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Intuitionistic Fuzzy Sets Approach in Appointment of Positions in an Organization Via Max-Min-Max Rule

By P. A. Ejegwa

University of Agriculture, Nigeria

Abstract- From the myriads of research on the applications of intuitionistic fuzzy sets theory in decision making, one can easy say that intuitionistic fuzzy sets theory is of great importance in decision science due to its efficiency and reliability. Here, we proposed a new area of application of intuitionistic fuzzy sets theory in appointment of positions in an organisation using intuitionistic fuzzy sets approach via max-min-max rule.

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Abstract- From the myriads of research on the applications of intuitionistic fuzzy sets theory in decision making, one can easy say that intuitionistic fuzzy sets theory is of great importance in decision science due to its efficiency and reliability. Here, we proposed a new area of application of intuitionistic fuzzy sets theory in appointment of positions in an organisation using intuitionistic fuzzy sets approach via max-min-max rule.

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I. Introduction

Zadeh [20] introduced the concept of fuzzy sets with the aim to model the vagueness and ambiguity in complex systems. Fuzzy sets theory is the generalization of classical or crisp set. It has greater flexibility to capture various aspects of incompleteness or imperfection in information about a situation. The key elements in the human thinking are not just the numbers but can be approximated to classes of objects in which the transition from membership to non-membership is gradual rather than abrupt. In dealing with vague notions, it is sometimes difficult to determine the exact boundaries of class, hence the decision that whether an element belongs to it or not is replaced by a measure from some scale. Each element of the class is evaluated by a measure which expresses its place and role in the class. This measure is called the grade of membership of the given class. This class in which each element is characterised by its membership grade is called a fuzzy set. These membership grades are very often represented by real number values ranging from the closed interval [0, 1].

Subsequently, Atanassov [1] proposed the concept of intuitionistic fuzzy sets (IFSs) as the generalisation of fuzzy sets. Since fuzzy set is only concern with the membership function without minding the significance of non-membership function and hesitation margin (which is integral in decision making), Atanassov then included the non-membership function and defined the hesitation margin as 1 minus the sum of the membership and non-membership functions. Lots have been done on IFSs theory; see [2, 5, 10, 15]. Sequel to the introduction of IFSs theory, many studies examined its applications in various areas such as in medical diagnosis, sustainable supplier

Ref

1. K. T. Atanassov, *Intuitionistic fuzzy sets,* VII ITKR's Session, Sofia, 1983.

Author: Dept. of Mathematics /Statistics /Computer Sci., University of Agriculture, P.M.B. 2373, Makurdi-Nigeria.
e-mail: ocholohi@gmail.com

evaluation, pattern recognition, medical imaging, electoral system [3-4, 6-9, 11-14, 16-19] etc.

In this paper, we shall propose a new application of our "famous" IFSs theory in appointment of positionsin an organisation with the aid of max-min-max rule.

a) Meaning of intuitionistic fuzzy sets

Definition 1: Crisp set A of X is defined as the characteristic function of A and is denoted by $f_A(x)$, mathematically, $f_A(x): X \to \{0,1\}$

$$\text{where, } f_A(x) = \begin{cases} 1, if\ x \in A \\ 0, if\ x \notin A \end{cases}$$

Definition 2: Fuzzy set A of a set X is defined by the membership function of the set $As.t.$ $`_A(x): X \to [0,1]$,

$$\text{where, } \mu_A(x) = \begin{cases} 1,\ if\ x\ is\ totally\ in\ A \\ 0, if\ x\ is\ not\ in\ A \\ (0,1), if\ x\ is\ partly\ in\ A \end{cases}$$

The closer the membership value $\mu_A(x)$ to 1, the more x belongs to A, where the grades 1 and 0 represents full membership and full non-membership.

Definition3[2]: Let X be nonempty set. An intuitionistic fuzzy set (IFS) A in X is an object having the form;

$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle : x \in X\}$, where the functions $\mu_A(x), \nu_A(x): X \longrightarrow [0,1]$define the degree of membership and degree of non-membership of the element$x \in X$ to the set A. For every $x \in X, 0 \leq \mu_A(x) + \nu_A(x) \leq 1$.

Furthermore, $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$ is the intuitionistic fuzzy set index or hesitation margin and is the degree of indeterminacy concerning the membership of$x$ in A, then $0 \leq \mu_A(x) + \nu_A(x) + \pi_A(x) \leq 1$. Whenever $\pi_A(x) = 0$, IFS reduces automatically to fuzzy set.

b) Appointment of positions in an organisation via max-min-max rule for IFSs

Suppose an organisation wants to reshuffle its cabinet, the challenge is how to appoint suitable officers into different positions assuming we have more than enough candidates for the positions. IFSs approach provides the solution because of its competency in handling uncertainties in decision making.

Let A be an IFS of nonempty set X and let R be the intuitionistic fuzzy relation (IFR) from $X \to Y$, then the max-min-max composition B of X with the IF relation R$(X \to Y)$ is defined as $B = R \circ A$ with membership and non-membership function defined as

$\mu_B(y) = \max_{x \in X}\{\min\,[\mu_A(x),\ \mu_R(x,y)]\}$and

$\nu_B(y) = \min_{x \in X}\{\max\,[\nu_A(x),\ \nu_R(x,y)]\}$.

Also let $Q = \{q_1, q_2, \dots, q_l\}$; $P = \{p_1, p_2, \dots, p_m\}$;$C = \{c_1, c_2, \dots, c_n\}$; be the finite set of qualifications, positions, and candidates respectively.

Suppose we have two IFRs $R(C \to Q)$ and $S(Q \to P)$ s.t.

$$R = \{\langle (c,q), \mu_R(c,q), \nu_R(c,q)\rangle : (c,q) \in C \times Q\}$$

Ref

3. T. Chaira, Intuitionistic fuzzy set theory in medical imaging, *Int. J. of Soft Computing and Engineering* 1 (2011) 35-37.

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$S = \{\langle (q,p), \mu_S(q,p), \nu_S(q,p)\rangle : (q,p) \in Q \times P\}$ where,

$\mu_R(c,q)$ indicate the degree to which the candidate c possesses the qualification q and $\nu_R(c,q)$ indicate the degree to which the candidate c does not possess the qualification q.

Similarly,

$\mu_S(q,p)$ indicate the degree to which the qualification q determines the position p and $\nu_S(q,p)$ indicate the degree to which the qualification q does not determine the position p.

The composition T of the IFRs R and S is given as $T = R \circ S$. It describes the state in which the candidates c_i in terms of the qualifications fit the positions p_j. It is given by membership and non-membership degrees as:

$\mu_T(c_i, p_j) = max_{q_j \in Q}\{min\,[\mu_R(c_i, q_j),\ \mu_S(q_j, p_j)]\}$ and

$\nu_T(c_i, p_j) = \min_{q_j \in Q}\{\max\,[\nu_R(c_i, q_j),\ \nu_S(q_j, p_j)]\} \forall c_i \in C$ and $p_j \in P$ for $i, j \in \mathbb{N}$.

From R and S, one can compute new measure of IFR T for which, the appointments of the candidates c_i for any position p s.t. the following are to be satisfied:

(i) $S_T = \mu_T - \nu_T.\pi_T$ is the greatest and

(ii) The equality $T = R \circ S$ is retained.

To see the application of this method, we frame a hypothetical case study:

Let $C = \{c_1, c_2, c_3, c_4\}$ be the set of candidates to be appointed, let $P = \{p_1, p_2, p_3, p_4, p_5\}$ be the positions to be occupied and let $\boldsymbol{Q}$={ **honesty, team spirit, hardworking, transparency, academic fitness**} be the set of qualifications the expected candidates ought to possessed. We assume the candidates are score by impartial member of the organisation appointment committee (10-member committee) using IFSs values.

Suppose the IFR $R(C \to Q)$ is given hypothetically below as scored by the 10-member committee.

Table 1

R	honesty	team spirit	hardworking	transparency	acad. fitness
c_1	(0.5, 0.2)	(0.6,0.3)	(0.7,0.1)	(0.8,0.1)	(0.6,0.2)
c_2	(0.8,0.1)	(0.5,0.2)	(0.7,0.2)	(0.6,0.2)	(0.4,0.5)
c_3	(0.5, 0.2)	(0.6,0.1)	(0.4,0.3)	(0.5,0.3)	(0.8,0.1)
c_4	(0.7,0.1)	(0.5,0.3)	(0.8,0.1)	(0.6,0.2)	(0.7,0.2)

Note that, the first entry is the membership value and the second entry is the non-membership value.

Suppose the IFR $S(Q \to P)$ is given hypothetically below as stipulated by the organisation appointment committee as standing qualifications for the positions.

Table 2

S	p_1	p_2	p_3	p_4	p_5
Honesty	(0.7,0.2)	(0.7,0.1)	(0.6,0.2)	(0.8,0.0)	(0.6,0.3)

team spirit	(0.8,0.1)	(0.7,0.2)	(0.8,0.0)	(0.7,0.2)	(0.8,0.1)
Hardworking	(0.8,0.2)	(0.8,0.1)	(0.8,0.1)	(0.6,0.2)	(0.8,0.1)
Transparency	(0.7,0.2)	(0.7,0.2)	(0.9,0.0)	(0.8,0.1)	(0.7,0.1)
acad. Fitness	(0.9,0.1)	(0.9,0.0)	(0.6,0.3)	(0.7,0.2)	(0.5,0.3)

The composition $T = R \circ S$ is as follows:

Table 3

T	p_1	p_2	p_3	p_4	p_5
c_1	(0.7,0.2)	(0.7,0.1)	(0.8,0.1)	(0.8,0.1)	(0.7,0.1)
c_2	(0.7,0.2)	(0.7,0.1)	(0.7,0.2)	(0.8,0.1)	(0.7,0.2)
c_3	(0.8,0.1)	(0.8,0.1)	(0.6,0.1)	(0.7,0.2)	(0.6,0.1)
c_4	(0.8,0.2)	(0.8,0.1)	(0.8,0.1)	(0.7,0.1)	(0.8,0.1)

Now, we calculate S_T as below:

Table 4

S_T	p_1	p_2	p_3	p_4	p_5
c_1	0.68	0.68	0.79	0.79	0.68
c_2	0.68	0.68	0.68	0.79	0.68
c_3	0.79	0.79	0.57	0.68	0.57
c_4	0.79	0.79	0.79	0.68	0.79

From Table 4 above, c_1 can fit into p_3 and p_4; c_2 can fit into p_4 only; c_3 can fit into p_1 and p_2; c_4 can fit into p_1, p_2, p_3 and p_5.

II. Conclusion

We conclude that IFSs theory is a very suitable and decisive tool use in critical decision making problem like this. We observe that without IFSs theory, this exercise would have been compromised with a consequent effect on the organisation.

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