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Medical Diagnosis by Roughness-Cosine Similarity Measure in Rough Neutrosophic Set Environment

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Abstract: Diagnosing the types of disease before treatment starts is the most important task for medical staff. Usually, a patient's disease is investigated based on the symptoms that exist such as temperature records for viral fever and stomach pain for malaria. Therefore, in this research, relationships between patients' records and symptoms and disease and symptoms were analyzed using the roughness-Cosine similarity measure. For a more presentable result, the rough neutrosophic set was used in the development of the proposition for the roughness-Cosine similarity measure. All the data collected were also represented in a rough neutrosophic set environment where lower and upper approximations exist. The comparative result indicates that all the patients were suffering from viral fever.

Keywords: Cosine similarity, Medical diagnosis, Rough neutrosophic, Roughness measure

1 Introduction

Information collected for medical diagnosis is according to real observations based on symptoms that appear from a patient when meeting a doctor. Then, the symptoms are investigated to identify the type of disease. Lastly, a medical report is completed. The record of the relationship between patient and symptoms, and disease and symptoms are risky data for medical staff. All the procedures involved in diagnosing medical problems can be described as risk investigation [1]. In the meantime, the data of medical findings are collected and represented in uncertainty set theory. Smarandache [2] introduced the neutrosophic set theory as a generalization of fuzzy set [3] and intuitionistic set theory [4]. Next, Wang et al. [5] improved the neutrosophic set to be more applicable in data collection and introduced a single-valued neutrosophic set. This uncertainty set theory [1-4] is only used for a single set data. A fuzzy set and intuitionistic fuzzy set can describe a truth membership and falsity membership functions by itself, and a neutrosophic set has an added indeterminacy membership functions for uncertainty conditions.

There is also an uncertainty condition involving belongingness set data which is the relationship between lower and upper approximations. Therefore, Broumi et al. [6] introduced the rough neutrosophic set by describing the lower approximation as sure belongingness, and the upper approximation as possible belongingness in a single set of data. For multiple set of data, Alias et al. [7] introduced the rough neutrosophic multisets. In addition, all the information collected is more precise and suitable to represent the medical report. In [8], the Pi-distance method was employed in identifying the disease. In [9], the medical pattern is proposed in relation to ranking correlation with the multiplicative simplified refined set environment. The patient is observed multiple times to get an accurate result and a better treatment. Besides that, Pramanik and Mondal [10] studied the Cosine similarity measure for rough neutrosophic set and applied it to medical diagnosis. The medical data collected is represented in a rough neutrosophic environment. In [8-10], all the relations between lower and upper approximations were determined by the average mean operator.

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Then, Alias et al. [11] introduced a roughness measure and extended Hausdorff distance measure for rough neutrosophic set data to get the proper medical diagnosis. This paper introduced the roughness measure for the lower and upper approximations of the rough neutrosophic set. The accuracy between these two approximations were also determined since the accuracy and roughness complement each other. Motivation for the roughness measure is from Pawlak's roughness measure [12] for a rough set. Then, Alias et al. [13] extended the application of roughness theory for rough neutrosophic multiset. The Dice and improved Cosine similarity measure for rough neutrosophic multisets is discussed in this paper.

The motivation from roughness measure theory [11] and the Cosine similarity measure of the rough neutrosophic set [10] were combined to introduce the roughness-Cosine similarity measure for this research. There are two main objectives underlying this study. First is to introduce a definition of similarity measure for a rough neutrosophic set. The proposed definition involves the roughness measure since the rough neutrosophic set has a lower and upper approximations. The theory is a generalization of the Cosine similarity measure of a rough neutrosophic set [10]. The second objective is to propose a medical procedure by applying the proposed roughness-Cosine similarity measure. By using the proposed procedure, a diagnosis of the patient's disease according to the symptoms that appear can be made.

The layout of the rest of this paper is presented as follows: In Section 2, some preliminaries of the uncertainty theory set of a single-valued neutrosophic set, rough neutrosophic set, Cosine similarity measure of a rough neutrosophic set, and roughness measure by rough neutrosophic set are given. In Section 3, the methodology phases are explained and a methodology flowchart is given for better understanding. Two phases were involved in this research. In Section 4, a proposition for a proposed roughness-similarity measure was proven completely, and the implementation of the medical procedure is shown as a result and discussion. Also, a comparative analysis is presented to demonstrate the theory's effectiveness. In Section 5, the conclusion of this study is summarized.

2 Preliminaries

This section recalled some important definition used in this research. All the basic properties and propositions are referred to in [1-6] and [10-11].

A Uncertainty Set Theory

Definition 2.1 Single-valued neutrosophic set (Smarandache [2], Wang et al. [5]):
Let X be a space of points (objects) with generic elements in X denoted by x. A single valued neutrosophic set A is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. For each point x in X, $T_A(x), I_A(x), F_A(x) \in [0,1]$. A single valued neutrosophic set A can be written as:

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

Definition 2.2 Rough neutrosophic set (Broumi et al. [6]):
Let U be a non-null set and R be an equivalence relation on U. Let A be neutrosophic set in U with the truth membership function T_A, indeterminacy function I_A, and non-membership function F_A. The lower and the upper approximations of A in the approximation (U, R) denoted by $\underline{N}(A)$ and $\overline{N}(A)$ are respectively defined as follows:

$$\underline{N}(A) = \left\{\langle x_j, T_{\underline{N}(A)}(x_j), I_{\underline{N}(A)}(x_j), F_{\underline{N}(A)}(x_j)\rangle | \, y \in [x_j]_R, j \in \mathbb{Z}^+, x_j \in U\right\}, \text{ and}$$
$$\overline{N}(A) = \left\{\langle x_j, T_{\overline{N}(A)}(x_j), I_{\overline{N}(A)}(x_j), F_{\overline{N}(A)}(x_j)\rangle | \, y \in [x_j]_R, j \in \mathbb{Z}^+, x_j \in U\right\}$$

where
$j = 1, 2, \ldots, q$ is a positive integer, $T_{\underline{N}(A)}(x_j) = \wedge_{y\in[x_j]_R} T_A(y_j)$, $I_{\underline{N}(A)}(x_j) = \vee_{y\in[x_j]_R} I_A(y_j)$, $F_{\underline{N}(A)}(x_j) = \vee_{y\in[x_j]_R} F_A(y_j)$, $T_{\overline{N}(A)}(x_j) = \vee_{y\in[x_j]_R} T_A(y_j)$, $I_{\overline{N}(A)}(x_j) = \wedge_{y\in[x_j]_R} I_A(y_j)$, and $F_{\overline{N}(A)}(x_j) = \wedge_{y\in[x_j]_R} F_A(y_j)$.

Here, $\wedge$ and $\vee$ denote "min" and "max'' operators, respectively, and $[x_j]_R$ is the equivalence class of the x_j. The $T_A(y_j)$, $I_A(y_j)$and $F_A(y_j)$ are the truth membership, indeterminacy membership, and falsity membership of y concerning A. The truth membership set $[T_{\underline{N}(A)}(x_j), T_{\overline{N}(A)}(x_j)]$, indeterminacy membership set $[I_{\underline{N}(A)}(x_j), I_{\overline{N}(A)}(x_j)]$, and falsity of membership $[F_{\underline{N}(A)}(x_j), F_{\overline{N}(A)}(x_j)]$ for lower and upper approximations of RNS may be in decreasing or increasing order.

Definition 2.3 Complement properties of rough neutrosophic set (Broumi et al. [6]):
If $N(A)$ is a rough neutrosophic set in (U, R), the rough complement of $N(A)$ is the rough neutrosophic set denoted by $\sim N(A) = (\underline{N}(A))^C, (\overline{N}(A))^C)$, where $(\underline{N}(A))^C$ and $(\overline{N}(A))^C$ are the complements of the neutrosophic set $\left(\underline{N}(A), \overline{N}(A)\right)$, respectively, given by:

$$\sim N(A) = \left((\underline{N}(A))^C, (\overline{N}(A))^C\right) = \left\{\left\langle x_j, \begin{pmatrix} [F_{\underline{N}(A)}(x_j), 1 - I_{\underline{N}(A)}(x_j), T_{\underline{N}(A)}(x_j)], \\ [F_{\overline{N}(A)}(x_j), 1 - I_{\overline{N}(A)}(x_j), T_{\overline{N}(A)}(x_j)] \end{pmatrix} \right\rangle \middle| \, x_j \in U \right\}$$

B Similarity Measure for Rough Neutrosophic Set

Definition 2.4 Cosine similarity measure (Pramanik & Mondal [10]):

Assume that A and B are any two rough neutrosophic sets in the universe of discourse U as follows:

$$A = \left\{\left\langle x_j, \begin{pmatrix} [T_{\underline{N}(A)}(x_j), I_{\underline{N}(A)}(x_j), F_{\underline{N}(A)}(x_j)], \\ [T_{\overline{N}(A)}(x_j), I_{\overline{N}(A)}(x_j), F_{\overline{N}(A)}(x_j)] \end{pmatrix} \right\rangle \middle| \, x_j \in U \right\} \text{ and}$$

$$B = \left\{\left\langle x_j, \begin{pmatrix} [T_{\underline{N}(B)}(x_j), I_{\underline{N}(B)}(x_j), F_{\underline{N}(B)}(x_j)], \\ [T_{\overline{N}(B)}(x_j), I_{\overline{N}(B)}(x_j), F_{\overline{N}(B)}(x_j)] \end{pmatrix} \right\rangle \middle| \, x_j \in U \right\}.$$

Then, a Cosine similarity measure between two rough neutrosophic sets A and B are defined as follows:

$$S_C(A, B) = \frac{1}{n}\sum_{j=1}^{n}\left[\frac{\Delta T_A(x_j)\Delta T_B(x_j) + \Delta I_A(x_j)\Delta I_B(x_j) + \Delta F_A(x_j)\Delta F_B(x_j)}{\left(\sqrt{\Delta T_A(x_j)^2 + \Delta I_A(x_j)^2 + \Delta F_A(x_j)^2}\right)\left(\sqrt{\Delta T_B(x_j)^2 + \Delta I_B(x_j)^2 + \Delta F_B(x_j)^2}\right)}\right]$$

where

$$\Delta T_A(x_j) = \frac{T_{\underline{N}(A)}(x_j) + T_{\overline{N}(A)}(x_j)}{2}, \Delta I_A(x_j) = \frac{I_{\underline{N}(A)}(x_j) + I_{\overline{N}(A)}(x_j)}{2}, \Delta F_A(x_j) = \frac{F_{\underline{N}(A)}(x_j) + F_{\overline{N}(A)}(x_j)}{2},$$

$$\Delta T_B(x_j) = \frac{T_{\underline{N}(B)}(x_j) + T_{\overline{N}(B)}(x_j)}{2}, \Delta I_B(x_j) = \frac{I_{\underline{N}(B)}(x_j) + I_{\overline{N}(B)}(x_j)}{2}, \Delta F_B(x_j) = \frac{F_{\underline{N}(B)}(x_j) + F_{\overline{N}(B)}(x_j)}{2}.$$

Proposition 1. The similarity measure $S_C(A,B)$ for rough neutrosophic sets A and B satisfies the following properties:

(S1) $0 \leq S_C(A,B) \leq 1$;
(S2) $S_C(A,B) = 1$ if and only if $A = B$;
(S3) $S_C(A,B) = S_C(B,A)$;
(S4) $S_C(A,C) \leq S_C(A,B)$ and $S_C(A,C) \leq S_C(B,C)$ if C is neutrosophic set in X and $A \subseteq B \subseteq C$.

Each of the proving development for Proposition 1 is referred from [4].

C Roughness Approximation for Rough Neutrosophic Set.

Definition 2.5 (Alias et al. [11]**)**: Assume that A and B be any two rough neutrosophic sets in the universe of discourse X. ρ denotes the "roughness approximation" operator by roughly approximating between the lower and upper approximations of rough neutrosophic sets, A and B while $|X|$ is the cardinality of the universal X, as followed:

$$\rho T_{N(A)}(x_j) = 1 - \left(\frac{T_{\underline{N}(A)}(x_j) + \left(T_{\overline{N}(A)}(x_j)\right)^C}{|X|}\right), \rho T_{N(B)}(x_j) = 1 - \left(\frac{T_{\underline{N}(B)}(x_j) + \left(T_{\overline{N}(B)}(x_j)\right)^C}{|X|}\right),$$

$$\rho I_{N(A)}(x_j) = 1 - \left(\frac{I_{\underline{N}(A)}(x_j) + \left(I_{\overline{N}(A)}(x_j)\right)^C}{|X|}\right), \rho I_{N(B)}(x_j) = 1 - \left(\frac{I_{\underline{N}(B)}(x_j) + \left(I_{\overline{N}(B)}(x_j)\right)^C}{|X|}\right),$$

$$\rho F_{N(A)}(x_j) = 1 - \left(\frac{F_{\underline{N}(A)}(x_j) + \left(F_{\overline{N}(A)}(x_j)\right)^C}{|X|}\right), \text{ and } \rho F_{N(B)}(x_j) = 1 - \left(\frac{F_{\underline{N}(B)}(x_j) + \left(F_{\overline{N}(B)}(x_j)\right)^C}{|X|}\right).$$

Such that $\rho T_{N(A)}(x_j), \rho I_{N(A)}(x_j), \rho F_{N(A)}(x_j), \rho T_{N(B)}(x_j), \rho I_{N(B)}(x_j), \rho F_{N(B)}(x_j) \in [0,1]$, and for $j = 1,2,\dots,n$.

3 Methodology

In section research, there are two different phases of methodology that need to be considered. Phase one (1) is the technical part, which is the development of the proposition for the roughness-Cosine similarity measure. Meanwhile, phase two (2) is the application part, which is the development procedure of medical analysis in a rough neutrosophic set of environments. Figure 1 depicts the flowchart for the phases involved in this research.

A Phase 1: Development of the proposition for the roughness-Cosine similarity measure

The roughness measure of the rough neutrosophic sets by Alias et al. [11] as Definition 2.5 will be used to develop the roughness-Cosine similarity for a rough neutrosophic set. It is an improvised version of the Cosine similarity measure by Pramanik and Mondal [10] in Definition 2.4, where instead of the mean operator used for the lower and upper approximations of the rough neutrosophic set, the roughness measure between them is also considered.

B Phase 2: Development procedure used for medical diagnosis process by using a roughness-Cosine similarity measure of a rough neutrosophic set.

Three (3) steps were required under phase two (2) as follows:

Step 1: Converting the medical report into rough neutrosophic set (RNS)-data
The data collected from the medical report was converted into RNS-data by using Definition 2.2. The data from Pramanik and Mondal [10] and Alias et al. [11] were adopted as our medical report.

Step 2: The determination of the roughness-similarity measure of the RNS-data for a medical report
In this step, the roughness measure was determined and, simultaneously, the roughness-Cosine similarity measure was defined. RNS-data was used to determine the roughness-similarity measure for medical findings by using Definition 4.1 and Eq.(1).

Step 3: The determination of the medical finding by the ranking process
The medical finding for each patient is determined in Step 3. If the result for the similarity measure is closer to one, the patient may suffer from the disease or vice versa. Therefore, for the ranking result, the closest value to one is the highest possibility the patient suffers from a disease.

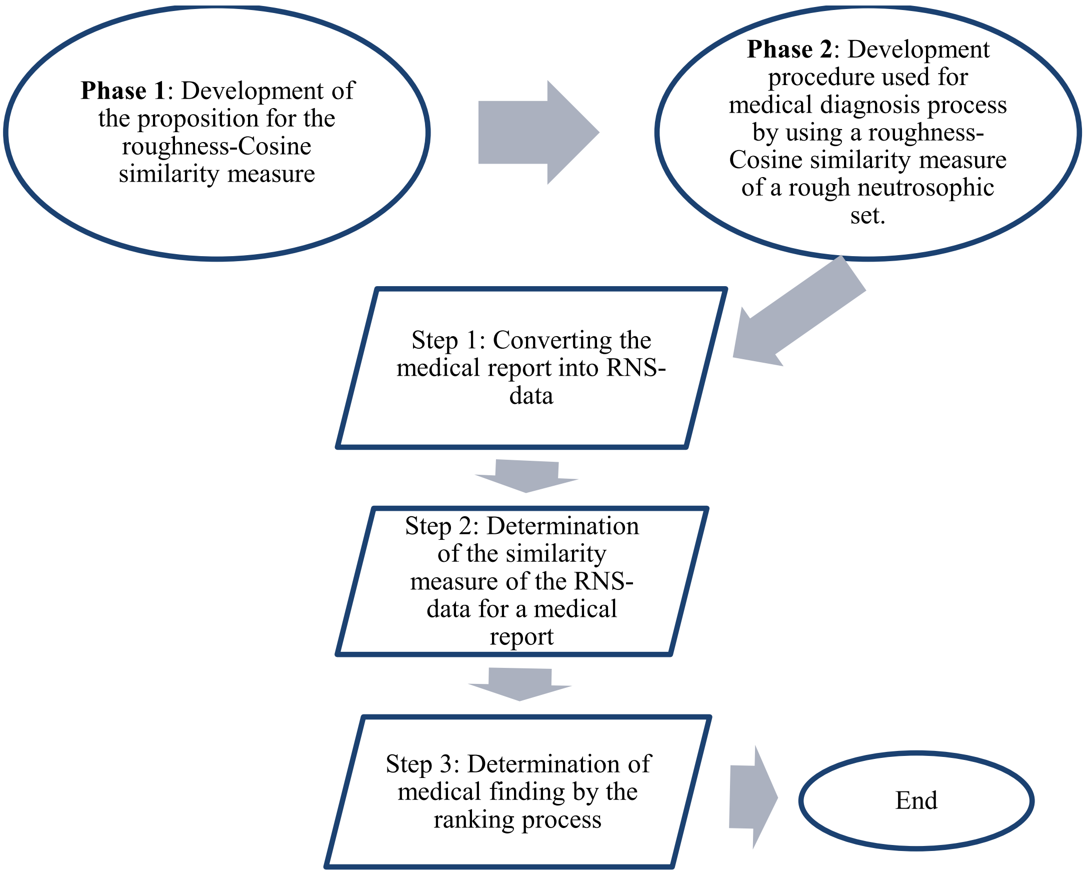

Figure 1: Flowchart for the phases involved in the methodology

4 Results and Discussion

This section introduced the roughness-similarity measure by satisfying Proposition 1 in Section 2. Then, the illustrative example is discussed as a procedure for diagnosing the patient's disease.

A Proposed roughness-Cosine similarity measure for a rough neutrosophic set

Referring to Phase 1, the proposed roughness-Cosine similarity measure for a rough neutrosophic set is defined as follows in Definitions 2.4 and 2.5:

Assume that A and B be any two rough neutrosophic sets in the universe of discourse U as follows:

$$A = \left\{ \left\langle x_j, \begin{pmatrix} [T_{\underline{N}(A)}(x_j), I_{\underline{N}(A)}(x_j), F_{\underline{N}(A)}(x_j)], \\ [T_{\overline{N}(A)}(x_j), I_{\overline{N}(A)}(x_j), F_{\overline{N}(A)}(x_j)] \end{pmatrix} \middle| x_j \in U \right\rangle \right\} \text{ and}$$

$$B = \left\{ \left\langle x_j, \begin{pmatrix} [T_{\underline{N}(B)}(x_j), I_{\underline{N}(B)}(x_j), F_{\underline{N}(B)}(x_j)], \\ [T_{\overline{N}(B)}(x_j), I_{\overline{N}(B)}(x_j), F_{\overline{N}(B)}(x_j)] \end{pmatrix} \middle| x_j \in U \right\rangle \right\}$$

Then, the roughness-Cosine similarity measure for RNS A and B is defined as:

Definition 4.1:

$$S_{rC}(A,B) = \frac{1}{n}\sum_{j=1}^{n}\left[\frac{\rho T_A(x_j)\rho T_B(x_j) + \rho I_A(x_j)\rho I_B(x_j) + \rho F_A(x_j)\rho F_B(x_j)}{\left(\sqrt{\rho T_A(x_j)^2 + \rho I_A(x_j)^2 + \rho F_A(x_j)^2}\right)\left(\sqrt{\rho T_B(x_j)^2 + \rho I_B(x_j)^2 + \rho F_B(x_j)^2}\right)}\right] \tag{1}$$

Here, ρ denotes the "roughness approximation" operator by rough approximation between the lower and upper approximations of rough neutrosophic set as Definition 2.5.

Proposition 2. The similarity measure $S_{rC}(A,B)$ for rough neutrosophic sets A and B satisfies the following properties:

(S1) $0 \le S_{rC}(A,B) \le 1$;
(S2) $S_{rC}(A,B) = S_{rC}(B,A)$;
(S3) $S_{rC}(A,B) = 1$ if and only if $A = B$;
(S4) $S_{rC}(A,C) \le S_{rC}(A,B)$ and $S_{rC}(A,C) \le S_{rC}(B,C)$ if C is neutrosophic set in X and $A \subseteq B \subseteq C$.

Proof.

(S1) It is obvious because all positive values of the cosine function are within 0 and 1.
(S2) It is obvious that $\rho T_A(x_j)\rho T_B(x_j) = \rho T_B(x_j)\rho T_A(x_j)$, $\rho I_A(x_j)\rho I_B(x_j) = \rho I_B(x_j)\rho I_A(x_j)$ and $\rho F_A(x_j)\rho F_B(x_j) = \rho F_B(x_j)\rho F_A(x_j)$.

Therefore,

$$S_{rC}(A,B)$$

$$= \frac{1}{n}\sum_{j=1}^{n}\left[\frac{\rho T_A(x_j)\rho T_B(x_j) + \rho I_A(x_j)\rho I_B(x_j) + \rho F_A(x_j)\rho F_B(x_j)}{\left(\sqrt{\rho T_A(x_j)^2 + \rho I_A(x_j)^2 + \rho F_A(x_j)^2}\right)\left(\sqrt{\rho T_B(x_j)^2 + \rho I_B(x_j)^2 + \rho F_B(x_j)^2}\right)}\right]$$

$$= \sum_{j=1}^{n}\left[\frac{\rho T_B(x_j)\rho T_A(x_j) + \rho I_B(x_j)\rho I_A(x_j) + \rho F_B(x_j)\rho F_A(x_j)}{\left(\sqrt{\rho T_B(x_j)^2 + \rho I_B(x_j)^2 + \rho F_B(x_j)^2}\right)\left(\sqrt{\rho T_A(x_j)^2 + \rho I_A(x_j)^2 + \rho F_A(x_j)^2}\right)}\right]$$

$$= S_{rC}(B,A)$$

Hence, $S_{rC}(A,B) = S_{rC}(B,A)$.

(S3) When $A = B$, then obviously $S_{rC}(A,B) = 1$. On the other hand if $S_{rC}(A,B) = 1$ then, $\rho T_A(x_j) = \rho T_B(x_j), \rho I_A(x_j) = \rho I_B(x_j)$ and $\rho F_A(x_j) = \rho F_B(x_j)$, i.e: $T_{\underline{N}(A)}(x_j) = T_{\underline{N}(B)}(x_j)$, $T_{\overline{N}(A)}(x_j) = T_{\overline{N}(B)}(x_j)$, $I_{\underline{N}(A)}(x_j) = I_{\underline{N}(B)}(x_j)$, $I_{\overline{N}(A)}(x_j) = I_{\overline{N}(B)}(x_j)$, and $F_{\underline{N}(A)}(x_j) = F_{\underline{N}(B)}(x_j)$, $F_{\overline{N}(A)}(x_j) = F_{\overline{N}(B)}(x_j)$. This implies that $A = B$.

(S4) If $A \subseteq B \subseteq C$ then we can write $T_{\underline{N}(A)}(x_j) \le T_{\underline{N}(B)}(x_j) \le T_{\underline{N}(C)}(x_j)$, $T_{\overline{N}(A)}(x_j) \le T_{\overline{N}(B)}(x_j) \le T_{\overline{N}(C)}(x_j)$, $I_{\underline{N}(A)}(x_j) \ge I_{\underline{N}(B)}(x_j) \ge I_{\underline{N}(C)}(x_j)$, $I_{\overline{N}(A)}(x_j) \ge I_{\overline{N}(B)}(x_j) \ge I_{\overline{N}(C)}(x_j)$, $F_{\underline{N}(A)}(x_j) \ge F_{\underline{N}(B)}(x_j) \ge F_{\underline{N}(C)}(x_j)$, $F_{\overline{N}(A)}(x_j) \ge F_{\overline{N}(B)}(x_j) \ge F_{\overline{N}(C)}(x_j)$. The cosine function is the decreasing function within the interval $\left[0, \frac{\pi}{2}\right]$. Therefore, it can be written as: $S_{rC}(A,C) \le S_{rC}(A,B)$ and $S_{rC}(A,C) \le S_{rC}(B,C)$.

This completes the proof ■

B Illustrative example in medical diagnosis

Referring to Phase 2, the illustrative example in medical diagnosis was used in the validation process. The secondary data from Pramanik and Mondal [10] and Alias et al. [11] was applied in this research as follows:

A medical report was converted to RNS-data.

Let $P = \{P_1, P_2\}$ be a set of patients, $D = \{D_1, D_2\}$ be a set of diseases and $S = \{S_1, S_2, S_3, S_4, S_5\}$ be a set of symptoms. The relationships between patients and symptoms is shown in Table 1 and the relationships between symptoms and diseases shown in Table 2 are considered in the same equivalence relation.

Table 1: The relationships between patients and symptoms

Relation A	**Temperature** (S_1)	**Headache** (S_2)	**Stomach pain** (S_3)	**Cough** (S_4)	**Chest pain** (S_5)
Patient (P_1)	$\langle(0.6,0.4,0.3),(0.8,0.2,0.1)\rangle$	$\langle(0.4,0.4,0.4),(0.6,0.2,0.2)\rangle$	$\langle(0.5,0.3,0.2),(0.7,0.1,0.2)\rangle$	$\langle(0.6,0.2,0.4),(0.8,0.0,0.2)\rangle$	$\langle(0.4,0.4,0.4),(0.6,0.2,0.2)\rangle$
Patient (P_2)	$\langle(0.5,0.3,0.4),(0.7,0.3,0.2)\rangle$	$\langle(0.5,0.5,0.3),(0.7,0.3,0.3)\rangle$	$\langle(0.5,0.3,0.4),(0.7,0.1,0.4)\rangle$	$\langle(0.5,0.3,0.3),(0.9,0.1,0.3)\rangle$	$\langle(0.5,0.3,0.3),(0.7,0.1,0.3)\rangle$

Table 2: The relationships between diseases and symptoms

Relation B	**Temperature (S_1)**	**Headache (S_2)**	**Stomach pain (S_3)**	**Cough (S_4)**	**Chest pain (S_5)**
Viral fever (D_1)	$\left\langle \begin{matrix}(0.6, 0.5, 0.4),\\(0.8, 0.3, 0.2)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.5, 0.3, 0.4),\\(0.7, 0.3, 0.2)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.2, 0.3, 0.4),\\(0.4, 0.3, 0.2)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.4, 0.3, 0.3),\\(0.6, 0.1, 0.1)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.2, 0.4, 0.4),\\(0.4, 0.2, 0.2)\end{matrix}\right\rangle$
Malaria (D_2)	$\left\langle \begin{matrix}(0.1, 0.4, 0.4),\\(0.5, 0.2, 0.2)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.2, 0.3, 0.4),\\(0.6, 0.3, 0.2)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.1, 0.4, 0.4),\\(0.3, 0.2, 0.2)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.3, 0.3, 0.3),\\(0.5, 0.1, 0.3)\end{matrix}\right\rangle$	$\left\langle \begin{matrix}(0.1, 0.3, 0.3),\\(0.3, 0.1, 0.1)\end{matrix}\right\rangle$

Next, the roughness measure is determined simultaneously with the roughness-Cosine similarity measure to find the medical findings by using Definition 4.1 and Eq. (1). The summary report for the medical findings is represented in Table 3.

Table 3: The summary report for medical findings

Roughness-Cosine similarity measure	**Viral fever (D_1)**	**Malaria (D_2)**
Patient (P_1)	0.9997	0.9994
Patient (P_2)	0.9996	0.9987

Lastly, the medical findings are summarized as shown in Table 3. In conclusion, all the results for medical findings by roughness-Cosine similarity measure is close to one. Here, the closest value to one indicates the result is possibly "more suffering". Therefore, it shows that both patients $\{P_1, P_2\}$ are suffering from viral fever.

By comparative analysis, the result of the roughness-Cosine similarity measure is compared with the previous result in [10] as shown in Table 4. Previously, all patients were diagnosed with viral fever and the same diagnosis result was determined in this study.

Table 4: The comparison results by similarity measure for a rough neutrosophic set

Similarity measure method	**Patient (P_1)**	**Patient (P_2)**
Roughness-Cosine similarity $S_{rC}(A, B)$	Viral fever (0.9997)	Viral fever (0.9996)
Cosine similarity $S_C(A, B)$ [10]	Viral fever (0.9595)	Viral fever (0.9624)

Based on the comparison result, the roughness-Cosine similarity values for both patients are the closest value to one. To be more practical, the research result is more accurate and presentable since the roughness measure for the lower and upper approximations of the rough neutrosophic set were determined in the first step. The roughness measure involved in this study was considered for every symptom and disease. Meanwhile, in [10], the only average mean operator between the lower and upper approximations is determined.

5 Conclusion

In this research, the definition of roughness-Cosine similarity measure for the rough neutrosophic set was introduced. All the proof of proposition for the similarity measure are completed. The lower and upper approximation of the rough neutrosophic set gave the roughness value between the information given and the similarity was used for the incomplete information collected. Then, the proposed definition was applied in the medical environment by converting the medical report to rough neutrosophic set data. The result for the medical summary has been proven close to one as predicted. Besides that, the proposed method was compared to the existing similarity method under a rough neutrosophic environment in medical diagnosis. Both results diagnosed patients 1 and 2 with a similar disease which is viral fever. According to the result, the roughness-Cosine similarity measure is more acceptable because the highest score (closest to one) is involved for roughness approximation and similarity values. Moreover, this is also because a proposed roughness is used in this research instead of the mean operator. In conclusion, the roughness measure is suitable to deal with lower and upper approximation values and incomplete information in data collection. Therefore, this research has met all the objectives. For future work, the roughness-Cosine similarity measure is recommended to apply to other fields, especially the data involving the lower and upper approximations such as big data, optimization, and scheduling problems.

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