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On Supra iR-Open Set in Topological Spaces and Some Applications

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***Abstract:** In this work we introduce the supra iR-open set in supra topological spaces. , a novel class of supra i-open sets. This class of sets exactly lies between supra regular open and supra i- open sets. We also look at its basic characteristics and compare it to other sorts of data supra semi open sets types as supra i- open set, supra regular open, regular open, regular closed, clopen, supra semi regular open set and supra clopen . By using this set , We introduce and define the notion of supra totally iR-continuous , supra iR-irresolute map and investigate some of its properties. We prove that every supra totally iR- continuous function is supra iR-irresolute, every totally iα-continuous function is supra totally iR-continuous and any strongly continuous function is supra totally iR-continuous, on the other hand, we give examples to show that the convers may not be true. At last , We have proved some theorem to discuss the properties of supra iR-normal space and supra iR-regular space*

***Keywords:** Supra iR-Open Set, Aupra Totally iR-continuous, Supra iR-irresolute.*

1. INTRODUCTION

In 1983, Mashhour [1] explored s-continuous and s*-continuous maps and established supra topological spaces. Thus, where the supra topological space is offered, the supra open sets are defined. Every topological space is a supra topological space, as we have known. Each open set is therefore a supra open set. The opposite, however, is not always true. It is not necessary to consider the intersection requirement to have a supra topological space. Supra α-open sets and supra α-continuous maps were created and researched as a kind of set and map between topo-logical spaces by Deve [11] in 2008. In 2012, Mohammed and Askandar [2] proposed the notion of *i*-open sets, which they could combine with a variety of other generalized open set concepts. In 2016, Jardo, presented the notions of supra *i*-open sets and discussed the notions of supra i-continuous maps, supra *i*-open maps, and supra *i*-closed maps in topological spaces[7] .The concept of supra totally πgr- continuous function in supra topological spaces

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was presented by C. Janaki and V. Jeyanthi [6] in 2015. New Types of Perfectly Supra Continuous Functions was presented by Humadi and Ali in [10] . Shaheen. S. A. [12] introduced the concept of *iR*-open sets. Supra *iR*-open sets are now presented. Supra *iR*-open sets are characterized and properties are obtained. As applications some new classes of functions namely Supra totally *iR*-continuous and supra *iR*-irresolute map are presented. Moreover, we investigate the relationship between these functions and other related classes of functions are also developed. last , For supra *iR*-open sets, we provide new weak separation axioms, and we show that supra totally *iR*-continuous function is related to supra iR-separation axioms.

2. RESEARCH METHOD

During this paper (P, μ) (simply P) denote supra topo-logical spaces on which, unless otherwise stated, no separation axioms are imposed. Let P be a space and $E \subseteq P$, the closure of E and the interior of E will be denoted by Cl (E) and Int (E) respectively. The supra closure of E and supra interior of E will be denoted by cl^{μ} (E) and int^{μ} (E) respectively. P-E is the complement of E.

2.1 Definition [5]
Supra topology on P refers to a subfamily of P. if :
1) $P, \emptyset \in \mu$. 2) If $E_i \in \mu$ for every one $i \in J$, then $\cup E_i \in \mu$.
A supra topo-logical space refers to the pair (E, μ) . The elements of in (E, μ) are referred to as supra open sets. while the complement of supra open set is known as supra closed set.

2.2 Definition [5]
(1) The symbol cl^{μ} (E) represents a set's supra closure and is defined as
$cl^{\mu}(E) = \cap\{F : F$ is supra closed and $E \subseteq F\}$.
(2) The symbol $int^{\mu}(E)$ represents a set's supra interior and is defined as
$int^{\mu}(E) = \cap\{F : F$ is supra open and $F \subseteq E\}$.

2.3 Definition [1]
Let (P,τ) denote a topo-logical space and μ a supra topology on P. We consider μ a supra topo-logy associated with if $\tau \subset \mu$.

2.4 Definition
The following is a subset E of a topo-logical space P :
1. regular open sets [8] if $E = Int(cl(E))$, and regular closed if $E = cl\big(int(E)\big)$
2. i-open set [2][4] if $\subseteq cl(E \cap U)$, $where \exists\, U \in \tau$ and $U \neq P, \emptyset$.
3. α-open set, denoted by α-OS, if $E \subseteq Int\,(cl(Int(E)))$[3]
4. $i\alpha$-open set [3] if $E \subseteq Cl(E \cap U)$, where $\exists\, U \in \alpha O(P)$ and $U \neq \emptyset, P$.
5. If E is both open and closed, clopen is set.
6. iR-open set [12][13] if $E \subseteq Cl(E \cap U)$, where $U \in RO(E)$ and $U \neq \emptyset$, P .
7. supra regular open set [8] if $E = int^{\mu}(cl^{\mu}(E))$.
8. supra semi regular open set [9] if there is a supra regular open set U^{μ} such that

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$U^{\mu} \subseteq E \subseteq cl^{\mu}(U^{\mu})$.

9. supra *i*-open set [7] if $E \subseteq cl^{\mu}(E \cap U^{\mu})$ where $\exists\, U^{\mu} \in \mu$ and $U^{\mu} \neq P, \emptyset$.

Close sets are the complement of the above open sets. The most important family of all open (or. supra regular open , supra semi regular open , supra *i*-open , $i\alpha$-open , supra clopen, supra *iR*-open , regular closed) sets of supra topo-logical space are denoted by τ (resp. $R^{\mu}O(P)$, $SR^{\mu}O(P)$, $i^{\mu}O(P)$, $i\alpha O(P)$, $CO^{\mu}(P)$, $iR^{\mu}O(P)$, $RC(P)$.
The definitions that follow will be helpful in the sequel.

2.5 Definition
Allow P and K be a topo-logical space, a map M: $P \longrightarrow K$ is said to be :
1. strongly continuous [14] if $M^{-1}(U) \in CO(P)$, $\forall\, U \in K$.
2. $i\alpha$ - totally continuous [3] if $M^{-1}(U) \in CO(P)$, $\forall\, U \in i\alpha O(K)$.
3. *i*-irresolute [3] if $M^{-1}(U) \in iO(P)$ $\forall\, U \in iO(K)$.

We recall the following definitions and results.

2.6 Lemma [12][13]
Every regular open set and regular closed set and clopen set is an *iR*-open set.

2.7 Lemma [12][13]
In a topo-logical space (P,τ), every *iR*-open set is an $i\alpha$-open set .

2.8 Lemma [9]
In a topo-logical space, an open set is any regular open set.

2.9 Lemma [8]
Any supra regular open is supra open.

3. RESULTS AND DISCUSSION

We now offer a different kind of supra open sets known as supra *iR*-open sets and examine how they relate to other supra open sets such as supra open, supra regular open, supra semi regular open, supra *i*-open, and supra clopen.

3.1 Definition
Consider the topo-logical space (P, μ) .If there exist a supra regular open set $U^{\mu} \neq P, \emptyset$ such that $E \subseteq cl^{\mu}(E \cap U^{\mu})$, the set E is called supra *iR*-open set. Supra *iR*-closed set is the complement of supra *iR*-open set. $iR^{\mu}O(P)$ stands for the universal family supra *iR*-open sets of topo-logical space.

3.2 Example
Assume that (P, μ) is a supra topo-logical space with P ={b ,a, c} , μ = {P, {a}, {b,a}, {c,b},$\emptyset$ }. $iR^{\mu}O(P)$ = {P,{b},{a},{c},{b, c}, $\emptyset$ }.

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3.3 Proposition
Every regular open set and regular closed set and clopen set is supra *iR*-open set.
Proof: Due to lemma 2.6 and the fact that every *iR*-open set is a supra *iR*-open set,

3.4 Theorem
A supra *iR*-open set is a supra semi regular open set.
Proof : Allow any supra semi regular open set $(P\ ,\mu\ )$ to be E .Then, according to the explanation given of supra semi regular open set , There is a regular open set U^{μ} such that $U^{\mu}\subseteq E\subseteq\ cl^{\mu}(U^{\mu})$.....(1) , Since $U^{\mu}\subseteq E$ then $E\cap U^{\mu}=\ U^{\mu}$ ...... (2)
From(1) and (2) we obtain $E\subseteq cl^{\mu}(A\cap U^{\mu})$. Thus E is an *iR*-open set ■

3.5 Proposition
Each and every supra *iR*-open set also exist as a supra i-open set.
Proof : Allow any E be any supra *iR*-open set in $(P\ ,\mu\ )$. Then according definition of supra *iR*-open set, there exist a supra regular open set $U^{\mu}\neq E,\emptyset$ like that $E\subseteq cl^{\mu}(E\cap U^{\mu})$. as a result that every supra regular open is a supra open set by lemma 2.9 , Then $U^{\mu}\ \in\mu$. We obtain $E\subseteq cl^{\mu}(E\cap U^{\mu})$ where $\exists\ U^{\mu}\in\mu$ and $U^{\mu}\neq P,\emptyset$. Thus E is supra *i*-open set ■

3.6 Proposition
There is a supra *iR*-open set for each supra regular open set.
Proof: Let E be any supra regular open set in $(P\ ,\mu\ )$. We prove that E is supra *iR*-open set if there exist $U^{\mu}\in R^{\mu}O(E)$ such that $E\subseteq cl^{\mu}(E\cap U^{\mu})$. Since E is supra regular open set by definition of supra regular open set $E=int^{\mu}(cl^{\mu}(A))$. Put $E=U^{\mu}$, we get $E\subseteq cl^{\mu}(E\cap E)=cl^{\mu}(E)$. This mean A is supra *iR*-open set ■
The following examples shows that the convers of proposition 3.4, proposition 3.5 , proposition 3.6 **,** in general is not true .

3.7 Example
$P=K$ = {a, c, b}, τ = {P, {a} ,{b, c} , $\emptyset$ } , *CO(P)*={$\emptyset$,{b,c}, {a}, P }, *RO(P)*={ P,{a},{b, c}, $\emptyset$}= *RC (P)* , μ ={ $\emptyset$,{a},{a,b},{b,c}, P }, $R^{\mu}O(P)$ ={$\emptyset$, {a} ,{c,b}, P} , $SR^{\mu}O(P)$ ={$\emptyset$, {a },{c,b} , P}. $iR^{\mu}O(P)$ ={ $\emptyset$, {a} ,{b},{c} ,{b,c}, P} , $i^{\mu}O(P)$ ={ $\emptyset$,{a} ,{c},{b} ,{a,b} ,{b,c}, P}.

3.8 Remark
Every supra clopen is supra regular open set according to the definition of this term , and hence by proposition 3.6 is supra *iR*- open set. .
The intersection of supra *iR*-open sets is not required to be supra *iR*-open set as showed in the example below:

3.9 Example
P={a,c,b} , μ={ $\emptyset$, {b} **,** {a} , {b,a} , P } , $iR^{\mu}O(P)$ = { $\emptyset$, {a} ,{b} ,{a,c} , {b,c} , P } , *then* {a,c} ∩ {b,c} = {c} $\notin iR^{\mu}O(P)$ **.**

- As shown in Example 3.9, A supra *iR*-open set not necessarily their union of other supra *iR*-open sets. {a} ∪ {b} = {a,b} $\notin iR^{\mu}O(P)$

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- The supra *iR*-open sets are independent of supra open sets as shown in the two examples : In example 3.9 we note that {a,b} is supra open set but it isn't supra *iR*-open set and in example 3.2, the set {b} is supra *iR*-open set isn't supra open set.
- The following implications can be seen as a result of the foregoing discussion and known results :

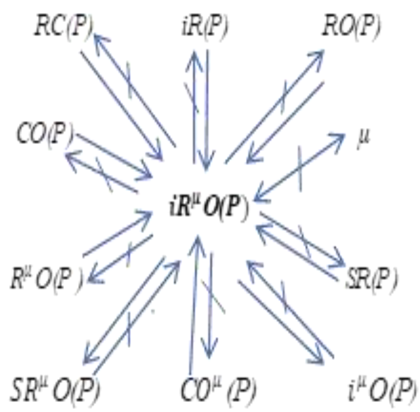

Figure1. The relationships of supra iR-open sets with other classes mentioned above

Mapping that are Supra Totally *Ir*-Continuous and Supra *Ir*-Irresolute

This section includes the notion of supra *iR*-totally cont. and supra *iR*-irresolute map

3.10 Definition

Consider P and K be a topo-logical space, a map $M : P \longrightarrow K$ is stated to be :

- supra totally (perfectly) *iR*-continuous if $M^{-1}(U) \in CO^{\mu}(P)$ $\forall$ $U \in iRO(K)$.
- supra *iR*-irresolute, if $M^{-1}(U) \in iR^{\mu}O(P)$ $\forall$ $U \in iRO(K)$.

3.11 Proposition

Every supra totally *iR*- continuous function is supra *iR*-irresolute.

Proof **:** Let V be any *iR*-open set in K and $M : P \rightarrow K$ be supra totally *iR*-continuous function. M is supra totally *iR*-continuous function , hence , $M^{-1}(V) \in CO^{\mu}(P)$ **.** Because, every supra clopen set is spura regular open set, so V is supra regular open set then by proposition 3.6 $M^{-1}(V)$ supra *iR*-open set in P . So M is supra *iR*-irresolute■ The following example explains how the opposite of the aforementioned need not be true.

3.12 Example

$P = \{a,b,c\}$, $\mu = \{\emptyset, \{c,b\}, \{a\}, P\}$, $CO^{\mu}(P) = \{\emptyset, \{b,c\}, \{a\}, P\}$, $\sigma = \{\emptyset, \{a\}, \{b\}, \{a,b\}, K\}$, $iRO(K) = \{\emptyset, \{a\}, \{b\}, \{c\}, \{b,c\}, K\}$, $iR^{\mu}O(P) = \{\emptyset, \{a\}, \{b\}, \{c\}, \{b,c\}, P\}$ The identity mapping $M : P \rightarrow K$ is clearly supra *iR*-irresolute but M is not supra totally *iR*-continuous .

3.13 Proposition

Every supra totally *iR*- continuous function is supra *i*-irresolute

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Proof**:** The same proof because every supra iR-open set is supra i-open set. The following example demonstrates how the opposite of the previous requirement must not be true.

3.14 Example

$P = K =$ {a,b,c} , μ ={ ∅ , {a} **,** {a ,b}, {b ,c}, P }, $\sigma = \{\emptyset, \{a\}, \{b, c\}, K\}$
$CO^{\mu}(P)$= { ∅ , {a} **,** {b, c},{c},P} , $iO(P)$ = {∅, {a},{b},{c},{a,b} ,{b, c} ,P}
$iO(K)$ = { ∅ , {a} , {b} , {c} , {b ,c} , K } , $iRO(K)$ = {∅, {a},{b},{c},{b, c}, K }.
Although f is not supra totally iR- continuous, it is obvious that the identity $f : P\to K$ is supra i-irresolute.

3.15 Theorem

Also supra totally iR-continuous. is the composition of two such maps.
Proof : let $f : P\to K$ and $g : K\to H$ any two supra iR- totally continuous , Give Y any iR -open set in H . Because g is supra iR-totally continuous, $g^{-1}(Y)$ is supra clopen set in K then $g^{-1}(Y) \in iR^{\mu}O(K)$ which shows $g^{-1}(Y)$ is supra iR-open set in K . Because f is supra totally iR-continuous then $f^{-1}g^{-1}(Y) = (gof)^{-1}(V) \in CO^{\mu}(P)$. Hence , $gof : P\to H$ is supra iR-totally continuous. ■

3.16 Proposition

Every totally $i\alpha$-continuous function is supra totally iR-continuous
Proof **:** Allow Y be any iR- open subset in K and let $f : P\to K$ be totally $i\alpha$- continuous function then, by lemma 2.7 Y is $i\alpha$-open set in K. Because f is totally $i\alpha$-continuous function , $f^{1}(Y)$ is clopen set in P by definition 2.5(2). Hence $f^{1}(Y) \in CO^{\mu}(P)$ set in P. So f is supra totally iR-continuous ■, As shown by the example below it is not necessary for the opposite of the above to be true.

3.17 Example

P=K={c,b,a}, μ ={ ∅ , {b},{a},{b,a},{c,b},{c,a}, P } , $CO^{\mu}(P)$ ={∅,{c,b},{c,a},{b},{a}{c}, P } , $\tau = \{\emptyset, \{a\}, \{b, c\}, P\} = CO(P)$, σ ={∅, {b,a},{a},{b }, K }, $i\alpha O(K)$={ ∅ ,{b},{a},{a,b} ,{c,a},{b ,c}, K }, $iRO(K)$ = {∅, {a},{b},{c, a},{c, b}, K}.The identity mapping $f : P\to K$ is clearly supra iR-totally cont. but f is also not totally $i\alpha$-cont.

3.18 Proposition

Any strongly continuous function is supra totally iR-continuous.
Proof **:** Let $M : P\to K$ any strongly continuous function and give Y any one iR- open subset in K . Because M is strongly continuous function , $M^{-1}(Y)$ is clopen set in P. Hence $M^{-1}(Y) \in CO^{\mu}(P)$ set in P. So f is supra totally iR-continuous ■

3.19 Theorem

A bijective map $M : P\to K$ is supra totally iR-continuous if and only if each supra iR-closed subset of K has a $cl^{\mu}open^{\mu}$ inverse image in P.
Proof : Let C be any supra iR-closed subset in K . Then K-C is supra iR-open in K . Because M is supra totally iR-continuous , $f^{-1}(K\text{-}C) = f^{-1}(K) - f^{-1}(C) = P - f^{-1}(C) \in CO^{\mu}(P)$ Hence $f^{-1}(C) \in CO^{\mu}(P)$. Conversely , let V be any supra iR-open subset in K . By

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assumption $f^{-1}(K\text{-}V) \in CO^{\mu}(P)$ .This denotes P -$f^{-1}(V) \in CO^{\mu}(P)$, $f^{-1}(V) \in CO^{\mu}(P)$. So f is supra totally iR-continuous.■

3.20 Theorem

If $f: P \to K$ is supra totally iR-continuous and $g: K \to H$ is supra iR-irresolute mapping then $gof: P \to H$ is iR- supra totally iR-continuous.

Proof : Assume that V is an iR-open set to H , because $g: K \to H$ is supra iR- irresolute mapping , $g^{-1}(V)$ is supra iR- open to K , Because f is supra iR- totally continuous , $f^{-1}g^{-1}(V) \in CO^{\mu}(P)$. Hence $gof: P \to H$ is supra totally iR-continuous.

3.21 Theorem

If $f: P \to K$ is supra iR-irresolute and $g: K \to H$ is supra totally iR-continuous then $gof: P \to H$ is supra iR-irresolute .

Proof : Let A any iR-open set in H , because g is supra totally iR-continuous function , $g^{-1}(A) \in CO^{\mu}(K)$. Then $g^{-1}(A)$ is supra iR- open in K . As f is supra iR-irresolute . After that $f^{-1}g^{-1}(A) = (gof)^{-1}(A)$ is supra iR-open in P . So gof is supra iR-irresolute ■

New Separation Axioms

We present some new weak supra separation axioms using supra iR-open set in this part.

3.22 Definition

(1) supra iR-regular if disjoint supra iR-open sets. can be separated for any closed set C not containing a point.

(2) If there are two disjoint supra iR-open sets G , W for each disjoint closed set C_1 and C_2 of P , such that $C_1 \subset$ G and $C_2 \subset$ W then supra iR-normal.

3.23 Theorem

Let $M: P \to K$ is supra totally iR-continuous and supra iR-closed injection function , if K is supra iR-regular , then P is supra iR-regular.

Proof: Take C be a supra closed set that does not contain e. We have $M(C)$ is iR-closed set in K not containing $M(e)$ since M is iR-closed. Since , K is supra iR-regular, there is disjoint supra iR-open set D , F such that $M(e) \in D$ and $M(C) \subset F$, which imply $e \in M^{-1}(D)$ and $C \subset M^{-1}(F)$. As M is supra totally iR-continuous. , $M^{-1}(D)$ and $M^{-1}(F)$ are supra clopen set in P . Then $M^{-1}(D)$ and $f^{-1}(F)$ are supra iR-open subset in P (remark 3.8) .Also , since M is an injective , there are $M^{-1}(D) \cap M^{-1}(F) = M^{-1}(D \cap F) = M^{-1}(\emptyset) = \emptyset$. disjoint supra iR-open sets $M^{-1}(D)$ and $M^{-1}(F)$ separate a point e and a closed set C that does not include e. As a result, P is an iR-regular.

3.24 Theorem

If $M: P \to K$ is supra totally iR-continuous and supra closed injection while K is supra iR-normal . Then P is supra iR-normal .

Proof: Take C_1 and C_2 be disjoint supra closed subset of P . Because M is supra closed , $M(C_1)$ and $M(C_2)$ are disjoint supra closed subset in K, and because K is supra iR-normal , $M(C_1)$ and $M(C_2)$ are separated by disjoint supra iR-open subset G and W of K such that $C_1 \subset$

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$M^{-1}(G)$ and $C_2 \subset M^{-1}(W)$. Since M is supra totally iR-continuous $M^{-1}(G)$ and $M^{-1}(W)$ are supra clopen set in P .Which imply $M^{-1}(A)$ and $M^{-1}(B)$ are supra iR-open sets .Also, we have $f^{-1}(G) \cap f^{-1}(W) = f^{-1}(G \cap W) = M^{-1}(\emptyset) = \emptyset$. Thus, In P, each pair of non-empty supra closed sets can be separated by iR-open sets. Therefore, P is supra iR-normal ■

4. CONCLUSIONS

We were able to define a new class of open set type- *i* and compare them with other semi-open sets using this definition. And we found that there is a close correlation between these classes and supra regular open, supra semi regular open ,supra *i*-open , $i\alpha$-open ,supra clopen and regular closed sets .The aforementioned correlation is the same for closed sets.

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