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Abstract. Many researchers have created some models based on soft set, to solve problems in decision making and medical diagnosis, but most of these models deal only with one expert. This causes a problem with the users, especially with those who use questionnaires in their work and studies. Therefore we present a new model i.e. Hypersoft Expert Set which not only addresses this limitation of soft-like models by emphasizing the opinion of all experts but also resolves the inadequacy of soft set for disjoint attribute-valued sets corresponding to distinct attributes. In this study, the existing concept of soft expert set is generalized to hypersoft expert set which is more flexible and useful. Some fundamental properties (i.e. subset, not set and equal set), results (i.e. commutative, associative, distributive and D' Morgan Laws) and set-theoretic operations (i.e. complement, union intersection AND, and OR) are discussed. An algorithm is proposed to solve decision-making problems and applied to recruitment process for hiring "right person for the right job".

Keywords: Soft Set; Soft Expert Set; Hypersoft Set; Hypersoft Expert Set.

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1. **Introduction**

Soft set presented by Molodtsov [1] is considered as a new parameterized family of subsets of the universe of discourse, which addresses the inadequacy of fuzzy-like structures for parameterization tools. It has helped the researcher (experts) to solve efficiently the decision-making problems involving some sort of uncertainty. Many researchers [2]- [13]studied and broadened this concept and applied to different fields. The gluing concept of soft set with expert system initiated by Alkhazaleh et al. [15] to emphasize the due status of the opinions of all experts regarding taking any decision in decision-making system. Al-Quran et al. [16] proposed neutrosophic vague soft expert set theory, Alkhazaleh et al. [17] characterized fuzzy soft expert set and its application. Bashir et al. [18, 19] presented possibility fuzzy soft expert set and fuzzy parameterized soft expert set. Sahin et al. [20] investigated neutrosophic soft expert sets. Alhazaymeh et al. [21, 22] studied mapping on generalized vague soft expert set and generalized vague soft expert set. Alhazaymeh et al. [23] explained the application of generalized vague soft expert set in decision making. Hassan et al. [24] reviewed Q-neutrosophic soft expert set and its application in decision making. Uluay et al. [25] studied generalized neutrosophic soft expert set for multiple-criteria decision-making. Al-Qudah et al. [26] explained bipolar fuzzy soft expert set and its application in decision making. Al-Qudah et al. [27] investigated complex multi-fuzzy soft expert set and its application. Al-Quran et al. [28] presented the complex neutrosophic soft expert set and its application in decision making. Pramanik et al. [29] studied the topsis for single valued neutrosophic soft expert set based multi-attribute decision making problems. Abu Qamar et al. [30] investigated the generalized Q-neutrosophic soft expert set for decision under uncertainty. Adam et al. [31] characterized the multi Q-fuzzy soft expert set and its application. Ulucay et al. [32] presented the time-neutrosophic soft expert sets and its decision making problem. Al-Quran et al. [33] studied fuzzy parameterised single valued neutrosophic soft expert set theory and its application in decision making. Hazaymeh et al. [34] researched generalized fuzzy soft expert set.

There are many real life scenarios when we are to deal with disjoint attribute-valued set for distinct attributes. In 2018, Smarandache [35] addressed this inadequacy of soft with the development of new structure hypersoft set by replacing single attribute-valued function to multi-attribute valued function. In 2020, Saeed et al. [36, 37] extended the concept and discussed the fundamentals of hypersoft set such as hypersoft subset, complement, not hypersoft set, aggregation operators along with hypersoft set relation, sub relation,complement relation, function, matrices and operations on hypersoft matrices. In the same year, Mujahid et al. [38] discussed hypersoft points in different fuzzy-like envorinments. In 2020, Rahman et al. [39] defined complex hypersoft set and developed the hybrids of hypersoft set with complex fuzzy set, complex intuitionistic fuzzy set and complex neutrosophic set respectively. They also discussed their fundamentals i.e. subset, equal sets, null set, absolute set etc. and theoretic operations i.e. complement, union, intersection etc. In 2020, Rahman et al. [40] conceptualized convexity cum concavity on hypersoft set and presented its pictorial versions with illustrative examples.

Dealing with disjoint attribute-valued sets is of great importance and it is vital for sensible decisions in decision-making techniques. Results will be varied and be considered inclined and odd on ignoring such kind of sets. Therefore, it is the need of the literature to adequate the exiting literature of soft and expert set for multi-attribute function. Having motivation from [15] and [35–38], new notions of hypersoft expert set are developed and an application is discussed in decision making through proposed method. The pattern of rest of the paper is: section 2 reviews the notions of soft sets, soft expert set, hypersoft set and relevant definitions used in the proposed work. Section 3, presents notions of hypersoft expert set with properties. Section 4, demonstrates an application of this concept in a decision-making problem. Section 5, concludes the paper.

1.1. *Motivation*

The novelty of hypersoft expert set (HSE-set) is as:

- it is the extension of soft set and soft expert set,
- it tackles all the hindrances of soft set and soft expert set for dealing with further partitions of attributes into attribute-valued sets,
- it facilitates the decision-makers to have decisions for uncertain scenarios without encountering with any inclined situation.

2. **Preliminaries**

In this section, some basic definitions and terms regarding the main study, are presented from the literature.

Definition 2.1. [1]
Let $P(\Omega)$ denote power set of Ω(universe of discourse) and F be a collection of parameters defining Ω. A *soft set* Ψ_M is defined by mapping

$$\Psi_M : F \rightarrow P(\Omega)$$

Definition 2.2. [3]
The union of two soft sets (Ψ_1, A_1) and (Ψ_2, A_2) over Ω is the soft set (Ψ_3, A_3) ; $A_3 \doteq A_1 \cup A_2$, and $\forall\ \xi \in A_3$,

$$\Psi_3(\xi) = \begin{cases} \Psi_1(\xi) & ; \xi \in A_1 - A_2 \\ \Psi_2(\xi) & ; \xi \in A_2 - A_1 \\ \Psi_1(\xi) \cup \Psi_2(\xi) & ; \xi \in A_1 \cap A_2 \end{cases}$$

Definition 2.3. [14]
The extended intersection of two soft sets (Ψ_1, A_1) and (Ψ_2, A_2) with Ω is the soft set (Ψ_3, A_3) while $A_3 \doteq A_1 \cup A_2$, ; $\xi \in A_3$,

$$\Psi_3(\xi) = \begin{cases} \Psi_1(\xi) & ; \xi \in A_1 - A_2 \\ \Psi_2(\xi) & ; \xi \in A_2 - A_1 \\ \Psi_1(\xi) \cup \Psi_2(\xi) & ; \xi \in A_1 \cap A_2 \end{cases}$$

Definition 2.4. [15]
Assume that Y be a set of specialists (operators) and $\ddot{O}$ be a set of conclusions, $T = F \times Y \times \ddot{O}$ with $S \subseteq T$ where Ω denotes the universe , F a set of parameters.
A pair(Φ_H, S) is known as a *soft expert set* over Ω, where Ψ_H is a mapping given by

$$\Phi_H : S \to P(\Omega)$$

Definition 2.5. [15]
A $(\Phi_1, S) \subseteq (\Phi_2, P)$ over Ω, if
(i) $S \subseteq P$,
(ii) $\forall\ \alpha \in P, \Phi_2(\alpha) \subseteq \Phi_1(\alpha)$.
While (Φ_2, P) is known as a *soft expert superset* of (Φ_1, S).

Definition 2.6. [19]
Let $h_1, h_2, h_3, ..., h_m$, for $m \geq 1$, be m distinct attributes, whose corresponding attribute values are respectively the sets $H_1, H_2, H_3, ..., H_m$, with $H_i \cap H_j = \emptyset$, for $i \neq j$, and $i, j \in \{1, 2, 3, ..., m\}$. Then the pair (Ψ, G), where $G = H_1 \times H_2 \times H_3 \times . ... \times H_m$ and $\Psi : G \to P(\Omega)$ is called a *hypersoft Set* over Ω.

3. Hypersoft Expert set (HSE-Set)

In this section, the fundamentals of hypersoft expert set are established and its basic properties, laws and operations are generalized

Definition 3.1. Hypersoft Expert set (HSE-Set)
A pair(Ψ, S) is known as a *hypersoft expert set* over Ω, where

$$\Psi : S \to P(\Omega)$$

where

- $S \subseteq T = G \times D \times C$
- $G = G_1 \times G_2 \times G_3 \times .... \times G_n$ where $G_1, G_2, G_3, ..., G_n$ are disjoint attributive sets corresponding to n distinct attributes $g_1, g_2, g_3, ..., g_n$
- D be a set of specialists (operators)
- C be a set of conclusions

For simplicity, $C = \{0 = disagree, 1 = agree\}$.

Example 3.2. Suppose that an organization manufactured modern kinds of its brands and intends to proceed the assessment of certain specialists about concerning these products. Let $\Omega = \{v_1, v_2, v_3, v_4\}$ be a set of products and

$G_1 = \{g_{11}, g_{12}\}$

$G_2 = \{g_{21}, g_{22}\}$

$G_3 = \{g_{31}, g_{32}\}$

be disjoint attributive sets for distinct attributes g_1= simple to use, g_2= nature, g_3= modest. Now $G = G_1 \times G_2 \times G_3$

$$G = \begin{Bmatrix} a_1 = (g_{11}, g_{21}, g_{31}), a_2 = (g_{11}, g_{21}, g_{32}), a_3 = (g_{11}, g_{22}, g_{31}), a_4 = (g_{11}, g_{22}, g_{32}), \\ a_5 = (g_{12}, g_{21}, g_{31}), a_6 = (g_{12}, g_{21}, g_{32}), a_7 = (g_{12}, g_{22}, g_{31}), a_8 = (g_{12}, g_{22}, g_{32}) \end{Bmatrix}$$

Now $T = G \times D \times C$

$$T = \begin{Bmatrix} (a_1, s, 0), (a_1, s, 1), (a_1, t, 0), (a_1, t, 1), (a_1, u, 0), (a_1, u, 1), \\ (a_2, s, 0), (a_2, s, 1), (a_2, t, 0), (a_2, t, 1), (a_2, u, 0), (a_2, u, 1), \\ (a_3, s, 0), (a_3, s, 1), (a_3, t, 0), (a_3, t, 1), (a_3, u, 0), (a_3, u, 1), \\ (a_4, s, 0), (a_4, s, 1), (a_4, t, 0), (a_4, t, 1), (a_4, u, 0), (a_4, u, 1), \\ (a_5, s, 0), (a_5, s, 1), (a_5, t, 0), (a_5, t, 1), (a_5, u, 0), (a_5, u, 1), \\ (a_6, s, 0), (a_6, s, 1), (a_6, t, 0), (a_6, t, 1), (a_6, u, 0), (a_6, u, 1), \\ (a_7, s, 0), (a_7, s, 1), (a_7, t, 0), (a_7, t, 1), (a_7, u, 0), (a_7, u, 1), \\ (a_8, s, 0), (a_8, s, 1), (a_8, t, 0), (a_8, t, 1), (a_8, u, 0), (a_8, u, 1) \end{Bmatrix}$$

let

$$S = \begin{Bmatrix} (a_1, s, 0), (a_1, s, 1), (a_1, t, 0), (a_1, t, 1), (a_1, u, 0), (a_1, u, 1), \\ (a_3, s, 0), (a_3, s, 1), (a_3, t, 0), (a_3, t, 1), (a_3, u, 0), (a_3, u, 1), \\ (a_5, s, 0), (a_5, s, 1), (a_5, t, 0), (a_5, t, 1), (a_5, u, 0), (a_5, u, 1), \end{Bmatrix}$$

be a subset of T and $D = \{s, t, u\}$ be a set of specialists.

Assume that the organization has appropriated a survey to three specialists to settle the choices on the organization's products, and we get the accompanying:

$\Psi_1 = \Psi(a_1, s, 1) = \{v_1, v_2, v_4\}$,

$\Psi_2 = \Psi(a_1, t, 1) = \{v_3, v_4\}$,

$\Psi_3 = \Psi(a_1, u, 1) = \{v_3, v_4\}$,

$\Psi_4 = \Psi(a_3, s, 1) = \{v_4\}$,

$\Psi_5 = \Psi(a_3, t, 1) = \{v_1, v_3\}$,

$\Psi_6 = \Psi(a_3, u, 1) = \{v_1, v_2, v_4\}$,

$\Psi_7 = \Psi(a_5, s, 1) = \{v_3, v_4\}$,

$\Psi_8 = \Psi(a_5, t, 1) = \{v_1, v_2\}$,
$\Psi_9 = \Psi(a_5, u, 1) = \{v_4\}$,
$\Psi_{10} = \Psi(a_1, s, 0) = \{v_3\}$,
$\Psi_{11} = \Psi(a_1, t, 0) = \{v_2, v_3\}$,
$\Psi_{12} = \Psi(a_1, u, 0) = \{v_1, v_2\}$,
$\Psi_{13} = \Psi(a_3, s, 0) = \{v_1, v_2, v_3\}$,
$\Psi_{14} = \Psi(a_3, t, 0) = \{v_2, v_4\}$,
$\Psi_{15} = \Psi(a_3, u, 0) = \{v_3\}$,
$\Psi_{16} = \Psi(a_5, s, 0) = \{v_1, v_2\}$,
$\Psi_{17} = \Psi(a_5, t, 0) = \{v_3, v_4\}$,
$\Psi_{18} = \Psi(a_5, u, 0) = \{v_1, v_2, v_3\}$,
The hypersoft expert set is

$$(\Psi, \mathrm{S}) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_1, t, 1), \{v_1, v_4\}), ((a_1, u, 1), \{v_3, v_4\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, t, 1), \{v_1, v_3\}), ((a_3, u, 1), \{v_1, v_2, v_4\}), \\ ((a_5, s, 1), \{v_3, v_4\}), ((a_5, t, 1), \{v_1, v_2\}), ((a_5, u, 1), \{v_4\}), \\ ((a_1, s, 0), \{v_3\}), ((a_1, t, 0), \{v_2, v_3\}), ((a_1, u, 0), \{v_1, v_2\}), \\ ((a_3, s, 0), \{v_1, v_2, v_3\}), ((a_3, t, 0), \{v_2, v_4\}), ((a_3, u, 0), \{v_3\}) \\ ((a_5, s, 0), \{v_1, v_2\}), ((a_5, t, 0), \{v_3, v_4\}), ((a_5, u, 0), \{v_1, v_2, v_3\}) \end{array} \right\}$$

Note that in this example the first specialist, s, "agrees" that the "simple to use" products are v_1, v_2, and v_4. The subsequent specialist t, "agrees" that the "simple to use" products are v_1 and v_4, and the third specialist, u, "agrees" that the "simple to use" products are v_3 and v_4. See here every one of specialists "agree" that product v_4 is "anything but simple to use."

Definition 3.3. Hypersoft Expert subset
A hypersoft expert set (Ψ_1, S) is said to be hypersoft expert subset of (Ψ_2, R) over Ω, if
(i) $S \subseteq R$,
(ii) $\forall\ \alpha \in S, \Psi_1(\alpha) \subseteq \Psi_2(\alpha)$.
and denoted by $(\Psi_1, S) \subseteq (\Psi_2, R)$. Similarly (Ψ_2, R) is said to be *hypersoft expert superset* of (Ψ_1, S).

Example 3.4. Considering Example 3.2, Suppose

$$A_1 = \Big\{ (a_1, s, 1), (a_3, s, 0), (a_1, t, 1), (a_3, t, 1), (a_3, t, 0), (a_1, u, 0), (a_3, u, 1) \Big\}$$

$$A_2 = \Big\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1), (a_1, t, 1), (a_3, t, 1), (a_5, t, 0), (a_3, t, 0), (a_1, u, 0), (a_3, u, 1), (a_5, u, 1) \Big\}$$

It is clear that $A_1 \subset A_2$. Suppose (Ψ_1, A_1) and (Ψ_2, A_2) be defined as following

$$(\Psi_1, \mathrm{A}_1) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2\}), ((a_1, t, 1), \{v_1\}), \\ ((a_3, t, 1), \{v_1, v_3\}), ((a_3, u, 1), \{v_1, v_2\}), \\ ((a_1, u, 0), \{v_1\}), ((a_3, s, 0), \{v_1, v_2\}), \\ ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

$$(\Psi_2, \mathrm{A}_2) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_1, t, 1), \{v_1, v_4\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, t, 1), \{v_1, v_3\}), \\ ((a_5, u, 1), \{v_4\}), ((a_3, u, 1), \{v_1, v_2, v_4\}), \\ ((a_1, u, 0), \{v_1, v_2\}), ((a_5, t, 0), \{v_3, v_4\}), \\ ((a_3, s, 0), \{v_1, v_2, v_3\}), ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

which implies that $(\Psi_1, A_1) \subseteq (\Psi_2, A_2)$.

Definition 3.5. Two hypersoft expert sets (Ψ_1, A_1) and (Ψ_2, A_2) over Ω are said to be equal if (Ψ_1, A_1) is a hypersoft expert subset of (Ψ_2, A_2) and (Ψ_2, A_2) is a hypersoft expert subset of (Ψ_1, A_1).

Definition 3.6. Let G be a set as defined in definition 3.1 and D , a set of experts. The NOT set of $T = G \times D \times C$ denoted by $\sim T$, is defined by $\sim T = \{(\sim g_i, d_j, c_k) \forall i, j, k\}$ where $\sim g_i$ is not g_i.

Definition 3.7. The complement of a hypersoft expert set (Ψ, S), denoted by $(\Psi, S)^c$, is defined by $(\Psi, S)^c = (\Psi^c, \sim S)$ while $\Psi^c : \sim S \to P(\Omega)$ is a mapping given by $\Psi^c(\beta) = \Omega - \Psi(\sim \beta)$, where $\beta \in \sim S$.

Example 3.8. Taking complement of hypersoft expert set determined in 3.2, we have

$$(\Psi, \mathrm{S})^c = \left\{ \begin{array}{l} ((\sim a_1, s, 1), \{v_3\}), ((\sim a_1, t, 1), \{v_2, v_3\}), ((\sim a_1, u, 1), \{v_1, v_2\}), \\ ((\sim a_3, s, 1), \{v_1, v_2, v_3\}), ((\sim a_3, t, 1), \{v_2, v_4\}), ((\sim a_3, u, 1), \{v_1, v_2, v_4\}), \\ ((\sim a_5, s, 1), \{v_1, v_2\}), ((\sim a_5, t, 1), \{v_3, v_4\}), ((\sim a_5, u, 1), \{v_1, v_2, v_3\}), \\ ((\sim a_1, s, 0), \{v_1, v_2, v_4\}), ((\sim a_1, t, 0), \{v_1, v_4\}), ((\sim a_1, u, 0), \{v_1, v_2\}), \\ ((\sim a_3, s, 0), \{v_4\}), ((\sim a_3, t, 0), \{v_1, v_3\}), ((\sim (a_3, u, 0), \{v_3\}) \\ ((\sim a_5, s, 0), \{v_3, v_4\}), ((\sim a_5, t, 0), \{v_1, v_3\},), ((\sim a_5, u, 0), \{v_4\}) \end{array} \right\}$$

Definition 3.9. An agree-hypersoft expert set $(\Psi, S)_{ag}$ over Ω, is a hypersoft expert subset of (Ψ, S) and is characterized as
$(\Psi, S)_{ag} = \{\Psi_{ag}(\beta) : \beta \in G \times D \times \{1\}\}$.

Example 3.10. Finding agree-hypersoft expert set determined in 3.2, we get

$$(\Psi, \mathrm{S}) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_1, t, 1), \{v_1, v_4\}), ((a_1, u, 1), \{v_3, v_4\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, t, 1), \{v_1, v_3\}), ((a_3, u, 1), \{v_1, v_2, v_4\}), \\ ((a_5, s, 1), \{v_3, v_4\}), ((a_5, t, 1), \{v_1, v_2\}), ((a_5, u, 1), \{v_4\}) \end{array} \right\}$$

Definition 3.11. A disagree-hypersoft expert set $(\Psi, S)_{dag}$ over Ω, is a hypersoft expert subset of (Ψ, S) and is characterized as
$(\Psi, S)_{dag} = \{\Psi_{dag}(\beta) : \beta \in G \times D \times \{0\}\}$.

Example 3.12. Getting disagree-hypersoft expert set determined in 3.2,

$$(\Psi, \mathrm{S}) = \left\{ \begin{array}{l} ((a_1, s, 0), \{v_3\},), ((a_1, t, 0), \{v_2, v_3\}), ((a_1, u, 0), \{v_1, v_2\}), \\ ((a_3, s, 0), \{v_1, v_2, v_3\}), ((a_3, t, 0), \{v_2, v_4\}), ((a_3, u, 0), \{v_3\}) \\ ((a_5, s, 0), \{v_1, v_2\}), ((a_5, t, 0), \{v_3, v_4\}), ((a_5, u, 0), \{v_1, v_2, v_3\}) \end{array} \right\}$$

Proposition 3.13. *If (Ψ, S) is a hypersoft expert set over Ω, then*

(1). $((\Psi, S)^c)^c = (\Psi, S)$
(2). $(\Psi, S)^c_{ag} = (\Psi, S)_{dag}$
(3). $(\Psi, S)^c_{dag} = (\Psi, S)_{ag}$

Definition 3.14. The union of (Ψ_1, S) and (Ψ_2, R) over Ω is (Ψ_3, L) with $L = S \cup R$, defined as

$$\Psi_3(\beta) = \begin{cases} S(\beta) & ; \beta \in S - R \\ R(\beta) & ; \beta \in R - S \\ S(\beta) \cup R(\beta) & ; \beta \in S \cap R \end{cases}$$

Example 3.15. Taking into consideration the concept of example 3.2, consider the following two sets

$$A_1 = \Big\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1), (a_1, t, 1), (a_3, t, 1), (a_5, t, 0), (a_3, t, 0), (a_1, u, 0), (a_3, u, 1), (a_5, u, 1) \Big\}$$

$$A_2 = \Big\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1), (a_1, t, 1), (a_3, t, 1), (a_5, t, 0), (a_3, t, 0), (a_1, u, 0), (a_3, u, 1) \Big\}$$

Suppose (Ψ_1, A_1) and (Ψ_2, A_2) over Ω are two hypersoft expert sets such that

$$(\Psi_1, \mathrm{A}_1) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2\}), ((a_1, t, 1), \{v_1\}), ((a_3, t, 1), \{v_1, v_3\}), \\ ((a_3, u, 1), \{v_1, v_2\}), ((a_1, u, 0), \{v_1\}), ((a_3, s, 0), \{v_1, v_2\}), \\ ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

$$(\Psi_2, \mathrm{A}_2) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_1, t, 1), \{v_1, v_4\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, t, 1), \{v_1, v_3\}), \\ ((a_5, u, 1), \{v_4\}), (((a_3, u, 1), \{v_1, v_2, v_4\}) \\ ((a_1, u, 0), \{v_1, v_2\}), ((a_5, t, 0), \{v_3, v_4\}), \\ ((a_3, s, 0), \{v_1, v_2, v_3\}), ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

Then $(\Psi_1, A_1) \cup (\Psi_2, A_2) = (\Psi_3, A_3)$

$$(\Psi_3, \mathrm{A}_3) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_1, t, 1), \{v_1, v_4\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, t, 1), \{v_1, v_3\}), \\ ((a_5, u, 1), \{v_4\}), ((a_3, u, 1), \{v_1, v_2, v_4\}), \\ ((a_1, u, 0), \{v_1, v_2\}), ((a_5, t, 0), \{v_3, v_4\}), \\ ((a_3, s, 0), \{v_1, v_2, v_3\}), ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

Proposition 3.16. *If (Ψ_1, A_1),(Ψ_2, A_2) and (Ψ_3, A_3) are three hypersoft expert sets over Ω, then*

(1). $(\Psi_1, A_1) \cup (\Psi_2, A_2) = (\Psi_2, A_2) \cup (\Psi_1, A_1)$
(2). $((\Psi_1, A_1) \cup (\Psi_2, A_2)) \cup (\Psi_3, A_3) = (\Psi_1, A_1) \cup ((\Psi_2, A_2) \cup (\Psi_3, A_3))$

Definition 3.17. The intersection of (Ψ_1, S) and (Ψ_2, R) over Ω is (Ψ_3, L) with $L = S \cap R$, defined as

$$\Psi_3(\beta) = \begin{cases} S(\beta) & ; \beta \in S - R \\ R(\beta) & ; \beta \in R - S \\ S(\beta) \cap R(\beta) & ; \beta \in S \cap R \end{cases}$$

Example 3.18. Taking into consideration the concept of example 3.2, consider the following two sets

$$A_1 = \left\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1), (a_1, t, 1), (a_3, t, 1), (a_5, t, 0), (a_3, t, 0), (a_1, u, 0), (a_3, u, 1), (a_5, u, 1) \right\}$$

$$A_2 = \left\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1), (a_1, t, 1), (a_3, t, 1), (a_5, t, 0), (a_3, t, 0), (a_1, u, 0), (a_3, u, 1) \right\}$$

Suppose (Ψ_1, A_1) and (Ψ_2, A_2) over Ω are two hypersoft expert sets such that

$$(\Psi_1, \mathrm{A}_1) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2\}), ((a_1, t, 1), \{v_1\}), ((a_3, t, 1), \{v_1, v_3\}), \\ ((a_3, u, 1), \{v_1, v_2\}), ((a_1, u, 0), \{v_1\}), ((a_3, s, 0), \{v_1, v_2\}), \\ ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

$$(\Psi_2, \mathrm{A}_2) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_1, t, 1), \{v_1, v_4\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, t, 1), \{v_1, v_3\},), \\ ((a_5, u, 1), \{v_4\}), (((a_3, u, 1), \{v_1, v_2, v_4\}) \\ ((a_1, u, 0), \{v_1, v_2\}), ((a_5, t, 0), \{v_3, v_4\}), \\ ((a_3, s, 0), \{v_1, v_2, v_3\}), ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

Then $(\Psi_1, A_1) \cap (\Psi_2, A_2) = (\Psi_3, A_3)$

$$(\Psi_1, \mathrm{A}_1) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2\}), ((a_1, t, 1), \{v_1\}), \\ ((a_3, t, 1), \{v_1, v_3\}), ((a_3, u, 1), \{v_1, v_2\}), \\ ((a_1, u, 0), \{v_1\}), ((a_3, s, 0), \{v_1, v_2\}), \\ ((a_3, t, 0), \{v_2, v_4\}) \end{array} \right\}$$

Proposition 3.19. *If* (Ψ_1, A_1),(Ψ_2, A_2) *and* (Ψ_3, A_3) *are three hypersoft expert sets over* Ω*, then*

(1). $(\Psi_1, A_1) \cap (\Psi_2, A_2) = (\Psi_2, A_2) \cap (\Psi_1, A_1)$
(2). $((\Psi_1, A_1) \cap (\Psi_2, A_2)) \cap (\Psi_3, A_3) = (\Psi_1, A_1) \cap ((\Psi_2, A_2) \cap (\Psi_3, A_3))$

Proposition 3.20. *If* (Ψ_1, A_1),(Ψ_2, A_2) *and* (Ψ_3, A_3) *are three hypersoft expert sets over* Ω*, then*

(1). $(\Psi_1, A_1) \cup ((\Psi_2, A_2) \cap (\Psi_3, A_3)) = ((\Psi_1, A_1) \cup ((\Psi_2, A_2)) \cap ((\Psi_1, A_1) \cup (\Psi_3, A_3))$
(2). $(\Psi_1, A_1) \cap ((\Psi_2, A_2) \cup (\Psi_3, A_3)) = ((\Psi_1, A_1) \cap ((\Psi_2, A_2)) \cup ((\Psi_1, A_1) \cap (\Psi_3, A_3))$

Definition 3.21. If (Ψ_1, A_1) and (Ψ_2, A_2) are two hypersoft expert sets over Ω then (Ψ_1, A_1) AND (Ψ_2, A_2) denoted by $(\Psi_1, A_1) \wedge (\Psi_2, A_2)$ is defined by
$(\Psi_1, A_1) \wedge (\Psi_2, A_2) = (\Psi_3, A_1 \times A_2)$,
while $\Psi_3(\beta, \gamma) = \Psi_1(\beta) \cap \Psi_2(\gamma), \forall (\beta, \gamma) \in A_1 \times A_2$.

Example 3.22. Taking into consideration the concept of example 3.2, let two sets

$$A_1 = \left\{ (a_1, s, 1), (a_1, t, 1), (a_3, s, 1), (a_3, s, 0) \right\}$$

$$A_2 = \left\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1) \right\}$$

Suppose (Ψ_1, A_1) and (Ψ_2, A_2) over Ω are two hypersoft expert sets such that

$$(\Psi_1, \mathrm{A}_1) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2\}), ((a_1, t, 1), \{v_1\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, s, 0), \{v_1, v_2\}), \end{array} \right\}$$

$$(\Psi_2, \mathrm{A}_2) = \left\{ ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_3, s, 0), \{v_1, v_2, v_3\}), \right\}$$

Then $(\Psi_1, A_1) \wedge (\Psi_2, A_2) = (\Psi_3, A_1 \times A_2)$,

$$(\Psi_3, \mathrm{A}_1 \times \mathrm{A}_2) = \left\{ \begin{array}{l} (((a_1, s, 1), (a_1, s, 1)), \{v_1, v_2\}), (((a_1, s, 1), (a_3, s, 0)), \{v_1, v_2\}), \\ (((a_1, t, 1), (a_1, s, 1)), \{v_1\}), (((a_1, t, 1), (a_3, s, 0)), \{v_1\}), \\ (((a_3, s, 1), (a_1, s, 1)), \{v_4\}), (((a_3, s, 1), (a_3, s, 0)), \phi), \\ (((a_3, s, 0), (a_1, s, 1)), \{v_1, v_2\}), (((a_3, s, 0), (a_3, s, 0)), \{v_1, v_2\}) \end{array} \right\}$$

Definition 3.23. If (Ψ_1, A_1) and (Ψ_2, A_2) are two hypersoft expert sets over Ω then (Ψ_1, A_1) OR (Ψ_2, A_2) denoted by $(\Psi_1, A_1) \vee (\Psi_2, A_2)$ is defined by
$(\Psi_1, A_1) \vee (\Psi_2, A_2) = (\Psi_3, A_1 \times A_2)$,
while $\Psi_3(\beta, \gamma) = \Psi_1(\beta) \cup \Psi_2(\gamma), \forall (\beta, \gamma) \in A_1 \times A_2$.

Example 3.24. Taking into consideration the concept of example 3.2, suppose the following sets

$$A_1 = \left\{ (a_1, s, 1), (a_1, t, 1), (a_3, s, 1), (a_3, s, 0) \right\}$$
$$A_2 = \left\{ (a_1, s, 1), (a_3, s, 0), (a_3, s, 1) \right\}$$

Suppose (Ψ_1, A_1) and (Ψ_2, A_2) over Ω are two hypersoft expert sets such that

$$(\Psi_1, \mathrm{A}_1) = \left\{ \begin{array}{l} ((a_1, s, 1), \{v_1, v_2\}), ((a_1, t, 1), \{v_1\}), \\ ((a_3, s, 1), \{v_4\}), ((a_3, s, 0), \{v_1, v_2\}), \end{array} \right\}$$

$$(\Psi_2, \mathrm{A}_2) = \left\{ ((a_1, s, 1), \{v_1, v_2, v_4\}), ((a_3, s, 0), \{v_1, v_2, v_3\}) \right\}$$

Then $(\Psi_1, A_1) \vee (\Psi_2, A_2) = (\Psi_3, A_1 \times A_2)$,

$$(\Psi_3, \mathrm{A}_1 \times \mathrm{A}_2) = \left\{ \begin{array}{l} (((a_1, s, 1), (a_1, s, 1)), \{v_1, v_2, v_4\}), (((a_1, s, 1), (a_3, s, 0)), \{v_1, v_2, v_3\}), \\ (((a_1, t, 1), (a_1, s, 1)), \{v_1, v_2, v_4\}), (((a_1, t, 1), (a_3, s, 0)), \{v_1, v_2\}), \\ (((a_3, s, 1), (a_1, s, 1)), \{v_1, v_2, v_4\}), (((a_3, s, 1), (a_3, s, 0)), \{v_1, v_2, v_3, v_4\}), \\ (((a_3, s, 0), (a_1, s, 1)), \{v_1, v_2, v_4\}), (((a_3, s, 0), (a_3, s, 0)), \{v_1, v_2, v_3\}) \end{array} \right\}$$

Proposition 3.25. *If* (Ψ_1, A_1),(Ψ_2, A_2) *and* (Ψ_3, A_3) *are three hypersoft expert sets over* Ω*, then*

(1). $((\Psi_1, A_1) \wedge (\Psi_2, A_2))^c = ((\Psi_1, A_1))^c \vee ((\Psi_2, A_2))^c$

(2). $((\Psi_1, A_1) \vee (\Psi_2, A_2))^c = ((\Psi_1, A_1))^c \wedge ((\Psi_2, A_2))^c$

Proposition 3.26. *If* (Ψ_1, A_1),(Ψ_2, A_2) *and* (Ψ_3, A_3) *are three hypersoft expert sets over* Ω*, then*

(1). $((\Psi_1, A_1) \wedge (\Psi_2, A_2)) \wedge (\Psi_3, A_3) = (\Psi_1, A_1) \wedge ((\Psi_2, A_2) \wedge (\Psi_3, A_3))$

(2). $((\Psi_1, A_1) \vee (\Psi_2, A_2)) \vee (\Psi_3, A_3) = (\Psi_1, A_1) \vee ((\Psi_2, A_2) \vee (\Psi_3, A_3))$

(3). $(\Psi_1, A_1) \vee ((\Psi_2, A_2) \wedge (\Psi_3, A_3) = ((\Psi_1, A_1) \vee ((\Psi_2, A_2)) \wedge ((\Psi_1, A_1) \vee (\Psi_3, A_3))$

(4). $(\Psi_1, A_1) \wedge ((\Psi_2, A_2) \vee (\Psi_3, A_3)) = ((\Psi_1, A_1) \wedge ((\Psi_2, A_2)) \vee ((\Psi_1, A_1) \wedge (\Psi_3, A_3))$

4. An Applications to Hypersoft expert set

In this section, an application of hypersoft expert set theory in a decision making problem, is presented.

Statement of the problem

A manufacturing company advertises a ”job opportunity” to fill its a vacant position. Its main slogan is ”the right person for the right post”. Eight applications received from the suitable candidates and company wants to complete this hiring process through through the selection board of some experts with some prescribed attributes.

Proposed Algorithm

The following algorithm may be followed by the company to fill the position.

(1). Construct hypersoft soft expert set (Ψ, K),

(2). Determine an agree-hypersoft expert set and a aisagree-hypersoft expert set,

(3). Compute $d_i = \sum_i c_{ij}$ for agree-hypersoft expert set,

(4). Determine $f_i = \sum_i c_{ij}$ for disagree-hypersoft expert set,

(5). Determine $g_j = d_j - f_j$ for agree-hypersoft expert set,

(6). Compute n, for which $p_n = \max p_j$ for agree-hypersoft expert set,

Step-1

Let eight candidates form the universe of discourse $\Omega = \{c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8\}$ and X = $\{E_1, E_2, E_3\}$ be a set of experts (committee members) for this recruitment process. The following are the attribute-valued sets for prescribed attributes:

$H_1 = Qualification = \{h_1, h_2\}$

$H_2 = Experience = \{h_3, h_4\}$

$H_3 = ComputerKnowledge = \{h_5, h_6\}$

$H_4 = Confidence = \{h_7, h_8\}$

$H_5 = Skills = \{h_9, h_{10}\}$

and then

$H = H_1 \times H_2 \times H_3 \times H_4 \times H_5$

$$H = \left\{ \begin{array}{l} (h_1,h_3,h_5,h_7,h_9),(h_1,h_3,h_5,h_7,h_{10}),(h_1,h_3,h_5,h_8,h_9),(h_1,h_3,h_5,h_8,h_{10}),(h_1,h_3,h_6,h_7,h_9), \\ (h_1,h_3,h_6,h_7,h_{10}),(h_1,h_3,h_6,h_8,h_9),(h_1,h_3,h_6,h_8,h_{10}),(h_1,h_4,h_5,h_7,h_9),(h_1,h_4,h_5,h_7,h_{10}), \\ (h_1,h_4,h_5,h_8,h_9),(h_1,h_4,h_5,h_8,h_{10}),(h_1,h_4,h_6,h_7,h_9),(h_1,h_4,h_6,h_7,h_{10}),(h_1,h_4,h_6,h_8,h_9), \\ (h_1,h_4,h_6,h_8,h_{10}),(h_2,h_3,h_5,h_7,h_9),(h_2,h_3,h_5,h_7,h_{10}),(h_2,h_3,h_5,h_8,h_9),(h_2,h_3,h_5,h_8,h_{10}), \\ (h_2,h_3,h_6,h_7,h_9),(h_2,h_3,h_6,h_7,h_{10}),(h_2,h_3,h_6,h_8,h_9),(h_2,h_3,h_6,h_8,h_{10}),(h_2,h_4,h_5,h_7,h_9), \\ (h_2,h_4,h_5,h_7,h_{10}),(h_2,h_4,h_5,h_8,h_9),(h_2,h_4,h_5,h_8,h_{10}),(h_2,h_4,h_6,h_7,h_9),(h_2,h_4,h_6,h_7,h_{10}), \\ (h_2,h_4,h_6,h_8,h_9),(h_2,h_4,h_6,h_8,h_{10}) \end{array} \right\}$$

and now take $K \subseteq H$ as

$K = \{a_1 = (h_1,h_3,h_5,h_7,h_9), a_2 = (h_1,h_3,h_6,h_7,h_{10}), a_3 = (h_1,h_4,h_6,h_8,h_9), a_4 = (h_2,h_3,h_6,h_8,h_9), a_5 = (h_2,h_4,h_6,h_7,h_{10})\}$

and

$$(\Psi, \mathrm{K}) = \left\{ \begin{array}{l} ((a_1,E_1,1) = \{c_1,c_2,c_4,c_7,c_8\}),((a_1,E_2,1) = \{c_1,c_4,c_5,c_8\}), \\ ((a_1,E_3,1) = \{c_1,c_3,c_4,c_5,c_6,c_7,c_8\}), \\ ((a_2,E_1,1) = \{c_3,c_5,c_8\}),((a_2,E_2,1) = \{c_1,c_3,c_4,c_5,c_6,c_8\}), \\ ((a_2,E_3,1) = \{c_1,c_2,c_4,c_7,c_8\}), \\ ((a_3,E_1,1) = \{c_3,c_4,c_5,c_7\}),((a_3,E_2,1) = \{c_1,c_2,c_5,c_8\}), \\ ((a_3,E_3,1) = \{c_1,c_7,c_8\}), \\ ((a_4,E_1,1) = \{c_1,c_7,c_8\}),((a_4,E_2,1) = \{c_5,c_1,c_4,c_8\}), \\ ((a_4,E_3,1) = \{c_1,c_6,c_7,c_8\}), \\ ((a_5,E_1,1) = \{c_1,c_3,c_4,c_5,c_7,c_8\}),((a_5,E_2,1) = \{c_1,c_4,c_5,c_8\}), \\ ((a_5,E_3,1) = \{c_1,c_3,c_4,c_5,c_7,c_8\}), \\ ((a_1,E_1,0) = \{c_3,c_5,c_6\}),((a_1,E_2,0) = \{c_2,c_3,c_6,c_7\}), \\ ((a_1,E_3,0) = \{c_2,c_5\}), \\ ((a_2,E_1,0) = \{c_1,c_2,c_4,c_5,c_6,c_7\}),((a_2,E_2,0) = \{c_2,c_7\}), \\ ((a_2,E_3,0) = \{c_2,c_3,c_4,c_5,c_6\}), \\ ((a_3,E_1,0) = \{c_1,c_2,c_6,c_8\}),((a_3,E_2,0) = \{c_3,c_4,c_6,c_7\}), \\ ((a_3,E_3,0) = \{c_2,c_3,c_4,c_5,c_7\}), \\ ((a_4,E_1,0) = \{c_2,c_3,c_3,c_4,c_5,c_7\}),((a_4,E_2,0) = \{c_2,c_3,c_6,c_7\}), \\ ((a_4,E_3,0) = \{c_2,c_3,c_4,c_5\}), \\ ((a_5,E_1,0) = \{c_4,c_6,c_7\}),((a_5,E_2,0) = \{c_2,c_3,c_6,c_7\}), \\ ((a_5,E_3,0) = \{c_2,c_4,c_6\}) \end{array} \right\}$$

is a hypersoft expert set.

Step-2

Table 1 presents an agree-hypersoft expert set and table 2 presents a disagree-hypersoft expert

Table 1. Agree-hypersoft expert set

v	c_1	c_2	c_3	c_4	c_5	c_6	c_8	c_7
(a_1, E_1)	✓	✓	×	✓	×	×	✓	✓
(a_2, E_1)	×	×	✓	×	✓	×	×	✓
(a_3, E_1)	×	×	✓	✓	✓	×	✓	×
(a_4, E_1)	✓	×	×	×	✓	×	✓	✓
(a_5, E_1)	✓	✓	✓	×	✓	×	×	✓
(a_1, E_2)	✓	×	×	✓	×	×	×	✓
(a_2, E_2)	✓	×	✓	✓	✓	✓	×	✓
(a_3, E_2)	×	×	✓	✓	✓	×	✓	×
(a_4, E_2)	✓	×	×	✓	✓	×	×	✓
(a_5, E_2)	✓	×	×	✓	✓	×	×	✓
(a_1, E_3)	✓	×	✓	✓	×	✓	✓	✓
(a_2, E_3)	✓	✓	×	✓	×	×	✓	✓
(a_3, E_3)	✓	×	×	×	×	×	✓	✓
(a_4, E_3)	✓	×	×	×	×	✓	✓	✓
(a_5, E_3)	✓	×	✓	×	✓	×	✓	✓
$d_j = \sum_i c_{ij}$	$d_1 = 12$	$d_2 = 3$	$d_3 = 7$	$d_4 = 9$	$d_5 = 9$	$d_6 = 3$	$d_7 = 9$	$d_8 = 13$

set respectively, such that if $c_i \in F_1(\beta)$ then $c_{ij} = \checkmark = 1$ otherwise $c_{ij} = \times = 0$, and if

$$c_i \in F_0(\beta)$$

then $c_{ij} = \checkmark = 1$ otherwise $c_{ij} = \times = 0$ where c_{ij} are the entries in tables 1 and 2.

Step-(3-6)

Table 3 presents $d_i = \sum_i c_{ij}$ for agree-hypersoft expert set, $f_i = \sum_i c_{ij}$ for disagree-hypersoft expert set, $g_j = d_j - f_j$ for agree-hypersoft expert set, and n, for which $p_n =$ max p_j for agree-hypersoft expert set.

Decision

As g_8 is maximum, so candidate c_8 is preferred to be selected for the said post. Then max g_8, so the committee will choose candidate 8 for the job.

5. Conclusions

Insufficiency of soft set and expert set for multi-attribute function (attribute-valued sets) is addressed with the development and characterization of novel hybrid structure i.e. hypersoft expert set, in this study. Moreover

(1) The fundamentals of hypersoft expert set (HSE-Set) are established and the basic properties of HSE-Set like subset, superset, equal sets, not set, agree HSE-Set and disagree HSE-Set are described with examples.

Table 2. Disagree-hypersoft expert set

V	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
(a_1, E_1)	×	×	✓	×	×	✓	×	×
(a_2, E_1)	✓	✓	×	✓	×	✓	✓	×
(a_3, E_1)	✓	✓	×	×	×	✓	×	✓
(a_4, E_1)	×	✓	✓	✓	✓	✓	×	×
(a_5, E_1)	×	×	×	✓	×	✓	✓	×
(a_1, E_2)	×	✓	✓	×	×	✓	✓	×
(a_2, E_2)	×	✓	×	×	×	×	✓	×
(a_3, E_2)	✓	✓	×	×	×	✓	×	✓
(a_4, E_2)	×	✓	✓	×	×	✓	✓	×
(a_5, E_2)	×	✓	✓	×	×	✓	✓	×
(a_1, E_3)	×	✓	×	×	✓	×	×	×
(a_2, E_3)	×	×	✓	×	✓	✓	×	×
(a_3, E_3)	×	✓	✓	✓	✓	✓	×	×
(a_4, E_3)	×	✓	✓	✓	✓	×	×	×
(a_5, E_3)	×	✓	×	✓	×	✓	×	×
$f_i = \sum_i c_{ij}$	$f_1 = 3$	$f_2 = 12$	$f_3 = 8$	$f_4 = 6$	$f_5 = 5$	$f_6 = 12$	$f_7 = 6$	$f_8 = 2$

Table 3. Optimal

$d_i = \sum_i c_{ij}$	$f_i = \sum_i c_{ij}$	$g_j = d_j - f_j$
$d_1 = 12$	$f_1 = 3$	$g_1 = 9$
$d_2 = 3$	$f_2 = 12$	$g_2 = -9$
$d_3 = 7$	$f_3 = 8$	$g_3 = -1$
$d_4 = 9$	$f_4 = 6$	$g_4 = 3$
$d_5 = 9$	$f_5 = 5$	$g_5 = 4$
$d_6 = 3$	$f_6 = 12$	$g_6 = -9$
$d_7 = 9$	$f_7 = 6$	$g_7 = 3$
$d_8 = 13$	$f_8 = 2$	$g_8 = 11$

(2) The essential set-theoretic operations on HSE-Set like complement, union, intersection, OR and AND operations are established and some laws such as commutative, associative and De Morgan are presented with suitable examples.

(3) A decision-making application regarding recruitment process is presented with the help of proposed algorithm.

(4) A daily life based example is discussed for the understanding of decision making process.

(5) Future work may include the extension of the presented work for other hypersoft-like hybrids i.e. fuzzy, intuitionistic fuzzy, interval-valued fuzzy, pythagorean fuzzy etc.

Conflicts of Interest: "The authors declare no conflict of interest."

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