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A NOTE ON THE NEW CLOSED CLASSES AND GP-REGULAR CLASSES IN SOFT SYSTEM

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Abstract

The main purpose of this paper is to introduce and study new closed classes of soft (1,2) −closed sets in bi-topological space like soft $(1,2)-w$-closed sets , soft $(1,2)-rw$-closed and soft $(1,2)-rsp$-closed sets. Also, we study in this work new gp-regular classes in soft system are called soft $(1,2)-$gpr-closed sets in soft bi-topological spaces (X,E,τ_1,τ_2). We introduce these concepts which are defined over an initial universe X with a fixed set of parameters E. Moreover, we investigate the relations between soft $(1,2)-rsp$-closed set and the associated soft closed sets in soft topological space(STS) (X,E,τ) and in soft bi-topological space (X,E,τ_1,τ_2). Furthermore, several examples are given to illustrate the concepts introduced in this paper.

Keywords: soft sets theory,soft w -closed, soft rw -closed, soft gp-regular.

AMS Subject Classification (2010): 54A10, 54C10, 54A05.

摘要

本文的主要目的是介绍和研究双拓扑空间中软（1,2）闭合集的新封闭类，如软（1,2）- 闭集，软（1,2）- 闭合和软（1,2）- 闭合集。此外，我们在这项工作中研究软系统中的新 gp-regular 类在软双拓扑空间中称为软（1,2）-gpr-闭集。我们介绍了这些概念，这些概念是在具有固定参数集的初始 Universe 中定义的。此外，我们研究了软拓扑空间（STS）和软双向拓扑空间中软（1,2）-rsp-闭集与相关软闭集之间的关系。此外，给出了几个例子来说明本文介绍的概念。

关键词:软集理论，软闭合，软闭合，软 gp-正则。

I. INTRODUCTION

The concept of soft sets is a novel notion was introduced in 1999, by Molodtsov [1]. This theory is applied in many directions such as fuzzy sets theory, algebra,Riemann integration, topologies and so on (see, for example, [19]-[32]). Furthermore, soft sets theory is given to find the solutions for complicated problems in engineering, economics, and environment. In this paper we will apply the soft sets in bi-topological spaces. The (STS) is investigated by Muhammad and Munazza [13] and they introduced the notions of soft open sets, soft closed sets, soft closure, soft interior points, soft neighborhood of a point and soft separation axioms. In 2013, the soft semi-open sets and its properties were given and discussed by Bin Chen [32]. The main purpose of this paper is to introduce and study new classes of soft closed sets like soft rgb-closed, soft rgα-closed, soft gpr-closed, soft gb-closed, soft gsp-closed, soft gα-closed, soft gαb-closed,and soft sgb-closed sets in soft topological spaces (STS)s. Moreover, the concept of soft semi-regularization of soft topology is introduced and studied their some properties. In 2014, Basavaraj [18] introduce and study the concept of soft bi-topological spaces which are defined over an initial universe with a fixed set of parameters. The main purpose of this paper is to introduce and study new classes of $(1,2)-$closed sets in bi-topological space like soft $(1,2)-rsp$-closed sets, soft $(1,2)-w$-closed sets, soft $(1,2)-gpr$-closed and soft $(1,2)-rw$-closed sets in soft bi-topological spaces (X,E,τ_1,τ_2). We show these notions which are given over an initial universe X with a fixed set of parameters E. Furthermore, we discuss the relations between soft $(1,2)-rsp$-closed set and the associated soft closed sets in (STS) (X,E,τ) and in soft bi-topological space (X,E,τ_1,τ_2). Moreover, several examples are given to illustrate the concepts introduced in this paper.

2. Preliminaries

We now begin by recalling some definitions and then we shall give some of the basic consequences of our definitions and results.

Definition 2.1: ([1], [8])Assume X is an initial universe set with E a set of parameters.Werefer to power set of X by $P(X)$ and K is a subset of E, A pair (F,K) is called a soft set over X if F is a multi-valued function of K into the set of all subsets of the set X, we say that (F,A) is a soft subset of (G,B) if $A\subseteq B$ and for all $e\in A$, $F(e)$ and $G(e)$ are identical approximations. We write $(F,A)\,\tilde{\subseteq}\,(G,B)$. A null soft set (F,A), denoted by $\Phi=(\phi,\phi)$, if for each $F(e)=\phi,\forall e\in A$. Similarly, it is called universal soft set, denoted by (X,E), if for each $F(e)=X,\forall e\in A$.

Definition 2.2 [9]The union of any two soft sets (F,A) and (G,B) is a soft set say (H,C), where $C=A\bigcup B$ and

$$H(e)=\begin{cases} F(e), \text{ if } e\in A-B \\ G(e), \text{if } e\in B-A \\ F(e)\bigcup G(e), \text{ if } e\in B\bigcap A \end{cases},\ \forall e\in C$$

we write $(F,A)\amalg(G,B)=(H,C)$. We refer to their intersection by $(H,C)=(F,A)\prod(G,B)$ where $C=A\bigcap B$, and it is defined as $H(e)=F(e)\bigcap G(e)$ for all $e\in C$.

Definition 2.3 [16]Assume (F,A) is soft set. We say (F,A) is a soft point in (X,E), denoted by e_F, if for the element $e\in A$, $F(e)\neq\phi$ and $F(e')=\phi$ for all $e'\in E-\{e\}$. The soft point e_F is said to be in the soft set (G,B), denoted by $e_F\,\tilde{\in}\,(G,B)$, if for the element $e\in A$ and $F(e)\subseteq G(e)$.

Definition 2.4[6]We refer to the complement of soft set (F,A) by $(F,A)^c$ with respect to the universal soft set (X,E) and is defined as (F^c,D),

where

$D=E\setminus\{e\in A\,|\,F(e)=X\}=\{e\in A\,|\,F(e)=X\}^C$,

and for all $e\in D$,

$$F^C(e)=\begin{cases} X\setminus F(e) & \text{, if } e\in A \\ X, & \text{Otherwise .}\end{cases}$$

Definition 2.5 [6] For any family $\tau=\{\Phi,(X,E)\}\bigcup\{(F_i,A_i)\,|\,i\in I\}$ of soft sets over X with parameter E satisfies $(F_i,A_i)\prod(F_k,A_k)\in\tau$ $(\forall i,k\in I)$ and $\coprod_{i\in J}(F_i,A_i)\in\tau$ $(\forall J\subseteq I)$. We say τ a soft topology on X.We say (X,E,τ) is a soft topological space (STS) over X. Also, for each $(F_i,A_i)\in\tau$, we say (F_i,A_i) is a soft open set in X and we say soft closed for its complement.

Definition:2.6 Let (F,A) be a soft set in (X,E,τ). We say (F,A) is;

(i) a soft generalized closed (briefly soft g-closed) in (X,E) [11] if $\mathrm{cl}^S(F,A)\,\tilde{\subseteq}\,(G,B)$ whenever $(F,A)\,\tilde{\subseteq}\,(G,B)$ and (G,B) is soft open in (X,E).

(ii) a soft semi open [5] if $(F,A) \tilde{\subseteq} \mathrm{cl}^S(\mathrm{int}^S(F,A))$

(iii) a soft regular open [13] if $(F,A) = \mathrm{int}^S(\mathrm{cl}^S(F,A))$. The family of all soft regular open sets of X is denoted by $SRO(X,\tau)$.

(iv) a soft α-open [14] if $(F,A) \tilde{\subseteq} \mathrm{int}^S(\mathrm{cl}^S(\mathrm{int}^S(F,A)))$

(v) a soft pre-open set [13] if $(F,A) \tilde{\subseteq} \mathrm{int}^S(\mathrm{cl}^S(F,A))$.

Also, we define soft regular closure, soft α-closure, soft pre-closure and soft semi closure of the soft set (F,A) of a (STS) (X,E) and are denoted by $\mathrm{rcl}^S(F,A)$, $\alpha\mathrm{cl}^S(F,A)$, $\mathrm{pcl}^S(F,A)$ and $\mathrm{scl}^S(F,A)$, respectively.

Remark 2.7[17]
For any soft set (F,A) in (STS) (X,E,τ) weconsiderthat:

$\mathrm{pcl}^S(F,A) \tilde{\subseteq} \alpha\mathrm{cl}^S(F,A) \tilde{\subseteq} \mathrm{cl}^S(F,A) \tilde{\subseteq} \mathrm{rcl}^S(F,A)$
.

Definition 2.8[10]Let (X,E,τ) be a (STS). The soft θ-interior of a soft subset (F,A) of (X,E) is the soft union of all soft open sets over (X,E) whose soft closures are contained in (F,A), and is denoted by $\mathrm{int}_\theta{}^S(F,A)$. The soft subset (F,A) is called soft θ-open if $\mathrm{int}_\theta{}^S(F,A) = (F,A)$. The complement of a soft θ-open set is called soft θ -closed. Alternatively, a soft set (F,A) of X is called soft θ-closed set if $cl_\theta{}^S(F,A) = (F,A)$, where $cl_\theta{}^S(F,A)$ is the soft θ-closure of (F,A) and is defined to be the soft intersection of all soft closed soft subsets of (X,E) whose soft interiors contain (F,A).

Definition 2.9[15]A soft point e_F in a (STS) (X,E,τ) is called a soft δ-cluster point of a soft set (F,A) if for each soft regular open set (G,B) containing e_F such that $(F,A) \sqcap (G,B) \neq \Phi$.The set of all soft δ-cluster points of (G,B) is called soft δ-closure of (G,B) and is denoted by $cl_\delta{}^S(G,B)$. Soft δ-interior of a soft set (F,A) denoted by:

$$cl_\delta{}^S(F,A) = \{e_F \tilde{\in} (X,E) \mid e_F \tilde{\in} (G,B) \tilde{\subseteq} \mathrm{int}^S(cl^S(G,B)) \tilde{\subseteq} (F,A);\ for\ some\ (G,B) \in \tau\}$$

Definition 2.10[15]A soft set (F,A) in a (STS) (X,E,τ) is called soft δ-closed set if $cl_\delta{}^S(F,A) = (F,A)$ and its compliment $(X,E) - (F,A)$ is called soft δ-open sets in (X,E). Or, equivalently, if (F,A) is the union of soft regular open sets, then (F,A) is said to be soft δ-open sets in (X,E). The collection of all soft δ-open sets & soft δ-closed sets are respectably, denoted by $S\delta O(X,\tau)$ & $S\delta C(X,\tau)$.

Remark 2.11
From (Definitions (2.10) and (2.11)) we consider that for any soft set (F,A) in (STS) (X,E,τ) we have:
(1) $pcl^S(F,A) \tilde{\subseteq} cl_\delta{}^S(F,A)$,
(2) $pcl^S(F,A) \tilde{\subseteq} cl_\theta{}^S(F,A)$.

Definition 2.12[3] A soft subset (F,A) of a soft space (X,E,τ) is called soft regular semi open if there is a soft regular open set (G,B) such that $(G,B) \tilde{\subseteq} (F,A) \tilde{\subseteq} \mathrm{cl}^S(G,B)$. The family of all soft regular semi open sets of (X,E) is denoted by $SRSO(X,\tau)$.

Definition 2.13[2]A soft subset (F,A) of a (STS) (X,E,τ) is called soft weakly closed (briefly soft w-closed) if $\mathrm{cl}^S(F,A) \tilde{\subseteq} (G,B)$ whenever $(F,A) \tilde{\subseteq} (G,B)$ and (G,B) is a soft semi open set in a (STS) (X,E,τ).

Definition 2.14[2]A soft subset (F,A) of a (STS) (X,E,τ) is called soft regular weakly closed (briefly soft rw-closed) if $\mathrm{cl}^S(F,A) \tilde{\subseteq} (G,B)$ whenever $(F,A) \tilde{\subseteq} (G,B)$ and $(G,B) \in SRSO(X,\tau)$ is a soft regular semi open in a (STS) (X,E,τ).

Definition 2.15[7]The finite union of soft regular open sets is called soft π -open set and its complement is soft π -closed set.

Definition 2.16[12] Let (X,E,τ) be a (STS). A subset (F,A) of (X,E) is said to be soft regular generalized closed (briefly soft rg-closed) if cl^S $(F,A)\ \tilde{\subseteq}\ (G,B)$ whenever $(F,A)\ \tilde{\subseteq}\ (G,B)$ and $(G,B)\in SRO(X,\tau)$.

Definition 2.17[4] Let (X,E,τ) be a (STS). A subset (F,A) of (X,E) is said to be soft generalized pre-regular closed (briefly soft gpr-closed) if $pcl^S(F,A)\ \tilde{\subseteq}\ (G,B)$ whenever (F,A) $\tilde{\subseteq}\ (G,B)$ and $(G,B)\in SRO(X,\tau)$

Definition 2.18[18]: Let (X,E,τ_1) and (X,E,τ_2) be the two different soft topologies on (X,E). Then (X,E,τ_1,τ_2) is called a soft bi-topological space.

3. A Note on The Soft *rsp*-Closed Sets in Soft Bi-Topological Spaces

After researching several soft closed sets through extensive knowledge we now investigate new notion to give and discuss the same class of that soft closed sets in soft Bi-topological spaces and also we will study the properties of our class and investigate that how they behaves under the new conditions or circumstances that we imposed on this class. So for this section the notion of soft rsp-closed set in bi-topological spaces is given as follows:

Definition 3.1: Let (X,E) be a (STS) with soft topology τ_1 and τ_2. Then a soft set(F,A) is said to be soft $(1,2)-rsp$-closed in (X,E,τ_1,τ_2) if τ_2 $-p\,cl^S(F,A)\ \tilde{\subseteq}\ (G,B)$, whenever $(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1 $-$ soft regular semi open.Now with the help an example we find out, which soft subsets of the following (STS) are soft $(1,2)-rsp$-closed sets and which are not.

Example 3.2:
Let the set of cars under consideration be $X=\{a_1,\ a_2,\ a_3\}$. Let $E=\{$ cheap (e_1); dark color (e_2); modern (e_3); beautiful $(e_4)\}$ be the set of "parameters framed" to choose the "best car". Suppose that the soft set (F,A) describing the "Mr. X " opinion to choose the best car was defined by

$A=\{e_1,e_2\}$

$F(e_1)=\{a_1\}$, $F(e_2)=\{a_3\}$

Furthermore, the "best car" in the opinion of his friend, say "Mr.Y", is described by the soft set (G,B), where $B=\{e_1,e_3,e_4\}$

$G(e_1)=\{a_2,a_3\}$, $G(e_3)=\{a_2\}$,

$G(e_4)=\{a_1,\ a_2,\ a_3\}=X$

Also, the “best car"in the opinion of his second friend, say Mr.Z, is described by the soft set (H,C), where $C=E, H(e_1)=X$, $H(e_2)=\{a_3\}$, $H(e_3)=\{a_2\}, H(e_4)=X$. Consider that: $\tau_1=\{\Phi,(X,E),(F,A),(G,B),(H,C)\}$ and $\tau_2=\{\Phi,(X,E),(G,B)\}$. Then (X,E,τ_1,τ_2) is a soft bi-topological space. Moreover, the τ_1-soft regular semi opensets are $\{\Phi,(X,E),(F,A),(G,B),(V,N),(R,M)\}$ where $(V,N),(R,M)$ are defined as:

$V(e_1)=\{a_1\}, V(e_2)=X$,

$V(e_3)=\{a_1,a_3\}, N=\{e_1,e_2,e_3\}$

$R(e_1)=\{a_2,a_3\}$, $R(e_2)=\{a_1,a_2\}, R(e_3)=X$,

$R(e_4)=X, M=X$ and τ_2 -soft pre-closed are $\{\Phi,(X,E),(F,A),(T,D),(V,N)\}$ where (T,D) is defined as: $T(e_2)=\{a_1,a_2\}$, $T(e_3)=\{a_1,a_3\}, D=\{e_2,e_3\}$, now if we take a soft set (F,A) then τ_2 - $pcl^S((F,A))=(F,A)\prod(V,N)\prod(X,E)=(F,A)$, which is contained in τ_1-soft regular semi open set (F,A). So (F,A) is soft $(1,2)-rsp$ -closed set in (X,E,τ_1,τ_2). Similarly $(T,D),(V,N),(H,C)$ all are soft $(1,2)-rsp$-closed sets. Now if we take soft set (G,B), then τ_2 - $pcl^S((G,B))=(X,E)$, which is not contained in τ_1-soft regular semi open set (G,B), so it is not soft $(1,2)-rsp$-closed set. Similarly (R,M) is also not soft $(1,2)-rsp$-closed set.

Definition 3.3: Let (X,E) be a (STS) with soft topology τ_1 and τ_2. Then a soft set(F,A) is said to be soft $(1,2)-rw$-closed in (X,E,τ_1,τ_2) if $\tau_2-cl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$, whenever $(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$, where (G,B) is τ_1 $-$ soft regular semi open.

Theorem 3.4: In a soft bi-topological space (X,E,τ_1,τ_2) any soft $(1,2)-rw$-closed set is soft $(1,2)-rsp$-closed set, but its converse is not true.

Proof: Let (F,A) be an arbitrary soft $(1,2)-rw$-closed in (X,E,τ_1,τ_2) such that $(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$, and (G,B), is τ_1-soft regular semi open. By definition of soft $(1,2)-rw$-closed we have, $\tau_2-\mathrm{cl}(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$. To prove (F,A) is soft $(1,2)-rsp$-closed it is sufficient to show that $\tau_2-\mathrm{p}cl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$. Since every soft closed set in a (STS) is soft pre-closed, therefore we consider that:
$\tau_2-\mathrm{p}cl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}\tau_2-cl^S(\mathrm{F},\mathrm{A})$, So we got $\tau_2-\mathrm{p}cl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}\tau_2-cl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$, this shows that $\tau_2-\mathrm{p}cl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$, whenever $(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$ and (G,B) is τ_1-soft regular semi open. Hence (F,A) is soft $(1,2)-rsp$-closed set.

Converse of the above theorem is not true, that is if we take any soft $(1,2)-rsp$-closed set than it may not be soft $(1,2)-rw$-closed in a soft bi-topological space it can be seen from the following example.

Example 3.5: In example 3.2 if we take a soft set (F,A) then τ_2-$\mathrm{cl}^S((\mathrm{F},\mathrm{A}))=(\mathrm{V},\mathrm{N})$ which is not contained in a τ_1-soft regular semi open set (F,A)so it is not soft $(1,2)-$rw closed, but it is soft $(1,2)-rsp-$closed as its $\tau_2-\mathrm{p}cl^S(\mathrm{F},\mathrm{A})$ is contained in (F,A).

Definition3.6: Let (X,E) be a (STS) with soft topology τ_1 and τ_2. Then a soft set(F,A) is said to be soft $(1,2)-$gpr-closed in (X,E,τ_1,τ_2) if $\tau_2-pcl^S(\mathrm{F},\mathrm{A})\tilde{\subseteq}(\mathrm{G},\mathrm{B})$, whenever$(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1- soft regular open.

Theorem 3.7: In a soft bi-topological space (X,E,τ_1,τ_2), any soft $(1,2)-rsp$-closed set is soft $(1,2)-$gpr-closed set, but its converse is not true.

Proof: Let (X,E,τ_1,τ_2) be a soft bi-topological space and(F,A) be soft $(1,2)-rsp$-closed subset of X such that $(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1- soft regular open. Now we have the fact that every τ_1-soft regular open set is τ_1- soft regular semi open, therefore$(G,B)$is τ_1-soft regular semi open and by definition of $(1,2)-rsp$-closed set we have $\tau_2-pcl^S(F,A)\tilde{\subseteq}(G,B)$and as given that (F,A) contained in (G,B). So we arrived at the stage at which $\tau_2-pcl^S(F,A)\tilde{\subseteq}(G,B)$, whenever $(F,A)\tilde{\subseteq}(G,B)$and $(G,B)$is τ_1-soft regular open that means(F,A) is soft $(1,2)-gpr$-closed set in a soft bi-topological space(X,E,τ_1,τ_2).

Converse of the above theorem is not true. That is every soft $(1,2)-gpr$-closed set in soft bi-topological space$X$is not soft $(1,2)-rsp$-closed set. It can be seen from the following example.

Example 3.8:

Let $X=\{a_1,a_2,a_3\}$, $E=\{e_1,e_2,e_3,e_4\}$ and
$\tau_1=\{\Phi,(X,E),(F,A),(G,B),(H,C),(T,K)\}$,
$\tau_2=\{\Phi,(X,E),(F,A),(G,B),(H,C),(T,K)\}$,
where $(F,A),(G,B),(H,C),(T,K)$ are soft sets over X, defined as follows:

$A=\{e_1,e_2\}$
$F(e_1)=\{a_1\}$, $F(e_2)=\{a_3\}$
$B=\{e_1,e_3,e_4\}$
$G(e_1)=\{a_2,a_3\}$, $G(e_3)=\{a_2\}$,
$G(e_4)=\{a_1,a_2\}$
$C=E$
$H(e_1)=X$, $H(e_2)=\{a_3\}$, $H(e_3)=\{a_2\}$,
$H(e_4)=\{a_1,a_2\}$
$K=E$
$T(e_1)=X$, $T(e_2)=\{a_1,a_3\}$, $T(e_3)=\{a_2,a_3\}$,
$T(e_4)=X$

In these (STS)s the τ_1-soft regular open sets are $\{\Phi,(X,E),(F,A),(G,B)\}$ and τ_2 –soft pre-closed sets are $\{\Phi,(X,E),(F,A)^c,(G,B)^c,(H,C)^c,(T,K)^c,(R,D)\}$ where (R,D) is defined as: $D=\{e_2,e_3,e_4\}$,

$R(e_2)=\{a_1\}, R(e_3)=\{a_3\}, R(e_4)=\{a_3\}$. Now if we take (V,L) where $L=E$, $V(e_1)=\{a_1\}, V(e_2)=\{a_1,a_3\}$, $V(e_3)=\{a_3\}, V(e_4)=\{a_3\}$. Then τ_2 -$pcl^S(V,L)=(G,B)^c$ is contained in τ_1 -soft regular open set (X,E), so it is a soft $(1,2)-gpr$-closed, but it is not soft $(1,2)-rsp$-closed because we have a τ_1-soft regular semi open set (V,L) which does not contain τ_2 -$pcl^S(V,L)$. Hence from the following example we can see that not every soft$(1,2)-gpr$-closed set is soft $(1,2)-rsp$-closed.

Corollary 3.9: Let (X,E,τ_1,τ_2) be a soft bi-topological space, then every soft closed set in (X,E,τ_2) is soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). But its converse is not true.

Proof: Assume that $(F,A)$is a soft closed subset in (X,E,τ_2), such that $(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1-soft regular semi open set. Now we want to prove that our assumed set (F,A) is also soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). As given (F,A) is soft closed therefore, $\tau_2-cl^S(F,A)=(F,A)$. So we got $\tau_2-pcl^S(A)\tilde{\subseteq}\tau_2-cl(F,A)=(F,A)$ whenever $(F,A)\tilde{\subseteq}(G,B)$, and (G,B) is τ_1-soft regular semi open set. Hence (F,A) is soft $(1,2)-rsp$-closed in (X,E,τ_1,τ_2).

Converse of this corollary is not true, that is every soft $(1,2)-rsp$-closed set in soft bi-topological space (X,E,τ_1,τ_2) is not always soft closed set in (STS) (X,E,τ_2) this can be seen from the following example.

Example 3.10

Let $X=\{a_1,a_2,a_3\}, E=\{e_1,e_2,e_3,e_4\}$ and $\tau_1=\{\Phi,(X,E),(F,A),(G,B),(H,C)\}$, $\tau_2=\{\Phi,(X,E),(G,B)\}$, where $(F,A),(G,B),(H,C)$ are soft sets over X, defined as follows:

$A=\{e_1,e_2\}$

$F(e_1)=\{a_1\}$, $F(e_2)=\{a_3\}$

$B=\{e_1,e_3,e_4\}$

$G(e_1)=\{a_2,a_3\}$, $G(e_3)=\{a_2\}$, $G(e_4)=\{a_1,a_2,a_3\}=X$, $C=E$

$H(e_1)=X$, $H(e_2)=\{a_3\}, H(e_3)=\{a_2\}$, $H(e_4)=X$

Consider that:

$\tau_1=\{\Phi,(X,E),(F,A),(G,B),(H,C)\}$ and $\tau_2=\{\Phi,(X,E),(F,A)\}$. Then (X,E,τ_1,τ_2) is a soft bi-topological space. Moreover, the τ_1-soft regular semi opensets are $\{\Phi,(X,E),(F,A),(G,B),(V,N),(R,M)\}$ where $(V,N),(R,M)$ are defined as:

$V(e_1)=\{a_1\}, V(e_2)=X$, $V(e_3)=\{a_1,a_3\}, N=\{e_1,e_2,e_3\}$

$R(e_1)=\{a_2,a_3\}$, $R(e_2)=\{a_1,a_2\}, R(e_3)=X$, $R(e_4)=X, M=X$ and τ_2 -soft pre-closed are $\{\Phi,(X,E),(F,A),(T,D),(V,N)\}$ where (T,D) is defined as: $T(e_2)=\{a_1,a_2\}$, $T(e_3)=\{a_1,a_3\}, D=\{e_2,e_3\}$, now if we take a soft set (H,C)then it is soft $(1,2)-rsp$-closed in soft bi-topological space (X,E,τ_1,τ_2) but not soft closed in (STS) (X,E,τ_2).

Corollary 3.11: Let (X,E,τ_1,τ_2) be a soft bi-topological space, then every soft regular closed set in (X,E,τ_2) is soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). But its converse is not true.

Proof: Assume that $(F,A)$is a soft regular closed subset in (X,E,τ_2), such that $(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1-soft regular semi open set. Now we want to prove that our assumed set (F,A) is also soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). As given (F,A) is soft regular closed, thus $\tau_2-rcl^S(F,A)=(F,A)$. So we got $\tau_2-pcl^S(A)\tilde{\subseteq}\tau_2-rcl^S(\mathrm{F},A)=(F,A)$ whenever $(F,A)\tilde{\subseteq}(G,B)$, and (G,B) is τ_1- soft regular semi open set. Hence (F,A) is soft $(1,2)-rsp$-closed in (X,E,τ_1,τ_2).

Converse of this corollary is not true, that is every soft $(1,2)-rsp$-closed set in soft bi-topological space (X,E,τ_1,τ_2) is not always soft regular closed set in (STS) (X,E,τ_2) this can be seen from the example 3.10, we have (F,A) is soft $(1,2)-rsp$-closed set in

(X, E, τ_1, τ_2) but not soft regular closed in (STS) (X, E, τ_2).

Corollary 3.12: Let (X, E, τ_1, τ_2) be a soft bi-topological space, then every soft $\theta-$closed set in (X, E, τ_2) is soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2). But its converse is not true.

Proof: Assume that (F, A) is a soft $\theta-$closed subset in (X, E, τ_2), such that $(F, A) \tilde{\subseteq} (G, B)$, where (G, B) is τ_1-soft regular semi open set. Now we want to prove that our assumed set (F, A) is also soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2). As given (F, A) is soft $\theta-$ closed, therefore, $\tau_2 - cl_\theta^S(F, A) = (F, A)$. So we got $\tau_2 - p\,cl^S(A) \tilde{\subseteq} \tau_2 - cl_\theta^S(F, A) = (F, A)$ whenever $(F, A) \tilde{\subseteq} (G, B)$, and (G, B) is τ_1-soft regular semi open set. Hence (F, A) is soft $(1,2)-rsp$-closed in (X, E, τ_1, τ_2).

Converse of this corollary is not true, that is every soft $(1,2)-rsp$-closed set in soft bi-topological space (X, E, τ_1, τ_2) is not always soft $\theta-$closed set in (STS) (X, E, τ_2) this can be seen from the example 3.10 and the fact that every soft θ −closed is a soft closed. This implies that in example 3.10. the soft set (F, A) is not soft $\theta-$closed in (STS) (X, E, τ_2). However, it is soft $(1,2)-rsp$-closed set in soft bi-topological space (X, E, τ_1, τ_2).

Corollary 3.13: Let (X, E, τ_1, τ_2) be a soft bi-topological space, then every soft δ-closed set in (X, E, τ_2) is soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2). But its converse is not true.

Proof: Assume that $(F, A)$is a soft closed subset in (X, E, τ_2), such that $(F, A) \tilde{\subseteq} (G, B)$, where (G, B) is τ_1-soft regular semi open set. Now we want to prove that our assumed set (F, A) is also soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2). As given (F, A) is soft δ-closed therefore $\tau_2 - cl_\delta^S(F, A) = (F, A)$. So we got $\tau_2 - p\,cl^S(A) \tilde{\subseteq} \tau_2 - cl_\delta^S(F, A) = (F, A)$ whenever $(F, A) \tilde{\subseteq} (G, B)$, and (G, B) is τ_1-soft regular semi open set. Hence (F, A) is soft $(1,2)-rsp$-closed in (X, E, τ_1, τ_2).

Converse of this corollary is not true, that is every soft $(1,2)-rsp$-closed set in soft bi-topological space (X, E, τ_1, τ_2) is not always soft δ-closed set in (STS) (X, E, τ_2) this can be seen from the example 3.10, we have (F, A) is soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2) but not soft δ-closed in (STS) (X, E, τ_2).

Corollary 314: Let (X, E, τ_1, τ_2) be a soft bi-topological space, then every soft π-closed set in (X, E, τ_2) is soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2). But its converse is not true.

Proof: Since every π-closed is closed. Then the proof of this corollary follows from (Corollary 3.9). Its converse can be seen from the example 3.10 we have (F, A) is soft $(1,2)-rsp$-closed set in (X, E, τ_1, τ_2) but not soft π-closed in (STS) (X, E, τ_2).

Definition3.15: Let (X, E) be a (STS) with soft topology τ_1 and τ_2. Then a soft set (F, A) is said to be soft $(1,2)-w$-closed in (X, E, τ_1, τ_2) if $\tau_2 - cl^S(F, A) \tilde{\subseteq} (G, B)$, whenever $(F, A) \tilde{\subseteq} (G, B)$, where (G, B) is τ_1- soft semi open.

Corollary 3.16: In a soft bi-topological space (X, E, τ_1, τ_2), any soft (1,2) $-w$-closed set is a soft (1,2) $-rsp$-closed set, but its converse is not true.

Proof: Let(F, A) be an arbitrary soft $(1,2)-w$-closed in (X, E, τ_1, τ_2). The proof is following from the (Definitions (3.3), (3.15)) and the fact that every soft regular semi open is a soft semi open. This implies that every soft w-closed set is soft rw-closed set and then by (Theorem (3.4)) we have (F, A) is soft (1,2) $-rsp$-closed set. Converse of this corollary can be seen from the following example.

Example 3.17:

Let $X = \{a_1, a_2, a_3\}, E = \{e_1, e_2, e_3, e_4\}$ and

$\tau_1 = \{\Phi, (X, E), (F, A), (G, B), (H, C), (T, K)\}$,

$\tau_2 = \{\Phi, (X, E), (F, A), (G, B), (H, C), (T, K)\}$,

where $(F, A), (G, B), (H, C), (T, K)$ are soft sets over X, defined as follows:

$A=\{e_1,e_2\}$
$F(e_1)=\{a_1\}$, $F(e_2)=\{a_3\}$
$B=\{e_1,e_3,e_4\}$
$G(e_1)=\{a_2,a_3\}$, $G(e_3)=\{a_2\}$,
$G(e_4)=\{a_1,\ a_2\}$
$C=E$
$H(e_1)=X$, $H(e_2)=\{a_3\},H(e_3)=\{a_2\}$,
$H(e_4)=\{a_1,a_2\}$
$K=E$
$T(e_1)=X$, $T(e_2)=\{a_1,a_3\},T(e_3)=\{a_2,a_3\}$,
$T(e_4)=X$

In these (STS)s the τ_1-soft regular semi open sets are
$\{\Phi,(X,E),(F,A),(G,B),(F,A)^c,(G,B)^c,(N,E),$
$(M,E),(V,U),(W,E)\}$

and τ_2 –soft pre-closed sets are
$\{\Phi,(X,E),(F,A)^c,(G,B)^c,(H,C)^c,(T,K)^c,$
$(R,D)\}$
where (N,E), (M,E), (V,U), (W,E), (L,I) and (R,D) are soft sets of (X,E) and defined as follows:
$U=\{e_1,e_2,e_3\},I=\{e_2,e_3\},D=\{e_2,e_3,e_4\}$
$N(e_1)=\{a_1\},N(e_2)=\{a_1,a_3\},N(e_3)=\{a_3\}$,
$N(e_4)=\{a_3\}$,
$M(e_1)=\{a_2,a_3\}$, $M(e_2)=X,M(e_3)=\{a_2,a_3\}$,
$M(e_4)=X$,
$V(e_1)=\{a_1\},V(e_2)=\{a_2,a_3\},V(e_3)=\{a_1\}$,
$W(e_1)=\{a_2,a_3\},W(e_2)=\{a_2\},W(e_3)=W(e_4)=$
$\{a_1,a_2\}$,
$L(e_2)=\{a_2\},L(e_3)=\{a_1\}$,
$R(e_2)=\{a_1\},R(e_3)=\{a_3\},R(e_4)=\{a_3\}$.

Now if we take a soft subset (R,D) of (X,E) then it is soft $(1,2)-rsp$-closed since we have τ_1-soft regular semi open set (M,E) which contains (R,D) and also τ_2 $-pcl^S(R,D)$ = (R,D) contained in (M,E). Now (R, D) is not soft $(1,2)-w$-closed set because we have τ_1 $-$soft semi open set (M,E) containing (R,D), and $cl^S(R,D)$ = $(H,C)^c$ does not contained in (M,E).

Theorem 3.18: Let (X,E,τ_1,τ_2) be a soft bi-topological space, then every soft per-closed set in (X,E,τ_2) is soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). But its converse is not true.

Proof: Assume that (F,A) is a soft pre-closed subset in (X,E,τ_2), such that $(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1 $-$ soft regular semi open set. Now we want to prove that our assumed set (F,A) is also soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). As given (F,A) is soft pre-closed, thus we consider that τ_2 $-\mathrm{p}\,cl^S(\mathrm{F,A})$ = $(\mathrm{F,A})$, whenever $(\mathrm{F,A})\tilde{\subseteq}(\mathrm{G,B})$, and $(\mathrm{G,B})$ is τ_1 $-$soft regular semi open set. Hence $(\mathrm{F,A})$ is soft $(1,2)-rsp$-closed in (X,E,τ_1,τ_2).

Converse of this corollary is not true, that is every soft $(1,2)-rsp$-closed set in soft bi-topological space (X,E,τ_1,τ_2) is not always soft pre-closed set in (STS) (X,E,τ_2) this can be seen from the following example.

Example 3.19:
Let $X=\{a_1,\ a_2,\ a_3\}, E=\{\ e_1,e_2,e_3,e_4\}$
and $\tau_1=\{\Phi,(X,E),(F,A),(G,B),(H,C)\}$,
$\tau_2=\{\Phi,(X,E),(G,B)\}$, where
$(F,A),(G,B),(H,C)$ are soft sets over X , defined as follows:
$A=\{e_1,e_2\},F(e_1)=\{a_1\}$, $F(e_2)=\{a_3\}$
$B=\{e_1,e_3,e_4\}$, $G(e_1)=\{a_2,a_3\}$, $G(e_3)=$
$\{a_2\},G(e_4)=\{a_1,\ a_2,\ a_3\}=X, C=E$
$H(e_1)=X$, $H(e_2)=\{a_3\},H(e_3)=\{a_2\}$,
$H(e_4)=X$. Then we consider that: $\tau_1=\{\Phi,(X,E),(F,A),(G,B),(H,C)\}$ and $\tau_2=\{\Phi,(X,E),(G,B)\}$. Then (X,E,τ_1,τ_2) is a soft bi-topological space. Moreover, the τ_1-soft regular semi opensets are $\{\Phi,(X,E),(F,A),(G,B),(V,N),(R,M)\}$ where $(V,N),(R,M)$ are defined as:
$V(e_1)=\{a_1\},V(e_2)=X$,
$V(e_3)=\{a_1,a_3\},N=\{e_1,e_2,e_3\}$
$R(e_1)=\{a_2,a_3\}$, $R(e_2)=\{a_1,a_2\},R(e_3)=X$,

$R(e_4)=X$, $M=X$ and τ_2 -soft pre-closed are $\{\Phi,(X,E),(F,A),(T,D),(V,N)\}$ where (T,D) is defined as: $T(e_2)=\{a_1,a_2\}$, $T(e_3)=\{a_1,a_3\}, D=\{e_2,e_3\}$, now if we take a soft set (H,C) then it is soft $(1,2)-rsp$ closed but not soft per-closed.

Corollary 3.20: Let (X,E,τ_1,τ_2) be a soft bi-topological space, then every soft $\alpha-$closed set in (X,E,τ_2) is soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). But its converse is not true.

Proof: Assume that (F,A) is a soft $\alpha-$closed subset in (X,E,τ_2), such that $(F,A)\tilde{\subseteq}(G,B)$, where (G,B) is τ_1-soft regular semi open set. Now we want to prove that our assumed set (F,A) is also soft $(1,2)-rsp$-closed set in (X,E,τ_1,τ_2). As given (F,A) is soft $\alpha-$closed, thus we consider that $\tau_2-\alpha cl^S(\mathrm{F,A})=(\mathrm{F,A})$ .So we got $\tau_2-p\,cl^S(A)\tilde{\subseteq}\tau_2-\alpha cl^S(\mathrm{F,A})=(F,A)$, whenever $(\mathrm{F,A})\tilde{\subseteq}(\mathrm{G,B})$, and $(\mathrm{G,B})$ is τ_1-soft regular semi open set. Hence $(\mathrm{F,A})$ is soft $(1,2)-rsp$-closed in (X,E,τ_1,τ_2).

Its converse can be seen from the example 3.19, if we take a soft set (H,C) then it is soft $(1,2)-rsp$ closed in soft bi-topological space but not soft $\alpha-$closed in (X,E,τ_2).

4. Conclusion

In this paper, we introduce the concepts of soft $(1,2)-rsp$-closed sets, soft $(1,2)-w$-closed sets, soft $(1,2)-\mathrm{gpr}$-closed and soft $(1,2)-rw$-closed sets in soft bi-topological spaces (X,E,τ_1,τ_2) and the relations between soft $(1,2)-rsp$-closed set and the associated soft closed sets in (STS) (X,E,τ) and in soft bi-topological space (X,E,τ_1,τ_2). Finally, we hope that this paper is just a beginning of new classes of soft $(1,2)-$closed sets in soft bi-topological spaces, it will be necessary to carry out more theoretical research to investigate the relations between them.

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