Soft ii-mappings in soft topological spaces

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Abstract. In this paper, we have presented new ideas of soft mappings from a soft topological space into another are called soft i-open, soft inter-open and soft ii-open mappings,(soft i-continuous, soft inter-continuous and soft ii-continuous mappings), (soft topological i-homeomorphisms, soft topological inter-homeomorphisms and soft topological ii-homeomorphisms. The relations among these concepts and some different concepts of soft mappings as soft open, soft semi-open and soft α-open mappings (separately, soft continuous, soft semi-continuous and soft α-continuous mappings), (separately, soft topological homeomorphisms, soft topological semi-homeomorphisms and soft topological α-homeomorphisms) are examined by utilizing evidences and guides to clarify and explain it.
Keywords: soft ii-open mappings, soft ii-continuity, soft open sets in soft topological spaces.

1. Introduction

The concepts of semi-open sets, α-open sets were presented in 1963, 1965 (see [17], [22]). Askandar [4] had presented the concept of i-open sets in standard topological spaces. In 2019 (see [19]) the ideas of inter-open, ii-open sets have been presented by Mohammed A.A. and Abdullah B.S. the idea of soft sets and its properties has been presented by Molodtsov and numerous different specialists in 1999, 2003, 2009, 2011, 2014 and 2015 (see [20], [18], [3], [26], [24], [10]). Chen [9] and Kannan [15] introduced the concept of soft semi-open sets and soft α-open sets individually in soft topological spaces. In 2008, Fing [11] defined soft semi-rings to establish the connection between soft sets and semi-rings.

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In 2009, Shabir and Ali [25] studied soft ideals over semi-groups. In 2011, Shabir and Naz [26] initiated the study of soft topological spaces. Many other studies of soft topological spaces have also been studied by many researchers (see [27], [6], [28], [21], [8] and [14]. In 2013, (see [7]) different soft point concepts from the studies in [27], [6], [28], [21], [8] and [14] were introduced. In 2014, Ozturk and Bayramov [23] have used the concepts of soft point in the study [7].

In this work, soft point concepts in the study [28] have been used.

All through this paper(X, τ, E) and (Y, ρ, H), and continuously indicate soft topological spaces $_ST_S$ and $f_{pu} : SS(X_E) \to SS(Y_H)$ is a soft mapping from (X, τ, E) into (Y, ρ, H) and $u : X \to Y$, $P : E \to H$, are mappings. We indicates by$(_SS)$ to the soft set, $int(K, E)$ and $Cl(K, E)$ denotes soft interior and soft closure of $_sS(K, E)$ individually. The individuals from τ are called soft open sets (SOS) of X_S , what's more, its supplements are called soft closed sets (SCS) of X_E. $\phi_E and X_E$denote soft null and soft absolute sets individually.

In the fragment 1, we give known fundamental thoughts and aftereffects of the hypothesis of soft sets and soft topological spaces. Additionally, we give basic meanings of soft inter-open; soft i-open and soft ii-open sets (see [5]).In the segment 2, we characterize new ideas of soft open mappings as soft i-open, soft inter-open and soft ii-open mappings and explore its properties. In the third and fourth segment, soft i-continuous, soft inter-continuous and soft ii-continuous mappings, soft topological i-homeomorphisms, soft topological inter-homeomorphisms and soft topological ii-homeomorphismsare characterized and numerous significant outcomes are determined.

Definition 1.1. A $_SS$ is named a soft point (sP) in X_E designated by e_K if $\exists x \in X$ and $\exists e \in E$, $K(e) \neq \phi$, $K(e^c = \phi \forall e^c \in E - e$. E_k is said to have a place the soft set (G, E), $e_K \widetilde{\in} (G, E)$,if $\forall e \in E, e_K \subseteq G(e)$, the arrangement of each single soft point of X meant by SP(X) ([28]).

Proposition 1.1 ([26]). *Let* $(K, A), (L, A) \widetilde{\in} SS(X_A)$, *then:*

i) $((K, A)\widetilde{\cup}(L, A))^c = (K, A)^c \widetilde{\cup} (L, A)^c$

ii) $((K, A)\widetilde{\cap}(L, A))^c = (K, A)^c \widetilde{\cap} (L, A)^c$

Theorem 1.1 ([14]). (K, E) *be a soft set in* (X, τ, E), *then:*

i) $Int(K, E)^c = (Cl(K, E)^c$

ii) $Cl(K, E)^c = (Int(K, E)^c$

iii) $Int(K, E) = (Cl(K, E)^c)^c$

Proposition 1.2 ([2],[12]). *Let* $(F, A), (F_1, A) \widetilde{\in} SS(X_E)$ *and* $(G, B), (G_1, B) \widetilde{\in} SS(Y_B)$ *at that point the following proclamations are valid:*

i) If $(F, A) \widetilde{\subseteq} (F_1, A)$, *then* $f_{pu}(F, A) \widetilde{\subseteq} f_{pu}(F_1, A)$

ii) $(G,B)\widetilde{\subseteq}(G_1,B)$, *then* $f_{pu}^{-1}(G,B)\widetilde{\subseteq}f_{pu}^{-1}(G_1,B)$

iii) $(F,A)\widetilde{\subseteq}f_{pu}^{-1}(f_{pu}(F,A))$

iv) $f_{pu}(f_{pu}^{-1}(G,B))\widetilde{\subseteq}(G,B)$

v) $f_{pu}^{-1}((G,B)^c)\widetilde{\subseteq}(f_{pu}^{-1}(G,B))^c$

vi) $f_{pu}((F,A)\widetilde{\cup}(F_1,A)) = f_{pu}(F,A)\widetilde{\cup}f_{pu}(F_1,A)$

vii) $f_{pu}((F,A)\widetilde{\cap}(F_1,A))\widetilde{\subseteq}f_{pu}(F,A)\widetilde{\cap}f_{pu}(F_1,A)$

viii) $f_{pu}^{-1}((G,B)\widetilde{\cup}(G_1,B)) = f_{pu}^{-1}(G,B)\widetilde{\cup}f_{pu}^{-1}(G_1,B)$

ix) $f_{pu}^{-1}((G,B)\widetilde{\cap}(G_1,B)) = f_{pu}^{-1}(G,B)\widetilde{\cap}f_{pu}^{-1}(G_1,B)$

Definition 1.2. Let (F,E) be a soft set $({}_SS)$ in (X,τ,E), then (F,E) considers:

i) Soft Inter-open set$({}_SIntO_S$ if there exists a ${}_SO_S(O,E) \neq \phi, X$ wherein $Int(F,E) = (O,E)$ ([5]).

ii) Soft i-open set $({}_SIO_S)$ if there exists a ${}_SO_S(O,E) \neq \phi, X$ wherein $(F,E)\widetilde{\subseteq}$ $Cl((F,E)\widetilde{\cap}(O,E))$ (see [5]).

iii) Soft ii-open set $({}_SIIO_S)$ if there exists a ${}_SO_S(O,E) \neq \phi, X$ wherein:

  a) $(F,E)\widetilde{\subseteq}Cl((F,E)\widetilde{\cap}(O,E))$

  b) $Int(F,E) = (O,E)$. As it were an ${}_SS(F,E)$ is named ${}_SIIO_S$ if it is ${}_SIntO_S$ and ${}_SIO_S$ together (see [5]).

iv) Soft semi-open set ${}_SSO_S$ if:

  a) $(F,E)\widetilde{\subseteq}Cl(Int(F,E))$.

  b) If there exists a ${}_SO_S(O,E) \neq \phi, X$ wherein $(O,E)\widetilde{\subseteq}(F,E)\widetilde{\subseteq}Cl(O,E)$ (see [9]).

v) Soft α-open set$({}_S\alpha O_S$, if $(F,E)\widetilde{\subseteq}Int(Cl(Int(F,E)))$ (see [15]).

The complement of ${}_SIIO_S$ (resp., ${}_SIntO_S, {}_SIO_S, {}_SSO_S$ and ${}_S\alpha O_S$) is called soft ii-closed $({}_SIIC_S)$ (resp., soft int-closed $({}_SIntC_S)$, soft i-closed$({}_SIC_S)$, soft semi-closed $({}_SSC_S)$ and soft α -closed $({}_S\alpha C_S)$). The intersection of all ${}_SIIC_S$ (resp., ${}_SIntC_S, {}_SIC_S, {}_SSC_S$ and ${}_S\alpha C_S$) over X containing (F,E) is called the soft ii-closure (resp., soft int-closure, soft i-closure, soft semi-closure and soft α-closure) of (F,E) and designated by $IICl(F,E)$ (resp., $INTCl(F,E), ICl(F,E), SCl(F,E)$ and $\alpha Cl(F,E)$. The union of all ${}_SIIO_S$ (resp., ${}_SIntO_S, {}_SIO_S, {}_SSO_S$ and ${}_S\alpha O_S$) over X contained in (F,E) is named a soft II-interior (resp., soft INT-interior, soft I-interior, soft Semi-interior and soft α-interior) of a soft set (F,E) and denoted by $IIInt(F,E)$ (resp., $INTInt(F,E)$, $IInt(F,E)$, $SInt(F,E)$ and

$\alpha Int(F,E)$. The collection of all ${}_SO_S$ (resp., ${}_SIIO_S$, ${}_SIntO_S$, ${}_SIO_S$, ${}_SSO_S$ and ${}_S\alpha O_S$, ${}_SC_S$, ${}_SIIC_S$,${}_SIntC_S$, ${}_SIC_S$,${}_SSC_S$ and ${}_S\alpha C_S$) in (X,τ,E) are denoted by (${}_SO_S(X_E)$ (resp., ${}_SIntO_S(X_E)$, ${}_SSIntO_S(X_E)$, ${}_SIO_S(X_E)$, ${}_SSO_S(X_E)$, ${}_S\alpha O_S(X_E)$, ${}_SC_S(X_E)$, ${}_SIIC_S(X_E)$, ${}_SIntC_S(X_E)$, ${}_SIC_S(X_E)$, ${}_SSC_S(X_E)$ and ${}_S\alpha_C S(X_E)$.

Definition 1.3. An ${}_sS(G,E)$ in ${}_ST_S(X,\tau,E)$ is named a soft ii-neighborhood of an ${}_SP$, $F(E)$ if there exists a ${}_SIIO_S(G_1,E)$ wherein $F(e)\widetilde{\in}(G_1,E)\widetilde{\subseteq}(G_1,E)$. An ${}_sS(G,E)$ in a ${}_ST_S(X,\tau,E)$, is named a soft ii-neighborhood of an ${}_sS(F,E)$ if there exists a ${}_SIIO_S(G_1,E)$ wherein $(F,E)\widetilde{\subseteq}(G_1,E)\widetilde{\subseteq}(G_1,E)$. The ii-neighborhood system of a ${}_sPF(e)$ designated by $IIN_\tau(F(e))$is the group of all its ii-neighborhoods.

Definition 1.4. Consider $f_{pu}:SS(X_E)\rightarrow SS(Y_H)$,$u:X\rightarrow Y$, $p:E\rightarrow H$, be mappings. Let $e_F\in SP(X)$. Then f_{pu} is a soft ii-pu-continuous at e_F if for each $(G,H)\widetilde{\in}N_\rho(f_{pu}(e_F))$,there exists $(G_1,E)\widetilde{\in}IIN_\tau(e_F)$ wherein , $f_{pu}(G_1,E)\widetilde{\subseteq}(G,H)$, f_{pu} is a soft ii-pu-continuous on X if it is a soft ii-pu-continuous at each soft point in X.

2. Soft ii-open mappings

Definition 2.1. Consider a mappings $f_{pu}:SS(X_E)\rightarrow SS(Y_H)$,$u:X\rightarrow Y$, $p:E\rightarrow H$. Then a mapping f_{pu} is named:

i) Soft open (${}_SOm$) if $f_{pu}(F,E)\widetilde{\in}{}_SO_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SO_S(X_E)$ ([28]).

ii) Soft closed (${}_SCm$) if $f_{pu}(F,E)\widetilde{\in}{}_SC_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SC_S(X_E)$ ([28]).

iii) Soft semi-open (${}_SSOm$) if $f_{pu}(F,E)\widetilde{\in}{}_SSO_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SSO_S(X_E)$ ([16]).

iv) Soft semi-closed (${}_SSCm$) if $f_{pu}(F,E)\widetilde{\in}{}_SSC_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SSC_S(X_E)$ ([16]).

v) Soft α-open (${}_S\alpha Om$) if $f_{pu}(F,E)\widetilde{\in}{}_S\alpha O_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SO_S(X_E)$ ([16]).

vi) Soft α-closed (${}_S\alpha Cm$) if $f_{pu}(F,E)\widetilde{\in}{}_S\alpha C_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SC_S(X_E)$ ([16]).

vii) Soft i-open (${}_SIOm$) if $f_{pu}(F,E)\widetilde{\in}{}_SIO_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SO_S(X_E)$.

viii) Soft i-closed (${}_SICm$) if $f_{pu}(F,E)\widetilde{\in}{}_SIC_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SC_S(X_E)$.

ix) Soft inter-open (${}_SIntOm$) if $f_{pu}(F,E)\widetilde{\in}{}_SIntO_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SO_S(X_E)$.

x) Soft inter-closed (${}_SIntCm$) if $f_{pu}(F,E)\widetilde{\in}{}_SIntC_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SC_S(X_E)$.

xi) Soft ii-open (${}_SIIOm$) if $f_{pu}(F,E)\widetilde{\in}{}_SIIO_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SO_S(X_E)$.

xii) Soft ii-closed (${}_SIICm$) if $f_{pu}(F,E)\widetilde{\in}{}_SIIC_S(Y_H)$, for each $(F,E)\widetilde{\in}{}_SC_S(X_E)$.

Theorem 2.1. *Each ${}_SOm$ is a ${}_SIOm$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_SOm$. Let (G,E) be an ${}_SO_S$ in (X,τ,E), we have $f_{pu}(G,E)$ is a ${}_SO_S$ in (Y,ρ,H) (by assume). Since each ${}_SO_S$ is a ${}_SIO_S$ ([5], Theorem 3.2) we have $f_{pu}(G,E)$ is a ${}_SIO_S$ in (Y,ρ,H). Hence f_{pu} is a ${}_SIOm$. □

Example 2.1. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l,w\}$ and $H = \{l',w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1,E)\}$ and $\rho = \{\phi_H, Y_H, (G_1,H), (G_2,H)\}$ are ${}_ST_S$ over X and Y respectively, where $(F_1,E) = \{(l,\{1,3\}),(w,\{1,3\})\}$, $(G_1,H) = \{(l',\{4\}),(w',\{4\})\}$, $(G_2,H) = \{(l',\{2,4\}),(w',\{2,4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 6, u(5) = 2$. ${}_SI-O_S(Y_H = \{\phi_H, Y_H, (G_1,H), (G_2,H), \{(l',2),(w',2)\}, \{(l',\{4,6\}),(w',\{4,6\})\}\})$. Apparently, f_{pu} isn't a ${}_SOm$ since (F_1,E) is ${}_SO_S$ in (X,τ,E) but $f_{pu}(F_1,E) = \{(l',\{4,6\}),(w',\{4,6\})\}$ isn't ${}_SO_S$ in (Y,ρ,H).Hence f_{pu} is a ${}_SIOm$.

Theorem 2.2. *Each ${}_SSOm$ is ${}_SIOm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_SSOm$. Let (G,E) be an ${}_SO_S$ in (X,τ,E), we have $f_{pu}(G,E)$ is a ${}_SSO_S$ in (Y,ρ,H) (by assume). Since each ${}_SSO_S$ is a ${}_SIO_S$ ([5], Theorem3.5), we have $f_{pu}(G,E)$ is a ${}_SIO_S$ in (Y,ρ,H). Hence f_{pu} is a ${}_SIOm$. □

Example 2.2. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l,w\}$ and $H = \{l',w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1,E)\}$ and $\rho = \{\phi_H, Y_H, (G_1,H)\}$, where $(F_1,E) = \{(l,\{1,3\}),(w,\{1,3\})\}$, $(G_1,H) = \{(l',\{2,4\}),(w',\{2,4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$.Essentially as in the example referenced previously, f_{pu} is not a ${}_SSOm$ since (F_1,E) is ${}_SO_S$ in (X,τ,E) but $f_{pu}(F_1,E) = \{(l',\{2,6\}),(w',\{2,6\})\}$ isn't ${}_SSO_S$ in (Y,ρ,H). Hence, f_{pu} is a ${}_SIOm$.

Theorem 2.3. *Any ${}_S\alpha Om$ is ${}_SSOm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_S\alpha Om$. Let (G,E) be an ${}_SO_S$ in (X,τ,E), we have $f_{pu}(G,E)$ is a ${}_S\alpha O_S$ in (Y,ρ,H) (by assume). Since each ${}_S\alpha O_S$ is a ${}_SSO_S$ ([5], Theorem 3.7), we have $f_{pu}(G,E)$ is a ${}_SSO_S$ in (Y,ρ,H). Hence f_{pu} is a ${}_SSOm$ (see [16]). □

Example 2.3. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l,w\}$ and $H = \{l',w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1,E)\}$ and $\rho = \{\phi_H, Y_H, (G_1,H), (G_2,H), (G_3,H)\}$, where $(F_1,E) = \{(l,\{1,3\}),(w,\{1,3\})\}$, $(G_1,H) = \{(l',\{2\}),(w',\{2\})\}$, $(G_2,H) = \{(l',\{4\}),(w',\{4\})\}$, $(G_3,H) = \{(l',\{2,4\}),(w',\{2,4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is not a $_S\alpha Om$ since (F_1, E) is $_SO_S$ in (X, τ, E) but $f_{pu}(F_1, E) = \{(l', \{2, 6\}), (w', \{2, 6\})\}$ isn't $_S\alpha O_S$ in (Y, ρ, H). Hence f_{pu} is a $_SSOm$.

Corollary 2.1. *Each $_S\alpha Om$ is $_SIOm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_S\alpha Om$. We have f_{pu} is an $_SSOm$. Hence f_{pu} is a $_SIOm$. □

Example 2.4. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1, 3\}), (w, \{1, 3\})\}$, $(G_1, H) = \{(l', \{2, 4\}), (w', \{2, 4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is not a $_S\alpha Om$ since (F_1, E) is $_SO_S$ in (X, τ, E) but $f_{pu}(F_1, E) = \{(l', \{2, 6\}), (w', \{2, 6\})\}$ isn't $_S\alpha O_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIOm$.

Theorem 2.4. *Any $_SIIOm$ is $_SIOm$, also it is a $_SIntOm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_SIIOm$. Let (G, E) be an $_SO_S$ in (X, τ, E), we have $f_{pu}(G, E)$ is a $_SIIO_S$ in (Y, ρ, H) (by assume). Since each $_SIIO_S$ is a $_SIO_S$ and $_SIntO_S$ ([5], Definition 3.1(3) and Remark 3.19), we have $f_{pu}(G, E)$ is a $_SIO_S$ and $_SIntO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIOm$, also it is a $_SIntOm$. □

Example 2.5. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H)\}$, where $(F_1, E) = \{(l, \{1, 5\}), (w, \{1, 5\})\}$, $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$ and $(G_2, H) = \{(l', \{2, 6\}), (w', \{2, 6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6$. Obviously, f_{pu} is not a $_SIIOm$ since (F_1, E) is $_SO_S$ in (X, τ, E) but $f_{pu}(F_1, E) = \{(l', \{4, 6\}), (w', \{4, 6\})\}$ isn't $_SIIO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIOm$.

Example 2.6. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H)\}$, where $(F_1, E) = \{(l, \{3, 5\}), (w, \{3, 5\})\}$, $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$ and $(G_2, H) = \{(l', \{4, 6\}), (w', \{4, 6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6$. Obviously, f_{pu} is not a $_SIIOm$ since (F_1, E) is $_SO_S$ in (X, τ, E), but $f_{pu}(F_1, E) = \{(l', \{2, 6\}), (w', \{2, 6\})\}$ isn't $_SIIO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIntOm$.

Theorem 2.5. *Each $_SSOm$ is $_SIIOm$.*

Proof. Assume that a function $f_{pu}: SS(X_E) \to SS(Y_H)$ be a $_SSOm$. Let (G, E) be an $_SO_S$ in (X, τ, E), we have $f_{pu}(G, E)$ is a $_SSO_S$ in (Y, ρ, H) (by assume). Since each $_SSO_S$ is a $_SIIO_S$ ([5], Theorem 3.11), we have $f_{pu}(G, E)$ is a $_SIIO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIIOm$. □

Theorem 2.6. *Any $_SOm$ is $_SIIOm$.*

Proof. Assume that a function $f_{pu}: SS(X_E) \to SS(Y_H)$ be a $_SOm$. Let (G, E) be an $_SO_S$ in (X, τ, E), we have $f_{pu}(G, E)$ is a $_SO_S$ in (Y, ρ, H) (by assume). Since each $_SO_S$ is a $_SIIO_S$ ([5], Theorem 3.12), we have $f_{pu}(G, E)$ is a $_SIIO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIIOm$. □

Example 2.7. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H)\}$, where $(F_1, E) = \{(l, \{1, 5\}), (w, \{1, 5\})\}$, $(G_1, H) = \{(l', \{4\}), (w', \{4\})\}$ and $(G_2, H) = \{(l', \{4, 6\}), (w', \{4, 6\})\}$. Presently characterize the mapping $f_{pu}: SS(X_E) \to SS(Y_H)$ where $u: X \to Y$, $p: E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is not a $_SOm$ since (F_1, E) is $_SO_S$ in (X, τ, E), but $f_{pu}(F_1, E) = \{(l', \{2, 4\}), (w', \{2, 4\})\}$ isn't $_SO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIIOm$.

Theorem 2.7. *Each $_S\alpha Om$ is $_SIIOm$.*

Proof. Assume that a function $f_{pu}: SS(X_E) \to SS(Y_H)$ be a $_S\alpha Om$. Let (G, E) be an $_SO_S$ in (X, τ, E), we have $f_{pu}(G, E)$ is a $_S\alpha O_S$ in (Y, ρ, H) (by assume). Since each $_S\alpha O_S$ is a $_SIIO_S$ ([5], Theorem 3.15), we have $f_{pu}(G, E)$ is a $_SIIO_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIIOm$. □

Example 2.8. Let $X = \{1, 3, 5, 7\}, Y = \{2, 4, 6, 8\}, E = \{l, w\}$ and $H = \{l', w'\}$.

Obviously $\tau=\{\phi_E, X_E, (F_1, E)\}$ and $\rho=\{\phi_H, Y_H, (G_1, H), (G_2, H), (G_3, H)\}$, where $(F_1, E) = \{(l, \{3, 5, 7\}), (w, \{3, 5, 7\})\}$, $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$ and $(G_2, H) = \{(l', \{6, 8\}), (w', \{6, 8\})\}$, $(G_3, H) = \{(l', \{2, 6, 8\}), (w', \{2, 6, 8\})\}$.

Presently characterize the mapping $f_{pu}: SS(X_E) \to SS(Y_H)$ where $u: X \to Y$, $p: E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6$ and $u(7) = 8$. Obviously, f_{pu} is not a $_S\alpha Om$ since (F_1, E) is $_SO_S$ in (X, τ, E), but $f_{pu}(F_1, E) = \{(l', \{4, 6, 8\}), (w', \{4, 6, 8\})\}$ isn't $_S\alpha O_S$ in (Y, ρ, H). Hence f_{pu} is a $_SIIOm$.

Corollary 2.2. *Any $_S\alpha Om$ is a $_SIntOm$.*

Proof. Clear. □

Example 2.9. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H)\}$, where $(F_1, E) = \{(l, \{1, 5\}), (w, \{1, 5\})\}$, $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$ and $(G_2, H) = \{(l', \{4, 6\}), (w', \{4, 6\})\}$. Presently characterize the mapping $f_{pu}: SS(X_E) \to$

$SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is not a ${}_S\alpha Om$ since (F_1, E) is ${}_SO_S$ in (X, τ, E), but $f_{pu}(F_1, E) = \{(l', \{2, 4\}), (w', \{2, 4\})\}$ isn't ${}_S\alpha O_S$ in (Y, ρ, H). Hence f_{pu} is a ${}_SIntOm$.

3. Soft ii-continuous mappings

Definition 3.1. Consider a mappings $f_{pu} : SS(X_E) \to SS(Y_H)$, $u : X \to Y$, $p : E \to H$. Then a mapping f_{pu} is called:

i) Soft continuous (${}_SCONm$) if $f_{pu}^{-1}(G, H)\widetilde{\in}{}_SO_S(X_E)$, $\forall(G, H)\widetilde{\in}{}_SO_S(Y_H)$ (see [28]).

ii) Soft α- continuous (${}_S\alpha CONm$) if $f_{pu}^{-1}(G, H)\widetilde{\in}{}_S\alpha O_S(X_E)$, $\forall(G, H)\widetilde{\in}{}_SO_S(Y_H)$ (see [16]).

iii) Soft semi-continuous (${}_SSCONm$) if $f_{pu}^{-1}(G, H)\widetilde{\in}{}_SSO_S(X_E)$, $\forall(G, H)\widetilde{\in}{}_SO_S(Y_H)$ (see [16]).

iv) Soft i-continuous (${}_SICONm$) if $f_{pu}^{-1}(G, H)\widetilde{\in}{}_SIO_S(X_E)$, $\forall(G, H)\widetilde{\in}{}_SO_S(Y_H)$.

v) Soft inter-continuous (${}_SINTCONm$) if $f_{pu}^{-1}(G, H)\widetilde{\in}{}_SIntO_S(X_E)$, $\forall(G, H)\widetilde{\in}{}_SO_S(Y_H)$.

vi) Soft ii-continuous (${}_SIICONm$) if $f_{pu}^{-1}(G, H)\widetilde{\in}{}_SIIO_S(X_E)$, $\forall(G, H)\widetilde{\in}{}_SO_S(Y_H)$.

Theorem 3.1. *Each ${}_SCONm$ is ${}_SICONm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_SCONm$. Let (G, H) be an ${}_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a ${}_SO_S$ in (X, τ, E) (by assume). Since each ${}_SO_S$ is a ${}_SIO_S$ ([5], Theorem 3.2), we have $f_{pu}^{-1}(G, H)$ is a ${}_SIO_S$ in (X, τ, E). Hence f_{pu} is a ${}_SICONm$. □

Example 3.1. Let $X = \{1, 3, 5, 7\}, Y = \{2, 4\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E), (F_3, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H)\}$, are ${}_ST_S$ over X and Y individually where $(F_1, E) = \{(l, \{3\}), (w, \{3\})\}$, $(F_2, E) = \{(l, \{5, 7\}), (w, \{5, 7\})\}$, $(F_3, E) = \{(l, \{3, 5, 7\}), (w, \{3, 5, 7\})\}$, $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$ and $(G_2, H) = \{(l', \{4\}), (w', \{4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(5) = 2, u(7) = 2, u(3) = 4$. ${}_SIO_S(X_E) = \{\phi_E, X_E, (F_1, E), (F_2, E), (F_3, E), \{(l, \{1, 5, 7\}), (w, \{1, 5, 7\})\}$.

Plainly, f_{pu} is not a ${}_SCONm$ since (G_1, H) is ${}_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\}= \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2\})), (w, u^{-1}(\{2\}))\}=\{(l, \{1, 5, 7\}), (w, \{1, 5, 7\})\}$, which isn't a ${}_SO_S$ in (X, τ, E). Be that as it may f_{pu} is a ${}_SICONm$.

Theorem 3.2. *Each $_SSCONm$ is $_SICONm$*

Proof. Consider $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_SSCONm$. Let (G, H) be an $_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a $_SSO_S$ in (X, τ, E) (by consider). Since each $_SSO_S$ is a $_SIO_S$ ([5], Theorem 3.5), we have $f_{pu}^{-1}(G, H)$ is a $_SIO_S$ in (X, τ, E). Hence f_{pu} is a $_SICONm$. □

Example 3.2. Let $X = \{1, 3, 5, 7\}, Y = \{2, 4\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{5, 7\}), (w, \{5, 7\})\}$, and $(G_1, H) = \{(l', \{4\}), (w', \{4\})\}$.

Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 2, u(7) = 2, u(5) = 4$. Plainly, f_{pu} is not a $_SSCONm$ since (G_1, H) is $_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{4\})), (w, u^{-1}(\{4\}))\} = \{(l, \{5\}), (w, \{5\})\}$, which isn't a $_SSO_S$ in (X, τ, E). Hence f_{pu} is a $_SICONm$.

Theorem 3.3. *Any $_S\alpha CONm$ is $_SICONm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_S\alpha CONm$. Let (G, H) be an $_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a $_S\alpha O_S$ in (X, τ, E) (by assume). Since each $_S\alpha O_S$ is a $_SIO_S$ ([5], Corollary 3.9), we have $f_{pu}^{-1}(G, H)$ is a $_SIO_S$ in (X, τ, E). Hence f_{pu} is a $_SICONm$. □

In Example 3.2, we have f_{pu} isn't a $_S\alpha CONm$ since (G_1, H) is a $_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\}$ $= \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{4\})), (w, u^{-1}(\{4\}))\} = \{(l, \{5\}), (w, \{5\})\}$,which isn't a $_S\alpha O_S$ in (X, τ, E).But f_{pu} is a $_SICONm$.

Theorem 3.4. *Each $_S\alpha CONm$ is $_SSCONm$.*

Proof. Consider $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_S\alpha CONm$. Let (G, H) be an $_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a $_S\alpha O_S$ in (X, τ, E) (by consider). Since each $_S\alpha O_S$ is a $_SSO_S$ ([5], Theorem 3.7), we have $f_{pu}^{-1}(G, H)$ is a $_SSO_S$ in (X, τ, E). Hence f_{pu} is a $_SSCONm$ (see [16]). □

Example 3.3. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E), (F_3, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$,$(F_2, E) = \{(l, \{3\}), (w, \{3\})\}$, $(F_3, E) = \{(l, \{1, 3\}), (w, \{1, 3\})\}$ and $(G_1, H) = \{(l', \{2, 4\}), (w', \{2, 4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$.

Obviously, f_{pu} is not a $_S\alpha CONm$ since (G_1, H) is $_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))),$ $(w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2, 4\})), (w, u^{-1}(\{2, 4\}))\} = \{(l, \{1, 5\}),$ $(w, \{1, 5\})\}$,which isn't a $_S\alpha O_S$ in (X, τ, E).Hence f_{pu} is a $_SSCONm$.

Theorem 3.5. *Each $_SIICONm$ is $_SICONm$ and a $_SINTCONm$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_SIICONm$. Let (G, H) be an $_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a $_SIIO_S$ in (X, τ, E) (by assume). Since each $_SIIO_S$ is a $_SIO_S$ and a $_SIntO_S$ ([5], Definition 3.1(1, 2 and 3)" and "Remark 3.19), we have $f_{pu}^{-1}(G, H)$ is a $_SIO_S$ and a $_SIntO_S$ in (X, τ, E). Hence f_{pu} is a $_SICONm$ and a $_SINTCONm$. □

Example 3.4. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$,$(F_2, E) = \{(l, \{1, 5\}), (w, \{1, 5\})\}$ and $(G_1, H) = \{(l', \{2, 6\}), (w', \{2, 6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$, where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6$.

Obviously, f_{pu} is not a $_SIICONm$ since (G_1, H) is $_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2, 6\})), (w, u^{-1}(\{2, 6\}))\} = \{(l, \{3, 5\}), (w, \{3, 5\})\}$, which isn't a $_SIIO_S$ in (X, τ, E). Hence f_{pu} is a $_SICONm$.

Example 3.5. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$,$(F_2, E) = \{(l, \{3, 5\}), (w, \{3, 5\})\}$ and $(G_1, H) = \{(l', \{4, 6\}), (w', \{4, 6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6$.

Obviously, f_{pu} is not a $_SIICONm$ since (G_1, H) is $_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{4, 6\})), (w, u^{-1}(\{4, 6\}))\} = \{(l, \{1, 5\}), (w, \{1, 5\})\}$, which isn't a $_SIIO_S$ in (X, τ, E). Hence f_{pu} is a $_SINTCONm$.

Theorem 3.6. *Any $_SSCONm$ is $_SIICONm$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_SSCONm$. Let (G, H) be an $_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a $_SSO_S$ in (X, τ, E) (by assume). Since each $_SSO_S$ is a $_SIIO_S$ ([5], Theorem 3.11), we have $f_{pu}^{-1}(G, H)$ is a $_SIIO_S$ in (X, τ, E). Hence f_{pu} is a $_SIICONm$. □

Theorem 3.7. *Any $_SCONm$ is $_SIICONm$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_SCONm$. Let (G, H) be an $_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a $_SO_S$ in (X, τ, E) (by assume). Since each $_SO_S$ is a $_SIIO_S$ ([5], Theorem 3.12), we have $f_{pu}^{-1}(G, H)$ is a $_SIIO_S$ in (X, τ, E). Hence f_{pu} is a $_SIICONm$. □

Example 3.6. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{3\}), (w, \{3\})\}$,$(F_2, E) = \{(l, \{3, 5\}), (w, \{3, 5\})\}$ and $(G_1, H) =$

$\{(l', \{2,6\}), (w', \{2,6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is not a ${}_SCONm$ since (G_1, H) is ${}_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2,6\})), (w, u^{-1}(\{2,6\}))\} = \{(l, \{1,3\}), (w, \{1,3\})\}$,which isn't a ${}_SO_S$ in (X, τ, E).Hence f_{pu} is a ${}_SIICONm$.

Theorem 3.8. *Any ${}_S\alpha CONm$ is ${}_SIICONm$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_S\alpha CONm$. Let (G, H) be an ${}_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a ${}_S\alpha O_S$ in (X, τ, E) (by assume). Since each ${}_S\alpha O_S$ is a ${}_SIIO_S$ ([5], Theorem 3.15), we have $f_{pu}^{-1}(G, H)$ is a ${}_SIIO_S$ in (X, τ, E). Hence f_{pu} is a ${}_SIICONm$. □

Example 3.7. Let $X = \{1,3,5,7\}, Y = \{2,4,6,8\}, E = \{l, w\}$ and $H = \{l', w'\}$.

Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E), (F_3, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$,$(F_2, E) = \{(l, \{5,7\}), (w, \{5,7\})\}$, $(F_3, E) = \{(l, \{1,5,7\}), (w, \{1,5,7\})\}$ and (G_1, H)=$\{(l', \{2,6,8\}), (w', \{2,6,8\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6, u(7) = 8$. Obviously, f_{pu} is not a ${}_S\alpha CONm$ since (G_1, H) is ${}_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2,6,8\})), (w, u^{-1}(\{2,6,8\}))\} = \{(l, \{3,5,7\}), (w, \{3,5,7\})\}$, which isn't a ${}_S\alpha O_S$ in (X, τ, E). Hence f_{pu} is a ${}_SIICONm$.

Theorem 3.9. *Any ${}_S\alpha CONm$ is ${}_SINTCONm$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_S\alpha CONm$. Let (G, H) be an ${}_SO_S$ in (Y, ρ, H), we have $f_{pu}^{-1}(G, H)$ is a ${}_S\alpha O_S$ in (X, τ, E) (by assume). Since each ${}_S\alpha O_S$ is a ${}_SIntO_S$ ([5], Corollary 3.17), we have $f_{pu}^{-1}(G, H)$ is a ${}_SIntO_S$ in (X, τ, E). Hence f_{pu} is a ${}_SINTCONm$. □

Example 3.8. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$,$(F_2, E) = \{(l, \{3,5\}), (w, \{3,5\})\}$ and $(G_1, H) = \{(l', \{2,6\}), (w', \{2,6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is not a ${}_S\alpha CONm$ since (G_1, H) is ${}_SO_S$ in (Y, ρ, H), but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2,6\})), (w, u^{-1}(\{2,6\}))\} = \{(l, \{1,3\}), (w, \{1,3\})\}$, which isn't a ${}_S\alpha O_S$ in (X, τ, E).

Hence f_{pu} is a ${}_SINTCONm$.

4. Soft topological ii-homeomorphisms

Definition 4.1. Consider $f_{pu} : SS(X_E) \to SS(Y_H)$ be mapping from (X, τ, E) into (Y, ρ, H) where $u : X \to Y$, $p : E \to H$ are two mappings, then f_{pu} is called bijection mapping (BM) if it is:

1. Onto wherein $f_{pu}(X_E) = Y_H$.
2. One-to-one if $(F_1, E) \neq (F_2, E)$, then $f_{pu}(F_1, E) \neq f_{pu}(F_2, E)$, $\forall (F_1, E)$, $(F_2, E) \in SS(X_E)$ (see [13]).

Definition 4.2. Consider $f_{pu} : SS(X_E) \to SS(Y_H)$ be a BM from (X, τ, E) into (Y, ρ, H) where $u : X \to Y$, $p : E \to H$ are two mappings, then f_{pu} is called:

i) Soft topological homeomorphism ($_STh$) if it is a $_SCONm$ and $_SOm$ (see [13]).

ii) Soft topological semi-homeomorphism ($_STSh$) if it is a $_SSCONm$ and $_SSOm$ (see [13]).

iii) Soft topological α-homeomorphism ($_ST\alpha h$) if it is a $_S\alpha CONm$ and $_S\alpha Om$ (see [16]).

iv) Soft topological i-homeomorphism ($_STIh$) if it is a $_SICONm$ and $_SIOm$.

v) Soft topological inter-homeomorphism ($_STINTh$) if it is a $_SINTCONm$ and $_SIntOm$.

vi) Soft topological ii-homeomorphism ($_STIIh$) if it is a $_SIICONm$ and $_SIIOm$.

Theorem 4.1. *Each $_STh$ is $_STIh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_STh$. We have f_{pu} is a $_SCONm$,$_SOm$ and a BM(by assume). By Theorem 3.1, we have that f_{pu} is a $_SICONm$ and Theorem 2.1 f_{pu} is a $_SIOm$. Hence, f_{pu} is a $_STIh$. □

Example 4.1. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, are $_ST_S$ over X and Y in dividually where $(F_1, E) = \{(l, \{1, 3\}), (w, \{1, 3\})\}$ and $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w)=w'$, $u(1)=2, u(3)=6, u(5)=4$.
$_SIO_S(X_E)=\{\phi_E, X_E, (F_1, E), \{(l, \{1\}), (w, \{1\})\}, \{(l, \{3\}), (w, \{3\})\}, \{(l, \{1, 5\}), (w, \{1, 5\})\}, \{(l, \{3, 5\}), (w, \{3, 5\})\}$. $_SIO_S(Y_H) = \{\phi_H, Y_H, (G_1, H), \{(l', \{2, 4\}), (w', \{2, 4\})\}, \{(l', \{2, 6\}), (w', \{2, 6\})\}\}$.

Apparently, f_{pu} is not a $_SCONm$ since (G_1, H) is $_SO_S$ in (Y, ρ, H), but $f^{-1}_{pu}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))),$

$(w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2\})), (w, u^{-1}(\{2\}))\} = \{(l, \{1\}), (w, \{1\})\}$, which isn't a $_SO_S$ in (X, τ, E). Hence f_{pu} is a $_SICONm$. f_{pu} Isn't a $_SOm$ since (F_1, E) is an $_SO_S$ in (X, τ, E) but $f_{pu}(F_1, E) = \{(l', \{2, 6\}), (w', \{2, 6\})\}$ isn't a $_SO_S$ in (Y, ρ, H). f_{pu} is a $_SIOm$. Since f_{pu} is BM. Hence, f_{pu} is $_sTIh$.

Theorem 4.2. *Any $_STSh$ is $_STIh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_STSh$. We have f_{pu} is a $_SSCONm$,$_SSOm$ and a BM(by assume). By Theorem 3.2, we have that f_{pu} is a $_SICONm$ and by Theorem 2.2 f_{pu} is a $_SIOm$. Hence, f_{pu} is a $_STIh$. □

Example 4.2. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$ and $(G_1, H) = \{(l', \{2, 4\}), (w', \{2, 4\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Essentially as in above example f_{pu} is a $_SSCONm$ Definition 3.1 (iii). f_{pu} is a $_SICONm$ Definition 3.1 (iv) ,f_{pu} isn't a $_SSOm$ since (F_1, E) is an $_SO_S$ in (X, τ, E) but $f_{pu}(F_1, E) = \{(l', \{2\}), (w', \{2\})\}$ isn't a $_SSO_S$ in (Y, ρ, H). f_{pu} is a $_SIOm$ Definition 2.1 (vii) and since f_{pu} is BM. Hence, f_{pu} is $_sTIh$ but it isn't a $_sTSh$

Theorem 4.3. *Each $_ST\alpha h$ is $_STIh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_ST\alpha h$. We have f_{pu} is a $_S\alpha CONm$,$_S\alpha Om$ and a BM(by assume). By Theorem 3.3, we have that f_{pu} is a $_SICONm$ and by Corollary 2.1 f_{pu} is a $_SIOm$. Hence, f_{pu} is a $_STIh$. □

In Example 4.2, we have f_{pu} is a $_S\alpha CONm$ Definition 3.1 (ii), f_{pu} is $_SICONm$ Definition 3.1(iv), but f_{pu} isn't a $_S\alpha Om$ since (F_1, E) is an $_SO_S$ in (X, τ, E) but $f_{pu}(F_1, E) = \{(l', \{2\}), (w', \{2\})\}$ isn't a $_S\alpha O_S$ in (Y, ρ, H). f_{pu} is a $_SIOm$ Definition 2.1 (vii) and since f_{pu} is BM. Hence, f_{pu} is $_sTIh$ but it isn't a $_sT\alpha h$

Theorem 4.4. *Each $_ST\alpha h$ is $_STSh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_ST\alpha h$. We have f_{pu} is a $_S\alpha CONm$,$_S\alpha Om$ and a BM(by assume). By Theorem 3.4, we have that f_{pu} is a $_SSCONm$ and by Theorem 2.3 f_{pu} is a $_SSOm$. Hence, f_{pu} is a $_STSh$ (see [16]). □

Example 4.3. Let $X = \{1, 3, 5\}, Y = \{2, 4, 6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), F_2, E), F_3, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H), (G_3, H), (G_4, H)\}$, where $(F_1, E) = \{(l, \{1\}), (w, \{1\})\}$, $(F_2, E) = \{(l, \{3\}), (w, \{3\})\}$, $(F_3, E) = \{(l, \{1, 3\}), (w, \{1, 3\})\}$, $(G_1, H) = \{(l', \{2\}), (w', \{2\})\}$,$(G_2, H) = \{(l', \{6\}), (w', \{6\})\}$, $(G_3, H) = \{(l', \{2, 6\}),(w', \{2, 6\})\}$

and $(G_4, H) = \{(l', \{4,6\}), (w', \{4,6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 2, u(3) = 6, u(5) = 4$. Obviously, f_{pu} is a $_SSCONm$ Definition 3.1(iii). f_{pu} isn't a $_S\alpha CONm$ since (G_4, H) is an $_SO_S$ in (Y, ρ, H) but $f_{pu}^{-1}(G_4, H) = \{(l, u^{-1}(G_4(p(l)))), (w, u^{-1}(G_4(p(w))))\} = \{(l, u^{-1}(G_4(p(l')))), (w, u^{-1}(G_4(p(w'))))\} = \{(l, u^{-1}(\{4,6\})), (w, u^{-1}(\{4,6\}))\} = \{(l, \{3,5\}), (w, \{3,5\})\}$ isn't a $_S\alpha O_S$ in (X, τ, E). f_{pu} is a $_SSOm$ Definition 2.1 (iii) and f_{pu} is a $_S\alpha Om$ Definition 2.1 (v), since f_{pu} is BM. Hence, f_{pu} is $_sTSh$ but it isn't a $_sT\alpha h$

Theorem 4.5. *Any $_STIIh$ is $_STIh$ and it is a $_STINTh$*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_STIIh$. We have f_{pu} is a $_SIICONm$,$_SIIOm$ and a BM(by assume). By Theorem 3.5, we have that f_{pu} is a $_SICONm$ and $_SINTCONm$ by Theorem 2.4 f_{pu} is a $_SIOm$ and $_SIntOm$. Hence, f_{pu} is a $_STIh$ and it is a $_STINTh$. □

Example 4.4. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H)\}$, where $(F_1, E) = \{(l, \{1,3\}), (w, \{1,3\})\}$, and $(G_1, H) = \{(l', \{2,6\}), (w', \{2,6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 2, u(5) = 6$.

Obviously, f_{pu} is a $_SICONm$ Definition 3.1(iv). f_{pu} isn't a $_SIICONm$ since (G_1, H) is an $_SO_S$ in (Y, ρ, H) but $f_{pu}^{-1}(G_1, H) = \{(l, u^{-1}(G_1(p(l)))), (w, u^{-1}(G_1(p(w))))\} = \{(l, u^{-1}(G_1(p(l')))), (w, u^{-1}(G_1(p(w'))))\} = \{(l, u^{-1}(\{2,6\})), (w, u^{-1}(\{2,6\}))\} = \{(l, \{3,5\}), (w, \{3,5\})\}$ isn't a $_SIIO_S$ in (X, τ, E). f_{pu} is a $_SIOm$ Definition 2.1 (vii) and f_{pu} is not a $_SIIOm$, since (F_1, E) is an $_SO_S$ in (X, τ, E), also $f_{pu}(F_1, E) = \{(l', \{2,4\}), (w', \{2,4\})\}$ isn't a $_SIIO_S$ in (Y, ρ, H). f_{pu} is BM. Hence, f_{pu} is $_sTIh$ but it isn't a $_sTIIh$

Example 4.5. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l, w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1, E), (F_2, E), (F_3, E)\}$ and $\rho = \{\phi_H, Y_H, (G_1, H), (G_2, H)\}$, where $(F_1, E) = \{(l, \{3\}), (w, \{3\})\}$,$(F_2, E) = \{(l, \{1,5\}), (w, \{1,5\})\}$, $(F_3, E) = \{(l, \{1,3\}), (w, \{1,3\})\}$, $(G_1, H) = \{(l', \{4\}), (w', \{4\})\}$ and $(G_2, H) = \{(l', \{2,6\}), (w', \{2,6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 6, u(3) = 4, u(5) = 2$. Obviously,$f_{pu}$ is a $_SINTCONm$ Definition 3.1 (v). f_{pu} is a $_SIICONm$ Definition 3.1 (vi). f_{pu} is a $_SIntOm$ Definition 2.1 (ix) f_{pu} isn't a $_SIIOm$ since (F_3, E) is an $_SO_S$ in $(X, \tau, E) f_{pu}(F_3, E) = \{(l', \{4,6\}), (w', \{4,6\})\}$ isn't a $_SIIO_S$ in (Y, ρ, H). f_{pu} is BM. Hence, f_{pu} is $_sTINTh$ but it isn't a $_sTIIh$

Theorem 4.6. *Any $_STSh$ is $_STIIh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a $_STSh$. We have f_{pu} is a $_SSCONm$,$_SSOm$ and a BM(by assume). By Theorem 3.5, we have that f_{pu} is a ${}_SICONm$ and ${}_SINTCONm$ by Theorem 3.6 f_{pu} is a ${}_SIICONm$ and by Theorem 2.5 f_{pu} is a ${}_SIIOm$. Hence, f_{pu} is a ${}_STIIh$. □

Theorem 4.7. *Any ${}_STh$ is ${}_STIIh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_STh$. We have f_{pu} is a ${}_SCONm$,${}_SOm$ and a BM(by assume). By Theorem 3.5, we have that f_{pu} is a ${}_SICONm$ and ${}_SINTCONm$ by Theorem 3.7 f_{pu} is a ${}_SIICONm$ and by Theorem 2.6 f_{pu} is a ${}_SIIOm$. Hence, f_{pu} is a ${}_STIIh$. □

Example 4.6. Let $X = \{1,3,5\}, Y = \{2,4,6\}, E = \{l,w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1,E), (F_2,E)\}$ and $\rho = \{\phi_H, Y_H, (G_1,H), (G_2,H)\}$, where $(F_1,E) = \{(l,\{3\}),(w,\{3\})\}$,$(F_2,E) = \{(l,\{3,5\}),(w,\{3,5\})\}$,$(G_1,H) = \{(l',\{2\}),(w',\{2\})\}$ and $(G_2,H) = \{(l',\{2,6\}),(w',\{2,6\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 6, u(3) = 2, u(5) = 4$. ${}_SO_S(X_E) = \{\phi_E, X_E, (F_1,E), (F_2,E)\},{}_SO_S(Y_H) = \{\phi_H, Y_H, (G_1,H), (G_2,H)\}$. Apparently,$f_{pu}$ is a ${}_SIICONm$ Definition 3.1 (vi). f_{pu} is a ${}_SIIOm$ Definition 2.1 (xi).f_{pu} isn't a ${}_SOm$ since (F_2,E) is an ${}_SO_S$ in $(X,\tau,E), f_{pu}(F_2,E) = \{(l',\{2,4\}),(w',\{2,4\})\}$ isn't a ${}_SO_S$ in (Y,ρ,H). f_{pu} is BM. Hence, f_{pu} is ${}_sTIIh$ but it isn't a ${}_sTh$

Theorem 4.8. *Any ${}_ST\alpha h$ is ${}_STIIh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_ST\alpha h$. We have f_{pu} is a ${}_S\alpha CONm$,${}_S\alpha Om$ and a BM(by assume). By Theorem 3.8, we have that f_{pu} is a ${}_SIICONm$ and by Theorem 2.7 f_{pu} is a ${}_SIIOm$. Hence, f_{pu} is a ${}_STIIh$. □

Example 4.7. Let $X = \{1,3,5,7\}, Y = \{2,4,6,8\}, E = \{l,w\}$ and $H = \{l', w'\}$. Obviously $\tau = \{\phi_E, X_E, (F_1,E), (F_2,E), (F_3,E), (F_4,E)\}$ and $\rho = \{\phi_H, Y_H, (G_1,H), (G_2,H), (G_3,H)\}$, where $(F_1,E) = \{(l,\{5\}),(w,\{5\})\}$,$(F_2,E) = \{(l,\{3,7\}),(w,\{3,7\})\}$, $(F_3,E) = \{(l,\{3,5,7\}),(w,\{3,5,7\})\}$, $(F_4,E) = \{(l,\{1,3,7\}),(w,\{1,3,7\})\}$, $(G_1,H) = \{(l',\{2\}),(w',\{2\})\}$,$(G_2,H) = \{(l',\{6,8\}),(w',\{6,8\})\}$ and $(G_3,H) = \{(l',\{2,6,8\}),(w',\{2,6,8\})\}$. Presently characterize the mapping $f_{pu} : SS(X_E) \to SS(Y_H)$ where $u : X \to Y$, $p : E \to H$ are characterized by $p(l) = l', p(w) = w', u(1) = 4, u(3) = 6, u(5) = 2$. Obviously,$f_{pu}$ is a ${}_SIICONm$ Definition 3.1 (vi). f_{pu} is a ${}_SIIOm$ Definition 2.1 (xi). f_{pu} isn't a ${}_S\alpha Om$ since (F_4,E) is an ${}_SO_S$ in $(X,\tau,E), f_{pu}(F_4,E) = \{(l',\{4,6,8\}),(w',\{4,6,8\})\}$ isn't a ${}_S\alpha O_S$ in (Y,ρ,H). f_{pu} is BM. Hence, f_{pu} is ${}_sTIIh$ but it isn't a ${}_sT\alpha h$

Theorem 4.9. *Any ${}_ST\alpha h$ is ${}_STINTh$.*

Proof. Assume that a function $f_{pu} : SS(X_E) \to SS(Y_H)$ be a ${}_ST\alpha h$. We have f_{pu} is a ${}_S\alpha CONm$,${}_S\alpha Om$ and a BM(by assume). By Theorem 3.9, we have that f_{pu} is a ${}_SIICONm$ and by Corollary 2.2 f_{pu} is a ${}_SIIOm$. Hence, f_{pu} is a ${}_STIIh$. □

In Example 4.7, we have f_{pu} is a $_SINTCONm$ Definition 3.1 (v). f_{pu} is a $_SIntOm$ Definition 2.1 (ix). f_{pu} isn't a $_S\alpha Om$ since (F_4, E) is an $_SO_S$ in $(X, \tau, E), f_{pu}(F_4, E) = \{(l', \{4, 6, 8\}), (w', \{4, 6, 8\})\}$ isn't a $_S\alpha O_S$ in (Y, ρ, H). f_{pu} is BM. Hence, f_{pu} is $_sTINTh$ but it isn't a $_sT\alpha h$

5. Conclusions

1. The relations among $(_SOm,_S IOm,_S INTOm,_S IIOm,_S \alpha Om$ and $_SSOm)$ depends on the relations among $(_SO_S,_S IO_S,_S INTO_S,_S IIO_S,_S \alpha O_S$ and $_SSO_S)$.

2. The relations among $(_SCONm,_S ICONm,_S INTCONm,_S IICONm,_S \alpha CONm$ and $_SSCONm)$ depends on the relations among $(_SO_S,_S IO_S,_S INTO_S,_S IIO_S,_S \alpha O_S$ and $_SSO_S)$.

3. The relations among $(_STh,_S TIh,_S TINTh,_S TIIh,_S T\alpha h$ and $_STSh)$ depends on the relations among $(_SOm,_S IOm,_S INTOm,_S IIOm,_S \alpha Om$ and $_SSOm)$ together with $(_SCONm,_S ICONm,_S INTCONm,_S IICONm,_S \alpha CONm$ and $_SSCONm$ and $_SSCONm)$.

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References

[1] U. Acar, F. Koyunco, B. Tanay, *Soft sets and soft rings, Computers and Mathematics with Applications*, 59 (2010), 3458-3463.

[2] B. Ahmad, A. Kharal, *Mappings on soft classes*, New Math. Nat. Comp., 7 (2011), 471-481.

[3] M.I. Ali, F. Feng, X. Liu, W.K. Min, M. Shabir, *On some new operations in soft set theory*, Comp. Math. App., 57 (2009), 1547-1553.

[4] S.W. Askandar, *The property of extended and non-extended topologically for semi-open, α-open and i-open sets with the application*, M.Sc., Thesis, College of Education, University of Mosul, Mosul, Iraq, 2012.

[5] S.W. Askandar, A.A. Mohammed, *Soft ii-open sets in soft topological spaces*, Open Access Library Journal, 7 (2020).

[6] A. Aygunoglu, A. Aygun, *Some notes on soft topological spaces*, Neural Computing and Applications, 21 (2012), 113-119.

[7] S. Bayramov, C. Gunduz, *Soft locally compact spaces and soft paracompact spaces*, Journal of Mathematics and System Science, 3 (2013), 122-130.

[8] N. Cagman, S. Karatas, S.Enginoglu, *Soft topology*, Comp. Math. Appl., 62 (2011), 351-358.

[9] B. Chen, *Soft semi-open sets and related properties in soft topological spaces*, Appl. Math. Inf. Sci., 7 (2013), 287-294.

[10] S. El-Sheikh, A.A. El-Latif, *Characterization of b-open soft sets in soft topological spaces*, Journal of New Theory 2 (2015), 8-18.

[11] F. Feng, Y.B. Jun, X. Zhao, *Soft semi rings*, Computers and Mathematics with Applications, 56 (2008), 2621-2628.

[12] D.N. Georgiou, A.C. Megaritis, *Soft set theory and topology*, Applied General Topology, 15 (2014), 93-109.

[13] A.C. Gunduz, Sonmez, H. Cakall, *On soft mappings*, arXiv: 1305.4545, 1 (2013) [math.GM].

[14] S. Hussain, B. Ahmad, *Some properties of soft topological spaces*, Comp. Math. App., 62 (2011), 4058-4067.

[15] G. Ilango, M. Ravindran, *On soft preopen sets in soft topological spaces*, International Journal of Mathematics Research, 4 (2013), 399-409.

[16] A. Kandil, O. Tantawy, El-Sheikh S., A.A. El-Latif , *γ–operation and decompositions of some forms of soft continuity in soft topological spaces*, Annals of Fuzzy Mathematics and Informatics, 7 (2014), 181-196.

[17] N. Levine, *Semi-open sets and semi-continuity in topological space*, Amer. Math. Monthly, 70 (1963), 36-41.

[18] P.K. Maji, R. Biswas, A.R. Roy, *Soft set theory*, Comp. Math. App., 45 (2003), 555-562.

[19] A.A. Mohammed, B.S. Abdullah,*ii-Open sets in topological spaces*, International Mathematics Forum, 14 (2019), 41-48.

[20] D.A. Molodtsov, *Soft set theory-first results*, Comp. Math. App., 37 (1999), 19-31.

[21] W.K. Min, *A note on soft topological spaces*, Computers and Mathematics Appl., 62 (2011), 3524-3528.

[22] O. Njastad, *On some classes of nearly open sets*, Pacific Journal of Mathematics, 15 (1965), 961-970.

[23] T.Y. Ozturk, S. Bayramov, *Soft mappings space*, Hindawi Publishing Corporation, the Scientific World Journal, Article ID 307292, (2014), 8 Pages.

[24] E. Peyghan, B. Samadi, A. Tayebi, *Some results related to soft topological spaces*, Journal Facta Universitatis, Ser. Math. Inform., 29 (2014), 325-336.

[25] M. Shabir, M. I.Ali, *Soft ideals and generalized fuzzy ideals in semi groups*, New Mathematics and Natural Computations, 5 (2009), 599-615.

[26] M. Shabir, M. Naz, *On soft topological spaces*, Comp. Math. App., 61 (2011), 1786-1799.

[27] M. Shabir, A. Bashir, *Some properties of soft topological spaces*, Computers and Mathematics with Applications, 62 (2011), 4058-4067.

[28] I. Zorlutuna, M. Akdag, W. Min, S. Atmaca, *Remarks on soft topological spaces*, Annals of Fuzzy Mathematics and Informatics, 3 (2012), 171-185.

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