A Warning and Urgent Decision-making Mechanism for Uncertain Network Public Sentiment Emergency

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***Abstract*—To deal with the uncertain network public sentiment emergency of which attribute represented by intuitionistic fuzzy language term, we present a new information entropy measure for intuitionistic fuzzy value. By using the entropy measure, the weight of each sentiment attribute of emergency can be determined. Then by means of the information fusion technique of intuitionistic fuzzy sentiment attribute values, we can rank all the severity of network emergencies and select the most serious network sentiment emergency. Finally, an example is given to illustrate the application of the proposed intuitionistic fuzzy information entropy and aggregation operator to the urgent decision-making of the uncertain network public sentiment emergency**

***Index Terms*—Emergency, Network sentiment, Intuitionistic fuzzy Entropy, Aggregation operator**

I. Introduction

Network sentiment is the public opinions of some event with some influence and strength. Recently, Network sentiment analysis and early warning become very important research issues. As is well known, the uncontrolled network sentiments easily incur the abrupt event or emergency. Simultaneously, abrupt events affect network public sentiment. So, in order to avoid or decrease the risk of emergency management and urgent decision [1, 10], there is much need to analyze and control the network public sentiment effectively. In the above areas, Zeng [18,19] and Zhang [20] proposed the methods of selecting sentiment indexes and determining their weights for network sentiment emergency. Peng [11] and Zhang [16] discussed the close relationship between network public sentiment and emergency. Also some authors [13, 17] have proposed many early warning decision methods for network emergency. However, the most existing related urgent decision methods and mechanisms can only deal with the emergency under precise condition and certain environment. Although Lin [8] proposed a method for the network sentiment early warning, it excessively depended on the selected fuzzy reasoning rules. Thus, the presented approach is inconvenient in some cases and it can not deal with network sentiment emergency with intuitionistic fuzzy language values. In fact, due to the increasing complexity of the socio-economic environment and the lack of knowledge about the problem domain, most of the real-world problems, such as network public sentiment analysis and uncertain urgent decision-making, are involved variety of fuzziness, like fuzzy value and intuitionistic fuzzy value, which are also generally represented by intuitionistic fuzzy language terms. Especially, in the process of uncertain network emergency urgent decision making, a decision maker may provide his/her preferences over alternate emergencies with intuitionistic fuzzy values or linguistic terms.

As we know, the unexpected emergency generally involves some public sentiment factors including the importance of topic, the tide of sentiment, the attention degree of topic, and popularity of topic, as well as the speed of spreading. Also, the values of above emergency influence factors are easily expressed by intuitionistic fuzzy language values. In this paper we aim to propose an effective method for dealing with the unknown emergency urgent decision under the uncertain environment.

Intuitionistic fuzzy set proposed by Atanassov [2] has drawn the attention of many researchers in order to cope with imperfectly defined facts and data, as well as with imprecise knowledge. As a useful generalization of ordinary fuzzy sets, intuitionistic fuzzy sets have more

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extensive applications to pattern recognition, medical diagnosis and decision-making. Particularly, information entropy [7] , similarity measure and distance measure play very important roles in the above-mentioned application areas. As far as we know, Grzegorzewski [5] and Hong [6] presented some distances and similarity measures between intuitionistic fuzzy sets or interval-valued fuzzy sets for multi-attribute decision making. In [9], Li applied similarity measure of intuitionistic fuzzy sets or intuitionistic fuzzy sets to pattern recognition. Xu [15] proposed intuitionistic fuzzy aggregation operator for decision making. Moreover, we proposed intuitionistic fuzzy entropy to deal with decision making and pattern recognition problems [21] .

The rest of this paper is organized as follows. In section 2, some necessary concepts of intuitionistic fuzzy set are reviewed and a new intuitionistic fuzzy entropy is redefined by using the membership degree and non-membership degree of intuitionistic fuzzy set which is different from that in [3]. And in section 3, we introduce a urgent decision making mechanism of network public sentiment emergency with intuitionistic fuzzy language information. In section 4, one numerous example is given to demonstrate the effectiveness of the proposed network emergency urgent decision making approach by using the proposed intuitionistic fuzzy information entropy and aggregation operator.

II. PRELIMINARIES

Intuitionistic fuzzy set (IFS) introduced by Atanassov [2] is a useful generalization of ordinary fuzzy set, which has been proved to be more suitable way for dealing with uncertainty. Particularly, the information entropy [21], similarity measure and distance measure of IFSs play very important roles in the application areas like pattern recognition, medical diagnosis, risk assessment [26] and decision-making [22, 25,27,28].

Definition 1[2]. An intuitionistic fuzzy set A in the universe $X=\{x_1,x_2,\cdots,x_n\}$ is defined as

$$A=\{(x_i,<u_A(x_i),\, f_A(x_i)>)/\, x_i\in X\},$$

i.e., $A(x_i)=[u_A(x_i),1-f_A(x_i)]$ and the condition $0\le u_A(x_i)+f_A(x_i)\le 1$ must hold for any $x_i\in X$,

where $u_A(x_i)$, $f_A(x_i)$ are called the membership degree and non-membership degree of element x_i to the intuitionistic fuzzy set A , respectively;

$\pi_A(x_i)=1-u_A(x_i)-f_A(x_i)$ is the hesitation degree of x_i to the IFS A .

Definition 2[2]**.** Let A,B be two intuitionistic fuzzy sets in the finite universe $X=\{x_1,x_2,\cdots,x_n\}$, the union, intersection and complement of intuitionistic fuzzy sets are defined as follows.

$$A\cup B=\{(x_i,<u_A(x_i)\vee u_B(x_i),\, f_A(x_i)\wedge f_B(x_i)>)\,|\,x_i\in X\},$$

$$A\cap B=\{(x_i,<u_A(x_i)\wedge u_B(x_i),\, f_A(x_i)\vee f_B(x_i)>)\,|\,x_i\in X\},$$

$$A^c=\{(x_i,<f_A(x_i),u_A(x_i)>)\,|\,x_i\in X\}.$$

Definition 3. A mapping from all the intuitionistic fuzzy sets in universe X to interval [0,1] is named as the intuitionistic fuzzy entropy, if it satisfies the following extension of De Luca-Termini axioms (cf. [4]),

(p1) $H(A)$ =0 (minimum) , if A is a crisp set, i.e., $A(x_i)=<0,1>$ *or* $<1,0>$ for all $x_i\in X$;

(p2) $H(A)$ =1 (maximum), iff $u_A(x_i)=f_A(x_i)$ for all $x_i\in X$;

(p3) $H(A^*)\le H(A)$, if $A^* <<< A$, i.e., intuitionistic fuzzy set A^* is a sharpened version of A defined as

$$\begin{cases} u_{A^*}(x_i)\le u_A(x_i) \quad and \quad f_{A^*}(x_i)\ge f_A(x_i), \\ \qquad\qquad\qquad for \quad u_A(x_i)\le f_A(x_i); \\ u_{A^*}(x_i)\ge u_A(x_i) \quad and \quad f_{A^*}(x_i)\le f_A(x_i), \\ \qquad\qquad\qquad for \quad u_A(x_i)\ge f_A(x_i). \end{cases}$$

(p4) $H(A)=H(A^c)$, where A^c is the complement set of intuitionistic fuzzy set A .

Theorem 1. For any parameter $\lambda\in[0,1]$,

$$H(A)=\frac{1}{n}\sum_{i=1}^{n}\frac{u_A(x_i)\wedge f_A(x_i)+\lambda\pi_A(x_i)}{u_A(x_i)\vee f_A(x_i)+\lambda\pi_A(x_i)} \qquad (1),$$

is an information entropy measure of intuitionistic fuzzy set A .

Proof. It suffices to prove that all the properties (p1)-(p4) hold.

(p1) If A is a crisp set, then for all $x_i\in X$,

$$A(x_i)=[u_A(x_i),1-f_A(x_i)]=[0,0] \quad or \quad [1,1],$$

then we get

$$H(A)=\frac{1}{n}\sum_{i=1}^{n}\frac{u_A(x_i)\wedge f_A(x_i)+\lambda\pi_A(x_i)}{u_A(x_i)\vee f_A(x_i)+\lambda\pi_A(x_i)}=0.$$

(p2) If A is the most intuitionistic fuzzy set, i.e., $u_A(x_i)=f_A(x_i)$, $\forall x_i\in X$, then $\dfrac{u_A(x_i)\wedge f_A(x_i)}{u_A(x_i)\vee f_A(x_i)}=1$.

If $H(A)=1$, then

$$u_A(x_i)\wedge f_A(x_i) = u_A(x_i)\vee f_A(x_i)$$

$$\Rightarrow\ u_A(x_i)= f_A(x_i)\quad \forall x_i\in X\ .$$

(p3) To prove it, we first subdivide X into two parts X_1 and X_2, where

$$X_1=\{x_i | u_A(x_i)\le f_A(x_i)\},$$

$$X_2=\{x_i | f_A(x_i)< u_A(x_i)\}.$$

Now suppose $A^* <<< A$, from the definition of sharpened version of A, we know that,

If $x_i\in X_1$, then

$$u_{A^*}(x_i)\le u_A(x_i)\ \ and\ \ f_{A^*}(x_i)\ge f_A(x_i),$$

$$for\ \ u_A(x_i)\le f_A(\ x_i);$$

i.e., $u_{A^*}(x_i)\le u_A(x_i)\le f_A(x_i)\le f_{A^*}(x_i)$, $\forall\ x_i\in X_1$.

Thus,

$$\sum_{\{x_i/x_i\in X_1\}}\frac{u_{A^*}(x_i)\wedge f_{A^*}(x_i)+\lambda\pi_{A^*}(x_i)}{u_{A^*}(x_i)\vee f_{A^*}(x_i)+\lambda\pi_{A^*}(x_i)}$$

$$=\sum_{\{x_i/x_i\in X_1\}}\frac{\lambda+(1-\lambda)u_{A^*}(x_i)-\lambda f_{A^*}(x_i)}{\lambda+(1-\lambda)f_{A^*}(x_i)-\lambda u_{A^*}(x_i)}$$

$$\le\sum_{\{x_i/x_i\in X_1\}}^{n}\frac{\lambda+(1-\lambda)u_A(x_i)-\lambda f_A(x_i)}{\lambda+(1-\lambda)f_A(x_i)-\lambda u_A(x_i)},$$

$$\forall\ x_i\in X_1.$$

If $x_i\in X_2$, then

$$u_{A^*}(x_i)\ge u_A(x_i)\ \ and\ \ f_{A^*}(x_i)\le f_A(x_i),$$

$$for\ \ u_A(x_i)\ge f_A(\ x_i);$$

i.e., $u_{A^*}(x_i)\ge u_A(x_i)\ge f_A(x_i)\ge f_{A^*}(x_i)$;

Thus, for any $x_i\in X_2$,

$$\sum_{\{x_i/x_i\in X_2\}}\frac{u_{A^*}(x_i)\wedge f_{A^*}(x_i)+\lambda\pi_{A^*}(x_i)}{u_{A^*}(x_i)\vee f_{A^*}(x_i)+\lambda\pi_{A^*}(x_i)}$$

$$\le\sum_{\{x_i/x_i\in X_2\}}^{n}\frac{\lambda+(1-\lambda)f_A(x_i)-\lambda u_A(x_i)}{\lambda+(1-\lambda)u_A(x_i)-\lambda f_A(x_i)}.$$

So, we can get $H(A^*)\le H(A)$.

(p4) It is clear that $\boldsymbol{A^c(x_i) =< f_A(x_i), u_A(x_i)>}$ for all $x_i\in X$, i.e., $u_{A^c}=f_A$, $f_{A^c}=u_A$.

Thus,

$$H(A^c)=\frac{1}{n}\sum_{i=1}^{n}\frac{u_{A^c}(x_i)\wedge f_{A^c}(x_i)+\lambda\pi_{A^c}(x_i)}{u_{A^c}(x_i)\vee f_{A^c}(x_i)+\lambda\pi_{A^c}(x_i)}$$

$$=\frac{1}{n}\sum_{i=1}^{n}\frac{f_A(x_i)\wedge u_A(x_i)+\lambda\pi_A(x_i)}{f_A(x_i)\vee u_A(x_i)+\lambda\pi_A(x_i)}=H(A).$$

Remark 1. When $\lambda=0$, $H(A)$ reduces to the intuitionistic fuzzy entropy form given in our work [21].

Especially when $\lambda=0$ and $u_A(x_i)=1-f_A(x_i)$, for any $x_i\in X$, $H(A)$ becomes fuzzy entropy [16].

When $\lambda=1$, $H(A)$ degenerates to the entropy formula for IFS as stated in [12] .

Thus, the proposed entropy $H(A)$ is more extensive than the existing intuitionistic fuzzy entropy formulae.

For convenience, according to the work of Xu [15], we call $\tilde{a} =< a,b >$ an intuitionistic fuzzy number (IFN), if $0\le a+b\le 1$.

Definition 4. Assume $\tilde{a} =< a,b >$ is an intuitionistic fuzzy number, the score function S to measure the degree of suitability of $\tilde{\boldsymbol{a}}$ is defined as $S(\tilde{a})=a-b$.

Definition 5. Assume $\tilde{a} =< a,b >$ is an intuitionistic fuzzy number, the accuracy function ϕ to evaluate the accuracy degree of an intuitionistic fuzzy number is defined as $\phi(\tilde{a})=a+b$.

Below we present a method to compare any two intuitionistic fuzzy numbers based on the above defined score function and accuracy function.

Proposition 1. For any two IFNs $\tilde{a}_1 =< a_1,b_1 >$ and $\tilde{a}_2 =< a_2,b_2 >$,

(1) if $S(\tilde{a}_1)<S(\tilde{a}_2)$, then $\tilde{a}_1$ is smaller than $\tilde{a}_2$, denoted by $\tilde{a}_1\prec\tilde{a}_2$;

(2) if $S(\tilde{a}_1)=S(\tilde{a}_2)$, then

- if $\phi(\tilde{a}_1)=\phi(\tilde{a}_2)$, then $\tilde{a}_1$ and $\tilde{a}_2$ represent the same information, denoted by $\tilde{a}_1=\tilde{a}_2$.
- if $\phi(\tilde{a}_1)<\phi(\tilde{a}_2)$, then $\tilde{a}_1$ is smaller than $\tilde{a}_2$, denoted by $\tilde{a}_1\prec\tilde{a}_2$.

Definition 6. Let $\tilde{a}_1 =< a_1,b_1 >$ and $\tilde{a}_2 =< a_2,b_2 >$ be two IFNs, two operations are defined as

$$\tilde{a}_1\oplus\tilde{a}_2 =< a_1+a_2-a_1a_2, b_1b_2 >,$$

$$\lambda\tilde{a}_1 =< 1-(1-a_1)^{\lambda}, b_1^{\lambda} >,\qquad \lambda>0.$$

To aggregate the intuitionistic fuzzy information, in what follows, the information fusion operator is defined.

Definition 7. Let $\{\tilde{a}_i =< a_i, b_i >\}$, $i = 1,2,\cdots,n$, be a collection of IFNs, the intuitionistic fuzzy weighted arithmetic aggregation operator of the IFNs is defined as

$$IFWAA_w(\tilde{a}_1, \tilde{a}_2, \cdots, \tilde{a}_n)^{w_i},$$
$$= \bigoplus_{i=1}^{n} w_i \tilde{a}_i =< 1 - \prod_{i=1}^{n}(1-a_i)^{w_i}, \prod_{i=1}^{n} b_i > \quad \textbf{(2)}$$

where $W = (w_1, w_2, \cdots, w_n)$ is the weight vector of $\tilde{a}_i$, $0 \le w_i \le 1$, $\sum_{i=1}^{n} w_i = 1$.

III. Warning And Decision-Making Mechanism for Uncertain Network Sentiment Emergency

We can regard the network public sentiment emergency urgent decision-making as a multi-attribute intuitionistic fuzzy decision problem.

Suppose the set of emergencies is the alternative set $E = \{e_1, e_2, \cdots, e_m\}$, and consider the network public sentiments as the attribute set $C = \{c_1, c_2, \cdots, c_n\}$.

As we know, in real-life network environment, each emergency is always influenced by all the sentiment attributes. Generally, the accurate value of each network public sentiment is difficult to measure in some cases. On the contrary, people can easily evaluate the uncertain attribute values of real-life field object by intuitionistic fuzzy language terms like *S* = {Very Strong, Strong, Medium, Weak, Very Weak} rather than accurate real numbers.

In order to simplify the treatment of judgments expression, a unified set of linguistic variables is predetermined in this paper, which can be used to every criteria from the satisfaction perspective as shown in Table 1.

TABLE I.

Linguistic terms for evaluating uncertain network sentiment emergency

Linguistic terms	IFNs
Extremly Strong (ES) / Extremly High(EH) / Extremly Important (EI)	<0.99, 0.01>
Very very strong (VVS) / Very very high(VVH) / Very very Important (VVI)	<0.9, 0.1>
Very Strong (VS) / Very high (VH) / Very Important (VI)	<0.8, 0.1>
Strong (S) / High (Q) / Important (I)	<0.7, 0.2>
Medium (M)	<0.5, 0.4>
Weak (W) / Low (L) / Unimportant (U)	<0.4, 0.5>
Very Weak (VW) / Very Low (VL) / Very unimportant (VU)	<0.3, 0.6>
Very very Weak(VVW) / Very very Low (VVL) /Very very unimportant (VVU)	<0.2, 0.8>
Extremly Weak (EW) / Extremly Low (EL) / Extremly unimportant (EU)	<0.01, 0.99>

Where each language term is assigned as an intuitionistic fuzzy values, for example, VS=<0.8, 0.1> represents the membership is 0.8 and non-membership is 0.1, indicating the degree of strength lies in interval [0.8, 0.9]. That is to say very strong.

On account of the different influence of each sentiment attribute on the emergency urgent decision, we should firstly determine the weight of each network sentiment attribute according to the corresponding network sentiment attribute values.

Moreover, we denote by l_{ij} the intuitionistic fuzzy language evaluation term of emergency $\boldsymbol{e_i}$ with respect to network public sentiment attribute c_j, where l_{ij} takes the above-mentioned intuitionistic fuzzy language values in the left column of Table 1. The evaluation decision matrix is expressed as $\tilde{R} = (l_{ij})_{m\times n}$.

Based on the above analysis and previous formulae, we give the following urgent decision making approach for the intuitionistic fuzzy network public sentiment emergency system.

Step 1. Let E be the set of alternative (emergencies), with multiple-attribute (semtiment) set C, We first translate the original intuitionistic fuzzy language evaluation matrix to intuitionistic fuzzy matrix $R = (r_{ij})_{m\times n}$, r_{ij} is one of the intuitionistic fuzzy values displayed in the right column of Table 1.

Step 2. We regard r_i as the intuitionistic fuzzy set with respect to all the network sentiment attributes, and it is expressed by intuitionistic fuzzy emergency $e_i = \{(c_j, r_{ij}) / c_j \in C\}$,

Compute the entropy of each intuitionistic fuzzy number of all the emergency $e_i (1 \le i \le m)$ and obtain the entropy decision matrix of emergencies. $D = (h_{ij})_{m\times n}$

Step 3. Normalized the IF entropy values in the decision matrix using the following equation:

$$\bar{h}_{ij} = \frac{h_{ij}}{\max_i h_{ij}}, \quad i = 1,2,\cdots,m; \; j = 1,2,\cdots,n. \quad (3)$$

And the normalized decision matrix is thus shown as $D = (\bar{h}_{ij})_{m\times n}$.

Step 4. Calculate the weights of network sentiment attribute by applying the following transformer.

$$w_j = \frac{1 - \sum_{i=1}^{m} \bar{h}_{ij}}{n - \sum_{j=1}^{n} \sum_{i=1}^{m} \bar{h}_{ij}}, \quad j = 1,2,\cdots,n. \quad (4)$$

Step 5. Calculate the intuitionistic fuzzy weighted arithmetic aggregate value $\tilde{\boldsymbol{e}}_i$ of each network emergency $\boldsymbol{e_i}$ ($1 \le i \le m$) by using the previous defined aggregation operator in Def 7.

Step 6. According to the method of comparing two intuitionistic fuzzy values in Proportion 1, we can rank all the network sentiment emergency, if $\tilde{e}_i \succ \tilde{e}_k$, then the uncertain event $\boldsymbol{e_i}$ is more critical than the event $\boldsymbol{e_k}$, then we must deal with emergency e_i earlier than e_k. if $\tilde{e}_i = \tilde{e}_k$, then the severity of event $\boldsymbol{e_i}$ is same as event $\boldsymbol{e_k}$, we can simultaneously deal with the two emergency e_i with the same solution.

By this decision procedure and approach, the urgent decision maker can deal with all the emergency more efficiently according to the warning degree or severity of each network public sentiment emergency.

IV. APPLICATION EXAMPLE

Recently, intuitionistic fuzzy sets, as an useful tool to deal with imperfect facts and data, as well as imprecise knowledge, have drawn the attention of many researchers in order to perform pattern recognition, decision making. And the applications of entropy and similarity measure to pattern recognition, image processing and medical diagnosis can be found in many literatures. In this section, we give a numeric example to illustrate the application of the proposed intuitionistic fuzzy information entropy and aggregation operator in uncertain network public sentiment emergency urgent decision-making [23, 24] problems.

Suppose m network sentiment emergencies $e_1, e_2, \cdots, e_m$ simultaneously happened in some area and each emergency is characterized by n sentiment criteria $\{c_1, c_2, \cdots, c_n\}$. Assume that the emergencies are normalized and simply denoted as

$$e_i = (<u_{i1}, f_{i1}>, <u_{i2}, f_{i2}>, \cdots, <u_{in}, f_{in}>), \quad \text{for } i = 1,2,\cdots,m.$$

In fact,

$$e_i = \{(c_j, <u_{e_i}(c_j), f_{e_i}(c_j)>) | c_j \in C\}$$
$$= \{(c_j, [u_{ij}, 1 - f_{ij}]) | c_j \in C\}$$

is an intuitionistic fuzzy set in the universe $C = \{c_1, c_2, \cdots, c_n\}$, for $i = 1,2,\cdots,m;\ j = 1,2,\cdots,n$. Here, C denotes the set of n sentiment attributes, and $u_{ij} = u_{e_i}(c_j)$, $f_{ij} = f_{e_i}(c_j)$ denote the true membership degree and the false membership degree that the i th emergency possesses the j th network sentiment attribute.

The emergency urgent decision-making problem is to decide which network emergency out of the m events $e_1, e_2, \cdots, e_m$ we must deal with firstly. And the main question is how to determine the sequence of the severity of all the emergencies. We can make final urgent decision according to the severity ranking of all the network sentiment emergency.

Example 1. Suppose there exist a set of network public sentiment emergencies $E = \{e_1, e_2, e_3, e_4\}$ in real world, which may be induced by many network public sentiments including $\boldsymbol{C}$ ={ importance of topic($\boldsymbol{c_1}$), tide of sentiment ($\boldsymbol{c_2}$), attention degree of topic ($\boldsymbol{c_3}$), popularity of topic($\boldsymbol{c_4}$), speed of spreading ($\boldsymbol{c_5}$)}, the intuitionistic fuzzy language values of all the existing emergencies are evaluated by related expertise and expressed by intuitionistic fuzzy linguistic terms listed in following Table 2.

TABLE II.

UNCERTAIN NETWORK SENTIMENT EMERGENCY DECISION SYSTEM WITH INTUITIONISTIC FUZZY LANGUAGE TERMS

Emergency	Importance of topic (c_1)	Ttide of sentiment (c_2)	Attention degree of topic (c_3)
$\boldsymbol{e_1}$	U	VS	VS
$\boldsymbol{e_2}$	VI	VW	M
$\boldsymbol{e_3}$	EI	VS	S
$\boldsymbol{e_4}$	VI	VS	VVW

Emergency	Popularity of topic (c_4)	Spreading speed of topic (c_5)
$\boldsymbol{e_1}$	W	VH
$\boldsymbol{e_2}$	ES	VVH
$\boldsymbol{e_3}$	VS	H
$\boldsymbol{e_4}$	S	L

Our main task is to determine the severity ranking of all the network emergency with intuitionistic fuzzy linguistic values. And then make final urgent decision to select the one emergency we should deal with first of all, out of the set of emergencies $\{e_1, e_2, \cdots, e_4\}$.

According to the previously mentioned decision method, we will employ the proposed intuitionistic fuzzy entropy measure to determine the weight of all the sentiment attribute of emergency and then make urgent decision for selecting the most severe emergency.

Now from the linguistic value table 1, we first translate each emergency $e_i (1 \le i \le 4)$ into the intuitionistic fuzzy set with respect to all the network public sentiments as follows.

$\boldsymbol{e_1} = \{(c_1, <0.4,0.5>), (c_2, <0.8,0.1>), (c_3, <0.8,0.1>), (c_4, <0.4,0.5>), (c_5, <0.8,0.1>)\}$;
$\boldsymbol{e_2} = \{(c_1, <0.8,0.1>), (c_2, <0.3,0.6>), (c_3, <0.5,0.4>), (c_4, <0.99,0.01>), (c_5, <0.9,0.1>)\}$;
$\boldsymbol{e_3} = \{(c_1, <0.99,0.01>), (c_2, <0.8,0.1>), (c_3, <0.7,0.2>), (c_4, <0.8,0.1>), (c_5, <0.7,0.2>)\}$;
$\boldsymbol{e_4} = \{(c_1, <0.8,0.1>), (c_2, <0.8,0.1>), (c_3, <0.2,0.8>), (c_4, <0.7,0.2>), (c_5, <0.4,0.5>)\}$.

And it is also expressed by the following intuitionistic fuzzy decision matrix.

$$R = (\tilde{r}_{ij})_{4\times5} =$$

$$\begin{pmatrix} <0.4,0.5> & <0.8,0.1> & <0.8,0.1> & <0.4,0.5> & <0.8,0.1> \\ <0.8,0.1> & <0.3,0.6> & <0.5,0.4> & <0.99,0.01> & <0.9,0.1> \\ <0.99,0.01> & <0.8,0.1> & <0.7,0.2> & <0.8,0.1> & <0.7,0.2> \\ <0.8,0.1> & <0.8,0.1> & <0.2,0.8> & <0.7,0.2> & <0.4,0.5> \end{pmatrix}.$$

By using the entropy formula (1) and taking $\lambda = 0.5$ for convenience, we compute the information entropy value of each intuitionistic fuzzy sentiment value of network emergency and get the following entropy matrix

$$D = (h_{ij})_{4\times5};$$

$$= \begin{pmatrix} 0.818 & 0.176 & 0.176 & 0.818 & 0.176 \\ 0.176 & 0.538 & 0.818 & 0.01 & 0.111 \\ 0.01 & 0.176 & 0.333 & 0.176 & 0.333 \\ 0.176 & 0.176, & 0.25 & 0.333 & 0.818 \end{pmatrix}$$

With formula (3), we transform the above entropy matrix to normalized entropy matrix below.

$$D = (\bar{h}_{ij})_{4\times5}$$

$$= \begin{pmatrix} 1.000 & 0.327 & 0.215 & 1.000 & 0.215 \\ 0.215 & 1.000 & 1.000 & 0.012 & 0.1357 \\ 0.012 & 0.327 & 0.407 & 0.215 & 0.407 \\ 0.215 & 0.327, & 0.3056 & 0.407 & 1.000 \end{pmatrix}$$

Then, by the following formula

$$w_j = \frac{1 - \sum_{i=1}^{4} \bar{h}_{ij}}{5 - \sum_{j=1}^{5} \sum_{i=1}^{4} \bar{h}_{ij}}, \quad j = 1,2,\cdots,5,$$

we compute the weight vector of all the sentiment attribute as W = (0.12 , 0.26,0.25,0.17,0.2).

Next, from the previous formulae (2), we calculate the intuitionistic fuzzy weighted arithmetic aggregation value $\tilde{\boldsymbol{e}}_{\boldsymbol{i}}$ of each uncertain network sentiment emergency $e_i (i = 1,2,3,4,5\}$, with sentiment attribute set $C = \{c_1, c_2, \cdots, c_5\}$, respectively, as follows.

$\tilde{e}_1 = IFWAA_W(\tilde{r}_{11}, \tilde{r}_{12}, \cdots, \tilde{r}_{15})$ = <0.725, 0.159>,
$\tilde{e}_2 = IFWAA_W(\tilde{r}_{21}, \tilde{r}_{22}, \cdots, \tilde{r}_{25})$ =<0.818, 0.152>,
$\tilde{e}_3 = IFWAA_W(\tilde{r}_{31}, \tilde{r}_{32}, \cdots, \tilde{r}_{35})$ =<0.832, 0.104>,
$\tilde{e}_4 = IFWAA_W(\tilde{r}_{41}, \tilde{r}_{42}, \cdots, \tilde{r}_{45})$ =<0.6225, 0.261>.

Also, according to formulae in Definition 4, 5 we compute the corresponding score and accuracy value of each network sentiment emergency, respectively, as follows:

$$S(\tilde{e}_1) = 0.566, \quad \phi(\tilde{e}_1) = 0.884;$$
$$S(\tilde{e}_2) = 0.666, \quad \phi(\tilde{e}_2) = 0.97;$$
$$S(\tilde{e}_3) = 0.728, \quad \phi(\tilde{e}_3) = 0.936;$$
$$S(\tilde{e}_4) = 0.3615, \quad \phi(\tilde{e}_4) = 0.8835;$$

Since $S(\tilde{e}_4) < S(\tilde{e}_1) < S(\tilde{e}_2) < S(\tilde{e}_3)$, from the method for comparing two intuitionistic fuzzy values we obtain that the severity ranking of all the emergencies is as follow:

$$\boldsymbol{e_4} \prec e_1 \prec \boldsymbol{e_2} \prec \boldsymbol{e_3}.$$

Thus, the emergency $\boldsymbol{e_3}$ has the greatest score value, so this event $\boldsymbol{e_3}$ is the best decision alternative. That is to say, e_3 is the most severe emergency in all the emergencies, the urgent decision maker must firstly deal with this emergency, next to cope with the secondary severe emergency e_2, then e_1, and so on.

V. CONCLUSION

We propose a new kind of intuitionistic fuzzy inform -ation entropy measure for intuitionistic fuzzy number, which can measure the uncertainty in an intuitionistic fuzzy event. By using the entropy decision matrix, we can determine the weight vector of each network sentiment attribute. And then by using intuitionistic fuzzy information aggregation operator of all the sentiment attribute value we can rank all the severity of emergencies and make optimal decision.

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