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Application of Bipolar Near Soft Sets

Hatice Taşbozan[1]

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Abstract — The bipolar soft set is supplied with two soft sets, one positive and the other negative. Whichever feature is stronger can be selected to find the object we want. In this paper, the notion of bipolar near soft set, which near set features are added to a bipolar soft set, and its fundamental properties are introduced. In this new set, its features can be restricted and the basic properties and topology of the set can be examined accordingly. With the soft set close to bipolar, it will be easier for us to decide to find the most suitable object in the set of objects. This new idea is illustrated with real-life examples. With the help of the bipolar near soft set, we make it easy to choose the one closest to the criteria we want in decision making. Among the many given objects, we can find the one with the properties we want by using the ones with similar properties.

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1. Introduction

The models used for each uncertainty problem are different from each other. For this, different set concepts have been created. With the help of objects and features on these objects, Pawlak [17] first presented the concept of rough set and then Peters [18, 19] presented the concept of near set, in which he examined sets close to each other with these features. Another set, the soft set, was created by Molodtsov [14] and has been studied by many people both in practice and in theory [1–3, 5–7, 12, 13, 15]. Feng and Li [9], on the other hand, established a new concept by integrating the concepts of soft set and near set. Similarly, Tasbozan et al. [22] combined the concepts of near and soft set. These concepts have been developed and produced in the topology [23, 24].

The idea of bipolar soft set was presented by Shabir and Naz [20] and later this definition was used by many researchers in applications. Karaaslan and Karatas [10] created the idea of bipolar soft cluster and used it in applications. Mahmood [11] gave the bipolar soft set approach and its application. The notion of bipolar soft set, which is a set in which human decisions are made with two types of notice, positive and negative, was defined [4, 8, 10, 11, 16, 21]. Parameters with positive or negative properties give us information about objects. In some uncertainty problems, a decision making approach should be established in order to make the most accurate object selection under these conditions with the parameters determined by the decision maker. The construction of all these mathematical models is up to the decision maker. By restricting this

[1]htasbozan@mku.edu.tr (Corresponding Author)
[1]Hatay Mustafa Kemal University, Department of Mathematics, TÜRKİYE.
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information to the selected parameters, we have obtained the concept of bipolar near soft set in order to distinguish the ones with similar properties more quickly. In the application with bipolar near soft sets, practicality can be provided in decision making so that we can find the object we will choose. Therefore, it can be applied to multi-criteria decision making problems. Today, bipolar theory is used in the evaluation system to understand people's positive or negative opinions about objects. In this way, organizations can track how much their products are liked or help buyers find the products closest to their needs.

In this study, the necessary definitions were given in the first part, and in the other part, we reached the concept of bipolar near soft sets, in which we added set characteristics near to bipolar sets. It is exemplified how this concept can be applied in an environment of uncertainty. In order to find the one with the features we want among many objects, we were restricted to the features desired by the decision maker, and with the choices we made, we were able to see the objects with similar features more clearly. This has provided us with the practice of choosing the most suitable products for us that we need.

2. Preliminary

Let $\mathscr{O}$ be an objects set, $\mathscr{F}$ be a set of parameters that define properties on objects and $\mathscr{P}(\mathscr{O})$ is the set of all subsets of $\mathscr{O}$.

Definition 2.1. [3] Let $B \subseteq \mathscr{F}$ and $F : B \to \mathscr{P}(\mathscr{O})$, then (F, B) is a soft set(SS) over $\mathscr{O}$.

Definition 2.2. [22] Let $NAS = (\mathscr{O}, \mathscr{F}, \sim_{Br}, N_r, \nu_{N_r})$ be a nearness approximation space, B be a non-empty subsets of $\mathscr{F}$ and (F, B) be a SS over $\mathscr{O}$. Then

$$N_r*((F,B)) = (N_r*(F(k) = \cup\{x \in \mathscr{O} : [x]_{Br} \subseteq F(k)\}, B))$$

and

$$N_r^*((F,B)) = (N_r^*(F(k) = \cup\{x \in \mathscr{O} : [x]_{Br} \cap F(k) \neq \emptyset\}, B))$$

are lower and upper near approximation operators where $[x]_{Br}$ be equivalence classes denoted by the subscript r for the cardinality of the restricted subset B_r. The SS $N_r((F,B))$ with $Bnd_{N_r(B)}((F,B)) \geqslant 0$ called a near soft set(NSS) where

$$Bnd_{N_r(B)}((F,B)) = N_r^*((F,B)) \setminus N_r*((F,B)).$$

Definition 2.3. [21] Let $F : B \to P(\mathscr{O})$ and $G : \neg B \to P(\mathscr{O})$ be a mappings which $F(k) \cap G(\neg k) = \emptyset$, $\forall k \in B$. (F, G, B) is called a bipolar soft set (BSS) over $\mathscr{O}$.

3. Bipolar Near Soft Set

In this section, by introducing the bipolar set, we have reached the concept of bipolar near soft sets, to which we add near set properties. How this concept can be applied in an environment of uncertainty is discussed with assumptions about the values of the data on the example. Thus, in order to find the one with the features we want among many objects, we can select objects with similar features by limiting them to the features the decision maker wants.

Definition 3.1. Let $\sigma = (F, B)$, $N_r(\sigma)$ be a NSS and (F, G, B) be a BSS over $\mathscr{O}$. $F : B \to P(\mathscr{O})$ and $G : \neg B \to P(\mathscr{O})$ are mappings which $F(k) \cap G(\neg k) = \emptyset$, $\forall k \in B$. Then the triplet $N(F, G, B)$ is called a bipolar near soft set over $\mathscr{O}$ ($BNSS$).

Definition 3.2. Let $N(F_s, G_s, A)$ and $N(F_1, G_1, B)$ be $BNSS$ over $\mathscr{O}$, if

1. $A \subseteq B$,

2. $F_s(k) \subseteq F_1(k)$ and $G_1(\neg k) \subseteq G_s(\neg k)$, $\forall k \in A$,

3. For $N_*(\sigma) = N_*(F_s(k), A)$ of a set (F_s, A) and $N_*(\mu) = N_*(F_1(k), B)$ of a set (F_1, B), $N_*(\sigma) \subseteq N_*(\mu)$,

then $N(F_s, G_s, A)$ is a bipolar near soft subset $BNSs$ of $N(F_1, G_1, B)$ and denoted by $N(F_s, G_s, A) \subseteq N(F_1, G_1, B)$.

Definition 3.3. If $N(F_s, G_s, A)$ is a $BNSs$ of $N(F_1, G_1, B)$ and $N(F_1, G_1, B)$ is a $BNSs$ of $N(F_s, G_s, A)$, then $N(F_s, G_s, A)$ and $N(F_1, G_1, B)$ are equal $BNSS$ over $\mathscr{O}$.

Definition 3.4. Let F^c and G^c be mappings where $F^c(k) = G(\neg k)$ and $G^c(\neg k) = F(k)$, $\forall k \in A$. $N(F, G, A)^c = N(F^c, G^c, A)$ is a complement of a $BNSS$.

Definition 3.5. If $\Phi(k) = \emptyset$ and $N(\mathscr{O}(\neg k)) = \mathscr{O}$, for all $k \in A$, then $N(\Phi, \mathscr{O}, A)$ is a null $BNSS$ over $\mathscr{O}$.

Definition 3.6. If $N(\mathscr{O}(k)) = \mathscr{O}$ and $N(\Phi(\neg k)) = \emptyset$, for all $k \in A$, then $N(\mathscr{O}, \Phi, A)$ is an absolute $BNSS$ over $\mathscr{O}$.

Definition 3.7. Let $N(F, G, A)$ and $N(F_1, G_1, B)$ be two $BNSS$ over $\mathscr{O}$. The intersection of $N(F, G, A)$ and $N(F_1, G_1, B)$, denoted by $N(H, I, C) = N(F, G, A) \cap N(F_1, G_1, B)$, $\forall k \in C = A \cap B$ where $H = F \cap F_1$ and $I = G \cap G_1$, the union of $N(F, G, A)$ and $N(F_1, G_1, B)$ where denoted by $N(H, I, C)$, $\forall k \in C = A \cup B$ where $H = F \cup F_1$ and $I = G \cup G_1$.

Example 3.8. Let $\mathscr{O} = \{y_1, y_2, y_3, y_4, y_5\}$ be a five person and $B = \{k_1, k_2\} \subseteq \mathscr{F} = \{k_1, k_2, k_3, k_4\}$ be a set of parameters, where k_1, k_2, k_3, k_4 stand for tall, strong, well dressed and intelligent, respectively. Sample values of the $k_i, i = 1, 2, 3, 4$ functions are shown

$$
\begin{aligned}
[y_1]_{k_1} &= \{y_1, y_4\}, [y_2]_{k_1} = \{y_2, y_3, y_5\}, \\
[y_1]_{k_2} &= \{y_1, y_4\}, [y_2]_{k_2} = \{y_2, y_3\}, [y_5]_{k_2} = \{y_5\}, \\
[y_1]_{k_1, k_2} &= \{y_1, y_4\}, \\
[y_2]_{k_1, k_2} &= \{y_2, y_3\}, \\
[y_5]_{k_1, k_2} &= \{y_5\}.
\end{aligned}
$$

Let $B = \{k_1, k_2\}$ and (F, B) be a SS defined by $(F, B) = ((k_1, \{y_1, y_4\}), (k_2, \{y_3, y_5\}))$ is a NSS with $r = 1$ and $r = 2$. We get

$$N_*((F, B)) = (F_*(k_2), B) = \{(k_2, \{y_5\})\}, for k_2 \in B$$

and

$$N^*((F, B)) = \{(k_2, \{y_2, y_3, y_5\})\}, for k_1, k_2 \in B.$$

Hence, $Bnd_N(\sigma) \geq 0$, then (F, B) is a NSS.

Let $F : B \to P(\mathscr{O})$ and $G : -B \to P(\mathscr{O})$ be mappings given as follows:

$$
\begin{aligned}
F(k_1) &= \{y_1, y_4\}, G(\neg k_1) = \{y_3\}, \\
F(k_2) &= \{y_3, y_5\}, G(\neg k_2) = \emptyset.
\end{aligned}
$$

Then

$$N(F, G, B) = \{(k_1, \{y_1, y_4\}, \{y_3\}), (k_2, \{y_3, y_5\}, \emptyset)\}$$

is a $BNSS$.

Definition 3.9. Let (F,B) be a NSS over $\mathcal{O}$, $u \in \mathcal{O}$. Then $N(F_u;G_u;B)$ denotes the bipolar near soft set over $\mathcal{O}$ and $(u_k, u'_{(-k)}, B)$ called a bipolar near soft point, defined by $F_u(k) = \{u\}$ and $F_u(k') = \emptyset$ for all $k' \in B - \{k\}$ and $G_u(-k) = \mathcal{O} - \{u\} = u'$, for each $k \in B$.

Definition 3.10. Let $\mu = N(F,G,B)$ be a $BNSS$ over $\mathcal{O}$ and τ be the collection of $BNSs$ of $\mathcal{O}$. If the following are provided

i) $(\emptyset, G, B), (\mathcal{O}, G, B) \in \tau$,

ii) $N(F_1, G_1, B), N(F_2, G_2, B) \in \tau$ then $N(F_1, G_1, B) \cap N(F_2, G_2, B) \in \tau$,

iii) $N(F_i, G_i, B), \forall k \in B$ then $\bigcup_i N(F_i, G_i, B) \in \tau$,

then $N(\mathcal{O}, \tau, B, -B)$ is a bipolar near soft topological space($BNSTS$).

Definition 3.11. Let $N(\mathcal{O}, \tau, B, -B)$ be called a $BNSTS$ over $\mathcal{O}$. Then the collection $\tau_k = \{F(k) : N(F,G,B) \in \tau\}$ for each $k \in B$ defines a topology on $\mathcal{O}$.

Definition 3.12. Let $N(\mathcal{O}, \tau, B, -B)$ be a $BNSTS$ over $\mathcal{O}$ and $N(F,G,B)$ be a $BNSS$ over $\mathcal{O}$. Then $N(F,G,B)$ is said to be bipolar near soft closed ($BNSC$) if and only if $N(F,G,B)^c$ in τ. Then $(\mathcal{O}, \tau, B, -B)$ is a $BNSTS$ over $\mathcal{O}$ and the members of are bipolar near soft open ($BNSO$) sets in $\mathcal{O}$.

Definition 3.13. Let $N(F,G,B)$ be a $BNSS$ over $\mathcal{O}$ and $Y \neq \emptyset \subseteq \mathcal{O}$. Then the $BNSS$ of $N(F,G,B)$ over Y is defined as follows: ${}^Y F(k) = Y \cap F(k)$ and ${}^Y G(-k) = Y \cap G(-k)$; for each $k \in B$ and denoted by $N({}^Y F, {}^Y G, B)$.

Definition 3.14. Let $N(\mathcal{O}, \tau, B, -B)$ be a $BNSTS$ over $\mathcal{O}$ and $Y \neq \emptyset \subseteq \mathcal{O}$. Then $\tau_Y = \{N({}^Y F, {}^Y G, B) : N(F,G,B) \in \tau\}$ is a $BNST$on Y.

Definition 3.15. Let $N(\mathcal{O}, \tau_s, B, -B)$ be a $BNSTS$ over $\mathcal{O}$. Then the collection consisting of $BNSS$, $N(F,G,B)$ such that $(F,B) \in \tau$, $G(-k) = F'(k) = \mathcal{O} \backslash F(k)\ \forall -k \in -B$, defined a $BNST$ over $\mathcal{O}$.

Example 3.16. Let $\mathcal{O}$, B be sets, $F : B \to P(\mathcal{O})$ and $G : -B \to P(\mathcal{O})$ be two maps as in Example 16. Then

$$\begin{aligned} N(F_1, G_1, B) &= \{(k_1, \{y_1, y_4\}, \{y_1\}), (k_2, \{y_3, y_5\}, \emptyset)\}, \\ N(F_2, G_2, B) &= \{(k_1, \{y_1, y_4, y_2\}, \{y_1\}), (k_2, \{y_5\}, \emptyset)\}, \\ N(F_3, G_3, B) &= \{(k_1, \{y_1, y_4\}, \{y_1\}), (k_2, \{y_5\}, \emptyset)\} \end{aligned}$$

are $BNSS$. Also, we obtained

$$\tau = \{N(F_1, G_1, B), N(F_2, G_2, B), N(F_3, G_3, B), (\emptyset, G, B), (\mathcal{O}, G, B)\}.$$

Then, $N(\mathcal{O}, \tau, B, -B)$ is a $BNSTS$.

Definition 3.17. Let $Y \neq \emptyset$ and $Y \subseteq \mathcal{O}$, then the whole $BNSS$, $N(Y, G, B)$ over $\mathcal{O}$ for which $Y(k) = Y$, for all $k \in B$.

Definition 3.18. Let $N(F,G,B)$ be a $BNSS$ over $\mathcal{O}$, $Y \neq \emptyset$ and $Y \subseteq \mathcal{O}$. Then the $BNSsS$ of $N(F,G,B)$ over Y is defined as follows:

$${}^Y F(k) = Y \cap F(k), \forall k \in B$$

and denoted by $N({}^Y F, G, B)$.

Definition 3.19. Let $N(K_1, P_1, B)$ and $N(K_2, P_2, D)$ be two $BNSS$ over $\mathscr{O}_1$ and $\mathscr{O}_2$, respectively. The cartesian product $N(K_1, P_1, B) \times N(K_2, P_2, D)$ is defined by $(K_1 \times K_2)_{(B\times C)}$ where $(K_1 \times K_2)_{(B\times D)}(k, m) = K_1(k) \times K_2(m)$, $\forall(k, m) \in B \times D$. According to this definition, the soft set $N(K_1, P_1, B) \times N(K_2, P_2, D)$ is a $BNSS$ over $\mathscr{O}_1 \times \mathscr{O}_2$ and its parameter universe is $B \times D$.

Definition 3.20. Let $N(\mathscr{O}, \tau, B, -B)$ be a $BNSTS$ over $\mathscr{O}$, then the members of τ are said to be bipolar near soft open($BNSO$) sets in $\mathscr{O}$.

Definition 3.21. Let $N(\mathscr{O}, \tau, B, -B)$ be a $BNSTS$ and $N(F, G, B)$ be a $BNSS$ over $\mathscr{O}$. Then the BNS closure $N(F, G, B)^-$ is the intersection of all $BNSC$ sets of (F, G, B) is the smallest $BNSC$ over $\mathscr{O}$ and the BNS interior $N(F, G, B)^\circ$ is the combination of all $BNSO$ sets of $N(F, G, B)$ is the biggest $BNSO$ set over $\mathscr{O}$.

3.1. Application of Bipolar Near Soft Sets

In this part, we will use the notion of bipolar near soft sets to make the best choice available to us. In order to do this, we will follow some steps. Let us now consider this with an example.

Example 3.22. Assume that a house selling firm has a set of houses $\mathscr{O}$ with a set of parameters $\mathscr{F}$. Let $\mathscr{O} = \{y_1, y_2, y_3, y_4, ..., y_{12}\}$ be a set of twelve house and $B = \{k_5, k_7\} \subseteq \mathscr{F} = \{k_1, k_2, k_3, ..., k_7\}$ be a set of seven parameters, where k_i, $i = (1,2,3,4,5,6,7)$ stand for "expensive,""cheap," "modern," "earthquake resistant" "good location," "multi-storey,"and "quality material,"respectively. We should noted that -k_1 does not denote "cheap" and $\neg k_2$ does not denote "expensive." Now, assume that a house selling firm categorises these houses with interest to the set of parameters using a concept of a $BNSS$, $N(F, G, B)$ as follows:

$$\begin{aligned}
F(k_1) &= \{y_i : i = 1,2,5,7,9\}, G(-k_1) = \{y_i : i = 3,4,10\},\\
F(k_2) &= \{y_i : i = 3,5,8,11,12\}, G(-k_2) = \{y_i : i = 1,2,9,10\},\\
F(k_3) &= \{y_i : i = 1,7,8,9,12\}, G(-k_3) = \{y_i : i = 2,5,10\},\\
F(k_4) &= \{y_i : i = 1,5,8,9,11,12\}, G(-k_4) = \{y_i : i = 2,3,4\},\\
F(k_5) &= \{y_i : i = 1,2,7,8,9,10,11,12\}, G(-k_5) = \{y_i : i = 4,5\},\\
F(k_6) &= \{y_i : i = 2,10\}, G(-k_6) = \{y_i : i = 7,9,11\},\\
F(k_7) &= \{y_i : i = 8,12\}, G(-k_7) = \{y_i : i = 6,7,11\}.
\end{aligned}$$

Now, suppose that we want to select a house with respect to $B = \{k_5, k_7\} \subseteq \mathscr{F}$. We will construct table respect with $F : B \to P(\mathscr{O})$ and $G : -B \to P(\mathscr{O})$.

Table 1

	k_1	$-k_1$	k_2	$-k_2$	k_3	$-k_3$	k_4	$-k_4$	k_5	$-k_5$	k_6	$-k_6$	k_7	$-k_7$
y_1	1	0	0	−1	1	0	1	0	1	0	0	0	0	0
y_2	1	0	0	−1	0	−1	0	−1	1	0	1	0	0	0
y_3	0	−1	1	0	0	0	0	−1	0	0	0	0	0	0
y_4	0	−1	0	0	0	0	0	−1	0	−1	0	0	0	0
y_5	1	0	1	0	0	−1	1	0	0	−1	0	0	0	0
y_6	0	0	0	0	0	0	0	0	0	0	0	0	0	−1
y_7	1	0	0	0	1	0	0	0	1	0	0	−1	0	−1
y_8	0	0	1	0	1	0	1	0	1	0	0	0	1	0
y_9	1	0	0	−1	1	0	1	0	1	0	0	−1	0	0
y_{10}	0	−1	0	−1	0	−1	0	0	1	0	1	0	0	0
y_{11}	0	0	1	0	0	0	1	0	1	0	0	−1	0	−1
y_{12}	0	0	1	0	1	0	1	0	1	0	0	0	1	0

We determine the value of $(y_n, F(k_i))$ and $(y_n, G(-k_i))$ by the following two roles and construct table:

$$(y_n, F(k_i)) = \begin{cases} 1, & y_n \in F(k_i) \\ 0, & y_n \notin F(k_i) \end{cases}.$$

If we combine it using $F(k_i) \cap G(\neg k_i) = \emptyset$ for each $k_i \in \mathscr{F}$, we get the following table:

$$(y_n, (F(k_i), G(-k_i))) = \begin{cases} 1, & y_n \in F(k_i) \\ -1, & y_n \in G(-k_i) \\ 0, & y_n \notin F(k_i) \cup G(-k_i) \end{cases}.$$

Table 2

	$(k_1,-k_1)$	$(k_2,-k_2)$	$(k_3,-k_3)$	$(k_4,-k_4)$	$(k_5,-k_5)$	$(k_6,-k_6)$	$(k_7,-k_7)$	Sum
y_1	1	−1	1	1	1	0	0	3
y_2	1	−1	−1	−1	1	1	0	0
y_3	−1	1	0	−1	0	0	0	−1
y_4	−1	0	0	−1	−1	0	0	−3
y_5	1	1	−1	1	−1	0	0	1
y_6	0	0	0	0	0	0	−1	−1
y_7	1	0	1	0	1	−1	−1	1
y_8	0	1	1	1	1	0	1	5
y_9	1	−1	1	1	1	−1	0	2
y_{10}	−1	−1	−1	0	1	1	0	−1
y_{11}	0	1	0	1	1	−1	−1	1
y_{12}	0	1	1	1	1	0	1	5

Enumerate the values by the rule

$$Sumn = \sum_{i=1}^{7} (y_n, (F(k_i), G(\neg k_i))).$$

Find the verdict, denoted by d, for which $d = \{maxSumn : n = 1, 2, ..., s\}$, where $s = |y|$. Then, d is the suitable select house. If d has more than one value, any of them can be selected.

Let $\sigma = (F, B)$, $B = \{k_5, k_7\}$ be a SS defined by

$N(F, G, B) = ((k_5, \{y_1, y_2, y_7, y_8, y_9, y_{10}, y_{11}, y_{12}\}, \{y_4, y_5\}), (k_7, \{y_8, y_{12}\}, \{y_6, y_7, y_{11}\}))$ is a $BNSS$ with $r = 2$. From the table, we obtained

$$\begin{aligned}
[y_1]_{k_5} &= \{y_1, y_2, y_7, y_8, y_9, y_{10}, y_{11}, y_{12}\}, [y_3]_{k_5} = \{y_3, y_4, y_5, y_6\}, \\
[y_8]_{k_7} &= \{y_8, y_{12}\}, [y_1]_{k_7} = \{y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_9, y_{10}, y_{11}\}, \\
[y_8]_{k_5, k_7} &= \{y_8, y_{12}\}, \\
[y_1]_{k_5, k_7}, &= \{y_1, y_2, y_7, y_9, y_{10}, y_{11}\}, \\
[y_3]_{k_5, k_7} &= \{y_3, y_4, y_5, y_6\}.
\end{aligned}$$

Hence, we get

$$\begin{aligned}
N_*(\sigma) &= N_*(F(k), B) \\
&= (N_* F(k), B) \\
&= (F_*(k), B) \\
&= (F_*(k_7), B) \\
&= \{(k_7, \{y_8, y_{12}\})\}, \quad for \quad k_7 \in B
\end{aligned}$$

and

$$\begin{aligned}
N^*(\sigma) &= (F^*(k), B) \\
&= \{((k_5, \{y_1, y_2, y_7, y_8, y_9, y_{10}, y_{11}, y_{12}\}), (k_7, \{y_8, y_{12}\}))\} \quad for \quad k_5, k_7 \in B.
\end{aligned}$$

Then, $N(F, G, B)$ is a $BNSS$.

Table 3

	$(k_5, -k_5)$	$(k_7, -k_7)$	Sum
y_1	1	0	1
y_2	1	0	1
y_3	0	0	0
y_4	-1	0	-1
y_5	-1	0	-1
y_6	0	-1	-1
y_7	1	-1	0
y_8	1	1	2
y_9	1	0	1
y_{10}	1	0	1
y_{11}	1	-1	0
y_{12}	1	1	2

From the table, we obtained

$$Sumn = \sum_{i=1}^{7} (y_n, (F(k_i), G(\neg k_i))) = 2.$$

Now, one can note from table that houses y_8 and y_{12} are the optimal houses. Therefore, any of them can be chosen by us to get the house, we want. Accordingly, we find the most suitable house or houses according to the k_5 and k_7 features.

4. Conclusions

In order to find the one with the properties we want among the many objects given in this study, we reached the concept of near soft sets, which we obtained that have properties near to each other, with a bipolar approach. The concept of bipolar near soft set enabled us to see more clearly what we want, namely the practice of choosing the best products. It reduced the features so we could choose what we needed. We aim to obtain similar examples according to the definitions we will find in future studies.

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