A Group Decision Making Methodology for Emergency Decision

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Abstract

As the emergency is always unconventional, sudden and complex, it is necessary to invite experts from different fields to make decisions. However, the decision makers are usually hesitant and cannot get hold of the emergency because of the lack of information and knowledge. In this paper, a group decision-making methodology based on intuitionistic fuzzy sets is proposed to solve the emergency group decision-making problem. The intuitionistic fuzzy set that was introduced by Atanassov can consider the degree of membership, the degree of non-membership and hesitant degree. As the preferences of emergency decision makers are usually hesitating and incomplete, the incomplete intuitionistic judgment matrix can be constructed to convey the preferences of decision makers. Considering the known elements of the incomplete intuitionistic judgment matrix, the incomplete preference is estimated according to some principles. Then, the individual's preference is aggregated into the group preference through IFWG operators. According to the results of the proposed method, the best emergency plan can be figured out. Finally, a case in emergency decision making in Jiangsu coastal development is introduced to demonstrate the feasibility and efficiency of the proposed method.

Keywords: *Incomplete intuitionistic judgment matrix, Group decision making, Emergency management.*

1. Introduction

Emergency events often lead to casualties, economic losses, destructions to the ecological environment and other unexpected catastrophic consequences [1-3]. In China, the emergency events have caused 200 thousand people died, 2 million people disabled, and the economic loss that was about 5 percent of the GDP every year [4]. In the emergency planning and management, how to choose the best from many emergency plans to minimize the losses of the destructive events is a valuable research topic [5-6].

As the emergency is always complex and involves many aspects, it needs the consensus decision that is made by experts, government workers, the public and other relevant departments. Accordingly, using group decision support systems (GDSS) to handle emergency decision problems could be extremely valuable. Yu and Lai proposed a distance-based group decision-making (GDM) methodology to solve unconventional multi-person multi-criteria emergency decision-making problems. The results demonstrated that the proposed distance-based multi-criteria GDM methodology can improve decision-making objectivity and emergency management effectiveness [7]. Mendonca et al. designed and used of a gaming simulation as a means of assessing one group decision support system (GDSS) for emergency response [8]. Levy and Taji proposed a GANP multi-criteria Decision Support System (DSS) that used quadratic mathematical programming and interval preference information [9]. Nils and Giampiero developed a participatory methodology that helps infrastructure providers, spatial planners and emergency responders converge their views on safety in infrastructure planning[10]. Jutta et al. proposed the multi-criteria decision support and evaluation of strategies for nuclear remediation management [11]. Selcuk and Cengiz developed a decision support system (DSS) based on fuzzy information axiom (FIA) in order to make the decision procedure easy [12]. Liu puted forward a Multiple Attribute Decision Making (MADM) based on water bloom emergency management decision-making methods, and applied to the lake reservoir water bloom emergency management program's selection [13].

The present studies have shown that GDSS can improve emergency management effectiveness and decision transparency because it can integrate group wisdom of multiple decision-makers into one group wisdom. In the process of emergency decision-making, how to express the preference of each decision-maker in the group realistically is a key issue for group decision making method. As emergency is always complex and uncertainty, the decision makers are usually hesitant and can't get hold of enough

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knowledge of the emergency. The emergency decision makers from different fields may be familiar with some aspects of the emergency, but not all. It is important to consider the incomplete and hesitating complements of the decision language when the decision makers express their preference. So, the paper tries to convey the information of decision makers in emergency management based on intuitionistic fuzzy sets.

Intuitionistic fuzzy set was proposed by Atanassov. It is commonly used because that it can consider the degree of membership, the degree of non-membership and the hesitancy degree[14]. Yu and Lai utilized fuzzy QFD method as a tool that makes the subjective judgment of the problem [7]. Dursun et al. used the ordered weighted averaging (OWA) operator to aggregate decision makers' opinions [15]. Chen et al. presented a new method to deal with fuzzy multiple attributes group decision-making problems based on ranking interval type-2 fuzzy sets [16]. Ye proposed an extended technique for order preference by similarity to ideal solution (TOPSIS) method for group decision making with interval-valued intuitionistic fuzzy numbers to solve the partner selection problem under incomplete and uncertain information envioronment[17]. Malekly and Meysam described the rating values regarding to each alternative and criteria throughout the phases in a fuzzy environment by means of linguistic variables [18]. Ben combined fuzzy logic with case-based reasoning to identify useful cases that can support the decision making [19].

The main purpose of the proposed multi-criteria GDM methodology is to improve decision accuracy, and to enhance decision transparency and thus to increase decision effectiveness. The rest of this paper is organized as follows. In Section 2, the general framework for the methodology is decribed. In Section 3, the multi-criteria GDM methodology based on intuitionistic fuzzy sets Theory is described in detail. For illustration and verification purposes, Section 4 presents a practical emergency decision case to illustrate the implementation process, and to verify the effectiveness of theproposed methodology. Finally, some concluding remarks are drawn in Section 5.

2. Preliminaries

In this section, the description of the emergency decision problem is given. Then, a general framework for the multi-criteria GDM methodology is presented. Finally, the basic knowledge of intuitionistic fuzzy sets is given.

2.1 Description of the emergency decision problem

As the emergency is always unconventional, sudden and complex, it is necessary to invite experts from different fields to make decisions. It is impossible to make an emergency plan considering all aspects of the emergency. The realistic choice is that we should have many emergency plans and let the decision makers to choose a best one. So, the emergency decision is a group decision-making problem. As the emergency decision-making must be made in a short time using partial or incomplete information, the decision makers may be hesitant and unfamiliar with some aspects of the emergency. The paper tries to introduce intuitionistic fuzzy sets to solve the problem. The description of the emergency group decision-making problem is as the following:

$Y=(Y_1,\ Y_2,\cdots,Y_n)$: the emergency plans that are made by emergency department to deal with the emergency . Y_i stands for the i th emergency plan, $i=1,2,\cdots,n$.

$E=(e_1,\ e_2,\cdots,e_l)^T$:the decision makers from different field to deal with the emergency, e_k stands for the k th decision maker, .

$\mu_{ij}^{(k)}$:the certain degree to which Y_i is preferred to that is assessed by emergency decision maker e_k .

$v_{ij}^{(k)}$: the certain degree to which Y_j is preferred to Y_i that is assessed by emergency decision maker e_k .

$1-\mu_{ij}^{(k)}-v_{ij}^{(k)}$:the uncertain degree to which Y_i is preferred to Y_j that is assessed by emergency decision maker.

$\xi=(\xi_1,\ \xi_2,\cdots,\xi_l)^T$: the weight vector of the emergency decision makers.

2.2 The general framework for the GDM methodology

The general framework for the GDM methodology is given as Fig.1. First, the emergency group decision making problem is described. As the emergency is always complex, the decision maker is usually hesitant and cannot get hold of the emergency because of the lack of information. So the incomplete intuitionistic judgment matrix is proposed when the decision makers express their preference for the emergency plan. Based on intuitionistic fuzzy set, we can get the average intuitionistic preference value and the comprehensive intuitionistic preference value. Finally, choose the best emergency plan to deal with the emergency.

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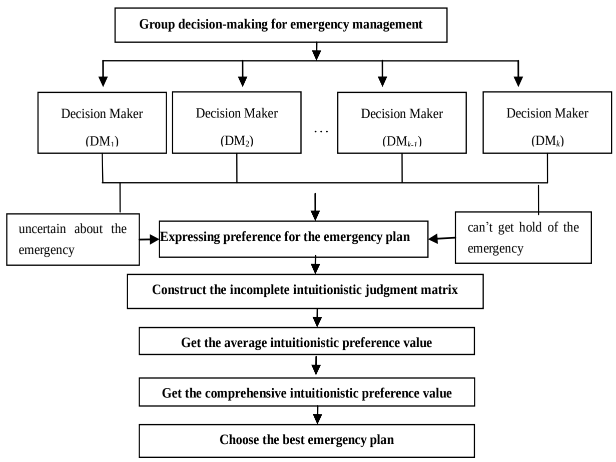

Fig. 1 General framework for the GDM methodology.

2.3 Basic knowledge of intuitionistic fuzzy sets

Definition1. Let $Q=(q_{ij})_{n\times n}$ be the intuitionistic judgment matrix[20], where $q_{ij}=(\mu_{ij},\nu_{ij})(i,j=1,2,\cdots,n)$, μ_{ij} stands for the decision maker's preference to Y_i when he or she compare Y_i with Y_j , ν_{ij} stands for the decision maker's preference

$$\mu_{ij}\in[0,1], \nu_{ij}\in[0,1], 0\le\mu_{ij}+\nu_{ij}\le 1, \mu_{ji}=\nu_{ij}, \nu_{ji}=\mu_{ij}, \mu_{ii}=\nu_{ii}=0.5 \ \ (i,j=1,2,\cdots,n) \quad (1)$$

then we call Q the intuitionistic judgment matrix.

Definition2. Let $Q=(q_{ij})_{n\times n}$ be the intuitionistic $Q=(q_{ij})_{n\times n}$ judgment matrix, if it contains incomplete elements and complete elements, be the incomplete elements, if

$$0\le\mu_{ij}+\nu_{ij}\le 1, \mu_{ji}=\nu_{ij}, \nu_{ji}=\mu_{ij}, \mu_{ii}=\nu_{ii}=0.5 \quad (2)$$

then we call Q the intuitionistic judgment matrix.

Definition3. If $q_{ij}=(\mu_{ij},\nu_{ij})$ and $q_{kl}=(\mu_{kl},\nu_{kl})$ are two intuitionistic fuzzy values, then

(1) $\bar{q}_{ij}=(\nu_{ij},\mu_{ij})$.

(2) $q_{ij}+q_{kl}=(\mu_{ij}+\mu_{kl}-\mu_{ij}\cdot\mu_{kl},\ \ \nu_{ij}\cdot\nu_{ij})$.

(3) $q_{ij}\cdot q_{kl}=(\mu_{ij}\cdot\mu_{ij},\ \ \nu_{ij}+\nu_{kl}-\nu_{ij}\cdot\nu_{kl})$.

(4) $\lambda q_{ij}=(1-(1-\mu_{ij})^{\lambda},\nu_{ij}^{\lambda}),\lambda>0$.

(5) $q_{ij}^{\lambda}=(\mu_{ij}^{\lambda},1-(1-\nu_{ij})^{\lambda}),\lambda>0$.

Definition4. Let $Q=(q_{ij})_{n\times n}$ be the incomplete intuitionistic judgment matrix, if $q_{ij}=q_{ik}\otimes q_{kj}, q_{ij}, q_{ik}, q\in\Omega$, then we call Q the consistency incomplete intuitionistic judgment matrix.

Definition5. Let $Q=(q_{ij})_{n\times n}$ be the incomplete intuitionistic judgment matrix, if $(i,j)\cap(k,l)\neq\varnothing$, then we call the element q_{ij} and q_{kl} are adjacent.

Definition6. Let $Q=(q_{ij})_{n\times n}$ be the incomplete intuitionistic judgment matrix, if each unknown element can be got from its adjacent elements, Q is acceptable, or Q is unacceptable.

In the face of the emergency, the decision maker ($e_k\in E$) is usually hesitant and uncertain, he or she gives the preference after compare two contingency plans, and we can get $q_{ij}^{(k)}=(\mu_{ij}^{(k)},\nu_{ij}^{(k)})$, where μ_{ij} stands for the decision maker's preference to Y_i when he or she compare Y_i with Y_j , ν_{ij} stands for the decision maker's preference .

Theorem1. Let $q_{ij}^{(1)},q_{ij}^{(2)},\ldots,q_{ij}^{(m)}$ be m intuitionistic fuzzy values, where $q_{ij}^{(c)}=(\mu_{ij}^{(c)},\nu_{ij}^{(c)})$, $c=1,2,\ldots,m$, and let $w=(w_1,w_2,\ldots,w_m)^T$ be the weight vector of $q_{ij}^{(1)},q_{ij}^{(2)},\ldots,q_{ij}^{(m)}$, then the aggregated value $\bar{q}_{ij}$ of $q_{ij}^{(1)},q_{ij}^{(2)},\ldots,q_{ij}^{(m)}$ is also an intuitionisitic fuzzy value, where $\bar{q}_{ij}$ is obtained by using the intuitionisitic fuzzy weighted arithmetic averaging operator:

$$\bar{q}_{ij}=\sum_{c=1}^{m} w_c q_{ij}^{(c)},\ i,j=1,2,\ldots,n \quad (3)$$

or by using the intuitionist fuzzy weighted geometric averaging operator:

$$\bar{q}_{ij}=\prod_{c=1}^{m}(q_{ij}^{(c)})^{w_c},\ i,j=1,2,\ldots,n \quad (4)$$

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In particular, if $w=(1/m,1/m,...,1/m)^T$, then(3)and(4)are, respectively, reduced to the intuitionistic fuzzy arithmetic averaging operator:

$$\bar{q}_{ij}=\frac{1}{c}\sum_{c=1}^{c}q_{ij}^{(c)},\ i,j=1,2,...,n \tag{5}$$

and the intuitionisitic fyzzy geometric averaging operator:

$$\bar{q}_{ij}=(\prod_{c=1}^{m}(q_{ij}^{(c)}))^{\frac{1}{m}},\ i,j=1,2,...,n \tag{6}$$

3. Group decision making model base on intuitionistic fuzzy sets

As the emergency is always complex, the decision maker is usually hesitant and cannot get hold of the emergency because of the lack of knowledge, the paper introduces the incomplete intuitional judgment matrix to express the preference of the decision maker. The decision makers express their preference according the knowledge about the emergency, then the paper aggregates individual preference to group preference, and finally get the best emergency plan.

3.1 Step1: Construct the incomplete intuitionistic judgment matrix

As the emergency is complex and sudden, the decision maker may be hesitant and can't get enough knowledge, he or she can make space when express the preference, then we can get the incomplete intuitional judgment matrix $Q_k=(q_{ij}^{(k)})_{n\times n}$, where

$q_{ij}^{(k)}=(\mu_{ij}^{(k)},v_{ij}^{(k)}),0\le\mu_{ij}^{(k)}+v_{ij}^{(k)}\le1,\mu_{ji}^{(k)}=v_{ij}^{(k)},v_{ji}=\mu_{ij},\mu_{ii}^{(k)}=v_{ii}^{(k)}=0.5(i,j\in\Omega)$.

As defined in 2.3, Q_k should be acceptable. If Q_k is unacceptable, the decision maker needs to construct a new one until it is acceptable.

3.2 Step2: Construct the improved incomplete intuitionistic judgment matrix

As described in 3.1, we can get the acceptable incomplete intuitionistic judgment matrix from each emergency decision maker. As there are incomplete and unknown elements in the intuitionistic judgment matrix, we should estimate them through other known elements.

Let $Q=(q_{ij})_{n\times n}$ be the acceptable incomplete intuitionistic judgment matrix, if each unknown element can be got through

$$\dot{q}_{ij}=(\bigotimes_{k\in N_{ij}}(q_{ik}\otimes q_{kj}))^{\frac{1}{n_{ij}}} \tag{7}$$

where $N_{ij}=\{k|q_{ik},q_{kj}\in\Delta\}$, then we get the improved $\dot{Q}=(\dot{q}_{ij})_{n\times n}$.

$$\dot{q}_{ij}=\begin{cases}q_{ij}, & q_{ij}\in\Omega\\ \dot{q}_{ij}, & q_{ij}\notin\Omega\end{cases} \tag{8}$$

The improved intuitionistic judgment matrix $\dot{Q}=(\dot{q}_{ij})_{n\times n}$ contains both the direct intuitionistic preference information given by the emergency decision maker and the indirect intuitionistic preference information derived from the known intuitionistic preference information.

3.3 Step3: Get the average intuitionistic preference value through IFWA operators

Through institutionistic fuzzy weighted aggregation (IFWA) operators:

$$\dot{q}_i^{(k)}=\frac{1}{n}(q_{i1}^{\cdot(k)}\oplus q_{i2}^{\cdot(k)}\oplus\cdots\oplus q_{in}^{\cdot(k)}) \tag{9}$$

we can aggregate the intuitionistic preference value of emergency plan ,then get the average intuitionistic preference value.

3.4 Step4: Get the comprehensive intuitionistic preference value through IFWG operators

Through intuitionistic fuzzy weighted geometric (IFWG) operator:

$$\dot{q}_i=(\xi_1\dot{q}_i^{(1)}\oplus\xi_2\dot{q}_i^{(2)}\oplus\cdots\oplus\xi_l\dot{q}_i^{(l)}) \tag{10}$$

We can aggregate the intuitionistic preference value of emergency plan, and then get the comprehensive intuitionistic preference value.

3.5 Step5: Choose the best emergency plan

Definition6. For any intuitionistic fuzzy number $q_{ij}=(\mu_{ij},v_{ij})$, we can asses it through the score function $s(q_{ij})$:

$$s(q_{ij})=\mu_{ij}-v_{ij} \tag{11}$$

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Where $s(q_{ij})$ is the score value, $s(q_{ij})\in[-1,1]$ .The larger the score $s(q_{ij})$, the greater the intutionistic fuzzy value q_{ij} .

Definition7. For any intuitionistic fuzzy number , we can asses it through the accuracy function:

$$h(q_{ij})=\mu_{ij}+\nu_{ij} \quad (12)$$

to evaluate the degree of accuracy of the intuitionistic fuzzy value q_{ij} , where $h(q_{ij})\in[-1,1]$. The larger the value of $h(q_{ij})$, the more the degree of accuracy of the intuitionistic fuzzy value q_{ij} .

Normally, we use score function to judge the intuitionistic fuzzy Numbers, in some special circumstances, such as the score value of two groups of intuitionistic fuzzy number is the same and it cannot through the score function to judge, then we can use the accuracy function to judge.

Definition8. Let $q_{ij}=(\mu_{ij},\nu_{ij})$ and $q_{kl}=(\mu_{kl},\nu_{kl})$ be two intuitionistic fuzzy values, $s(q_{ij})=\mu_{ij}-\nu_{ij}$ and $s(q_{kl})=\mu_{kl}-\nu_{kl}$ be the scores of q_{ij} and q_{kl} , respectively, and let $h(q_{ij})=\mu_{ij}+\nu_{ij}$ and $h(q_{kl})=\mu_{kl}+\nu_{kl}$ be the accuracy degrees of q_{ij} and q_{kl} , respectively, then

If $s(q_{ij})<s(q_{kl})$, then q_{ij} is smaller than , denoted by $q_{ij}<q_{kl}$.

If $s(q_{ij})=s(q_{kl})$, then

(1)If $h(q_{ij})=h(q_{kl})$, then q_{ij} and q_{kl} represent the same information, denoted by $q_{ij}=q_{kl}$.

(2)If $h(q_{ij})<h(q_{kl})$, then q_{ij} is smaller than q_{kl} , denoted by $q_{ij}<q_{kl}$.

According formula (5) and (6), we can sort the comprehensive intuitionistic preference value $q_i^{\cdot}(i=1,2,\cdots,n)$, then we can sort the emergency plans $Y_i(i=1,2,\cdots,n)$ and choose the best one.

4. Application

In June 2009, the State Council of China reviewed the Jiangsu Coastal Area Development Plan. The Jiangsu Coastal Area has brought fast development of economy since 2009. However , the coastal areas is also easy to happen emergency in its development ,such as safe production, land expropriation demolition, traffic accident, natural disaster and so on. The safety of coastal needs our attention. The paper takes the emergency in Jiangsu coastal area development for example for simulation analysis. To assess the emergency plans, we consider the following four aspects: economic loss, personnel losses, environmental impact and social influence. We suppose that there are four decision makers to choose the best plan from four emergency plans of Jiangsu coastal area development. In order to deal with the emergency, the emergency department has made four emergency plans considering with different situations. The committee comprise of four decision makers $e_k(k=1,2,3,4)$ (whose weight vector is $\xi=(0.22,0.25,0.3,0.23)^T$) has been set up to provide assessment information on the emergency plans.

Step1.The decision makers $e_k(k=1,2,3,4)$ provide their preference information by incomplete intuitionistic judgment matrix $Q^{(k)}=(q_{ij}^k)_{4\times4}(k=1,2,3,4)$ as follows, respectively:

$$Q_1=\begin{pmatrix}(0.5,0.5)&(0.4,0.5)&(x_1,x_2)&(0.3,0.5)\\(0.5,0.4)&(0.5,0.5)&(0.5,0.3)&(0.4,0.5)\\(x_2,x_1)&(0.3,0.5)&(0.5,0.5)&(0.3,0.6)\\(0.5,0.3)&(0.5,0.4)&(0.6,0.3)&(0.5,0.5)\end{pmatrix}$$

$$Q_2=\begin{pmatrix}(0.5,0.5)&(0.3,0.6)&(0.5,0.3)&(x_3,x_4)\\(0.6,0.3)&(0.5,0.5)&(0.6,0.3)&(0.5,0.4)\\(0.3,0.5)&(0.3,0.6)&(0.5,0.5)&(0.4,0.5)\\(x_4,x_3)&(0.4,0.5)&(0.5,0.4)&(0.5,0.5)\end{pmatrix}$$

$$Q_3=\begin{pmatrix}(0.5,0.5)&(x_5,x_6)&(0.5,0.4)&(0.3,0.6)\\(x_6,x_5)&(0.5,0.5)&(0.3,0.5)&(0.6,0.3)\\(0.4,0.5)&(0.4,0.5)&(0.5,0.5)&(0.4,0.3)\\(0.6,0.3)&(0.3,0.6)&(0.3,0.4)&(0.5,0.5)\end{pmatrix}$$

$$Q_4=\begin{pmatrix}(0.5,0.5)&(0.3,0.5)&(0.5,0.3)&(0.3,0.6)\\(0.5,0.3)&(0.5,0.5)&(x_7,x_8)&(0.5,0.4)\\(0.3,0.5)&(x_8,x_7)&(0.5,0.5)&(0.3,0.6)\\(0.6,0.3)&(0.4,0.5)&(0.6,0.3)&(0.5,0.5)\end{pmatrix}$$

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Step2. Use (7) to construct the improved intuitionistic judgment matrix $\dot{Q}^{(k)}=(\dot{q}_{ij}^{(k)})_{4\times4}(k=1,2,3,4)$ of $Q^{(k)}=(q_{ij}^{k})_{4\times4}(k=1,2,3,4)$.

$$\dot{Q}_1=\begin{pmatrix}(0.5,0.5)&(0.4,0.5)&(0.44,0.29)&(0.3,0.5)\\(0.5,0.4)&(0.5,0.5)&(0.5,0.3)&(0.4,0.5)\\(0.39,0.44)&(0.3,0.5)&(0.5,0.5)&(0.3,0.6)\\(0.5,0.3)&(0.5,0.4)&(0.6,0.3)&(0.5,0.5)\end{pmatrix}$$

$$\dot{Q}_2=\begin{pmatrix}(0.5,0.5)&(0.3,0.6)&(0.5,0.3)&(0.42,0.44)\\(0.6,0.3)&(0.5,0.5)&(0.6,0.3)&(0.5,0.4)\\(0.3,0.5)&(0.3,0.6)&(0.5,0.5)&(0.4,0.5)\\(0.44,0.42)&(0.4,0.5)&(0.5,0.4)&(0.5,0.5)\end{pmatrix}$$

$$\dot{Q}_3=\begin{pmatrix}(0.5,0.5)&(0.37,0.52)&(0.5,0.4)&(0.3,0.6)\\(0.52,0.37)&(0.5,0.5)&(0.3,0.5)&(0.6,0.3)\\(0.4,0.5)&(0.4,0.5)&(0.5,0.5)&(0.4,0.3)\\(0.6,0.3)&(0.3,0.6)&(0.3,0.4)&(0.5,0.5)\end{pmatrix}$$

$$\dot{Q}_4=\begin{pmatrix}(0.5,0.5)&(0.3,0.5)&(0.5,0.3)&(0.3,0.6)\\(0.5,0.3)&(0.5,0.5)&(0.52,0.32)&(0.5,0.4)\\(0.3,0.5)&(0.32,0.52)&(0.5,0.5)&(0.3,0.6)\\(0.6,0.3)&(0.4,0.5)&(0.6,0.3)&(0.5,0.5)\end{pmatrix}$$

Step3. Use (3) to aggregate all corresponding to the emergency plan Y_i, and then get the averaged intuitionistic fuzzy value of the emergency plan over all the other emergency plans.

$$q_1^{(1)}=\frac{1}{4}(q_{11}^{(1)}\oplus q_{12}^{(1)}\oplus q_{13}^{(1)}\oplus q_{14}^{(1)})$$
$$=\frac{1}{4}((0.5+0.4+0.44+0.3),(0.5+0.5+0.39+0.5))$$
$$=(0.41,0.47)$$

$q_1^{(2)}=(0.43,0.46)$， $q_1^{(3)}=(0.42,0.51)$, $q_1^{(4)}=(0.4,0.48)$

$q_2^{(1)}=(0.48,0.45)$， $q_2^{(2)}=(0.55,0.38)$， $q_2^{(3)}=(0.48,0.42)$, $q_2^{(4)}=(0.51,0.38)$

$q_3^{(1)}=(0.37,0.51)$， $q_3^{(2)}=(0.3,0.53)$， $q_3^{(3)}=(0.43,0.45)$, $q_3^{(4)}=(0.36,0.53)$

$q_4^{(1)}=(0.53,0.33)$， $q_4^{(2)}=(0.46,0.46)$， $q_4^{(3)}=(0.53,0.45)$, $q_4^{(4)}=(0.48,0.4)$

Step4. Use (4) to aggregate all into a collective intuitionistic fuzzy value of the emergency plan over all the other emergency plans:

$$\dot{q}_1=(\xi_1\dot{q}_1^{(1)}\oplus\xi_2\dot{q}_1^{(2)}\oplus\xi_3\dot{q}_1^{(3)}\oplus\xi_4\dot{q}_1^{(4)})$$
$$=(0.42,0.47)$$

$$\dot{q}_2=(0.50,0.41)$$

$$\dot{q}_3=(0.37,0.50)$$

$$\dot{q}_4=(0.50,0.42)$$

Finally, choose the best emergency plan. Through formula (11), we can get:

$s(\dot{q}_1)=\text{-}0.05$, $s(\dot{q}_2)=0.09$, $s(\dot{q}_3)=\text{-}0.13$, $s(\dot{q}_4)=0.08$.

Then

$$q_2>q_4>q_1>q_3$$

and hence

$$Y_2\succ Y_4\succ Y_1\succ Y_3.$$

The emergency plan 2 is the best.

5. Conclusions

In emergency decision making, the decision makers may be hesitated and lack of knowledge. To solve this group decision making problem, a method that based on incomplete intuitionistic judgment matrix is proposed for emergency management. In this paper, the incomplete intuitionistic judgment matrix is constructed to convey the information of experts in group decision making. Finally, a case in emergency decision making in Jiangsu coastal development is introduced to demonstrate the feasibility and efficiency of the proposed method.

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