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Impact of Online Education During Covid Pandemic through Pythagorean Fuzzy Environment

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Abstract: The COVID-19 pandemic has provided us with an opportunity to pave the way for introducing digital learning. Like there are two sides to the same coin, online learning also has many advantages and disadvantages. While online classes did start as there was no other choice, their impact started creeping in gradually. Children had difficulty to focus but various techniques helped in solving that issue. The project aims to provide a comprehensive report on the impact of the COVID-19 pandemic during online education on students and we analyze the observed data in multiple attribute decision-making methodologies in a Pythagorean fuzzy environment.

Key Words – Pythagorean Fuzzy Sets, Improved Correlation Coefficients.

I. Introduction

Coronavirus, also known as COVID-19, has spread to several countries around the world. Due to the COVID-19 pandemic, the biggest part of the education process (subject, social, even physical) was transferred from the direct form into the form of virtual education. This sudden change caused by unforeseen conditions affected the interactions, involvement, and roles of both teachers and students in the educational process. This situation forced everyone to remember and apply the already well-known experience of online learning and to look for criteria to improve the quality of online learning process. Online learning has provided the opportunity to teach and learn in innovative ways unlike the teaching and learning experiences in the normal classroom setting.Today the magnanimity of technology is recognized by all age groups and not just the tech or business industry. However it created some sense of isolation, lack of self-motivation and several more negative effects on students.

Correlation coefficient is an effective mathematical tool to measure the strength of the relationship between two variables. A correlation coefficient is a statistical measure which contributes in deciding the degree to which changes in one variable predict changes in another. Correlation coefficients plays an important role in many real world problems like multiple attribute group decision making, clustering analysis, pattern recognition, medical diagnosis etc.,

Multiple criteria decision making problems refer to make decisions when several attributes are involved in real-life problem. For example one may buy a dress by analyzing the attributes which is given in terms of price, style, safety, comfort etc,.

II. PRELIMINARIES

Definition 2.1

Let X be universe set. Then a Pythagorean fuzzy set A which is set of ordered pairs over X

$$A = \{\langle x, M_A(x), N_A(x)\rangle : x \in X\}$$

Where $M_A: X \rightarrow [0,1]$, $N_A: X \rightarrow [0,1]$ denote the degree of membership and degree of non-membership of element $x \in X$ to the set A which is a subset of X and

$$0 \leq (M_A(x))^2 + (N_A(x))^2 \leq 1 \text{ for any } x \in X$$

$M_A(x)$ and $N_A(x)$ is the degree of membership and non-membership of the element of x respectively.

Definition 2.2

Let A and B be Pythagorean fuzzy sets in a topological space X of the form $A = \{\langle x, M_A(x), N_A(x)\rangle : x \in X\}$, $B = \{\langle x, M_B(x), N_B(x)\rangle : x \in X\}$

$$A \cup B = \{x, \max(M_A(x), M_B(x)), \min(N_A(x), N_B(x)) | x \in X\}$$
$$A \cap B = \{x, \min(M_A(x), M_B(x)), \max(N_A(x), N_B(x)) | x \in X\}$$
$$A^C = \{(x, N_A(x), M_A(x)) | x \in X\}$$

III. Improved Correlation Coefficients of Pythagorean Fuzzy Sets

Definition 3.1

Let P and Q be any two Pythagorean fuzzy sets in the universe of discourse R = {$r_1, r_2, r_3, \ldots, r_n$}, then the improved correlation coefficient between P and Q is defined as follows

$$K(P,Q) = \frac{1}{2n}\sum_{k=1}^{n}[\lambda_k(1-\Delta M_k) + \mu_k(1-\Delta N_k)] \quad (1)$$

Where,

$$\lambda_k = \frac{1-\Delta M_k-\Delta M_{max}}{1-\Delta M_{min}-\Delta M_{max}},$$
$$\mu_k = \frac{1-\Delta N_k-\Delta N_{max}}{1-\Delta N_{min}-\Delta N_{max}},$$
$$\Delta M_k = |M_P^2(r_k) - M_Q^2(r_k)|,$$
$$\Delta N_k = |N_P^2(r_k) - N_Q^2(r_k)|,$$
$$\Delta M_{min} = \min_k|M_P^2(r_k) - M_Q^2(r_k)|,$$
$$\Delta N_{min} = \min_k|N_P^2(r_k) - N_Q^2(r_k)|,$$
$$\Delta M_{max} = \max_k|M_P^2(r_k) - M_Q^2(r_k)|,$$
$$\Delta N_{max} = \max_k|N_P^2(r_k) - N_Q^2(r_k)|,$$

For any $r_k \in R$ and k = 1,2,3,…,n.

Theorem 3.2

For any two Pythagorean fuzzy sets P and Q in the universe of discourse R = {$r_1, r_2, r_3, \ldots, r_n$}, the improved correlation coefficient K(P,Q) satisfies the following properties.

(i) K(P,Q) = K(Q,P);
(ii) $0 \le K(P,Q) \le 1$;
(iii) K(P,Q) = 1 iff P = Q.

Proof:

(i) It is obvious and straightforward.

(ii) Here, $0 \le \lambda_k \le 1$, $0 \le \mu_k \le 1$,
$0 \le (1-\Delta M_k) \le 1$, $0 \le (1-\Delta N_k) \le 1$,
Therefore the following inequation satisfies
$0 \le \lambda_k(1-\Delta M_k) + \mu_k(1-\Delta N_k) \le 2$.
Hence we have $0 \le K(P,Q) \le 1$.

(iii) If K(P,Q) = 1,then we get $\lambda_k(1-\Delta M_k) + \mu_k(1-\Delta N_k) = 2$
Since $0 \le \lambda_k(1-\Delta M_k) \le 1$, $0 \le \mu_k(1-\Delta N_k) \le 1$,
there are $\lambda_k(1-\Delta M_k) = 1$, $\mu_k(1-\Delta N_k) = 1$.
And also since $0 \le \lambda_k \le 1$, $0 \le \mu_k \le 1$
$0 \le (1-\Delta M_k) \le 1$, $0 \le (1-\Delta N_k) \le 1$.
We get $\lambda_k = \alpha_k = \mu_k = 1$ and
$1-\Delta M_k = 1-\Delta N_k = 1$.

This implies, $\Delta M_k = \Delta M_{min} = \Delta M_{max} = 0$, $\Delta N_k = \Delta N_{min} = \Delta N_{max} = 0$.
Hence $M_P(r_k) = M_Q(r_k)$, $N_P(r_k) = N_Q(r_k)$ for any $r_k \in R$ and k = 1,2,3,…,n. Hence P = Q.
Conversely, assume that P = Q, this implies $M_P(r_k) = M_Q(r_k)$, $N_P(r_k) = N_Q(r_k)$ for any $r_k \in R$ and k = 1,2,3,…,n.
Thus $\Delta M_k = \Delta M_{min} = \Delta M_{max} = 0$, $\Delta N_k = \Delta N_{min} = \Delta N_{max} = 0$.
Hence we get K(P,Q) = 1.

The improved correlation coefficient formula which is defined is correct and also satisfies these properties in the above theorem .When we use any constant $\varepsilon > 2$ in the following expressions

$$\lambda_k = \frac{\varepsilon-\Delta M_k-\Delta M_{max}}{\varepsilon-\Delta M_{min}-\Delta M_{max}},$$

$$\alpha_k = \frac{\varepsilon-\Delta H_k-\Delta H_{max}}{\varepsilon-\Delta H_{min}-\Delta H_{max}},$$

$$\mu_k = \frac{\varepsilon-\Delta N_k-\Delta N_{max}}{\varepsilon-\Delta N_{min}-\Delta N_{max}}$$

Example 3.3

Let A = {r,0,0} and B = {r,0.4,0.2} be any two Pythagorean fuzzy sets in R. Therefore by equation (1) we get K(A,B) = 0.9. It shows that the above defined improved correlation coefficient overcome the disadvantages of the correlation coefficient.

In the following, we define a weighted correlation coefficient between Pythagorean fuzzy sets since the differences in the elements are considered into an account. Let w_k be the weight of each element r_k(k = 1,2,…,n), $w_k \in [0,1]$ and $\sum_{k=1}^{n} w_k = 1$, then the weighted correlation coefficient between the Pythagorean fuzzy sets A and B.

$$K_w(A,B) = \frac{1}{2}\sum_{k=1}^{n} w_k[\lambda_k(1-\Delta M_k) + \mu_k(1-\Delta N_k)] \quad (2)$$

Theorem 3.4
Let w_k be the weight of each element $r_k(k = 1,2,\ldots,n)$, $w_k \in [0,1]$ and $\sum_{k=1}^{n} w_k=1$, then the weighted correlation coefficient between the Pythagorean fuzzy sets A and B which is denoted by $K_w(A,B)$ defined in equation (2) satisfies the following properities.

1) $K_w(A,B) = K_w(B,A)$;
2) $0 \le K_w(A,B) \le 1$;
3) $K_w(A,B) = 1$ iff A = B.

It is similar to prove the properities in theorem (3.2).

IV. DECISION MAKING USING THE IMPROVED CORRELATION COEFFICIENT OF PYTHAGOREAN FUZZY SETS

Multiple criteria decision making problems refers to make decisions when several attributes are involved in real-life problem. For example one may buy a dress by analysing the attributes which is given in terms of price, style, safety,comfort etc.,

Here we consider a multiple attribute decision making problem with Pythagorean fuzzy information and the characteristic of an alternative $A_i(i=1,2,\ldots,m)$ on an attribute $C_j(j=1,2,\ldots,n)$ is represented by the following Pythagorean fuzzy set:

$$A_i= \{C_j, M_{A_i}(C_j), N_{A_i}(C_j) \,/\, C_j \in C, j = 1,2,\ldots n\}$$

where, $M_{A_i}(C_j), N_{A_i}(C_j) \in [0,1]$ and
$0 \le M_{A_j}{}^2(C_j) + N_{A_j}{}^2(C_j) \le 1$
for $C_j \in C$, $j = 1,2,\ldots n$ and $i = 1,2,\ldots m$.

To make it convenient, we are considering the following two functions $M_{A_i}(C_j)$, $N_{A_i}(C_j)$ in terms of Pythagorean fuzzy value.

$$d_{ij} = (m_{ij},n_{ij}) \quad (i = 1,2,\ldots,m;\ j = 1,2,\ldots n)$$

Here the values of d_{ij} are usually derived from the evaluation of an alternative A_i with respect to a criteria C_j by the expert or decision maker. Therefore we got a Pythagorean fuzzy decision matrix $D=(d_{ij})_{m\times n}$.

In the case of ideal alternative A^* an ideal Pythagorean fuzzy sets can be defined by $d_j^* = m_j^*, n_j^* = (1,0)(j = 1,2,\ldots,n)$ in the decision making method, Hence the weighted correlation coefficient between an alternative $A_i(i=1,2,\ldots,m)$ and the ideal alternative A^* is given by,

$$K_w(A_i,A^*) = \frac{1}{2}\sum_{j=1}^{n} w_j[\lambda_{ij}\left(1-\Delta m_{ij}\right) + \mu_{ij}(1-\Delta n_{ij})] \quad (3)$$

Where,

$$\lambda_{ij} = \frac{1-\Delta m_{ij}-\Delta m_{imax}}{1-\Delta m_{imin}-\Delta m_{imax}},$$
$$\mu_{ij} = \frac{1-\Delta n_{ij}-\Delta n_{imax}}{1-\Delta n_{imin}-\Delta n_{imax}},$$
$$\Delta m_{ij} = |m_{ij}^2 - m_j^*|,$$
$$\Delta n_{ij} = |n_{ij}^2 - n_j^*|,$$
$$\Delta m_{imin} = \min_j |m_{ij}^2 - m_j^*|,$$
$$\Delta n_{imin} = \min_j |n_{ij}^2 - n_j^*|,$$
$$\Delta m_{imax} = \max_j |m_{ij}^2 - m_j^*|,$$
$$\Delta n_{imax} = \max_j |n_{ij}^2 - n_j^*|,$$

For $i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$.

By using the above weighted correlation coefficient we can derive the ranking order of all alternatives and we can choose the best one among those.

Example 4.1
This section deals the example for the multiple attribute decision making problem with the given alternatives corresponds to the criteria allotted under Pythagorean fuzzy environment. For this example which we will discuss here is about the few factors that had a great impact during the online education on students of all available factors based on various criteria. The factors A_1, A_2, A_3 respectively denotes the Vision impairment, Lack of knowledge, Social isolation. We must take a decision according to the following four attributes that is (1) C_1 is the Duration of online classes (2) C_2 is the Network (3) C_3 is the Laziness (4) C_4 is the Poor online portal quality. According to this attributes we will derive the ranking order of all factors and based on this ranking order the factor with great impact will be selected.

The weight vector of the above attributes is given by $w = (0.2, 0.35, 0.25, 0.20)^T$. In general the evaluation of a factor A_i with respect to an attribute $C_j(i = 1,2,3;\ j = 1,2,3,4)$ will be done.

A_iC_j	C_1	C_2	C_3	C_4
A_1	[0.2,0.5]	[0.1,0.2]	[0.3,0.2]	[0.4,0.1]
A_2	[0.1,0.2]	[0.3,.0.5]	[0.8,0.1]	[0.3,0.4]
A_3	[0.2,0.4]	[0.2,0.7]	[0.6,0.1]	[0.4,0.1]

Then by using the proposed method we will obtain the most desirable factor. We can get the values of the correlation coefficient $K_w(A_i, A^*)(i= 1,2,3)$ by using Equation (3).Hence $K_w(A_1,A^*) = 0.46084$, $K_w(A_2,A^*) = 0.51796$, $K_w(A_3,A^*) =$

0.36833. Therefore the ranking order is, $A_2 > A_1 > A_3$.The factor A_2 (Lack of Knowledge) is the greatest impact among all the three.

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