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Review Article

Innovative Approaches for N-valued Interval Neutrosophic Sets and their Execution in Medical Diagnosis

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Abstract

The objective of the study was to find out the relationship between the disease and the symptoms seen within patients and diagnose the disease that impacted the patient using n-valued interval neutrosophic sets. Neoteric methods were devised in n-valued interval neutrosophic sets. Utilization of medical diagnosis was commenced with using prescribed procedures to identify a person suffering from the disease for a considerable period. The result showed that the proposed methods were free from shortcomings that affect the existing methods and found to be more accurate in diagnosing the diseases. It was concluded that the techniques adopted in this study were more reliable and easier to handle medical diagnosis problems.

Key words: N-valued interval neutrosophic set, grade function, logarithmic distance, exponential measure, medical diagnosis

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Kumbakonam is a thickly populated town. Although underground drainage system is available here, it is yet to cover all the houses in the town. So, open drainage system continues to be in practice in different places of the town. Further this town is racing fast towards total sanitation in all spheres. As a result, Kumbakonam continues to be a repository of all new kinds of diseases. This created an urge to carry out research in the medical field. By introducing innovative methods in the research, the diseases can be diagnosed instantly and infallibly.

A number of real life problems in engineering, medical sciences, social sciences, economics etc., involve imprecise data and their solution involves the use of mathematical principles based on uncertainty and imprecision. Such uncertainties are being dealt with the help of topics like probability theory, fuzzy set theory¹, rough set theory² etc., Healthcare industry has been trying to complement the services offered by conventional clinical decision making systems with the integration of fuzzy logic techniques in them. As it is not an easy task for a clinician to derive a fool proof diagnosis, it is advantageous to automate few initial steps of diagnosis which would not require intervention from an expert doctor. Neutrosophic set which is a generalized set possesses all attributes necessary to encode medical knowledge base and capture medical inputs.

As medical diagnosis demands large amount of information processing, large portion of which is quantifiable, also intuitive thought process involve rapid unconscious data processing and combines available information by law of average, the whole process offers low intra and inter personal consistency. So contradictions, inconsistency, indeterminacy and fuzziness should be accepted as unavoidable as they are integrated in the behavior of biological systems as well as in their characterization. To model an expert doctor it is imperative that it should not disallow uncertainty as it would be then inapt to capture fuzzy or incomplete knowledge that might lead to the danger of fallacies due to misplaced precision.

As medical diagnosis contains lots of uncertainties and increased volume of information available to physicians from new medical technologies, the process of classifying different sets of symptoms under a single name of disease becomes difficult. In some practical situations, there is the possibility of each element having different truth membership, indeterminate and false membership functions. The unique feature of n-valued interval neutrosophic set is that it contains multi truth membership, indeterminate and false membership.

By taking one time inspection, there may be error in diagnosis. Hence, multi time inspection, by taking the samples of the same patient at different times gives the best diagnosis. So, n-valued interval neutrosophic sets and their applications play a vital role in medical diagnosis.

In 1965, fuzzy set theory was firstly given by Zadeh¹ which is applied in many real applications to handle uncertainty. Sometimes membership function itself is uncertain and hard to be defined by a crisp value. So the concept of interval valued fuzzy sets was proposed to capture the uncertainty of grade of membership. Atanassov³ introduced the intuitionistic fuzzy sets which consider both truth-membership and falsity-membership. De *et al.*⁴ presented an application of intuitionistic fuzzy set in medical diagnosis. Ye⁵ introduced the concept of cosine similarity measures for intuitionistic fuzzy sets. Miaoying⁶ presented the cotangent similarity function for intuitionistic fuzzy sets. Later on, intuitionistic fuzzy sets were extended to the interval valued intuitionistic fuzzy sets. Intuitionistic fuzzy sets and interval valued intuitionistic fuzzy sets can only handle incomplete information not the indeterminate information and inconsistent information which exists commonly in belief systems. So, neutrosophic set (generalization of fuzzy sets, intuitionistic fuzzy sets and so on) defined by Smarandache⁷ has capability to deal with uncertainty, imprecise, incomplete and inconsistent information which exists in real world from philosophical point of view. Wang *et al.*⁸ proposed the single valued neutrosophic set. Similarity and entropy between neutrosophic sets were proposed by Mamjumdar and Samanta⁹. Wang *et al.*¹⁰ proposed the set theoretic operations on an instance of neutrosophic set is called interval valued neutrosophic set which is more flexible and practical than neutrosophic set. Similarity measures between interval valued neutrosophic sets were proposed by Ye¹¹. Interval valued neutrosophic soft sets were introduced by Deli¹².

Sebastian and Ramakrishnan¹³ studied a new concept called fuzzy multi sets (FMS), which is the generalization of multi sets. Shinoj and Sunil¹⁴ extended the concept of fuzzy multi sets by introducing intuitionistic fuzzy multi sets (IFMS). Rajarajeswari and Uma¹⁵ proposed the normalized hamming similarity measure between them. However, the concepts of FMS and IFMS are not capable of dealing with indeterminacy. Ye and Ye¹⁶ introduced the concept of single valued neutrosophic multi sets. Distance based similarity measures between them were introduced by Ye *et al.*¹⁷. Smarandache¹⁸ extended the classical neutrosophic logic to n-valued refined neutrosophic logic, by refining each neutrosophic component T, I, F into respectively, $T_1, T_2, \dots, T_m, I_1, I_2, \dots, I_p$ and F_1, F_2, \dots, F_T . Deli *et al.*¹⁹ studied a new concept called neutrosophic refined

sets. Broumi and Deli²⁰ proposed the correlation measure between them. Broumi *et al.*²¹ generalize the concept of n-valued neutrosophic sets to the case of n-valued interval neutrosophic sets.

In this study, using the notion of n-valued interval neutrosophic set was provided an exemplary for medical diagnosis. In order to make this, various methods were implemented.

PRELIMINARIES

Interval neutrosophic set¹⁰: Let X be a space of points (objects), with a generic element in X denoted by x. An interval neutrosophic set A in X is characterized by the truth-membership function T_A , indeterminacy-membership function I_A and falsity-membership function F_A . For each point x in X, $T_A(x), I_A(x), F_A(x) \subseteq [0,1]$ with the condition that $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

Interval neutrosophic relation¹⁰: Let X and Y be two non-empty crisp sets. An interval neutrosophic relation R(X, Y) is a subset of product space $X \times Y$ and is characterized by the truth membership function $T_R(x, y)$, the indeterminacy membership function $I_R(x, y)$ and the falsity membership function $F_R(x, y)$, where $x \in X$ and $y \in Y$ and $T_R(x, y), I_R(x, y), F_R(x, y) \subseteq [0, 1]$.

Sup-star composition¹⁰: Let X and Y be two non-empty crisp sets. An interval neutrosophic relation R(X, Y) is a subset of product space $X \times Y$ and is characterized by the membership functions for the composition of interval neutrosophic relations R(X, Y) and S(Y, Z) are given by the interval neutrosophic sup-star composition of R and S:

$$\begin{aligned}
 T_{R \circ S}(x, z) &= \sup_{y \in Y} \min(T_R(x, y), T_S(y, z)) \\
 I_{R \circ S}(x, z) &= \sup_{y \in Y} \min(I_R(x, y), I_S(y, z)) \\
 F_{R \circ S}(x, z) &= \inf_{y \in Y} \max(F_R(x, y), F_S(y, z))
 \end{aligned}
 \tag{1}$$

where, $x \in X$ and $y \in Y$ and $T_R(x, y), I_R(x, y), F_R(x, y) \subseteq [0, 1]$.

N-valued interval neutrosophic set²¹: Let X be a universe, a n-valued interval neutrosophic set on X can be defined as follows:

$$A = \left\{ x, \left(\left[\inf T_A^1(x), \sup T_A^1(x) \right], \left[\inf T_A^2(x), \sup T_A^2(x) \right], \dots \right), \left(\left[\inf T_A^p(x), \sup T_A^p(x) \right] \right), \left(\left[\inf I_A^1(x), \sup I_A^1(x) \right], \left[\inf I_A^2(x), \sup I_A^2(x) \right], \dots \right), \left(\left[\inf I_A^p(x), \sup I_A^p(x) \right] \right), \left(\left[\inf F_A^1(x), \sup F_A^1(x) \right], \left[\inf F_A^2(x), \sup F_A^2(x) \right], \dots \right), \left(\left[\inf F_A^p(x), \sup F_A^p(x) \right] \right) : x \in X \right\}$$

Where:

$$\begin{aligned}
 &\inf T_A^1(x), \inf T_A^2(x), \dots, \inf T_A^p(x), \inf I_A^1(x), \inf I_A^2(x), \dots, \inf I_A^p(x) \\
 &\inf F_A^1(x), \inf F_A^2(x), \dots, \inf F_A^p(x), \sup T_A^1(x), \sup T_A^2(x), \dots, \sup T_A^p(x) \\
 &\sup I_A^1(x), \sup I_A^2(x), \dots, \sup I_A^p(x), \sup F_A^1(x), \sup F_A^2(x), \dots, \sup F_A^p(x) \in [0,1]
 \end{aligned}$$

Such that:

$$0 \leq \sup T_A^j(x) + \sup I_A^j(x) + \sup F_A^j(x) \leq 3 \quad \forall j = 1, 2, 3, \dots, p$$

Inclusion²¹: A n-valued interval neutrosophic set A is contained in the other n-valued interval neutrosophic set B, denoted by $A \subseteq B$ if and only if:

$$\begin{aligned}
 &\inf T_A^1(x) \leq \inf T_B^1(x), \inf T_A^2(x) \leq \inf T_B^2(x), \dots, \inf T_A^p(x) \leq \inf T_B^p(x) \\
 &\sup T_A^1(x) \leq \sup T_B^1(x), \sup T_A^2(x) \leq \sup T_B^2(x), \dots, \sup T_A^p(x) \leq \sup T_B^p(x) \\
 &\inf I_A^1(x) \geq \inf I_B^1(x), \inf I_A^2(x) \geq \inf I_B^2(x), \dots, \inf I_A^p(x) \geq \inf I_B^p(x) \\
 &\sup I_A^1(x) \geq \sup I_B^1(x), \sup I_A^2(x) \geq \sup I_B^2(x), \dots, \sup I_A^p(x) \geq \sup I_B^p(x) \\
 &\inf F_A^1(x) \geq \inf F_B^1(x), \inf F_A^2(x) \geq \inf F_B^2(x), \dots, \inf F_A^p(x) \geq \inf F_B^p(x) \\
 &\sup F_A^1(x) \geq \sup F_B^1(x), \sup F_A^2(x) \geq \sup F_B^2(x), \dots, \\
 &\sup F_A^p(x) \geq \sup F_B^p(x) \quad \forall x \in X
 \end{aligned}
 \tag{2}$$

PROPOSED DEFINITIONS

The proposed definitions are as follows:

Grade function: Let $A = ([a, b], [c, d], [e, f])$ be an interval neutrosophic number, a grade function E of an interval neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree and falsity-membership degree is defined as:

$$E(A) = \frac{((1-a)+b+c+d+e-f)^2}{4} \quad (3)$$

Proposition 1:

$$E(A) \geq 0$$

Proof: The proof is straightforward.

Theorem 1: Let:

$$A = ([a_1, b_1], [c_1, d_1], [e_1, f_1])$$

and:

$$B = ([a_2, b_2], [c_2, d_2], [e_2, f_2])$$

be two interval neutrosophic numbers. If $A \subseteq B$ then $E(A) \geq E(B)$.

Proof: By'(3)':

$$E(A) = \frac{((1-a_1)+b_1+c_1+d_1+e_1-f_1)^2}{4}$$

and:

$$E(B) = \frac{((1-a_2)+b_2+c_2+d_2+e_2-f_2)^2}{4}$$

Since $A \subseteq B$, $a_1 \leq a_2$, $b_1 \leq b_2$, $c_1 \geq c_2$, $d_1 \geq d_2$, $e_1 \geq e_2$ and $f_1 \geq f_2$:

$$\therefore (a_2 - a_1) \geq 0, (b_2 - b_1) \geq 0, (c_1 - c_2) \geq 0, (d_1 - d_2) \geq 0, (e_1 - e_2) \geq 0$$

and $(f_1 - f_2) \geq 0$

Hence $E(A) - E(B) \geq 0$.

Similarity grade function: Let $A = ([a, b], [c, d], [e, f])$ be an interval neutrosophic number, a similarity grade function N of an interval neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree and falsity-membership degree is defined as:

$$N(A) = 1 - \frac{(1-a)+b+c+d+e-f}{6} \quad (4)$$

Proposition 2:

$$N(A) \in [0, 1]$$

Proof: The proof is straightforward.

Theorem 2: Let:

$$A = ([a_1, b_1], [c_1, d_1], [e_1, f_1])$$

and:

$$B = ([a_2, b_2], [c_2, d_2], [e_2, f_2])$$

be two interval neutrosophic numbers. If $A \subseteq B$ then $N(A) \leq N(B)$.

Proof: By'(4)':

$$N(A) = 1 - \frac{(1-a_1)+b_1+c_1+d_1+e_1-f_1}{6}$$

and:

$$N(B) = 1 - \frac{(1-a_2)+b_2+c_2+d_2+e_2-f_2}{6}$$

Since $A \subseteq B$, $a_1 \leq a_2$, $b_1 \leq b_2$, $c_1 \geq c_2$, $d_1 \geq d_2$, $e_1 \geq e_2$ and $f_1 \geq f_2$:

$$\therefore (a_2 - a_1) \geq 0, (b_2 - b_1) \geq 0, (c_1 - c_2) \geq 0, (d_1 - d_2) \geq 0, (e_1 - e_2) \geq 0$$

and $(f_1 - f_2) \geq 0$

Hence $N(A) - N(B) \leq 0$.

Logarithmic distance: Let:

$$A = \left\{ \begin{array}{l} x, \left[\left[\inf T_A^1(x), \sup T_A^1(x) \right], \left[\inf T_A^2(x), \sup T_A^2(x) \right], \dots \right], \\ \left[\inf T_A^p(x), \sup T_A^p(x) \right] \\ \left[\inf I_A^1(x), \sup I_A^1(x) \right], \left[\inf I_A^2(x), \sup I_A^2(x) \right], \dots, \\ \left[\inf I_A^p(x), \sup I_A^p(x) \right] \\ \left[\inf F_A^1(x), \sup F_A^1(x) \right], \left[\inf F_A^2(x), \sup F_A^2(x) \right], \dots, \\ \left[\inf F_A^p(x), \sup F_A^p(x) \right] \end{array} \right\} : x \in X$$

and:

$$B = \left\{ \begin{array}{l} x, \left[\left[\inf T_B^1(x), \sup T_B^1(x) \right], \left[\inf T_B^2(x), \sup T_B^2(x) \right], \dots \right], \\ \left[\inf T_B^p(x), \sup T_B^p(x) \right] \\ \left[\inf I_B^1(x), \sup I_B^1(x) \right], \left[\inf I_B^2(x), \sup I_B^2(x) \right], \dots, \\ \left[\inf I_B^p(x), \sup I_B^p(x) \right] \\ \left[\inf F_B^1(x), \sup F_B^1(x) \right], \left[\inf F_B^2(x), \sup F_B^2(x) \right], \dots, \\ \left[\inf F_B^p(x), \sup F_B^p(x) \right] \end{array} \right\} : x \in X$$

Be two n-valued interval neutrosophic sets then the logarithmic distance:

$$LD_{NVINS}(A, B) = \frac{1}{p} \sum_{j=1}^p \left[\frac{1}{2n} \sum_{i=1}^n \log \left[\frac{\pi}{2} + \frac{\sqrt{\left(\begin{array}{l} |\inf T_A^j(x_i) - \inf T_B^j(x_i)| + |\sup T_A^j(x_i) - \sup T_B^j(x_i)| + \\ |\inf I_A^j(x_i) - \inf I_B^j(x_i)| + \\ |\sup I_A^j(x_i) - \sup I_B^j(x_i)| + |\inf F_A^j(x_i) - \inf F_B^j(x_i)| + \\ |\sup F_A^j(x_i) - \sup F_B^j(x_i)| \end{array} \right)}}{6} \right] \right]$$

(5)

$$= \frac{1}{p} \sum_{j=1}^p \left[\frac{1}{2n} \sum_{i=1}^n \log \left[\frac{\pi}{2} + \frac{\sqrt{\left(\begin{array}{l} |\inf T_B^j(x_i) - \inf T_A^j(x_i)| + |\sup T_B^j(x_i) - \sup T_A^j(x_i)| + \\ |\inf I_B^j(x_i) - \inf I_A^j(x_i)| + \\ |\sup I_B^j(x_i) - \sup I_A^j(x_i)| + |\inf F_B^j(x_i) - \inf F_A^j(x_i)| + \\ |\sup F_B^j(x_i) - \sup F_A^j(x_i)| \end{array} \right)}}{6} \right] \right]$$

= LD_{NVINS}(B, A)

Proposition 3:

- LD_{NVINS}(A, B) > 0
- LD_{NVINS}(A, B) = LD_{NVINS}(B, A)
- If A ⊆ B ⊆ C then LD_{NVINS}(A, C) ≥ LD_{NVINS}(A, B) and LD_{NVINS}(A, C) ≥ LD_{NVINS}(B, C)

Proof:

- The proof is straightforward
- It was well known that:

$$|\inf T_A^j(x_i) - \inf T_B^j(x_i)| = |\inf T_B^j(x_i) - \inf T_A^j(x_i)|$$

$$|\sup T_A^j(x_i) - \sup T_B^j(x_i)| = |\sup T_B^j(x_i) - \sup T_A^j(x_i)|$$

$$|\inf I_A^j(x_i) - \inf I_B^j(x_i)| = |\inf I_B^j(x_i) - \inf I_A^j(x_i)|$$

$$|\sup I_A^j(x_i) - \sup I_B^j(x_i)| = |\sup I_B^j(x_i) - \sup I_A^j(x_i)|$$

$$|\inf F_A^j(x_i) - \inf F_B^j(x_i)| = |\inf F_B^j(x_i) - \inf F_A^j(x_i)|$$

$$|\sup F_A^j(x_i) - \sup F_B^j(x_i)| = |\sup F_B^j(x_i) - \sup F_A^j(x_i)|$$

$$\therefore LD_{NVINS}(A, B) = \frac{1}{p} \sum_{j=1}^p \left[\frac{1}{2n} \sum_{i=1}^n \log \left[\frac{\pi}{2} + \frac{\sqrt{\left(\begin{array}{l} |\inf T_A^j(x_i) - \inf T_B^j(x_i)| + |\sup T_A^j(x_i) - \sup T_B^j(x_i)| + \\ |\inf I_A^j(x_i) - \inf I_B^j(x_i)| + \\ |\sup I_A^j(x_i) - \sup I_B^j(x_i)| + |\inf F_A^j(x_i) - \inf F_B^j(x_i)| + \\ |\sup F_A^j(x_i) - \sup F_B^j(x_i)| \end{array} \right)}}{6} \right] \right]$$

- By '(2)':

$$\inf T_A^j(x_i) \leq \inf T_B^j(x_i) \leq \inf T_C^j(x_i)$$

$$\sup T_A^j(x_i) \leq \sup T_B^j(x_i) \leq \sup T_C^j(x_i)$$

$$\inf I_A^j(x_i) \geq \inf I_B^j(x_i) \geq \inf I_C^j(x_i)$$

$$\sup I_A^j(x_i) \geq \sup I_B^j(x_i) \geq \sup I_C^j(x_i)$$

$$\inf F_A^j(x_i) \geq \inf F_B^j(x_i) \geq \inf F_C^j(x_i)$$

$$\sup F_A^j(x_i) \geq \sup F_B^j(x_i) \geq \sup F_C^j(x_i)$$

Hence:

$$|\inf T_A^j(x_i) - \inf T_B^j(x_i)| \leq |\inf T_A^j(x_i) - \inf T_C^j(x_i)|$$

$$|\sup T_A^j(x_i) - \sup T_B^j(x_i)| \leq |\sup T_A^j(x_i) - \sup T_C^j(x_i)|$$

$$|\inf I_A^j(x_i) - \inf I_B^j(x_i)| \leq |\inf I_A^j(x_i) - \inf I_C^j(x_i)|$$

$$|\sup I_A^j(x_i) - \sup I_B^j(x_i)| \leq |\sup I_A^j(x_i) - \sup I_C^j(x_i)|$$

$$|\inf F_A^j(x_i) - \inf F_B^j(x_i)| \leq |\inf F_A^j(x_i) - \inf F_C^j(x_i)|$$

$$|\sup F_A^j(x_i) - \sup F_B^j(x_i)| \leq |\sup F_A^j(x_i) - \sup F_C^j(x_i)|$$

Here, the logarithmic distance is an increasing function:

∴ LD_{NVINS}(A, C) ≥ LD_{NVINS}(A, B) and LD_{NVINS}(A, C) ≥ LD_{NVINS}(B, C)

Exponential measure: Let:

$$A = \left\{ x, \left[\begin{array}{l} [\inf T_A^1(x), \sup T_A^1(x)], [\inf T_A^2(x), \sup T_A^2(x)], \dots \\ [\inf T_A^p(x), \sup T_A^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf I_A^1(x), \sup I_A^1(x)], [\inf I_A^2(x), \sup I_A^2(x)], \dots \\ [\inf I_A^p(x), \sup I_A^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf F_A^1(x), \sup F_A^1(x)], [\inf F_A^2(x), \sup F_A^2(x)], \dots \\ [\inf F_A^p(x), \sup F_A^p(x)] \end{array} \right] : x \in X \right\}$$

and:

$$B = \left\{ x, \left[\begin{array}{l} [\inf T_B^1(x), \sup T_B^1(x)], [\inf T_B^2(x), \sup T_B^2(x)], \dots \\ [\inf T_B^p(x), \sup T_B^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf I_B^1(x), \sup I_B^1(x)], [\inf I_B^2(x), \sup I_B^2(x)], \dots \\ [\inf I_B^p(x), \sup I_B^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf F_B^1(x), \sup F_B^1(x)], [\inf F_B^2(x), \sup F_B^2(x)], \dots \\ [\inf F_B^p(x), \sup F_B^p(x)] \end{array} \right] : x \in X \right\}$$

be two n-valued interval neutrosophic sets then the exponential measure:

$$EM_{NVINS}(A, B) = \frac{1}{2np} \sum_{j=1}^p \sum_{i=1}^n \left[\frac{\pi}{4} + e^{-\frac{|\inf T_A^j(x) - \inf T_B^j(x)| + |\sup T_A^j(x) - \sup T_B^j(x)| + |\inf I_A^j(x) - \inf I_B^j(x)| + |\sup I_A^j(x) - \sup I_B^j(x)| + |\inf F_A^j(x) - \inf F_B^j(x)| + |\sup F_A^j(x) - \sup F_B^j(x)|}{n}} \right] \quad (6)$$

Proposition 4:

- $EM_{NVINS}(A, B) > 0$
- $EM_{NVINS}(A, B) = EM_{NVINS}(B, A)$
- If $A \subseteq B \subseteq C$ then $EM_{NVINS}(A, C) \leq EM_{NVINS}(A, B)$ and $EM_{NVINS}(A, C) \leq EM_{NVINS}(B, C)$

Proof:

- The proof is straightforward
- It was well known that:

$$|\inf T_A^j(x) - \inf T_B^j(x)| = |\inf T_B^j(x) - \inf T_A^j(x)|$$

$$|\sup T_A^j(x) - \sup T_B^j(x)| = |\sup T_B^j(x) - \sup T_A^j(x)|$$

$$|\inf I_A^j(x) - \inf I_B^j(x)| = |\inf I_B^j(x) - \inf I_A^j(x)|$$

$$|\sup I_A^j(x) - \sup I_B^j(x)| = |\sup I_B^j(x) - \sup I_A^j(x)|$$

$$|\inf F_A^j(x) - \inf F_B^j(x)| = |\inf F_B^j(x) - \inf F_A^j(x)|$$

$$|\sup F_A^j(x) - \sup F_B^j(x)| = |\sup F_B^j(x) - \sup F_A^j(x)|$$

$$\begin{aligned} \therefore EM_{NVINS}(A, B) &= \frac{1}{2np} \sum_{j=1}^p \sum_{i=1}^n \left[\frac{\pi}{4} + e^{-\frac{|\inf T_A^j(x) - \inf T_B^j(x)| + |\sup T_A^j(x) - \sup T_B^j(x)| + |\inf I_A^j(x) - \inf I_B^j(x)| + |\sup I_A^j(x) - \sup I_B^j(x)| + |\inf F_A^j(x) - \inf F_B^j(x)| + |\sup F_A^j(x) - \sup F_B^j(x)|}{n}} \right] \\ &= \frac{1}{2np} \sum_{j=1}^p \sum_{i=1}^n \left[\frac{\pi}{4} + e^{-\frac{|\inf T_B^j(x) - \inf T_A^j(x)| + |\sup T_B^j(x) - \sup T_A^j(x)| + |\inf I_B^j(x) - \inf I_A^j(x)| + |\sup I_B^j(x) - \sup I_A^j(x)| + |\inf F_B^j(x) - \inf F_A^j(x)| + |\sup F_B^j(x) - \sup F_A^j(x)|}{n}} \right] \\ &= EM_{NVINS}(B, A) \end{aligned}$$

- By '(2)':

$$\inf T_A^j(x) \leq \inf T_B^j(x) \leq \inf T_C^j(x)$$

$$\sup T_A^j(x) \leq \sup T_B^j(x) \leq \sup T_C^j(x)$$

$$\inf I_A^j(x) \geq \inf I_B^j(x) \geq \inf I_C^j(x)$$

$$\sup I_A^j(x) \geq \sup I_B^j(x) \geq \sup I_C^j(x)$$

$$\inf F_A^j(x) \geq \inf F_B^j(x) \geq \inf F_C^j(x)$$

$$\sup F_A^j(x) \geq \sup F_B^j(x) \geq \sup F_C^j(x)$$

Hence:

$$|\inf T_A^j(x) - \inf T_B^j(x)| \leq |\inf T_A^j(x) - \inf T_C^j(x)|$$

$$|\sup T_A^j(x) - \sup T_B^j(x)| \leq |\sup T_A^j(x) - \sup T_C^j(x)|$$

$$|\inf I_A^l(x_i) - \inf I_B^l(x_i)| \leq |\inf I_A^l(x_i) - \inf I_C^l(x_i)|$$

$$|\sup I_A^l(x_i) - \sup I_B^l(x_i)| \leq |\sup I_A^l(x_i) - \sup I_C^l(x_i)|$$

$$|\inf F_A^l(x_i) - \inf F_B^l(x_i)| \leq |\inf F_A^l(x_i) - \inf F_C^l(x_i)|$$

$$|\sup F_A^l(x_i) - \sup F_B^l(x_i)| \leq |\sup F_A^l(x_i) - \sup F_C^l(x_i)|$$

Here, the exponential measure is a decreasing function:

$$\therefore EM_{NVINS}(A, C) \leq EM_{NVINS}(A, B) \text{ and } EM_{NVINS}(A, C) \leq EM_{NVINS}(B, C)$$

Similarity measure: Let:

$$A = \left\{ \begin{array}{l} x, \left[\begin{array}{l} [\inf T_A^l(x), \sup T_A^l(x)], [\inf T_A^2(x), \sup T_A^2(x)], \dots \\ [\inf T_A^p(x), \sup T_A^p(x)] \end{array} \right], \\ \left[\begin{array}{l} [\inf I_A^l(x), \sup I_A^l(x)], [\inf I_A^2(x), \sup I_A^2(x)], \dots \\ [\inf I_A^p(x), \sup I_A^p(x)] \end{array} \right], \\ \left[\begin{array}{l} [\inf F_A^l(x), \sup F_A^l(x)], [\inf F_A^2(x), \sup F_A^2(x)], \dots \\ [\inf F_A^p(x), \sup F_A^p(x)] \end{array} \right] : x \in X \end{array} \right\}$$

and:

$$B = \left\{ \begin{array}{l} x, \left[\begin{array}{l} [\inf T_B^l(x), \sup T_B^l(x)], [\inf T_B^2(x), \sup T_B^2(x)], \dots \\ [\inf T_B^p(x), \sup T_B^p(x)] \end{array} \right], \\ \left[\begin{array}{l} [\inf I_B^l(x), \sup I_B^l(x)], [\inf I_B^2(x), \sup I_B^2(x)], \dots \\ [\inf I_B^p(x), \sup I_B^p(x)] \end{array} \right], \\ \left[\begin{array}{l} [\inf F_B^l(x), \sup F_B^l(x)], [\inf F_B^2(x), \sup F_B^2(x)], \dots \\ [\inf F_B^p(x), \sup F_B^p(x)] \end{array} \right] : x \in X \end{array} \right\}$$

be two n-valued interval neutrosophic sets then the similarity measure:

$$SM_{NVINS}(A, B) = \frac{1}{2np} \sum_{j=1}^p \sum_{i=1}^n \left[1 - \frac{\sqrt{|\inf T_A^l(x_i) - \inf T_B^l(x_i)| + |\sup T_A^l(x_i) - \sup T_B^l(x_i)| + |\inf I_A^l(x_i) - \inf I_B^l(x_i)| + |\sup I_A^l(x_i) - \sup I_B^l(x_i)| + |\inf F_A^l(x_i) - \inf F_B^l(x_i)| + |\sup F_A^l(x_i) - \sup F_B^l(x_i)|}}{6} \right] \quad (7)$$

Proposition 5:

- $SM_{NVINS}(A, B) \leq 1$
- $SM_{NVINS}(A, B) = SM_{NVINS}(B, A)$

- If $A \subseteq B \subseteq C$ then $SM_{NVINS}(A, C) \leq SM_{NVINS}(A, B)$ and $SM_{NVINS}(A, C) \leq SM_{NVINS}(B, C)$

Proof:

- The proof is straightforward
- It was well known that:

$$|\inf T_A^l(x_i) - \inf T_B^l(x_i)| = |\inf T_B^l(x_i) - \inf T_A^l(x_i)|$$

$$|\sup T_A^l(x_i) - \sup T_B^l(x_i)| = |\sup T_B^l(x_i) - \sup T_A^l(x_i)|$$

$$|\inf I_A^l(x_i) - \inf I_B^l(x_i)| = |\inf I_B^l(x_i) - \inf I_A^l(x_i)|$$

$$|\sup I_A^l(x_i) - \sup I_B^l(x_i)| = |\sup I_B^l(x_i) - \sup I_A^l(x_i)|$$

$$|\inf F_A^l(x_i) - \inf F_B^l(x_i)| = |\inf F_B^l(x_i) - \inf F_A^l(x_i)|$$

$$|\sup F_A^l(x_i) - \sup F_B^l(x_i)| = |\sup F_B^l(x_i) - \sup F_A^l(x_i)|$$

$$\therefore SM_{NVINS}(A, B) = \frac{1}{2np} \sum_{j=1}^p \sum_{i=1}^n \left[1 - \frac{\sqrt{|\inf T_A^l(x_i) - \inf T_B^l(x_i)| + |\sup T_A^l(x_i) - \sup T_B^l(x_i)| + |\inf I_A^l(x_i) - \inf I_B^l(x_i)| + |\sup I_A^l(x_i) - \sup I_B^l(x_i)| + |\inf F_A^l(x_i) - \inf F_B^l(x_i)| + |\sup F_A^l(x_i) - \sup F_B^l(x_i)|}}{6} \right]$$

$$= \frac{1}{2np} \sum_{j=1}^p \sum_{i=1}^n \left[1 - \frac{\sqrt{|\inf T_B^l(x_i) - \inf T_A^l(x_i)| + |\sup T_B^l(x_i) - \sup T_A^l(x_i)| + |\inf I_B^l(x_i) - \inf I_A^l(x_i)| + |\sup I_B^l(x_i) - \sup I_A^l(x_i)| + |\inf F_B^l(x_i) - \inf F_A^l(x_i)| + |\sup F_B^l(x_i) - \sup F_A^l(x_i)|}}{6} \right]$$

$$= SM_{NVINS}(B, A)$$

- By '(2)':

$$\inf T_A^l(x_i) \leq \inf T_B^l(x_i) \leq \inf T_C^l(x_i)$$

$$\sup T_A^l(x_i) \leq \sup T_B^l(x_i) \leq \sup T_C^l(x_i)$$

$$\inf I_A^l(x_i) \geq \inf I_B^l(x_i) \geq \inf I_C^l(x_i)$$

$$\sup I_A^l(x_i) \geq \sup I_B^l(x_i) \geq \sup I_C^l(x_i)$$

$$\inf F_A^l(x_i) \geq \inf F_B^l(x_i) \geq \inf F_C^l(x_i)$$

$$I_{NVINS}(A, B) = \frac{1}{2p} \log \left[\frac{2 + SM_{NVINS}(A, B)}{2 - SM_{NVINS}(A, B)} \right] \quad (8)$$

$$\sup F_A^l(x_i) \geq \sup F_B^l(x_i) \geq \sup F_C^l(x_i)$$

Hence:

$$|\inf T_A^l(x_i) - \inf T_B^l(x_i)| \leq |\inf T_A^l(x_i) - \inf T_C^l(x_i)|$$

$$|\sup T_A^l(x_i) - \sup T_B^l(x_i)| \leq |\sup T_A^l(x_i) - \sup T_C^l(x_i)|$$

$$|\inf I_A^l(x_i) - \inf I_B^l(x_i)| \leq |\inf I_A^l(x_i) - \inf I_C^l(x_i)|$$

$$|\sup I_A^l(x_i) - \sup I_B^l(x_i)| \leq |\sup I_A^l(x_i) - \sup I_C^l(x_i)|$$

$$|\inf F_A^l(x_i) - \inf F_B^l(x_i)| \leq |\inf F_A^l(x_i) - \inf F_C^l(x_i)|$$

$$|\sup F_A^l(x_i) - \sup F_B^l(x_i)| \leq |\sup F_A^l(x_i) - \sup F_C^l(x_i)|$$

Here, the similarity measure is a decreasing function:

$$\therefore SM_{NVINS}(A, C) \leq SM_{NVINS}(A, B) \text{ and } SM_{NVINS}(A, C) \leq SM_{NVINS}(B, C)$$

Logarithmic function: Let:

$$A = \left\{ x, \left[\begin{array}{l} [\inf T_A^l(x), \sup T_A^l(x)], [\inf T_A^2(x), \sup T_A^2(x)] \\ \dots, [\inf T_A^p(x), \sup T_A^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf I_A^l(x), \sup I_A^l(x)], [\inf I_A^2(x), \sup I_A^2(x)] \\ \dots, [\inf I_A^p(x), \sup I_A^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf F_A^l(x), \sup F_A^l(x)], [\inf F_A^2(x), \sup F_A^2(x)] \\ \dots, [\inf F_A^p(x), \sup F_A^p(x)] \end{array} \right] : x \in X \right\}$$

and:

$$B = \left\{ x, \left[\begin{array}{l} [\inf T_B^l(x), \sup T_B^l(x)], [\inf T_B^2(x), \sup T_B^2(x)], \dots \\ [\inf T_B^p(x), \sup T_B^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf I_B^l(x), \sup I_B^l(x)], [\inf I_B^2(x), \sup I_B^2(x)], \dots \\ [\inf I_B^p(x), \sup I_B^p(x)] \end{array} \right], \left[\begin{array}{l} [\inf F_B^l(x), \sup F_B^l(x)], [\inf F_B^2(x), \sup F_B^2(x)], \dots \\ [\inf F_B^p(x), \sup F_B^p(x)] \end{array} \right] : x \in X \right\}$$

be two n-valued interval neutrosophic sets. Then, the logarithmic function based on similarity measure formula:

Proposition 6:

- $I_{NVINS}(A, B) \leq 1$
- $I_{NVINS}(A, B) = I_{NVINS}(B, A)$
- If $A \subseteq B \subseteq C$ then $I_{NVINS}(A, C) < I_{NVINS}(A, B)$ and $I_{NVINS}(A, C) < I_{NVINS}(B, C)$

Proof:

- The proof is straightforward
- Since $SM_{NVINS}(A, B) = SM_{NVINS}(B, A)$:

$$I_{NVINS}(A, B) = \frac{1}{2p} \log \left[\frac{2 + SM_{NVINS}(A, B)}{2 - SM_{NVINS}(A, B)} \right]$$

$$= \frac{1}{2p} \log \left[\frac{2 + SM_{NVINS}(B, A)}{2 - SM_{NVINS}(B, A)} \right]$$

$$= I_{NVINS}(B, A)$$

- By '(2)':

$$\inf T_A^l(x_i) \leq \inf T_B^l(x_i) \leq \inf T_C^l(x_i)$$

$$\sup T_A^l(x_i) \leq \sup T_B^l(x_i) \leq \sup T_C^l(x_i)$$

$$\inf I_A^l(x_i) \geq \inf I_B^l(x_i) \geq \inf I_C^l(x_i)$$

$$\sup I_A^l(x_i) \geq \sup I_B^l(x_i) \geq \sup I_C^l(x_i)$$

$$\inf F_A^l(x_i) \geq \inf F_B^l(x_i) \geq \inf F_C^l(x_i)$$

$$\sup F_A^l(x_i) \geq \sup F_B^l(x_i) \geq \sup F_C^l(x_i)$$

Hence:

$$|\inf T_A^l(x_i) - \inf T_B^l(x_i)| \leq |\inf T_A^l(x_i) - \inf T_C^l(x_i)|$$

$$|\sup T_A^l(x_i) - \sup T_B^l(x_i)| \leq |\sup T_A^l(x_i) - \sup T_C^l(x_i)|$$

$$|\inf I_A^l(x_i) - \inf I_B^l(x_i)| \leq |\inf I_A^l(x_i) - \inf I_C^l(x_i)|$$

$$|\sup I_A^l(x_i) - \sup I_B^l(x_i)| \leq |\sup I_A^l(x_i) - \sup I_C^l(x_i)|$$

$$|\inf F_A^i(x_i) - \inf F_B^i(x_i)| \leq |\inf F_A^i(x_i) - \inf F_C^i(x_i)|$$

$$|\sup F_A^i(x_i) - \sup F_B^i(x_i)| \leq |\sup F_A^i(x_i) - \sup F_C^i(x_i)|$$

$$e_{NVINS}(A, B) = \frac{1}{2n} \left[e^{\left[\frac{2+SM_{NVINS}(A,B)}{P(2-SM_{NVINS}(A,B))} \right]} \right]$$

Here, the logarithmic function is a decreasing function:

$$\therefore I_{NVINS}(A, C) \leq I_{NVINS}(A, B) \text{ and } I_{NVINS}(A, C) \leq I_{NVINS}(B, C)$$

$$= \frac{1}{2n} \left[e^{\left[\frac{2+SM_{NVINS}(B,A)}{P(2-SM_{NVINS}(B,A))} \right]} \right]$$

Definition: Let:

$$A = \left\{ \begin{array}{l} x, \left(\left[\inf T_A^1(x), \sup T_A^1(x) \right], \left[\inf T_A^2(x), \sup T_A^2(x) \right], \dots \right), \\ \left[\inf T_A^p(x), \sup T_A^p(x) \right] \\ \left(\left[\inf I_A^1(x), \sup I_A^1(x) \right], \left[\inf I_A^2(x), \sup I_A^2(x) \right], \dots \right), \\ \left[\inf I_A^p(x), \sup I_A^p(x) \right] \\ \left(\left[\inf F_A^1(x), \sup F_A^1(x) \right], \left[\inf F_A^2(x), \sup F_A^2(x) \right], \dots \right), \\ \left[\inf F_A^p(x), \sup F_A^p(x) \right] \end{array} \right\}; x \in X$$

$$= e_{NVINS}(B, A)$$

• By '(2)':

$$\inf T_A^1(x_i) \leq \inf T_B^1(x_i) \leq \inf T_C^1(x_i)$$

$$\sup T_A^1(x_i) \leq \sup T_B^1(x_i) \leq \sup T_C^1(x_i)$$

$$\inf I_A^1(x_i) \geq \inf I_B^1(x_i) \geq \inf I_C^1(x_i)$$

$$\sup I_A^1(x_i) \geq \sup I_B^1(x_i) \geq \sup I_C^1(x_i)$$

$$\inf F_A^1(x_i) \geq \inf F_B^1(x_i) \geq \inf F_C^1(x_i)$$

$$\sup F_A^1(x_i) \geq \sup F_B^1(x_i) \geq \sup F_C^1(x_i)$$

and:

$$B = \left\{ \begin{array}{l} x, \left(\left[\inf T_B^1(x), \sup T_B^1(x) \right], \left[\inf T_B^2(x), \sup T_B^2(x) \right], \dots \right), \\ \left[\inf T_B^p(x), \sup T_B^p(x) \right] \\ \left(\left[\inf I_B^1(x), \sup I_B^1(x) \right], \left[\inf I_B^2(x), \sup I_B^2(x) \right], \dots \right), \\ \left[\inf I_B^p(x), \sup I_B^p(x) \right] \\ \left(\left[\inf F_B^1(x), \sup F_B^1(x) \right], \left[\inf F_B^2(x), \sup F_B^2(x) \right], \dots \right), \\ \left[\inf F_B^p(x), \sup F_B^p(x) \right] \end{array} \right\}; x \in X$$

Hence:

$$|\inf T_A^i(x_i) - \inf T_B^i(x_i)| \leq |\inf T_A^i(x_i) - \inf T_C^i(x_i)|$$

$$|\sup T_A^i(x_i) - \sup T_B^i(x_i)| \leq |\sup T_A^i(x_i) - \sup T_C^i(x_i)|$$

$$|\inf I_A^i(x_i) - \inf I_B^i(x_i)| \leq |\inf I_A^i(x_i) - \inf I_C^i(x_i)|$$

$$|\sup I_A^i(x_i) - \sup I_B^i(x_i)| \leq |\sup I_A^i(x_i) - \sup I_C^i(x_i)|$$

$$|\inf F_A^i(x_i) - \inf F_B^i(x_i)| \leq |\inf F_A^i(x_i) - \inf F_C^i(x_i)|$$

$$|\sup F_A^i(x_i) - \sup F_B^i(x_i)| \leq |\sup F_A^i(x_i) - \sup F_C^i(x_i)|$$

be two n-valued interval neutrosophic sets. Then the exponential function based on similarity measure formula:

$$e_{NVINS}(A, B) = \frac{1}{2n} \left[e^{\left[\frac{2+SM_{NVINS}(A,B)}{P(2-SM_{NVINS}(A,B))} \right]} \right] \quad (9)$$

Proposition 7:

- $e_{NVINS}(A, B) > 0$
- $e_{NVINS}(A, B) = e_{NVINS}(B, A)$
- If $A \subseteq B \subseteq C$ then $e_{NVINS}(A, C) \leq e_{NVINS}(A, B)$ and $e_{NVINS}(A, C) \leq e_{NVINS}(B, C)$

Proof:

- The proof is straightforward
- Since, $SM_{NVINS}(A, B) = SM_{NVINS}(B, A)$:

Here, the exponential function is a decreasing function:

$$\therefore e_{NVINS}(A, C) \leq e_{NVINS}(A, B) \text{ and } e_{NVINS}(A, C) \leq e_{NVINS}(B, C)$$

METHODOLOGY

In this section, it was presented an application of n-valued interval neutrosophic set in medical diagnosis. In a given pathology, suppose S is a set of symptoms, D is a set of diseases and P is a set of patients and let Q be an n-valued interval neutrosophic relation from the set of patients to the symptoms. i.e., Q(P-S) and R be an interval neutrosophic relation from the set of symptoms to the diseases i.e., R(S-D) and then the methodology involves three main jobs:

- Determination of symptoms
- Formulation of medical knowledge based on n-valued interval neutrosophic sets and interval neutrosophic sets
- Determination of diagnosis on the basis of various computation techniques of n-valued interval neutrosophic sets

Algorithm:

- Step 1:** The symptoms of the patients are given to obtain the patient-symptom relation and are noted in Table 1
- Step 2:** The medical knowledge relating the symptoms with the set of diseases under consideration are given to obtain the symptom-disease relation and are noted in Table 2
- Step 3:** Table 3 is obtained by calculating average values for Table 1

Step 4: Table 4 is obtained by applying '(1)' between Table 2 and 3

Step 5: The computation T of the relation of patients and diseases is found using '(3)' and '(4)' in Table 4 and are noted in Table 5

Step 6: The computation T of the relation of patients and diseases is found '(5)', '(6)', '(7)', '(8)' and '(9)' and are noted in Table 6

Step 7: Finally, the minimum value from Table 5 (grade function) and Table 6 (logarithmic distance) and maximum value from Table 5 (similarity grade function and Table 6 (exponential measure, similarity measure, logarithmic function and exponential function) of each row were selected to find the possibility of the patient affected with the respective disease and then it was concluded that the patient was suffering from the disease

CASE STUDY²¹

Let there be three patients $P = \{P_1, P_2, P_3\}$ and the set of symptoms $S = \{S_1 = \text{Temperature}, S_2 = \text{Cough}, S_3 = \text{Throat pain}, S_4 = \text{Headache}, S_5 = \text{Body pain}\}$. The n-valued interval neutrosophic relation Q(P-S) is given as in Table 1. Let the set of diseases $D = \{D_1 = \text{Viral fever}, D_2 = \text{Tuberculosis}, D_3 = \text{Typhoid}, D_4 = \text{Throat disease}\}$. The interval neutrosophic relation R(S-D) is given as in Table 2.

From Table 5 and 6, it is obvious that, if the doctor agrees, then P_1 and P_3 suffers from Viral fever and P_2 suffers from Throat disease.

Table 1: Patient-symptom relation (using step1)

Q	Temperature	Cough	Throat pain	Headache	Body pain
P ₁	[0.3,0.4], [0.4,0.5],	[0.1,0.2], [0.3,0.6],	[0.0,0.5],	[0.2,0.3],	[0.0,0.4],
	[0.3,0.7]	[0.6,0.8]	[0.2,0.6], [0.0,0.4]	[0.3,0.5], [0.0,0.7]	[0.6,0.7], [0.2,0.5]
	[0.0,0.3], [0.1,0.3],	[0.0,0.5], [0.4,0.7],	[0.3,0.4],	[0.4,0.5],	[0.2,0.4],
	[0.0,0.5]	[0.4,0.5]	[0.2,0.3], [0.3,0.4]	[0.4,0.7], [0.3,0.6]	[0.4,0.5], [0.1,0.2]
	[0.0,0.6], [0.4,0.5],	[0.2,0.3], [0.0,0.5],	[0.0,0.7],	[0.2,0.6],	[0.1,0.3],
[0.3,0.4]	[0.4,0.6]	[0.3,0.7], [0.3,0.5]	[0.0,0.6], [0.3,0.4]	[0.0,0.6], [0.2,0.3]	[0.1,0.3], [0.2,0.3]
P ₂	[0.2,0.03],	[0.5,0.7], [0.0,0.4],	[0.5,0.6],	[0.2,0.5],	[0.2,0.4],
	[0.4,0.5], [0.1,0.2]	[0.7,0.8]	[0.0,0.6], [0.2,0.3]	[0.5,0.6], [0.1,0.5]	[0.4,0.6], [0.1,0.4]
	[0.4,0.5], [0.2,0.5],	[0.6,0.7], [0.0,0.5],	[0.4,0.7],	[0.2,0.3],	[0.0,0.5],
	[0.0,0.3]	[0.4,0.5]	[0.4,0.6], [0.3,0.4]	[0.2,0.5], [0.5,0.6]	[0.2,0.4], [0.5,0.6]
	[0.6,0.7], [0.4,0.5],	[0.4,0.6], [0.2,0.7],	[0.1,0.3],	[0.1,0.3],	[0.5,0.7],
[0.4,0.5]	[0.0,0.3]	[0.2,0.3], [0.5,0.7]	[0.3,0.4], [0.4,0.5]	[0.0,0.7], [0.2,0.4]	
P ₃	[0.1,0.3], [0.0,0.5],	[0.2,0.3], [0.0,0.7],	[0.2,0.4],	[0.2,0.3],	[0.0,0.6],
	[0.4,0.6]	[0.1,0.4]	[0.3,0.6], [0.0,0.6]	[0.5,0.6], [0.4,0.5]	[0.4,0.7], [0.2,0.3]
	[0.1,0.2], [0.3,0.4],	[0.5,0.6], [0.0,0.3],	[0.4,0.5],	[0.2,0.4],	[0.2,0.3],
	[0.2,0.5]	[0.3,0.5]	[0.0,0.3], [0.3,0.4]	[0.0,0.4], [0.2,0.7]	[0.2,0.3], [0.1,0.2]
	[0.2,0.4], [0.4,0.5],	[0.3,0.5], [0.2,0.5],	[0.5,0.7],	[0.4,0.5],	[0.0,0.6],
[0.3,0.7]	[0.4,0.6]	[0.4,0.6], [0.3,0.7]	[0.2,0.3], [0.3,0.5]	[0.2,0.4], [0.4,0.6]	

Table 2: Symptom-disease relation (using step2)

R	Viral fever	Tuberculosis	Typhoid	Throat disease
Temperature	[0.2,0.4], [0.3,0.5], [0.3,0.7]	[0.1,0.4], [0.2,0.6], [0.6,0.7]	[0.0,0.3], [0.4,0.6], [0.0,0.2]	[0.3,0.4], [0.2,0.5], [0.0,0.6]
Cough	[0.2,0.4], [0.2,0.3], [0.0,0.5]	[0.3,0.4], [0.2,0.5], [0.7,0.8]	[0.3,0.4], [0.2,0.3], [0.1,0.2]	[0.4,0.5], [0.1,0.3], [0.0,0.5]
Throat pain	[0.0,0.4], [0.2,0.4], [0.2,0.4]	[0.0,0.2], [0.3,0.6], [0.6,0.7]	[0.1,0.2], [0.4,0.5], [0.3,0.4]	[0.2,0.4], [0.2,0.5], [0.3,0.7]
Headache	[0.4,0.7], [0.0,0.3], [0.3,0.5]	[0.1,0.2], [0.0,0.5], [0.0,0.6]	[0.3,0.4], [0.2,0.3], [0.2,0.5]	[0.0,0.3], [0.3,0.6], [0.2,0.5]
Body pain	[0.1,0.4], [0.2,0.5], [0.3,0.4]	[0.5,0.7], [0.4,0.5], [0.2,0.5]	[0.2,0.3], [0.2,0.4], [0.2,0.3]	[0.0,0.4], [0.1,0.2], [0.1,0.3]

Table 3: Average for patient-symptom relation

Q	Temperature	Cough	Throat pain	Headache	Body pain
P ₁	[0.1,0.43], [0.3,0.43], [0.2,0.53]	[0.1,0.33], [0.23,0.6], [0.46,0.63]	[0.1,0.53], [0.23,0.53], [0.2,0.43]	[0.26,0.46], [0.23,0.6], [0.2,0.56]	[0.1,0.36], [0.36,0.5], [0.16,0.33]
P ₂	[0.4,0.5], [0.33,0.5], [0.16,0.33]	[0.5,0.66], [0.06,0.53], [0.36,0.53]	[0.33,0.53], [0.2,0.5], [0.33,0.46]	[0.16,0.36], [0.33,0.5], [0.33,0.53]	[0.23,0.53], [0.2,0.56], [0.26,0.46]
P ₃	[0.13,0.3], [0.23,0.46], [0.3,0.6]	[0.33,0.46], [0.06,0.5], [0.26,0.5]	[0.36,0.53], [0.23,0.5], [0.2,0.56]	[0.26,0.4], [0.23,0.43], [0.3,0.56]	[0.06,0.5], [0.26,0.46], [0.23,0.36]

Table 4: Sup-star composition between symptom-disease relation and average for patient-symptom relation

T	Viral fever	Tuberculosis	Typhoid	Throat disease
P ₁	[0.26,0.46], [0.3,0.5], [0.2,0.4]	[0.1,0.4], [0.36,0.53], [0.2,0.5]	[0.26,0.4], [0.3,0.5], [0.2,0.33]	[0.1,0.4], [0.23,0.6], [0.16,0.33]
P ₂	[0.2,0.4], [0.3,0.5], [0.3,0.46]	[0.3,0.53], [0.2,0.5], [0.26,0.5]	[0.3,0.4], [0.33,0.5], [0.16,0.33]	[0.4,0.5], [0.3,0.5], [0.16,0.46]
P ₃	[0.26,0.4], [0.23,0.46], [0.2,0.4]	[0.3,0.5], [0.26,0.5], [0.23,0.5]	[0.3,0.4], [0.23,0.5], [0.23,0.36]	[0.33,0.46], [0.23,0.5], [0.23,0.36]

Table 5: Grade function and similarity grade function (using step 5 and step 7)

T	Viral fever	Tuberculosis	Typhoid	Throat disease
Grade function				
P ₁	0.8100	0.8930	0.8190	0.9604
P ₂	0.8464	0.7140	0.7744	0.6400
P ₃	0.6642	0.7140	0.7225	0.7482
Similarity grade function				
P ₁	0.7000	0.6850	0.6983	0.6733
P ₂	0.6933	0.7183	0.7066	0.7333
P ₃	0.7283	0.7183	0.7166	0.7116

Table 6: Logarithmic distance, exponential measure, similarity measure, logarithmic function and exponential function(using step 6 and step 7)

T	Viral fever	Tuberculosis	Typhoid	Throat disease
Logarithmic distance				
P ₁	0.1180	0.1208	0.1196	0.1193
P ₂	0.1208	0.1217	0.1201	0.1191
P ₃	0.1174	0.1210	0.1187	0.1180
Exponential measure				
P ₁	0.8108	0.7906	0.7991	0.8019
P ₂	0.7907	0.7827	0.7952	0.8038
P ₃	0.8145	0.7884	0.8059	0.8126
Similarity measure				
P ₁	0.4226	0.4115	0.4161	0.4175
P ₂	0.4115	0.4078	0.4142	0.4184
P ₃	0.4247	0.4106	0.4197	0.4226
Logarithmic function				
P ₁	0.0310	0.0302	0.0305	0.0306
P ₂	0.0302	0.0299	0.0304	0.0307
P ₃	0.0312	0.0301	0.0308	0.0310
Exponential function				
P ₁	0.1668	0.1658	0.1662	0.1663
P ₂	0.1658	0.1655	0.1661	0.1664
P ₃	0.1670	0.1657	0.1665	0.1668

CONCLUSION

In this study, it was analyzed that the relationship between the set of symptoms found within patients and set of

diseases and employed seven methods (grade function, similarity grade function, logarithmic distance, exponential measure, similarity measure, logarithmic function, exponential function) to find out the disease possibly affected the patient. The techniques considered in this study were more reliable to handle medical diagnosis problems quiet comfortably. The proposed methods had more accuracy than the others and they could handle the limitations and drawbacks of the previous works well.

SIGNIFICANCE STATEMENTS

This study discovers the relationship between the symptoms found within patients and set of diseases. This study will help the researcher to find out the diseases accurately that impacted the patients. The methods employed are free from the limitations that are commonly found in other studies. Without such limitations, in this study a new theory on image processing, cluster analysis etc., has been developed.

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