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Soft Expert Generalized Closed Sets with Respect to Soft Expert Ideals

Research Article

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Abstract: The soft expert models are richer than soft set models since the soft set models are created with the help of one expert whereas but the soft expert models are made with the opinions of all experts. In this paper, we introduce soft expert generalized closed sets and soft expert generalized open sets with respect to soft expert ideals in soft expert topological spaces and study their basic properties.

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Keywords: Soft expert sets, Soft expert topological space, Soft expert g-closed sets, Soft expert $\mathcal{I}_g$-closed sets and Soft expert $\mathcal{I}_g$-open sets.

1. Introduction

Several set theories such as theory of vague sets, theory of interval mathematics [5, 10], theory of fuzzy sets [29], theory of intuitionistic fuzzy sets [6] and theory of rough sets [27] can be used as tools for dealing with uncertainties, but all these theories have their own difficulties. According to Molodtsov in [23], in-adequacy of the parametrization tool of the theory is the main reason for these difficulties. To overcome this, he initiated the concept of soft set theory as a new mathematical tool which is free from the problems mentioned above and presented the fundamental results of the new theory. In [23, 24], Molodtsov successfully applied it to several directions such as smoothness of functions, game theory, operations research, Riemann-integration, Perron integration, probability, theory of measurement, and so on.

After presentation of the operations of soft sets [21], the properties and applications of soft set theory have been studied increasingly [3, 18, 24]. In recent years, many interesting applications of soft set theory have been expanded by embedding the ideas of fuzzy sets [1, 2, 8, 19–22, 24, 25]. To develop soft set theory, the operations of the soft sets are redefined and a uni-int decision making method was constructed by using these new operations [9].

Recently, in 2011, Shabir and Naz [28] initiated the study of soft topological spaces. They defined soft topology on the collection τ of soft sets over X. Consequently, they defined basic notions of soft topological spaces such as soft open and

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soft closed sets, soft subspace, soft interior, soft closure, soft neighborhood of a point, soft separation axioms, soft regular spaces and soft normal spaces and established their several properties. Hussain and Ahmad [11] investigated the properties of soft open, soft closed, soft interior, soft closure and soft neighborhood of a point. They also defined and discussed the properties of soft interior, soft exterior and soft boundary which are fundamental for further research on soft topology and will strengthen the foundations of the theory of soft topological spaces.

Kandil et al.[13] introduced a unification of some types of different kinds of subsets of soft topological spaces using the notions of γ-operation. The notion of soft ideal is initiated for the first time by Kandil et al.[15]. They also introduced the concept of soft local function. These concepts are discussed with a view to find new soft topologies from the original one, called soft topological spaces with soft ideal (X, τ, E, $\mathcal{I}$). Applications to various fields were further investigated by Kandil et al. [14, 15].

Shawkat Alkhazaleh and Abdul Razak Salleh [4] defined soft expert sets and created the model in which user can know the opinion of all experts in one model. Sabir Hussain [12] introduced soft expert topological spaces which are defined over an initial universe with a fixed set of parameters and with the opinion of all expert instead of only one expert. The notions of soft expert open sets, soft expert closed sets, soft expert closure, soft expert interior, soft expert exterior and soft expert boundary are introduced and their basic properties are investigated. Finally, these notions have been applied to the problem of decision-making.

In this paper we introduce and study the notion of soft expert generalized closed sets in soft expert topological spaces with soft expert ideals and give basic definitions and theorems about it.

2. Preliminaries

Definition 2.1 ([4]). *Let U be an initial universe, E be a set of parameters, X be a set of expets(agents) and O=$\{$1=agree, 0=disagree$\}$ be a set of opinions, Z=E $\times$ X $\times$ O and A$\subset$Z. Let $\wp$(U) denote the power set of U and A be a non-empty subset of Z. A pair (F, A) is called a soft expert set over U, where F is a mapping given by F : A $\rightarrow$ $\wp$(U).*

Definition 2.2 ([4]). *For two soft sets (F, A) and (G, B) over a common universe U, we say that (F, A) is a soft expert subset of (G, B) if (1) A$\subset$B and (2) for all e$\in$B, G(e)$\subset$F(e). We write (F, A)$\subset$(G, B).*

Definition 2.3 ([4]). *Let E be a set of parameters and X be a set of experts. The NOT set of Z=E $\times$ X $\times$ O denoted by $\rceil$Z, is defined by $\rceil$Z=$\{(\rceil e_i, x_j, o_k), \forall i, j, k\}$ where $\rceil e_i$ is not e_i.*

Definition 2.4 ([4]). *The complement of a soft expert set (F, A) is denoted by $(F, A)^c$ and is defined by $(F, A)^c=(F^c, \rceil A)$ where $F^c : \rceil A \rightarrow \wp(U)$ is a mapping given by $F^c(e)=U-F(\rceil e)$ for all $e \in \rceil A$.*

Definition 2.5 ([4]). *An agree-soft expert set $(F, A)_1$ over U is a soft expert subset of (F, A) defined as follows: $(F, A)_1=\{F_1(e) : e \in E \times X \times \{1\}\}$*

Definition 2.6 ([4]). *A disagree-soft expert set $(F, A)_0$ over U is a soft expert subset of (F, A) defined as follows: $(F, A)_0=\{F_0(e) : e \in E \times X \times \{0\}\}$*

Definition 2.7 ([17]). *The union of two soft expert sets of (F, A) and (G, B) over the common universe U is the soft expert* *set (H, C), where C = A∪B and for each e∈C,*

$$H(e) = \begin{cases} F(e)\ if\ e \in A\text{-}B, \\ G(e)\ if\ e \in B\text{-}A \\ F(e) \cup G(e)\ if\ e \in A \cap B \end{cases}$$

We write (F, A)∪(G, B)=(H, C).

Definition 2.8 ([17]). *The intersection of two soft expert sets of (F, A) and (G, B) over the common universe U, denoted (F, A)∩(G, B), is defined as C=A∩B, and H(e)=F(e)∩G(e) for all e∈C.*

Definition 2.9 ([17]). *A soft expert set (F, A) over U is said to be a NULL soft expert set denoted by ∅ if for all e∈A, F(e)=∅.*

Definition 2.10 ([17]). *A soft expert set (F, A) over U is called an absolute soft expert set, denoted by $\tilde{U}$, if e∈A, F(e)=U.*

Definition 2.11 ([17]). *Let x∈U, then (x, A) denotes the soft expert set over U for which x(e)={x}, for all e∈A.*

Definition 2.12 ([17]). *A soft expert topology τ is a family of soft expert sets over U satisfying the following properties.*

(1) ∅, $\tilde{U}$ belong to τ.

(2) The union of any number of soft expert sets in τ belongs to τ.

(3) The intersection of any two soft expert sets in τ belongs to τ.

The triplet (U, τ, A) is called a soft expert topological space.

Definition 2.13 ([17]). *Let (U, τ, A) be a soft expert topological space. Then*

(1) The members of τ are called soft expert open sets in U.

(2) A soft expert set (F, A) over U is said to be a soft expert closed set in U if $(F, A)^c \in \tau$.

(3) The soft expert interior of a soft expert set (F, A) is the union of all soft expert open subsets of (F, A). The soft expert interior of (F, A) is denoted by $(F, A)^0$.

(4) The soft expert closure of (F, A) is the intersection of all soft expert closed super sets of (F, A). The soft expert closure of (F, A) is denoted by $\overline{(F, A)}$.

Definition 2.14 ([17]). *A soft expert set (F, A) in a soft expert topological space (U, τ, A) is called soft expert generalized closed (briefly soft expert g-closed) if $\overline{(F, A)} \subset (G, A)$ whenever $(F, A) \subset (G, A)$ and (G, A) is soft expert open in U.*

Definition 2.15 ([17]). *Every soft expert closed set is soft expert g-closed.*

3. Soft Expert Generalized Closed Sets with Respect to Soft Expert Ideal

Definition 3.1. *A non-empty collections $\mathcal{I}$ of soft expert subsets over U is called a soft expert ideal on U if the following holds*

(1) If (F, A)$\in\mathcal{I}$ and (G, A)$\subset$(F, A) implies (G, A)$\in\mathcal{I}$ (heredity).

(2) If (F, A)$\in\mathcal{I}$ and (G, A)$\in\mathcal{I}$, then (F, A)$\cup$(G, A)$\in\mathcal{I}$ (additivity).

Definition 3.2. *A soft expert set (F, A) in a soft expert topological space (U, τ, A) is called soft expert generalized closed set with respect to soft expert ideal (briefly soft expert $\mathcal{I}_g$-closed) if $\overline{(F,\ A)}\backslash$(G, A)$\in\mathcal{I}$ whenever (F, A)$\subset$(G, A) and (G, A) is soft expert open in U.*

Example 3.1. *Let U=$\{u_1,\ u_2\}$, X=$\{a\}$, E=$\{e\}$ and (F, A) be a soft expert set where (F, A)=$\{$((e, a, 1), $\{u_1\}$), ((e, a, 0), U)$\}$. Then τ=$\{\emptyset$, $\tilde{U}$, (F, A)$\}$ is a soft expert topology and $\mathcal{I}$=$\{\emptyset$, (G, A), (H, A), (K, A)$\}$ is a soft expert ideal on U, where* $(G, A) = \{((e, a, 1), \{u_2\}), ((e, a, 0), \emptyset)\}$

$$(H, A) = \{((e, a, 1), \emptyset), ((e, a, 0), \{u_1\})\}$$
$$(K, A) = \{((e, a, 1), \{u_2\}), ((e, a, 0), \{u_1\})\}$$

Clearly (F, A) is soft expert $\mathcal{I}_g$-closed.

Proposition 3.1. *Every soft expert g-closed set is soft expert $\mathcal{I}_g$-closed but not conversely*

Proof. Let (F, A) be a soft expert g-closed set and (F, A)$\subset$(G, A) and (G, A)$\in\tau$. Since (F, A) is soft expert g-closed, then $\overline{(F,\ A)}\subset$(G, A) and hence $\overline{(F,\ A)}\backslash$(G, A)=$\emptyset\in\mathcal{I}$. Therefore (F, A) is soft expert $\mathcal{I}_g$-closed. □

Example 3.2. *In example 3.1, (F, A) is soft expert $\mathcal{I}_g$-closed but not soft expert g-closed.*

Theorem 3.1. *Let $\mathcal{I}$ be a soft expert ideal on a soft expert topological space (U, τ, A). Then, the concepts of soft expert g-closed set and soft expert $\mathcal{I}_g$-closed set are the same if $\mathcal{I}=\{\emptyset\}$.*

Proof. Suppose that $\mathcal{I}=\{\emptyset\}$. If (F, A) is soft expert $\mathcal{I}_g$-closed, then $\overline{(F,\ A)}\backslash$(G, A)$\in\mathcal{I}$ whenever (F, A)$\subset$(G, A) and (G, A)$\in\tau$ and so $\overline{(F,\ A)}\subset$(G, A), proving that (F, A) is soft expert g-closed. □

Remark 3.1. *soft expert closed $\Rightarrow$ soft expert g-closed $\Rightarrow$ soft expert $\mathcal{I}_g$-closed*

Theorem 3.2. *A soft expert set (F, A) is soft expert $\mathcal{I}_g$-closed in a soft expert topological space (U, τ, A) iff (G, A)$\subset\overline{(F,\ A)}\backslash$(F, A) and (G, A) is soft expert closed implies (G, A)$\in\mathcal{I}$.*

Proof. Assume that (F, A) is soft expert $\mathcal{I}_g$-closed. Let (G, A)$\subset\overline{(F,\ A)}\backslash$(F, A) and (G, A) be soft expert closed. Then (F, A)$\subset$(G, A)^c and (G, A)^c is soft expert open. By our assumption, $\overline{(F,\ A)}\backslash$(G, A)$^c\in\mathcal{I}$. But (G, A)$\subset\overline{(F,\ A)}\backslash$(G, A)^c, then (G, A)$\in\mathcal{I}$.

Conversely, assume that (G, A)$\subset\overline{(F,\ A)}\backslash$(F, A) and (G, A) is soft expert closed implies that (G, A)$\in\mathcal{I}$. Suppose that (F, A)$\subset$(H, A) and (H, A)$\in\tau$. Then $\overline{(F,\ A)}\backslash$(H, A)=$\overline{(F,\ A)}\cap$(H, A)^c is a soft expert closed set and $\overline{(F,\ A)}\backslash$(H, A)$\subset\overline{(F,\ A)}\backslash$(F, A). By assumption $\overline{(F,\ A)}\backslash$(H, A)$\in\mathcal{I}$. This implies that (F, A) is soft expert $\mathcal{I}_g$-closed. □

Theorem 3.3. *If (F, A) and (G, A) are soft expert $\mathcal{I}_g$-closed sets in a soft expert topological space (U, τ, A), then their union (F, A)$\cup$(G, A) is also soft expert $\mathcal{I}_g$-closed.*

Proof. Suppose (F, A) and (G, A) are soft expert $\mathcal{I}_g$-closed sets. If (F, A)$\cup$(G, A)$\subset$(H, A) and (H, A)$\in\tau$, then (F, A)$\subset$(H, A) and (G, A)$\subset$(H, A). By assumption, $\overline{(F,\ A)}\setminus$(H, A)$\in\mathcal{I}$ and $\overline{(G,\ A)}\setminus$(H, A)$\in\mathcal{I}$ and hence $\overline{((F,\ A)\cup(G,\ A))}\setminus$(H, A)=($\overline{(F,\ A)}\setminus$(H, A))$\cup$($\overline{(G,\ A)}\setminus$(H, A))$\in\mathcal{I}$. That is (F, A)$\cup$(G, A) is soft expert $\mathcal{I}_g$-closed. □

Proposition 3.2. *$\emptyset$ and $\tilde{U}$ are always soft expert $\mathcal{I}_g$-closed.*

Remark 3.2. *The intersection of two soft expert $\mathcal{I}_g$-closed sets need not be a soft expert $\mathcal{I}_g$-closed as shown by the following example.*

Example 3.3. *Let U={u_1, u_2, u_3}, X={a}, E={e} and (F, A) be a soft expert set where (F, A)={((e, a, 1), {u_2}), ((e, a, 0), {u_1})}. Then τ={$\emptyset$, $\tilde{U}$, (F, A)} is a soft expert topology and $\mathcal{I}$={$\emptyset$} is a soft expert ideal on U. Let (G, A) and (H, A) be soft expert sets such that (G, A)={((e, a, 1), {u_1, u_2}), ((e, a, 0), $\emptyset$)} and (H, A)={((e, a, 1), {u_2, u_3}), ((e, a, o), $\emptyset$)}. Thus (G, A) and (H, A) are soft expert $\mathcal{I}_g$-closed but their intersection (G, A)$\cap$(H, A)={((e, a, 1), {u_2}), ((e, a, 0), $\emptyset$)} is not soft expert $\mathcal{I}_g$-closed.*

Theorem 3.4. *If (F, A) is soft expert $\mathcal{I}_g$-closed in a soft expert topological space (U, τ, A) and (F, A)$\subset$(G, A)$\subset\overline{(F,\ A)}$, then (G, A) is soft expert $\mathcal{I}_g$-closed.*

Proof. If (F, A) is soft expert $\mathcal{I}_g$-closed and (F, A)$\subset$(G, A)$\subset\overline{(F,\ A)}$. Suppose that (G, A)$\subset$(H, A) and (H, A)$\in\tau$. Then (F, A)$\subset$(H, A). Since (F, A) is soft expert $\mathcal{I}_g$-closed, then $\overline{(F,\ A)}\setminus$(H, A)$\in\mathcal{I}$. Now (G, A)$\subset\overline{(F,\ A)}$ implies that $\overline{(G,\ A)}\subset\overline{(F,\ A)}$. So $\overline{(G,\ A)}\setminus$(H, A)$\subset\overline{(F,\ A)}\setminus$(H, A) and thus $\overline{(G,\ A)}\setminus$(H, A)$\in\mathcal{I}$. Therefore (G, A) is soft expert $\mathcal{I}_g$-closed. □

Theorem 3.5. *If (F, A) is soft expert $\mathcal{I}_g$-closed and (G, A) is soft expert closed in a soft expert topological space (U, τ, A). Then (F, A)$\cap$(G, A) is soft expert $\mathcal{I}_g$-closed.*

Proof. Assume that (F, A)$\cap$(G, A)$\subset$(H, A) and (H, A)$\in\tau$. Then (F, A)$\subset$(H, A)$\cup$(G, A)^c and (H, A)$\cup$(G, A)^c is soft expert open in U. Since (F, A) is soft expert $\mathcal{I}_g$-closed, we have $\overline{(F,\ A)}\setminus$((H, A)$\cup$(G, A)^c)$\in\mathcal{I}$. Now, $\overline{(F,\ A)\cap(G,\ A)}\subset\overline{(F,\ A)}\cap$(G, A)=($\overline{(F,\ A)}\cap$(G, A))$\setminus$(G, A)^c. Therefore ($\overline{(F,\ A)\cap(G,\ A)}$)$\setminus$(H, A)$\subset$($\overline{(F,\ A)}\cap$(G, A))$\setminus$((H, A)$\cap$(G, A)^c)$\subset\overline{(F,\ A)}\setminus$((H, A)$\cup$(G, A)^c)$\in\mathcal{I}$. Hence (F, A)$\cap$(G, A) is soft expert $\mathcal{I}_g$-closed. □

Definition 3.3. *A soft expert set (F, A) in a soft expert topological space (U, τ, A) is called soft expert generalized open set with respect to soft expert ideal (briefly soft expert $\mathcal{I}_g$-open) iff the relative complement (F, A)^c is soft expert $\mathcal{I}_g$-closed.*

Theorem 3.6. *A soft expert set (F, A) is soft expert $\mathcal{I}_g$-open in (U, τ, A) iff (G, A)$\setminus$(H, A)$\subset$(F, A)^0 for some (H, A)$\in\mathcal{I}$, whenever (G, A)$\subset$(F, A) and (G, A) is soft expert closed.*

Proof. Suppose that (F, A) is soft expert $\mathcal{I}_g$-open. Suppose (G, A)$\subset$(F, A) and (G, A) is soft expert closed. We have (F, A)$^c\subset$(G, A)^c, (F, A)^c is soft expert $\mathcal{I}_g$-closed and (G, A)$^c\in\tau$. By assumption, $\overline{(F,\ A)^c}\setminus$(G, A)$^c\in\mathcal{I}$. Hence $\overline{(F,\ A)^c}\subset$(G, A)$^c\cup$(H, A) for some (H, A)$\in\mathcal{I}$. So $((G,A)^c\cup(H,A))^c\subset(\overline{(F,\ A)^c})^c$=(F, A)^0 and therefore (G, A)$\setminus$(H, A)$\subset$(F, A)^0. Conversely, assume that (G, A)$\subset$(F, A) and (G, A) is soft expert closed imply (G, A)$\setminus$(H, A)$\subset$(F, A)^0, for some (H, A)$\in\mathcal{I}$. Consider a soft expert open set (V, A) such that (F, A)$^c\subset$(V, A). Then (V, A)$^c\subset$(F, A). By assumption (V, A)$^c\setminus$(H, A)$\subset$(F, A)^0 for some (H, A)$\in\mathcal{I}$. This give that ((V, A)$\cup$(H, A))$^c\subset$($\overline{(F,\ A)^c}$)^c. Then $\overline{(F,\ A)^c}\subset$(V, A)$\cup$(H, A) for some (H, A)$\in\mathcal{I}$. This shows that $\overline{(F,\ A)^c}\backslash$(V, A)$\in\mathcal{I}$. Hence (F, A)^c is soft expert $\mathcal{I}_g$-closed and therefore (F, A) is soft expert $\mathcal{I}_g$-open. □

Theorem 3.7. *If (F, A)$^0\subset$(G, A)$\subset$(F, A) and (F, A) is soft expert $\mathcal{I}_g$-open in a soft expert topological space (U, τ, A), then (G, A) is soft expert $\mathcal{I}_g$-open.*

Proof. Suppose that (F, A)$^0\subset$(G, A)$\subset$(F, A) and (F, A) is soft expert $\mathcal{I}_g$-open. Then (F, A)$^c\subset$(G, A)$^c\subset\overline{(F,\ A)^c}$ and (F, A)^c is soft expert $\mathcal{I}_g$-closed. By Theorem 3.4, (G, A)^c is soft expert $\mathcal{I}_g$-closed and hence (G, A) is soft expert $\mathcal{I}_g$-open. □

Proposition 3.3. *Let $\mathcal{I}$ and $\mathcal{I}'$ be two soft expert ideals on a soft expert topological space (U, τ, A).*

(1) $\mathcal{I}\subset\mathcal{I}'$, then every soft expert $\mathcal{I}_g$-open set (F, A) is soft expert $\mathcal{I}'_g$-open.

(2) If (F, A) is soft expert $(\mathcal{I}\cap\mathcal{I}')_g$-open, then it is simultaneously soft expert $\mathcal{I}_g$-open and soft expert $\mathcal{I}'$-open.

4. Conclusion

In the present work, we have continued to study the properties of soft expert topological spaces. We introduce the notions of soft expert $\mathcal{I}_g$-closed sets and soft expert $\mathcal{I}_g$-open sets and have established several interesting properties. Hence, generalized closed set concepts are possible in soft expert topological spaces. We hope the findings in this paper will help the researchers to enhance and promote the further study on soft expert topology to carry out a general framework for their applications in practical life.

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