Multi-criteria Decision-making Applications Based on Set Valued Generalized Neutrosophic Quadruple Sets for Law

Necmiye Merve Şahin[1] and Merve Sena Uz[2]

[1]Faculty of Law, Hasan Kalyoncu University, Gaziantep 27410, Turkey, necmiyemerve.sahin@gmail.com

[2]Department of Mathematics, Gaziantep University, Gaziantep27310-Turkey, evrem_anes@yahoo.com

Corresponding: evrem_anes@yahoo.com

Abstract

In this article, an algorithm has been introduced that enables judges to see the decisions that should be made in a way that is closest to the conscience and the law, without transferring the cases to the higher authorities, without anyone objecting to their decisions. This algorithm has been introduced depending on the generalized set-valued neutrosophic quadruple numbers and the Euclidean similarity measure in sets, what the decision is made by considering all the situations, regardless of which case the defendants come before the judge, how similar these decisions are to the legal decisions that should be made. In this way, we can easily see the decisions given to the accused in all kinds of cases, and we can arrange the decisions according to the similarity value. The closer the similarity value is to 1, the more correct the judge's decision from a legal point of view.

Keywords: generalized set valued neutrosophic quadruple numbers, generalized Euclid similarity measure, law, decision making

1. Introduction

When we encounter a situation in our daily life, we may not always get precise results. As technology develops and as time progresses, the situations of uncertainty that we face also increase. In order to cope with uncertain situations, Zadeh first introduced fuzzy logic and fuzzy set structures [10] in 1965. Fuzzy sets have a membership value up to some degree. That is, a number, object, state has the value of being a member of the set, and he named this value as the membership function. He introduced the membership function to take values in the range of 0 to 1. Atanassov introduced the intuitive fuzzy logic and intuitive fuzzy set structures [11] by defining the degree of non-membership in addition to the degree of membership in 1986. Membership and non-membership degrees have been introduced to take values between 0 and 1.

Samarandache introduced the neutrosophic logic [12], which is more general than the fuzzy set and the intuitive fuzzy set in 1998. Neutrosophic logic and neutrosophic sets have a degree of membership T (degree of correctness),

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a degree of uncertainty I (degree of instability), and a degree of non-membership F (degree of falsehood). He introduced these degrees independent of each other. Many researchers studied neutrosophic theory [30 - 35].

Smarandache and Ali introduced triplet sets and neutrosophic triplet group [13]. For every element "y" of a neutrosophic triplet set Y, there exist the neutral of "y" and the anti of "y". Also, the neutral of "y" is different from the classical neutral element. Therefore, the neutrosophic triplet set is different from the classical set. Also, an element "y" in the neutrosophic triplet is denoted by < y, neutral (y), anti (y) >. In addition, many researchers have conducted studies on neutrosophic triplet structures.

Smarandache introduced the neutrosophic quadruple sets and the neutrosophic quadruple numbers [14] after the neutrosophic triplets. Neutrosophic quadruple sets are the generalization of neutrosophic sets. A neutrosophic quadruple set is shown as NQS= {(x,yT,zI,tF):x, y, z, t ∈ R or C }. Here, x is the known part; (yT,zI,tF) is called the unknown part and T,I,F has the usual neutrosophic logic tools. After this work of Smarandache, Şahin and Kargın introduced the set-valued neutrosophic quadruples and set-valued neutrosophic quadruple number structures [8]. In addition, many researchers have studies on neutrosophic quadruple structures. Şahin and Kargın [15] introduced single-valued neutrosophic quadruple sets (SVNQS) and numbers (SVNQN), and introduced the single-valued neutrosophic quadruple graph (SVNQG). Sahin et al. [16] introduced neutrosophic triplet field and the neutrosophic vector space on the set-valued neutrosophic quadruple numbers. Kargin et al. [17] introduced the generalized Hamming similarity measure based on neutrosophic quadruple numbers and their applications to the legal sciences. Sahin et al. [18] introduced the set-valued generalized neutrosophic quadruple numbers and Hausdorff measures on decision-making applications for the adequacy of online education. Sahin et al. [19] introduced generalized neutrosophic quadruple sets and numbers. Sahin et al. [20] introduced set-valued generalized neutrosophic quadruple sets and numbers. Ibrahim et al. [21] introduced hypervector spaces on neutrosophic quadruples. Aslan et al. [22] introduced Talcott Parsons' neutrosophic modeling of action and its decision making applications. Kargın et al. [23] introduced neutrosophic triplet m-Banach space. Şahin et al. [24] obtained neutrosophic triplet bipolar metric space. Kandasamy et al. [25] introduced neutrosophic quadruple vector spaces and their properties. Şahin et al. [26] defined neutrosophic triplet partial g-metric space. Rezaei et al. [27] introduced the neutrosophic quadruple a-ideals. Şahin and Kargın [28] introduced a new measure of similarity between single-valued neutrosophic sets and decision-making practices in professional competencies.

In recent years the objections to the decisions made by judges in the cases, the long time delays of the cases due to indecision, and the transfer of most cases to higher courts have been widely observed. Just as it is important for the law to be specific and clear, its fair application is equally important in terms of justice. Many researchers have worked on these decision-making problems in the legal sense. Most of the researchers have focused on the problems arising from the gaps in the law, the legal expressions developed by the people or the studies such as the types of judges. Our aim in this study is to make it easier for the judges to reach the right decision and to make it an acceptable decision by everyone, by ensuring that the decisions brought by the laws are compared with the decisions made by the judges. The results should be clear, and should not depend on the legal expressions created according to the judge types or the individuals.

In this study;

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In the first part, fuzzy set [10], intuitive fuzzy set [11], neutrosophic set [12], neutrosophic triplet set [13], neutrosophic quadruple sets and neutrosophic quadruple numbers [14], set-valued neutrosophic quadruple set and set-valued neutrosophic set are discussed. The history of quadruple number structures [8] is mentioned. In the second part, some definitions and theorems used in the study are given. In chapter 3, an algorithm is introduced to facilitate judges' decision making and ensure that their decisions are accepted by everyone. Our aim in this algorithm is to show the similarity of the decisions that should be made according to the law in cases with the decisions made by the judges. This similarity shows how the decisions made by the judges in the cases are similar to the decisions that should be made. In this case, we will both facilitate the decision making of the judges and eliminate the objections to the decision of the judges. Some examples are given to show the applicability of the algorithm we have defined on set-valued generalized neutrosophic quadruple numbers and sets in this instability situations. In the fourth section, the results and recommendations obtained from the study are given.

2. Preliminaries

Definition 2.1: [1] Let E be the universal set. A neutrosophic set A on E is denoted by

$$A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle : x \in E\}$$

where $\forall x \in E, 0^- \leq T_A(x) + I_A(x) + F_A(x) \leq 3^+$ and the functions $T_A: E \to]^-0, 1^+[$, $I_A: E \to]^-0, 1^+[$ and $F_A: E \to]^-0, 1^+[$.

Here,$T_A(x), I_A(x)$ and $F_A(x)$ are the degrees of trueness, indeterminacy and falsity respectively. Also, $^-0 = 0 + \varepsilon$ and $1^+ = 1 + \varepsilon$.

Definition 2.2: [2] Let E be the universal set. A single-valued neutrosophic set A on E is denoted by

$$A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle : x \in E\}$$

where $\forall x \in E, 0^- \leq T_A(x) + I_A(x) + F_A(x) \leq 3$ and the functions $T_A: E \to [0,1]$, $I_A: E \to [0,1]$ and $F_A: E \to [0,1]$.

Here,$T_A(x), I_A(x)$ and $F_A(x)$ are the degrees of trueness, indeterminacy and falsity respectively.

Theorem 2.3: [5] Let $S: E \times E \to [0,1]$. The similarity measure between A_1 and A_2 is denoted by $S(A_1, A_2)$ and for the neutrosophic sets $A_1, A_2, A_3 \in E$, $S(A_1, A_2)$ satisfies the below conditions:

i. $0 \leq S(A_1, A_2) \leq 1$
ii. $S(A_1, A_2) = 1 \Leftrightarrow A_1 = A_2$
iii. $S(A_1, A_2) = S(A_2, A_1)$
iv. If $A_1 \subseteq A_2 \subseteq A_3 \in E$, then $S(A_1, A_3) \leq S(A_1, A_2)$ and $S(A_1, A_3) \leq S(A_2, A_3)$.

Definition 2.4: [7] NQN is a number of the form (x, yT, zI, tF), where T, I, F are used as the usual neutrosophic logic tools and $x, y, z, t \in \mathbb{R}$ or $\mathbb{C}$. The NQS defined by NQS = $\{(x, yT, zI, tF)$: x, $y, z, t \in \mathbb{R}$ or $\mathbb{C}\}$.

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For an NQN, In (x, yT, zI, tF), x is named as the known part and it represents any number, idea, object, etc. and (yT, zI, tF)) is named as the unknown part.

Definition 2.5: [8] Let N be a set and let $P(N)$ be the power set of N. An SVNQN is of the form $(A_1, A_2\,T, A_3 I, A_4\,F)$. Here, $\mathrm{T, I, F}$ are the degrees of trueness, indeterminacy and falsity respectively. Also, $A_1, A_2, A_3, A_4 \in P(N)$. Here,

$$N_q = \{(A_1, A_2T, A_3I, A_4F) : A_1, A_2, A_3, A_4 \in P(N)\}.$$

Similar to NQS, A_1 is called the known part and (A_2T, A_3I, A_4F) is called the unknown part.

Definition 2.6: [8] Let $A = (A_1, A_2T, A_3I, A_4F)$ and $B = (B_1, B_2T, B_3I, B_4F)$ be two SVNQNs. On A and B, the classical set theoretic operations are defined as below:

$A \cup B = (A_1 \cup B_1, (A_2 \cup B_2)\,T, (A_3 \cup B_3)\,I, (A_4 \cup B_4)\,F)$

$A \cap B = (A_1 \cap B_1, (A_2 \cap B_2)\,T, (A_3 \cap B_3)\,I, (A_4 \cap B_4)F)$

$A\backslash B = (A_1\backslash B_1, (A_2\backslash B_2)\,T, (A_3\backslash B_3)\,I, (A_4\backslash B_4)\,F)$

$A' = (A'_1, A'_2\,T, A'_3\,I, A'_4\,F)$.

Definition 2.7: [8] Let $A =(A_1, A_2\,T, A_3\,I, A_4\,F)$, $B =(B_1, B_2\,T, B_3\,I, B_4\,F)$ be two SVNQNs. If $A_1 \subset B_1$, $A_2 \subset B_2$, $A_3 \subset B_3$, $A_4 \subset B_4$, then we say A is a subset of B and denote it as $A \subset B$.

Definition 2.8: [9] Let X be a set and let $P(X)$ be the power set of X. A Generalized element of the set SVNQS (GSVNQS) is of the form:

$G_{s_i} = \{(A_{s_i}, B_{s_i}T_{s_i}, C_{s_i}I_{s_i}, D_{s_i}F_{s_i}) : A_{s_i}, B_{s_i}, C_{s_i}, D_{s_i} \in P(X);\ i = 1, 2, 3, \ldots, n\}$

where T_i, I_i and F_i are the usual neutrosophic logic tools and $G_{N_i} = (A_{s_i}, B_{s_i}T_{s_i}, C_{s_i}I_{s_i}, D_{s_i}F_{s_i})$ is generalized by SVNQN (GSVNQN).

Similar to NQN, a GNQN $(A_{s_i}, B_{s_i}T_{s_i}, C_{s_i}I_{s_i}, D_{s_i}F_{s_i})$ represents any asset, A_{s_i} is called the known part and $(B_{s_i}T_{s_i}, C_{s_i}I_{s_i}, D_{s_i}F_{s_i})$ is called the unknown part.

Also, $G_{s_i} = \{G_{N_i} : i = 1, 2, 3, \ldots, n\}$ can be used as another representation.

Definition 2.9: [29] Let : $X \neq \emptyset$ be a non-empty set and $P(X)$ be the power set of X.

Let $G_{N_i^1} = (A_{s_i^1}, B_{s_i^1}T_{s_i^1}, C_{s_i^1}I_{s_i^1}, D_{s_i^1}F_{s_i^1})$ and $G_{N_i^2} = (A_{s_i^2}, B_{s_i^2}T_{s_i^2}, C_{s_i^2}I_{s_i^2}, D_{s_i^2}F_{s_i^2})$ be two generalized set-valued neutrosophic quadruple numbers.

Define a function $d_E : G_{N_i^1} \times G_{N_i^2} \rightarrow [0,1]$ such that

$$d_G\left(G_{N_i^1}, G_{N_i^2}\right) = \frac{1}{2}\left[\frac{\sqrt{\left(T_{s_i^1} - T_{s_i^2}\right)^2} + \sqrt{\left(I_{s_i^1} - I_{s_i^2}\right)^2} + \sqrt{\left(F_{s_i^1} - F_{s_i^2}\right)^2}}{3}\right.$$

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$$+\frac{\sqrt{\frac{s\left(A_{S_i^1}\backslash A_{S_i^2}\right)+s\left(A_{S_i^2}\backslash A_{S_i^1}\right)}{\max\{s\left(A_{S_i^1}\cup A_{S_i^2}\right),1\}}+\frac{s\left(B_{S_i^1}\backslash B_{S_i^2}\right)+s\left(B_{S_i^2}\backslash B_{S_i^1}\right)}{\max\{s\left(B_{S_i^1}\cup B_{S_i^2}\right),1\}}+\frac{s\left(C_{S_i^1}\backslash C_{S_i^2}\right)+s\left(C_{S_i^2}\backslash C_{S_i^1}\right)}{\max\{s\left(C_{S_i^1}\cup C_{S_i^2}\right),1\}}+\frac{s\left(D_{S_i^1}\backslash D_{S_i^2}\right)+s\left(D_{S_i^2}\backslash D_{S_i^1}\right)}{\max\{s\left(D_{S_i^1}\cup D_{S_i^2}\right),1\}}}}{2}]$$

Then, $d_G\left(G_{N_i^1}, G_{N_i^2}\right)$ is called generalized Euclid distance measure for generalized set valued neutrosophic quadruple numbers.

Where, s(A) is the number of element of set A.

3. Algorithm That Facilitates Judges' Decision Making and Defined by Euclidean Measures on Generalized Set Valued Neutrosophic Quadruple Sets

Judges are expected to make decisions according to law and their conscience. In today's world, it is seen that the judges have difficulty in making decisions. It is observed that the judges have difficulty in making decisions in cases day by day and either the cases are concluded in a haphazard way or they are transferred to the higher courts. It is also observed that the opposition to the decisions of the judges has increased recently. In order to find solutions to such problems, a similarity algorithm is introduced that will enable the judges to decide in the most appropriate way according to the law. By the help of this algorithm, making the most appropriate decision is ensured, no matter what type of case the trial is on. The fact that the judge does not make a conscientious decision here does not mean that there will be no situations such as good conduct or uncertainty in the case. The main task here is to make a decision by taking into account both the law and every aspect of the case. An algorithm is being developed that will ensure that the case need not be transferred to higher courts and that there is going to be no objections against the final decisions.

Algorithm: It is an algorithm that makes it easier for us to find out how accurate the decision was made according to the constitution. A set of defendants is formed. The cases in which the defendants are tried are determined. Weight values are given according to the importance of these cases. An ideal set is determined so that we can find out how correctly the cases are decided according to the constitution. Cases are expressed in sets of neutrosophic quadruple sets. These defined expressions are given in tables. Then, the similarity of the decisions made on the cases according to the constitution is measured. This measurement value is multiplied by the weight value of the case and a table is obtained again. In this table, taking into account the status of the defendants, the accuracy of the decision made for each case is observed.

1. Step: Let the set of lawsuits be $D = \{d_1, d_2, \dots, d_m\}$.

2. Step: Let the set of the weight values of the lawsuits according to their importance be $V = \{v_1, v_2, \dots, v_m\}$.

In other words;

weight value of the lawsuit d_1 is v_1,

weight value of the lawsuit d_2 is v_2,

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weight value of the lawsuit d_m is v_m .

Also, $\sum_{j=1}^{m} v_j = 1$.

3. Step:

For the generalized set valued neutrosophic quadruple number

$J = \{d_1: \big(P(K), P(K)T_{1j}, \emptyset I_{1j}, \emptyset F_{1j}\big), d_2: \big(P(L), P(L)T_{2j}, \emptyset I_{2j}, \emptyset F_{2j}\big), ...,$

$d_m: \big(P(H), P(H)T_{mj}, \emptyset I_{mj}, \emptyset F_{mj}\big)\}$,

the set of decision that must be given for the condition $P(K)$ of the lawsuit d_1, the set of decision that must be given for the situation ($P(K)T_{1j}, \emptyset I_{1j}, \emptyset F_{1j}$),

the set of decision that must be given for the condition $P(L)$ of the lawsuit d_2, the set of decision that must be given for the situation ($P(L)T_{2j}, \emptyset I_{2j}, \emptyset F_{2j}$),

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the set of decision that must be given for the condition $P(H)$ of the lawsuit d_m, the set of decision that must be given for the situation ($P(H)T_{mj}, \emptyset I_{mj}, \emptyset F_{mj}$), and let $K = \{k_1, k_2, ..., k_m\}$, $L = \{l_1, l_2, ..., l_m\}$,…, $H = \{h_1, h_2, ..., h_m\}$ be the sets of the decided cases. Take

$T_{1j} = T_{2j} = \cdots = T_{mj} = 1$

$I_{1j} = I_{2j} = \cdots = I_{mj} = 0$

$F_{1j} = F_{2j} = \cdots = F_{mj} = 0$.

Let J be our ideal set.

4. Step:

Let the set of defendants be $S = \{S_1, S_2, ..., S_m\}$. Let us express the decision for the lawsuits of each defendant in this set by a set valued generalized neutrosophic quadruple.

$S_1 = \{d_1: (K_{11}, K_{12}T_{11}, K_{13}I_{11}, K_{14}F_{11}), d_2: (L_{11}, L_{12}T_{12}, L_{13}I_{12}, L_{14}F_{12}), ...,$

$d_m: (H_{11}, H_{12}T_{1m}, H_{13}I_{1m}, H_{14}F_{1m})\}$

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$S_2 = \{d_1: (K_{21}, K_{22}T_{21}, K_{23}I_{21}, K_{24}F_{21}), d_2: (L_{21}, L_{22}T_{22}, L_{23}I_{22}, L_{24}F_{22}), \ldots,$

$d_m: (H_{21}, H_{22}T_{2m}, H_{23}I_{2m}, H_{24}F_{2m})\}$

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$S_j = \{d_1: \left(K_{j1}, K_{j2}T_{j1}, K_{j3}I_{j1}, K_{j4}F_{j1}\right), d_2: \left(L_{j1}, L_{j2}T_{j2}, L_{j3}I_{j2}, L_{j4}F_{j2}\right), \ldots,$

$d_m: \left(H_{j1}, H_{j2}T_{jm}, H_{j3}I_{jm}, H_{j4}F_{jm}\right)\}$, $j = 1,2, \ldots, m$

are all evaluated separately.

Here,

$K_{11}, K_{12}, K_{13}, K_{14}, K_{21}, K_{22}, K_{23}, K_{24}, \ldots, K_{j1}, K_{j2}, K_{j3}, K_{j4} \in P(K)$

$L_{11}, L_{12}, L_{13}, L_{14}, L_{21}, L_{22}, L_{23}, L_{24}, \ldots, L_{j1}, L_{j2}, L_{j3}, L_{j4} \in P(L)$

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$H_{11}, H_{12}, H_{13}, H_{14}, H_{21}, H_{22}, H_{23}, H_{24}, \ldots, H_{j1}, H_{j2}, H_{j3}, H_{j4} \in P(H)$.

5. Step: Denote the decisions given in the lawsuits of the generalized set valued neutrosophic quadruple defendants in a table.

Table 1. Presentation of the decisions given per defendants

	d_1	d_2	$\ldots$	d_m
S_1	$(K_{11}, K_{12}T_{11}, K_{13}I_{11}, K_{14}F_{11})$	$(L_{11}, L_{12}T_{12}, L_{13}I_{12}, L_{14}F_{12})$	$\ldots$	$(H_{11}, Y_{12}T_{1m}, Y_{13}I_{1m}, Y_{14}F_{1m})$
S_2	$(K_{21}, K_{22}T_{21}, K_{23}I_{21}, K_{24}F_{21})$	$(L_{21}, L_{22}T_{22}, L_{23}I_{22}, L_{24}F_{22})$	$\ldots$	$(H_{21}, H_{22}T_{2m}, H_{23}I_{2m}, H_{24}F_{2m})$
.	.	.	$\ldots$	.
.	.	.	$\ldots$	.
.	.	.	$\ldots$	.

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S_j	$(K_{j1}, K_{j2}T_{j1}, K_{j3}I_{j1}, K_{j4}F_{j1})$	$(L_{j1}, L_{j2}T_{j2}, L_{j3}I_{j2}, L_{j4}F_{j2})$	…	$(H_{j1}, H_{j2}T_{jm}, H_{j3}I_{jm}, H_{j4}F_{jm})$

6. Step: Calculate the Euclidean similarity measure of each lawsuit of the defendants in Table.1 with the ideal set.

Table 2. Table of the Euclidean similarity measure between the defendants and the ideal set

	d_1	d_2	…	d_m
S_1	$Q_E(\mathrm{J}(d_1), S_1(d_1))$	$Q_E(\mathrm{J}(d_2), S_1(d_2))$	…	$Q_E(\mathrm{J}(d_m), S_1(d_m))$
S_2	$Q_E(\mathrm{J}(d_1), S_2(d_1))$	$Q_E(\mathrm{J}(d_2), S_2(d_2))$	…	$Q_E(\mathrm{J}(d_m), S_2(d_m))$
. . .	. . .	. . .	… . .	. . .
S_j	$Q_E(\mathrm{J}(d_1), S_j(d_1))$	$Q_E(\mathrm{J}(d_2), S_j(d_2))$	…	$Q_E(\mathrm{J}(d_m), S_j(d_m))$

7. Step: Multiply the similarity measure in Table 2 with the weight value in the k-th column. In Table 3, the similarity value of the j-th defendant to the ideal set is measured by $Q_{Ej}(J, S_j) = \sum_{k=1}^{m} v_k \, . \, Q_E(\mathrm{J}(d_k), S_j(d_k))$.

Table 3. Table of weighted similarity of the lawsuits and the ideal set

	$v_1 d_1$	$v_2 d_2$	…	$v_m d_m$	$\sum_{k=1}^{n} v_k \, . \, S_E(\mathrm{J}(d_k), S_j(d_k))$
S_1	$v_1 . Q_E(\mathrm{J}(d_1), S_1(d_1))$	$v_2 . Q_E(\mathrm{J}(d_2), S_1(d_2))$	…	$v_m . Q_E(\mathrm{J}(d_m), S_1(d_m))$	$Q_{E1}(\mathrm{J}, S_1)$
S_2	$v_1 . Q_E(\mathrm{J}(d_1), S_2(d_1))$	$v_2 . Q_E(\mathrm{J}(d_2), S_2(d_2))$	…	$v_m . Q_E(\mathrm{J}(d_m), S_2(d_m))$	$Q_{E2}(\mathrm{J}, S_2)$
. . .	. . .	. . .	… . .	. . .	. . .
S_j	$v_1 . Q_E(\mathrm{J}(d_1), S_j(d_1))$	$v_2 . Q_E(\mathrm{J}(d_2), S_j(d_2))$	…	$v_m . Q_E(\mathrm{J}(d_m), S_j(d_m))$	$Q_{Ej}(\mathrm{J}, S_j)$

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Example 3.1: First, the set of lawsuits is determined. The weight values of these lawsuits, that is, the size of the damage caused by the lawsuit, are determined. The ideal set of decisions to be made for cases is given. This ideal set is given as our ideal decision set. In order to give final decisions to the cases, the set of the relevant defendants is determined. The lawsuits for which a decision is sought for each of the defendants are written as generalized set-valued neutrosophic quadruple numbers. A table is formed to show the decisions of each lawsuits for each defendants. The similarity value between the decisions given to these defendants and the ideal decisions is calculated. This similarity value obtained is multiplied by the weight value of each case. Thus, the weighted similarity value is calculated. The similarity values of the decisions made in the cases where the defendants are tried are found by adding the weighted similarity values of each defendant.

1. Step: Let the set of lawsuits be D ={violence, burglary, forest fire}

2. Step: Let the weight values of the lawsuits be

0.3 for violence,

0.2 for burglary and

0.5 for forest fire.

3. Step:

For the generalized set valued neutrosophic quadruple number

$J=$ {violence:({aggravated life imprisonment, imprisonment},{imprisonment, suspension}1,∅0, ∅0),burglary:({imprisonment, fine},{imprisonment, fine}1, ∅0, ∅0),forest fire:({imprisonment},{imprisonment, fine}1, ∅0, ∅0)},

decision for the violence lawsuit according to the constitution {aggravated life imprisonment, imprisonment}, decision with respect to the conditions of the case and the defendant ({imprisonment, suspension}1,∅0, ∅0), decision for the burglary lawsuit according to the constitution {imprisonment, fine}, decision with respect to the conditions of the case and the defendant ({imprisonment, fine}1, ∅0, ∅0),

decision for the forest fire lawsuit according to the constitution {imprisonment}, decision with respect to the conditions of the case and the defendant ({imprisonment, fine}1, ∅0, ∅0) and let

K ={suspension, imprisonment, acquitment, aggravated life sentence},

L ={imprisonment, fine, acquitment},

H ={imprisonment, fine} .

4. Step: Let the set of the defendants be = $\{S_1, S_2, S_3, S_4\}$.

S_1 ={violence:({imprisonment,suspension},{acquitment,suspension}(0.4),{acquitment}(0.3),{aggravated life sentence}(0.3)),

burglary: ({fine},{imprisonment, fine}(0.3),{acquitment, imprisonment}(0.2), {acquitment}(0.5)),

forest fire: ({fine},{imprisonment}(0.1),{imprisonment, fine}(0.2), ∅ (0.7))}.

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S_2 ={violence:({suspension, aggravated life sentence},{acquitment, imprisonment} (0.4),{aggravated life sentence}(0.2),{acquitment}(0.4)),
burglary: ({imprisonment},{fine}(0.6), ∅ (0.2),{acquitment}(0.2)),
forest fire: ({imprisonment, fine},{imprisonment}(0.5),{fine}(0.3), ∅ (0.2))}.

S_3 ={violence:({imprisonment, aggravated life sentence},{imprisonment}(0.6), {aggravated life sentence}(0.1),{aggravated life sentence, acquitment}(0.3)),
burglary:({fine},{imprisonment}(0.2),{acquitment, imprisonment}(0.5),{acquitment, fine}(0.3)),
forest fire: ({fine},{imprisonment}(0.2),{fine}(0.3), {imprisonment, fine}(0.5))}.

S_4 ={violence:({suspension},{imprisonment}(0.1),{aggravated life sentence}(0.7), {acquitment, suspension}(0.2)),
burglary:({imprisonment}, ∅(0.3),{fine}(0.5),{acquitment, imprisonment}(0.2)),
forest fire: ({imprisonment},{imprisonment}(0.8),{fine}(0.1), {imprisonment, fine} (0.1))}.

5. Step: Show the decisions for the defendants on a table.

Table 1. Table of decisions

	violence	burglary	forest fire
S_1	({imprisonment,suspension}, {acquitment,suspension}(0.4), {acquitment}(0.3), {aggravated life sentence}(0.1))	({fine}, {imprisonment, fine}(0.3), {acquitment, imprisonment}(0.2), {acquitment}(0.4))	({fine}, {imprisonment}(0.1), {imprisonment, fine}(0.2), ∅ (0.5))
S_2	({suspension, aggravated life sentence}, {acquitment, imprisonment}(0.3), {aggravated life sentence}(0.2), {acquitment}(0.1))	({imprisonment}, {fine}(0.6), ∅ (0.2), {acquitment}(0.1))	({imprisonment, fine}, {imprisonment}(0.5), {fine}(0.3), ∅ (0.1))

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S_3	({imprisonment,aggravated life sentence}, {imprisonment}(0.6), {aggravated life sentence}(0.1), {aggravated life sentence, acquitment }(0.3))	({para cezası}, {imprisonment}(0.2), {acquitment, imprisonment}(0.5), {acquitment,fine}(0.3))	({fine}, {imprisonment}(0.2), {fine}(0.3), {imprisonment, fine}(0.5))
S_4	({suspension}, {imprisonment}(0.1), {aggravated life sentence}(0.7), {acquitment,suspension}(0.2))	({imprisonment}, ∅ (0.3), {fine}(0.5), {acquitment, imprisonment}(0.2))	({imprisonment}, {imprisonment}(0.8), {fine}(0.1), {imprisonment, fine} (0.1))

6. Step: Calculate the similarity value between the given and ideal decisions.

Table 2. Table of similarity between the given and ideal decisions

	violence	burglary	forest fire
S_1	0,3435	0,3713	0,3047
S_2	0,3435	0,5131	0,4797
S_3	0,4713	0,3003	0,2656
S_4	0,2322	0,2989	0,5380

7. Step: Now, we multiply each similarity value of the k-th column with the k-th weight value (k=1,2,…,m). By adding the weighted similarity values of each defendant in Table 3, we get the similarity between the given decisions and the ideal decisions.

Table 3. Table of weighted similarity between the given and ideal decisions

	(0,3).violence	(0,2).burglary	(0,5).forest fire	$\sum_{k=1}^{3} v_k \cdot Q_E(\mathrm{K}(d_k), S_j(d_k))$
S_1	0,1030	0,0742	0,1523	$Q_{E1}(J, S_1) = 0{,}3295$

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S_2	0,1030	0,1026	0,2398	$Q_{E2}(J, S_2) = 0{,}4454$
S_3	0,1413	0,0600	0,1328	$Q_{E3}(J, S_3) = 0{,}3341$
S_4	0,0696	0,0597	0,2690	$Q_{E4}(J, S_4) = 0{,}3983$

$$S_2 > S_4 > S_3 > S_1$$

After the calculations, we see that the most accurate decision is given to S_2 and has a similarity value of 0,4454.

Example 3.2:

1. Step: Let the set of the lawsuits be D ={divorce, arson, fraud, breaching an information system, plagiarism}.

2. Step: Let the weights of these lawsuits be

0.1 for the divorce,

0.2 for the arson,

0.1 for fraud,

0.3 for breaching the information system and

0.3 for plagiarism.

3. Step:

For the generalized set valued neutrosophic quadruple number

J = { divorce:({compensation},{fine, suspension}1,∅0, ∅0),

arson:({aggravated life sentence, imprisonment},{ life sentence, imprisonment, fine}1, ∅0, ∅0),

fraud:({life sentence, fine},{imprisonment, acquitment}1, ∅0, ∅0),

breaching the information system:({life sentence, imprisonment},{aggravated life sentence, acquitment}1, ∅0, ∅0),

plagiarism:({imprisonment, fine},{acquitment, fine}1, ∅0, ∅0)},

decision for the violence lawsuit according to the constitution {compensation}, decision with respect to the conditions of the case and the defendant ({fine, suspension}1,∅0, ∅0),

decision for the arson lawsuit according to the constitution {aggravated life sentence, imprisonment}, decision with respect to the conditions of the case and the defendant ({life sentence, imprisonment, fine}1, ∅0, ∅0),

decision for the arson lawsuit according to the constitution {life sentence, fine}, decision with respect to the conditions of the case and the defendant ({imprisonment, acquitment}1, ∅0, ∅0),

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decision for the breaching the information systems lawsuit according to the constitution {life sentence, imprisonment}, decision with respect to the conditions of the case and the defendant ({aggravated life sentence, acquitment}1, ∅0, ∅0),

decision for the plagiarism lawsuit according to the constitution {imprisonment, fine}, decision with respect to the conditions of the case and the defendant ({acquitment, fine}1, ∅0, ∅0) and let

K ={compensation, fine, suspension} ,

L ={imprisonment, fine, life sentence, aggravated life sentence},

H ={imprisonment, fine, life sentence, acquitment},

M ={imprisonment, life sentence, aggravated life sentence, acquitment},

N ={imprisonment, fine, acquitment}.

4. Step: Let the set of defendants be $S = \{S_1, S_2, S_3, S_4, S_5, S_6, S_7\}$.

S_1 ={divorce:({compensation,fine},{compensation}(0.5),{fine}(0.3),{suspension} (0.2)),
arson:({fine},{aggravated life sentence}(0.1),{life sentence}(0.6), {imprisonment} (0.3)),
fraud:({fine},{imprisonment, fine,acquitment}(0.4),{acquitment}(0.2),{life sentence} (0.4)),
breaching the information systems: ({life sentence,aggravated life sentence}, {aggravated life sentence, acquitment}(0.5),{acquitment}(0.1),{aggravated life sentence}(0.4)),
plagiarism:({fine},{acquitment,fine}(0.8),{acquitment}(0.2), ∅0)}.

S_2 ={divorce:({suspension},{fine}(0.3),{compensation,suspension}(0.6), {suspension}(0.1)),
arson:({aggravated life sentence},{life sentence}(0.6),{life sentence,imprisonment} (0.2),{fine}(0.2)),
fraud:({imprisonment},{imprisonment,life sentence}(0.4),{fine}(0.3),{life sentence} (0.3)),
breaching the information systems: ({acquitment, imprisonment},{acquitment,life sentence,imprisonment}(0.3),{aggravated life sentence, acquitment}(0.5), {acquitment,life sentence}(0.2)),
plagiarism:({fine,imprisonment},{acquitment}(0.2),{imprisonment}(0.4), {fine,acquitment}(0.4))}.

S_3 ={divorce:({suspension},{compensation,suspension}(0.7),{fine}(0.2), {suspension}(0.1)),
arson:({fine,life sentence},{life sentence, aggravated life sentence}(0.4),{fine}(0.3), {imprisonment}(0.3)),
fraud:({fine},{acquitment}(0.7),{fine, acquitment}(0.2), ∅(0.1)),
breaching the information systems: ({imprisonment}, {acquitment}(0,6), ∅(0.3), {life sentence}(0.1)),
plagiarism:({imprisonment},{acquitment,fine}(0.2),{fine,imprisonment}(0.6), {imprisonment, acquitment}(0.2))}.

S_4 ={divorce:({compensation,fine,suspension},{compensation}(0.4),{suspension} (0.3), fine}(0.3)),
arson:({imprisonment, aggravated life sentence}, {life sentence, imprisonment}(0.5), {fine}(0), ∅(0.5)),
fraud:({acquitment, fine},{imprisonment, life sentence}(0.2), {imprisonment}(0.5), {acquitment}(0.3)),
breaching the information systems: ({imprisonment, acquitment},{acquitment}(0.6), {aggravated life sentence, life sentence }(0.3), {imprisonment}(0.1)),
plagiarism:({fine,acquitment},{fine}(0.7),{fine,imprisonment}(0.2), {acquitment}(0.1))}.

S_5 ={divorce:({compensation,suspension},{fine,compensation}(0.4),∅(0.4), {compensation}(0.2)),
arson:({imprisonment, life sentence, fine},{fine}(0.1),{aggravated life sentence, life sentence}(0.4), ∅(0.5)),

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fraud:({fine,life sentence},{imprisonment}(0.3),{life sentence,fine, imprisonment} (0.2),{fine, acquitment}(0.5)), breaching the information systems:({aggravated life sentence, imprisonment, life sentence},∅(0.8),{aggravated life sentence}(0.1),(acquitment)(0.1)),
plagiarism:({imprisonment,acquitment},{imprisonment, fine,acquitment}(0.3),
{fine, acquitment}(0.7), {imprisonment, acquitment}(0))}.

S_6 ={divorce:({suspension},{fine}(0.6),{fine,suspension}(0.1), {compensation,fine} (0.3)),
arson:(∅,{fine, life sentence}(0.2),{imprisonment}(0.2), {life sentence, aggravated life sentence}(0.6)),
fraud:({imprisonment, life sentence},{imprisonment}(0.5),{life sentence,fine}(0.2), {imprisonment, acquitment}(0.3)),
breaching the information systems:({acquitment},{acquitment, imprisonment}(0.7), {aggravated life sentence,life sentence}(0.2),(acquitment)(0.1)),
plagiarism:({imprisonment},{fine}(0.3),{fine,imprisonment}(0.1),{acquitment} (0.6))}.

S_7 ={divorce:({compensation,fine},{fine,suspension}(0.3),{suspension}(0.6), {compensation}(0.1)),
arson:({life sentence},{imprisonment,aggravated life sentence}(0.2),{fine,life sentence}(0.4),{imprisonment, fine}(0.4)),
fraud:({acquitment},{fine,acquitment}(0.3),{imprisonment}(0.5),{fine}(0.2)), breaching the information systems:({imprisonment},{imprisonment,life sentence} (0.5),{imprisonment}(0),(aggravated life sentence)(0.5)),
plagiarism:({imprisonment, fine},{fine}(0.4),∅(0.5),{imprisonment}(0.1))}.

5. Step: Show the decisions for the defendants on a table.

Table 1. Table of decisions

	divorce	arson	fraud	breaching the information systems	plagiarism
S_1	({compensation, fine}, {compensation}(0.5), {fine}(0.3), {suspension}(0.2))	({fine}, {aggravated life sentence}(0.1), {life sentence}(0.6), {imprisonment}(0.3))	({fine}, {imprisonment, fine, acquitment}(0.4), {acquitment}(0.2), {life sentence}(0.4))	({life sentence, aggravated life sentence}, {aggravated life sentence}, acquitment}(0.5), {acquitment}(0.1),	({fine}, {acquitment, fine}(0.8), {acquitment}(0.2), ∅0)

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				{aggravated life sentence}(0.4))	
S_2	({suspension}, {fine}(0.3), {compensation, suspension}(0.6), {suspension}(0.1))	({aggravated life sentence}, {life sentence} (0.6), {life sentence, imprisonment}(0.2), {fine}(0.2))	({imprisonment}, {imprisonment, life sentence}(0.4), {fine}(0.3), {life sentence}(0.3))	({acquitment, imprisonment}, {acquitment,life sentence, imprisonment}(0. 3) {aggravated life sentence, acquitmentt}(0.5), {acquitment,life sentence} (0.2))	({fine, imprisonment} {acquitment} (0.2), {imprisonment} (0.4), {fine,acquitment }(0.4))
S_3	({suspension}, {compensation,suspen sion}(0.7), {fine}(0.2), {suspension}(0.1))	({fine,life sentence}, {life sentence,aggrav ated life sentence}(0.4), {fine} (0.3), {imprisonment} (0.3))	({fine}, {acquitment}(0.7), {fine,acquitment} (0.2), ∅(0.1))	({imprisonment}, {acquitment}(0,6) ∅(0.3), {life sentence}(0.1))	({imprisonment}, {acquitment, fine}(0.2), {fine, imprisonment} (0.6), {imprisonment, acquitment} (0.2))
S_4	({compensation,fine, suspension}, {compensation}(0.4), (suspension)(0.3), {fine}(0.3))	({imprisonment, aggravated life sentence}, {life sentence,impris onment} (0.5), {fine} (0), ∅(0.5))	({acquitment,fine} , {imprisonment,life sentence}(0.2), {life sentence} (0.5), {acquitment} (0.3))	({imprisonment, acquitment}, {acquitment}(0.6) , {aggravated life sentence, life sentence}(0.3), {imprisonment} (0.1))	({fine,acquitment }, {fine} (0.7), {fine,imprisonme nt}(0.2), {acquitment}(0.1))

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S_5	({compensation,suspension}, {fine,compensation}(0.4), ∅(0.4), {compensation}(0.2))	({imprisonment, life sentence,fine}, {fine}(0.1), {aggravated life sentence,life sentence}(0.4), ∅(0.5))	({fine, life sentence}, {imprisonment}(0.3), {life sentence,fine, imprisonment}(0.2), {fine,acquitment}(0.5))	({aggravated life sentence,imprisonment,life sentence}, ∅(0.8), {aggravated life sentence} (0.1), (acquitment)(0.1))	({imprisonment, acquitment}, {imprisonment, fine,acquitment}(0.3), {fine,acquitment} (0.7), {imprisonment, acquitment}(0))
S_6	({suspension}, {fine}(0.6), {fine,suspension}(0.1), {compensation,fine}(0.3))	(∅, {fine,life sentence} (0.2), {imprisonment}(0.2), {life sentence, aggravated life sentence}(0.6))	({imprisonment, life sentence}, {imprisonment}(0.5), {life sentence,fine}(0.2), {imprisonment,acquitment} (0.3))	({acquitment}, {acquitment, imprisonment}(0.7), {aggravated life sentence}(0.2), (acquitment)(0.1))	({imprisonment}, {fine}(0.3), {fine,imprisonment}(0.1), {acquitment}(0.6))
S_7	({compensation,fine}, {fine,suspension}(0.3), {suspension}(0.6), {compensation}(0.1))	({life sentence}, {imprisonment, aggravated life sentence}(0.2), {fine, life sentence}(0.4), {imprisonment, fine}(0.4))	({acquitment}, {fine, acquitment}(0.3), {imprisonment}(0.5), {fine}(0.2))	({imprisonment}, {imprisonment, life sentence}(0.5), {imprisonment}(0), (aggravated life sentence)(0.5))	({imprisonment, fine}, {fine}(0.4), ∅(0.5), {imprisonment}(0.1))

6. Step: Calculate the similarity value between the given and ideal decisions.

Table 2. Table of similarity between the given and ideal decisions

	divorce	arson	fraud	breaching the	plagiarism

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				information systems	
S_1	0,1718	0,2000	0,4614	0,4250	0,6271
S_2	0,2989	0,4458	0,3212	0,3045	0,3380
S_3	0,4435	0,3158	0,5464	0,5131	0,3380
S_4	0,3212	0,5446	0,2768	0,4217	0,4551
S_5	0,4320	0,3113	0,3713	0,4768	0,3336
S_6	0,3989	0,2768	0,3884	0,4212	0,2666
S_7	0,3713	0,2492	0,2879	0,3656	0,4938

7. Step: We multiply each similarity value of the k-th column with the k-th weight value (k=1,2,…,m). By adding the weighted similarity values of each defendant in Table 3, we get the similarity between the given decisions and the ideal decisions.

Table 3. Table of weighted similarity between the given and ideal decisions

	(0,1).divorce	(0,2).arson	(0,1).fraud	(0,3).breaching the information systems	(0,3).plagiarism	$\sum_{k=1}^{5} v_k \cdot Q_E(\mathrm{K}(d_k),S_j(d_k))$
S_1	0,0171	0,0400	0,0461	0,1275	0,1881	$Q_{E1}(J,S_1) = 0,4188$
S_2	0,0298	0,0891	0,0321	0,0913	0,1014	$Q_{E2}(J,S_2) = 0,3437$
S_3	0,0443	0,0631	0,0546	0,1539	0,1014	$Q_{E3}(J,S_3) = 0,4173$
S_4	0,0321	0,1089	0,0276	0,1265	0,1365	$Q_{E4}(J,S_4) = 0,4316$
S_5	0,0432	0,0622	0,0371	0,1430	0,1000	$Q_{E5}(J,S_5) = 0,3855$
S_6	0,0398	0,0553	0,0388	0,1263	0,0799	$Q_{E6}(J,S_6) = 0,3401$
S_7	0,0371	0,0498	0,0287	0,1096	0,1481	$Q_{E7}(J,S_7) = 0,3733$

$$S_4 > S_1 > S_3 > S_5 > S_7 > S_2 > S_6$$

After the calculations, we see that the most accurate decision is given to S_4 and has a similarity value of 0,4316.

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4. Conclusion

In this article, an algorithm structure has been introduced in order to eliminate the problems that occur in many jurisprudential decision-making situations such as transferring the decisions to the higher courts, appeals against the decisions, and the judges' adding their own opinions. The aim of this algorithm is to enable the judges to easily make changes in their decisions by finding similarity values with respect to an ideal decision-making set consisting of the decisions that the judges have to make according to the law, taking into account each case and the situation of each defendant. In this case, there will be no problems such as objections to the judges' decisions or making decisions merely with their own conscience. In addition, although there is a definite penalty for each crime according to the laws in the legal sense, the introduced algorithm will speed up and facilitate the decision making of the judges by considering other possibilities such as remedial penalties. In this article, some numerical examples are given to make the algorithm more understandable. By all means, the number of defendants, the number of cases, the number of decision sets can be increased as much as desired.

Abbreviations

NQN: Neutrosophic quadruple numbers

NQS: Neutrosophic quadruple sets

SVNQN: Set valued neutrosophic quadruple numbers

SVNQS: Set valued neutrosophic quadruple sets

GNQN: Generalized neutrosophic quadruple numbers

GSVNQN: Generalized set valued neutrosophic quadruple numbers

GSVNQS: Generalized set valued neutrosophic quadruple sets

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