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An algorithm for generating permutation algebras using soft spaces

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ABSTRACT

Soft set theory has recently gained significance for finding rational and logical solutions to various real-life problems, which involve uncertainty, impreciseness and vagueness. In this paper, we introduced an algorithm to find permutation algebras using soft topological space. Moreover, this class of permutation algebras is called even (odd) permutation algebras if its permutation is even (odd). Furthermore, new concepts in permutation algebras are investigated such as splittable permutation algebra and ambivalent permutation algebra. Furthermore, several examples are given to illustrate the concepts introduced in this paper.

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1. Introduction

The concept of soft sets is a novel notion was introduced by Molodtsov [1]. Next, Shabir and Naz [2] introduced the notion of soft topological spaces. Some notions of this concept with its applications fundamental concepts of fuzzy soft topology and Intuitionistic fuzzy soft topology are studied by many mathematicians see the following references [3–15]. BCK-algebra as a class of abstract algebras is introduced by Imai and Iseki [16,17]. Next, the concept of d -algebras, which is another useful generalization of BCK-algebras, is introduced (see refs [18–20]). Also, the notion of d^* -algebras is investigated [21]. After then, the concepts of ρ -algebras and $\rho/\bar{\rho}$ -ideals are introduced and studied [22]. In 2009, the concept of soft d -algebras is introduced (see Jun et al. [23]). Also, some extensions using power set are introduced such as soft ρ -algebra and soft edge ρ -algebra of the power set [24], soft BCL-algebras of the power set [25] and soft BCH-algebra of the power set [26]. Next, the notion of Γ -fuzzy d -algebra is given [27]. In this paper, we introduced an algorithm to find permutation algebras using soft topological space. Moreover, this class of permutation algebras is called even (odd) permutation algebras if its permutation is even (odd). Furthermore, new concepts in permutation algebras are investigated such as splittable permutation algebra and ambivalent permutation algebra. Furthermore, several examples are given to illustrate the concepts and introduced in this paper.

2. Preliminaries

In this section, we recall basic definitions and results that are needed later.

Definition 2.1: We call the partition $\alpha = \alpha(\beta) = (\alpha_1(\beta), \alpha_2(\beta), \dots, \alpha_{c(\beta)}(\beta))$ the cycle type of β [28].

Definition 2.2: Let α be a partition of n . We define $C^\alpha \subset S_n$ to be the set of all elements with cycle type α [28].

Definition 2.3: Let $\beta \in C^\alpha$, where β is a permutation in alternating group A_n . $A(\beta)$ conjugacy class of β in A_n is defined by [29]

$$A(\beta) = \{\gamma \in A_n \mid \gamma = t\beta t^{-1}; \text{ for some } t \in A_n\}$$

$$= \begin{cases} C^\alpha, & (\text{if } \beta \notin H_n) \\ C^{\alpha+} \text{ or } C^{\alpha-}, & (\text{if } \beta \in H_n) \end{cases},$$

where $C^{\alpha\pm}$ are two classes of equal order in alternating group A_n such that $C^\alpha = C^{\alpha+} \cup C^{\alpha-}$ and $H_n = \{C^\alpha \text{ of } S_n \mid n > 1, \text{ with all parts } \alpha_k \text{ of } \alpha \text{ different and odd}\}$.

Proposition 2.4: The conjugacy classes $C^{\alpha\pm}$ of A_n are ambivalent if $4 \mid (\alpha_i - 1)$ for each part α_i of α [30].

Definition 2.5: Suppose β is permutation in a symmetric group S_n on the set $\Omega = \{1, 2, \dots, n\}$ and the cycle type of β is $\alpha(\beta) = (\alpha_1, \alpha_2, \dots, \alpha_{c(\beta)})$, then β composite of pairwise disjoint cycles $\{\lambda_i\}_{i=1}^{c(\beta)}$ where $\lambda_i = (b_1^i, b_2^i, \dots, b_{\alpha_i}^i), 1 \leq i \leq c(\beta)$. For any k -cycle $\lambda = (b_1, b_2, \dots, b_k)$ in S_n , we define β -set as $\lambda^\beta = \{b_1, b_2, \dots, b_k\}$ and is called β -set of cycle λ . So the β -sets of $\{\lambda_i\}_{i=1}^{c(\beta)}$ are defined by $\{\lambda_i^\beta = \{b_1^i, b_2^i, \dots, b_{\alpha_i}^i\} \mid 1 \leq i \leq c(\beta)\}$ [31].

Remark 2.6: Suppose that λ_i^β and λ_j^β are β -sets in Ω , where $|\lambda_i| = \sigma$ and $|\lambda_j| = v$. Then, the known definitions will be written as follows.

Definition 2.7: We call λ_i^β and λ_j^β are disjoint β -sets in Ω , if and only if $\sum_{k=1}^{\sigma} b_k^i = \sum_{k=1}^v b_k^j$ and there exists $1 \leq d \leq \sigma$, for each $1 \leq r \leq v$ such that $b_d^i \neq b_r^j$ [31].

Definition 2.8: We call λ_i^β and λ_j^β are equal β -sets in Ω , if and only if for each $1 \leq d \leq \sigma$ there exists $1 \leq r \leq v$ such that $b_d^i = b_r^j$ [31].

Definition 2.9: We call λ_i^β is contained in λ_j^β , if and only if $\sum_{k=1}^{\alpha_i} b_k^i < \sum_{k=1}^{\alpha_j} b_k^j$ [31].

Definition 2.10: Let $\lambda^\beta = \{b_1, b_2, \dots, b_r\}$ and $\eta^\beta = \{a_1, a_2, \dots, a_v\}$ be two subsets of Ω [32]. Then, we call λ^β and η^β are similar β -sets in Ω , if and only if $\sum_{k=1}^r b_k = \sum_{k=1}^v a_k$ and one of them contains at least two points say $b_i, b_j \in \lambda^\beta$ such that $b_i \in \eta^\beta$ and $b_j \notin \eta^\beta$. Let $\lambda^\beta = \{b_1, b_2, \dots, b_r\}$ and $\eta^\beta = \{a_1, a_2, \dots, a_v\}$ be similar β -sets in Ω and $\Delta = \text{Max}\{\text{Max}\{\eta^\beta - \omega\}, \text{Max}\{\lambda^\beta - \omega\}\}$, where $\omega = \{b_1, b_2, \dots, b_r\} \cap \{a_1, a_2, \dots, a_v\}$. Then

$$\lambda^\beta \hat{c} \eta^\beta \text{ if } \Delta \in \eta^\beta, \quad \eta^\beta \hat{c} \lambda^\beta \text{ if } \Delta \in \lambda^\beta, \quad \eta^\beta \wedge \lambda^\beta =$$

$$\begin{pmatrix} \lambda^\beta, & \text{if } \Delta \in \eta^\beta \\ \eta^\beta, & \text{if } \Delta \in \lambda^\beta \end{pmatrix} \text{ and } \eta^\beta \vee \lambda^\beta = \begin{pmatrix} \eta^\beta, & \text{if } \Delta \in \eta^\beta \\ \lambda^\beta, & \text{if } \Delta \in \lambda^\beta \end{pmatrix}.$$

For any $\lambda^\beta = \{b_1, b_2, \dots, b_r\}$ and $\eta^\beta = \{a_1, a_2, \dots, a_v\}$ two subsets of Ω . Then,

$$\lambda^\beta \wedge \eta^\beta =$$

$$\begin{cases} \lambda^\beta, & \text{if } \left(\sum_{k=1}^r b_k < \sum_{k=1}^v a_k\right) \text{ Or } (\lambda^\beta \& \eta^\beta \text{ are similar and } \Delta \in \eta^\beta) \\ \eta^\beta, & \text{if } \left(\sum_{k=1}^r b_k > \sum_{k=1}^v a_k\right) \text{ Or } (\lambda^\beta \& \eta^\beta \text{ are similar and } \Delta \in \lambda^\beta) \\ \mu^\beta, & \text{if } \lambda^\beta = \eta^\beta = \mu^\beta \\ \phi, & \text{if } \lambda^\beta \& \eta^\beta \text{ are disjoint} \end{cases}$$

and

$$\lambda^\beta \wedge \eta^\beta =$$

$$\begin{cases} \lambda^\beta, & \text{if } \left(\sum_{k=1}^r b_k > \sum_{k=1}^v a_k\right) \text{ Or } (\lambda^\beta \& \eta^\beta \text{ are similar and } \Delta \in \lambda^\beta) \\ \eta^\beta, & \text{if } \left(\sum_{k=1}^r b_k < \sum_{k=1}^v a_k\right) \text{ Or } (\lambda^\beta \& \eta^\beta \text{ are similar and } \Delta \in \eta^\beta) \\ \mu^\beta, & \text{if } \lambda^\beta = \eta^\beta = \mu^\beta \\ \Omega, & \text{if } \lambda^\beta \& \eta^\beta \text{ are disjoint} \end{cases}$$

Definition 2.11: For any collection of not disjoint β -sets $\{\lambda_i^\beta = \{b_1^i, b_2^i, \dots, b_{\sigma_i}^i\} | i \in I\}$. We define the union (respectively, intersection) of $\{\lambda_i^\beta\}_{i \in I}$ by $\bigvee \lambda_i^\beta = \lambda_j^\beta$, where $\sum_{k=1}^{\sigma_j} b_k^j = \sup \{ \sum_{k=1}^{\sigma_i} b_k^i | i \in I \}$ and $\bigwedge \lambda_i^\beta = \lambda_j^\beta$, where $\sum_{k=1}^{\sigma_j} b_k^j = \inf \{ \sum_{k=1}^{\sigma_i} b_k^i | i \in I \}$ [31].

Definition 2.12: Let β be permutation in a symmetric group S_n , and β composite of pairwise disjoint cycles $\{\lambda_i\}_{i=1}^{c(\beta)}$, where $|\lambda_i| = \alpha_i$, $1 \leq i \leq c(\beta)$, then (Ω, t_n^β) permutation topological space (PTS), where $\Omega = \{1, 2, \dots, n\}$ and t_n^β is a collection of β -set of the family $\{\lambda_i\}_{i=1}^{c(\beta)}$ union Ω and empty set [31].

Definition 2.13: Let (Ω, τ_n^β) be a PTS. Then (Ω, τ_n^β) is called permutation single space (PSS) if and only if each proper open β -set is a singleton [32].

Definition 2.14: Let (Ω, τ_n^β) be a permutation topological space. Then (Ω, τ_n^β) is called permutation indiscrete space (PIS) if and only if each open β -set is trivial β -set [32].

Definition 2.15: Let U be an initial universe set and let E be a set of parameters [1]. A pair (F, A) is called a soft set (over X) where $A \subseteq E$ and F is a multivalued function $F: A \rightarrow P(X)$. In other words, the soft set is a parameterized family of subsets of the set X . Every set $F(e)$, $e \in E$, from this family may be considered as the set of e -elements of the soft set (F, A) , or as the set of e -approximate elements of the soft set. Clearly, a soft set is not a set. For two soft sets (F, A) and (G, B) over the common universe X , we say that (F, A) is a soft subset of (G, B) if $A \subseteq B$ and for all $e \in A$, $F(e)$ and $G(e)$ are identical approximations. We write $(F, A) \hat{\subseteq} (G, B)$. (F, A) is said to be a soft superset of (G, B) , if (G, B) is a soft subset of (F, A) . Two soft sets (F, A) and (G, B) over a common universe X are said to be soft equal if (F, A) is a soft subset of (G, B) and (G, B) is a soft subset of (F, A) . A soft set (F, A) over X is called a null soft set, denoted by $\Phi = (\phi, \phi)$, if for each $F(e) = \phi$, $\forall e \in A$. Similarly, it is called universal soft set, denoted by (X, E) , if for each $F(e) = X$, $\forall e \in A$. The collection of soft sets (F, A) over a universe X and the parameter set A is a family of soft sets denoted by $SS(X_A)$.

Definition 2.16: The union of two soft sets (F, A) and (G, B) over X is the soft set (H, C) , where $C = A \cup B$ and for all $e \in C$, $H(e) = F(e)$ if $e \in A - B$, $G(e)$ if $e \in B - A$, $F(e) \cup G(e)$ if $e \in A \cap B$ [33]. We write $(F, A) \cup (G, B) = (H, C)$. The intersection (H, C) of (F, A) and (G, B) over X , denoted $(F, A) \cap (G, B)$, is defined as $C = A \cap B$, and $H(e) = F(e) \cap G(e)$ for all $e \in C$ [21].

Definition 2.17: Let (F, A) be a soft set over X [2]. The complement of (F, A) with respect to the universal soft set (X, E) , denoted by $(F, A)^c$, is defined as (F^c, D) , where $D = E - \text{backslash}\{e \in A | F(e) = X\} = \{e \in A | F(e) = X\}^c$, and for all $e \in D$,

$$F^c(e) = \begin{cases} X - F(e), & \text{if } e \in A \\ X, & \text{Otherwise.} \end{cases}$$

Definition 2.18: Let τ be the collection of soft sets over X [2]. Then τ is called a soft topology on X if τ satisfies the following axioms:

- (i) Φ and (X, E) belong to τ .
- (ii) The union of any number of soft sets in τ belongs to τ .
- (iii) The intersection of any two soft sets in τ belongs to τ .

The triplet (X, E, τ) is called a soft topological space over X . The members of τ are called soft open sets in X and complements of them are called soft closed sets in X . Furthermore, (X, E, τ) is said to be a soft indiscrete space over X , if $\tau = \{\Phi, (X, E)\}$. Also, (X, E, τ) is said to be a soft discrete space over X , if τ is the collection of all soft sets which can be defined over X .

Some results on permutations 2.19: [29]

- (1) $\beta = (b_1, b_2, \dots, b_r)$ is even $\Leftrightarrow r$ is odd.
- (2) $\beta \in S_n$ is even $\Leftrightarrow n - c(\beta)$ is even,
- (3) $\beta = (1)$ (Identity) $\Leftrightarrow \beta = (b)$ for some $b \in \Omega$.

Remark 2.20: In this work, for any set $D = \{d_1, d_2, \dots, d_k\}$ of k distinct objects and for any cycle $B = (b_1, b_2, \dots, b_m)$, we will use the same symbol ($|B|$) to refer to the cardinality of set X and to refer to the length of the cycle B . Hence $|D| = k$ and $|B| = m$.

Definition 2.21: A d -algebra is a non-empty set X with a constant 0 and a binary operation $*$ satisfying the following axioms [18]:

- (i) $x * x = 0$
- (ii) $0 * x = 0$
- (iii) $x * y = 0$ and $y * x = 0$ imply that $y = x$ for all x, y in X .

Definition 2.22: A d -algebra $(X, *, 0)$ is said to be BCK algebra if X satisfies the following additional axioms [21]:

- (1) $((x * y) * (x * z)) * (z * y) = 0$,
- (2) $(x * (x * y)) * y = 0$, for all $x, y \in X$.

Definition 2.23: A d -algebra $(X, *, 0)$ is said to be ρ -algebra if X satisfies for all $y \neq x \in X - \{0\}$ imply that $x * y = y * x \neq 0$ [22].

Definition 2.24: Let $(X, *, 0)$ be a d -algebra [21]. Then X is called a d^* -algebra if it satisfies the identity $(x * y) * x = 0$, for all $x, y \in X$.

Definition 2.25: Let (X, E, Γ) be a soft topological space, where $X = \{s_1, s_2, \dots, s_k\}$, $E = \{e_1, e_2, \dots, e_n\}$

and $\Gamma = \{\Phi, (X, E), \{(F_i, E)\}_{i=1}^m\}$ [34]. Now, let $T_1 = \{F_i(e_1)\}_{i=1}^m$, $T_2 = \{F_i(e_2)\}_{i=1}^m$, $\dots$, $T_n = \{F_i(e_n)\}_{i=1}^m$. For each $1 \leq i \leq n$, let $T'_i = \{B \in T_i / B \neq \phi\}$. For each $(1 \leq i \leq n)$, let $\delta_i: X \rightarrow N$ be a map from X into natural numbers N defined by $\delta_i(s_j) = j + (i - 1)k$, for all $s_j \in X$ and $(1 \leq i \leq n)$ where $k = |X|$. Then $\sigma = \prod_{i=1}^n \sigma_i$ is called permutation in a symmetric group S_{nk} where for all $1 \leq i \leq n$, $\sigma_i = \prod_{L=1}^{|T'_i|} (\delta_i(s_{g_1}) \delta_i(s_{g_2}) \dots \delta_i(s_{g_{|\omega_L|}}))$ is permutation which is the product of $|T'_i|$ cyclic factors of the length $|\omega_L|$, where $\omega_L = \{s_{g_1}, s_{g_2}, \dots, s_{g_{|\omega_L|}}\} \in T'_i$ and $1 \leq L \leq |T'_i|$. Furthermore, $\sigma_i = (\delta_i(s_i))$ if $T'_i = \phi$. Then $(\Omega, t_h^\sigma)_\Gamma$ is called permutation topological space induced by soft topology Γ , where $\Omega = \{1, 2, \dots, h\}$, $h = nk$ and t_h^σ is a collection of σ -set of the family $\{\sigma_i\}_{i=1}^n$ together with Ω and the empty set. Also, if (X, E, Γ) is a soft indiscrete topological space. Then $(\Omega, t_h^\sigma)_\Gamma$ is called PIS induced by soft topology Γ , where $\sigma = (1, 2, 3, \dots, h)$. Finally, for any non-indiscrete soft topological space (X, E, Γ) , where $X = \{s_1, s_2, \dots, s_k\}$, $E = \{e_1, e_2, \dots, e_n\}$ and $\Gamma = \{\Phi, (X, E), \{(F_i, E)\}_{i=1}^m\}$ we can generate permutation topological space $(\Omega, t_h^\sigma)_\Gamma$ as follows:

- (1) Find $T_i = \{F_j(e_i)\}_{j=1}^m$, for all $1 \leq i \leq n$,
- (2) Find $T'_i = \{\omega \in T_i / \omega \neq \phi\}$, for all $1 \leq i \leq n$,
- (3) Find $\delta_i(s_j) = j + (i - 1)k$, for all $(1 \leq j \leq k)$ and $(1 \leq i \leq n)$,
- (4) Find σ_i for all $1 \leq i \leq n$, where $\sigma_i = \begin{cases} (\delta_i(s_i)), & \text{if } T'_i = \phi, \\ \prod_{L=1}^{|T'_i|} (\delta_i(s_{g_1}) \delta_i(s_{g_2}) \dots \delta_i(s_{g_{|\omega_L|}})), & \text{if } T'_i \neq \phi, \end{cases}$ where $\omega_L = \{s_{g_1}, s_{g_2}, \dots, s_{g_{|\omega_L|}}\} \in T'_i$, if O.W.,
- (5) Find $\sigma = \prod_{i=1}^n \sigma_i$,
- (6) Find the disjoint cycle factors including the 1-cycle of σ say $\lambda_1, \lambda_2, \dots, \lambda_{c(\sigma)}$,
- (7) Find the σ -sets of $\{\lambda_i\}_{i=1}^{c(\sigma)}$
- (8) Find Ω , where $\Omega = \{1, 2, \dots, h\}$ and $h = nk$,
- (9) Find t_h^σ , where $t_h^\sigma = \{\phi, \Omega, \lambda_1^\sigma, \lambda_2^\sigma, \dots, \lambda_{c(\sigma)}^\sigma\}$.
- (10) Then $(\Omega, t_h^\sigma)_\Gamma$ is PTS.

Remark 2.26: For all $1 \leq i \leq n$, let $T_i^* = \{\phi, X\} \cup T'_i$. Here we used normal union ($\cup$), normal intersection ($\cap$) and empty set (ϕ) then we have (X, T_i^*) is a topological space for each $(1 \leq i \leq n)$ [34].

- (1) We consider that $\delta_i: (X, T_i^*) \rightarrow (X_i, T_i^*)$ is isomorphic, where $X_i = \delta_i(X)$ and $T_i = \{Y | Y = \delta_i(Z); Z \in T_i^*\}$. In other words, for each $1 \leq t \leq mk$, we have $\delta_i^{-1}(t) = s_c$, where $c = t - k(i + 1)$.
- (2) For any $(1 \leq i \neq q \leq n)$ and $(1 \leq j \leq k)$, we have $\delta_i(s_j) \notin X_q$ (since $\delta_i(s_j) = j + (i - 1)k \neq j + (q - 1)k, \forall j = 1, 2, \dots, k$)
- (3) If $\delta_i(s_j) \notin \bigcup_{\psi \in T_i^* - \{X_i\}} \psi$, for some $(1 \leq i \leq n)$ and

($1 \leq j \leq k$). Then $\delta_i(s_j) \notin \bigcup_{\psi \in T_q - \{X_q\}} \psi$ for all
 ($1 \leq q \leq n$).

Definition 2.27: Let $(\Omega, t_n^\beta)_\Gamma$ be a permutation space induced by soft topology Γ , $\lambda^\beta \subset \Omega$ and $T_i^\beta = \lambda^\beta \wedge \lambda_i^\beta$, for each proper $\lambda_i^\beta \in t_n^\beta$, then $T_i^\beta =$

$$\begin{cases} \{b_1^i, b_2^i, \dots, b_{i_k}^i\}, & \text{if } \lambda^\beta \& \lambda_i^\beta \text{ are not disjoint} \\ \phi, & \text{if } \lambda^\beta \& \lambda_i^\beta \text{ are disjoint} \end{cases} \quad [34]$$

Let $\mathfrak{K} = \{T_i^\beta | T_i^\beta \text{ non-empty open } \beta\text{-set}\}$. For each $T_i^\beta \in \mathfrak{K}$, let $b_k^i = \text{Max}\{b_1^i, b_2^i, \dots, b_{i_k}^i\}$ and $m = \text{Max}\{b_k^i; T_i^\beta \in \mathfrak{K}\}$. Let $B = \bigcap_{T_i^\beta \in \mathfrak{K}} (\Omega' - T_i^\beta)$ where

$\Omega' = \{1, 2, \dots, m\}$. Here we used normal intersection ($\cap$) between pairwise sets to find the set B . For each $T_i^\beta \in \mathfrak{K}$, we have $T_i = (b_1^i, b_2^i, \dots, b_{i_k}^i)$ is i_k cycle in S_m . Then the disjoint cycles decomposition of new permutation in a symmetric group S_m induced by λ^β saying γ^{λ^β} where $\gamma^{\lambda^\beta} = \prod_{T_i^\beta \in \mathfrak{K}} \prod_{r=1}^t (b_r)$ and $\gamma^{\lambda^\beta} = \prod_{T_i^\beta \in \mathfrak{K}} T_i$

whenever $B = \phi$. Hence $(\Omega', t_m^{\gamma^{\lambda^\beta}})_\Gamma$ is called permutation subspace induced by soft topology Γ where $t_m^{\gamma^{\lambda^\beta}}$ is a family of all γ^{λ^β} -sets of disjoint cycles decomposition of γ^{λ^β} together with Ω' and the empty set.

3. An algorithm to generate permutation algebras from soft spaces

In this section, we will introduce an algorithm to generate permutation algebra by analysis soft topological space and this class of permutation algebra is called even (odd) permutation algebra if its permutation is even (odd). Moreover, some basic properties of permutation spaces are studied.

Steps of the work 3.1: Let (X, E, Γ) be a soft topological space, where $X = \{s_1, s_2, \dots, s_k\}$, $E = \{e_1, e_2, \dots, e_n\}$ and $\Gamma = \{\Phi, (X, E), \{(F_i, E)\}_{i=1}^m\}$. Now, let $T_1 = \{F_i(e_1)\}_{i=1}^m$, $T_2 = \{F_i(e_2)\}_{i=1}^m$, $\dots$, $T_n = \{F_i(e_n)\}_{i=1}^m$. For each $1 \leq i \leq n$, let $T_i' = \{B \in T_i / B \neq \phi\}$. For each ($1 \leq i \leq n$), let $\delta_i: X \rightarrow N$ be a map from X into natural numbers N defined by $\delta_i(s_j) = j + (i - 1)k$, for all $s_j \in X$ and ($1 \leq i \leq n$) where $k = |X|$. Then $\sigma = \prod_{i=1}^n \sigma_i$ is called permutation in a symmetric group S_{nk} where
 for all $1 \leq i \leq n$, $\sigma_i = \prod_{L=1}^{|T_i'|} (\delta_i(s_{g_1}) \delta_i(s_{g_2}) \dots \delta_i(s_{g_{|\omega_L|}}))$ is permutation which is the product of $|T_i'|$ cyclic factors of the length $|\omega_L|$, where $\omega_L = \{s_{g_1}, s_{g_2}, \dots, s_{g_{|\omega_L|}}\} \in T_i'$

and $1 \leq L \leq |T_i'|$. Furthermore, $\sigma_i = (\delta_i(s_i))$ if $T_i' = \phi$. Hence, by Definition 2.5, we consider that:
 $(\Omega, t_n^\sigma)_\Gamma$ is permutation topological space induced by soft topology Γ , where $\Omega = \{1, 2, \dots, h\}$, $h = nk$ and t_n^σ is a collection of σ -set of the family $\{\sigma_i\}_{i=1}^n$ together with Ω and the empty set. Now, we need to follow these steps:

- (1) Defend binary operation #: $t_n^\beta \times t_n^\beta \rightarrow t_n^\beta$ on permutation topology t_n^β by $\#(A, B) = A\#B$, $\forall(A, B) \in t_n^\beta \times t_n^\beta$.
- (2) Find #: $t_n^\beta \times t_n^\beta \rightarrow t_n^\beta$ which is holed as follows:
 (i) $A\#B = \phi$, (ii) $\phi\#B = \phi$, (iii) $A\#B = \phi$ and $B\#A = \phi$ imply that $A = B$ for all $A, B \in t_n^\beta$.
- (3) Then $(t_n^\beta, \#, \phi)_\Gamma$ is a permutation d -algebra induced by soft topology Γ .

Definitions 3.2:

- (1) Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation d -algebra induced by soft topology Γ . Then $(t_n^\beta, \#, \phi)_\Gamma$ is called permutation BCK-algebra induced by soft topology Γ , if t_n^β satisfying the following axioms: (i) $((B\#C)\#(B\#D))\#(D\#C) = \phi$, (ii) $(B\#(B\#C))\#C = \phi$, for all $B, C, D \in t_n^\beta$.
- (2) Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation d -algebra induced by soft topology Γ . Then $(t_n^\beta, \#, \phi)_\Gamma$ is called permutation d^* -algebra induced by soft topology Γ , if it satisfies the identity $(B\#C)\#B = \phi$, for all $B, C \in t_n^\beta$.
- (3) Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation d -algebra induced by soft topology Γ . Then $(t_n^\beta, \#, \phi)_\Gamma$ is called permutation ρ -algebra induced by soft topology Γ , if it satisfies the identity $(B\#C) = (C\#B) \neq \phi$, for all $B \neq C \in t_n^\beta - \{\phi\}$.
- (4) Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation d -algebra (ρ -algebra, BCK-algebra, d^* -algebra) induced by soft topology Γ and $H = \{h_i\}_{i \in I} \subseteq t_n^\beta$ be a collection of some random subsets of t_n^β . Then H is called permutation d -subalgebra (resp. ρ -subalgebra, BCK-subalgebra, d^* -subalgebra) induced by soft topology Γ , if $h_m \# h_k \in H$, for any $h_m, h_k \in H$.

Permutation subalgebras induced by soft topology Γ 3.3:

Let $(\Omega, t_n^\beta)_\Gamma$ be a permutation space induced by soft topology Γ and $\lambda^\beta \subset \Omega$. By Definition 2.7, we consider that $(\Omega', t_m^{\gamma^{\lambda^\beta}})_\Gamma$ is called permutation subspace induced by soft topology Γ where $t_m^{\gamma^{\lambda^\beta}}$ is a family of all γ^{λ^β} -sets of disjoint cycles decomposition of γ^{λ^β} together with Ω' and the empty set. Also, $(t_m^{\gamma^{\lambda^\beta}}, \#, \phi)_\Gamma$ is called permutation $d/d^*/\text{BCK}/\rho$ -subalgebra of $(t_n^\beta, \#, \phi)_\Gamma$ induced by soft topology Γ if $(t_n^\beta, \#, \phi)_\Gamma$ is permutation $d/d^*/\text{BCK}/\rho$ -algebra and $t_m^{\gamma^{\lambda^\beta}} \subseteq t_n^\beta$ with $\#(A, B) \in t_m^{\gamma^{\lambda^\beta}}$, $\forall(A, B) \in t_m^{\gamma^{\lambda^\beta}} \times t_m^{\gamma^{\lambda^\beta}}$.

Remarks 3.4: If there are two permutation subspaces $(\Omega', t_m^{\gamma^{\lambda\beta}})_\Gamma$ and $(\Omega'', t_k^{\gamma^{\mu\beta}})_\Gamma$ of $(\Omega, t_n^\beta)_\Gamma$, and $(t_m^{\lambda\beta}, \#, \phi)_\Gamma$ is permutation $d/d^*/\text{BCK}/\rho$ -subalgebra of $(t_n^\beta, \#, \phi)_\Gamma$ induced by soft topology Γ , then $(t_k^{\gamma^{\mu\beta}}, \#, \phi)_\Gamma$ need not be permutation $d/d^*/\text{BCK}/\rho$ -subalgebra of $(t_n^\beta, \#, \phi)_\Gamma$ too.

Example 3.5: Let the set of houses under consideration be $X = \{a_1, a_2, a_3\}$. Let $E = \{\text{big } (e_1); \text{ with pool swimming } (e_2); \text{ with garden } (e_3); \text{ old } (e_4)\}$ be the set of parameters framed to buy the best house. Suppose that the soft set (F, A) describing the Mr X opinion to choose the best house was defined by

$$A = \{e_1, e_3, e_4\},$$

$$F(e_1) = \{a_1, a_3\}, F(e_3) = \{a_2\}, F(e_4) = X.$$

In addition, we assume that the "best house" in the opinion of his friend, say Mr Y , is described by the soft set (G, B) , where

$$B = \{e_1, e_4\},$$

$$G(e_1) = \{a_3\}, G(e_4) = \{a_2, a_3\}.$$

Consider that:

$\Gamma = \{\Phi, (U, E), (F, A), (G, B)\}$ is a soft topology. Find permutation space $(\Omega, t_n^\sigma)_\Gamma$ induced by soft topology Γ . Also, find $(\Omega'_1, t_m^{\gamma^{\lambda^\sigma}})_\Gamma$ and $(\Omega'_2, t_m^{\gamma^{\mu^\sigma}})_\Gamma$ where $\lambda^\sigma = \{1, 4\}$ and $\mu^\sigma = \{10\}$.

Solution: We consider that

$$\begin{aligned} T_1 &= \{F(e_1), G(e_1)\}, T_2 = \{F(e_2), G(e_2)\}, T_3 = \{F(e_3), G(e_3)\}, T_4 = \{F(e_4), G(e_4)\} \Rightarrow \\ T_1 &= \{\{a_1, a_3\}, \{a_3\}\}, T_2 = \{\phi, \phi\}, T_3 = \{\{a_2\}, \phi\}, T_4 = \{X, \{a_2, a_3\}\} \Rightarrow \\ T'_1 &= \{\{a_1, a_3\}, \{a_3\}\}, T'_2 = \phi, T'_3 = \{a_2\}, T'_4 = \{X, \{a_2, a_3\}\} \Rightarrow \\ T_1^* &= \{\phi, X, \{a_3\}, \{a_1, a_3\}\}, \\ T_2^* &= \{\phi, X\}, T_3^* = \{\phi, X, \{a_2\}\}, T_4^* = \{\phi, X, \{a_2, a_3\}\}. \end{aligned}$$

Hence we have $(X, \bar{T}_i)$ is a topological space for each

$(1 \leq i \leq 4)$. Now, we consider that $(X_i, \bar{T}_i^*)$ is a topological space for each $(1 \leq i \leq n)$. where

$$\begin{aligned} (X_1, \bar{T}_1^*) &= (\{1, 2, 3\}, \{\phi, \{1, 2, 3\}, \{3\}, \{1, 3\}\}), (X_2, \bar{T}_2^*) \\ &= (\{4, 5, 6\}, \{\phi, \{4, 5, 6\}\}), \end{aligned}$$

$$(X_3, \bar{T}_3^*) = (\{7, 8, 9\}, \{\phi, \{7, 8, 9\}, \{8\}\}),$$

$$(X_4, \bar{T}_4^*) = (\{10, 11, 12\}, \{\phi, \{10, 11, 12\}, \{11, 12\}\}).$$

Moreover, for all $1 \leq i \leq n$, $\sigma_i =$

$\prod_{l=1}^{|\bar{T}_i^*|} (\delta_i(a_{g_1})\delta_i(a_{g_2}) \dots \delta_i(a_{g_{|\omega_L|}}))$ is permutation which is the product of $|\bar{T}_i^*|$ cyclic factors of the length $|\omega_L|$,

where $\omega_L \in \bar{T}_i^*$ and $1 \leq L \leq |\bar{T}_i^*|$. Hence we have

$$\sigma_1 = (\delta_1(a_2), \delta_1(a_3))(\delta_1(a_3)) = (1 \ 3)(3),$$

$$\sigma_2 = (\delta_2(a_2)) = (5),$$

$$\sigma_3 = (\delta_3(a_2)) = (8),$$

$$\begin{aligned} \sigma_4 &= (\delta_4(a_2)\delta_4(a_3))(\delta_4(a_1)\delta_4(a_2)\delta_4(a_3)) \\ &= (11 \ 12)(10 \ 11 \ 12). \end{aligned}$$

Then $\sigma = \prod_{i=1}^4 \sigma_i = (1 \ 3)(3)(5)(8)(11 \ 12)(10 \ 11 \ 12) = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\ 3 & 2 & 1 & 4 & 5 & 6 & 7 & 8 & 9 & 12 & 11 & 10 \end{pmatrix}$ is a permutation in a symmetric group S_{12} . For any permutation can be decomposed essentially uniquely into the product of disjoint cycles. So we can write $\sigma \in S_n$ as $\lambda_1, \lambda_2, \dots, \lambda_{c(\sigma)}$. With λ_i disjoint cycles of length $|\lambda_i|$ and $c(\sigma)$ is the number of disjoint cycle factors including the 1-cycle of σ . Hence $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\ 3 & 2 & 1 & 4 & 5 & 6 & 7 & 8 & 9 & 12 & 11 & 10 \end{pmatrix} = (1 \ 3)(2)(4)(5)(6)(7)(8)(9)(11)(10 \ 12)$.

Therefore, (Ω, t_n^σ) is a permutation space induced by soft topology Γ , where $t_n^\sigma = t_{12}^\sigma = \{\Omega, \phi, \{1, 3\}, \{2\}, \{4\}, \{5\}, \{6\}, \{7\}, \{8\}, \{9\}, \{11\}, \{10, 12\}\}$ and $\Omega = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12\}$. Now to find the permutation subspace for $\lambda^\sigma = \{1, 4\}$, we consider that

$$\begin{aligned} T_1^\sigma &= \{1, 3\}, T_2^\sigma = \{2\}, T_3^\sigma = \{4\}, T_4^\sigma = \phi, T_5^\sigma = \{1, 4\}, T_6^\sigma = \{1, 4\}, T_7^\sigma = \{1, 4\}, T_8^\sigma = \{1, 4\}, T_9^\sigma = \{1, 4\}, T_{10}^\sigma = \{1, 4\} \Rightarrow \mathfrak{K} = \\ &= \{\{1, 3\}, \{2\}, \{4\}, \{1, 4\}\} \Rightarrow \\ &= \text{Max}\{\text{Max}\{1, 3\}, \text{Max}\{2\}, \text{Max}\{4\}, \text{Max}\{1, 4\}\} = \\ &= \text{Max}\{3, 2, 4\} = 4 = m \Rightarrow \Omega'_1 = \{1, 2, 3, 4\}, \end{aligned}$$

$$B = \bigcap_{T_i^\sigma \in \mathfrak{K}} (\Omega'_1 - T_i^\sigma) = \phi. \quad \text{Then} \quad \gamma^{\lambda^\sigma} =$$

$$(1 \ 3)(2)(4)(1 \ 4) = \begin{pmatrix} 1 & 2 & 3 & 4 \\ 4 & 2 & 1 & 3 \end{pmatrix} = (1 \ 4 \ 3)(2) \text{ is a}$$

permutation in a symmetric group S_4 induced by $\lambda^\sigma = \{1, 4\}$ and $(\Omega'_1, t_4^{\gamma^{\lambda^\sigma}})$ is a permutation subspace induced by soft topology Γ , where $t_m^{\gamma^{\lambda^\sigma}} = t_4^{\gamma^{\lambda^\sigma}} = \{\Omega'_1, \phi, \{2\}, \{1, 3, 4\}\}$. Now to find the permutation subspace for $\mu^\sigma = \{10\}$, we consider that:

$$\begin{aligned} T_1^\sigma &= \{1, 3\}, T_2^\sigma = \{2\}, T_3^\sigma = \{4\}, T_4^\sigma = \{5\}, T_5^\sigma = \{6\}, \\ T_6^\sigma &= \{7\}, T_7^\sigma = \{8\}, T_8^\sigma = \{9\}, T_9^\sigma = \{10\}, \\ T_{10}^\sigma &= \{10\} \Rightarrow \\ \mathfrak{K} &= \{\{1, 3\}, \{2\}, \{4\}, \{5\}, \{6\}, \{7\}, \{8\}, \{9\}, \{10\}\} \Rightarrow \\ m &= 10 \Rightarrow \Omega'_2 = \{1, 2, \dots, 10\} \sum_{T_i^\sigma \in \mathfrak{K}} |T_i| = s = 10 \quad \text{and} \end{aligned}$$

$$B = \bigcap_{T_i^\sigma \in \mathfrak{K}} (\Omega'_2 - T_i^\sigma) = \phi. \text{ Therefore, we have } \gamma^{\mu^\sigma} =$$

$(1 \ 3)(2)(4)(5)(6)(7)(8)(9)(10)$ is a permutation in a symmetric group S_{10} induced by $\mu^\sigma = \{10\}$ and $(\Omega'_2, t_{10}^{\gamma^{\mu^\sigma}})_\Gamma$ is a permutation subspace induced by soft topology Γ , where $t_m^{\gamma^{\mu^\sigma}} = t_{10}^{\gamma^{\mu^\sigma}} = \{\Omega'_2, \phi, \{1, 3\}, \{2\}, \{4\}, \{5\}, \{6\}, \{7\}, \{8\}, \{9\}, \{10\}\}$. Now,

define $\#: t_{12}^\sigma \times t_{12}^\sigma \rightarrow t_{12}^\sigma$ by

$$\#(A, B) = A\#B = \begin{cases} \phi, & \text{if } A \cap B = A, \\ A, & \text{if } A \cap B \neq A \text{ \& } A \cap B = \phi, \\ B, & \text{if } A \cap B \neq A \text{ \& } A \cap B \neq \phi. \end{cases}$$

$\forall A, B \in t_{12}^\sigma$. Then $(t_{12}^\sigma, \#, \phi)_\Gamma$ is permutation d -algebra, since $\#$ satisfies conditions for d -algebra. Also, $(t_{10}^{\gamma^{\sigma\sigma}}, \#, \phi)_\Gamma$ is permutation d -subalgebra of $(t_{12}^\sigma, \#, \phi)_\Gamma$. But $(t_4^{\gamma^{\lambda\sigma}}, \#, \phi)_\Gamma$ is not permutation d -subalgebra of $(t_{12}^\sigma, \#, \phi)_\Gamma$ since $t_4^{\gamma^{\lambda\sigma}} \not\subseteq t_{12}^\sigma$.

4. Some notions of permutation algebras

Definition 4.1: Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation $d/\text{BCK}/d^*/\rho$ -algebra induced by soft topology Γ . Then $(t_n^\beta, \#, \phi)_\Gamma$ is called even (odd) permutation $d/\text{BCK}/d^*/\rho$ -algebra if its permutation β is even (odd) in S_n .

Example 4.2: Let $(t_6^\beta, \#, \phi)_\Gamma$ be a permutation d -algebra induced by soft topology Γ , where $\beta = (1\ 3\ 5\ 6)(2\ 4)$ in Example 3.1.7. Then $(t_6^\beta, \#, \phi)_\Gamma$ is an even permutation d -algebra since $\beta \in S_6$ is an even.

Definition 4.3: Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation $d/\text{BCK}/d^*/\rho$ -algebra induced by soft topology Γ . Then $(t_n^\beta, \#, \phi)_\Gamma$ is called splittable permutation $d/\text{BCK}/d^*/\rho$ -algebra if its permutation β satisfies $\beta \in H_n$.

Example 4.4: Let $(\Omega, t_9^\beta)_\Gamma$ be a permutation topological space induced by soft topology Γ , where $t_9^\beta = \{\Omega, \phi, \{1, 4, 9\}, \{6\}, \{2, 3, 5, 7, 8\}\}$ and $\Omega = \{1, 2, \dots, 9\}$, let $\#: t_9^\beta \times t_9^\beta \rightarrow t_9^\beta$ be a binary operation defined in the following table:

#	ϕ	$\{1, 4, 9\}$	$\{6\}$	$\{2, 3, 5, 7, 8\}$	Ω
ϕ	ϕ	ϕ	ϕ	ϕ	ϕ
$\{1, 4, 9\}$	$\{1, 4, 9\}$	ϕ	Ω	$\{2, 3, 5, 7, 8\}$	Ω
$\{6\}$	$\{6\}$	Ω	ϕ	$\{2, 3, 5, 7, 8\}$	Ω
$\{2, 3, 5, 7, 8\}$	$\{2, 3, 5, 7, 8\}$	$\{2, 3, 5, 7, 8\}$	$\{2, 3, 5, 7, 8\}$	ϕ	Ω
Ω	Ω	Ω	Ω	Ω	ϕ

Then $(t_9^\beta, \#, \phi)_\Gamma$ is splittable permutation d/ρ -algebra since $\beta = (1\ 4\ 9)(6)(2\ 3\ 5\ 7\ 8) \in H_9$.

Remark 4.5: It is clearly that every even (odd) permutation $\text{BCK}/d^*/\rho$ -algebra is even (odd) permutation d -algebra, but the converse need not be true, see Example 3.5 $(t_{12}^\sigma, \#, \phi)_\Gamma$ is an even permutation d -algebra but is not even permutation ρ -algebra.

Definition 4.6: Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation $d/\text{BCK}/d^*/\rho$ -algebra induced by soft topology Γ . Then $(t_n^\beta, \#, \phi)_\Gamma$ is called ambivalent permutation space if $(t_n^\beta, \#, \phi)_\Gamma$ is splittable permutation $d/\text{BCK}/d^*/\rho$ -algebra and for each part α_i of $\alpha(\beta)$ satisfies $4|(\alpha_i - 1)$.

Example 4.7: Let $(\Omega, t_{66}^\beta)_\Gamma$ be a permutation topological space induced by soft topology Γ , where $t_{66}^\beta = \{\Omega, \phi, a, b, c, d, e, f\}$, $a = \{1\}$, $b = \{2, 3, \dots, 6\}$, $c = \{7, 8, \dots, 15\}$, $d = \{16, 17, \dots, 28\}$, $e = \{29, 30, \dots, 45\}$, $f = \{46, 47, \dots, 66\}$ and $\Omega = \{1, 2, \dots, 66\}$. Let $\#: t_{66}^\beta \times t_{66}^\beta \rightarrow t_{66}^\beta$ be a binary operation defined in the following table:

#	ϕ	a	b	c	d	e	f	Ω
ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ	ϕ
a	a	ϕ	a	a	ϕ	ϕ	a	ϕ
b	b	b	ϕ	b	ϕ	b	ϕ	ϕ
c	c	c	c	ϕ	c	ϕ	ϕ	ϕ
d	d	b	a	d	ϕ	b	a	ϕ
e	e	c	e	a	c	ϕ	a	ϕ
f	f	f	c	b	c	b	ϕ	ϕ
Ω	Ω	f	e	d	c	b	a	ϕ

Then $(t_{66}^\beta, \#, \phi)_\Gamma$ is an ambivalent permutation $d/\text{BCK}/d^*$ -algebra induced by soft topology Γ .

The maps induced by soft topologies 4.8: Suppose that (X, E, τ_1) , (X, E, τ_2) and (X, E, τ_3) are three soft topological spaces over the common universe X the parameter set E with their permutations β, μ and δ in a symmetric group S_n , and let $\delta: (\Omega, t_n^\beta)_{\tau_1} \rightarrow (\Omega, t_n^\mu)_{\tau_2}$ be a map, where for each β -set $\lambda^\beta = \{b_1, b_2, \dots, b_k\}$, the image of λ^β under δ is said to be μ -set and defined by the rule $\delta(\lambda^\beta) = \{\delta(b_1), \delta(b_2), \dots, \delta(b_k)\}$. In another side, let $\eta^\mu = \{a_1, a_2, \dots, a_r\}$ be μ -set, the inverse image of η^μ under δ is called β -set and defined by the rule $\delta^{-1}(\eta^\mu) = \{\delta^{-1}(a_1), \delta^{-1}(a_2), \dots, \delta^{-1}(a_r)\}$. Then δ is called a permutation map induced by soft topology τ_3 .

Definition 4.9: Suppose that (X, E, τ_1) , (X, E, τ_2) and (X, E, τ_3) are three soft topological spaces over the common universe X the parameter set E with their permutations β, μ and δ in a symmetric group S_n . Then $\delta: (\Omega, t_n^\beta)_{\tau_1} \rightarrow (\Omega, t_n^\mu)_{\tau_2}$ is called a permutation continuous induced by soft topology τ_3 , if $\delta^{-1}(\lambda^\mu) \in t_n^\beta$ under δ^{-1} of any open μ -set in t_n^μ is an open β -set in t_n^β whenever $\lambda^\mu \in t_n^\mu$.

Theorem 4.10: Let $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ be a soft topological space. If for any pair $\omega_{i_1} \neq \omega_{i_2} \in T'_i (1 \leq i \leq n)$ such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in \bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n)$ and

$(1 \leq j \leq k)$. Then $c(\beta) = \sum_{i=1}^n |T'_i|$, where $(\Omega, t_{nk}^\beta)_\Gamma$ is a permutation space induced by soft topology Γ .

Proof: Let $\omega_{i_1} = \{x_{g_1}, x_{g_2}, \dots, x_{g_{\omega_{i_1}}}\}$, $\omega_{i_2} = \{x_{h_1}, x_{h_2}, \dots, x_{h_{\omega_{i_2}}}\} \in T'_i, (1 \leq i \leq n)$ and $\bar{\omega}_{ij} = |\omega_{ij}|, j = 1, 2$. Since any pair $\omega_{i_1} \neq \omega_{i_2} \in T'_i (1 \leq i \leq n)$ such that $\omega_{i_1} \cap \omega_{i_2} = \phi$. Then $(\delta_i(x_{g_1})\delta_i(x_{g_2})\dots\delta_i(x_{g_{\omega_{i_1}}}))$ and $(\delta_i(x_{h_1})\delta_i(x_{h_2})\dots\delta_i(x_{h_{\omega_{i_2}}}))$ are disjoint cycles in a symmetric group S_{nk} (since $\delta_i(x_{g_r}) \neq \delta_i(x_{h_r})$, for any $x_{g_r} \neq x_{h_r} \in X$). Also, for any $\omega_j = \{x_{g_1}, x_{g_2}, \dots, x_{g_{\omega_j}}\} \in T'_i$ and

$\omega_l = \{x_{h_1}, x_{h_2}, \dots, x_{h_{|\omega_l|}}\} \in T'_l$, ($1 \leq l \leq n$), we consider that $(\delta_i(x_{g_1})\delta_i(x_{g_2})\dots\delta_i(x_{g_{|\omega_l|}}))$ and $(\delta_l(x_{h_1})\delta_l(x_{h_2})\dots\delta_l(x_{h_{|\omega_l|}}))$ are disjoint cycles in a symmetric group S_{nk} (since $\delta_i(x_j) \neq \delta_l(x_f)$, for any $1 \leq i \neq l \leq n$ and $x_j, x_f \in X$). But $\beta = \prod_{i=1}^n (\prod_{j=1}^{|\omega_i|} (\delta_i(x_{g_1})\delta_i(x_{g_2})\dots\delta_i(x_{g_{|\omega_i|}}))) \in S_{nk}$ is a permutation for the permutation space $(\Omega, t_{nk}^\beta)_\Gamma$. Therefore, we consider that $\sum_{i=1}^n |\omega_i|$ is the number of disjoint cycle factors of $\prod_{i=1}^n (\prod_{j=1}^{|\omega_i|} (\delta_i(x_{g_1})\delta_i(x_{g_2})\dots\delta_i(x_{g_{|\omega_i|}})))$. Furthermore, $c(\beta)$ is the number of disjoint cycle factors including the 1-cycle of β . Hence $c(\beta) \geq \sum_{i=1}^n |\omega_i|$ in general. That means either $c(\beta) = \sum_{i=1}^n |\omega_i|$ or $c(\beta) > \sum_{i=1}^n |\omega_i|$. If $c(\beta) > \sum_{i=1}^n |\omega_i|$, then there is at least 1-cycle say $(\delta_i(x_j))$ for some $(x_j \in X, 1 \leq i \leq n)$ with $\delta_i(x_j) \notin \bigcup_{\psi \in T'_i - \{X_i\}} \psi$ and this contradiction with our hypothesis. Hence $c(\beta) = \sum_{i=1}^n |\omega_i|$.

Theorem 4.11: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and for any pair $\omega_{i_1} \neq \omega_{i_2} \in T'_i$ ($1 \leq i \leq n$) such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in$

$\bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n)$ and $(1 \leq j \leq k)$. Then $(t_{nk}^\beta, \#, \phi)_\Gamma$ is an even permutation $d/BCK/d^*/\rho$ -algebra, if $2|(nk - \sum_{i=1}^n |\omega_i|)$.

Proof: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and for any pair $d/BCK/d^*/\rho$ such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in$

$\bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n)$ and $(1 \leq j \leq k)$. Then

by Theorem 4.10), we consider that $(\Omega, t_{nk}^\beta)_\Gamma$ is a permutation space induced by soft topology Γ and its permutation β in a symmetric group S_{nk} satisfies $c(\beta) = \sum_{i=1}^n |\omega_i|$. However, $2|(nk - \sum_{i=1}^n |\omega_i|)$ and hence $nk - c(\beta)$ is even. This implies that β is even permutation in a symmetric group S_{nk} . Then $(t_{nk}^\beta, \#, \phi)_\Gamma$ is an even permutation $d/BCK/d^*/\rho$ -algebra.

Lemma 4.12: Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft topological space (X, E, Γ) . Then $(t_n^\beta, \#, \phi)_\Gamma$ is odd permutation $d/BCK/d^*/\rho$ -algebra, if (X, E, Γ) is a soft indiscrete topological space and $2|n$.

Proof: Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft indiscrete topological space (X, E, Γ) and $2|n$. Hence $\beta = (1, 2, 3, \dots, n)$ (since (X, E, Γ) is soft indiscrete space), thus $c(\beta) = 1$. Also, since $2|n$, Then there is a positive integer

number q such that $n = 2q$ and hence $n - c(\beta) = (\text{even}) - (\text{odd}) = (\text{odd})$. Hence β is odd permutation in S_n . Then $(t_n^\beta, \#, \phi)_\Gamma$ is odd permutation space.

Lemma 4.13: Let $(t_n^\beta, \#, \phi)_\Gamma$ be a permutation ρ -algebra and $H \subseteq t_n^\beta$. Then H is permutation d -subalgebra induced by soft topology Γ , if H is permutation ρ -subalgebra induced by soft topology Γ .

Proof: Suppose that $(t_n^\beta, \#, \phi)_\Gamma$ is permutation ρ -algebra and H is permutation ρ -subalgebra induced by soft topology Γ . Then we consider that $(t_n^\beta, \#, \phi)_\Gamma$ is permutation d -algebra induced by soft topology Γ . Also, H satisfies $h_1 \# h_2 \in H$ whenever $h_1 \in H$ and $h_2 \in H$. Hence H is permutation d -subalgebra of d -algebra induced by soft topology Γ .

Lemma 4.14: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$. Then $(t_{nk}^\beta, \#, \phi)_\Gamma$ is an even permutation $d/BCK/d^*/\rho$ -algebra, if $|\omega_i| = 1, \forall \omega_i \in T'_i$, where $(1 \leq i \leq n)$.

Proof: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and $|\omega_i| = 1, \forall \omega_i \in T'_i$, where $(1 \leq i \leq n)$. This implies that $\omega_i = \{x_g\}$ for some $x_g \in X$. Therefore $\beta = \prod_{i=1}^n (\prod_{j=1}^{|\omega_i|} (\delta_i(x_{g_j})))$ for some $x_{g_j} \in X$. Then $(\Omega, t_n^\beta)_\Gamma$ is (PSS) (since each proper open β -set is a singleton). Thus, β composite of pairwise disjoint cycles $\{\lambda_i\}_{i=1}^{c(\beta)}$ where $\lambda_i = (\delta_i(x_{g_j}))$, for some $x_{g_j} \in X$ and $1 \leq i \leq c(\beta)$ (since each proper open β -set is a singleton). However, $\beta = \prod_{i=1}^n (\prod_{j=1}^{|\omega_i|} (\delta_i(x_{g_j}))) = e \in S_{nk}$. But e is an identity element in S_{nk} . Thus $\beta = e = (1)(2)(3)\dots(nk)$ and hence $c(\beta) = nk$. This implies $nk - c(\beta) = 0$ (even). Hence $(t_{nk}^\beta, \#, \phi)_\Gamma$ is an even permutation $d/BCK/d^*/\rho$ -algebra.

Theorem 4.15: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/BCK/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and for any pair $\omega_{i_1} \neq \omega_{i_2} \in T'_i$ ($1 \leq i \leq n$) such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in$

$\bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n)$ and $(1 \leq j \leq k)$. Then $(t_{nk}^\beta, \#, \phi)_\Gamma$ is a splittable permutation $d/BCK/d^*/\rho$ -algebra, if the following are hold.

- (1) $2(|\omega_i| - 1), \forall \omega_i \in T'_i$ ($1 \leq i \leq n$),
- (2) If $\omega_i \neq \omega_j$, then $|\omega_i| \neq |\omega_j|$, where $\omega_i \in T'_i$ and $\omega_j \in T'_j$ ($1 \leq j, i \leq n$).

Proof: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/\text{BCK}/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and for any pair $\omega_{i_1} \neq \omega_{i_2} \in T'_i (1 \leq i \leq n)$ such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in$

$\bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n, 1 \leq j \leq k)$ with the following are hold.

- (1) $2(|\omega_i| - 1), \forall \omega_i \in T'_i (1 \leq i \leq n)$,
- (2) If $\omega_i \neq \omega_j$, then $|\omega_i| \neq |\omega_j|$, where $\omega_i \in T'_i$ and $\omega_j \in T'_j (1 \leq j, i \leq n)$.

Then by Theorem 4.10, we consider that $(\Omega, t_{nk}^\beta)_\Gamma$ is a permutation space induced by soft topology Γ and its permutation β in a symmetric group S_{nk} satisfies $c(\beta) = \sum_{i=1}^n |T'_i|$. Moreover, $\beta = \prod_{i=1}^n \sigma_i$ where for all $1 \leq i \leq n, \sigma_i =$

$\prod_{L=1}^{|T'_i|} \sigma_{i_L} = \prod_{L=1}^{|T'_i|} (\delta_i(x_{g_1}) \delta_i(x_{g_2}) \dots \delta_i(x_{g_{|\omega_{i_L}|}}))$ is permutation which is the product of $|T'_i|$ cyclic factors of the length $|\omega_{i_L}|$, where $\omega_{i_L} \in T'_i$ and $1 \leq L \leq |T'_i|$. For any permutation $\beta \in S_n$ can be decomposed essentially uniquely into the product of disjoint cycles. Thus, we can write β as $\lambda_1, \lambda_2, \dots, \lambda_{c(\beta)}$. With λ_i disjoint cycles of length $|\lambda_i| = \alpha_i$ and $c(\beta)$ is the number of disjoint cycle factors including the 1-cycle of β . Then $\alpha = \alpha(\beta) = (\alpha_1, \alpha_2, \dots, \alpha_{c(\beta)})$ is the cycle type of β .

Since $\beta = \prod_{i=1}^n \prod_{L=1}^{|T'_i|} \sigma_{i_L}$ and $c(\beta) = \sum_{i=1}^n |T'_i|$. Then for any λ_i there exists σ_{i_L} satisfies $\lambda_i = \sigma_{i_L}$, where $(1 \leq i \leq n)$. The length of any cycle $\sigma_{i_L} = (\delta_i(x_{g_1}) \delta_i(x_{g_2}) \dots \delta_i(x_{g_{|\omega_{i_L}|}}))$ is $|\omega_{i_L}|$ and this implies that $(\alpha_1, \alpha_2, \dots, \alpha_{c(\beta)}) = (|\omega_{1_1}|, |\omega_{1_2}|, \dots, |\omega_{1_{|T'_1|}}|, |\omega_{2_1}|,$

$|\omega_{2_2}|, \dots, |\omega_{2_{|T'_2|}}|, \dots, |\omega_{n_1}|, |\omega_{n_2}|, \dots, |\omega_{n_{|T'_n|}}|)$ Now, if $|\omega_{i_L}|$ is even number for some $(1 \leq i \leq n)$ and $1 \leq L \leq |T'_i|$, thus $(|\omega_{i_L}| - 1)$ is odd and this contradiction with (1) of our hypothesis which states that $2(|\omega_i| - 1), \forall \omega_i \in T'_i (1 \leq i \leq n)$. Then $|\omega_{i_L}|$ are odd numbers for all $(1 \leq i \leq n)$ and $(1 \leq L \leq |T'_i|)$. Also, for any $(i \neq j)$ or $(g \neq h)$, we have $\omega_{i_g} \neq \omega_{j_h}$ where $(1 \leq i, j \leq n), (1 \leq g \leq |T'_i|)$ and $(1 \leq h \leq |T'_j|)$. Then $\{\omega_{i_L} | 1 \leq i \leq n, 1 \leq L \leq |T'_i|\}$ are different sets and by (2) of our hypothesis we consider that $\{|\omega_{i_L}| | 1 \leq i \leq n, 1 \leq L \leq |T'_i|\}$ are different too. Therefore $\beta \in H_n$ and hence $(t_{nk}^\beta, \#, \phi)_\Gamma$ is a splittable permutation $d/\text{BCK}/d^*/\rho$ -algebra.

Theorem 4.16: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/\text{BCK}/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and for any pair $\omega_{i_1} \neq \omega_{i_2} \in$

$T'_i (1 \leq i \leq n)$ such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in$

$\bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n)$ and $(1 \leq j \leq k)$. Then $(t_{nk}^\beta, \#, \phi)_\Gamma$ is an ambivalent permutation $d/\text{BCK}/d^*/\rho$ -algebra, if the following are hold.

- (1) $2(|\omega_i| - 1), \forall \omega_i \in T'_i (1 \leq i \leq n)$,
- (2) If $\omega_i \neq \omega_j$, then $|\omega_i| \neq |\omega_j|$, where $\omega_i \in T'_i$ and $\omega_j \in T'_j (1 \leq j, i \leq n)$,
- (3) If $4(|\omega_i| - 1), \forall \omega_i \in T'_i (1 \leq i \leq n)$.

Proof: Let $(t_{nk}^\beta, \#, \phi)_\Gamma$ be a permutation $d/\text{BCK}/d^*/\rho$ -algebra induced by soft topological space $(X = \{x_j\}_{j=1}^k, E = \{e_r\}_{r=1}^n, \Gamma)$ and for any pair $\omega_{i_1} \neq \omega_{i_2} \in T'_i (1 \leq i \leq n)$ such that $\omega_{i_1} \cap \omega_{i_2} = \phi$ and $\delta_i(x_j) \in \bigcup_{\psi \in T'_i - \{X_i\}} \psi$, for any $(1 \leq i \leq n, 1 \leq j \leq k)$ with the following are hold.

- (1) $2(|\omega_i| - 1), \forall \omega_i \in T'_i (1 \leq i \leq n)$,
- (2) If $\omega_i \neq \omega_j$, then $|\omega_i| \neq |\omega_j|$, where $\omega_i \in T'_i$ and $\omega_j \in T'_j (1 \leq j, i \leq n)$,
- (3) If $4(|\omega_i| - 1), \forall \omega_i \in T'_i (1 \leq i \leq n)$. Then from (1) and (2), we consider that $(t_{nk}^\beta, \#, \phi)_\Gamma$ is a splittable permutation $d/\text{BCK}/d^*/\rho$ -algebra (by Theorem 4.15). Also, from (1) and (2) that easy to show that $(\alpha_1, \alpha_2, \dots, \alpha_{c(\beta)}) = (|\omega_{1_1}|, |\omega_{1_2}|, \dots, |\omega_{1_{|T'_1|}}|, |\omega_{2_1}|, |\omega_{2_2}|, \dots, |\omega_{2_{|T'_2|}}|, \dots, |\omega_{n_1}|, |\omega_{n_2}|, \dots,$

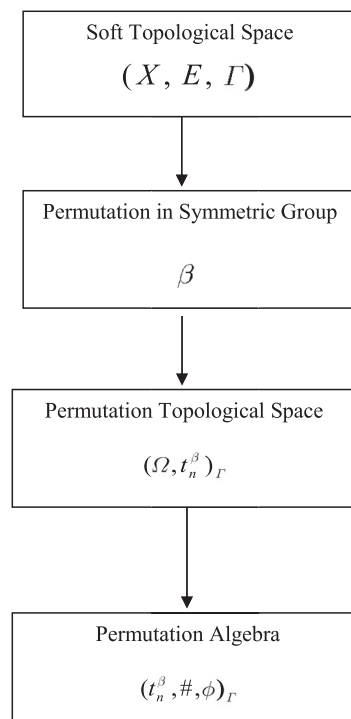


Figure 1. Generating permutation algebra from soft topological space.

$|\omega_{n_{|T'_i|}}|$). That means for any part α_i of $\alpha(\beta)$, there exists $\omega_{i_L} \in T'_i$ for some $(1 \leq i \leq n)$ and $(1 \leq L \leq |T'_i|)$ satisfies $\alpha_i = |\omega_{i_L}|$ and hence from (3) we have $4|(\alpha_i - 1)|, \forall (1 \leq i \leq c(\beta))$. Then $(t_{nk}^\beta, \#, \phi)_T$ is an ambivalent permutation $d/BCK/d^*/p$ -algebra.

5. Methodology flowchart

The flow of this work is explained by using the chart in Figure 1 to generate permutation algebras from soft topological spaces.

6. Conclusions and open problems

In this work, an algorithm has been introduced to find the permutation algebra using soft topological space. Furthermore, the aim of this work was to delve into the aspects of a symmetric group that has a link with soft topological space in terms of permutation in symmetric. This would aid authors to appreciate the role it plays in the theories and applications of soft topological space and deal with these in permutation algebras. Assume that (X, E, τ_1) , (X, E, τ_2) and (X, E, τ_3) are three soft topological spaces over the common universe X the parameter set E with their permutations β, μ and δ in a symmetric group S_n . Hence the questions can be summarized as follows:

Is necessarily true, if $(t_n^\beta, \#, \phi)_{\tau_1}$ is an even (res. odd, splittable, ambivalent) permutation algebra induced by soft topology τ_1 and $\delta: (\Omega, t_n^\beta)_{\tau_1} \rightarrow (\Omega, t_n^\mu)_{\tau_2}$ is continuous permutation map. Then $(\delta(t_n^\beta), \#, \phi)_{\tau_2}$ is even (res. odd, splittable, ambivalent) permutation algebra induced by soft topology τ_2 .

Is necessarily true, if $(t_n^\beta, \#, \phi)_{\tau_1}$ and $(t_n^\mu, \#, \phi)_{\tau_2}$ are two permutation algebras induced by soft topologies τ_1 and τ_2 , respectively. Then $(t_n^\beta \times t_n^\mu, \#, \phi)_T$ is a permutation algebra induced by soft topology T , where $T = \tau_1 \times \tau_2$ and $\#'$ is defined by $\#'(A, B), (C, D) = (A \# C, B \# C), \forall (A, B), (C, D) \in t_n^\beta \times t_n^\mu$.

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