

# A Collaborative Decision Approach for Internet Public Opinion Emergency with Intuitionistic Fuzzy Value

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**Abstract:** This paper presents a collaborative group decision approach for selecting optimal internet public opinion emergency plan with intuitionistic fuzzy indexes involved multiple emergency sections. By using the proposed emergency group decision model, the collective performance of each emergency plan can be properly evaluated by integrating its individual performance and collaborative performance of each emergency plan. Based on the score and accuracy value of intuitionistic fuzzy collective performance, the priority ranking of all the alternative emergency plans can be determined. With the presented collective emergency decision method the top emergency decision-maker can choose the best emergency plan to deal with the internet public opinion emergency and execute emergency operation. Finally, a numerical example is given to illustrate the effectiveness of the presented collaborative decision method for internet public opinion emergency.

**Keywords:** Internet Public Opinion Emergency, Intuitionistic Fuzzy Value, Collaborative Decision, Emergency Plan

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## 1. Introduction

With the growth of enthusiasm that netizens participate in discussions about public events, the rapid transmissions of internet public opinions which consist of complicated social emotion, attitude and opinions have triggered many unconventional emergencies. This type of internet public opinion emergency [1, 2] will impair the harmony and stability of the society severely. Therefore, it is necessary to take effective warning mechanism [3] and group decision approach for selecting optimal emergency plan to dispose Internet Public Opinion Emergency (IPOE).

Once the Internet Public Opinion Emergency happened, how to choose the best emergency plan is an important issue. Due to the difficulties of collecting accurate public opinion information, emergency experts hardly evaluate all the alternative emergency plans with precise data.

Generally, in the uncertain internet public opinion emergency decision scenarios the emergency experts intend to use fuzzy values or linguistic terms [4-8] to estimate the decision indexes of emergency plan. Although many scholars have put forward some decision models for unconventional emergencies [9-13], they are not suitable for dealing with uncertain emergency decision problems. In uncertain

emergency decision environment, Zhang [14] recently proposed a hesitant group emergency decision-making method based on prospect theory, Wu [15] presented a fuzzy multi-criteria emergency decision-making method, Jing [16] presented an emergency decision-making method based on interval preference relations [17, 18]. However, there is few works on intuitionistic fuzzy collaborative decision of internet public opinion emergency. Since intuitionistic fuzzy set [19] as the extension of fuzzy set and interval set are more suitable to assess the indexes of emergency plan, this paper proposes an intuitionistic fuzzy group decision making method for internet public opinion emergency.

Generally, uncertain internet public opinion emergency group decision-making problems involve multiple emergency experts from different emergency departments with different interests and goals [20, 21]. Also, the internet public opinion emergency is usually affected by some individual and collaborative indexes. Hence, it is essential to integrate all the emergency departments to determine the optimal weights of emergency experts and evaluate the individual performance and collaborative performance of internet public opinion emergency plan. Therefore, in this paper we develop an intuitionistic fuzzy collaborative group decision approach regarding all the individual and collaborative indexes with

intuitionistic fuzzy values. By ranking the collective performance of each alternative emergency plan, the optimal emergency plan can be determined.

Rest of this paper is organized as follows. In Section 2, some basic concepts and operators of intuitionistic fuzzy linguistic values are given. Section 3 presents detailed description of intuitionistic fuzzy collaborative group decision method for IPOE. In Section 4, a numerical example is demonstrated to display the effectiveness of the proposed collaborative decision approach.

## 2. Preliminaries

For convenience of analysis, some basic linguistic concepts and aggregation operators of intuitionistic fuzzy values are briefly introduced in this section.

Definition 1 [22]  $L = \{l_i / i = -T, \dots, -1, 0, 1, \dots, T\}$  is called intuitionistic fuzzy linguistic set, if  $l_i$  represents a ordered intuitionistic fuzzy linguistic variable value.

In this paper, intuitionistic fuzzy linguistic set  $L_1 = \{\text{Very important (VI}=\langle 0.9, 0.1 \rangle), \text{Important (I}=\langle 0.75, 0.2 \rangle), \text{Fair (F}=\langle 0.5, 0.45 \rangle), \text{Unimportant (U}=\langle 0.35, 0.6 \rangle), \text{Very unimportant (VU}=\langle 0.1, 0.9 \rangle)\}$  is used to rate the importance of emergency decision-makers and indexes.

And the intuitionistic fuzzy linguistic terms in  $L_2 = \{\text{Definitely high (DH}=\langle 1.0, 0.0 \rangle), \text{very very high (VVH}=\langle 0.9, 0.1 \rangle), \text{very high (VH}=\langle 0.8, 0.2 \rangle), \text{High (H}=\langle 0.7, 0.3 \rangle), \text{medium high (MH}=\langle 0.6, 0.4 \rangle), \text{Medium (M}=\langle 0.5, 0.5 \rangle), \text{medium low (ML}=\langle 0.4, 0.6 \rangle), \text{low (L}=\langle 0.3, 0.7 \rangle), \text{very low (VL}=\langle 0.2, 0.8 \rangle), \text{very very low (VVL}=\langle 0.1, 0.9 \rangle), \text{Definitely low (DL}=\langle 0.0, 1.0 \rangle)\}$  are used to rate the internet public opinion emergency plans.

Definition 2 [23].  $\tilde{a} = \langle \mu_a, \nu_a \rangle$  is called a intuitionistic fuzzy value (IFV), if  $u_a, v_a \in [0, 1]$ ,  $0 \leq u_a + v_a \leq 1$ , where  $\mu_a, \nu_a$  represent the membership and nonmembership of  $\tilde{a}$ , respectively. The hesitation degree of IFV  $\tilde{a}$  is also defined as  $\pi_a = 1 - \mu_a - \nu_a$ .

Definition 3 [24]. Let  $\tilde{a} = \langle \mu_a, \nu_a \rangle$ ,  $\tilde{b} = \langle \mu_b, \nu_b \rangle$  be two intuitionistic fuzzy values, some basic operations between two IFVs are defined as

$$\tilde{a} \oplus \tilde{b} = \langle \mu_a + \mu_b - \mu_a \mu_b, \nu_a \nu_b \rangle = \langle 1 - (1 - \mu_a)(1 - \mu_b), \nu_a \nu_b \rangle,$$

$$\lambda \tilde{a} = \langle 1 - (1 - \mu_a)^\lambda, \nu_a^\lambda \rangle, \forall \lambda \geq 0,$$

$$\bar{\lambda} \tilde{a} = \langle (\mu_a)^\lambda, 1 - (1 - \nu_a)^\lambda \rangle, \forall \lambda \geq 0,$$

$$\tilde{a} \otimes \tilde{b} = \langle \mu_a \mu_b, \nu_a + \nu_b - \nu_a \nu_b \rangle = \langle \mu_a \mu_b, 1 - (1 - \nu_a)(1 - \nu_b) \rangle.$$

Definition 4. Let  $\tilde{a}_i = \langle \mu_{a_i}, \nu_{a_i} \rangle$  be a serial of intuitionistic fuzzy values and  $\lambda = (\lambda_1, \lambda_2, \dots, \lambda_n)$  be a weighted vector, the intuitionistic fuzzy weighted aggregation operation is defined as [24-25]

$$IFWA_\lambda(\tilde{a}_1, \tilde{a}_2, \dots, \tilde{a}_n) = \lambda_1 \tilde{a}_1 \oplus \lambda_2 \tilde{a}_2 \oplus \dots \oplus \lambda_n \tilde{a}_n$$

$$= \langle 1 - \prod_{i=1}^n (1 - \mu_{a_i})^{\lambda_i}, \prod_{i=1}^n (\nu_{a_i})^{\lambda_i} \rangle.$$

Definition 5 [25] Let  $a = \langle \mu_a, \nu_a \rangle$  be a intuitionistic fuzzy value, the score function and accuracy function of it are defined as

$$S(\tilde{a}) = u_a - v_a \in [-1, 1], \quad H(\tilde{a}) = u_a + v_a \in [0, 1].$$

Obviously, the larger is the score function  $s(\tilde{a})$ , the greater is the IFV  $\tilde{a}$ .

Definition 6. Let  $\tilde{a} = \langle \mu_a, \nu_a \rangle$ ,  $\tilde{b} = \langle \mu_b, \nu_b \rangle$  be two intuitionistic fuzzy values, the rank order between two IFVs is defined as below [26].

If  $s(\tilde{a}) < s(\tilde{b})$ , then  $\tilde{a} < \tilde{b}$ ,

If  $s(\tilde{a}) = s(\tilde{b})$ ,

and if  $h(\tilde{a}) = h(\tilde{b})$ , then  $\tilde{a} = \tilde{b}$ ,

If  $h(\tilde{a}) < h(\tilde{b})$ , then  $\tilde{a} < \tilde{b}$ .

To rank a series of  $q$  intuitionistic fuzzy arguments  $\tilde{a}_i = \langle \mu_{a_i}, \nu_{a_i} \rangle, i = 1, 2, \dots, q$ , each argument need to be compared with all the other arguments by the above definition.

## 3. Collaborative Decision Approach for IPOE Plans with Intuitionistic Fuzzy Linguistic Assessment Value

In this section, a collaborative decision approach [27-28] for internet public opinion emergency involved multiple emergency plans is developed. The aim of collective emergency decision approach is to rank all the alternative emergency plans with intuitionistic fuzzy linguistic assessment values and select the best emergency solution.

Suppose there are some emergency plans  $P = \{P_h / h = 1, 2, \dots, q; q \geq 2\}$  for an internet public opinion emergency (IPOE). To rank all the related emergency plans and make group decision,  $l$  decision experts from different emergency sections are choosed as the emergency committee  $\{DM_1, DM_2, \dots, DM_l\}$ , and the important degree of each emergency decision expert is expressed by intuitionistic fuzzy linguistic term in linguistic variable set  $L_1$ .

Evidently, the effectiveness of each alternative emergency plan is not only affected by some individual indexes  $I = \{I_i / i = 1, 2, \dots, m\}$  but also affected by some collaborative indexes  $C = \{C_j / j = 1, 2, \dots, n\}$ . Suppose the linguistic weight vectors of individual indexes and collaborative indexes given by  $k$ -th emergency decision-maker  $DM_k$  from  $k$ -th emergency department are respectively denoted by  $\tilde{w}_k = (\tilde{w}_{1k}, \tilde{w}_{2k}, \dots, \tilde{w}_{mk})$  and  $\tilde{v}_k = (\tilde{v}_{1k}, \tilde{v}_{2k}, \dots, \tilde{v}_{nk})$ , where  $\tilde{w}_{ik}, \tilde{v}_{jk} \in L_1$ .

Assume each emergency decision-maker  $DM_k$  evaluates all the alternative internet public opinion emergency plans

regarding all the individual indexes as the following intuitionistic fuzzy linguistic assessment matrix.

$$\tilde{P}_k = [\tilde{p}_{hik}]_{q \times m} = \begin{bmatrix} \tilde{p}_{11k} & \tilde{p}_{12k} & \cdots & \tilde{p}_{1mk} \\ \tilde{p}_{21k} & \tilde{p}_{22k} & \cdots & \tilde{p}_{2mk} \\ \cdots & \cdots & \cdots & \cdots \\ \tilde{p}_{q1k} & \tilde{p}_{q2k} & \cdots & \tilde{p}_{qm k} \end{bmatrix}$$

where  $\tilde{p}_{hik} \in L_2$  is the  $i$ th individual index linguistic assessment information of the  $h$ -th internet public opinion emergency plan  $P_h$  for emergency decision-maker  $DM_k$ .

Also, suppose each emergency expert  $DM_k$  ( $k = 1, 2, \dots, l$ ) evaluates the alternative emergency plan regarding each collaborative index  $C_j$  ( $j = 1, 2, \dots, n$ ) as the following intuitionistic fuzzy linguistic assessment matrix.

$$\tilde{C}_{jk} = [\tilde{c}_{hjk}]_{q \times q} = \begin{bmatrix} \tilde{c}_{11jk} & \tilde{c}_{12jk} & \cdots & \tilde{c}_{1qjk} \\ \tilde{c}_{21jk} & \tilde{c}_{22jk} & \cdots & \tilde{c}_{2qjk} \\ \cdots & \cdots & \cdots & \cdots \\ \tilde{c}_{q1jk} & \tilde{c}_{q2jk} & \cdots & \tilde{c}_{qqjk} \end{bmatrix}$$

where  $\tilde{c}_{ghjk} \in L_2$  is the collaborative performance linguistic assessment value of emergency plans  $P_h$  and  $P_g$  regarding the  $j$ -th collaborative index for decision-maker  $DM_k$ . Obviously,  $\tilde{C}_{jk}$  is a symmetric matrix and  $\tilde{c}_{hhjk} = <1, 0>$ ,  $h = 1, 2, \dots, q$ .

To deal with the collaborative decision-making for multiple internet public opinion emergency plans involving multiple individual and collaborative indexes, we need to take the following decision procedures.

Step 1. Determine the weight vector of all the emergency decision-makers

Assume that emergency decision group contains  $l$  decision-makers. The importance of the emergency decision-maker are expressed by intuitionistic fuzzy linguistic terms denoted by intuitionistic fuzzy value  $\langle \mu_k, \nu_k \rangle$ . Then the weight  $\gamma_k$  of  $k$ -th emergency decision-maker can be calculated as

$$\gamma_k = [\mu_k + \pi_k(\frac{\mu_k}{\mu_k + \nu_k})] / \sum_{k=1}^l [\mu_k + \pi_k(\frac{\mu_k}{\mu_k + \nu_k})], \quad k = 1, 2, \dots, l \quad (1)$$

$$\tilde{c}_{hgi} = IFWA_{\gamma}(\tilde{c}_{hgi1}, \tilde{c}_{hgi2}, \dots, \tilde{c}_{hgil}) = \gamma_1 \tilde{c}_{hgi1} \oplus \gamma_2 \tilde{c}_{hgi2} \oplus \cdots \oplus \gamma_l \tilde{c}_{hgil}, \quad (6)$$

Then we can aggregate the collaborative assessment matrix  $\tilde{C}_j$  ( $j = 1, 2, \dots, n$ ) with the collaborative index weight vector  $\tilde{v}$  and get the collaborative performance between two

The weight vector of all the emergency decision-makers is  $\gamma = (\gamma_1, \gamma_2, \dots, \gamma_l)$ .

Step 2. Integrating all the individual index weight  $\tilde{w}_{ik}$  given by different emergency expert  $DM_k$  ( $k = 1, 2, \dots, l$ ), we compute the collective intuitionistic fuzzy weight of  $i$ -th individual index as

$$\tilde{w}_i = \gamma_1 \tilde{w}_{i1} \oplus \gamma_2 \tilde{w}_{i2} \oplus \cdots \oplus \gamma_l \tilde{w}_{il} \quad (2)$$

and obtain the weight vector  $\tilde{w} = (\tilde{w}_1, \tilde{w}_2, \dots, \tilde{w}_m)$  of all the individual indexes for emergency plan.

Aggregate all the assessment matrix  $\tilde{P}_k = [\tilde{p}_{hik}]_{q \times m}$  for different emergency decision-makers into the overall intuitionistic fuzzy linguistic assessment matrix  $\tilde{P} = [\tilde{p}_{hi}]_{q \times m}$  for internet public opinion emergency plan, where

$$\tilde{p}_h = \sum_{k=1}^l \gamma_k \tilde{p}_{hk} = \gamma_1 \tilde{p}_{h1} \oplus \gamma_2 \tilde{p}_{h2} \oplus \cdots \oplus \gamma_l \tilde{p}_{hl}, \quad \forall i = 1, 2, \dots, m. \quad (3)$$

Then we can aggregate the individual index decision matrix with intuitionistic fuzzy weight vector  $\tilde{w}$  and get the overall individual performance of each alternative emergency plan as

$$\begin{aligned} \tilde{P}_h &= IFWA_{\tilde{w}}(\tilde{p}_{h1}, \tilde{p}_{h2}, \dots, \tilde{p}_{hm}) \\ &= (\tilde{w}_1 \otimes \tilde{p}_h) \oplus (\tilde{w}_2 \otimes \tilde{p}_h) \oplus \cdots \oplus (\tilde{w}_m \otimes \tilde{p}_h) \end{aligned} \quad (4)$$

Step 3. Integrating all the collaborative index weight  $\tilde{v}_{jk}$  given by different emergency decision-maker  $DM_k$ , one can get the overall collaborative index weight of the  $j$ -th collaborative index as

$$\tilde{v}_j = \sum_{k=1}^l \gamma_k \tilde{v}_{jk} = \gamma_1 \tilde{v}_{j1} \oplus \gamma_2 \tilde{v}_{j2} \oplus \cdots \oplus \gamma_l \tilde{v}_{jl} \quad (5)$$

and get the collaborative index weight vector  $\tilde{v} = (\tilde{v}_1, \tilde{v}_2, \dots, \tilde{v}_n)$  for internet public opinion emergency plan.

Aggregate all the collaborative emergency assessment matrix  $\tilde{C}_{jk} = [\tilde{c}_{hjk}]_{q \times q}$  of different emergency decision-maker  $DM_k$  ( $k = 1, 2, \dots, l$ ) into an overall collaborative emergency assessment matrix  $\tilde{C}_j = [\tilde{c}_{hgi}]_{q \times q}$  regarding  $j$ -th collaborative decision index, where

internet public opinion emergency plans  $P_h$  and  $P_g$  as below.

$$\tilde{c}_{hg} = IFWA_{\tilde{v}}(\tilde{c}_{hg1}, \tilde{c}_{hg2}, \dots, \tilde{c}_{hgn}), \quad \forall h, g = 1, 2, \dots, q$$

$$= (\tilde{v}_1 \otimes \tilde{c}_{hg1}) \oplus (\tilde{v}_2 \otimes \tilde{c}_{hg2}) \oplus \dots \oplus (\tilde{v}_n \otimes \tilde{c}_{hgn}), \quad (7)$$

Finally, one can calculate the overall collaboration assessment value  $\tilde{C}_h$  of each emergency plan  $P_h$  by aggregating all the collaborative performance of  $P_h$  with other internet public opinion emergency plan  $P_g (g=1,2,\dots,q)$  as follows.

$$\tilde{C}_h = \frac{1}{q} [\tilde{C}_{h1} \oplus \tilde{C}_{h2} \oplus \dots \oplus \tilde{C}_{hq}], \quad \forall h=1,2,\dots,q \quad (8)$$

Step 4. Considering the top emergency decision-maker may assign different weight  $\alpha$  to individual performance and  $1-\alpha$  to collaborative performance for internet public opinion emergency plan, we can calculate the collective performance  $\tilde{\Phi}_h$  of each alternative emergency plan  $P_h$  by combining individual performance and collaborative performance as below.

$$\tilde{\Phi}_h = \alpha \tilde{P}_h \oplus (1-\alpha) \tilde{C}_h, \quad \forall h=1,2,\dots,q \quad (9)$$

Step 5. Compute the score function  $S(\tilde{\Phi}_h)$  and accuracy function  $H(\tilde{\Phi}_h)$  of intuitionistic fuzzy collective performance value  $\tilde{\Phi}_h (h=1,2,\dots,q)$ , and we can rank all the alternative emergency plans according to score and accuracy function value of collective performance  $\tilde{\Phi}_h$  of each emergency plan according to Definition 4. Then, the top emergency decision-maker could select the most efficient emergency plan to undertake emergency rescue according to the rank order of all the alternative emergency plans.

## 4. Numerical Example

In this section, we demonstrate an internet public sentiment emergency group decision problem involved with four emergency departments including urban government office, sentiment monitoring department, public security department and traffic department. Suppose the related emergency departments design four alternative emergency plans  $\{P_1, P_2, P_3, P_4\}$  to handle the abrupt internet public opinion emergency. In fact, each emergency plan has its advantage regarding its executive department. In order to help the top decision-maker eventually select the optimal emergency plan with high satisfaction degree for all the emergency departments, we first choose four emergency experts  $d_k (k=1,2,3,4)$  from the above-mentioned internet public opinion emergency departments and comprise an emergency decision committee  $D = \{d_1, d_2, d_3, d_4\}$  to assess the effect of all the candidate emergency plans. Suppose the importance degree of each emergency expert is given by intuitionistic fuzzy linguistic value or linguistic term as in Table 1.

Since the internet public opinion emergencies outbreak suddenly, it is difficult for the emergency decision experts to get accurate index assessment of emergency plan in a short

time. Therefore, in order to evaluate the alternative internet public opinion emergency plans, the emergency experts often employ intuitionistic fuzzy linguistic terms to assess some individual indexes like the emergency response efficiency ( $I_1$ ), the emergency rescue effect ( $I_2$ ), the emergency cost ( $I_3$ ), and the satisfaction degree of netizen ( $I_4$ ). Also the emergency experts usually consider the emergency program complementarity ( $c_1$ ), emergency resource equipment sharing ( $c_2$ ), emergency goal coordination ( $c_3$ ), and emergency task consistency ( $c_4$ ) as the collaborative indexes of internet public opinion emergency plans.

Assume that the weight information of each individual index and collaborative index assigned by four emergency experts from different emergency sections are assessed by intuitionistic fuzzy linguistic terms as listed in Table 2.

**Table 1.** Intuitionistic fuzzy linguistic terms for rating the importance of emergency decision-makers.

	DM1	DM2	DM3	DM4
Linguistic terms	VI	I	F	I

**Table 2.** Intuitionistic fuzzy linguistic weight of individual indexes and collaborative indexes.

Decision-maker	Individual index				Collaborative index			
	I1	I2	I3	I4	C1	C2	C3	C4
DM1	VI	I	I	F	VI	I	VI	I
DM2	VI	I	I	I	I	VI	I	F
DM3	I	VI	F	F	VI	I	F	I
DM4	VI	F	VI	I	I	F	VI	I

Below the linguistic assessment information of individual indexes of emergency plan for all the emergency decision-makers are listed as in the following Table 3.

**Table 3.** Intuitionistic fuzzy linguistic assessment for individual index of internet public opinion emergency plans.

Decision-maker	Emergency Plans	Linguistic assesement for individual index of emergency plan			
		I1	I2	I3	I4
DM1	P1	L	H	VL	VH
	P2	VH	H	VH	L
	P3	H	VL	DL	M
	P4	VVH	M	VL	H
DM2	P1	H	M	L	M
	P2	H	MH	M	VH
	P3	VL	M	H	L
	P4	M	L	VH	VVH
DM3	P1	M	L	H	M
	P2	H	VH	VL	H
	P3	VH	H	L	M
	P4	H	ML	L	VH
DM4	P1	L	M	H	H
	P2	VL	L	H	M
	P3	L	M	DL	VH
	P4	M	H	VVL	M

Also, every emergency decision-maker employs intuitionistic fuzzy linguistic value to evaluate the collaborative index information between internet public opinion emergency plans as in the following Table 4-7.

**Table 4.** Collaborative index linguistic assesment of emergency plans for DM1.

Collaborative index	Emergency plans	Emergency plans			
		P1	P2	P3	P4
C1	P1	DH	ML	VL	H
	P2	M	DH	MH	VVL
	P3	VH	H	DH	ML
	P4	VVL	MH	M	DH
C2	P1	DH	L	M	VH
	P2	L	DH	VH	VVL
	P3	MH	M	DH	ML
	P4	ML	H	MH	DH
C3	P1	DH	H	L	VL
	P2	VH	DH	DL	MH
	P3	M	VVL	DH	H
	P4	VL	VH	M	DH
C4	P1	DH	VL	M	VVL
	P2	VL	DH	VVH	L
	P3	VVH	M	DH	H
	P4	M	VH	ML	DH

**Table 5.** Collaborative index linguistic assesment of emergency plans for DM2.

Collaborative index	Emergency plans	Emergency plans			
		P1	P2	P3	P4
C1	P1	DH	M	H	ML
	P2	VVH	DH	M	VL
	P3	VH	ML	DH	L
	P4	VL	MH	VH	DH
C2	P1	DH	VVL	M	VH
	P2	VL	DH	VH	ML
	P3	ML	M	DH	VL
	P4	L	VVH	MH	DH
C3	P1	DH	H	ML	VL
	P2	VH	DH	VVL	M
	P3	L	M	DH	MH
	P4	VL	VH	MH	DH
C4	P1	DH	ML	VL	M
	P2	VVL	DH	VVH	L
	P3	VH	ML	DH	VL
	P4	MH	VH	VL	DH

**Table 6.** Collaborative index linguistic assesment of emergency plans for DM3.

Collaborative index	Emergency plans	Emergency plans			
		P1	P2	P3	P4
C1	P1	DH	M	VH	M
	P2	ML	DH	DL	VVH
	P3	VVH	VVL	DH	L
	P4	VVL	MH	H	DH
C2	P1	DH	DL	MH	VL
	P2	VVL	DH	VH	ML
	P3	H	VVH	DH	L
	P4	VL	H	M	DH
C3	P1	DH	H	MH	VVL
	P2	VH	DH	M	VH
	P3	M	VH	DH	H
	P4	VL	VVL	H	DH
C4	P1	DH	ML	M	VL
	P2	L	DH	VVH	M
	P3	VH	M	DH	VVL
	P4	ML	H	VL	DH

**Table 7.** Collaborative index linguistic assesment of emergency plans for DM4.

Collaborative index	Emergency plans	Emergency plans			
		P1	P2	P3	P4
C1	P1	DH	ML	VVH	VL
	P2	VL	DH	M	VH
	P3	VVL	H	DH	MH
	P4	ML	VL	VH	DH
C2	P1	DH	MH	VH	VVL
	P2	VH	DH	L	VL
	P3	VVH	VL	DH	M
	P4	ML	VVL	VH	DH
C3	P1	DH	H	VVH	DL
	P2	H	DH	H	VL
	P3	VH	H	DH	ML
	P4	M	VVL	VVH	DH
C4	P1	DH	VL	VH	L
	P2	L	DH	VH	VVL
	P3	VH	M	DH	VL
	P4	M	H	VL	DH

To make group decision for evaluating all the alternative internet public opinion emergency plans with multiple intuitionistic fuzzy individual and collaborative indexes, the linguistic assessment terms in above Tables 4-7 are transformed to the corresponding intuitionistic fuzzy values in  $L_2$ .

According to Table 1 and formula (1) one can calculate the importance degree of all the emergency experts from different emergency sections below.

$$\gamma_k = [\mu_k + \pi_k (\frac{\mu_k}{\mu_k + \nu_k})] / \sum_{k=1}^4 [\mu_k + \pi_k (\frac{\mu_k}{\mu_k + \nu_k})]$$

$$\gamma_1 = 0.2995, \gamma_2 = 0.2627, \gamma_3 = 0.1751, \gamma_4 = 0.2627.$$

Then the weight vector of all the emergency decision-makers is

$$\gamma = (0.2995, 0.2627, 0.1751, 0.2627).$$

According to Table 2 and formula (2)  $\tilde{w}_i = \frac{1}{4}[\tilde{w}_{i1} \oplus \tilde{w}_{i2} \oplus \dots \oplus \tilde{w}_{i4}]$ , one can calculate the overall weight of each individual index of emergency plan as

$$\tilde{w}_1 = \langle 0.883, 0.113 \rangle, \tilde{w}_2 = \langle 0.745, 0.219 \rangle,$$

$$\tilde{w}_3 = \langle 0.778, 0.192 \rangle, \tilde{w}_4 = \langle 0.653, 0.294 \rangle.$$

Using weight information of collaborative index in Table 2 and formula (5)  $\tilde{v}_j = \frac{1}{4}[\tilde{v}_{j1} \oplus \tilde{v}_{j2} \oplus \dots \oplus \tilde{v}_{j4}]$ , the weight of each collaborative index can be obtained as

$$\tilde{v}_1 = \langle 0.838, 0.144 \rangle, \tilde{v}_2 = \langle 0.764, 0.206 \rangle,$$

$$\tilde{v}_3 = \langle 0.8314, 0.156 \rangle, \tilde{v}_4 = \langle 0.7, 0.2475 \rangle$$

Based on formula (3) one can easily compute the individual performance regarding each individual index  $i$  ( $i = 1, 2, 3, 4$ ) and obtain the collective individual

performance of all the alternative emergency plan in the following Table 8.

**Table 8.** Intuitionistic fuzzy individual performance assesment of internet public opinion emergency plan.

Emergency plans $P_h$	$\tilde{P}_{h1}$	$\tilde{P}_{h2}$	$\tilde{P}_{h3}$	$\tilde{P}_{h4}$
P1 (h=1)	<0.451, 0.419>	<0.539, 0.349>	<0.47, 0.397>	<0.668, 0.2201>
P2 (h=2)	<0.645, 0.23>	<0.617, 0.263>	<0.632, 0.246>	<0.594, 0.278>
P3 (h=3)	<0.526, 0.335>	<0.455, 0.428>	<0.307, 0.599>	<0.563, 0.309>
P4 (h=4)	<0.718, 0.234>	<0.498, 0.386>	<0.413, 0.446>	<0.761, 0.177>

With formula (4)  $\tilde{P}_h = IFWA_w(\tilde{P}_{h1}, \tilde{P}_{h2}, \tilde{P}_{h3}, \tilde{P}_{h4})$  one can compute the overall individual performance  $\tilde{P}_h$  of each internet public opinion emergency plan  $P_h$  as follows.

$$\tilde{P}_1 = \langle 0.871, 0.055 \rangle, \tilde{P}_2 = \langle 0.928, 0.026 \rangle, \tilde{P}_3 = \langle 0.83, 0.078 \rangle, \tilde{P}_4 = \langle 0.921, 0.039 \rangle.$$

Also, by utilizing formlae (5-7) one can calculate the intuitionistic fuzzy collaborative performance of all the alternative emergency plans as listed in Table 9.

**Table 9.** Intuitionistic fuzzy collaborative performance assessment of each emergency plan.

Collaboration	P1	P2	P3	P4
P1	<0.994, 0.005>	<0.798, 0.119>	<0.898, 0.058>	<0.7, 0.172>
P2	<0.883, 0.061>	<0.994, 0.005>	<0.811, 0.105>	<0.771, 0.138>
P3	<0.906, 0.049>	<0.838, 0.093>	<0.994, 0.005>	<0.759, 0.138>
P4	<0.484, 0.35>	<0.869, 0.071>	<0.919, 0.04>	<0.994, 0.005>

By utilizing formula (8)  $\tilde{C}_h = \frac{1}{4}[\tilde{C}_{h1} \oplus \tilde{C}_{h2} \oplus \tilde{C}_{h3} \oplus \tilde{C}_{h4}]$  one can get the overall collaborative performance of each alternative emergency plan as follows:

$$\tilde{C}_1 = \frac{1}{4}[\tilde{C}_{11} \oplus \tilde{C}_{12} \oplus \tilde{C}_{13} \oplus \tilde{C}_{14}] = \langle 0.922, 0.049 \rangle;$$

$$\tilde{C}_2 = \frac{1}{4}[\tilde{C}_{21} \oplus \tilde{C}_{22} \oplus \tilde{C}_{23} \oplus \tilde{C}_{24}] = \langle 0.926, 0.046 \rangle;$$

$$\tilde{C}_3 = \frac{1}{4}[\tilde{C}_{31} \oplus \tilde{C}_{32} \oplus \tilde{C}_{33} \oplus \tilde{C}_{34}] = \langle 0.931, 0.042 \rangle;$$

$$\tilde{C}_4 = \frac{1}{4}[\tilde{C}_{41} \oplus \tilde{C}_{42} \oplus \tilde{C}_{43} \oplus \tilde{C}_{44}] = \langle 0.924, 0.047 \rangle.$$

If the internet public opinion emergency department consider the individual and collaborative performance have equal importance, the emergency department should assign weight  $\alpha = 0.5$  to individual performance and  $1 - \alpha = 0.5$  to collaborative performance for internet public opinion emergency plan. Then we can use formlae (9)  $\tilde{\Phi}_h = \alpha \tilde{P}_h \oplus (1 - \alpha) \tilde{C}_h$  to aggregate the individual performance and collaborative performance for internet public opinion emergency plan and get the overall performance of each alternative emergency plan  $P_h$  ( $h = 1, 2, 3, 4$ ) as follows.

$$\tilde{\Phi}_1 = 0.5 \langle 0.871, 0.055 \rangle \oplus 0.5 \langle 0.922, 0.049 \rangle = \langle 0.8997, 0.0519 \rangle;$$

$$\tilde{\Phi}_2 = 0.5 \langle 0.928, 0.026 \rangle \oplus 0.5 \langle 0.926, 0.046 \rangle = \langle 0.927, 0.0346 \rangle;$$

$$\tilde{\Phi}_3 = 0.5 \langle 0.83, 0.078 \rangle \oplus 0.5 \langle 0.931, 0.042 \rangle = \langle 0.8917, 0.0572 \rangle;$$

$$\tilde{\Phi}_4 = 0.5 \langle 0.921, 0.039 \rangle \oplus 0.5 \langle 0.924, 0.047 \rangle = \langle 0.9225, 0.0428 \rangle.$$

Compute score function  $S(\tilde{\Phi}_h)$  and accuracy function  $H(\tilde{\Phi}_h)$  of intuitionistic fuzzy collective performance value  $\tilde{\Phi}_h$  ( $h = 1, 2, 3, 4$ ) of each emergency plan below.

$$S(\tilde{\Phi}_1) = 0.8478, \quad H(\tilde{\Phi}_1) = 0.9516$$

$$S(\tilde{\Phi}_2) = 0.8924, \quad H(\tilde{\Phi}_2) = 0.9616$$

$$S(\tilde{\Phi}_3) = 0.8345, \quad H(\tilde{\Phi}_3) = 0.9489$$

$$S(\tilde{\Phi}_4) = 0.8797, \quad H(\tilde{\Phi}_4) = 0.9653.$$

Thus, the ranking order of collective performance is  $\tilde{\Phi}_2 \succ \tilde{\Phi}_4 \succ \tilde{\Phi}_1 \succ \tilde{\Phi}_3$ .

So, the emergency decision-makers can rank all the alternative emergency plans as  $P_2 \succ P_4 \succ P_1 \succ P_3$ .

In fact, the emergency departments would have different preference degree of individual performance and collaborative performance for internet public opinion emergency plans. If each emergency plan is very collaborative with other emergency plans,  $\beta$  should be assigned greater. If the emergency plan is less collaborative

with other plans,  $\beta$  should be assigned less. In the following, we compute all the intuitionistic fuzzy collective performance  $\tilde{\Phi}_h$  of each emergency plan  $P_h$  when the importance  $\alpha$  of individual performance and importance

$\beta(=1-\alpha)$  of collaborative performance is changed. The sensitivity analysis of emergency decision results and the priority ranking of all the alternative emergency plans are displayed in Table 10.

**Table 10.** Sensitivity analysis of internet public opinion emergency decision.

$\alpha$	$\beta$	Overall performance of each emergency plan				Ranking of emergency plans
		$\tilde{\Phi}_1$	$\tilde{\Phi}_2$	$\Phi_3$	$\Phi_4$	
1	0	<0.871, 0.055>	<0.928, 0.026>	<0.83, 0.078>	<0.921, 0.039>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.9	0.1	<0.8773, 0.0544>	<0.9278, 0.0275>	<0.8447, 0.0733>	<0.9213, 0.0397>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.8	0.2	<0.8833, 0.0537>	<0.9276, 0.0291>	<0.8581, 0.0689>	<0.9216, 0.0405>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.7	0.3	<0.8891, 0.0531>	<0.9274, 0.0309>	<0.8703, 0.0648>	<0.9219, 0.0412>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.6	0.4	<0.8945, 0.0525>	<0.9272, 0.0327>	<0.8815, 0.0609>	<0.9222, 0.0420>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.5	0.5	<0.8997, 0.0519>	<0.927, 0.0346>	<0.8917, 0.0572>	<0.9225, 0.0428>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.4	0.6	<0.9046, 0.0513>	<0.9268, 0.0366>	<0.9010, 0.0538>	<0.9228, 0.0436>	$P_2 \succ P_4 \succ P_1 \succ P_3$
0.3	0.7	<0.9093, 0.0507>	<0.9266, 0.0388>	<0.9096, 0.0506>	<0.9231, 0.0444>	$P_2 \succ P_4 \succ P_3 \succ P_1$
0.2	0.8	<0.9137, 0.0501>	<0.9264, 0.0410>	<0.9174, 0.0475>	<0.9234, 0.0453>	$P_2 \succ P_4 \succ P_3 \succ P_1$
0.1	0.9	<0.918, 0.0496>	<0.9262, 0.0434>	<0.9245, 0.0447>	<0.9237, 0.0461>	$P_2 \succ P_3 \succ P_4 \succ P_1$
0	1	<0.922, 0.049>	<0.926, 0.046>	<0.931, 0.042>	<0.924, 0.047>	$P_3 \succ P_2 \succ P_4 \succ P_1$

From the above Table 10, one can see that the optimal emergency plan is  $P_2$  no matter the importance degree  $\alpha$  of individual performance and the importance degree  $\beta$  of collaborative performance are assigned. Therefore, the emergency department should select the best emergency  $P_2$  to deal with the internet public opinion emergency and execute emergency operation.

## 5. Conclusion

This paper proposes a new group decision method for internet public opinion emergency with intuitionistic fuzzy collaborative index involved multiple decision-makers from different internet public safety departments. By utilizing the proposed collaborative emergency decision approach the emergency decision-maker can obtain the optimal weight of each decision index and select the best emergency plan. According to the ranking of the collective performance of emergency plans, the top emergency section can effectively handle internet public opinion emergency by taking the corresponding emergency plan to execute emergency operation in order.

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