New decomposition of soft supra locally α -closed sets applied to soft supra continuity

Alaa M. Abd El-Latif, Shaaban M. Shaaban & Chandrashekhar Meshram

Journal of Interdisciplinary Mathematics
ISSN: 0972-0502 (Print), ISSN: 2169-012X (Online)
Vol. 24 (2021), No. 5, pp. 1163–1173
DOI : 10.1080/09720502.2021.1885811

Taylor & Francis
Taylor & Francis Group

New decomposition of soft supra locally α-closed sets applied to soft supra continuity

Alaa M. Abd El-Latif *
Department of Mathematics
Faculty of Arts and Science
Northern Border University
Rafha
Saudi Arabia

and

Department of Mathematics
Faculty of Education
Ain Shams University
Roxy 11341
Cairo
Egypt

Shaaban M. Shaaban
Department of Engineering Basic Science
Faculty of Engineering
Menofiya University
Menofiya 32511
Egypt

and

Department of Electrical Engineering
Northern Border University
Arar 1321
Saudi Arabia

*E-mail: alaa_8560@yahoo.com, alaa.ali@nbu.edu.sa

Chandrashekhar Meshram
Department of Mathematics and Computer Science
Rani Durgawati University
Jabalpur 482001
Madhya Pradesh
India

and

Department of Post Graduate Studies and Research in Mathematics
Jayawanti Haksar Government Post Graduate College
College of Chhindwara University
Betul 460001
Madhya Pradesh
India

Abstract

In this paper, firstly we introduce the notions of soft supra locally α-closed sets in soft supra topological spaces. We investigate the relationships with different types of subsets of soft supra topological spaces. Secondly, we introduce the notion of SSL-α C-continuous functions and a decomposition of soft supra continuity is obtained.

Subject Classification: *(2010) 54A05, 54A40, 54B05, 06D72.*

Keywords: *Soft supra topological spaces, SSL-α-closed sets, SSL-α C-continuous functions.*

1. Introduction

Since soft set theory [13, 14] has rich potential for practical applications in several domains, it has been studied by many authors [5, 6, 8, 11, 13, 15]. In 2011, Shabir et al. [16] initiated the notions of soft topological spaces (sts's). The notions of soft supra topological spaces (ssts's) were first introduced by El-Sheikh et al. [7] which generalized in [2]. A new concept of supra open soft sets, named soft supra strongly generalized closed sets was initiated by Abd El-latif in [3]. In 2018, Abd El-latif [1] introduced the concepts of soft supra locally closed sets and SSLC-continuous functions in ssts's. The notion of supra soft pre-locally closed sets was introduced in [9] as a generalization to that's in [1].

Our purpose of this paper, is to use the notion of soft supra α-open sets with a different manner of [9] to investigate new notions named, Soft supra locally α-closed sets, SSL-αC-continuous functions, and discuss their properties.

2. Preliminaries

This section is devoted to introduce the basic definitions of earlier studies which have already given in [1, 7, 12, 13, 16, 17].

Definition 2.1 : [14] A pair (G, E), denoted by G_E, is called a soft set over X,, where $G : E \to P(X)$. The family of all soft sets over X is denoted by $SS(X)_E$.

Definition 2.2 : [16] The collection $\tau \subseteq SS(X)_E$ is called a soft topology on X if it is contain $\tilde{X}, \tilde{\varphi}$ and closed under finite intersection and arbitrary union. The triplet (X, τ, E) is called a soft topological space (sts, for short) over X.

Definition 2.3 : [7] The collection $\mu \subseteq SS(X)_E$ is called a soft supra topology on X with a fixed set E if it is contain $\tilde{X}, \tilde{\varphi}$ and closed under arbitrary union. The triplet (X, μ, E) is called soft supra topological space (ssts, for short) over X. We denote the set of all soft supra open sets by $SSO(X)$ and the set of all soft supra closed sets by $SSC(X)$. If (X, τ, E) is a soft topological space, then we say that, μ is ssts associated with τ if $\tau \subset \mu$.

Definition 2.4 : [1, 7] Let (X, μ, E) be a ssts and $(A, E) \in SS(X)_E$. Then, (A, E) is said to be,

(1) Soft supra α-open set if $(A, E) \tilde{\subseteq} int^s(cl^s(int^s(A, E)))$,

(2) Soft supra A-set if $(A, E) = (G, E) - (H, E)$ where (G, E) is soft supra open and (H, E) is soft supra regular open in X.

(3) Soft supra locally closed (SSL-closed, for short) if $(A, E) = (G, E) \tilde{\cap} (H, E)$ where (G, E) is soft supra open and (H, E) is soft supra closed.

We will denote the set of all soft supra α-open (resp. A-, SSL-closed) sets by $SS\alpha O(X)$ (resp. $SSA(X)$), $SSLC(X)$.

3. Soft supra locally α-closed sets

In the present section, we initiate the notions of soft supra locally α-closed sets, soft supra locally α^*-closed sets and soft supra locally α^{**}-closed sets in ssts's and study their basic properties.

Definition 3.1 : Let (A,E) be a soft subset of a ssts (X,μ,E) such that $(A,E)=(B,E)\tilde{\cap}(C,E)$, if:

1. (B,E) is soft supra α-open and (C,E) is soft supra α-closed in X, then (A,E) is said to be a soft supra locally α-closed (SSL-α-closed, for short).
2. (B,E) is soft supra α-open and (C,E) is soft supra closed in X, then (A,E) is said to be a soft supra locally α^*-closed (SSL-α^*-closed, for short).
3. (B,E) is soft supra open and (C,E) is soft supra α-closed in X, then (A,E) is said to be soft supra locally α^{**}-closed (SSL-α^{**}-closed, for short).

If we denoted the family of all SSL-α- (resp. α^*- and α^{**}-) closed sets of a ssts X by SSL-$\alpha C(X)$ (resp. SSL-$\alpha^* C(X)$ and SSL-$\alpha^{**}C(X)$, then for a ssts (X,μ,E) we have the following implications.

$$\begin{array}{ccccc} & \text{SSL-}\alpha C(X) & \leftarrow & \text{SSL-}\alpha^{*}C(X) & \\ & \uparrow & & \uparrow & \\ \text{SSL-}\alpha^{**}C(X) & \leftarrow & \text{SSL-}C(X) & \leftarrow & SSA(X) \\ & & & & \uparrow \\ & & & & SSO(X) \end{array}$$

These implications are easy to be proved, also these implications are not reversible as shall shown in the following examples.

Examples 3.2 :

(1) Let $X=\{h,i,j,k\}$ and $E=\{e_1,e_2\}$ be the set of decision parameters. Let (H_1,E), (H_2,E), (H_3,E), (H_4,E), (H_5,E) be five soft sets over the common universe X defined as follows:

$$H_1(e_1)=\{h,i,k\},\ \ H_1(e_2)=\{h,i,k\},$$

$$H_2(e_1)=\{h,j\},\ \ H_2(e_2)=\{i,j\},$$

$$H_3(e_1)=\{i,j,k\},\ \ H_3(e_2)=\{i,j,k\},$$

$$H_4(e_1)=\{i,j\},\ \ H_4(e_2)=\{h,j\},$$

$$H_5(e_1)=\{h,i,j\},\ \ H_5(e_2)=\{h,i,j\}.$$

Hence, $\mu = \{\tilde{X}, \tilde{\varphi}, (H_1, E), (H_2, E), (H_3, E), (H_4, E), (H_5, E)\}$ is a ssts over X.

The soft set (Z, E), where $Z(e_1) = \{i\}$, $Z(e_2) = \{h\}$ is SSL-α-closed, but it is not SSL-α^*-closed.

The soft set (S, E) where $S(e_1) = \{h, j, k\}$, $S(e_2) = \{i, j, k\}$ is SSL-α-closed in (X, μ, E), but it is not

SSL-α^{**}-closed.

The soft set (T, E) is SSL-α^*-closed, but it is not SSL-closed, where $T(e_1) = \{h\}$, $T(e_2) = \{k\}$.

The soft set (U, E) is SSL-α^{**}-closed, but it is not SSL-closed, where $U(e_1) = \{h\}$, $U(e_2) = \{i, j\}$.

The soft sets (S, E) (resp. (T, E) and (U, E)) are SSL-α- (resp. α^*- and α^{**}-) closed, respectively. But, each of them neither soft supra open nor soft supra closed in (X, μ, E).

(2) Let $X = \{x, y, z, w\}$ and $E = \{e_1, e_2\}$ be the set of decision parameters. Let $(G_1, E), (G_2, E), (G_3, E), (G_4, E), (G_5, E), (G_6, E), (G_7, E), (G_8, E), (G_9, E), (G_{10}, E)$ be ten soft sets over the common universe X defined as follows:

$$G_1(e_1) = \{x, y\},\ G_1(e_2) = \{x, y\},$$
$$G_2(e_1) = \{x\},\ G_2(e_2) = \{x\},$$
$$G_3(e_1) = \{x, y\},\ G_3(e_2) = \{x\},$$
$$G_4(e_1) = \{x, y, z\},\ G_4(e_2) = \{x, z\},$$
$$G_5(e_1) = \{x, y, z\},\ G_5(e_2) = \{x, y, z\},$$
$$G_6(e_1) = X,\ G_6(e_2) = \{x, y, z\},$$
$$G_7(e_1) = \{x, y\},\ G_7(e_2) = \{x, y, z\},$$
$$G_8(e_1) = \{y\},\ G_8(e_2) = \{y\},$$
$$G_9(e_1) = \{x, y, w\},\ G_9(e_2) = \{x, y, z\},$$
$$G_{10}(e_1) = \{x, y\},\ G_{10}(e_2) = \{x, z\}.$$

Hence, $\mu = \{\tilde{X}, \tilde{\varphi}, (G_1, E), (G_2, E), (G_3, E), (G_4, E), (G_5, E), (G_6, E), (G_7, E), (G_8, E), (G_9, E), (G_{10}, E)\}$ is a ssts over X. Consider the soft set $(P, E) = (G_6, E) \tilde{\cap} (V, E)$, where (G_6, E) is soft supra open and (V, E) is soft supra closed in X given by $V(e_1) = \{z, w\}$, $V(e_2) = \{y, w\}$. Hence, (P, E), where $P(e_1) = \{z, w\}$, $P(e_2) = \{y\}$ is SSL-α- (resp. α^*- and α^{**}-) closed, but it is not soft supra A-set.

Definition 3.3 : [7] Let (X, μ, E) be a ssts over X and $(F, E) \in SS(X)_E$. Then, the soft supra α-interior of (F, E), denoted by $int^s_\alpha(F, E)$, is the soft union of all soft supra α-open subsets of (F, E). Also, the soft supra α-closure of (F, E), denoted by $cl^s_\alpha(F, E)$, is the soft intersection of all soft supra α-closed super sets of (F, E).

Theorem 3.4 : *Let (A, E) be a subset of a ssts (X, μ, E). Then, $(A, E) = (B, E) \tilde{\cap} cl^s_\alpha(A, E)$ for some soft supra α-open set (B, E). if and only if (A, E) is SSL-α-closed.*

Proof : It is similar to the proof of [Theorem 4, [9]]. □

Proposition 3.5 : Let (A, E) be a subset of a ssts (X, μ, E). Then, the following are equivalent:

(a) $(A, E) \in$ SSL-$\alpha C(X)$.

(b) $(A, E) \tilde{\cup} [cl^s_\alpha(A, E)]^{\tilde{c}}$ is soft supra α-open.

(c) $cl^s_\alpha(A, E) - (A, E)$ is soft supra α-closed.

Proof : Follows from Theorem 3.4 and [[7], Theorem 4.1]. □

Theorem 3.6 : *Let (A, E) be a subset of a ssts (X, μ, E). Then, $(A, E) = (H, E) \tilde{\cap} cl^s(A, E)$ for some soft supra α-open set (H, E) if and only if (A, E) is SSL-α^*-closed.*

Proof : The proof necessity direction is straightforward from Definition 3.1 (2).

For the sufficient direction, let (A, E) be a SSL-α^*-closed set in X. it follows, $(A, E) = (H, E) \tilde{\cap} (B, E)$ where (H, E) is soft supra α-open and (B, E) is soft supra closed in X. Therefore, $cl^s(A, E) \tilde{\subseteq} cl^s(B, E) = (B, E)$. Hence, $(A, E) \tilde{\subseteq} (H, E) \tilde{\cap} cl^s(A, E) \tilde{\subseteq} (H, E) \tilde{\cap} (B, E) = (A, E)$. Thus, $(A, E) = (H, E) \tilde{\cap} cl^s(A, E)$. □

Corollary 3.7 : *Let* (M,E) *be a subset of a ssts* (X,μ,E). *Then,* $(M,E)=(N,E)\tilde{\cap}cl_{\alpha}^{s}(M,E)$ *for some soft supra* α *-open set* (N,E) *if and only if* (M,E) *is SSL-*α^{*} *-closed.*

Proof : Follows from Theorem 3.6. □

The proof of the following theorems are similar to the previous theorems.

Theorem 3.8 : *Let* (F,E) *be a subset of a ssts* (X,μ,E). *Then, the following are equivalent:*

(a) $(F,E)\in$ *SSL-*$\alpha^{*}C(X)$.

(b) $(F,E)\tilde{\cup}[cl^{s}(F,E)]^{\tilde{c}}$ *is soft supra* α *-open.*

(c) $cl^{s}(F,E)-(F,E)$ *is soft supra* α *-closed.*

Theorem 3.9 : *Let* (S,E) *be a subset of a ssts* (X,μ,E) *Then,* $(S,E)=(G,E)\tilde{\cap}cl_{\alpha}^{s}(S,E)$ *for some soft supra open set* (G,E) *if and only if* (S,E) *is SSL-*α^{**} *-closed*

Definition 3.10 : For a soft supra topological space (X,μ,E), the soft subset (Q,E) is called soft supra α -dense set if $cl_{\alpha}^{s}(Q,E)=\tilde{X}$.

Proposition 3.11 : A soft supra α -dense set (R,E) in a ssts (X,μ,E) is SSL-α -closed if and only if it is soft supra α -open.

Proof : from Theorem 3.4. □

4. Applications on soft supra locally α -closed sets

Here, we apply the notion of SSL-α -closed sets to soft continuity. Especially, we introduce the notions of SSL-α C-continuous functions, SSL-α^{*} C-continuous functions and SSL-α^{**} C-continuous functions. Also, we investigate their relationships with different types of soft continuity of ssts's provided with the counterexamples. Also, a decomposition of soft supra continuity is obtained.

Definition 4.1 : [1, 7] Let (X,τ_1,A) and (Y,τ_2,B) be sts's. Let μ_1 be an associated ssts with τ_1.. Let $u:X\to Y$ and $p:A\to B$ be mappings. Then, the function $f_{pu}:SS(X)_A\to SS(Y)_B$ is called:

(1) Soft supra continuous (SS-continuous) if $f_{pu}^{-1}(G,B)\in\mu_1\ \forall\,(G,B)\in\tau_2$.

(2) Soft supra α-continuous if $f_{pu}^{-1}(G,B) \in SS\alpha O(X)\ \forall\ (G,B) \in \tau_2$.

(3) Soft supra A-continuous function (SSA-continuous) if $f_{pu}^{-1}(G,B) \in SSA(X)\ \forall\ (G,B) \in \tau_2$.

(4) Soft supra locally closed continuous function (SSLC-continuous) if $f_{pu}^{-1}(G,B) \in SSLC(X)\ \forall\ (G,B) \in \tau_2$.

Definition 4.2 : Let (X,τ_1,A) and (Y,τ_2,B) be sts's. Let μ_1 be an associated ssts with τ_1. Let $u: X \to Y$ and $p: A \to B$ be mappings. Then, the function $f_{pu}: SS(X)_A \to SS(Y)_B$ is called:

(1) Soft supra locally α-closed continuous function (SSL-αC-continuous) if $f_{pu}^{-1}(G,B) \in$ SSL-$\alpha C(X)\ \forall\ (G,B) \in \tau_2$.

(2) Soft supra locally α^*-closed continuous function (SSL-α^*C-continuous) if $f_{pu}^{-1}(G,B) \in$ SSL-$\alpha^* C(X)\ \forall\ (G,B) \in \tau_2$.

(3) Soft supra locally α^{**}-closed continuous function (SSL-α^{**}C-continuous) if $f_{pu}^{-1}(G,B) \in$ SSL-$\alpha^{**} C(X)\ \forall\ (G,B) \in \tau_2$.

For a ssts (X,μ,E) we have the following implications.

$$\begin{array}{ccccc}
\text{SSL-}\alpha C-continuous & \leftarrow & \text{SSL-}\alpha^* C-continuous & & \\
\uparrow & & \uparrow & & \\
\text{SSL-}\alpha^{**} C-continuous & \leftarrow & SSLC-continuous & \leftarrow & SSA-continuous \\
 & & & & \uparrow \\
 & & & & SS-continuous
\end{array}$$

These implications are not reversible as shall shown in the following examples.

Examples 4.3 :

(1) Let $X=\{h,i,j,k\}$, $Y=\{l,m,n\}$, $A=\{k_1,k_2\}$ and $B=\{e_1,e_2\}$. Define $u: X \to Y$ and $p: A \to B$ as follows:

$u(h)=\{n\}$, $u(i)=\{m\}$, $u(j)=\{l\}$, $u(k)=\{l\}$ and

$p(k_1)=\{e_2\}$, $p(k_2)=\{e_1\}$. Let (X,τ_1,A) be a soft topological space over X where,

$\tau_1=\{\tilde{X},\tilde{\varphi},(S_1,A)\}$, where (S_1,A) defined as follows:

$$S_1(k_1)=\{i,j\},\quad S_1(k_2)=\{h,j\}.$$

Consider the soft supra topology $\mu_1 = \{\tilde{X}, \tilde{\varphi}, (H_1, A), ..., (H_5, A)\}$ in Example 3.2 (1). Let (Y, τ_2, B) be a soft topological space over Y where,

$\tau_2 = \{\tilde{Y}, \tilde{\varphi}, (L, B)\}$, where (L, B) is defined by:

$$L(e_1) = \{m\}, \ \ L(e_2) = \{n\}.$$

Consider the soft function $f_{pu} : (X, \tau_1, A) \to (Y, \tau_2, B)$. Then, $f_{pu}^{-1}((L, B)) = \{(k_1, \{b\}), (k_2, \{a\})\}$ is SSL-α-closed but not SSL-α^*-closed . Hence, f_{pu} is a SSL-α C-continuous but not supra S α^* LC-continuous.

Also, if we take (L, B) as follows: $L(e_1) = \{l, n\},$, $L(e_2) = \{l, m\}$. Then, $f_{pu}^{-1}((L, B)) = \{(k_1, \{a, c, d\}), (k_2, \{b, c, d\})\}$ is SSL-α-closed but not SSL-α^{**}-closed . Hence, f_{pu} is SSL-α C-continuous but SSL-α^{**} C-continuous.

Moreover it is SSL-α C-continuous but not SSLC-continuous.

(2) In (1), if we take $u : X \to Y$ and (L, B) as follows

$$u(h) = \{n\}, \ \ u(i) = \{m\}, \ \ u(j) = \{m\}, \ \ u(k) = \{l\},$$

$$L(e_1) = \{n\}, \ \ L(e_2) = \{l\}.$$

Then, $f_{pu}^{-1}((L, B)) = \{(k_1, \{h\}), (k_2, \{k\})\}$ is SSL-α^*-closed but not SSL-closed. Hence, f_{pu} is SSL-α^* C-continuous but not supra SLC-continuous.

Also, if we take (L, B) as follows: $L(e_1) = \{n\}$, $L(e_2) = \{m\}$.

Then, $f_{pu}^{-1}((L, B)) = \{(k_1, \{h\}), (k_2, \{i, j\})\}$ is SSL-α^{**}-closed but not SSL-closed. Hence, f_{pu} is SSL-α^{**} C-continuous but not supra SLC-continuous.

(3) Let $X = \{x, y, z, w\}$, $Y = \{a, b, c, d\}$, $A = \{k_1, k_2\}$ and $B = \{e_1, e_2\}$. Define $u : X \to Y$ and $p : A \to B$ as follows:

$u(x) = \{c\}$, $u(y) = \{d\}$, $u(z) = \{a\}$, $u(w) = \{b\}$ and

$p(k_1) = \{e_2\}$, $p(k_2) = \{e_1\}$. Let (X, τ_1, A) be a soft topological space over X where,

$\tau_1 = \{\tilde{X}, \tilde{\varphi}, (T, A)\}$, where (T, A) is defined as follows:

$$T(k_1) = \{x, y\}, \ \ T(k_2) = \{x, y\}.$$

Consider the soft supra topology μ_1 in Example 3.2 (2), $\mu_1 = \{\tilde{X}, \tilde{\varphi}, (G_1, A), ...(G_{10}, A)\}$. Let (Y, τ_2, B) be a soft topological space over Y where,

$\tau_2 = \{\tilde{Y}, \tilde{\varphi}, (L, B)\}$, where (L, B) is defined by:

$$L(e_1) = \{a, b\}, \ L(e_2) = \{d\}.$$

Consider the soft function $f_{pu} : (X, \tau_1, A) \to (Y, \tau_2, B)$. Then, $f_{pu}^{-1}((L, B)) = \{(k_1, \{z, w\}), (k_2, \{y\})\}$ is SSL-α- (resp. α^*- and α^{**}-) closed but not soft supra A-set. Hence, f_{pu} is SSL-α C- (resp. SSL-α^* C- and SSL-α^{**} C)-continuous but not soft supra A-continuous.

5. Conclusion

In this paper, we introduced some weaker forms of soft sets in ssts's as a generalization of soft supra locally closed sets [1]. We investigated their relationships with different types of subsets of ssts's with the help of counterexamples. Also, new types of soft continuity are introduced. Furthermore, some of their basic properties are obtained. In future, the generalization of these concepts to fuzzy supra soft topological spaces [2, 4] will be studied.

References

[1] A. M. Abd El-latif, Decomposition of supra soft locally closed sets and supra SLC-continuity, *Int. J. Nonlinear Anal. Appl.*, 9 (1) (2018), 13-25.

[2] A. M. Abd El-Latif, Results on fuzzy supra soft topological spaces, *Journal of Interdisciplinary Mathematics,* 22 (8) (2019), 1311-1323, DOI: 10.1080/09720502.2019.1698804

[3] A. M. Abd El-latif, Soft supra strongly generalized closed sets, *Intelligent & Fuzzy Systems*, 31 (3) (2016) 1311--1317.

[4] A. M. Abd El-latif, Some properties of fuzzy supra soft topological spaces, *European Journal Of Pure And Applied Mathematics*, (12) 3 (2019), 999-1017.

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

[6] Ali Haydar Kocaman and Naime Tozlu, Soft locally closed sets and decompositions of soft continuity, *Ann. Fuzzy Math. Inform.*, 11 (2) (2016), 173-181.

[7] S. A. El-Sheikh and A. M. Abd El-latif, Decompositions of some types of supra soft sets and soft continuity, *International Journal of Mathematics Trends and Technology*, 9 (1) (2014), 37-56.

[8] A. Kalavathi anad G. Sai Sundara Krishnan, Soft g* closed and soft g*open sets in soft topological spaces, *Journal of Interdisciplinary Mathematics*, 19 (1) (2016), 65-82, DOI: 10.1080/09720502.2015.1103110

[9] F. A. Gharib, M. Ezzat Mohamed and A. I. El-Maghrabi,On new classes of soft sets and functions via supra pre open soft sets, *European Journal Of Pure And Applied Mathematics*, 10(4) (2017), 835-849.

[10] A. Kandil, O. A. E. Tantawy, S. A. El-Sheikh and A. M. Abd El-latif, Soft semi separation axioms and irresolute soft functions, *Ann. Fuzzy Math. Inform.*, 8 (2) (2014) 305--318.

[11] D. V. Kovkov, V. M. Kolbanov and D. A. Molodtsov, Soft sets theory-based optimization, *Journal of Computer and Systems Sciences International*, 46 (6) (2007), 872-880.

[12] P. K. Maji,R. Biswas and A. R. Roy, Soft set theory, C*omput. Math. Appl.*, 45 (2003), 555-562.

[13] D. Molodtsov, V. Y. Leonov and D. V. Kovkov, Soft sets technique and its application, Nechetkie Sistemy i Myagkie Vychisleniya, 1 (1) (2006), 8-39.

[14] D. Molodtsov, Soft set theory-first results, *Comput. Math. Appl.*, 37 (1999), 19-31.

[15] D. Pei and D. Miao, From soft sets to information systems, in: X. Hu, Q. Liu, A. Skowron, T. Y. Lin, R. R. Yager, B. Zhang (Eds.), *Proceedings of Granular Computing*, in: IEEE, vol.2, 2005, pp. 617-621.

[16] M. Shabir and M. Naz, On soft topological spaces, *Comput. Math. Appl.*, 61 (2011), 1786-1799.

[17] Zehra Guzel Ergul and Saziye Yuksel, Supra regular generalized closed sets in supra soft topological spaces, *Ann. Fuzzy Math. Inform.*, 11 (3) (2016), 349-360.

Received December, 2019

Revised May, 2020