The Intuitionistic Fuzzy Multi-Criteria Decision Making based on Inclusion Degree

Samina Ashraf, Etienne E Kerre and Madiha Qayyum
Department of Mathematics,
Queen Mary College For Women,
Lahore 54000, Pakistan
saminaa561@gmail.com
Department of Applied Mathematics and Computer Science,
Gent University, Krijgslaan 281, S9,
B-9000 Gent, Belgium
etienne.kerre@ugent.be
Department of Mathematics,
COMSATS Institute of Information Technology,
Lahore 54000, Pakistan
mqayyum@ciitlahore.edu.pk

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Abstract: This paper introduces a new intuitionistic fuzzy multicriteria decision making method of evaluation based on degree of inclusion of two intuitionistic fuzzy sets. We have called the new technique TOPIIS (Technique to Order Preference by Inclusion of Ideal Solution). The technique is applied to develop an effective employee performance appraisal.
Key words: Intuitionistic fuzzy set; Fuzzy measure; Intuitionistic fuzzy inclusion measure; TOPSIS Method.

1 Introduction

The rapid globalization and developing economy has mounted the competition among the enterprises. Performance appraisal is an important aspect of human resource management. The effective employee performance appraisal plays a vital role in creating a flawless internal management, improving the market competitiveness of enterprise and attracting and retaining the excellent employee. The human resource appraisal is a comprehensive evaluation with multiple levels, dimensions and factors implicated in it and with a lot of fuzziness involved in quantifying the performance indexes of the employees. Thus, it is one of the focuses of management theory research in recent decades [8, 9, 11, 12].

In this paper, we shall introduce an intuitionistic fuzzy inclusion based technique for solving MCDM problems similar to the TOPSIS method and apply it to develop an effective human resource appraisal technique. The TOPSIS technique was introduced in 1981, by Huang Qinglai for the sorting of the optimal alternative that will have minimum distance from the ideal solution and are farthest from non ideal solution simultaneously.

Working on the similar lines, and instead of using distances as the basic tool of comparisons of alternative schemes from ideal and non ideal solution, we wish to use the concept of inclusion degree of intuitionistic fuzzy sets to obtain the best scheme. Our technique will also create an *Ideal solution* and a *Negative ideal solution* that can be regarded as the most excellent and worst solutions not existing in the given set of alternative schemes that are to be judged. Then each alternative scheme under consideration is judged according to its degree of inclusion in the non ideal solution and the degree of inclusion of ideal solution in it. The optimal solution is the highest ranked alternative scheme which simultaneously contains the ideal solution maximally and is contained in the negative ideal solution minimally. We shall call this technique TOPIIS (Technique to Order Preference by Inclusion of Ideal Solution). The rest of the paper is organized as follows:

In section 1, a review of some necessary concepts of intuitionistic fuzzy set theory involved in this paper are presented, while section 2 and subsection 2.1, are reserved for the proposed method and its case study respectively.

Throughout this paper X denotes a finite universe of discourse i.e., $X = \{x_1, x_2, ...x_n\}$.

Definition 1.1 [1] An *intuitionistic fuzzy set* (*IFS*) on a universe X is an object of the form $A = \{(x, \mu_A(x), \nu_A(x)) \mid x \in X\}$, where the functions $\mu_A(x)$ and $\nu_A(x) \in [0,1]$ define respectively the degree of membership and the degree of non membership of x in the set A, while μ_A and ν_A satisfy $(\forall x \in X)(\mu_A(x)+\nu_A(x) \leq 1)$. The class of all intuitionistic fuzzy sets on X is denoted by $IFS(X)$.

Definition 1.2 [5] The set $L^* = \left\{(x_1, x_2) \in [0,1]^2 \mid x_1 + x_2 \leq 1\right\}$ is a complete bounded lattice $(L^*, \leq_{L^*})$ equipped with order $\leq_{L^*}$, which is defined as: $(x_1, x_2) \leq_{L^*} (y_1, y_2)$ if and only if $x_1 \leq y_1$ and $x_2 \geq y_2$. The elements $1_{L^*} = (1, 0)$ and $0_{L^*} = (0, 1)$ are the greatest and the smallest elements of the lattice L^* respectively.

Definition 1.3 [7] An *L-fuzzy set* on a universe X is an $X \longrightarrow L$ mapping, where $(L, \leq_L, N)$ is a complete lattice with negator N.

Remark 1.4 The intuitionistic fuzzy set $A = \{(x, \mu_A(x), \nu_A(x)) \mid x \in X\}$ is thus a special case of $L-$fuzzy set in the sense of [7], where $L = L^*$. In the sequel we will use the same notation for an intuitionistic fuzzy set and its associated L^*-fuzzy set. So for the intuitionistic fuzzy set A we will also use the notation $A(x) = (\mu_A(x), \nu_A(x)) = (a_1, a_2) \in L^*$.

Definition 1.5 [4] Let $(X, \pounds)$ be an intuitionistic fuzzy measurable space. A function $m : \pounds \rightarrow [0, \infty]$ is called a *fuzzy measure of intuitionistic fuzzy sets* if it satisfies the following conditions:
(i) $m(\phi) = 0$;
(ii) For any $A, B \in \pounds$, $A \subseteq B$ implies $m(A) \leq m(B)$.

The measure m with the boundary condition $m(X) = 1$ is called a normalized or normal fuzzy measure. The following are some normal fuzzy measures of intuitionistic fuzzy sets introduced in [10] : For any $A \in IFS(X)$,

1. $m_1(A) = \frac{1}{2}(\inf_{x\in X}\mu_A(x) + (1 - \sup_{x\in X}\nu_A(x)))$;
2. $m_2(A) = \frac{1}{4}(\inf_{x\in X}\mu_A(x) + (1 - \sup_{x\in X}\nu_A(x)) + \sup_{x\in X}\mu_A(x) + (1 - \inf_{x\in X}\nu_A(x)))$;
3. $m_3(A) = \frac{|A|}{|X|} = \frac{\sum_{x\in X}\theta\mu_A(x)+\gamma(1-\nu_A(x))}{n}$; where $\theta, \gamma \in [0, 1]$ and $\theta \geq \gamma$ such that $\theta + \gamma = 1$.
4. $m_4(A) = \frac{\sum_{x\in X}\sqrt{\mu_A(x)(1-\nu_A(x))}}{n}$.

Definition 1.6 [10] An intuitionistic fuzzy inclusion measure is a mapping $m_{IInc} : IFS(X) \times IFS(X) \longrightarrow [0, 1]$, which allocates to all $A, B \in IFS(X)$ a value in the interval $[0, 1]$ defined as:

$$m_{IInc}(A, B) = m(IInc(A, B)) \tag{1}$$

where $IInc(A, B)(x) = (\min(1, b_1 - a_1 + 1, a_2 - b_2 + 1), \max(0, a_1 + b_2 - 1))$ is the intuitionistic fuzzy inclusion of A into B and m is a fuzzy measure of intuitionistic fuzzy sets.

2 Technique to Order Preference by Inclusion of Ideal Solution(TOPIIS)

Let $A = \{A_1, A_2, A_3, ..., A_m\}$ be a scheme set consisting of m evaluated alternatives or objects. The evaluation indexes (criteria) for the evaluated objects can be given by index set $U = \{U_1, U_2, U_3, ..., U_n\}$. An evaluation index system is a logical and comprehensive system of a sequence of mutually connected and restricted indexes, which is designed to elaborate the features and regularity of multilevel and multifactor complex phenomena. Moreover, we shall define the weight of an evaluation index U_j as w_j, such that $w_j \geq 0$ and $\sum_{j=1}^{n} w_j = 1$. The procedure can be outlined in the following steps:

(1). Establish an intuitionistic fuzzy relation between A and U represented by the following evaluation matrix:

$$R = \begin{bmatrix} (U_1, \mu_{11}, \nu_{11}) & . & . & (U_s, \mu_{1s}, \nu_{1s}) & . & . & (U_n, \mu_{1n}, \nu_{1n}) \\ . & & & . & & & . \\ . & & & . & & & . \\ . & & & . & & & . \\ . & & & . & & & . \\ (U_1, \mu_{m1}, \nu_{m1}) & . & . & (U_s, \mu_{ms}, \nu_{ms}) & . & . & (U_n, \mu_{mn}, \nu_{mn}) \end{bmatrix}$$

The intuitionistic fuzzy relation matrix R clearly elaborates that each scheme A_i with regard to the evaluation index U_j can be expressed by the intuitionistic fuzzy set $A_{ij} = (U_j, \mu_{ij}, \nu_{ij})$ where μ_{ij} indicates the degree of importance of the evaluation index $U_j \in U$ to the scheme $A_i \in A$ and ν_{ij} the unimportance of the evaluation index $U_j \in U$ to the scheme $A_i \in A$, satisfying $0 \leq \mu_{ij} + \nu_{ij} \leq 1$ where $i = 1, 2, ...m$ and $j = 1, 2, ...n$. The evaluation value of scheme A_i with regard to n indexes can be denoted by:

$A_i = \{A_{i1}, A_{i2}, ..., A_{in}\} = \{(U_1, \mu_{i1}, \nu_{i1}), (U_2, \mu_{i2}, \nu_{i2}), ..., (U_n, \mu_{in}, \nu_{in})\}$.

(2). Determine the weight of an evaluation index by the intuitionistic fuzzy entropy method:

Given an intuitionistic fuzzy set $A = \{(x, \mu_A(x), \nu_A(x)) \mid x \in X\}$, in which $\mu_A(x)$ is the degree of membership and $\nu_A(x)$ is the degree of non membership of x in the set A, then $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$ is the hesitancy degree and $\lambda_A(x) = 1 - |\mu_A(x) - \nu_A(x)|$, is the fuzzy degree of x in the set A respectively. The intuitionistic fuzzy entropy of evaluation index U_j is:

$$E(U_j) = \frac{1}{m} \sum_{i=1}^{m} \sqrt{\frac{\pi_{ij}^2 + \lambda_{ij}^2}{2}}$$

The greater value of the intuitionistic fuzzy entropy $E(U_j)$ means the uncertainty level of index U_j is higher which results in a smaller weight for index U_j. Thus the weight of index U_j is given as:

$$w_j = \frac{1 - E(U_j)}{\sum_{j=1}^{n} (1 - E(U_j))}$$

The above formula provides the weight vector $w = (w_1, w_2..., w_n)^t$ of the evaluation index set.

(3). Determine the intuitionistic fuzzy set positive ideal solution A^+ (the best scheme) and the intuitionistic fuzzy negative ideal solution (worst scheme) A^- given as:

$$\begin{aligned} A^+ &= \{A_j^+\} = \left\{(U_j, \mu_j^+, \nu_j^+)\right\} = \left\{(U_j, \bigvee_{i=1}^{m} \mu_{ij}, \bigwedge_{i=1}^{m} \nu_{ij})\right\} \\ A^- &= \{A_j^-\} = \left\{(U_j, \mu_j^-, \nu_j^-)\right\} = \left\{(U_j, \bigwedge_{i=1}^{m} \mu_{ij}, \bigvee_{i=1}^{m} \nu_{ij})\right\} \end{aligned}$$

where the pair $\left(\bigwedge, \bigvee\right)$ stands for fuzzy conjunction and disjunction respectively which can be modeled by t-norms and their dual conorms respectively.

(4). Calculate the weighted degree $D(A^+, A_i)$ of inclusion of positive ideal solution A^+ in alternative A_i and the weighted degree $d(A_i, A^-)$ of inclusion of the alternative A_i in negative ideal solution by formulas given below:

$$\begin{aligned} D(A^+, A_i) &= \bigvee_{j=1}^{n} (w_j m_{IInc}(A_j^+, A_{ij})) \\ d(A_i, A^-) &= \bigwedge_{j=1}^{n} (w_j m_{IInc}(A_{ij}, A_j^-)) \end{aligned}$$

where in Definition 1.6 we have defined $m_{IInc}(A,B)(x) = m(IInc(A,B)(x))$ and $IInc(A,B)(x) = IInc(A,B)(x) = (\min(1, b_1 - a_1 + 1, a_2 - b_2 + 1), \max(0, a_1 + b_2 - 1))$ for all $A, B \in IFS(X)$ such that $A(x) = (a_1, a_2), B(x) = (b_1, b_2) \in L^*$. Moreover, as mentioned in step (3) $\bigwedge$ stands for fuzzy conjunction and $\bigvee$ stands for fuzzy disjunction which can be modeled by t-norms and their dual conorms.

(5). Define a ranking index of alternative scheme A_i as:

$$r_i = \frac{D(A^+, A_i)}{D(A^+, A_i) + d(A_i, A^-)}$$

where $i = 1, 2, 3..., m$. The best scheme among A_i, $i = 1, 2, 3...m$ is chosen on the basis of its ranking index value r_i. The highest ranking value r_i assigns the scheme A_i as the optimal solution of the multicriteria decision making problem since the degree of inclusion of positive ideal solution in the respective scheme will be maximum and degree of inclusion of this scheme in negative ideal solution will be minimal. However, in a situation when two schemes have same degree of inclusion with respect to ideal solution, the negative ideal solution plays its part to discriminate which alternative is better than the other. In such a situation, the scheme with smaller degree of inclusion with respect to negative ideal solution is the suitable choice. Similarly, we may come across the situation when two or more schemes have equal $d(A_i, A^-)$, then the scheme with greater $D(A^+, A_i)$ will be the better choice.

2.1 The Application of TOPIIS to Employee's Performance Appraisal

This subsection is reserved for a rework on the case study originally made in [11]. In [11], the authors designed a human resource appraisal index system and utilized the TOPSIS technique to rank the best employee based on the evaluation indexes they have developed. This subsection will elaborate and compare the results obtained from the new TOPIIS method with the results appearing in [11]. But, firstly to build a background of the problem we present a short review of the index system of employee appraisal developed by [11] in the form Table 1.

The index system of employee performance	The first class index	The second class index
	Talent quality U_1	Enterprise U_{11}
		Responsibility U_{12}
		Integrity U_{13}
		Professional responsibility U_{14}
	Personal ability U_2	Professional skill U_{21}
		Coordination ability U_{22}
		Learning ability U_{23}
		Decision making ability U_{24}
	Work performance U_3	The quantity of work U_{31}
		The quality of work U_{32}
		The efficiency of work U_{33}
		The effect of work U_{34}
		The innovation of work U_{35}
	Work attitude U_4	Active learning and training U_{41}
		The enthusiasm of work U_{42}
		Execution U_{43}
		Attendance rate U_{44}
		Discipline U_{45}

Table 1: The index system of employee performance

Clearly, from Table 1 we see that authors have proposed an employee evaluation index system based on four first class indexes namely, talent quality U_1, personal ability U_2, work performance U_3, and work attitude U_4 . Each of these first class indexes is further subclassified into various second class sub indexes. For a detailed study about the selection and this particular classification of first class and second class indexes we refer the reader to [11]. Next, we present the case study as follows:

Assuming an enterprise chooses five employees to evaluate their performance. The employees are A_1, A_2, A_3, A_4, A_5 respectively, denoted by scheme set $A = \{A_1, A_2, A_3, A_4, A_5\}$. According to the characteristics of the employee performance appraisal, we shall choose four first class indexes, which are talent quality U_1, personal ability U_2, work performance U_3, and work attitude U_4. These can be combined into a set of attributes $U = \{U_1, U_2, U_3, U_4\}$ to judge the employees work performance. Now applying the above mentioned technique we get

(1). Using the present knowledge, research and experience of human resource managers we can construct the intuitionistic fuzzy evaluation matrix as follows:

$$R = \begin{bmatrix} (U_1, 0.6, 0.3) & (U_2, 0.4, 0.3) & (U_3, 0.3, 0.5) & (U_4, 0.6, 0.3) \\ (U_1, 0.5, 0.3) & (U_2, 0.5, 0.3) & (U_3, 0.4, 0.1) & (U_4, 0.4, 0.1) \\ (U_1, 0.8, 0.1) & (U_2, 0.3, 0.2) & (U_3, 0.6, 0.1) & (U_4, 0.5, 0.4) \\ (U_1, 0.7, 0.2) & (U_2, 0.1, 0.6) & (U_3, 0.5, 0.3) & (U_4, 0.2, 0.5) \\ (U_1, 0.6, 0.2) & (U_2, 0.5, 0.1) & (U_3, 0.3, 0.4) & (U_4, 0.6, 0.2) \end{bmatrix}$$

(2). Determine the weights of each evaluation index by intuitionistic fuzzy entropy method i.e.,

$$E(U_1)=\frac{1}{m}\sum_{i=1}^{m}\sqrt{\frac{\pi_{i1}^2+\lambda_{i1}^2}{2}}=0.423.$$

Similarly, we obtain $E(U_2)=0.581, E(U_3)=0.571, E(U_4)=0.547$. Next, we use these entropies to calculate the weight vector $w=(w_1,w_2,w_3,w_4)^t=(0.307,0.223,0.229,0.241)^t$ of the evaluation indexes.

(3). We find the intuitionistic fuzzy positive ideal solution A^+ and the intuitionistic fuzzy negative ideal solution A^- by formulas:

$$\begin{aligned} A^+ &= \{A_j^+\}=\{(U_j,\mu_j^+,\nu_j^+)\}=\left\{(U_j,\bigvee_{i=1}^{m}\mu_{ij},\bigwedge_{i=1}^{m}\nu_{ij})\right\} \\ A^- &= \{A_j^-\}=\{(U_j,\mu_j^-,\nu_j^-)\}=\left\{(U_j,\bigwedge_{i=1}^{m}\mu_{ij},\bigvee_{i=1}^{m}\nu_{ij})\right\}\end{aligned}$$

Now, among different choices for t-norm and their dual conorm we fix the pair $\left(\bigwedge,\bigvee\right)$ by (T_M,S_M) where $T_M(x,y)=\min(x,y)$ and $S_M(x,y)=\max(x,y)$ for all $x,y\in[0,1]$. The main motivation for this particular choice is the fact that we wish to compare our results with the result presented in [11].

$$\begin{aligned} A^+ &= \{(U_1,0.8,0.1),(U_2,0.5,0.4),(U_3,0.6,0.3),(U_4,0.6,0.1)\} \\ A^- &= \{(U_1,0.5,0.3),(U_2,0.1,0.6),(U_3,0.3,0.5),(U_4,0.2,0.5)\}\end{aligned}$$

(4). Next, we calculate the weighted degree $D(A^+,A_i)$ of inclusion of positive ideal solution A^+ in alternative A_i and the weighted degree $d(A_i,A^-)$ of inclusion of the alternative A_i in negative ideal solution by formulas given below:

$$\begin{aligned} D(A^+,A_i) &= \bigvee_{j=1}^{n}(\frac{w_j}{2}(\min(1,\nu_j^+-\mu_j^++1,\mu_{ij}-\nu_{ij}+1) \\ &\quad +1-\max(0,\mu_j^++\nu_{ij}-1))). \\ d(A_i,A^-) &= \bigwedge_{j=1}^{n}(\frac{w_j}{2}(\min(1,\nu_{ij}-\mu_{ij}+1,\mu_j^--\nu_j^-+1) \\ &\quad +1-\max(0,\mu_{ij}+\nu_j^--1))).\end{aligned}$$

The above formulas are obtained by choosing the measure $m_1(A)=\frac{1}{2}(\inf_{x\in X}\mu_A(x)+(1-\sup_{x\in X}\nu_A(x)))$ among different fuzzy measures m introduced in Definition 1.5 in order to define the degree of inclusion of two intuitionistic fuzzy sets as presented in Definition 1.6. Moreover, we have multiple choices for the pair $\left(\bigwedge,\bigvee\right)$ due to the existence of different pairs of t-norm and their dual conorm. In this case study, we shall discuss three different scenarios for the degrees $D(A^+,A_i)$ and

$d(A_i, A^-)$ when we model $\left(\bigwedge, \bigvee\right)$ by three basic t-norms namely, Min (T_M), Product (T_P) and Lukasiewicz (T_L) and their dual t-conorms. The results of these calculations will be exhibited by three different tables showing the degrees of inclusion $D(A^+, A_i)$ and $d(A_i, A^-)$ for each employee A_i where $i = 1, 2, 3, 4, 5$.

Table 2 : The Degree of Inclusion of Each Employee when the Pair $\left(\bigwedge, \bigvee\right)$ is Modeled by (T_M, S_M) where $T_M(x, y) = \min(x, y)$ and $S_M(x, y) = \max(x, y)$ for all $x, y \in [0, 1]$:

	A_1	A_2	A_3	A_4	A_5
$D(A^+, A_i)$	0.2609	0.2456	0.8330	0.6112	0.2763
$d(A_i, A^-)$	0.1895	0.1672	0.1717	0.223	0.1561

Table 3 : The Degree of Inclusion of Each Employee when the Pair $\left(\bigwedge, \bigvee\right)$ is Modeled by (T_P, S_P) where $T_P(x, y) = xy$ and $S_P(x, y) = x + y - xy$ for all $x, y \in [0, 1]$:

	A_1	A_2	A_3	A_4	A_5
$D(A^+, A_i)$	0.6168	0.6198	0.8330	0.6112	0.6508
$d(A_i, A^-)$	0.0024	0.0018	0.0015	0.0033	0.0017

Table 4 : The Degree of Inclusion of Each Employee when the Pair $\left(\bigwedge, \bigvee\right)$ is Modeled by (T_L, S_L) where $T_L(x, y) = \max(0, x + y - 1)$ and $S_L(x, y) = \min(1, x + y)$ for all $x, y \in [0, 1]$:

	A_1	A_2	A_3	A_4	A_5
$D(A^+, A_i)$	0.8558	0.8581	0.9415	0.8346	0.9229
$d(A_i, A^-)$	0	0	0	0	0

(5). Next, corresponding to each Table in step (4) we calculate the ranking index of alternative scheme A_i by the formula:

$$r_i = \frac{D(A^+, A_i)}{D(A^+, A_i) + d(A_i, A^-)}$$

Now, using Table 2 we get the following set of ranking values:

$$r_1 = 0.579, r_2 = 0.594, r_3 = 0.829, r_4 = 0.732, r_5 = 0.638$$

and the ranking of employees as $A_3 \succ A_4 \succ A_5 \succ A_2 \succ A_1$.
Using Table 3, we get the ranking values

$$r_1 = 0.9960, r_2 = 0.9970, r_3 = 0.9981, r_4 = 0.9946, r_5 = 0.9972$$

and the ranking of employees as $A_3 \succ A_5 \succ A_2 \succ A_1 \succ A_4$.

The data from Table 4 reveals that we are in a situation in which there is no discrimination existing among all the alternatives A_i on the basis of their inclusions in the negative ideal solution. In such a case, we will rank the employees on the basis of the degree of inclusion of positive ideal solution in them. Thus, from the given data we get the ranking of employees as: $A_3 \succ A_5 \succ A_2 \succ A_1 \succ A_4$, which is the same as obtained from Table 3.

The above rankings reveal that the performance of employee A_3 is highest among his competitors, conforming to the calculation results of his inclusions as well. That is to say that the data from all three tables show that the employee A_3 has maximum degree of inclusion of positive ideal solution in it. Not only this, its inclusion degrees in negative ideal solution are negligible and even minimum as appearing in Table 3 and Table 4. The enterprise should give priority to the employee A_3 when giving promotion and reward. Now, as far as the identification of the weakest performer is concerned, we see that there is a tie between A_1 and A_4. Although, A_4 has been ranked the weakest twice yet we confirm his position in the given chain of performance appraisal by deeply analyzing the given data. This analysis will also result in a final ranking chain. Now, in both the chains we see that performance of the employee A_2 has been better than that of A_1. Thus, A_2 must be ranked higher than A_1 in any ranking chain. Moreover, the employee A_5 has been a good performer in both the analysis and it is acceptable if he or she is assigned a second or third ranking position in the given situation. Now, as far as the decision about the positions of A_1 and A_4 is concerned, we see that in both the Tables (3,4), the candidate A_4 has the same degree of inclusion of positive ideal in him or her, while in both the situations he or she has a maximum containment in negative ideal solution than any of the five candidates. Thus, beside his or her abilities, there are a few hidden factors which do not allow him or her to position better than A_1 who is a moderate to weak performer. Finally, we conclude that the ranking chain $A_3 \succ A_5 \succ A_2 \succ A_1 \succ A_4$ is more realistic and thus the candidate A_4 is judged as the lowest performer among all the five employees. The concerned employee and the management should work as a team to improve self quality and level of work, so as to improve his or her performance as a whole. The given ranking also matches with the result produced in [11].

Conclusion

This paper introduces a new intuitionistic fuzzy multicriteria decision making method of evaluation based on degree of inclusion of two intuitionistic fuzzy sets. We have called the new technique TOPIIS. The technique is applied to develop an effective employee performance appraisal. The new TOPIIS technique firstly develops an intuitionistic fuzzy evaluation matrix based on evaluation indexes. The TOPIIS technique utilizes intuitionistic fuzzy sets to represent the qualitative indexes which were considered as the most difficult index to quantify and hence had been a major hindrance in designing an effective and fair performance appraisal method for employees. The effectiveness of the proposed technique is elaborated by the help of a case study which was originally conducted in [11]. The new results were supportive of the study done in [11]. However, our new technique uses general fuzzy conjunction and disjunction that could be modeled by different t-norms and their dual conorms. Moreover, a variety of fuzzy measures of intuitionistic fuzzy sets can provide multiple choices for the degree of inclusion of intuitionistic fuzzy sets used in the technique. This provides a more broader and flexible framework to the decision maker who has to deal with any type of data in a complex multiple attribute decision making environment of actual economic management and similar fields.

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