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ON SOFT CONTRA $g^*\beta$-CONTINUOUS FUNCTIONS IN SOFT TOPOLOGICAL SPACES

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Abstract: We introduce a new class of soft contra generalized star beta continuous function (contra $g^*\beta^s$-conts function) in soft topological spaces. Also we present almost contra $g^*\beta^s$-continuous functions and we derive some basic properties.

Keywords and Phrases: Contra $g^*\beta^s$-continuous, almost contra $g^*\beta^s$-continuous, contra $g^*\beta^s$-irresolute.

2020 Mathematics Subject Classification: 54A40, 54C05, 54C10, 54C08.

1. Introduction

Initially the concept of generalized closed sets were introduced by Levine [3] in topological spaces in 1970. Molodtsov [4] pioneered the study of soft set theory as a new mathematical tool and confronted the fundamental results of the soft sets in 1996. Soft topological spaces(STS) are defined over an initial universe with a fixed set of parameters and was introduced by Munazza Naz & Muhammad Shabir [5]. The authors [6, 7] introduced the concept of generalized star β-closed sets in TS and soft $g^*\beta$-closed sets in STS. In this paper we introduced the new concept of contra $g^*\beta^s$-continuous function and contra $g^*\beta^s$-irresolute functions and we have discussed some properties. Also we present almost contra $g^*\beta^s$-continuous functions and we derive some of its characteristics and several properties are investigated. For the concepts of STS we refer [1, 2, 6, 7, 9].

2. Soft Contra $g^*\beta$-Continuous Function

Definition 2.1. *A function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is said to be soft contra $g^*\beta$-continuous, denoted by contra $g^*\beta^s$-conts function, if $g^{-1}(F, \mathcal{K})$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$ for every soft open (briefly,open^s)set $(F, \mathcal{K})$ of $(\mathcal{V}, \mu, \mathcal{K})$.*

Theorem 2.2.

(a) *Every soft contra conts is contra $g^*\beta^s$- conts.*

(b) *Every contra g^s- conts is contra $g^*\beta^s$- conts.*

(c) *Every contra gs^s- conts is contra $g^*\beta^s$- conts.*

(d) *Every contra α^s-conts is contra $g^*\beta^s$- conts.*

(e) *Every contra $g\alpha^s$-conts is contra $g^*\beta^s$- conts.*

(f) *Every contra πg^s-conts is contra $g^*\beta^s$- conts.*

(g) *Every contra πgb^s-conts is contra $g^*\beta^s$- conts.*

(h) *Every contra β^s- conts is contra $g^*\beta^s$- conts.*

(i) *Every contra $g\beta^s$- conts is contra $g^*\beta^s$- conts.*

(j) *Every contra $rg\beta^s$- conts is contra $g^*\beta^s$- conts.*

Proof.

(a) Let a function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is soft contra conts and let $(F, \mathcal{K})$ be a open^s in $(\mathcal{V}, \mu, \mathcal{K})$. Then $g^{-1}(F, \mathcal{K})$ is closed^s in $(\mathcal{U}, \tau, E)$. Because every closed^s set is $g^*\beta^s$-closed, so $g^{-1}(F, \mathcal{K})$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Therefore g is contra $g^*\beta^s$-conts.

(b) Let a function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra g^s- conts and let $(F, \mathcal{K})$ be a open^s in $(\mathcal{V}, \mu, \mathcal{K})$. Then $g^{-1}(F, \mathcal{K})$ is g^s- closed in $(\mathcal{U}, \tau, E)$. Because every g^s- closed set is $g^*\beta^s$-closed, so $g^{-1}(F, \mathcal{K})$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Therefore g is contra $g^*\beta^s$-conts.

(c) Let a function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ contra gs^s- conts and let $(F, \mathcal{K})$ be a open^s in $(\mathcal{V}, \mu, \mathcal{K})$. Then $g^{-1}(F, \mathcal{K})$ is gs^s- closed in $(\mathcal{U}, \tau, E)$. Because every gs^s- closed set is $g^*\beta^s$-closed, so $g^{-1}(F, \mathcal{K})$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Therefore g is contra $g^*\beta^s$-conts.

The proof will same for remaining.

Example 2.3. Make $\mathcal{U} = \{p, q, r\} = \mathcal{V}, E = \{e_1, e_2\}$.
Let $F_1, F_2, F_3, F_4, F_5, F_6, F_7$ are functions from E to $P(\mathcal{U})$ and are defined as follows:
$F_1(e_1) = \{p\}, F_1(e_2) = \{p\}, F_2(e_1) = \{q\}, F_2(e_2) = \{q\}, F_3(e_1) = \{r\}$, $F_3(e_2) = \{p\}, F_4(e_1) = \{p, q\}, F_4(e_2) = \{p, q\}, F_5(e_1) = \{p, r\}, F_5(e_2) = \{p\}$, $F_6(e_1) = \{q, r\}, F_6(e_2) = \{q\}$
Then $\tau = \{\Phi, \mathcal{U}, (F_1, E), \ldots, (F_6, E)\}$ is a soft topology and elements in τ are open^s sets.
Let $\mathcal{H}_1, \mathcal{H}_2, \mathcal{H}_3, \mathcal{H}_4, \mathcal{H}_5, \mathcal{H}_6$ are functions from E to $P(\mathcal{K})$ and are defined as follows:
$\mathcal{H}_1(e_1) = \{r\}, \mathcal{H}_1(e_2) = \{q\}, \mathcal{H}_2(e_1) = \{r\}, \mathcal{H}_2(e_2) = \{p\}, \mathcal{H}_3(e_1) = \{r\}$, $\mathcal{H}_3(e_2) = \{q, p\}, \mathcal{H}_4(e_1) = \{p, r\}, \mathcal{H}_4(e_2) = \{p\}, \mathcal{H}_5(e_1) = \{r, p\}, \mathcal{H}_5(e_2) = \{q, p\}$, $\mathcal{H}_6(e_1) = \{p, r\}, \mathcal{H}_6(e_2) = \{q\}$.
So, $\mu = \{\Phi, \mathcal{V}, (\mathcal{H}_1, E), \ldots, (\mathcal{H}_6, E)\}$ is a soft topology on $\mathcal{V}$.
Defined an identity map $g : \mathcal{U} \to \mathcal{V}$. Now the inverse image of the open^s set in $(\mathcal{V}, \mu)$ is $g^*\beta$-closed. Then g is contra $g^*\beta^s$-conts.
Hence $(\mathcal{S}, E) = \{\{p\}, \{p, q\}\}, \{\{p, r\}, \{p\}\}, \{\{p, q\}, \{q\}\}, \{\{p, r\}, \{p, q\}\}$ in $(\mathcal{V}, \mu)$ is closed^s, g^s-closed, gs^s-closed, α^s- closed, $g\alpha^s$-closed, πg^s- closed, πgb^s-closed, β^s-closed, $g\beta^s$-closed, $rg\beta^s$-closed in $\mathcal{U}$.
Therefore g is contra $g^*\beta^s$-conts is not soft contra conts, contra g^s- conts, contra gs^s- conts, contra α^s-conts, contra $g\alpha^s$-conts, contra πg^s-conts, contra πgb^s-conts, contra β^s- conts, contra $g\beta^s$- conts, contra $rg\beta^s$- conts .

Theorem 2.4. *If $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ be a function is contra $g^*\beta^s$-conts and $(\mathcal{H}, E)$ is open^s in $(\mathcal{U}, \tau, E)$, then $(g/\mathcal{H}) : (\mathcal{H}, \tau', E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts.*

Proof. Consider $(F, \mathcal{K})$ be soft closed in $\mathcal{V}$. Since $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts, $g^{-1}(F, \mathcal{K})$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Then $(g/\mathcal{H})^{-1}(F, \mathcal{K}) = g^{-1}((F, \mathcal{K}) \cap (\mathcal{H}, E))$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Therefore $(g/\mathcal{H})^{-1}(F, \mathcal{K})$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$.

Theorem 2.5. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ be a function, then the following are equivalent*

(a) g is contra $g^*\beta^s$-conts.

b) For every closed^s set $(F, \mathcal{K})$ of $(\mathcal{V}, \mu, \mathcal{K})$, $g^{-1}(F, \mathcal{K})$ $g^*\beta^s$-open.

Proof. Straightforward. Thus $(a) \Leftrightarrow (b)$ is obvious.

Definition 2.6. *A STS $(\mathcal{U}, \tau, E)$ is said to be $g^*\beta^s$-locally indiscrete, denoted by $g^*\beta^s$- lc.indisc, if every $g^*\beta^s$-open is closed^s.*

Theorem 2.7. *If a function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts and $\mathcal{U}$ be a $g^*\beta^s$- lc.indisc, then g is soft contra conts.*
Proof. Consider $(\mathcal{S}, E)$ be open^s in $(\mathcal{V}, \mu, \mathcal{K})$. Then $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$ -open in $(\mathcal{U}, \tau, E)$. Since $\mathcal{U}$ is $g^*\beta^s$- lc.indisc, $g^{-1}(\mathcal{S}, E)$ is closed in $(\mathcal{U}, \tau, E)$. Therefore g is soft contra continuous.

Theorem 2.8. *If $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts and the space $(\mathcal{U}, \tau, E)$ is $g^*\beta^s$-space then g is soft contra continuous.*
Proof. Consider $(\mathcal{S}, E)$ be open^s in $(\mathcal{V}, \mu, \mathcal{K})$. Since g is contra $g^*\beta^s$-conts, $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Since $\mathcal{U}$ is $g^*\beta^s$- space, $g^{-1}(\mathcal{S}, E)$ is closed set in $\mathcal{U}$. Therefore g is soft contra continuous.

Remark 2.9. *The composition of two contra $g^*\beta^s$-conts functions need not be contra $g^*\beta^s$-conts.*

Theorem 2.10. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is soft continuous then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-conts.*
Proof. Let $(\mathcal{S}, E)$ be open^s in $(\mathcal{W}, \gamma, \mathcal{Z})$. Because h is soft conts, So $h^{-1}(\mathcal{S}, E)$ is open^s in $(\mathcal{V}, \mu, \mathcal{K})$. Then $g^{-1}(h^{-1}(\mathcal{S}, E))$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Since g is contra $g^*\beta^s$-conts. So $(h \circ g)^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-closed in $\mathcal{U}$. Therefore $h \circ g$ is contra $g^*\beta^s$-conts.

Theorem 2.11. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-conts then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is soft conts.*
Proof. Straightforward.

Definition 2.12. *A function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is soft contra $g^*\beta$ -irresolute, denoted by contra $g^*\beta^s$ -ir.solute, if $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$ for each $g^*\beta^s$-open in $(\mathcal{S}, E)$ in $(\mathcal{V}, \mu, \mathcal{K})$.*

Theorem 2.13. *If a function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$ -irresolute and $\mathcal{U}$ be a $g^*\beta^s$ - lc.indisc, then g is soft contra conts.*
Proof. Obvious.

Theorem 2.14. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$ -ir.solute and*

$h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is soft conts then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-conts.

Proof. Let $(\mathcal{S}, E)$ be closed^s in $(\mathcal{W}, \gamma, \mathcal{Z})$. As h is soft conts then $h^{-1}(\mathcal{S}, E)$ is closed^s in $(\mathcal{V}, \mu, \mathcal{K})$. Then $g^{-1}(h^{-1}(\mathcal{S}, E))$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Since g is contra $g^*\beta^s$-ir.solute. So $(h \circ g)^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$ -open in $\mathcal{U}$. Therefore $h \circ g$ is contra $g^*\beta^s$-conts.

Theorem 2.15. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-ir.solute and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-conts then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-conts.*

Proof. Let $(\mathcal{S}, E)$ be closed^s in $(\mathcal{W}, \gamma, \mathcal{Z})$. As h is contra $g^*\beta^s$-conts then $h^{-1}(\mathcal{S}, E)$ is closed^s in $(\mathcal{V}, \mu, \mathcal{K})$. Since g is contra $g^*\beta^s$-ir.solute, then $g^{-1}(h^{-1}(\mathcal{S}, E))$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Therefore $h \circ g$ is contra $g^*\beta^s$-conts.

Theorem 2.16. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ contra $g^*\beta^s$ -ir.solute and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-ir.solute then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is contra $g^*\beta^s$-ir.solute.*

Proof. Let $(\mathcal{S}, E)$ be closed^s in $(\mathcal{W}, \gamma, \mathcal{Z})$. As h is contra $g^*\beta^s$-ir.solute, then $h^{-1}(\mathcal{S}, E)$ is closed^s in $(\mathcal{V}, \mu, \mathcal{K})$. Since g is contra $g^*\beta^s$-ir.solute, then $g^{-1}(h^{-1}(\mathcal{S}, E))$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Therefore $h \circ g$ is contra $g^*\beta^s$-ir.solute.

Theorem 2.17. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ be a two functions in STS such that $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$*

1. *If g is contra $g^*\beta^s$-ir.solute and h is contra $g^*\beta^s$-conts, then $h \circ g$ is contra $g^*\beta^s$-conts.*

2. *If g is $g^*\beta^s$-ir.solute and h is contra $g^*\beta^s$-ir.solute, then $h \circ g$ is contra $g^*\beta^s$-ir.solute.*

Proof. Obvious.

3. Soft Almost Contra $g^*\beta$- Continuous Function

Definition 3.1. *A function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is soft almost contra $g^*\beta$-continuous, denoted by Alm.contra $g^*\beta^s$-conts, if $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$ for each soft regular open (briefly, r^s-open) in $(\mathcal{V}, \mu, \mathcal{K})$.*

Theorem 3.2. *If $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ contra $g^*\beta^s$-conts then it is Alm.contra $g^*\beta^s$-conts.*

Proof. Since every r^s-open set is open set.

Theorem 3.3. *Let $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ be a function then every $g^*\beta^s$-ir.solute continuous is Alm.contra $g^*\beta^s$-conts.*

Theorem 3.4. *A function $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$, then the following conditions are equivalent.*

(a) g is Alm.contra $g^*\beta^s$-conts.

(b) The inverse image of each r^s- closed in $(\mathcal{V}, \mu, \mathcal{K})$ is $g^*\beta^s$-open.

Proof. $(a) \Rightarrow (b)$:
Let $(\mathcal{S}, E)$ is r^s- closed in $(\mathcal{V}, \mu, \mathcal{K})$. Thus $\mathcal{V} - (\mathcal{S}, E)$ is r^s-open set in $(\mathcal{V}, \mu, \mathcal{K})$. Hence by $(a), g^{-1}(\mathcal{V} - (\mathcal{S}, E)) = \mathcal{U} - g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Therefore $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$
$(b) \Rightarrow (a)$:
Let $(\mathcal{S}, E)$ is r^s- open in $(\mathcal{V}, \mu, \mathcal{K})$. Thus $\mathcal{V} - (\mathcal{S}, E)$ is r^s closed set in $(\mathcal{V}, \mu, \mathcal{K})$. Hence by $(b), g^{-1}(\mathcal{V} - (\mathcal{S}, E)) = \mathcal{U} - g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Therefore $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$.

Theorem 3.5. *If $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is Alm. contra $g^*\beta^s$-cont and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is r^s-set connected, then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is Alm. contra $g^*\beta^s$-cont and Alm. $g^*\beta^s$-conts*
Proof. Let $(\mathcal{S}, E)$ is r^s open in $\mathcal{W}$. As h is r^s-connected set, then $h^{-1}(\mathcal{S}, E)$ is clopen^s in $(\mathcal{V}, \mu, \mathcal{K})$. Since g is Alm.contra $g^*\beta^s$-conts, then $g^{-1}(h^{-1}(\mathcal{S}, E))$ is $g^*\beta^s$-open and $g^*\beta^s$-closed in $(\mathcal{U}, \tau, E)$. Therefore $h \circ g$ is Alm.contra $g^*\beta^s$-conts and Alm $g^*\beta^s$-conts.

Theorem 3.6. *If $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is contra $g^*\beta^s$-conts and $h : (\mathcal{V}, \mu, \mathcal{K}) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is r^s-set connected, then $h \circ g : (\mathcal{U}, \tau, E) \to (\mathcal{W}, \gamma, \mathcal{Z})$ is $g^*\beta^s$ conts and Alm.$g^*\beta^s$-conts.*
Proof. Obvious.

Theorem 3.7. *If $g : (\mathcal{U}, \tau, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is an Alm.contra $g^*\beta^s$-conts and $(\mathcal{H}, E)$ is open^s subset of $\mathcal{U}$, then the restriction $g/(\mathcal{H}, E) : (\mathcal{H}, E) \to (\mathcal{V}, \mu, \mathcal{K})$ is Alm.contra $g^*\beta^s$-conts.*
Proof. Let $(\mathcal{S}, E)$ is r^s- closed in $\mathcal{V}$. Because g is Alm.contra $g^*\beta^s$-conts, $g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$-open in $(\mathcal{U}, \tau, E)$. Since $(\mathcal{H}, E)$ is open^s. Hence $(g/(\mathcal{H}, E))^{-1}(\mathcal{S}, E) = (\mathcal{H}, E) \cap g^{-1}(\mathcal{S}, E)$ is $g^*\beta^s$ -open in $(\mathcal{H}, E)$. Thus $g/(\mathcal{H}, E)$ is Alm.contra $g^*\beta^s$-conts.

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