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Application of Neutrosophic Soft Sets for Selecting the Maternal Nutrition and Diet

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Abstract
This paper proposes a comparative study between extended approaches based on the score function algorithm in a neutrosophic environment.The solution procedures are used to solve a multi-criteria decision making problem for selecting the maternal nutrition and diet. The results of different MCDM methods are compared with the existing approach. In addition, a practical example has been demonstrate the efficiency of these new enhanced methods.
Keywords: *Neutrosophic soft set, Neutrosophic soft matrix, Basic results of NSM, Mean value matrix, Score function.*

1. Introduction

Soft set theory was introduced by D.Molodtsov[1] in 1999,it deals with uncertainty in a parametric manner. Neutrosophic set (NS) was proposed by F.Smarandache[2] in 1998, which is a generalization of fuzzy sets and intuitionistic fuzzy set, it is a powerful tool to deal with incomplete, indeterminate and inconsistent information that exists in the real world. Maji [3] combined the concept of soft set and neutrosophic set together by introducing a new concept called Neutrosophic soft set(NSS). The concept of NSS has been modified by I.Deli and Broumi[6]

Multi-criteria decision making (MCDM) is a subfield of operation research. MCDM methods are used to score or rank a finite number of alternatives based on multiple criteria. Recently, Numerous studies have been conducted on the theoretical and application aspects of MCDM and fuzzy MCDM. Recently, I.Deli and Broumi[6] introduced Neutrosophic soft matrices(NSM) and applied it in decision making problem. Tuhin B, Mahapatra[7] extend the concept of NSM with some new operations. Rajeswari, Dhanalakshmi [5] developed a new MCDM technique based on intuitionistic soft matrices.

In this paper, score function algorithm is developed to solve multi-criteria decision making problem in the context of neutrosophic soft sets (NSS). This article is organized as follows: Section 2 deals with basic definitions of neutrosophic soft sets. Section 3 discusses the proposed methods. Case study is presented in section 4. The conclusion is given in section 5.

2.Preliminaries

Definition 2.1[2]

Let U be an universe of discourse. The neutrosophic set A in U is expressed by $\mathrm{A} = \{\langle \mathrm{x}: \mathrm{T_{A(X)}}, \mathrm{I_{A(X)}}, \mathrm{F_{A(X)}} \rangle, \mathrm{x} \in \mathrm{U}\}$, where the characteristic functions $\mathrm{T, I, F} : \mathrm{U} \rightarrow]{-0}, 1^{+}[$ respectively define the degree of membership, the degree of indeterminacy and the degree of non-membership of the element $\mathrm{x} \in \mathrm{U}$ to the set A with the condition, $-0 \leq \mathrm{T_{A(X)}} + \mathrm{I_{A(X)}} + \mathrm{F_{A(X)}} \leq 3^{+}$.

Definition 2.2 [3]

Let U be a universe of discourse and E be a set of parameters. Let $\mathrm{NS}\,(\mathrm{U})$ denotes the set of all neutrosophic subsets of U and $\mathrm{A} \subset \mathrm{E}$. A pair $(N_{\{A\}}, E)$ is called a neutrosophic soft set over U, where $N_{\{A\}}$ is a mapping given by $N_{\{A\}}: E \rightarrow NS(U)$.

Definition 2.3 [7]

a. Let $\mathrm{A} = [a_{ij}]$ be an NSM where a_{ij}=$(T_{ij}^{a}, I_{ij}^{a}, F_{ij}^{a})$, Then the value of the matrix A is denoted by $\mathrm{V(A)}$ and is defined as, $\mathrm{V(A)} = [v_{ij}^{a}]$, where v_{ij}^{a}= $T_{ij}^{a} - I_{ij}^{a} - F_{ij}^{a}$ $\forall$i, j.

b. The Score of two NSMs A and B is defined as $S(A, B) = s_{ij}$,where $s_{ij} = v_{ij}^{a} + v_{ij}^{b}$. that is , $S(A, B) = V(A) + V(B)$.

c. The total score of each object in U is $\sum_{j-1}^{n} s_{ij}$.

2.4 Arithmetic operations on NSM[8]

a. Arithmetic mean of two NSMs, $[a_{ij}] \circledast [b_{ij}] = [c_{ij}]$ where $T_{ij}^{c} = \frac{T_{ij}^{a}+T_{ij}^{b}}{2}$, $I_{ij}^{c} = \frac{I_{ij}^{a}+I_{ij}^{b}}{2}$, $F_{ij}^{c} = \frac{F_{ij}^{a}+F_{ij}^{b}}{2}$, ∀i, j.

b. Addition of two NSMs, $(N, A)_{m\times n} = [a_{ij}]_{m\times n}$ and $(N, B)_{m\times n} = [b_{ij}]_{m\times n}$ are said to conformable for addition, if they have the same order. The addition of two NSMs matrices $[a_{ij}]_{m\times n}$ and $[b_{ij}]_{m\times n}$ is defined by $[c_{ij}]_{m\times n} = [a_{ij}]_{m\times n} \oplus [b_{ij}]_{m\times n}$, where $[c_{ij}]_{m\times n}$ is also the NSM of order $m \times n$ and

$$(c_{ij}) = \left(max\left\{T_{a_{ij}}, T_{b_{ij}}\right\}, avg\left\{I_{a_{ij}}, I_{b_{ij}}\right\}, min\left\{F_{a_{ij}}, F_{b_{ij}}\right\}\right) \forall \text{ i, j}$$
.

3.Multi Criteria Decision Making Methods Using NSM

In this section, we present a decision making method based on value matrix and score matrix to solve multi criteria decision making problem. Let us consider the decision making problem adapted from Tuhin Bera and N.K.Mahapatra [7].

3.1 Solution Procedure-I

Step 1: Construct the neutrosophic soft matrices (N, A) and (N, B).

Step 2: Calculate the complement of neutrosophic soft matrices $(N, A)^c$ and $(N, B)^c$.

Step 3: Obtain the addition of neutrosophic soft matrices $M_{A+B} = (N, A)\oplus(N, B)$ and the addition of complement NSMs $M_{A^c+B^c} = (N, A)^c\oplus(N, B)^c$.

Step 4: Calculate the value matrices of resultant neutrosophic soft matrices, denoted by $V(M_{A+B})$ and $V(M_{A^c+B^c})$.

Step 5: Compute the score matrix $S_{(A+B,A^c+B^c)}$ from value matrices.

Step 6: Compute the total score S_i for each object in U. The maximum score is the optimal solution.

3.2 Solution Procedure-II

Step 1: Construct the neutrosophic soft matrices (N, A) and (N, B).

Step 2: Calculate the complement of neutrosophic soft matrices $(N, A)^c$ and $(N, B)^c$.

Step 3: Obtain the arithmetic mean value of neutrosophic soft matrices $\mathcal{M}_{A+B} = (N, A)\oplus(N, B)$ and the arithmetic mean value of complement NSMs $\mathcal{M}_{A^c+B^c} = (N, A)^c\oplus(N, B)^c$.

Step 4: Calculate the value matrices of resultant neutrosophic soft matrices, denoted by $V(\mathcal{M}_{A+B})$ and $V(\mathcal{M}_{A^c+B^c})$.

Step 5: Compute the score matrix $S_{(A+B,A^c+B^c)}$ from value matrices.

Step 6: Compute the total score S_i for each object in U. The maximum score is the optimal solution.

4.Case Study

This section presents an application of neutrosophic soft sets for selecting the maternal nutrition and diet. A nutrient-rich diet during pregnancy is associated with improved fetal health and immune system of maternal and infant. The focus of this study is to select the most essential nutrient-rich diet for maternal health during the first trimester of pregnancy. The researcher personally communicated with two medical professionals and used their information for choosing the appropriate alternative. The below five criteria are used to select the foods based on the information of experts.

Fetal growth: Maternal nutrition plays a vital role in fetal growth and development. Each stage of fetal development is dependent on and influenced by appropriate maternal nutrient supply.

Immune system development: A deficiency of single nutrient can alter the immune response. The nutrient-rich diet improves the antibodies of mother. Vitamin A plays a crucial role in development of immune system. The mothers antibodies protect the fetus from illnesses.

Prevent birth defects: Restricted maternal diet can cause birth defects and preterm birth. Deficiency in some essential vitamins increases the risk of birth defects. Folic acid foods and supplements prevent the birth defects of infant.

Prevent low birth weight: Maternal under nutrition can lead to low weight of the infant at birth. Premature birth is the key factor causing low birth weight. Mothers diet during pregnancy may have a long-term impact on child weight.

Prevent anemia: The most common cause of anemia includes nutritional deficiencies, particularly iron deficiency. Iron supplementation is used to prevent iron deficiency during pregnancy. Iron-rich foods are most essential to prevent anemia.

The list of nutrition rich foods are given below.

Iron rich foods: Dried fruits, apricots, green peas and beans, broccoli, red meat and liver, lamb meat, Salmon fish, leafy greens, collard greens, spinach, fig fruit, pomegranate, dates, lentils, cereal, beetroot.

Protein rich foods: Eggs, fish, milk, lentils, cottage cheese, chicken, legumes, nuts and seeds (peanuts,walnuts,cashews,pistachios,almonds), grains, meat.

Calcium rich foods: Milk, yogurt, cheese, paneer, salmon, spinach, cereal, green leafy vegetables, sesame seeds, nachni, dal varieties.

Folic acid rich foods: Citrus fruits (oranges,grapes,lemons), broccoli, nuts and seeds (peanuts,walnuts,cashews,pistachios,almonds), bananas, avocado, fortified grains, dark leafy greens, eggs, legumes, beets, carrots, corn, ladies finger, brussels sprouts.

4.1 Numerical Example

In this section, an example of the multi-criteria decision making problem of alternatives is used to demonstrate the application and effectiveness of the proposed decision making method.

Assume that, $\mathrm{U} = \{\mathrm{F}_1, \mathrm{F}_2, \ldots, \mathrm{F}_\mathrm{n}\}$ be the set of alternatives, $\mathrm{E} = \{\mathrm{C}_1, \mathrm{C}_2, \ldots, \mathrm{C}_\mathrm{m}\}$ be the set of parameters or criterion, $\mathrm{D} = \{\mathrm{M}_1, \mathrm{M}_2, \ldots, \mathrm{M}_\mathrm{k}\}$ be the set of decision makers. Now construct a neutrosophic soft set $(N_{\{A\}}, E)$ over U, where $N_{\{A\}}$ is a mapping $N_{\{A\}}: E \rightarrow NS^U$ and NS^U is the collection of all neutrosophic subsets of U. Then construct another neutrosophic soft set $(N_{\{B\}}, E)$ over U, where $N_{\{B\}}$ is a mapping $N_{\{B\}}: E \rightarrow NS^U$ and NS^U is the collection of all neutrosophic subsets of U. The above neutrosophic soft sets gives the neutrosophic soft matrices (N, A) and (N, B). Then compute the complement matrix of (N, A) and (N, B), denoted by $(N, A)^c$ and $(N, B)^c$. Now obtain the addition of NSMs $(N, A) \oplus (\mathrm{N}, \mathrm{B})$ and complement NSMs $(N, A)^c \oplus (N, B)^c$, it is denoted by M_{A+B} and $M_{A^c+B^c}$. In the second procedure, obtain the arithmetic mean of NSMs and complement NSMs, it is denoted by $\mathcal{M}_{A+B}$ and $\mathcal{M}_{A^c+B^c}$. Then compute $\mathrm{V}(M_{A+B})$, $\mathrm{V}(M_{A^c+B^c})$, $S_{(A+B, A^c+B^c)}$ and the total score S_i, using def 2.5. Finally find $S_i = max(S_i)$, then conclude that the maximum score of alternative F_n is the optimal solution.

Let us consider, $\mathrm{D} = \{\mathrm{M}_1, \mathrm{M}_2\}$ be the set of women, they want to select their nutrition rich diet by the recommendation of their medical professionals.

Let U be the universal set, $\mathrm{U} = \{\mathrm{F}_1, \mathrm{F}_2, \mathrm{F}_3, \mathrm{F}_4\}$ be the set of alternatives, where,

$\mathrm{F}_1 -$ Iron rich foods, $\mathrm{F}_2 -$ Protein rich foods, $\mathrm{F}_3 -$ Calcium rich foods, $\mathrm{F}_4 -$ Folic acid rich food. Let $\mathrm{E} = \{\mathrm{C}_1, \mathrm{C}_2, \mathrm{C}_3, \mathrm{C}_4, \mathrm{C}_5\}$ be the set of parameters or criteria, where, $\mathrm{C}_1 -$ Fetal growth, $\mathrm{C}_2 -$ Immune system development, $\mathrm{C}_3 -$ Prevent birth defects, $\mathrm{C}_4 -$ Prevent low birth weight, $\mathrm{C}_5 -$ Prevent anemia. Medical professionals of M_1 and M_2 have given their valuable opinions by the following neutrosophic soft sets $(N_{\{A\}}, E)$ and $(N_{\{B\}}, E)$ separately.

$\left(N_{\{A\}}, E\right) = \{f_A(C_1), f_A(C_2), f_A(C_3), f_A(C_4), f_A(C_5)\}$ where

$f_A(C_1) = \{(\mathrm{F}_1, 0.3,0.5,0.6), (\mathrm{F}_2, 0.6,0.4,0.7), (\mathrm{F}_3, 0.8,0.6,0.5), (\mathrm{F}_4, 0.7,0.4,0.3)\}$

$f_A(C_2) = \{(\mathrm{F}_1, 0.8,0.3,0.5), (\mathrm{F}_2, 0.7,0.5,0.6), (\mathrm{F}_3, 0.4,0.7,0.3), (\mathrm{F}_4, 0.8,0.9,0.5)\}$

$f_A(C_3) = \{(\mathrm{F}_1, 0.5,0.2,0.4), (\mathrm{F}_2, 0.6,0.4,0.3), (\mathrm{F}_3, 0.9,0.6,0.7), (\mathrm{F}_4, 0.8,0.7,0.5)\}$

$f_A(C_4) = \{(\mathrm{F}_1, 0.2,0.3,0.1), (\mathrm{F}_2, 0.3,0.5,0.9), (\mathrm{F}_3, 0.6,0.7,0.5), (\mathrm{F}_4, 0.9,0.6,0.4)\}$

$f_A(C_5) = \{(\mathrm{F}_1, 0.1,0.5,0.3), (\mathrm{F}_2, 0.8,0.6,0.7), (\mathrm{F}_3, 0.3,0.7,0.4), (\mathrm{F}_4, 0.4,0.9,0.8)\}$

$\left(N_{\{B\}}, E\right) = \{f_B(C_1), f_B(C_2), f_B(C_3), f_B(C_4), f_B(C_5)\}$ where

$f_B(C_1) = \{(\mathrm{F}_1, 0.4,0.6,0.7), (\mathrm{F}_2, 0.3,0.9,0.8), (\mathrm{F}_3, 0.9,0.6,0.5), (\mathrm{F}_4, 0.7,0.5,0.8)\}$

$f_B(C_2) = \{(\mathrm{F}_1, 0.5,0.3,0.1), (\mathrm{F}_2, 0.2,0.5,0.7), (\mathrm{F}_3, 0.6,0.8,0.9), (\mathrm{F}_4, 0.9,0.7,0.5)\}$

$f_B(C_3) = \{(\mathrm{F}_1, 0.2,0.5,0.7), (\mathrm{F}_2, 0.8,0.7,0.5), (\mathrm{F}_3, 0.9,0.5,0.5), (\mathrm{F}_4, 0.6,0.4,0.3)\}$

$f_B(C_4) = \{(\mathrm{F}_1, 0.2,0.3,0.4), (\mathrm{F}_2, 0.4,0.6,0.6), (\mathrm{F}_3, 0.7,0.7,0.8), (\mathrm{F}_4, 0.9,0.5,0.3)\}$

$f_B(C_5) = \{(\mathrm{F}_1, 0.1,0.3,0.5), (\mathrm{F}_2, 0.8,0.4,0.1), (\mathrm{F}_3, 1,0.5,0.6), (\mathrm{F}_4, 0.4,0.3,0.6)\}$

Procedure-1

The above two neutrosophic soft sets are represented by the following neutrosophic soft matrices,

$$(N,A) = \begin{bmatrix} (0.3,0.5,0.6) & (0.8,0.3,0.5) & (0.5,0.2,0.4) & (0.2,0.3,0.1) & (0,1,0.5,0.3) \\ (0.6,0.4,0.7) & (0.7,0.5,0.6) & (0.6,0.4,0.3) & (0.3,0.5,0.9) & (0.8,0.6,0.7) \\ (0.8,0.6,0.5) & (0.4,0.7,0.3) & (0.9,0.6,0.7) & (0.6,0.7,0.5) & (0.3,0.7,0.4) \\ (0.7,0.4,0.3) & (0.8,0.9,0.5) & (0.8,0.7,0.5) & (0.9,0.6,0.4) & (0.4,0.9,0.8) \end{bmatrix}$$

$$(N,B) = \begin{bmatrix} (0.4,0.6,0.7) & (0.5,0.3,0.1) & (0.2,0.5,0.7) & (0.2,0.3,0.4) & (0,1,0.3,0.5) \\ (0.3,0.9,0.8) & (0.2,0.5,0.7) & (0.8,0.7,0.5) & (0.4,0.6,0.6) & (0.8,0.4,0.1) \\ (0.9,0.6,0.5) & (0.6,0.8,0.9) & (0.9,0.5,0.5) & (0.7,0.7,0.8) & (1,0.5,0.6) \\ (0.7,0.5,0.8) & (0.9,0.7,0.5) & (0.6,0.4,0.3) & (0.9,0.5,0.3) & (0.4,0.3,0.6) \end{bmatrix}$$

Now, calculate the complement matrix $(N,A)^c$, $(N,B)^c$ of above neutrosophic soft matrices ,

$$(N,A)^c = \begin{bmatrix} (0.6,0.5,0.3) & (0.5,0.7,0.8) & (0.4,0.8,0.5) & (0.1,0.7,0.2) & (0.3,0.5,0.1) \\ (0.7,0.6,0.6) & (0.6,0.5,0.7) & (0.3,0.6,0.6) & (0.9,0.5,0.3) & (0.7,0.4,0.8) \\ (0.5,0.4,0.8) & (0.3,0.3,0.4) & (0.7,0.4,0.9) & (0.5,0.3,0.6) & (0.4,0.3,0.3) \\ (0.3,0.6,0.7) & (0.5,0.1,0.8) & (0.5,0.3,0.8) & (0.4,0.4,0.9) & (0.8,0.1,0.4) \end{bmatrix}$$

$$(N,B)^c = \begin{bmatrix} (0.7,0.4,0.4) & (0.1,0.7,0.5) & (0.7,0.5,0.2) & (0.4,0.7,0.2) & (0.5,0.7,0.1) \\ (0.8,0.1,0.3) & (0.7,0.5,0.2) & (0.5,0.3,0.8) & (0.6,0.4,0.4) & (0.1,0.6,0.8) \\ (0.5,0.4,0.9) & (0.9,0.2,0.6) & (0.5,0.5,0.9) & (0.8,0.3,0.7) & (0.6,0.5,0.1) \\ (0.8,0.5,0.7) & (0.5,0.3,0.9) & (0.3,0.6,0.6) & (0.3,0.5,0.9) & (0.6,0.7,0.4) \end{bmatrix}$$

Using definition 2.4, calculate the addition of neutrosophic soft matrices $(N,A) \oplus (\mathrm{N},\mathrm{B})$ and calculate the addition of complement NSMs $(N,A)^c \oplus (N,B)^c$.

$$M_{A+B} = (N,A) \oplus (\mathrm{N},\mathrm{B}) == \begin{bmatrix} (0.4,0.55,0.6) & (0.8,0.3,0.1) & (0.5,0.35,0.4) & (0.2,0.3,0.1) & (0.1,0.4,0.3) \\ (0.6,0.65,0.7) & (0.7,0.5,0.6) & (0.8,0.55,0.3) & (0.4,0.55,0.6) & (0.8,0.5,0.1) \\ (0.9,0.6,0.5) & (0.6,0.75,0.3) & (0.9,0.55,0.5) & (0.7,0.7,0.5) & (1,0.6,0.4) \\ (0.7,0.45,0.3) & (0.9,0.8,0.5) & (0.8,0.55,0.3) & (0.9,0.55,0.3) & (0.4,0.6,0.6) \end{bmatrix}$$

$M_{A^c+B^c} = (N,A)^c \oplus (N,B)^c =$

$$= \begin{bmatrix} (0.7,0.45,0.3) & (0.5,0.7,0.5) & (0.7,0.65,0.2) & (0.4,0.7,0.2) & (0.5,0.6,0.1) \\ (0.8,0.35,0.3) & (0.7,0.5,0.2) & (0.5,0.45,0.6) & (0.9,0.45,0.3) & (0.7,0.5,0.8) \\ (0.5,0.4,0.8) & (0.9,0.25,0.4) & (0.7,0.45,0.9) & (0.8,0.3,0.6) & (0.6,0.4,0.3) \\ (0.8,0.55,0.7) & (0.5,0.2,0.8) & (0.5,0.45,0.6) & (0.4,0.45,0.9) & (0.8,0.4,0.4) \end{bmatrix}$$

Then calculate the value matrices of the above resultant neutrosophic soft matrices using definition 2.3,

$$\mathrm{V}(M_{A+B}) = \begin{bmatrix} -0.75 & 0.4 & -0.25 & -0.2 & -0.6 \\ -0.75 & -0.4 & -0.05 & -0.75 & 0.2 \\ -0.2 & -0.45 & -0.15 & -0.5 & 0 \\ -0.05 & -0.4 & -0.05 & 0.05 & -0.8 \end{bmatrix}$$

$$\mathrm{V}(M_{A^c+B^c}) = \begin{bmatrix} -0.05 & -0.7 & -0.15 & -0.5 & -0.2 \\ 0.15 & 0 & -0.55 & 0.15 & -0.6 \\ -0.7 & 0.25 & -0.65 & -0.1 & -0.1 \\ -0.45 & -0.5 & -0.55 & -0.95 & 0 \end{bmatrix}$$

Now, compute the Score matrix by definition 2.3,

$$S_{(A+B,A^c+B^c)} = \begin{bmatrix} -0.7 & 1.1 & -0.1 & 0.3 & -0.4 \\ -0.9 & -0.4 & 0.5 & -0.9 & 0.8 \\ 0.5 & -0.7 & 0.5 & -0.4 & 0.1 \\ 0.4 & 0.1 & 0.5 & 1 & -0.8 \end{bmatrix}$$

Then, obtain the total score S_i,

$$\text{Total score} = \begin{bmatrix} 0.2 \\ -0.9 \\ 0 \\ 1.2 \end{bmatrix}$$

From the above score value, the ranking of the four alternatives is $F_4 > F_1 > F_3 > F_2$.

Procedure-2

Using definition 2.4, calculate the arithmetic mean value of neutrosophic soft matrices $(N,A)\oplus(\mathrm{N},\mathrm{B})$ and the arithmetic mean value of complement NSMs $(N,A)^c\oplus(N,B)^c$.

$$\mathcal{M}_{A+B} = (N,A)\oplus(\mathrm{N},\mathrm{B}) = \begin{bmatrix} (0.35,0.55,0.65) & (0.65,0.3,0.3) & (0.35,0.35,0.55) & (0.2,0.3,0.25) & (0.1,0.4,0.4) \\ (0.45,0.65,0.75) & (0.45,0.5,0.65) & (0.7,0.55,0.4) & (0.35,0.55,0.75) & (0.8,0.5,0.4) \\ (0.85,0.6,0.5) & (0.5,0.75,0.6) & (0.9,0.55,0.6) & (0.65,0.7,0.65) & (0,65,0.6,0.5) \\ (0.7,0.45,0.55) & (0.85,0.8,0.5) & (0.7,0.55,0.4) & (0.9,0.55,0.35) & (0.4,0.6,0.7) \end{bmatrix}$$

$$\mathcal{M}_{A^c+B^c} = (N,A)^c\oplus(N,B)^c = \begin{bmatrix} (0.65,0.45,0.35) & (0.3,0.7,0.65) & (0.55,0.65,0.35) & (0.25,0.7,0.2) & (0.4,0.6,0.1) \\ (0.75,0.35,0.45) & (0.65,0.5,0.45) & (0.4,0.45,0.7) & (0.75,0.45,0.35) & (0.4,0.5,0.8) \\ (0.5,0.4,0.85) & (0.6,0.25,0.5) & (0.6,0.45,0.9) & (0.65,0.3,0.65) & (0.5,0.4,0.65) \\ (0.55,0.55,0.7) & (0.5,0.2,0.85) & (0.4,0.45,0.7) & (0.35,0.45,0.9) & (0.7,0.4,0.4) \end{bmatrix}$$

Then calculate the value matrices of the above resultant neutrosophic soft matrices using definition 2.3,

$$\mathrm{V}(\mathcal{M}_{A+B}) = \begin{bmatrix} -0.85 & 0.05 & -0.55 & -0.35 & -0.7 \\ -0.95 & -0.7 & -0.25 & -0.95 & -0.1 \\ -0.25 & -0.85 & -0.25 & -0.7 & -0.45 \\ -0.3 & -0.45 & -0.25 & 0 & -0.9 \end{bmatrix}$$

$$V(\mathcal{M}_{A^c+B^c}) = \begin{bmatrix} -0.15 & -1.05 & -0.45 & -0.65 & -0.3 \\ -0.05 & -0.3 & -0.75 & -0.05 & -0.9 \\ -0.75 & -0.15 & -0.75 & -0.3 & -0.55 \\ -0.7 & -0.55 & -0.75 & -1 & -0.1 \end{bmatrix}$$

Now, compute the Score matrix by definition 2.3,

$$S_{(A+B,A^c+B^c)} = \begin{bmatrix} -0.7 & 1.1 & -0.1 & 0.3 & -0.4 \\ -0.9 & -0.4 & 0.5 & -0.9 & 0.8 \\ 0.5 & -0.7 & 0.5 & -0.4 & 0.1 \\ 0.4 & 0.1 & 0.5 & 1 & -0.8 \end{bmatrix}$$

Then, obtain the total score S_i,

$$\text{Total score} = \begin{bmatrix} 0.2 \\ -0.9 \\ 0 \\ 1.2 \end{bmatrix}$$

From the above score value, the ranking of the four alternatives is $F_4 > F_1 > F_3 > F_2$.

The alternative F_4 has the maximum value, it is clear that F_4 is the most desirable alternative.

Results and Discussion

According to the outcomes, Folic acid rich foods (F_4) are most essential for early pregnancy period. All rich foods are beneficial to consume during pregnancy, but those high in folic acid are particularly beneficial during the first trimester. The same result is obtained using method-1 and method-2. The comparison table of proposed methods and existing approach are given below,

Table1. Comparison table of methods

Methods	Ranking	Optimal Choice
Existing Score function algorithm	$F_4 > F_1 > F_3 > F_2$	F_4
Solution Procedure-1	$F_4 > F_1 > F_3 > F_2$	F_4
Solution Procedure-2	$F_4 > F_1 > F_3 > F_2$	F_4

5. Conclusion

In this study, the new extended methods for solving the MCDM problem have been established with the assistance of the score matrix. The final results obtained from maximum score value of the alternatives and the results are compared with the existing method to verify the effectiveness of the improved approaches. Finally, a diet selection problem has been solved to show the applicability of the proposed methods.

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