Review Article

A Further Study on Multiperiod Health Diagnostics Methodology under a Single-Valued Neutrosophic Set

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Employing the concept and function of tangency with similarity measures and counterpart distances for reliable medical consultations has been extensively studied in the past decades and results in lots of isomorphic measures for application. We compared the majority of such isomorphic measures proposed by various researchers and classified them into (a) maximum norm and (b) one-norm categories. Moreover, we found that previous researchers used monotonic functions to transform an identity function and resulted in complicated expressions. In this study, we provide a theoretical foundation to explain the isomorphic nature of a newer measure proposed by the following research paper against its studied existing one in deriving the same pattern recognition results. Specifically, this study initially proposes two similarity measures using maximum norm, arithmetic mean, and aggregation operators and followed by a detailed discussion on their mathematical characteristics. Subsequently, a simplified version of such measures is presented for easy application. This study completely covers two previous methods to point out that the complex approaches used were unnecessary. The findings will help physicians, patients, and their family members to obtain a proper medical diagnosis during multiple examinations.

1. Introduction

With the current state of medical consultations, a patient may present with several different inclinations of diseases, especially for multilevel diagnosis. This poses a critical question on how can a physician provide a reliable conclusion for the patient's health status and extend to the patient and his or her family members. Zadeh [1] pioneered the development of fuzzy sets (FSs) to deal with complex, uncertain, vague, and incomplete problems in the physical world. There are many important extensions of the FSs such as the neutrosophic sets (NSs) that were proposed by Smarandache [2]. However, NSs pose to be difficult in actual applications such that Wang et al. [3, 4] developed single-valued neutrosophic sets (SVNSs) to provide a simplification of NSs. SVNSs have three membership functions: truth, indeterminacy, and falsity, which give sufficient information to analyze a patient's condition and will be used to construct a systematic approach to determine the most probable disease. Many papers studied SVNSs: for example, Ye [5] constructed an operator using weighted averages under a hesitant fuzzy element (HFE) environment and a single-valued neutrosophic set. Another study is Ye [6] to consider similarity measures with the cosine function, and then Ye and Fu [7] referred to the similarity measures in Ye [6]. Ninety-three papers have cited Ye [6] in their references. We list them in the following: Peng and Dai [8], Ye [9], Biswas et al. [10], Broumi et al. [11], Chatterjee et al. [12, 13], Cui and Ye [14], Fan [15], Fan et al. [16], Fu et al. [17], Gou and Wang [18], Jha et al. [19, 20], Li et al. [21–23], Liu and Luo [24], Luo et al. [25], Nancy and Garg [26], Nguyen et al. [27], Peng [28], Peng and Dai [29], Rajangam and Annamalai [30], Şahin [31], Shao et al. [32], Shi and Yuan [33], Tian et al. [34], Wang et al. [35], Wei and Zhang [36], Xie et al. [37], Ye [38], Zhai et al. [39], Zhang et al. [40], Zhao et al. [41], Akram et al. [42], Ali et al. [43], Cai and Yang [44], Fan et al. [45], Garg and Nancy [46], Guan et al.

[47], Karaaslan and Hayat [48], Khanet al. [49], Küçük and Şahin [50], Liu [51], Liu et al. [52], Liu et al. [53], Liu and You [54], Mondal et al. [55–57], Ngan et al. [58], Peng et al. [59], Pramanik et al. [60, 61], Şahin [62], Singh [63], Tian et al. [64], Tu et al. [65], Wei and Wei [66], Wu et al. [67], Wu et al. [68], Xiong and Cheng [69], Ye [70], Zeming et al. [71], Zhang et al. [72], Chen and Ye [73], Deli and Şubaş [74], Fan and Ye [75], Fu and Ye [76], Hu et al. [77], Lu and Ye [78], Ma et al. [79], Peng et al. [80–82], Pramanik et al. [83], Singh [84], Thanh et al. [85], Tian et al. [86], Wang and Zhang [87], Xu et al. [88], Zhou and Abdel Wahab [89], Chou [90], Liu and Tang [91], Meng et al. [92], Nancy and Garg [93], Shi [94], Son [95], Ye [96], Ye and Fu [7], Zhang et al. [97], Zhang et al. [98], and Zhang et al. [99]. Among those 93 papers, 92 papers only mentioned Ye [6] in their introduction, and then they concentrated on their new similarity measures and applied their new similarity measures to solve real application problems. Only one paper, Ye and Fu [7] have written down the similarity measures proposed by Ye [6]. However, Ye and Fu [7] did not provide any discussion for the similarity measures proposed by Ye [6] with cosine functions. Instead, Ye and Fu [7] developed new similarity measures with tangent functions. Hence, Ye and Fu [7] developed two tangent similarity measures and subsequently defined aggregation operators for multiperiod medical diagnosis. There are 49 papers that have cited Ye and Fu [7] in their references. We list them in the following: Liu et al. [100], Peng and Dai [8], Awang et al. [101], Chatterjee et al. [12, 13], Cui and Ye [14], Fu et al. [17], Gou and Wang [18], Hu et al. [102], Li et al. [21], Long et al. [103], Luo et al. [25], Nancy and Garg [26], Nguyen et al. [27], Rajangam and Annamalai [30], Ren et al. [104], Shen et al. [105], Shi and Yuan [33], Smith [106], Xie et al. [37], Akram et al. [107], Ali et al. [43], Hu et al. [108], Ji et al. [109–111], Karaaslan [112], Karaaslan and Hayat [48], Khan et al. [113], Liu [51], Mondal et al. [55–57], Naz et al. [114], Peng and Dai [115], Tu et al. [65], Uluçay et al. [116], Wu et al. [67], Ye [70], Ashraf et al. [117], Chen and Ye [73], Fu and Ye [76], Guan et al. [118], Guo et al. [119], Hu et al. [77], Lu and Ye [78], Naz et al. [120], Peng and Dai [121], and Thanh et al. [85]. We have examined those 49 papers to find out that they only review Ye and Fu [7] in their literature study without any further discussions concerning Ye and Fu [7]. There are many similarity measures developed by researchers. However, there are only a few studies that conduct comprehensive examinations for previously published papers. For example, Julian et al. [122] improved three questionable results of Mitchell [123]. Deng and Chao [124] and Tung et al. [125] further revised two questionable findings of Julian et al. [122]. We follow this trend to examine the findings of Ye [6] and Ye and Fu [7] with a detailed analysis.

Prior studies generally repeated in proposing a newer similarity measure and been evaluated against an existing one (i.e., a studied measure) in deriving the same pattern recognition results for medical diagnosis problems. Thus, they result in lots of isomorphic measures. Many researchers as mentioned above claimed that their new similarity measures are supported by existing ones. We took a detailed examination for some similarity measures and found that their coun-

terpart distances (that is, similarity measure plus distance is the unity) can be classified into (a) maximum norm and (b) one-norm categories. Additionally, many researchers used monotonic functions to transform the identity function (that is, $f(x) = x$) into complicated expressions. These review comments trigger us to study the similarity measures and point out that they are isomorphic when compared to those two categories. Hence, we provide a theoretical foundation to explain why a newly proposed measure by the following paper will derive the same results as its studied one (i.e., an existing measure).

Initially, we will use a simple example to explain the isomorphic property of this research for ordinary readers. We concentrate on Ye [6] and Ye and Fu [7], and they are representing an existing measure (i.e., Ye [6]) and the following measure (i.e., Ye and Fu [7]). Ye [6] used the cosine function, and Ye and Fu [7] applied the tangent function, where cosine is a strictly decreasing function, and tangent is a strictly increasing function. The isomorphic property can be understood by assuming $1 > \text{dist}(a, x) > \text{dist}(a, y)$, then

$$\text{Sim}(a, x) < \text{Sim}(a, y). \tag{1}$$

The strictly decreasing property of cosine implies $\cos(\text{dist}(a, x)) < \cos(\text{dist}(a, y))$. In this example, Ye [6] would create a new similarity measure as

$$\text{Sim}_{[6]}(a, x) = \cos(\text{dist}(a, x)), \tag{2}$$

such that

$$\text{Sim}_{[6]}(a, x) < \text{Sim}_{[6]}(a, y). \tag{3}$$

In fact, the similarity measure proposed by Ye [6] preserves the original ordering of Equation (1). The strictly increasing property of tangent implies $\tan(\text{dist}(a, x)) > \tan(\text{dist}(a, y))$. As an example of the following study, Ye and Fu [7] would create a new similarity measure as

$$\text{Sim}_{[7]}(a, x) = 1 - \tan(\text{dist}(a, x)), \tag{4}$$

such that

$$\text{Sim}_{[7]}(a, x) < \text{Sim}_{[7]}(a, y). \tag{5}$$

The new similarity measure proposed by Ye and Fu [7] preserves the original ordering of Equation (1) as well. In Ye and Fu [7], they claimed that they used the tangent function to develop a new similarity measure. We point out that Ye and Fu [7] applied "one minus tangent function" to create a new similarity measure. Based on the isomorphic property, Ye [6] and Ye and Fu [7] will preserve the same orderings as those in previously published papers that were constructed with different monotonic functions. Therefore, we decide to provide a reasonable explanation for researching the reason why a newer similarity measure will still derive the same results as those in already published papers.

The rest of the paper is organized as follows. Section 2 of this paper introduced some previous results related to Ye and Fu [7] in terms of the tangent similarity measures and aggregation operators. Section 3 highlighted the theoretical results of Jaccard [126], Dice [127], and Salton and McGill [128]. Our theoretical development of two similarity measures using maximum norm, arithmetic mean, and two aggregation operators is presented in Section 4. Section 5 showed how this study used the subject example of Ye and Fu [7] as a comparison for the proposed two aggregation operators and thereby showing that it has the same diagnosis results. A detailed analysis is presented in Section 6 about the tangent and improved cosine similarity measures and how there are transformations of the proposed revision thereby showing that these complicated computations of Ye [6] and Ye and Fu [7] are redundant. The discussion is concluded in Section 7.

2. Review of Related Results for Ye and Fu [7]

Wang et al. [4] defined an SVNS as $A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle | x \in X\}$, such that X is a universe of discourse with the three membership functions: truth $T_A(x)$, indeterminacy $I_A(x)$, and falsity $F_A(x)$ that satisfy $T_A(x)$, $I_A(x)$, and $F_A(x)$ $\in [0, 1]$.

For $A = \{\langle x_j, T_A(x_j), I_A(x_j), F_A(x_j)\rangle | x_j \in X\}$ and $B = \{\langle x_j, T_B(x_j), I_B(x_j), F_B(x_j)\rangle | x_j \in X\}$ which are different SVNSs with a universal set $X = \{x_1, x_2, \cdots, x_n\}$, Ye and Fu [7] reviewed three similarity measures: Jaccard [126], Dice [127], and Salton and McGill [128] as follows.

Jaccard [126] defined the "Jaccard index"

$$S_J(A, B) = \frac{1}{n} \sum_{j=1}^{n} \frac{\Omega_j}{\Delta_{Aj} + \Delta_{Bj} - \Omega_j}, \tag{6}$$

where

$$\Omega_j = T_A(x_j) T_B(x_j) + I_A(x_j) I_B(x_j) + F_A(x_j) F_B(x_j), \tag{7}$$

$$\Delta_{Aj} = T_A^2(x_j) + I_A^2(x_j) + F_A^2(x_j), \tag{8}$$

$$\Delta_{Bj} = T_B^2(x_j) + I_B^2(x_j) + F_B^2(x_j). \tag{9}$$

Dice [127] defined the "Dice similarity measure":

$$S_D(A, B) = \frac{1}{n} \sum_{j=1}^{n} \frac{2\Omega_j}{\Delta_{Aj} + \Delta_{Bj}}. \tag{10}$$

Salton and McGill [128] presented that

$$S_C(A, B) = \frac{1}{n} \sum_{j=1}^{n} \frac{\Omega_j}{\sqrt{\Delta_{Aj} \Delta_{Bj}}}, \tag{11}$$

which is based on the inner product of two vectors and then normalizes the result.

Next, Ye and Fu [7] claimed that Equation (11) has some disadvantages such that they presented two improved cosine similarity measures as follows in Ye [6]:

$$C_1(A, B) = \frac{1}{n} \sum_{j=1}^{n} \cos\left[\pi \frac{\max\left\{|T_A(x_j) - T_B(x_j)|, |I_A(x_j) - I_B(x_j)|, |F_A(x_j) - F_B(x_j)|\right\}}{2}\right], \tag{12}$$

$$C_2(A, B) = \frac{1}{n} \sum_{j=1}^{n} \cos\left[\pi \frac{\left\{|T_A(x_j) - T_B(x_j)| + |I_A(x_j) - I_B(x_j)| + |F_A(x_j) - F_B(x_j)|\right\}}{6}\right]. \tag{13}$$

Using the concept of tangency, Ye and Fu [7] developed two new equations as follows:

$$T_1(A, B) = 1 - \frac{1}{n} \sum_{j=1}^{n} \tan\left[\pi \frac{\max\left\{|T_A(x_j) - T_B(x_j)|, |I_A(x_j) - I_B(x_j)|, |F_A(x_j) - F_B(x_j)|\right\}}{4}\right], \tag{14}$$

and

$$T_2(A, B) = 1 - \frac{1}{n} \sum_{j=1}^{n} \tan\left[\pi \frac{\left\{|T_A(x_j) - T_B(x_j)| + |I_A(x_j) - I_B(x_j)| + |F_A(x_j) - F_B(x_j)|\right\}}{12}\right]. \tag{15}$$

Finally, Ye and Fu [7] constructed two weighted measures that are still built on tangency:

$$T_{w1}(A,B) = 1 - \sum_{j=1}^{n} w_j \tan\left[\pi \frac{\max\left\{\left|T_A(x_j) - T_B(x_j)\right|, \left|I_A(x_j) - I_B(x_j)\right|, \left|F_A(x_j) - F_B(x_j)\right|\right\}}{4}\right], \tag{16}$$

$$T_{w2}(A,B) = 1 - \sum_{j=1}^{n} w_j \tan\left[\pi \frac{\left\{\left|T_A(x_j) - T_B(x_j)\right| + \left|I_A(x_j) - I_B(x_j)\right| + \left|F_A(x_j) - F_B(x_j)\right|\right\}}{12}\right]. \tag{17}$$

During a multiple period diagnosis, Ye and Fu [7] used tangent and improved cosine measures to find out the most probable disease suffered by the patient. We recall the decision algorithm proposed by Ye and Fu [7]:

Assign $S = \{S_1, S_2, \cdots, S_m\}$ as the group of different symptoms, $T = \{t_1, t_2, \cdots, t_q\}$ as a series of multiple periods, and $D = \{D_1, D_2, \cdots, D_n\}$ as a group of possible diagnoses. Let the weight of period t_k be denoted as $w(t_k)$ with $w(t_k) > 0$ and $\sum_{k=1}^{q} w(t_k) = 1$. For a patient P with various symptoms, Ye and Fu [7] used $S_j(t_k)$ to denote the SVNS for this patient throughout the period t_k for symptoms S_j and C_{ij}, and to represent the SVNS for disease D_i related to the symptom S_j. The algorithm is cited as follows:

Step 1. Ye and Fu [7] applied T_2 of Equation (15) or C_2 of Equation (13) to compute the similarity between $S_j(t_k)$ and C_{ij} as $T_2(P, D_i, t_k)$ or $C_2(P, D_i, t_k)$.

Remark 1. Ye and Fu [7] used $T_{wi}(P, t_k)$ where the relation of the patient's disease D_i and the period t_k is not indicated clearly. Hence, the proposed change of the expression is from $T_{wi}(P, t_k)$ to $T_2(P, D_i, t_k)$.

Step 2. To derive the weighted aggregation value, $M(P, D_i)$ for the patient related to the disease D_i:

$$M_{T_2}(P, D_i) = \sum_{k=1}^{q} w(t_k) T_2(P, D_i, t_k), \tag{18}$$

or

$$M_{C_2}(P, D_i) = \sum_{k=1}^{q} w(t_k) C_2(P, D_i, t_k). \tag{19}$$

Step 3. Present the most probable diagnosis to the patient according to the highest amount among weighted aggregations.

Step 4. Finish.

3. Our Theoretical Results for Similarity Measures of Jaccard, Dice, and Cosine

This section demonstrated that

$$S_C(A,B) \geq S_D(A,B) \geq S_J(A,B). \tag{20}$$

Hence, we will prove that relations among the three similarity measures proposed by Jaccard [126], Dice [127], and Ye [6].

Building on the concept of the arithmetic average is greater than or equal to the geometric average, it is found that

$$\frac{\Delta_{Aj} + \Delta_{Bj}}{2} \geq \sqrt{\Delta_{Aj}\Delta_{Bj}}, \tag{21}$$

and thereby deriving that

$$S_C(A,B) \geq S_D(A,B). \tag{22}$$

From the definition of Δ_{Aj}, Δ_{Bj}, and Ω_j of Equations (7)–(9), respectively, the following is obtained:

$$\Delta_{Aj} + \Delta_{Bj} - 2\Omega_j = \left(T_A(x_j) - T_A(x_j)\right)^2 + \left(I_A(x_j) - I_A(x_j)\right)^2 + \left(F_A(x_j) - F_A(x_j)\right)^2 \geq 0, \tag{23}$$

such that

$$\frac{2}{\Delta_{Aj} + \Delta_{Bj}} \geq \frac{1}{\Delta_{Aj} + \Delta_{Bj} - \Omega_j}, \tag{24}$$

$$S_D(A,B) \geq S_J(A,B).$$

Theorem 2 below summarizes the findings.

Theorem 2. *Using two SVNSs* $A = \{\langle x_j, T_A(x_j), I_A(x_j), F_A(x_j)\rangle | x_j \in X\}$ *and* $B = \{\langle x_j, T_B(x_j), I_B(x_j), F_B(x_j)\rangle | x_j \in X\}$ *together with the universe of discourse* $X = \{x_1, x_2, \cdots, x_n\}$, $S_C(A,B) \geq S_D(A,B) \geq S_J(A,B)$ *is confirmed.*

TABLE 1: (Reproduction of Table 5 of Ye and Fu [7]) Characteristic values related to the patients and their symptoms for three periods.

	t_k	S_1 (temperature)	S_2 (headache)	S_3 (stomach pain)	S_4 (cough)	S_5 (chest pain)
P_1	t_1	(0.8,0.6,0.5)	(0.5,0.4,0.3)	(0.2,0.1,0.3)	(0.7,0.6,0.3)	(0.4,0.3,0.2)
	t_2	(0.7,0.3,0.2)	(0.6,0.3,0.2)	(0.3,0.2,0.4)	(0.6,0.5,0.2)	(0.6,0.5,0.3)
	t_3	(0.5,0.2,0.4)	(0.6,0.3,0.4)	(0.3,0.3,0.5)	(0.4,0.3,0.2)	(0.6,0.4,0.4)
P_2	t_1	(0.6,0.6,0.1)	(0.1,0.2,0.6)	(0.3,0.2,0.8)	(0.6,0.2,0.3)	(0.2,0.3,0.7)
	t_2	(0.5,0.4,0.2)	(0.2,0.2,0.6)	(0.2,0.1,0.7)	(0.8,0.3,0.1)	(0.1,0.1,0.8)
	t_3	(0.8,0.3,0.1)	(0.2,0.1,0.5)	(0.1,0.1,0.9)	(0.7,0.2,0.0)	(0.1,0.1,0.8)
P_3	t_1	(0.3,0.1,0.2)	(0.3,0.2,0.2)	(0.7,0.6,0.7)	(0.3,0.2,0.2)	(0.4,0.4,0.3)
	t_2	(0.4,0.2,0.2)	(0.5,0.1,0.3)	(0.4,0.2,0.2)	(0.5,0.3,0.3)	(0.6,0.3,0.2)
	t_3	(0.8,0.7,0.6)	(0.7,0.5,0.5)	(0.4,0.1,0.1)	(0.7,0.3,0.4)	(0.7,0.4,0.5)
P_4	t_1	(0.2,0.1,0.7)	(0.2,0.3,0.7)	(0.2,0.2,0.7)	(0.2,0.1,0.8)	(0.8,0.2,0.1)
	t_2	(0.1,0.1,0.6)	(0.1,0.2,0.8)	(0.2,0.1,0.8)	(0.3,0.0,0.9)	(0.7,0.1,0.2)
	t_3	(0.1,0.1,0.8)	(0.1,0.2,0.7)	(0.3,0.1,0.8)	(0.2,0.1,0.9)	(0.9,0.1,0.1)

4. Our Proposed Similarity Measures

Using the two SVNSs A and B with a universal set $X = \{x_1, x_2, \cdots, x_n\}$ as above, it is assumed that:

$$M_{w1}(A, B) = 1 - \sum_{j=1}^{n} w_j \alpha_j, \qquad (25)$$

with

$$\alpha_j = \max \left\{ \left| T_A(x_j) - T_B(x_j) \right|, \left| I_A(x_j) - I_B(x_j) \right|, \\ \cdot \left| F_A(x_j) - F_B(x_j) \right| \right\}, \qquad (26)$$

and

$$M_{w2}(A, B) = 1 - \sum_{j=1}^{n} w_j \beta_j, \qquad (27)$$

with

$$\beta_j = \frac{\left| T_A(x_j) - T_B(x_j) \right| + \left| I_A(x_j) - I_B(x_j) \right| + \left| F_A(x_j) - F_B(x_j) \right|}{3}, \qquad (28)$$

such that M_{w1} is related to the maximum norm, and M_{w2} is related to the arithmetic mean.

Our proposed weighted aggregation value for a patient, P, to a disease, D, is computed as

$$M_{w1}(P, D_i) = \sum_{k=1}^{q} w(t_k) M_{w1} \left(S_j^P(t_k), C_{ij} \right), \qquad (29)$$

where $S_j^P(t_k)$ is the SVNS for the patient P, with the symptom S_j, at period t_k, and C_{ij} is the SVNS for the disease D_i and the symptom S_j. On the other hand, we provide a second aggregated value by our proposed second similarity measure of Equation (27) as

$$M_{w2}(P, D_i) = \sum_{k=1}^{q} w(t_k) M_{w2} \left(S_j^P(t_k), C_{ij} \right). \qquad (30)$$

5. Diagnoses Illustration

The example from Ye and Fu [7] is used, wherein a patient group presents with an array of diseases, $D = \{D_1, D_2, \cdots, D_5\} = \{$viral fever, malaria, typhoid, gastritis, stenocardia$\}$, the list of symptoms as, $S = \{S_1, S_2, \cdots, S_5\} = \{$temperature, headache, stomach pain, cough, chest pain$\}$, and a set of four patients, $\{P_1, P_2, P_3, P_4\}$. The characteristic values of the patients and symptoms for a certain period are listed in Table 1. For example, $S_1^{P_1}(t_1)$ is the SVNS for the patient P_1 with the symptom S_1 at period $t_1 = (0.8, 0.6, 0.5)$.

Table 2 continues the list between (a) probable diseases and (b) their corresponding symptoms. For example, $C_{12} = (0.3, 0.2, 0.5)$ is the SVNS for disease D_1 with the symptom S_2.

With the proposed method of $M_{w1}(P_s, D_i)$ and $M_{w2}(P_s, D_i)$, for $s = 1, 2, 3, 4$ and $i = 1, 2, \cdots, 5$ with weights for periods $w(t_1) = 0.25$, $w(t_2) = 0.35$, and $w(t_3) = 0.4$ and weights for symptoms $w_j = 1/5$, for $j = 1, 2, \cdots, 5$, the results are presented in Table 3.

From Table 3, by the aggregation operator of M_{w1} with the maximum norm or the aggregation operator M_{w2} with the arithmetic mean, the same results are derived for patients P_1 and P_3 suffering from viral fever, the patient P_2 suffering malaria, and the patient P_4 suffering stenocardia. The study's derivations are the same as that of Yu and Fu [7] with the aggregation operator M_{T_2} of Equation (18) and the aggregation operator M_{C_2} of Equation (19).

TABLE 2: (Reproduction of Table 4 of Ye and Fu [7]) Characteristic values related to five diseases and five symptoms.

	S_1 (temperature)	S_2 (headache)	S_3 (stomach pain)	S_4 (cough)	S_5 (chest pain)
D_1 viral fever	(0.4,0.6,0.0)	(0.3,0.2,0.5)	(0.1,0.3,0.7)	(0.4,0.3,0.3)	(0.1,0.2,0.7)
D_2 malaria	(0.7,0.3,0.0)	(0.2,0.2,0.6)	(0.0,0.1,0.9)	(0.7,0.3,0.0)	(0.1,0.1,0.8)
D_3 typhoid	(0.3,0.4,0.3)	(0.6,0.3,0.1)	(0.2,0.1,0.7)	(0.2,0.2,0.6)	(0.1,0.0,0.9)
D_4 gastritis	(0.1,0.2,0.7)	(0.2,0.4,0.4)	(0.8,0.2,0.0)	(0.2,0.1,0.7)	(0.2,0.1,0.7)
D_5 stenocardia	(0.1,0.1,0.8)	(0.0,0.2,0.8)	(0.2,0.0,0.8)	(0.2,0.0,0.8)	(0.8,0.1,0.1)

TABLE 3: Study findings of $M_{w1}(P_s, D_i)$ and $M_{w2}(P_s, D_i)$.

	D_1	D_2	D_3	D_4	D_5	Diagnosis result
$M_{w1}(P_1, D_i)$	0.6730*	0.5990	0.6560	0.5260	0.5270	D_1 viral fever
$M_{w1}(P_2, D_i)$	0.7970	0.8730*	0.6780	0.5510	0.5330	D_2 malaria
$M_{w1}(P_3, D_i)$	0.5860*	05040	0.5540	0.5300	0.4520	D_1 viral fever
$M_{w1}(P_4, D_i)$	0.5210	0.4750	0.5640	0.6020	0.8910*	D_5 stenocardia
$M_{w2}(P_1, D_i)$	0.7770*	0.7323	0.7483	0.6810	0/6510	D_1 viral fever
$M_{w2}(P_2, D_i)$	0.8683	0.9250*	0.7897	0.6883	0.6670	D_2 malaria
$M_{w2}(P_3, D_i)$	0.7573*	0.6983	0.6960	0.7133	0.6573	D_1 viral fever
$M_{w2}(P_4, D_i)$	0.6917	0.6617	0.7170	0.7577	0.9443*	D_5 stenocardia

*Maximum values and thus, the most probable diagnosis.

6. Further Discussion for Aggregation Operators

In this section, we will explain that previous researchers used monotonic functions to transform the identity function (that is, $f(x) = x$) to complicated expressions. Based on the abbreviations of α_j and β_j, it is possible to rewrite T_{w1} of Equation (16) and T_{w2} of Equation (17) proposed by Yu and Fu [7] to simplify their expressions as follows

$$T_{w1}(A, B) = 1 - \sum_{j=1}^{n} w_j \tan\left(\pi\alpha_j/4\right), \quad (31)$$

$$T_{w2}(A, B) = 1 - \sum_{j=1}^{n} w_j \tan\left(\pi\beta_j/4\right). \quad (32)$$

Comparing Equation (25) with Equation (31), the following general expression is implied:

$$\text{Sim}_{w1}(A, B) = 1 - \sum_{j=1}^{n} w_j f(\alpha_j), \quad (33)$$

such that in Equation (25), for M_{w1}, $f(x) = x$, and in Equation (31), for T_{w1}, $f(x) = \tan(\pi x/4)$.

By the same argument, comparing Equation (27) with Equation (32) obtains a general expression:

$$\text{Sim}_{w2}(A, B) = 1 - \sum_{j=1}^{n} w_j f\left(\beta_j\right), \quad (34)$$

such that in Equation (27), for M_{w2}, $f(x) = x$, and in Equation (32), for T_{w2}, $f(x) = \tan(\pi x/4)$.

Consequently, we can further simplify $C_1(A, B)$ of Equation (12) and $C_2(A, B)$ of Equation (13) proposed by Ye [6] as follows

$$C_1(A, B) = \frac{1}{n} \sum_{j=1}^{n} \cos(\pi\alpha_j/2), \quad (35)$$

$$C_2(A, B) = \frac{1}{n} \sum_{j=1}^{n} \cos\left(\pi\beta_j/2\right). \quad (36)$$

Hence, Equations (25), (31), and (35) are used in comparison to determine their relationship with α_j of Equation (26). By the same observation, it is found that Equations (27), (32), and (36) are related to β_j of Equation (28).

In Equations (25) and (27), the most natural approach $f(x) = x$ is applied by us. Meanwhile, in Equations (31) and (32), Ye and Fu [7] used $f(x) = \tan(\pi x/4)$, and in Equations (35) and (36), Ye [6] used $f(x) = \cos(\pi x/2)$.

$f(x) = x$ and $f(x) = \tan(\pi x/4)$ are both increasing functions from $f(0) = 0$ to $f(1) = 1$. On the other hand, $f(x) = \cos(\pi x/2)$ is a decreasing function from $f(0) = 1$ to $f(1) = 0$. All of them are monotonic functions.

For a similarity measure, say Sim, $\text{Sim}(0) = 1$, and $\text{Sim}(1) = 0$ are ideal, such as in Equations (25), (27), (31), and (32) and then abstractly expressed in Equations (33) and (34), researchers use $1 - \sum_{j=1}^{m} w_j f(\alpha_j)$ or $1 - \sum_{j=1}^{m} w_j f(\beta_j)$.

There are infinite increasing functions that satisfy $f(0) = 0$ and $f(1) = 1$. However, Ye and Fu [7] did not provide

any explanation of why $f(x) = \tan(\pi x/4)$ was selected by them.

Moreover, there are infinite decreasing functions that satisfy $f(0) = 1$ and $f(1) = 0$. Ye [6] and Ye and Fu [7] also did not explain why $f(x) = \cos(\pi x/2)$ was used.

Since our proposed approach to use the simplest form $f(x) = x$ can still derive the desired diagnosis, the study recommends not to apply the complicated method proposed by Ye [6] with $f(x) = \cos(\pi x/2)$ and Ye and Fu [7] with $f(x) = \tan(\pi x/4)$. Instead, using our simplest form $f(x) = x$ will help researchers solve their similarity measure problems and also reduce the complicated computation caused by Ye [6] and Ye and Fu [7].

For completeness, we point out that Section 5.3 of Ye and Fu [7] shows the comparative analysis of Ye and Fu [7]. It is mentioned that the multiple period method is better than a single period of Ye [6] since the latter poses more difficulty in giving a suitable diagnosis for a specific patient presenting with a specific disease. Recalling the example of Section 5 of Ye and Fu [7], it showed that the aggregation operator M_{T_2} of Equation (18) was used with tangent similarity measure T_2 of Equation (15) and the aggregation operator M_{C_2} of Equation (19) with tangent similarity measure C_2 of Equation (13) which was proposed by Ye [6]. Both operators derived the same diagnosis results for four patients as obtained in Table 3 by aggregation operator M_{w1} of Equation (29) and aggregation operator M_{w2} of Equation (30).

In Ye and Fu [7], the improved similarity measure C_2 of Ye [6] was used and repeated three times, then combined with the weighted mean such that the improved similarity measure C_2 of the latter study can be used to solve multiperiod medical diagnosis problems. Ye and Fu [7] already successfully applied C_2 in their algorithm as mentioned that using the tangent function and cosine measure, the diagnoses are similar and therefore proving that their proposed multiperiod method was indeed effective. The reference implies the possibility to use the cosine measure from Ye [6] for medical diagnoses over multiple periods. Ye and Fu [7] first used the improved cosine similarity measure of Equation (13) proposed by Ye [6] to support their tangent similarity measure of Equation (15), since aggregation approach by the two measures derive identical diagnosis results. On the contrary, in the same section, Ye and Fu [7] claimed that the improved cosine similarity measure of Equation (13) proposed by Ye [6] is unable to solve multiperiod medical diagnosis problems. Hence, the study points out that Section 5.2 or the comparative analysis of Ye and Fu [7] contained questionable results.

7. Conclusion

In this paper, we tried to claim that there is an isomorphism between (a) our simplest similarity measures and (b) those complicated similarity measures. Hence, to construct new similarity measures that can be explained by isomorphism is tedious and unnecessary. This study provided a detailed analysis of the improved cosine similarity measure proposed by Ye [6] and the tangent similarity measure proposed by Ye and Fu [7] to point out that these are transformations of the maximum norm and the arithmetic mean. As a recommendation, researchers can directly apply the well-known distance: the maximum norm and the arithmetic mean, to simplify the complicated computations in Ye and Fu [7].

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgments

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