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Choice of an Online Teaching App in the E-learning Process of School Children based on Distance Measures

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#### Abstract

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In this paper, various E-learning Apps have been compared and analysed by two distance measures and formulate their comparison with limited number of students and factors with the scope of their extension. Hamming Distance and Euclidean Distance are two distance measures used in this paper. Moreover, the variables considered for this purpose follows the Intuitionistic Fuzzy Set (IFS) theory.

**Keywords**: intuitionistic fuzzy set, intuitionistic fuzzy relations, normalized hamming distance measure, normalized Euclidian distance measure, online learning apps

#### 1. Introduction

E-learning Apps has become popular among students and teachers during and after the pandemic period. Although, the restrictions have been lifted almost everywhere but the online education still remains an integral part of our educational set up. Students are still learning through online applications. It has many benefits with flexible working hours and a reach to larger audience. Students remain in touch with the teacher and exchange study material. Learning apps are used by teachers and students as per their own convenience. A designed mathematical model is adopted to develop action plans and online learning apps are selected from the set available options.Some most important benefits of online classes are (a) flexible in working hours (b) opportunity to teach a large audience (c) access to online services etc.

To teach online through any app can make the process easier. It is easy to add some videos and pictures while taking an online class. Teaching apps are comprehensive apps which permit students to keep in touch with their teachers. These apps also assist teachers in making announcements, sharing study material etc. with students. A lot of learning apps are available in the

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market but each app has its own advantages. A teacher uses a suitable online app according to the available resources and classroom management. A student selects a particular online learning app after keeping in mind the influencing factors. The selection of the online learning app is based on the set of availableoptions. Adlassnig[1] and Yao[20] have applied fuzzy set theory in medical diagnosis of some particular diseases. Atanassov [3] have invented various new operations over intuitionistic fuzzy set theory. Ejegwa, Akubo and Joshua [5] have discussed the importance of intuitionistic fuzzytheory in career determination. Rajeshwari and Uma [13] have studied normalized geometric and normalized hamming distance measures in intuitionistic fuzzy sets and interval valued intuitionistic fuzzy sets. Szmidt [15] has developed various distance and similaritymeasures in intuitionistic fuzzy set and did their application in various disciplines.

#### 2. Material and Methodology

Information theory is mainly based on probability theory and communication theory. The work of information theory is to transmit the data efficiently and to find errors in data transmission and reception. The concept of information theory was first given by C E Shannon [14] in 1948. The Shannon's measure is also known as measure of uncertainty. The concept of fuzzy theory and intuitionistic fuzzy set theory is used in vague situation. The main difference between the information theory and fuzzy theory is that the information theory deals with uncertaintieswhile fuzzy theory deals with vagueness and ambiguous. The fuzzy theory can be said as a generalization of crisp set theory. Fuzzy theory was given by Zadeh [21] and intuitionistic fuzzy set theory was given by Atanassov [2]. IF theory has given a new scientific tool to handle acomplex system in the real world. The elements have degree of membership, degree of non-membership and hesitant index (intuitionistic fuzzy set theory as:

- (i) Intuitionistic fuzzification
- (ii) Application of operation rules
- (iii) Intuitionistic defuzzification

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Szmidt and Kacprzyk [17] have invented new entropy measures for intuitionistic fuzzy sets. Prince et. al. [12] have seen the interest of customers towards life insurance policies in IFS theory. Hung and Yang [6] gave some fuzzy entropy functions on intuitionistic fuzzy sets.

The distance is a quantity which is used to compare similarity or dissimilarity of cases in variable space calculated by the used variables taken from a data set. The distance measures contain the properties of symmetry, positivity etc. These measures are generally used to calculate the distance between numerical, mixed or categorical data. It may also said that a distance measure is a measure of closeness between two objects. These objects may describe a subject (such as person, house or car) or an event (such as diagnosis, purchase etc.). There are various distance measures which can be used to calculate the distance say Hamming distance, Geometric distance, Euclidean Distance, Manhattan distance, Minkowski distance etc. but in this paper, two distance measures (Hamming distance and Euclidean Distance) are applied to obtain the result. Szmidt and Kacprzyk [16] derived some distances between intuitionistic fuzzy sets in pattern recognition. Ke et. al. [8] made some new distance measure for Atanassov's intuitionistic fuzzy sets and applied them in decision making.

In this paper, different types of popular E-learning Apps have been compared and analyzed. A questionnaire was filled from some school students about their liking and disliking for online learning apps. While preparing questionnaire it was keep in mind that the questionnaire should be related to the new technology and the influencing factors. The aim of this study is to find out which online teaching app is more popular in school students. The studies also discuss the characteristics of these online teaching apps. The complete analysis has been done in the form of cross tables (containing membership value, non-membership value, intuitionistic index). In the first step, the matrix shows the IF relation betweenstudents and the factors influencing their choice for selecting an online app (with assigned degree of membership, non-membership and hesitant index values) as given in first table. Second table reveal the IF relation between the factors or features and important online teaching/learning apps (with assigned degree of membership, non-membership and hesistant index values). In the third and fourth step, hamming distance and normalized hamming distance is applied on table one and two and get results as table third and fourth. At last, Euclidean and normalized Euclidean distance measures are applied on table one and two and find results as table fifth and sixth. The comparison between the values of tables (third to sixth) has also done. The lowest value from all the tables has been selected by the school students. If there is any tie in

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values, then it shows that the student may be interested in selecting both types of online teaching/learning apps.

#### **3. Mathematical Methods**

In this section, some basic definitions related to fuzzy set theory and intuitionistic set theory was studied brieflyto facilitate subsequentexposition.

**Definition 1.**Let a non-empty set  $X = \{x_1, x_2, \dots, x_n\}$  be the universe of discourse. Then a fuzzy set A in X is defined as:

A = { < x, 
$$\mu_A(x) > | x \in X$$
 } Where  $\mu_A(x) : X \rightarrow [0,1]$  is the membership degree.

**Definition 2.** Let  $X = \{x_1, x_2, x_3, ..., x_n\}$  be a universal set. Then an intuitionistic fuzzy set A in X given by Atanassov can be written as:

A = { < x,  $\mu_A(x)$ ,  $v_A(x) > | x \in X$  } Where  $\mu_A(x) : X \rightarrow [0,1]$  and  $v_A(x) : X \rightarrow [0,1]$  are membership degree and non-membership degree respectively, having the condition

$$0 \le \mu_A(x) + v_A(x) \le 1$$

**Definition 3.** The hesitant degree of intuitionistic fuzzy set A defined in X is denoted by  $\pi_A(x)$ . its value is determined by the following expression:

$$\pi_{\mathrm{A}}(\mathrm{x}) = 1 - \mu_{\mathrm{A}}(\mathrm{x}) - \mathrm{v}_{\mathrm{A}}(\mathrm{x})$$

Apparently, we can get  $\pi_A(x) \in [0,1]$  for each  $x \in X$ .  $\pi_A(x)$  is also called the intuitionistic index of x to A. Greater  $\pi_A(x)$  indicates more vagueness. Obviously, when  $\pi_A(x) = 0$  for all  $x \in X$ , then IFS degenerates into and ordinary fuzzy set. Generally, the couple  $[\mu_A(x), v_A(x)]$  is also called an intuitionistic fuzzy value (IFV) for clarity.

#### 3.1 Some Basic Distance Measures in IFS

Definition 3: Let X be a non-empty set. Such that IFS A, B, C  $\in$  X. Then the distance

measuredbetween IFS A and B is a mapping  $d: X * X \rightarrow [0,1]$ ;

If d (A, B) satisfies the following axioms

$$A_1: 0 \le d(A, B) \le 1$$
$$A_2: d(A, B) = 0 \Leftrightarrow A = B$$
$$A_3: d(A, B) = d(B, A)$$
$$A_4: d(A, C) + d(B, C) \ge d(A, B)$$
$$A_5: if A \subseteq B \subseteq C$$

Then  $d(A, C) \ge d(A, B)$  and  $d(A, C) \ge d(B, C)$ .

Now we make the use of the fourdistance measures which are proposed here.

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Let

$$A = \{ < x, \mu_A(x_i), v_A(x_i), \pi_A(x_i) >: x \in X \}$$
  
and  
$$B = \{ < x, \mu_B(x_i), v_B(x_i), \pi_B(x_i) >: x \in X \}$$

Be two IF sets in  $X = \{x_1, x_2, x_3, x_4, \dots, x_n, \}, i = 1,2,3,4,\dots, n$  based on the geometric interpretation of IFS theory proposed by Szmidt and Kacprzyk [2001].

1. Hamming Distance:

$$d_H(A,B) = \frac{1}{2} \sum_{i=1}^{n} [|\mu_A(x_i) - \mu_B(x_i)| + |\nu_A(x_i) - \nu_B(x_i)| + |\pi_A(x_i) - \pi_B(x_i)|]$$

2. The Euclidean Distance:

$$d_E(A,B) = \sqrt{\frac{1}{2} \sum_{i=1}^{n} \left[ \left( \mu_A(x_i) - \mu_B(x_i) \right)^2 + \left( \nu_A(x_i) - \nu_B(x_i) \right)^2 + \left( \pi_A(x_i) - \pi_B(x_i) \right)^2 \right]}$$

3. The Normalized Hamming Distance:

$$d_{n-H}(A,B) = \frac{1}{2n} \sum_{i=1}^{n} \left[ |\mu_A(x_i) - \mu_B(x_i)| + |\nu_A(x_i) - \nu_B(x_i)| + |\pi_A(x_i) - \pi_B(x_i)| \right]$$

4. The Normalized Euclidean Distance:

$$d_{n-E}(A,B) = \sqrt{\frac{1}{2n} \sum_{i=1}^{n} \left[ \left( \mu_A(x_i) - \mu_B(x_i) \right)^2 + \left( \nu_A(x_i) - \nu_B(x_i) \right)^2 + \left( \pi_A(x_i) - \pi_B(x_i) \right)^2 \right]}$$

Husain, Ahmad and Alam [7] did application of intuitionistic fuzzy sets in some decision making problems. Chen et. al. [4] derived some distance and similarity measures for intuitionistic hesistant fuzzy sets and did their application. Tugrul et. al. [18] did application of IF sets in high school determination by using normalized euclidean distance method. Recently, Kozae et. al. [9] applied distance measures in intuitionistic fuzzy set theory to detect Corona patients.

#### 4. Mathematical Analysis

In this section, the problem related to the selection of online learning apps by the students has been solved. For this purpose, all the influencing factors characterize by each student are kept in mind. There are many online learning apps are available in the market but some of them are more popular according to their features. In this study, five students, some important online apps and the basic influencing factors are considered. A questionnaire was prepared for the collection of data. The data has been collected according to the Likert Scale in the range (0 to 1). The questionnaire is 5110

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prepared for this purpose (see link https://forms.gle/exA1DypgZyPt9GJm8). In this article,Szmidt and Kacprzyk [16] methods based on some distance measures in intuitionistic fuzzy set theory are proposed.

Let  $S = [s_1, s_2, s_3, s_4]$  be the group (separately) of students (school students) and  $F = [f_1, f_2, f_3, f_4, f_5] =$  [family Back ground, personal views, learning abilities and skills, social aspects, financial conditions] be the set of factors which influence the interest of students for the selection of an online app. Then  $A = [a_1, a_2, a_3, a_4, a_5] =$  [zoom app, google meet, Microsoft Team, Cisco Webex, Digital Class] be the set of some online apps respectively.

Then the fuzzy relations Q and R are given as:

 $Q = \{ < (s, f), \, u_Q(s, f), \, v_Q(s, f) > | \, (s, f) \, \in \, S \times F \}$ 

 $R = \{ <\!\!(f, a), u_R(f, a), v_R(f, a) > \mid (f, a) \in F \times A \},\$ 

Where  $u_Q(s, f)$  means the interest of the student s is characterized by the factor f. The value  $v_Q(s, f)$  means the interest of the student s is not characterized by the factor f. And  $u_R(f, a)$  shows the degree to which the factor f confirm the selection of online app a. Similarly  $v_R(f, a)$  shows the degree to which the factor f does not confirm the selection of online app a.

Now we can study about the selection of online learning app by using the information taken from the chart of case study. This information will play a vital role in the whole analysis when various types of online apps are available for school students.

### 5. Data Analysis

Let  $S = [s_1, s_2, s_3, s_4]$  be the number of school students and  $F = [f_1, f_2, f_3, f_4, f_5]$  be the set of influencing factors about the selection of an app.

Q	F <sub>1</sub>	$F_2$	F <sub>3</sub>	F <sub>4</sub>	F <sub>5</sub>
Students	$(\mu_Q, v_Q, \pi_Q)$				
$\mathbf{S}_1$	(0.8,0.1,0.1)	(0.6,0.1,0.3)	(0.2,0.8,0.0)	(0.6,0.1,0.3)	(0.1,0.6,0.3)
<b>S</b> <sub>2</sub>	(0.0,0.8,0.2)	(0.4,0.4,0.2)	(0.6,0.1,0.3)	(0.1,0.7,0.2)	(0.1,0.8,0.1)
<b>S</b> <sub>3</sub>	(0.8,0.1,0.1)	(0.8,0.1,0.1)	(0.0,0.6,0.4)	(0.2,0.7,0.1)	(0.0,0.5,0.5)
$S_4$	(0.6,0.1,0.3)	(0.5,0.4,0.1)	(0.3,0.4,0.3)	(0.7,0.2,0.1)	(0.3,0.4,0.3)

Suppose the intuitionistic fuzzy theory relation  $Q(S \rightarrow F)$  is taken as:

 Table – I (membership, non-membership and hesistant index values of school students and influencing factors of online apps)

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Again,  $A = [a_1, a_2, a_3, a_4, a_5]$  be the types of some online apps which are available according to their features. The students will select one or more than one app according to their interest.

Q	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	$A_4$	A <sub>5</sub>
Factors	$(\mu_Q, v_Q, \pi_Q)$				
F <sub>1</sub>	(0.4,0.0,0.6)	(0.7,0.0,0.3)	(0.3,0.3,0.4)	(0.1,0.7,0.2)	(0.1,0.8,0.1)
F <sub>2</sub>	(0.3,0.5,0.2)	(0.2,0.6,0.2)	(0.6,0.1,0.3)	(0.2,0.4,0.4)	(0.0,0.8,0.2)
F <sub>3</sub>	(0.1,0.7,0.2)	(0.0,0.9,0.1)	(0.2,0.7,0.1)	(0.8,0.0,0.2)	(0.2,0.8,0.0)
F <sub>4</sub>	(0.4,0.3,0.3)	(0.7,0.0,0.3)	(0.2,0.6,0.2)	(0.2,0.7,0.1)	(0.2,0.8,0.0)
F <sub>5</sub>	(0.1,0.7,0.2)	(0.1,0.8,0.1)	(0.1,0.9,0.0)	(0.2,0.7,0.1)	(0.8,0.1,0.1)

Secondly, the intuitionistic fuzzy theory relation R ( $F \rightarrow A$ ) is taken as:

 $Table-II\ (membership,\ non-membership\ and\ hesistant\ index\ values\ of\ factors$ 

of their corresponding types of online apps)

Now by applying Hamming distance formula between two intuitionistic fuzzy sets the following result is obtained

Hamming	Zoom	Google	Microsoft	Cisco	Digital
Distance	Арр	Meet	Team	Webex	Class
$\mathbf{S}_1$	1.4	1.2	1.4	2.7	2.8
<b>S</b> <sub>2</sub>	2.0	2.5	1.5	0.7	2.1
<b>S</b> <sub>3</sub>	1.9	2.2	1.6	2.5	2.7
$\mathbf{S}_4$	1.4	1.5	1.9	2.2	2.7

Table–III (students and their corresponding types of online apps)

Again, applying Normalized Hamming distance between these two intuitionistic fuzzy sets. The results are as follows:

N <sub>HD</sub>	Zoom	Google	Microsoft	Cisco	Digital
	Арр	Meet	Team	Webex	Class
$S_1$	0.28	0.24	0.28	0.54	0.56
$S_2$	0.40	0.50	0.31	0.14	0.42

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$S_3$	0.38	0.44	0.32	0.50	0.55
$\mathbf{S}_4$	0.28	0.30	0.38	0.44	0.54

Table – IV (students and their corresponding types of online apps)

From the above two tables we find the final result. We conclude that student  $S_1$  want to take learning by google meet, and  $S_2$  selects Cisco Webex. While the students  $S_3$  and  $S_4$  are interested in Microsoft Team and Zoom app.

In the next step, Euclidean distance and Normalized Euclidean distance is applied on table I and table II and get the results as table III and table IV.

By applying Euclidean distance between two intuitionistic fuzzy sets for all factors about the selection of online app by school students.

Euclidean	Zoom	Google	Microsoft	Cisco	Digital
Distance	Арр	Meet	Team	Webex	Class
<b>S</b> <sub>1</sub>	0.65	0.56	0.71	1.18	1.30
<b>S</b> <sub>2</sub>	0.97	1.25	0.75	0.32	1.03
<b>S</b> <sub>3</sub>	0.80	0.97	0.72	1.16	1.29
<b>S</b> <sub>4</sub>	0.56	0.65	0.78	0.96	1.11

Table – V (students and their corresponding types of online apps)

At last, applying Normalized Euclidean distance between two intuitionistic fuzzy sets for the selection of online app by school students.

N <sub>ED</sub>	Zoom	Google	Microsoft	Cisco	Digital
	Арр	Meet	Team	Webex	Class
$\mathbf{S}_1$	0.29	0.25	0.32	0.53	0.58
$S_2$	0.43	0.56	0.33	0.14	0.46
$S_3$	0.36	0.41	0.32	0.52	0.58
$\mathbf{S}_4$	0.25	0.29	0.35	0.43	0.50

Table – VI (students and their corresponding types of online apps)

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Again, from the above tables (V and VI) we obtain the similar result (after applying hamming and normalized hamming distance). We see that the student  $S_1$  is interesting in google meet app and student  $S_2$  chooses Cisco Webex. But the students  $S_3$  and  $S_4$  are interested in learning through Microsoft Teamand Zoom app.

#### 6. Conclusion and Future Aspects

Table -III and Table -IV collectively concludes that student  $S_1$  prefers learning by google meet, and  $S_2$  selects Cisco Webex. While the students  $S_3$  and  $S_4$  are interested in Microsoft Team and Zoom app. Again, Table -V and Table -VI collectively concludes the similar result (after applying hamming and normalized hamming distance) i.e. the student  $S_1$  is interesting in google meet app and student  $S_2$  chooses Cisco Webex. But the students  $S_3$  and  $S_4$  are interested in learning through Microsoft Team and Zoom app.

In the present paper, four groups of school students who were selected randomlyhave been researched in order to form the above result tables.Moreover, this research technique can be applied to larger groups of students.Every student has his/her own desires and qualities. Here, some aspects as psychology of the students, success rate of schools, and role of the teacher, preference order and different city preference etc. have been ignoredbecause these influencing factors or features may have positive or negative effects on high school determination. Data related to some of the factors discussed in this paper shows variability.In this paper the application of IFS theory is discussed. Because the idea of intuitionistic fuzzy sets is of immense significance in decision mathematics. The IFS theory captures all the possibilities involve in real life decision problems. Thus the distance methods are more suitable in order to achieve more sensible results. This paper also shows that the used method can be applied to evaluation system through various arrangements.The available evaluation system can be renewed by using intuitionistic fuzzy logic system. In the last we can say that the applied distance measures are well suitable and beneficial and may be applied for various decision making problems. In this paper, five Apps have been compared influenced by factors. It can also be extended to any number of variables.

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### **Questionnaire for Table I**

The students have to give number according to the Likert Scale measurement tool given below:

### Part I

- 1. Do your parents are worried about your education?
- 2. Are your parents are educated (minimum graduate)?
- 3. Do your parents like classroom teaching in comparison of online learning?

#### Part II

- 1. Do you think this new technology is confused?
- 2. Do you feel stress while taking online classes?
- 3. Do you feel online learning requires more time for problem solving?

### Part III

- 1. Are you comfortable while using these online apps?
- 2. Do your teachers and classmates help you to use these apps?
- 3. Are you satisfied with this online learning?

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# Part IV

- 1. Do your teachers and parents encourage you for online learning?
- 2. Do you think that the online learning is the demand of present society?
- 3. Does government encourage online teaching/learning?

# Part V

- 1. Do your parents give you recharge facility for online classes regularly?
- 2. Do your parents have provided you and android mobile phone or laptop or notepad separately for online learning?
- 3. Do your parents allow you to for any part time job in addition to online learning?

# **Questionnaire for Table II**

The students have to give number according to the Likert Scale measurement tool given below:

## Part I

- 1. Have your parents have heard about this app?
- 2. Have your parents have used this app?
- 3. Do your parents permit you to learn by this app?

## Part II

- 1. Do you like to learn through this app?
- 2. Does this app give you the download facility?
- 3. Does this app provide you the best content for learning?

# Part III

- 1. This app gives you the audio/video facility in a clear manner?
- 2. This app provides you the more knowledge in comparison of other apps?
- 3. When you learn through this app, your knowledge increase?

## Part IV

- 1. Does this app contain social engagement tools?
- 2. To learn through this app is the demand of the society?
- 3. You can interact with so many tutors while using this app?

## Part V

- 1. This app gives us time saving facility?
- 2. This app gives us money saving facility?
- 3. We can acquire new skills which will help us in future?