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On mg - Continuous Function in Minimal Structure

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Abstract: In this paper we introduce a new class of mg-continuous mapping and studied some of its basic properties.We obtain some characterizations of such fuctions. Moreover we define subminimal structure and further study certain properties of mg-closed sets.

Keywords: m-structure, mg-continuous mapping, minimal structure, mg $T_2 space$,
sub minimal structure, $T_{\frac{1}{2}}$ space, mg-compact set

1. Introudction

Semi-open sets, preopensets, α -open sets, β -open sets and δ -open sets play an important part in the researches of generalisations of continuity in topological spaces. By using these sets several authors introduced and studied various types of non-continuous functions. Certain of these non-continuous functions have properties similar to those of continuous function and they hold in many part parallel to the theory of continuous functions. Further the analogy in their definitions and result suggests the need of formulating a unified theory in the setting of functions.

In 1961, Levin [10] introduced the concepts of semi-continuous functions. Neubrunnova [14] showed that semi-continuity is equivalent to quasi continuity due to Maicus [14]. In 1973, Popa and San [21] introduced the concept of weakly quasi-continuous functions. Weak quasi continuity is implied by both quasi-continuity and weak continuity which are independent of each other. It is shown in [16]that weak quasi-continuity is equivalent to semi weak-continuity in the sense of Costovici[4] and weak semi-continuity in the sense of Arya and Bhamini[1] and kar and Bhattacharyya[11]. Many properties of weakly quasi continuity are studied in [10],[11], [16], [18],[20] and [51]. In 1985, Jankovic [9] introduced the notion of almost weakly continuous functions. It is shown that in [23] that almost weak continuity is equivalent to quasi pre-continuity due to Paul and Bhattacharya [26]. Further properties of almost weakly continuous functions are studied in [8],[26],[28]and [23]. Noiri[17] introduced the notion of weakly α-continuous functions several properties of weakly α -continuous functions are studied in [17],[30],and [31]. Moreover, Popa [24] introduced and studied weakly β-continuous functions. Di maio and Noiri [6] introduced and studied the notion of quasi irresolute functions. Some properties of quasi-irresolute functions are studied by [7] and [25]. The notion of quasi preirresolute function is introduced and studied in [27]. As other generlisations of weak continuity there are almost s-continuity [19], P_θ -continuity [5] and P - continuity [29].

Balachandran et al [2] introduced the concept of genralized continuous maps and gc-irresolute maps on a topological space .Charber[3] investigated open-closed maps. Nagaveni [15] introduced wg-closed sets continuous maps in topological spaces. Valeriu Popa [32] introduced on m-continuous fucntion.

In this paper, we introduce a new class of mg-continuous functions as a function defined between sets satisfying some minimal conditions and we obtain some characterisations of such functions. Moreover we define subminimal structure and study further properties of mg-closed sets.

2. Preliminaries

Defintion 2.1 [32]: A subfamily m_X of the power set P(x) of a nonempty set X is called a minimal sturcture(briefly m-structure) on X if $\varphi \in m_X$ and X$\in m_X$.

Remark 2.2 [32]: Let (X, τ) be a topological space.Then the families τ, SO(X), PO(x), $\alpha(X)$, $\beta(X)$, $\delta(X)$, δSO(x) and SR(x) are all m-structure on X.

Definiton 2.3 [32]: Let X be a nonempty set and m_X an m-structure on X. For a subset A of X, the m_X closure of

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A and the m_X interior of A are defined in [13] as follows:

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

(2)$m_X - int(A) = \bigcup\{F : U \subset A, U \in m_X\}$

Remark 2.4 [32]: Let (X, τ) be a topological space and A a subset of X. If $m_X = \tau$ [Respectively SO(X), PO(X), $\alpha(X)$, $\beta(X)$, $\delta PO(X)$, SR(X)] then we have

(1)$m_X - cl(A) = cl(A)[resScl(A), Pcl(A), \alpha cl(A), \beta cl(A), \delta Pcl(A), \delta Scl(A), S_(\theta)cl(A)]$
(2) $m_X - int(A) = int(A)[resSint(A), Pint(A), \alpha int(A), \beta int(A), \delta Sint(A), s_(\theta)int(A)]$

Lemma 2.5 [13]: Let X be a nonempty set and m_X a minimal structure on X. For subsets A and B of X the following hold.

(1) m_X-cl(X-A) $= X - (m_X - int(A))$ and $m_X - int(X - A) = X - (m_X - cl(A))$

(2)if $(X - A) \in m_X$ then $m_X - cl(A) = A$ and if $A \in m_X$ then $m_X - int(A) = A$

(3)$m_X - cl(\varphi) = \varphi, m_X - cl(X) = X, m_X - int(\varphi) = \varphi$ and $m_X - int(X) = X$

(4) if$A \subset B$ then $m_X cl(A) \subset m_X cl(B)$ and $m_X - int(A) \subset m_X - int(B)$

(5)$A \subset m_X - cl(A)$ and $m_X - intA \subset A$

(6)$m_X - cl(m_X - cl(A)) = m_X - cl(A)$ and $m_X - int((m_X - int(A) = m_X - int(A)$

Lemma 2.6 [32]: Let X be a nonempty set with minimal structure m_X and A be a subset of X. Then x$\in m_X - cl(A)$ if and only if U$\cap A \neq \phi$ for every U$\in m_X$ containing X.

Proof: Necessity: suppose that there exist $U \in m_X$ containing S such that $U \cap A = \varphi$. Then A$\subset X - U$ and X-(X-U)$= U \in m_X$. Then $m_X - cl(A) \subset X - U$. Since $X \in U$ we have $X \notin m_X - cl(A)$.

Sufficiencey: suppose that $X \notin m_X - cl(A)$.There exsit a subset F of X such that X-F$\in m_X$, A$\subset F$ and X$\notin F$

Then there exsist $X - F \in m_X$ containing X such that $(X - F) \cap A = \varphi$.

3.mg-Continuous Functions

Definition 3.1: A function $f : (X, m_X) \rightarrow (Y, m_Y)$ is said to be mg-continuous if f^{-1}(V) is mg-closed in (X, m_X) for every mg-closed V in (Y,m_Y).

Therorem 3.2: If a map $f : (X, m_X) \rightarrow (Y, m_Y)$ from a minimal space (X, m_X) into a minimal space (Y, m_Y) is m-continuity [15] then it is mg-continuous but not conversely

Proof: Let $f : (X, m_X) \rightarrow (Y, m_Y)$ be m-continuous .

Let F be any closed set in (Y, m_Y) . Then the inverse image f^{-1}(F) is closed in (Y, m_Y). since every closed set is mg-closed set f^{-1}(F) is mg-closed set in (X, m_X). Therefore f is mg-continuous
The converse of the above theorem need not be true from the following example.

Example 3.3: Let $X = \{a, b, c\}, \tau = \{\varphi, \{a\}, X\}$, $Y = \{p, q\}$ and $\sigma = \{\varphi, \{p\}, Y\}$. Let $f : (X, \tau) \rightarrow (Y, \sigma)$ be defined by $f(a) = f(c) = q, f(b) = p$. Then f is m-continuouis. But f is not mg-continuous. Since for the open set $G = \{p\}$ in (Y, m_Y) $f^{-1}(a) = \{b\}$ is not open in (X, m_X).

Theroem 3.4: Let $f : (X, m_X) \rightarrow (Y, m_Y)$ be a mapping from a minimal space (X, m_X) into a minimal space (Y, m_Y) The following statements are equivalent (a) f is mg-continuous (b) the inverse image of each open set in (Y, m_Y) is g-open in (X, m_X)

Proof: Assume that $f : (X, m_X) \rightarrow (Y, m_Y)$is mg-continuous Let G be open in (Y, m_Y) Then G^c is closed in (Y, m_Y). Since f is mg-continuous $f^{-1}(G^c)$is mg-closed in (X, m_X) But $f^{-1}(G^c) = X - f^{-1}(G)$. Thus $X - f^{-1}(G)$is mg-closed in X and so $f^{-1}(G)$ is mg-open in (X, m_X). Therefore (a) implies (b)

conversely Assume that the inverse image of each open set in (Y, m_Y) is mg-open in (X, m_X). Let F be any closed set in (Y, m_Y).

By assumption, $f^{-1}(F^c)$ is mg-open in (X, m_X). But $f^{-1}(F^c) = X - f^{-1}(F)$. Thus $X - f^{-1}$ (F) is mg-open in (X, m_X). Therefore f is mg-continuous. Hence (b)implies (a). Therefore (a) and (b) are equivalent.

Defintion 3.5: A non empty set X with a minimal structure $(X, m_X\ )$ is said to be mg-T_2 if for each distincit points $x, y \in X$ there exist $u, v \in m_X$ containing x and y respectively such that $u \cap v = \varphi$

Theorem 3.6 : If $f : (X, m_X) \rightarrow (Y, m_Y)$ is a m-continuous injection and (Y, m_Y) is mg- T_2 then (X, m_X) is mg- T_2.

Proof: Let x, y be any distinct points of X. Then $f(x) \neq f(y)$ since (Y, m_Y) is mg-T_2. There exist a disjoint sets u, v in m_Y cotaining $f(x)$ and $f(y)$ respectively. Since f is m-continuous there exist $G, H \in m_X$ containing x, y respectively such that $f(G) \subset U$ and $f(H) \subset U$. This implies that $G \cap H = \varphi$. Hence X is mg-T_2.

Theorem 3.7: Let X and Z be any minimal spaces and Y be $T_{1/2}$ space. Then the composition $g \circ f : (X, m_X) \rightarrow (Z, m_Z)$ of the mg-continuous maps $f : (X, m_X) \rightarrow (Y, m_Y)$ and$g : (Y, m_Y) \rightarrow (Z, m_Z)$ is also mg-continuous.

Proof: Let F be closed in (Z,m_Z). Since g is mg-continuous, $g^{-1}(F)$ is mg-closed in (Y, m_Y) But (Y, m_Y) is $T_{1/2}$ and so $g^{-1}(F)$ is closed. Since f is mg-continuous, $f^{-1}(g^{-1}(F))$ is mg-closed in (X, m_X). But $f^{-1}(g^{-1}(F)) = (g \circ f)^{-1}(F)$. Therefore $g \circ f$is mg-continuous. The following example shows that the above preposition need not be true if y is not $T_{1/2}$.

Example 3.8: Let $x = y = z = \{a, b, c\}$. Let $\tau = \{\phi, a, \{a, b\}, X\}\sigma = \{\phi, \{a\}, \{b, c\}, X\}$
$\eta = \{\phi, \{a, c\}, z\}$. Let $f : (X, m_X) \rightarrow (Y, m_Y)$ be defined by $f(a) = c, f(b) = b$and $f(c) = c$. Let$g : (Y, m_Y) \rightarrow (Z, m_Z)$ be the identity map. Then f and g are mg-continuous. But $g \circ f$ is not mg-continuous. Since $F = \{b\}$ is closed in (Z, m_Z). $g^{-1}(F) = F$ and $f^{-1}(F) = F$is not mg-closed in (X,m_X). Therefore $g \circ f$ is not mg-continuous. Regarding the restriction of a mg-continuous map . We have the following
Theorem 3.9: Let $f : (X, m_X) \rightarrow (Y, m_Y)$ be a mg-continuous map from minimal space (X, m_X) into a minmal space (Y, m_Y) and H be a closed subset of X. Then the restriction $f/H : H \rightarrow (Y, m_Y)$ is mg-continuous. Where H is endowed with subminimal structure.

Definition 3.10: Let (X, m_X) be a minimal space. Let $A \subset X$ be subset of X. Consider a minimal structure μ_A of A, then the space (A, μ_A) is called the subminimal space of (X, m_X).

Let F be any closed subset in (Y, m_Y) since f is mg-continuous $f^{-1}(F)$ is mg -closed in (X, m_X) In chapter 4, the intersection of a closed set and a mg-closed set is mg-closed set. Thus if $f^{-1}(F) \cap H = H_1$ and H_1 is a mg-closed set in (X, m_X). Since $(f/H)^{-1}(F) = H_1$. It is sufficient to show that $H_1$is mg-closed in H. Let G_1 be any open set of H such that $G_1 \supset H_1$. Let $G_1 = G \cap H$ where G is open in (X,m_X). Now $H_1 \supset G \cap H \subset G$ since H_1 is mg-closed in (X, m_X). $H_1^- \subset G$ Now $cl_H(H_1) = H_1 \cap H \subset G \cap H = G_1$where $cl_H(A)$is the closure of a subset $A(cH)$ in a subminimal H of$X$. Therefore f/H is mg-continuous.

Remark 3.11: In the above preposition, the assumption of the closedness of H cannot be removed as seen from the folowing example

Example 3.12: Let (X, m_X) and (Y, m_Y) and f be as in $y = \{p, q\}$

$X = \{a, b, c\}$ $\tau = \{\phi, \{a\}, X\}$ and $\sigma = \{\phi, \{p\}, Y\}$ Let $f : (X, m_X) \rightarrow (Y, m_Y)$ be defined by $f(a) = f(c) = \{q\} f(b) = \{p\}$. Now $H = \{a, b\}$ is not closed in X. Then f is mg-continuous but the restriction f/H is not mg-continuous. Since for the closed set $F = \{q\} in(y, m_y)$ $f^{-1}(F)$ ={a,c} and $f^{-1}(F) \cap H = \{a\}$ is not mg -closed in H

4. mg- Compact set

Definition 4.1: A non empty set X with a minimal structure m_X is said to be mg-compact if for every cover of X by sets of m_X has finite subcover.
A subset K of a nonempty set X with a minimal structure m_X is said to be mg-compact if every cover K by subset of m_X has a finite subcover
Theroem 4.2: if $f : (X, m_X) \rightarrow (Y, m_Y)$ is mg-continuous function and K is an mg-compact set of (X, m_X) then $f(K)$ is mg-compact

Proof: Let $\{v_i : i \in I\}$ be any cover of $f(k)$ by sets of m_Y For each $x \in X$, there exist $i(x) \in I$ such that $f(x) \in v_{i(x)}$ since f is mg-continuous there exist $U(x) \in m_X$ containing x such that $f(U(x)) \subset v_i(x)$ The family $\{v(x) : x \in k\}$is a cover of k by sets of m_x. Since K is mg-compact, there exist a finite number of points say$x_1, x_2....x_n$ in k such that $k \subset \bigcup\{U(x_k) : x_k, 1 \leq k \leq n\}$ Therefore we obtain $f(K) \subset \bigcup\{f(U(x_k) : x_k \in K, 1 \leq k \leq n\} \subset \bigcup\{v_{ix(k)} : x_k \in K1 \leq k \leq n\}$ this shows that f(k) is mg-compact
Definition 4.3: A function $f : (X, m_X) \rightarrow (Y, m_Y)$ is said to have strongly mg-closed graph if for each $(x, y) \in (X \times Y) - G(f)$, there exist$v \in m_X$ containing x and $V \in m_Y$ such that $[UXm_Y - cl(v)] \cap G(f) = \varphi$ [respectively $[UXV] \cap G(f) = \phi$]
Lemma 4.4: A function $f : (X, m_X) \rightarrow (Y, m_Y)$ has a strongly mg-closed graph (respectively mg-closed graph) if and only if for each $(x, y) \in (X \times Y) - G(f)$ there exist $U \in m_X$containing x and $v \in m_Y$ containing y such that $f(U) \cap m_Y - cl(V) = \phi$(respectively $f(v) \cap V = \phi$)
Thereoem4.5 if f:(X,m_X)$\rightarrow$ (Y, m_Y) is mg-continuous function and (Y, m_Y) is
m_Yg-T_2 then G(f) is strongly mg-closed
Proof: suppose that (x,y)∈(X × Y)-G(f). Then $y \neq$

$f(x)$since Y is $m_Y g - T_2$there exist disjoint sets V and W in m_Y-containing y and f(x) respectively By Lemma 2.6, We have $m_Y - cl(V) \cap W = \phi$ since f is mg-continuous there exist$U \in m_X$contining x such that $f(U) \subset W$. This implied that $f(U) \cap m_Y - cl(V) = \phi$ and by lemma 4.4 , G(f) is strongly mg-closed.

5. mg-Closed sets

Therem 5.1: The intersection of two mg-closed set is mg-closed set in (X, m_X).

Proof: Let A and B be any two mg-closed sets in (X, m_X). To prove $A \cap B$ is mg-closed set. Let G be m_X-open set such that $A \cap B \subseteq G \Rightarrow A \subseteq G \text{and} B \subseteq G$ Since A and B are mg-closed sets, $m_X - cl(A) \subseteq G$ and $m_X - cl(B) \subseteq G$ $m_X - cl(A) \cap m_X - cl(B) \subseteq G$ Hence $m_X - cl(A \cap B) \subseteq G$

Correlloary 5.2: If A is m_X-closed and B is mg-closed in (X,m_X) then $A \cap B$ is mg-closed in (X, m_X)

Proof: Let A be any m_X-closed set and B is mg-closed set To prove $A \cap B$ is mg-closed set in (X, m_X) Let G be m_X-open set such that $A \cap B \subseteq G \Rightarrow A \subseteq G$ and $B \subseteq G$ since A is m_X -closed set, m_X-cl(A)=A [32] m_X-cl(A)$\subseteq$ G. —–(1) since B is mg-closed set, m_X-cl(B)$\subseteq$ G.—(2) From (1) and (2) we get $m_X - cl(A) \cap m_X - cl(B) \subseteq G$. Hence m_X-cl(AnB)$\subseteq$ G. **Remark 5.3:** The union of two mg-closed set is not mg-closed set as seen from the following example

Example 5.3: Let X= {a,b,c} with minimal structure m_X= {ϕ,{a},{b}{a,c},{b,c}} then the sets {a} and {b} are mg-closed sets in (X,m_X). But the Union {a,b} is not mg-closed set in (X, m_X)

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