Generalized multiset and multiset ideal continuous function

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Abstract. In this article, we define the multiset ideal continuous function and generalized multiset continuous function. We have defined different types of continuous function between multiset-ideal and generalized multiset topological space. We have studied different properties and verify different example for the results. The concept of multi-continuity in ideal structure in multiset ideal topological space has been studied.

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1 Introduction

Cantor's set is not enough for representing the all kind of situations of our real world. In Cantor's set theory, repetition of elements is not allowed. However, there are many situations where repetition of elements plays a vital role. This led the introduction of the theory of the notion of multisets, which was first studied by Blizard [1] in the year 1989. Thus, a multiset is a collection of elements in which certain elements may occur more than once and number of times an element occurs is called its multiplicity.

In this article our aim is to study the properties of continuous function on multiset-ideal and multiset-generalized topological spaces. Many authors had been studied on this direction of multiset ideal and generalized multiset topological spaces.

In 1991 Bilzard [2] designing the multiset theory and further developed the multiset theory in 1989. Many researchers defined the multiset topological spaces; one may refer to New axioms in topological spaces [4] , Separation axioms on multiset topological Space [5], Relations and functions in multiset context [6]. There after different properties of multiset topological space, such as compactness studied by Mahanta and Samanta [9], multiset quasicoincidence studied by Shravan and Tripathy multiset quasiconcidence between multisets, continuous function on multisets, generalized closed multiset [11] , [12], [13], [14]. Multiset mixed topological space between two

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m-sets studied by Tripathy and Das [18].

In this article we have established many results between generalized multiset and multiset ideal topological space. We define different types of continuous function between two multiset generalized topological space, Multiset Ideal and generalized topological space. By the results of this article we can study the ideal structure and generalized topological structure at a time, and we can can find the similarity between the topological structures.

This paper is organized in the following way, first section is introduction part in this section author focused on the previous work and back ground of the research. In the section two, author provides some preliminary results and definitions for the article which is necessary for the work. In the section 3 is the main section in which author established main results of this article and define some new definition. . In the section 4 author discussed about the properties of msgp and $m-I$-continuous functions. Section five is the conclusion section in which future plane of this work has been discussed and the application field has been analyzed by the author.

2 Preliminaries

In this section we procure some basic definitions and notations those will be used throughout this article.

A multiset with domain set X, in which no element occurs more than w times is denoted by $[X]^w$. The count function C_m on X represents the repetition of an element, denoted by $C_m(x)$, for $x \in X$. When $C_m(x) = 1$, for all $x \in X$, then the multiset becomes a Cantor's set.

Thought the articles we shall use the definition of Multiset mixed topological space (Shravan and Tripathy [13]) and ltra-Separation Axioms in Generalized Topological Space (Powar and Rajak [10]) for the union, intersection, compliment, support set, empty set, equality of msets, partial whole sub-mset etc. on msets.

Definition 2.1. A domain X is defined as a set of elements from which msets are constructed. The mset space $[X]^m$ is the set of all msets whose elements are in X such that no element in the mset occurs more than m times. The set $[X]^\infty$ is the set of all msets over a domain X such that there is no limit on the number of occurrences of an element in an mset.
Let $M, N \in [X]^m$. Then, the following are defined:

(1) M is a submset of N denoted by $(M \subseteq N)$ if $C_M(x) \leq C_N(x) \forall x \in X$.

(2) $M = N$ if $M \subseteq N$ and $N \subseteq M$.

(3) M is a proper submset of N denoted by $(M \subset N)$ if $C_M(x) \leq C_N(x) \forall x \in X$ and there exists at least one element $x \in X$ such that $C_M(x) < C_N(x)$.

(4) $P = M \cup N$ if $C_P(x) = max\{CM_(x), C_N(x)\}$ for all $x \in X$.

(5) $P = M \cap N$ if $C_P(x) = min\{C_M(x), C_N(x)\}$ for all $x \in X$.

(6) Addition of M and N results is a new mset $P = M \bigoplus N$ such that $C_P(x) = min\{C_M(x) + C_N(x), m\}$ for all $x \in X$.

(7) Subtraction of M and N results in a new mset $P = M \ominus N$ such that $C_P(x) = max\{C_M(x) - C_N(x), 0\}$ for all $x \in X$, where $\bigoplus$ and $\ominus$ represent mset addition and mset subtraction, respectively.

(8) An mset M is empty if $C_M(x) = 0 \forall x \in X$.

(9) The support set of M denoted by M^* is a subset of X and $M^* = \{x \in X : C_M(x) > 0\}$; that is, M^* is an ordinary set and it is also called root set.

(10) The cardinality of an mset M drawn from a set X is $Card(M) = \sum_{x \in X} C_M(x)$.

(11) M and N are said to be equivalent if and only if $Card(M) = Card(N)$.

Definition 2.2. Let $M \in [X]^m$ and $N \subseteq M$. Then, the complement N^c of N in $[X]^m$ is an element of $[X]^m$ such that $N^c = M - N$.

Definition 2.3. Let $M \subseteq [X]^m$ and $P^*(M)$. Then τ is called a multiset topology of M if satisfies the following properties,
1. The mset M and the empty mset $\varnothing$; are in τ.
2. The mset union of elements of any subcollection of τ is in τ.
3. The mset intersection of the elements of any finite sub-collection of τ is in τ.
The elements of τ are called open msets. The complement of an open mset in an M-Topological space is said to be closed mset.

Definition 2.4. Given a submset A of M-topological space M in $[X]^w$ the interior of N is denoted by $Int(N)$ and is defined as the mset union of all open msets contained in N, i.e $C_{Int(N)}(x) = max\{C_G(x) : G \subseteq N\}$.

Definition 2.5. Given a submset A of an M-topological space M in $[X]^w$, the closure of A is defined as the mset intersection of all closed msets containing A and is denoted by $Cl(A)$, i.e $C_{Cl(N)}(x) = min\{C_K(x) : N \subseteq K\}$.

Definition 2.6. Let (M, τ) be an M-topological space and M_1 is a sub-mset of M. The collection $\tau_N = \{U' = U \cap M_1 : U \in \tau\}$ is an M-topology on M_1, called the subspace M-topology. With this M-topology, M_1 is called a subspace of M and its open msets consisting of all mset intersections of open msets of M with M_1.

Definition 2.7. A non-empty collection I of submsets of a non-empty mset M is said to be an mset ideal on M, if it satisfies the following conditions:
(1). $N_1 \in I$ and $N_2 \subseteq N_1$ with $C_{N_2}(x) \leqslant C_{N_1}(x)$ for all $x \in X \Rightarrow N_2 \in I$.
(2). $N_1 \in I, N_2 \in I \Rightarrow N_1 \cup N_2 \in I$. The mset ideal is abbreviated as M-ideal. The triplet (M, τ, I) is called ideal topological space with the ideal I and topology τ.

Definition 2.8. Let $[X]^w$ be a space of multisets. A multipoint is a multiset M in X such that $C_M(x) = \begin{cases} k, for x \in M; \\ 0, otherwise, \end{cases}$
where $k \in \{1, 2, 3, ...w\}$ and $C_M(x)$ is the multiplicity of x in X.

A multipoint, denoted by $\{k/x\}$ is a subset of a multiset M or $\{\frac{k}{x}\} \in M\ if\ k \leqslant C_M(x)$ for all x. Let (M, τ) be a M-topological space and I be an M-ideal on M. N is any submset of M, then the local function denoted by $N^*(I, \tau)$ is defined by, $N^*(I, \tau) = \{\frac{m_i}{x_i} \in M : C_U(x_j) - C_{N^c}(x_j) > C_I(x_j), I \in I$ for every $U \in N_q(m_i/x_i)$ and at least one $x_j \in X\}$, where $N_q(m_i/x_i)$ is the set of $q - nbhd$ of m_i/x_i. We will write $N^*(I)$ or N^* in place of $N^*(I, \tau)$.

Definition 2.9. Let M be any non-empty multiset and τ be the collection of subsets of the multiset M. the pair (M, τ) is said to be a generalized multiset topological space if the following property holds
1. $\varnothing \in \tau$.
2. If $H, G \in \tau$ then $H \cap G \in \tau$.
3. If $u_{i\in\Lambda} \in \tau$ then $\cup_{i\in\Lambda} u_i \in \tau$.

Remark 2.10. The multiset generalized topological space is the generalized form of multiset topology. Sometimes we denote generalized multiset topology by $(M(N), \tau)$, where $\cup_{i\in\Lambda} u_i = N$.

3 Main Results

Definition 3.1. Let (M, τ) be a multiset topological space on $[X]^w$ and N be a sub-mset of M. We define the following definition:

(i) A semi-open mset if $N \subseteq Cl(Int(N))$ with $C_N(x) \leq C_{Cl(Int(N))}(x), \forall x \in X$

(ii) A semi-closed mset if $Int(Cl(N)) \subseteq N$ with $C_{Int(Cl(N))}(x) \leq C_N(x), \forall x \in X$

(iii) A semi-pre-open mset if $N \subseteq Cl(Int(Cl(N)))$ with $C_N(x) \leq C_{Cl(Int(Cl(N)))}(x), \forall x \in X$.

(iv) A semi-pre closed mset if $Int(Cl(Int(N))) \subseteq N$ with $C_{Int(Cl(Int(N)))}(x) \leq C_N(x), \forall x \in X$.

(v) A preopen mset if $N \subseteq Int(Cl(N))$ with $C_N(x) \leq C_{Int(Cl(N)))}(x), \forall x \in X$.

(vi) A pre-closed mset if $Cl(Int(N)) \subseteq N$ with $C_{Cl(Int(N))}(x) \leq CN(x), \forall x \in X$.

(vii) An α-open mset if $N \subseteq Int(Cl(Int(N))$ with $C_{Cl(Int(N))}(x) \leq C_N(x), \forall x \in X$.

(viii) A α-closed if $Cl(Int(Cl(N))) \subseteq N$ with $C_{Cl(Int(Cl(N)))}(x) \leq C_N(x), \forall x \in X$.

The family of all semi open and semi pre-open multiset of M will be denoted by $mSO(M)$ and $mSPO(M)$.

The multiset semi-closure, semi-pre closure, the pre-closure, the α-closure of a sub-mset N of a multiset topological space (M, τ) is the intersection of all multiset semi-closed, semi pre closed, preclosed, α-closed sets that contain N and is denoted by $msCl(N), (mspCl(N), mpCl(N), m\alpha - Cl(N)$.

The multiset semi-interior (multiset semi-pre-interior) of a sub-mset N of a multiset topological space (M, τ). Is the union of all multiset semi-open (multiset semi-pre-open) sets which are contained in N and is denoted by $msInt(N)(mspInt(N))$.

Lemma 3.1. *A sub mset N in a multiset topological space (M, τ) is said to be semi-pre closed if and only if $N = spCl(N)$.*

Definition 3.2. A sub-mset N of a multiset topological space (M, τ) is called:
(i) A multiset generalized semi-closed (briefly mgs-closed) set if $msCl(N) \subseteq U$ whenever $N \subseteq U$ and U is open in generalized M space.

(ii) An α-generalized multise closed (briefly αmg-closed) set if $\alpha Cl(N) \subseteq U$ whenever $N \subseteq U$ and U is open in generalized M space. The complement of an αmg-closed set is called an αmg-open set.

(iii) A generalized multiset α-closed (briefly $mg\alpha$-closed) set if $\alpha Cl(N) \subseteq U$ whenever $N \subseteq U$ and U is $\alpha-$open in generalized M space.

(iv) A generalized multise pre-closed (briefly mgp-closed set if $pCl(N) \subseteq U$ whenever $N \subseteq U$ and U is open in generalized M space.

(v) A generalized multise semi-pre closed (briefly $mgsp$-closed) set if $spcl(N) \subseteq U$ whenever $N \subseteq U$ and U is open in generalized M space.

Definition 3.3. Let (M_1, τ_1) and (M_2, τ_2) be two topological spaces a function $f : M_1 \to M_2$ is called
(i) multi-semi-continuous if the inverse image of each m-open set of M_2 is m-semi-open in M_1.

(ii) multi-semi pre continuous if the inverse image of each m-open set of M_2 is $m-$semi-preopen in M_1.

(iii) multi-g-continuous if the inverse image of each m-open set of M_2 is mg-open in M_1.

(iv) multi-gp-continuous if the inverse image of each m-open set of M_2 is mgp-open in M_1.

(v) multi-gsp-continuous if the inverse image of each m-open set of M_2 is $m-gsp$-open in M_1.

(vi) multi-pre-continuous if the inverse image of each m-open set of M_2 is m-preopen in M_1.

(vii) multi-pre-irresolute if the inverse image of each m-preopen set of M_2 is m-preopen in M_1.

Definition 3.4. Let (M, I, τ) be an multiset ideal topological space on $[X]^w$. A subset A of multiset ideal space is said to be $pre-I-open M$-set if $A \subseteq int(cl(A^*))$ with $C_A(x) \leqslant C_{int(cl(A^*))}(x)$ for all $x \in X$. The compliment of $pre-I-open$ M-set is called $pre-I-closed$ M-set.

Definition 3.5. Let (M, I, τ) be an multiset ideal topological space in $[X]^W$. A sub M-set A of M is called a $semi-I-open$ M-set if $A \subseteq cl(int(A^*))$ with $C_A(x) \leqslant C_{cl(int(A^*))}(x)$, for all $x \in X$. The complement of a semi-open M-set is called a $semi-I-closed$ M-set.

4 Properties of msgp and $m-I$-Continuous Functions

Definition 4.1. Let (M_1, τ_1) and (M_2, τ_2) be two topological spaces a function $f : M_1 \to M_2$ is called mgsp-continuous if $f^{-1}(N)$ if mgsp-closed in M_1 for every closed set N of M_2.

Lemma 4.1. *Every g-continuous function is mgsp-continuous function.*

Lemma 4.2. *Every gp-continuous function is gsp-continuous function.*

We recall the following:

Definition 4.2. Let (M_1, τ_1) and (M_2, τ_2) be two topological spaces a function $f : M_1 \to M_2$ is called generalized multiset semi-pre irresolute (in short $mgsp$-irresolute) if $f^{-1}(N)$ is $mgsp$-closed in M_1 for every $mgsp$-closed m-set N of M_2.

Lemma 4.3. *Every mgp-irresolute is mgsp-irresolute.*

Theorem 4.4. *If the bijective function $f : M_1 \to M_2$ is m-semi-pre continuous and m-open then f is $mgsp - irresolute$.*

Proof. Let N be gsp-closed in M_2 and let $f^{-1}(N) \subseteq K$, where K is open set in M_1.

Clearly, $N \subseteq f(K)$. Since $f(K)$ is open set in M_2 as f is open and as N is gsp-closed in M_2, then $spCl(N) \subseteq f(K)$ and thus $f^{-1}(spCl(N)) \subseteq K$. since f is m-semi-pre irresolute and $mspCl(N)$ is a $m-$semi-irresolute closed set, then $f^{-1}(spCl(N))$ is m-semi-pre closed in M_1.

Thus, $mspCl(f^{-1}(N)) \subseteq spCl(f^{-1}(mspCl(N))) = f^{-1}(mspCl(N)) \subseteq K$. So $f^{-1}(N)$ is $mgsp$-closed set and f is $mgsp$-irresolute. □

We recall the following.

Definition 4.3. Let (M_1, τ_1) and (M_2, τ_2) be two topological spaces a function $f : M_1 \to M_2$ is called αmg-continuous if $f^{-1}(N)$ is αmg-closed in M_1 for every closed set N of M_2.

Lemma 4.5. *Every $\alpha - mg$-continuous $\alpha - mgp$-continuous $\alpha - mgsp$-continuous. We define the following.*

Definition 4.4. A topological space (M, τ) is called a T^* mg-space if every $mgsp$-closed set is mg-closed.

Theorem 4.6. *Every mgsp-continuous function $f : M_1 \to M_2$ is mg-continuous if M_1 is a T^* mg-space.*

Definition 4.5. Let (M_1, τ_1) and (M_2, τ_2) be two topological spaces a function $f : M_1 \to M_2$ is said to be pre-mgsp-continuous if inverse image of each m-semi-pre-open set of M_2 is $mgsp$-open in M_1.

Definition 4.6. Let (M_1, τ_1) and (M_2, τ_2) be two topological spaces a function $f : M_1 \to M_2$ is said to be $m - p - mgsp$-continuous if inverse image of each m-pre-open mset of M_2 is $mgsp$-open in M_1.

Next, we prove the following.

Theorem 4.7. *For any mgsp-irresolute function $f : M_1 \to M_2$ and $p - mgsp$-continuous function $g : M_2 \to M_3$, the composition $g \circ f : M_1 \to M_3$ is $p - mgsp$-continuous.*

Proof. Let N be any pre-open mset in M_3. Since g is $p - mgsp$-continuous, then $g^{-1}(N)$ is mgsp-open in M_2. Hence, $f^{-1}(g^{-1}(N))$ is $mgsp$-open in M_1 since, f is $mgsp$-irresolute. But $f^{-1}(g^{-1}(N)) = (g \circ f)^{-1}(N)$. So $g \circ f$ is $p - mgsp$-continuous. □

Theorem 4.8. *Let $f : M_1 \rightarrow M_2$ is a $p-$mgsp-continuous function and $g : M_2 \rightarrow M_3$ is pre-continuous function, then their composition is a mgsp-continuous.*

Theorem 4.9. *Let $f : M_1 \rightarrow M_2$ is a pre-mgsp-continuous and $g : M_2 \rightarrow M_3$ is semi-precontinuous, then their composition $g \circ f$ is mgsp-continuous.*

Theorem 4.10. *Let $f : M_1 \rightarrow M_2$ is a pre-mgsp-continuous and $g : M_2 \rightarrow M_3$ is semi-preirresolute, then their composition $g \circ f$ is pre-mgsp-continuous.*

Theorem 4.11. *Let $f : M_1 \rightarrow M_2$ is a pre-mgsp-continuous and $g : M_2 \rightarrow M_3$ is $p -$ mgsp-continuous, then their composition gof is $p -$ mgsp-continuous.*

Theorem 4.12. *Let $f : M_1 \rightarrow M_2$ is a mgsp-irresolute and $g : M_2 \rightarrow M_3$ is $pre -$ mgsp-continuous, then their composition $g \circ f$ is $pre -$ mgsp-continuous.*

Theorem 4.13. *A function $f : M_1 \rightarrow M_2$ is called strongly mgsp-continuous if the inverse image of every mgsp-open mset of M_2 is m-open in M_1.*

Theorem 4.14. *every strongly mgsp-continuous function is m-continuous.*

Definition 4.7. A function $f : M_1 \rightarrow M_2$ is called strongly m-continuous if the inverse image of every sub-mset in M_2 is $m - cl - open$ in M_1.

On the basis of the above definition we give the following results:

Theorem 4.15. *If the function $f : M_1 \rightarrow M_2$ is strongly m-continuous, then f is strongly mgsp-continuous.*

Theorem 4.16. *If the function $f : M_1 \rightarrow M_2$ is strongly mgsp-continuous and the function $g : M_2 \rightarrow M_3$ is mgsp-continuous, then $g \circ f : M_1 \rightarrow M_3$ is m-continuous.*

Proof. Let N be any open mset in M_3. Since g is *mgsp*-continuous, then $g^{-1}(N)$ is *mgsp*-open in M_2. Hence, $f^{-1}(g^{-1}(N))$ is open multiset in M_1 because f is strongly *mgsp*-continuous.

But $f^{-1}(g^{-1}(U)) = (g \circ f)^{-1}(U)$. So $g \circ f$ is m-continuous.
□

Theorem 4.17. *If the function $f : M_1 \rightarrow M_2$ is mgsp-continuous and the function $g : M_2 \rightarrow M_3$ is strongly mgsp-continuous, then $g \circ f : M_1 \rightarrow M_3$ is mgsp-irresolute.*

Theorem 4.18. *If the function $f : M_1 \to M_2$ is strongly mgsp-continuous and the function $g : M_2 \to M_3$ is mgsp-irresolute, then $g \circ f : M_1 \to M_3$is strongly mgsp-continuous.*

We, define the following.

Definition 4.8. A function $f : M_1 \to M_2$ is said to be contra *mgsp*-continuous if the inverse image of each open mset of M_2 is *mgsp*-closed set in M_1.

Definition 4.9. A function $f : M_1 \to M_2$ is said to be contra $mpre - gsp$-continuous if the inverse image of each $m-$semi-preopen mset of M_2 is *mgsp*-closed set in M_1.

Definition 4.10. A function $f : M_1 \to M_2$ is said to be contra *mgsp*-irresolute if the inverse image of each *mgsp*-open set of M_2 is *mgsp*-closed set in M_1.

Definition 4.11. A function $f : M_1 \to M_2$ is said to be s-gsp-continuous if the inverse image of each semi-open mset of M_2 is *mgsp*-open mset in M_1.

We, give the following.

Theorem 4.19. *If the function $f : M_1 \to M_2$ is contra mgsp-irresolute and the function $g : M_2 \to M_3$ is mgsp-continuous, then $g \circ f : M_1 \to M_3$ is contra mgsp-continuous.*

Theorem 4.20. *If the function $f : M_1 \to M_2$ is strongly mgsp-continuous and the function $g : M_2 \to M_3$ is contra mgsp-irresolute, then $g \circ f : M_1 \to M_3$ is strongly mgsp-continuous.*

Theorem 4.21. *Let $f : M_1 \to M_2$ is a contra pre-mgsp-continuous and $g : M_2 \to M_3$ is multiset semi-pre-continuous, then their composition $g \circ f$ is contra mgsp-continuous.*

Theorem 4.22. *Let $f : M_1 \to M_2$ is a mgsp-continuous and $g : M_2 \to M_3$ is strongly mgsp-continuous, then their composition $g \circ f$ is mgsp-irresolute.*

Theorem 4.23. *Let $f : M_1 \to M_2$ is a contra mgsp-irresolute and $g : M_2 \to M_3$ is $p -$ mgsp-continuous, then their composition $g \circ f$ is $p -$ mgsp-continuous.*

Theorem 4.24. *Let $f : M_1 \to M_2$ is a mgsp-irresolute and $g : M_2 \to M_3$ is contra pre-mgsp-continuous, then their composition $g \circ f$ is contra pre-mgsp-continuous.*

Definition 4.12. Let (M_1, I, τ_1) and (M_2, I, τ_2) be two a m-ideal topological space, a function $f : M_1 \to M_2$ is said to be $m - I$ -continuous if inverse image of each $m - I$ -open mset of M_2 is $m - I$-open in M_1.

Definition 4.13. Let (M_1, I, τ_1) be a m-ideal topological space and (M_2, τ_2) be generalized m-topological spaces a function $f : M_1 \to M_2$ is said to be $m - I - gn$-continuous if inverse image of each mg -open mset of M_2 is $m - I$-open in M_1.

Theorem 4.25. *If $f : M_1 \to M_2$ be $m - I - gn$-continuous function from an multiset ideal topological space to generalized multiset topological space then the following are equivalent.*

1. for each local function A^* in M_1 there exist an multiset local function $f(A^*)$ in M_2.

2. For the multiset ideal I there exist an ideal $f(I)$ in M_2.

3. For every mgsp-closed(Open) set in M_2 there exist a multiset-semi-pre-ideal closed (open) set in M_1.

Theorem 4.26. *If the function $f : M_1 \to M_2$ be $m - I$ -continuous and the function $g : M_2 \to M_3$ be $m-I-gn$-continuous, then $g \circ f : M_1 \to M_3$ is $m-I-gn$-continuous.*

Proof. Let N be any open mset in M_3. Since g is $m - I - gn$-continuous, then $g^{-1}(N)$ is $m - I$-semi-pre-open in M_2. Again, f is $m - I$ -continuous. Hence, $f^{-1}(g^{-1}(N))$ is $m - I$-open multiset in M_1
But $f^{-1}(g^{-1}(N)) = (g \circ f)^{-1}(N)$. So $g \circ f$ is $m - I - gn$-continuous. □

5 Conclusion

In this paper we introduce the different types of generalized multiset continuous function. Continuous function between Ideal structure and generalized multiset topological space has been studied. Many interesting results between ideal and generalized multiset topological structure can be analyzed. Many research works can be done in this dimension in future.

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