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TheNotion ofnewmappingsinMinimalStructure

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Abstract—This paper aims formingat the some mappings like m_X-feebly regular open with its complementmapping.Theseconceptsaredefinedatthediscu m_X-feeblyregularcontinuousfunctionandalso ssedatthesomerelatedtheoremsinit.

Keywords— m_X-feeblyopen, m_X-feeblyclosed, m_X-feeblyinterior, m_X-feeblyclosure, m_X-feebly clopen,m_X-feeblyregularopenandm_X-feeblyregularclosed.

I INTRODUCTION

Generaltopologyisthemainroleofmathematicalfield.In1963, Levineintroducedattheconceptsofsemiopensetandsemi-continuous.Thesemiopensets,preopensets,α-opensets,β-opensets,b-opensets and δ-open sets play an important role in the research of generalization of continuity in topologicalspaces.Byusingthesesetsseveralauthorsintroducedatthevarioustypesof Non-continuousfunctions.

Further the analogy in their definitions and properties suggests the need of formulating in the setting offunctions.In1982Tong.,Jinvestigatedattheseparationaxiomsanddecompositionofcontinuity.In1982, S.N Maheswari and P.C. Jain defined and studied at the concepts of feebly open and feebly closed sets intopologicalspaces. In2000,theconceptsofminimalstructure(brieflym_X-structure)wasintroducedbyV. Popaand T.Noiri. They introducedatthenotionsof m_X-opensetsand m_X-closedsetsandcharacterizeof those sets using m_X-closure and $m_X$operators, respectively and also obtained the definitions and characterizationsofsomemappingsbyusingattheconceptofminimalstructure.

II PRELIMINARIES

Definition2.1: Let(X,τ)beatopologicalspace.AsubsetAofXissaidtobe

1) α-open[9]ifA⊂int(cl(int(A)))
2) Semi-open[6]ifA⊂cl(int(A))
3) Preopen[9]ifA⊂int(cl(A))
4) b-open[2]ifA⊂int(cl(A))∪cl(int(A))
5) β-open[1]orsemi-preopenifA⊂cl(int(cl(A)))
6) Feeblyopen[7]ifA⊂scl(int(A))
7) Feeblyclosed[7]ifint(cl(A))⊂A

The family of all α-open (resp., semi-open, preopen, b-open, β-open, feebly open, feebly closed) setsin(X,τ)isdenotedbyα(X)(resp.,$SO(X)$,$PO(X)$,$BO(X)$,β(X),$FO(X)$.

Definition2.2[11,12]: Asubfamily$m_X$ofthepowersetP(X)ofanon-emptysetXiscalledaminimal structure(brieflym-structure)onXifφ$\in m_X$ and $X\in m_X$.By(X,m_X)wedenoteanon-emptyset$X$witha minimalstructurem_X on$X$andcallitanm-space.Eachmemberofm_X issaidtobe m_X-openandthe complementofanm_X-openissaidtobem_X-closed.

Remark2.3: Let(X,τ)beatopologicalspace.Thenthefamiliesτ,$SO(X)$,$PO(X)$,$BO(X)$*and*β(X)areall m-structureon$X$.

Definition2.4: Let(X,m_X) be$m$–space.ForasubsetAof m_X–closureofAand m_X–interior of Aare definedin[8]asfollows:

(i) m_X–cl(A)=$\cap\{F{:}A\subset F, X-F\in m_X\}$

(ii) m_X–int(A)=$\cup\{U{:}U\subset A, U\in m_X\}$

Remark 2.5: Let (X,τ) be a topological space and let A be a subset of X. If $m_X=\tau$ (resp., $so(X)$,$PO(X)$,$\alpha(X)$,$BO(X)$and$\beta(X)$thenwehave

(a) m_X–cl(A)=cl(A)(resp$S$.cl(A),P.cl(A),α.cl(A),b.cl(A)andβ.cl(A)).

(b) m_X–int(A)=int(A)(resp$S$.int(A),P.int(A),α.int(A),b.int(A)andβ.int(A)).

Remark2.6: LetAbeasubsetof(X,m_X)

(a) Theunionofallm_X–semiopensetsof$X$containedinAiscalledthem_X–semi-interiorofA.

(b) Theintersectionofall m_X–semiclosedsetsof$X$containingAiscalledthe m_X–semiclosureof A.

(c) Aiscalled m_X–semipreopenifA$\subset m_X$–cl(m_X–int(m_X–cl(A))).Itscomplementis m_X–semi-preclosed.

Definition2.7[7]: Asubset$A$of (X,m_X) issaid to be m_X– regularopen(briefly m_X–RO)ifA=m_X–int (A) andm_X–regularclosedifA=m_X–cl(A).

Definition2.8[12]: Let $f{:}(X,m_X)\rightarrow(Y,m_Y)$beafunctionbetweenaspace$(X,m_X)$withminimal structure m_X andatopologicalspace(Y,m_Y).Then$f$saidtobe$m$-continuousifforeach$x$andeachopen setVcontaining$f(x)$,thereexistsanm-opensetUcontaining$x$suchthat$f$(U)$\subseteq$V.

Definition2.9[5]: Let(X,m_X)beatopologicalspace.Anysubset$A$of$X$iscalledfeeblyclopenifitisbothfeeblyopenandfeeblyclosed.

Definition2.10: Amap $f{:}X\rightarrow Y$ issaidtobe

1. Feeblyclosed(resp.,feeblyopen)[10]iftheimageofeachclosedset(resp.,openset)inXisfeeblyclosed(resp.,feeblyopen)setinY
2. Feeblycontinuous[10]iff^{-1}(V)isfeeblyopenin$X$foreachsetVofY.
3. Feeblyclopen[5]iftheimageofeveryopenandclosedsetinXisbothfeeblyopenandclosedinY.

Definition 2.11[3]:A subset(E, m_X) of am_X –space$(X, m_X)$is said to bem_X –feebly open if E $\subset m_X$ –s cl(m_X–int(E)).

Definition2.12[3]: A subset(E, m_X) of am_X–space$(X, m_X)$is said to bem_X–feebly closed ifint(m_X– m_X–cl(E))$\subset$E.

Definition2.13[3]: Them_X–feeblyclosureof(E,m_X)istheintersectionofallm_X–feeblyclosedsetcontaining(E,m_X)andisdenotedbym_X–f.cl(E).

Definition2.14[3]: The m_X–feeblyinteriorof(E,m_X) is theunionofallm_X–feebly opensets containedin $(E, m_X)$and is denotedbym_X–f.int(E).

Definition2.15[13]: AsubsetAof(X, m_X)is saidtobe m_X–**Feeblyregularopen**(briefly m_X–f.reg.open) ifA=m_X–f.int(m_X–f.cl(A)).

Definition2.16[13]: AsubsetAof(X, m_X)is saidtobe m_X– **Feeblyregularclosed**if A= m_X–*f*.cl(m_X–*f*.int(A))(brieflym_X–*f*.reg.closed).

Definition2.17[13]: AsubsetAof(X, m_X)issaidtobem_X–**Feeblyregularclopen**ifA= m_X–*f*.int(m_X–*f*.cl(m_X–*f*.int(A))).Ontheotherhand,ifAism_X–*f*.reg.openandm_X–*f*.reg.closed.

Definition2.18[13]: LetAbeasubsetof(X, m_X).The m_X–**Feeblyregularclosure**ofA(briefly m_X–*f*.reg.cl(A))istheintersectionofall m_X–FeeblyregularclosedsetscontainingAandthe m_X–**Feeblyregularinterior**ofA(briefly m_X–*f*.reg.int(A))istheunionofall m_X–Feeblyregularopensetscontained inA.Thecomplementofm_X–Feeblyregularopensetism_X–Feeblyregularclosed.

IIIm_X–Feeblyregularopenmappingswithitscomplement

Inthissectionweintroducem_X–Feeblyregularopenandm_X–Feeblyregularclosedmappingsandsomeofitspropertiesarediscussed.

Definition3.1: Afunction f:$(X,m_X) \rightarrow (Y,m_Y)$iscalledthe$m_X$–Feeblyregularclosediftheimageof eachm_X–Feeblyregularclosedin(X,m_X)isam_X–Feeblyregularclosedin(Y,m_Y).

Definition3.2: Afunction $f : (X , m_X) \rightarrow (Y , m_Y)$ is calledm_X– Feebly regular open if the image of m_X–opensetin(X,m_X) eachism_X–Feeblyregularopensetin(Y,m_Y).

Theorem3.3: Everym_X–openmappingism_X–Feeblyregularopenmapping.
Proof: Let f:$(X,m_X)\rightarrow(Y,m_Y)beam_X$–openmapping.Nowwehavetoprovethatfism_X–Feebly regularopen.LetHbeanym_X–opensubsetof(X,m_X).Since*f*ism_X–openmapping,*f*(H)ism_X–openin(Y,m_Y),*f*(H)ism_X–Feeblyregularopen.Hence*f*ism_X–feeblyopenmapping.

Theorem3.4: Everym_X–closedmappingism_X–Feeblyregularclosedmapping.
Proof: Let f:$(X,m_X)\rightarrow(Y,m_Y)beam_X$– closedmapping.Nowwehavetoprovethat*f*ism_X–Feebly regularclosedmapping.LetHbeanym_X–closedsubsetof(X,m_X).Since*f*ism_X–closedmapping,*f*(H) ism_X–closed in(Y , m_Y) .*f*(H) ism_X– Feebly regular closed. Hence *f* ism_X– Feebly closedmapping.

Theorem3.5: Let f:$(X,m_X)\rightarrow(Y,m_Y)beam_X$–Feeblyregularclosedmappingthentheimageofevery m_X–closedsubsetof(X,m_X) ism_X–Feeblyregularclosedin (Y,m_Y).

Proof: LetHbeanym_X–closedsubsetof$(X,m_X)$and*f*(H)ism_X–Feeblyregularclosedin (Y,m_Y) then *f*(H)ism_X–Feeblyregularclosedin(Y,m_Y).

Theorem 3.6: A f:$(X,m_X)\rightarrow(Y,m_Y)ism_X$–Feeblyregularopenif*f*($m_X$–F.reg.int(H))$\subseteq$ m_X–mappingF.reg.int*f*(H)foreve (X,m_X).
ryH$\subseteq$

Proof: LetHbeanym_X–opensetin(X,m_X).Sothatm_X–F.reg.int(H)=H,then*f*(m_X–F.reg.int(H))$\subseteq$ m_X–F.reg.int*f*(H).Therefore*f*(H)$\subseteq$ m_X–F.reg.int*f*(H).But m_X–F.reg.int(*f*(H))$\subseteq$*f*(H)always. Hencem_X–F.reg.int(*f*(H))=*f*(H).Therefore*f*(H)ism_X–openin(X,m_X),then*f*ism_X–open.Bytheorem3.3,*f*ism_X–Feeblyregularopen.

Theorem3.7: Amapping $f:(X,m_X)\to(Y,m_Y)$ ism_X–Feeblyregularclosedifm_X–F.reg.cl(f(H))⊂ f(m_X–F.reg.cl(H))foreveryH⊂(X,m_X).

Proof: LetHbeanym_X–closedsetin(X,m_X).Sothat m_X–F.reg.cl(H)=H.Byhypothesism_X–F.reg.cl$f$(H)⊂f(m_X–F.reg.cl(H))=f(H).Therefore,m_X–F.reg.cl(f(H))⊂f(H).But$f$(H)⊂m_X–F.reg.cl$f$(H)always.Hence m_X–F.reg.cl$f$(H)=f(H),thus$f$(H)ism_X–closed,then$f$ism_X–closedmap. Bytheorem3.4,$f$ism_X–Feeblyregularclosed.

Theorem3.8: Let $f:(X,m_X)\to(Y,m_Y)$and $g:(Y,m_Y)\to(Z,m_Z)$beamappingsthen $g\circ f:(X,m_X)\to(Z,m_Z)ism_X$– Feebly regular open if **(i)** f and g be them_X–open mappings **(ii)** f ism_X–openandgism_X–Feeblyregularopenmappings**.**

Proof: (i) Let H be anym_X–open subset of(X,m_X) .Now we have to prove that$(g\circ f)$(H) ism_X–Feebly regular open in(Z,m_Z) .Since f ism_X–open, then f(H) ism_X–open in (Y,m_Y) .Also we have g ism_X–open,then$g$(f(H))ism_X–openin(Z,m_Z).Therefore$(g\circ f)$(H)ism_X–Feeblyregularopenin (Z,m_Z).Thus$g\circ f$ism_X–Feeblyregularopenmapping.

(ii)Bysamemethodinpart(i).

Remark3.9:(i) Let $f:(X,m_X)\to(Y,m_Y)$and $g:(Y,m_Y)\to(Z,m_Z)$bethem_X–closedmappingstheng$\circ f$ $:(X,m_X)\to(Z,m_Z)$ism_X–Feeblyregularclosed.**(ii)**Let $f:(X,m_X)\to(Y,m_Y)$be m_X–closedandg: $(Y,m_Y)\to(Z,m_Z)$ bem_X– Feebly regular closed, then g$\circ$f : $(X,m_X)\to(Z,m_Z)$ ism_X– Feebly regularclosed.

4. m_X**–Feeblyregularcontinuousfunctions**

Definition4.1:Am_X–mapping$f:(X,m_X)\to(Y,m_Y)$issaidtobem_X–Feeblyregularcontinuousifthe softinverseimageby$f$ofeachm_X–opensetHof(Y,m_Y)ism_X–Feeblyregularopenin(X,m_X).

Remark4.2:(i)Let(X,m_X)beam_X–topologicalspace,AandB⊂(X,m_X)ifA⊂B,then$f$(m_X–F.reg.cl(A))⊂f (m_X–F.reg.cl(B)). (ii) Let(X,m_X)be a minimal topological space if A ism_X– Feebly regularopenifandifonlyA^cism_X–Feeblyregularclosed.Fromourdefinitionofm_X–Feeblyregularopenandm_X–Feeblyregularclosedsets,weobtainthem.

Theorem4.3: If $f:(X,m_X)\to(Y,m_Y)$ism_X–Feeblyregularcontinuousifandifonlytheinverseimage ofeverym_X–closedsubsetof(Y,m_Y)ism_X–Feeblyregularclosedin(X,m_X).

Proof: We have f ism_X– Feebly regular continuous.Let H ism_X–closed in(Y,m_Y) , H^c ism_X–open inminimal structure,$f^1(H)^c=(f^1(H))^c$ ism_X – Feebly regular open in(X,m_X), then by remark 4.2(ii) f^1(H)ism_X–Feeblyregularclosed.Hisam_X–opensetin(Y,m_Y),H^cism_X–closed,thenbyhypothesis$f^1(H)^c$ism_X – Feebly regular closed in(X,m_X) , then by remark 4.5(ii) f^1(H) ism_X – Feebly regular open set in(Y,m_Y).Thus$f$ism_X–Feeblyregularcontinuous.

Theorem4.4: Everym_X–continuousmappingism_X–Feeblyregularcontinuousmapping.

Proof: Let $f:(X,m_X)\to(Y,m_Y)$ ism_X–continuousmapping.Nowwehavetoprovethat$f$ism_X–Feeblyregularcontinuous.LetHbeanym_X–opensubsetof(Y,m_Y).Sincefism_X–continuousthen f^1(H)ism_X–openin(X,m_X).Thereforef^1(H)ism_X–Feeblyregularopen.Hence$f$ism_X–Feeblyregular continuousmapping.

Theorem 4.5: Let(X , m_X) be am_X–topological space, A (X,m_X),thenAism_X–Feeblyregularopen ⊂ifandifonly$f$$m_X$–F.reg.int(A)=A.

Proof: WehaveAism_X–Feeblyregularopensetin(X,m_X).Itisclear$f$(m_X–F.reg.int(A))⊂A-→(1).SinceAism_X–Feeblyregularopensetand$f$(m_X–F.reg.int(A))islargestm_X–Feeblyregularopenset.ThenA⊂f(m_X–F.reg.int(A))----→(2).From(1)and(2)weobtain$f$(m_X–F.reg.int(A))=A.Converselylet f (m_X–F.reg.int (A)) =A.Since$f$(m_X–F.reg.int (A))ism_X– Feebly regular open set, then A ism_X–Feeblyregularopenset.

Corollary4.6: Let(X,m_X)beam_X– (X,m_X)thenAism_X–Feeblyregular topologicalspace,A⊂closedifandifonly$f$(m_X–F.reg.cl(A))=A.

Theorem4.7: If f:(X,m_X)→(Y,m_Y)ism_X–Feeblyregularcontinuousifandifonly$f$(f(m_X–F.reg.cl (A)))⊂f(A^c)foreveryA⊂(X,m_X).

Proof: Wehave$f$ism_X–Feeblyregularcontinuous.Since$f$(A^c)issoft-closedin(Y,m_Y),thenbytheorem4.3, f^1(f(A^c)) ism_X– Feebly regular closed in(X , m_X) .By corollary 4.6, f(m_X–F.reg.cl (f^1(f(A^c))))= f^1(f(A^c))--→(1).Now$f$(A)⊂f(A^c)⇒A⊂f^1(f(A))thenA⊂f^1(f(A^c)),thusbyremark4.2(i),f(m_X–F.reg.cl(A))⊂f(m_X–F.reg.cl(f^1(f(A^c))))accordingto(1),weget$f$(m_X–F.reg.cl(A))⊂f^1(f(A^c)),then f(f(m_X–F.reg.cl(A)))⊂(f(A))^c.Conversely,let$f$(f(m_X–F.reg.cl(A)))⊂(f(A))^{c}foreveryA⊂(X,m_X).Let Hism_X–closedsetin(Y,m_Y).ThenH^c=H,letf^1(H)beanym_X–subsetof(X,m_X),thenbyhypothesis f(m_X–F.reg.cl(f^1(A)))⊂f((f^1(H))^c)=H^c=H.Thus$f$(m_X–F.reg.cl(f^1(H)))⊂f^1(H)butf^1(H)⊂f(m_X–F.reg.cl(f^1(H)))alwaysthusf^1(H)=f(m_X–F.reg.cl(f^1(H))).Thereforebycorollary4.6,f^1(H)ism_X–Feeblyregularclosedin(X,m_X),hencebytheorem4.6,fism_X–Feeblyregularcontinuous.

Theorem4.8: If f:(X,m_X)→(Y,m_Y) ism_X–Feeblyregularcontinuousifandifonly$f$(m_X–F.reg.cl(f^1(B)))⊂f^1(B^c)foreveryB⊂(Y,m_Y).

Proof: We have f ism_X– Feebly regular continuous.Since B^c ism_X–closed in(Y , m_Y) .Then by theorem4.3,f^1(B^c)ism_X–Feeblyregularclosedin(X,m_X) andbycorollary4.6,f(m_X–F.reg.cl(f^1(B^c)))=f^1(B^c)---→(1).NowB⊂B^c⇒f^1(B)⊂f^1(B^c)thenbyremark4.2(i),f(m_X–F.reg.cl(f^1(B)))⊂f(m_X–F.reg.cl(f^1(B^c))),accordingto(1)weget,f(m_X–F.reg.cl(f^1(B)))⊂f^1(B^c).Conversely,let$f$(m_X–F.reg.cl(f^1(B)))⊂f^1(B^c) for every B ⊂ (Y , m_Y) .Let H be anym_X–closed in(Y , m_Y) .Then H^c = H by hypothesis f(m_X–F.reg.cl (f^1(H)))⊂f^1(H^c) = f^1(H).Thus$f$(m_X–F.reg.cl (f^1(H)))⊂f^1(H) , but f^1(H)⊂f(m_X–F.reg.cl (f^1(H))),therefore$f$(m_X–F.reg.cl(f^1(H)))=f^1(H).Thenbycorollary4.6,f^1(H)ism_X–Feeblyregularclosedin(X,m_X),hencebytheorem4.3,fism_X–Feeblyregularcontinuous.

Theorem4.9: Let f:(X,m_X) →(Y,m_Y)beam_X–mappingif$f$(m_X–F.reg.cl(H))⊂f(m_X–F.reg.cl$f$(H)) foreveryH⊂(X,m_X)then$f$ism_X–Feeblyregularcontinuous.

Proof: Let H be anym_X–closed set in(Y , m_Y) , then by remark 4.2(ii), let H ism_X– Feebly regular closedsothatbycorollary,f(m_X–F.reg.cl(H))=H,f^1(H)isam_X–subsetof(X ,m_X)sothatbyhypothesis$f$(m_X–F.reg.cl(f^1(H)))⊂f(m_X–F.reg.cl(f(f^1(H))))=f(m_X–F.reg.cl(H))=H.Therefore$f$(m_X–F.reg.cl(f^1(H)))⊂f^1(H)always.Hence$f$(m_X–F.reg.cl(f^1(H)))=f^1(H)thenbycorollary4.6,f^1(H)ism_X–Feeblyregularclosedin(X,m_X).Thereforebytheorem4.3,fism_X–Feeblyregularcontinuous.

Theorem4.10: Let $f:(X,m_X)\rightarrow(Y,m_Y)beam_X$–mappingif$f(m_X$–F.reg.cl$(f^{-1}$(H)))$\subset f^{-1}(f(m_X$–F.reg.cl(H)))foreveryH$\subset(Y,m_Y)$then$fism_X$–Feeblyregularcontinuous.

Proof: LetHbeanym_X–closedsetin(X,m_X)thenbyresult3.5,wehaveHisam_X–Feeblyregularclosedsetandsobycorollary4.6,$f(m_X$–F.reg.cl(H))=H.Byhypothesis$f(m_X$–F.reg.cl$(f^{-1}$(H))) $\subset f^{-1}(f(m_X$–F.reg.cl(H)))=f^{-1}(H). Therefore m_X–F.reg.cl$(f^{-1}$(H))$\subset f^{-1}$(H).Butf^{-1}(H)$\subset f(m_X$–F.reg.cl$(f^{-1}$(H)))always.Hence$f(m_X$–F.reg.cl$(f^{-1}$(H)))=f^{-1}(H)thenbycorollary4.6,f^{-1}(H)ism_X–Feeblyregularclosedin(X,m_X).Therefore bytheorem4.3,fism_X–Feeblyregularcontinuous.

IIICONCLUSIONS

Infurtherwork,atthesemappingsbasedonthesesetswithitsrelatedpointswillbegeneralizedandalsoextended.

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