_m-closedset[6].

Remark2.9: FuzzyminimalstructureonXmaintainsonlythefirstconditionofthedefinitionoffuzzytopology[6].

Remark2.10: Let(X,r)beafuzzytopologicalspace.Thenthesubfamilies$r$,FSO(X),FPO(X), $F\eth PO$(X),$FSPO$(X),$FS\eth PO$(X),of$F$(X)areallfuzzyminimalstructuresonX[6].

Definition 2.11: Let X be a nonempty set and $F_m$be a fuzzy minimal structure on X.Then theF_m-closureandtheF_m-interior ofafuzzyset ofXaredefinedinasfollows[6]:

(i)$F_m Cl(A) = \cap\{\sigma : A \subseteq \sigma, \sigma^c \in F_m\}$,

(ii)$F_m Ikt(A) = \cup\{\delta : \delta \subset A, \delta \in F_m\}$.

Lemma2.12: Let(X,F_m)be aF_m-space onXand$A \in F_m$and$x_\alpha$beafuzzypoint inX. Then$x_\alpha \in F_m Cl(A)$ifand onlyif$\mu q A$foranyfuzzy set$\mu \in F_m$satisfyingthecondition$x_\alpha q \mu$.[6].

3.1FuzzyMinimalIdealspace

Definition3.1: Let F(X) be a class of fuzzy subsetsof a non empty set X. A subclass $F_m$of F(X) iscalledfuzzyminimalidealstructureonX(ora$F_m I$-structure)(i)if$A \in I$and$B \leq A$,then$B \in I$

(heredity),(ii)if $A \in I$ and $B \in I$ then $A \cup B \in I$ (finite additivity) is called a fuzzy ideal on X. The triplex (X, F_m, I) denotes a fuzzy minimal ideal topological space.

The local function for a fuzzy set A of X with respect to F_m and I denoted by $A*$ (F_m, I) (briefly A*) in a fuzzy minimal ideal topological space (X, F_m, I) is the union of all fuzzy points x_β such that if U is a fuzzy Q-neighbourhood of x_β and $E \in I$ then for at least one point $y \in$ X for which $U(y)+A(y)-1>E(y)$.

Remark 3.2: Let (X, F_m, I) be a fuzzy minimal structure. Then
(i) If $I=\{\emptyset\}$, then $A^*_m(\emptyset)=mCl(A)$,
(ii) If $I=\wp$(X), then $A^*_m(\wp(X))=\emptyset$

Definition 3.3: Let (X, F_m, I) be a fuzzy minimal space with an ideal I on X. For $A \subset$ X the set operator mCl^* is called a fuzzy minimal $*$-closure ideal and is defined as $mCl^*(A)=A \cup A^*_m$. It is denoted as $m^*_S(X, F_m, I)$ the fuzzy minimal structure generated by mCl^*, that is, $m^*_S(X, F_m, I)=\{U \subset X: mCl^*(X-U)=X-U\}$; $m^*_S(X, F_m)$ is called fuzzy $*$-minimal ideal structure which is finer than F_m.

Remark 3.4: The elements of $m^*_S(X, F_m, I)$ are called fuzzy minimal $*$-open (briefly, fuzzy $m*$-open) and the complement of a fuzzy $m*$-open set is called fuzzy minimal $*$-closed (briefly, fuzzy $m*$-closed).

Theorem 3.5: Let (X, F_m) be a fuzzy minimal-space with an fuzzy ideal I on X and A, B be fuzzy subsets of X. Then the following properties hold:

(i) $A \subset B \Rightarrow A^*_m \subset B^*_m$,
(ii) $I \subset I' \Rightarrow A^*_m(I') \subset A^*_m(I)$,
(iii) $A^*_m = mCl(A^*_m) \subset mCl(A)$,
(iv) $A^*_m \cup B^*_m \subset (A \cup B)^*_m$,
(v) $(A^*_m)^*_m \subset A^*_m$.

Proof:(i) Since $A \subset B \Rightarrow A^*_m \subset B^*_m$, for every $x \in A^*_m$. Then by the definition $x \in A^*_m$ implies $x \in B^*_m$ Which completes the proof.

(ii) The proof is obvious
(iii) The proof is obvious
(iv) Let $x_\beta \notin A^*_m \cup B^*_m$ therefore x_β is not contained in both A^*_m and B^*_m. Then there is one Q-neighbourhood u_1 of x_β such that for every $y \in$ X, $u_1+A(y)-1 \leq E_1$, for some $E_1 \in I$. Similarly there is one Q-neighborhood of u_2 of x_β such that for every $y \in$ X, $u_2+A(y)-1 \leq E_2$, for some $E_2 \in I$. Let $u=u_1 \cup u_2$, u is also Q-neighbourhood of x_β such that $u(y)+A \cup B(y)-1 \leq E_1 \cup E_1$ for every $y \in$ X. Therfore by fininte additivity of fuzzy ideal $E_1 \cup E_1 \in I$ and $x_\beta \notin (A \cup B)^*_m$. Hence $A^*_m \cup B^*_m \subset (A \cup B)^*_m$.
(v) The proof is obvious.

Remark 3.6: Let (X, F_m, I) be a fuzzy minimal ideal space with an ideal I on X, then $A^*_m \cup B^*_m = (A \cup B)^*_m$.

Corollary 3.7: Let (X, F_m, I) be a fuzzy minimal space and $A \subset$ X. Then the set operator fuzzy $mCl^*(A)$ satisfies the following conditions:

(i) $A \subset mCl^*(A)$,
(ii) $mCl(\emptyset)=\emptyset akd mCl^*$(X)=X, (iii) If $A \subset B$, $thek mCl^*(A) \subset mCl^*(B)$, (iv) $mCl^*(A) \cup mCl^*(B) \subset mCl^*(A \cup B)$.

4.1 Fuzzy minimal I_g-closed

Definition 4.1: A subset A of fuzzy minimal ideal space (X, F_m, I) is fuzzy minimal $-I$-generalized closed (in brief, fuzzy minimal I_g-closed) if A^* $\subset U$ whenever U is fuzzy minimal-open and denoted as (X, F_m, I_g).

Proposition 4.2: Let (X, m_S) be a fuzzy minimal space. Every fuzzy minimal-closed set is fuzzy minimal I_g-closed.

Remark 4.3: Every fuzzy minimal $*$-closed set is fuzzy minimal I_g-closed. But the converse may not be true.

Examples can be easily constructed to show that the converse may not be true.

Example 4.4: Let X={a,b} and A and U be defined as follows:

$$A(a)=0.3, A(b)=0.2$$

$$U(a)=0.5, U(b)=0.7$$

Let r={0,U,1} be the fuzzy minimal topology on X and I={0} be a fuzzy minimal ideal on X. Then A is fuzzy minimal I_g-closed in (X, F_m, I), but not fuzzy minimal $*$-closed.

Remark 4.5: Let (X, F_m, I) be a fuzzy minimal ideal space then every fuzzy g-closed set (resp. fuzzy $*$-closed) set is fuzzy minimal I_g-closed.

Theorem 4.7: Let (X, F_m, I) be a fuzzy minimal ideal topological space. Then A^* is fuzzy minimal I_g-closed for every fuzzy set A of X.

Proof: Let A be a fuzzy set of X and U be any fuzzy minimal open set of X such that $A^*\leq U$. Since $(A^*)^*\leq A^*$ it follows that $(A^*)^*\leq U$. Hence A^* is fuzzy minimal I_g-closed.

Theorem 4.8: Let (X, F_m, I) be a fuzzy minimal ideal topological space and A be a fuzzy minimal I_g-closed and fuzzy open set in X. Then A is fuzzy minimal $*$-closed.

Proof: Since A is fuzzy open and fuzzy minimal I_g-closed and $A\leq A$. It follows that $A^*\leq A$ because A is fuzzy minimal I_g-closed. Hence $Cl^*(A)=A\cup A^*\leq A$ and A is fuzzy minimal $*$-closed.

Theorem 4.9: Let (X, F_m, I) be a fuzzy minimal ideal topological space and A be a fuzzy minimal set of X. Then the following are equivalent:

(i) A is fuzzy minimal I_g-closed.

(ii) $Cl^*(A)\leq U$ whenever $A\leq U$ and U is fuzzy minimal open in X.

(iii) $\rceil(AqF)\Longrightarrow\rceil(Cl^*(A)qF)$ for every fuzzy minmal closed set F of X.

(iv) $\rceil(AqF)\Longrightarrow\rceil(A^*qF)$ for every fuzzy minimal closed set F of X.

Proof: (i) $\Longrightarrow$(ii). Let A be a fuzzy minimal I_g-closed set in X. Let $A\leq U$ where U is fuzzy minimal open set in X. Then $A^*\leq U$. Hence $Cl^*(A)=A\cup A^*\leq U$. Which implies that $Cl^*(A)\leq U$.

(ii)⟹(i).Let$A$beafuzzysetofX.Byhypothesis $Cl^*(A)\leq U$.Whichimpliesthat $A^*\leq U$.Hence$A$isfuzzyminimalI_g-closed.

(ii) ⟹(iii).Let Fbea fuzzy minimal closedset of X and $\rceil(AqF)$.Then $1-F$is fuzzy minimalopen inXandbyLemma2.7,≤$1-F$.Therefore,$Cl^*(A)\leq 1-F$,because$A$isfuzzy minimalI_g-closed. HencebyLemma2.7,, $\rceil(Cl^*(A)qF)$.

(iii) ⟹(ii).Let$U$beafuzzyminimalopensetofXsuchthat$A\leq U$.ThenbyLemma2.7,, $\rceil(Aq(1-U))$and$1-U$is fuzzyminimalclosedinX.Thereforebyhypothesis $\rceil(Cl^*(A)q(1-U))$.Hence, $Cl^*(A)\leq U$.

(i)⟹(iv). Let Fbe a fuzzy minimal closed set in X such that $\rceil(AqF)$. Then $A\leq 1-F$where $1-F$isfuzzyminimalopen. Thereforeby(i)$A^*\leq 1-F$. Hence $\rceil(A^*qF)$.

(iv) ⟹(i).Let$U$beafuzzyminimalclosedsetinXsuchthat$A\leq U$.ThenbyLemma2.7,, $\rceil(Aq(1-U))$and$1-U$isfuzzyminimalclosedinX.Thereforebyhypothesis $\rceil(A^*q(1-U))$.Hence$A^*\leq U$ and$A$isfuzzyminimal I_g-closedsetinX.

Theorem4.10: Let (X,F_m,I)beafuzzyminimalidealtopologicalspaceand$A$beafuzzy minimal I_g-closedset. Then$xqCl^*(A)\Longrightarrow Cl(x)qA$foranyfuzzypoint$x$ofX.

Proof: Let $xqCl^*(A)$. If $\rceil(Cl(x)qA)$. Then by Lemma 2.7, , $A\leq(1-Cl(x))$. And so by Theorem3.3(ii), $Cl^*(A)\leq(1-Cl(x))$ because $(1-Cl(x))$ isfuzzyminimalopensetin X.Whichimpliesthat$Cl^*(A)\leq(1-x)$.Hence by Theorem3.3(ii), $\rceil(xqCl^*(A))$,which is acontradiction.

Theorem4.11: Let(X,F_m,I) beafuzzyminimalidealtopologicalspaceand$A$beafuzzy minimal I_g-closedsetinX.Then$A$isfuzzyminimal∗-closed.
Proof: Theproofisobvious.

Theorem 4.12: Let (X, F_m, I) be a fuzzy minimal ideal topological space and Abe fuzzy ∗-dense in itselffuzzyminimalI_g-closedsetofX.Then Aisfuzzy$g$-closed.
Proof: Let Ube a fuzzy minimal open set of X such that $A\leq U$.Since A is fuzzy minimal I_g-closed, byTheorem 4.9 (ii), $Cl^*(A)\leq U$.Therefore, $Cl(A)\leq U$,because A isfuzzy ∗-dense in itself. Hence Aisfuzzy$g$-closed.

Theorem4.13: Let (X, F_m, I) beafuzzyminimalidealtopologicalspacewhere $I=\{0\}$ and Abeafuzzyminimalsetof X.Then$A$is fuzzyminimalI_g-closedifandonlyif$A$is fuzzy$g$-closed.
Proof: Since$I=\{0\}$,$A^*=Cl(A)$foreachsubset$A$of.Nowtheresultcanbeeasilyproved.

Theorem4.14: Let (X,F_m,I)beafuzzyminimalidealtopologicalspaceand$A$,BarefuzzyminimalI_g-closed setsofX. Then$A\cup B$isfuzzy minimalI_g-closed.
Proof: Let$U$beafuzzyminimalopensetofXsuchthat$A\cup B\leq U$.Then$A\leq U$and$B\leq U$ .Therefore$A^*\leq U$and$B^*\leq U$because$A$and$B$arefuzzyminimalI_g-closedsetsofX.Hence$(A\cup B)^*\leq U$and$A\cup B$isfuzzy minimalI_g-closed.

Remark4.15: The intersection of two fuzzy minimal I_g-closed setsinafuzzyminimalidealtopological space(X,F_m,I)maynotbefuzzyminimalI_g-closed.

Example 4.16: LetX={a,b}andA,Bbetwofuzzyminimalsetsdefinedas follows :

A(a) =0.9 , A(b) =0.7
B(a) =0.8 , B(b)=0.7
U(a) =0.3 , U(b) =0.4

Let τ={0,U,1} and I={0}.Then Aand B are fuzzyminimalI_g-closedsetsin (X,F_m,I) butA∩B is notfuzzy minimalI_g-closed.

Theorem4.17: Let(X,F_m,I)beafuzzyidealtopologicalspaceandA,BarefuzzyminimalsetsofXsuchthatA≤B≤ Cl*(A).IfAisfuzzyminimalI_g-closedset inX,thenBis fuzzyminimalI_g-closed.**Proof:**LetUbeafuzzyminimalopensetsuchthatB≤U.SinceA≤BwehaveA≤U.Hence,Cl*(A)≤Ubecause A isfuzzyminimalI_g-closed.NowB ≤Cl*(A)impliesthatCl*(B)≤Cl*(A)≤U .ConsequenlyBisfuzzyminimalI_g-closed.

Theorem4.18: Let(X,F_m,I)beafuzzyminimalidealtopologicalspaceand$A$,BarefuzzyminimalsetsofXsuch that$A$≤B≤A*.Then$A$and$B$arefuzzyI_g-closed.
Proof: Theproofisobvious.

Theorem 4.19: Let(X, F_m, I) be a fuzzy minimal ideal topological space .If $A$and $B$are fuzzysubsets ofXsuch that$A \leq B \leq A^*$ and$A$isfuzzy minimal I_g-closed . Then $A^* = B^*$ and Bisfuzzyminimal∗-open initself.

Proof: Obvious.

Theorem 4.20: Let(X, F_m, I)bea fuzzy minimal ideal topological spaceand$\mathcal{F}$bethefamilyofallfuzzy minimal∗- closedsetsofX . Thenτ ⊂$\mathcal{F}$ifandonlyifeveryfuzzysetofXisfuzzyminimalI_g-closed.

Proof:Necessity. Let τ⊂$\mathcal{F}$and$U$ bea fuzzyminimal opensetinXsuchthat A≤U.Now U∈r⟹U∈$\mathcal{F}$.Andso $Cl^*(A) \leq Cl^*(U) = U$and A is fuzzy minimalI_g -closedsetin X.
Sufficiency. Suppose that everyfuzzy minimalsetofXisfuzzy minimal I_g-closed .Let$U$∈ r.Since Uisfuzzyminimal I_g -closed andU≤ U, $Cl^*(U) \leq U$.Hence $Cl^*(U) = U$and $U \in \mathcal{F}$.Thereforeτ⊂$\mathcal{F}$.

Definition 4.21: A fuzzy set $A$of a fuzzy minimal ideal topological space (X, F_m, I)is called fuzzyminimalI_g-open ifits complement1−AisfuzzyminimalI_g-closed.

Remark 4.22: Every fuzzy$g$-open setis fuzzyminimalI_g-open . Buttheconverse maynotbetrue.

Remark 4.23: Every fuzzy ∗-open set in a fuzzy minimal ideal topological space (X, F_m, I)is fuzzyminimalI_g-open. But the conversemay notbetrue.

Theorem4.24: Let(X,F_m,I) beafuzzyminimalidealtopologicalspaceand$A$isfuzzysetofX.Then AisfuzzyminimalI_g-openif andonlyif$F \leq Ikt^*(A)$whenever Fisfuzzyminimal closedand$F \leq A$.

Proof: Necessity. Let Abe fuzzy minimal I_g-open and $F$is fuzzy minimal closed set such that $F \leq A$.Then1 −AisfuzzyminimalI_g-closed,1 − A≤1 −Fand1 −Fisfuzzyminimalopenin X.Hence $Cl^*(1-A) \leq (1-F)$.Whichimpliesthat $F \leq Ikt^*(A)$.

Sufficiency. Let$U$beafuzzyminimalopensetsuchthat1 $-A\leq U$.Then1$-U$isfuzzyminimalclosedsetofXsuchthat1$-U\leq A$.Andsobyhypothesis,1$-U\leq Ikt^*(A)$.Whichimpliesthat $Cl^*(1-A)\leq U$and1$-A$isfuzzyminimal I_g-closed.Hence$A$isfuzzyminimalI_g-open.

Theorem4.25: Let(X,F_m,I) beafuzzyminimalidealtopologicalspaceand$A$beafuzzysetofX.If Aisfuzzyminimal I_g-open and $Ikt^*(A)\leq B\leq A$,then$B$ is fuzzy minimalI_g-open.
Proof: FollowsfromDefinition4.21andTheorem 4.18.

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