Index Selection Preference and Weighting for Uncertain Network Sentiment Emergency

Qiansheng Zhang[1], **Fuchun Liu**[2], **Bailin Xie**[3], **Yirong Huang**[*4]
[1,3]School of Informatics, Guangdong University of Foreign Studies, Guangzhou 510420, China
[2]Faculty of Computer, Guangdong University of Technology, Guangzhou 510006, China
[*4]Sun Yat-sen Business School, Sun Yat-sen University, Guangzhou 510275, China
*Corresponding author, e-mail: huangyr@mail.sysu.edu.cn

Abstract

To more effectively cope with the network public sentiment emergency involved many interval-valued warning indexes, we present a new method of early warning index selection and weight assignment for uncertain network public sentiment emergency decision-making. By using a new interval fuzzy AHP, the interval weight of each early warning index of network public sentiment emergency can be obtained. Then by means of the weighted aggregation values of all the emergency warning indexes, we can rank the severity of every network public sentiment emergency and select the most severe one. Finally, a numerical example is given to illustrate the application of the proposed method of warning index selecting and weighting to uncertain network public sentiment emergency decision.

Keywords*: Network public sentiment emergency, Warning index, Weight assignment, Preference relation*

1. 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 emergency. Simultaneously, emergency will affect network public sentiment. So, in order to decrease the risk of emergency management and decision [1, 2], there is much need to analyze and control the network public sentiment effectively. In the above areas, Zeng [3, 4] and Zhang [5] proposed the methods of selecting sentiment indexes and determining their weights for network sentiment emergency. Peng [6] and Zhang [7] discussed the close relationship between network public sentiment and emergency. Also some authors [8, 9] have proposed many early warning decision or alarm severity priority ordering methods for network emergency. However, the most existing related emergency decision methods and alarm severity ranking mechanics can only deal with the emergency under precise condition and certain environment. Although Lin [10] proposed a method for network sentiment early warning, it excessively depended on the selected fuzzy reasoning rules, and the weight of network sentiment index is not considered. Thus, this proposed approach is inconvenient in some cases and it can not deal with network sentiment emergency with interval linguistic terms. 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, like network public sentiment analysis and uncertain decision-making, are involved variety of fuzziness, like fuzzy value and interval value. Especially, in the process of uncertain network emergency decision making, a decision maker may provide his/her preferences over the alternate emergencies with interval numbers [11, 12] or interval linguistic values [13] rather than real numbers.

As we know, the unexpected emergency generally involves many public sentiment factors, including the importance of topic, the tide of sentiment, the attention degree of topic, and the popularity of topic, as well as the spreading speed of topic. Also, the values of above emergency influence factors are easily expressed by interval numbers. In this paper we aim to propose an effective method for determining the alarm severity priority ordering of the uncertain

network sentiment emergency, which can efficiently conduct the emergency urgent decision in the uncertain environment.

We first propose some basic operators between interval numbers in section 2. And in section 3, we introduce the alarm severity priority ordering process of network public sentiment emergency with interval linguistic value. In section 4, one numerous example is given to demonstrate the effectiveness of the proposed network sentiment emergency decision making approach by using the proposed interval fuzzy fusion operator and interval preference matrix.

Recently, many researchers studied the approaches of index analysis and weight assignment. For example, Kahraman et al. [14] employed fuzzy AHP in supplier selection and service quality evaluation, but the interval fuzzy index selection and weight assignment were not considered. In fact, most of the existing fuzzy index analysis methods cannot effectively determine the weights of interval fuzzy indexes. Thus, in this paper we try to propose a new effective approach for early warning index selection and weight assignment of network sentiment emergency with interval linguistic terms, and then deal with the network public sentiment emergency decision problem involved interval evaluation value in uncertain environment. To the end, it will greatly facilitate the network public sentiment emergency management adopting the corresponding decision strategy to cope with the most severe alternate network public sentiment emergency according to the severity ranking result of all the possible network public sentiment emergences.

2. Preliminaries

Interval valued fuzzy set (IvFS) is a useful generalization of the ordinary fuzzy set, which has been proved to be more suitable way for dealing with vagueness and uncertainty. Particularly, the information entropy [15], similarity measure and distance measure [16] of IvFSs play very important roles in the application areas of pattern recognition, medical diagnosis, and decision-making [12,17,18].

Definition 1. An interval fuzzy set A in the universe $X = \{x_1, x_2, \cdots, x_n\}$ is defined as $A = \{(x_i, A(x_i) = [A^-(x_i), A^+(x_i)] \subseteq [0,1] / x_i \in X\}$, where $A^-(x_i), A^+(x_i)$ are called membership degree and non-membership degree of element x_i to set A, respectively.

For simplicity, in this paper we call $\tilde{a} = [a^-, a^+]$ to be an interval number, if $0 \le a^- \le a^+ \le 1$.

Definition 2. Let $\tilde{a} = [a^-, a^+], \tilde{b} = [b^-, b^+]$ be two interval numbers, some basic operations between them are defined as follows.

$$\tilde{a} + \tilde{b} = [a^-, a^+] + [b^-, b^+] = [a^- + b^-, a^+ + b^+] \tag{1}$$

$$\tilde{a} \times \tilde{b} = [a^-, a^+] \times [b^-, b^+] = [a^- b^-, a^+ b^+]$$

$$w\tilde{a} = w[a^-, a^+] = [wa^-, wa^+], \text{ if } w > 0.$$

$$\tilde{a} / \tilde{b} = [a^-, a^+] / [b^-, b^+] = [a^- / b^+, a^+ / b^-], \text{ if } a^-, b^- > 0.$$

Definition 3. Let $C = \{c_1, c_2, \cdots, c_n\}$ be the early warning index set of network sentiment emergency, suppose $(g_{ij})_{n \times n}$ is the pair-wise comparison interval fuzzy preference relation matrix constructed by the knowledge of experts, where g_{ij} represents the interval preference degree of index c_i over index c_j, $g_{ji} = 1 / g_{ij}$. The interval weights of indexes can be given by following formula

$$w_i = \frac{(\prod_{j=1}^{n} g_{ij})^{1/n}}{\sum_{i=1}^{n} (\prod_{j=1}^{n} g_{ij})^{1/n}}, \qquad \text{for} \quad i, j = 1, 2, \cdots, n. \tag{2}$$

Definition 4. Let $\tilde{a} = [a^-, a^+]$, $\tilde{b} = [b^-, b^+]$ be any two interval numbers, the preference degree of $\tilde{a}$ over $\tilde{b}$ is defined as

$$P(\tilde{a} \geq \tilde{b}) = \max\{1 - \max\{\frac{b^+ - a^-}{(a^+ - a^-) + (b^+ - b^-)}, \quad 0\}, \quad 0\}, \tag{3}$$

Notably, $P(\tilde{a} \geq \tilde{b}) + P(\tilde{b} \geq \tilde{a}) = 1$, and $P(\tilde{a} \geq \tilde{a}) = 0.5$.

Definition 5. Let $\{\tilde{r}_i = [r_i^-, r_i^+] | 1 \leq i \leq n\}$ be an interval number sequence, by pair-wise comparison between interval numbers we construct the preference relation matrix $(P_{ij})_{n \times n}$, where $p_{ij} = P(\tilde{r}_i \geq \tilde{r}_j)$. The non-dominance degree of the i th interval number is defined as

$$NDD_i = \min_{j \neq i}\{1 - p_{ji}^*\}, \tag{4}$$

where $p_{ji}^* = \max\{p_{ji} - p_{ij}, 0\}$ represents the degree to which $\tilde{r}_i$ strictly dominated by $\tilde{r}_j$.

Definition 6. The full ranking of all the n interval numbers are determined by the ascending order of NDD_i, and the set of non-dominated alternate emergency is defined as

$$e^{ND} = \{e_i / NDD_i = \max_j\{NDD_j\}\}. \tag{5}$$

3. Early Warning Index Selection and Weight Assignment for Network Public Sentiment Emergency with Interval Values

As we know, many kinds of indexes probably incur network public sentiment emergency. Especially in the uncertain emergency decision environment, the accurate value of early warning index information is difficult to measure. However, by interval linguistic value, we can conveniently compare the preference degree between two emergency indexes and get the interval fuzzy preference relation on early warning index set. Through the interval fuzzy AHP analysis method, we can weight all the early warning indexes of network sentiment emergency.

Generally, by emergency management expert questionnaire survey and statistical analysis from network public sentiment emergency management we can easily get some important indexes which possibly cause the network public sentiment emergency. Also, through emergency supervisors and search engines, we can obtain much information of network public sentiment emergency warning indexes including subjective and objective indexes. For the sake of dealing with early warning and emergency decision making, we firstly choose the finite comprehensive and hierarchical indexes from all the possible alternate indexes based on the well-established principle that each index should possess independency, sensitivity, and representation, as well as guidance quality. Therefore, we need to select the relative important early warning index with higher scores. Generally, after index early warning analysis and selection, there are still multi-level warning indexes that should be taken into account. Usually, every network public sentiment emergency mainly comprises the following first-grade indexes: network public sentiment emergency power index, network sentiment intensity index and emergency coping capacity index.

Additionally, each first-grade early warning index also has many second-grade warning indexes. In general, network public sentiment emergency power index briefly consists of the following second-grade indexes, including time duration, extent of diffusion, environment disruption degree, severity of economic loss. And network sentiment intensity index briefly consists of the following second-grade indexes, including sentiment attention degree, spreading speed of network sentiment, emotion tendency, behavior tendency, authenticity of network public sentiment. The government emergency coping capacity briefly consists of the following second-grade indexes, including response speed, information transparency, emergency

evacuation capacity, emergency resource allocation capacity, government responsibility, people-centralized degree, etc.

Notably, in complex uncertain decision environment the above-mentioned network public sentiment emergency early warning indexes are difficult to measure by precise real numbers, instead, they are easily assessed by emergency managers and related field experts in terms of interval linguistic values, like strong emergency power, serious economic loss, severe environment disruption, enormous diffusion degree, wicked behavior liability, unreliable sentiment report, low response speed, weak emergency evacuation capacity, incomplete emergency rescue facility, and so on.

Moreover, the evaluation value of every alternate network public sentiment emergency with multiple early warning indexes are easily expressed by the interval fuzzy linguistic terms like extremely strong, very strong, strong, medium, weak, very weak, extremely weak rather than by using accurate real numbers. In order to simplify the treatment of judgment expression of network public sentiment warning index, a unified set of interval linguistic variables is predetermined in Table 1.

Table 1. Linguistic Terms for Evaluating Network Sentiment Emergency with Interval Index

Linguistic terms	Interval numbers
Extremely Strong (ES) / Extremely High(EH) / Extremely Big (EB)	[0.9, 1.0]
Very very strong (VVS) / Very very high(VVH) / Very very Big (VVB)	[0.8, 0.9]
Very Strong (VS) / Very high (VH) / Very Big (VB)	[0.7, 0.8]
Strong (S) / High (H) / Big (B)	[0.6, 0.7]
Medium (M)	[0.4, 0.6]
Weak (W) / Low (L) / Tiny(T)	[0.3, 0.4]
Very Weak (VW) / Very Low (VL) / Very tiny (VT)	[0.2, 0.3]
Very very Weak(VVW) / Very very Low (V VL) / Very very tiny (V VT)	[0.1, 0.2]
Extremely Weak (EW) / Extremely Low (EL) / Extremely tiny (ET)	[0.0, 0.1]

Based on the above analysis and the previous formulae, we aim to develop an interval fuzzy AHP approach to determine the rational weight of warning index and then make emergency decision for network public sentiment emergency involved interval linguistic values in uncertain environment.

Step 1. By statistical questionnaire and the scores assigned by emergency management experts, we first construct all the interval fuzzy preference relations over each warning index level. Let $\tilde{B}^{(1)} = (\tilde{b}_{ij}^{(1)})_{n \times n}$, $\tilde{B}^{(2k)} = (\tilde{b}_{ij}^{(2k)})_{m \times m}$ represent interval fuzzy preference matrixes of the first-grade emergency early warning indexes, and the second-grade indexes of first-grade index c_k, respectively, where $\tilde{b}_{ij}$ take some interval values listed in Table 2. Then, by interval fuzzy AHP method and formula (2) we can first assign the weight vector to each first-grade index level and to each second-grade index level. Ultimately, by using multiplication of the weights of all the warning indexes of top-level and its sub-level, we obtain the overall weight of each warning index regarding the network public sentiment emergency decision goal.

Table 2. Linguistic terms for Comparing the Importance Degree of Early Warning Indexes

Intensity of importance	Definition of grade	Interval degree
$\tilde{9}$	Extremely strong importance	[8,10]
$\tilde{7}$	Very strong importance	[6, 8]
$\tilde{5}$	Strong importance	[5,6]
$\tilde{3}$	Moderate importance	[2,4]
$\tilde{2}$	Fair importance	[1,3]
1.5	Just Equal importance	[1,2]
$\tilde{1}$	Equal importance	[1,1]

Step 2. By using the above-evaluated weight vector and formula (1), we can compute the interval weighted arithmetic aggregation value $\widetilde{e}_i$ of each potential network public sentiment emergency e_i.

Step 3. According to formulae (3)-(5), we rank all the possible network public sentiment emergencies. That is, if $NDD_i > NDD_k$, then the alternate network public sentiment emergency e_i is severe than the emergency e_k, then we must deal with emergency e_i earlier than e_k. if $\widetilde{e}_i = \widetilde{e}_k$, then the severity of emergency e_i is same as e_k, we can simultaneously deal with the two network public sentiment emergencies with the same emergency solution.

By the above emergency decision approach, the network public sentiment emergency management can cope with the emergency more efficiently according to the severity of every potential network public sentiment emergency. From the selected early warning indexes and the severity ranking of all the alternate network public sentiment emergencies, we can also design the decision mechanism and adopt the corresponding emergency response or decision strategy to decrease the possible losses of network public sentiment emergency.

4. Application Example

In uncertain setting, the network sentiment emergency management experts usually use the linguistic value to evaluate the importance of the index and to rate the alternatives involved various warning indexes. Most of the existing emergency decision methods have only precise values for the performance ratings and the index weighting. Therefore, in order to select the most severe one from a number of possible network sentiment emergencies with different interval indexes, we will develop an interval fuzzy AHP to determine the priority of different early warning indexes, and then choose the most severe network sentiment emergency for network public sentiment emergency management.

Example 1. Suppose the network sentiment emergency management departments acquire much information of uncertain early warning indexes for some potential network sentiment emergencies by employing supervisor control platforms or search engines, and they need to evaluate the severity of all the possible city emergencies, then make final emergency decision making. Now assume there exist multiple alternate network sentiment emergencies E =$\{e_1, e_2, e_3, e_4\}$, which may possesses many uncertain early warning indexes. By the aid of statistical questionnaire from emergency decision experts and through our established principle of early warning index selection, here we choose three first-grade warning indexes including network public sentiment emergency power index (c_1), government emergency coping capacity(c_2) and network sentiment intensity index (c_3). Moreover, in first-grade warning index level c_1 we select the following second-grade indexes: severity of economic loss(c_{11}), extent of diffusion(c_{12}) and time duration(c_{13}). And in first-grade warning index level c_2 we also select the following second-grade indexes including response speed(c_{21}), network sentiment information transparency(c_{22}). Also, in the network sentiment intensity index c_3 we choose the following sub-indexes: sentiment attention degree(c_{31}), emotional liability of network sentiment (c_{32}), and authenticity of network sentiment(c_{33}).

Moreover, by emergency experts comparing each pair of warning indexes, we can easily get the interval fuzzy preference matrix over each warning index level as shown in Tables 3. Also, the evaluated values of all the alternate network sentiment emergencies with respect to the uncertain warning indexes are given by related expertise as shown in the following Table 4. Our next task is to determine the severity ranking of all the potential network sentiment emergencies involved interval linguistic terms. Ultimately, we make final urgent decision to select the most severe one we must deal with first of all out of all the alternate network public sentiment emergencies.

Table 3. Interval Fuzzy Preference Relation over Network Sentiment Emergency Index Levels

	C1	C2	C3	C11	C12	C13	C21	C22	C31	C32	C33
C1	[1,1]	[2,4]	[4,6]								
C2	[1/4,1/2]	[1,1]	[1/8,1/6]								
C3	[1/6,1/4]	[6,8]	[1,1]								
C11				[1,1]	[4,6]	[6,8]					
C12				[1/6,1/4]	[1,1]	[1/4,1/2]					
C13				[1/8,1/6]	[2,4]	[1,1]					
C21							[1,1]	[2,4]			
C22							[1/4,1/2]	[1,1]			
C31									[1,1]	[4,6]	[2,4]
C32									[1/6,1/4]	[1,1]	[1/8.1/6]
C33									[1/4,1/2]	[6,8]	[1,1]

Table 4. Network Sentiment Emergency Decision System with Interval Linguistic Terms

Emergency	C11	C12	C13	C21	C22	C31	C32	C33
e_1	VT	B	V S	V VH	H	M	B	S
e_2	EB	VB	VW	H	V VL	S	T	W
e_3	VB	T	M	VH	V VH	W	VT	VVW
e_4	T	B	V S	V VH	H	V VW	M	VS

First, from the pair-wise comparison preference matrix of the first-grade indexes and second-grade indexes in Table 3, by employing interval fuzzy AHP and formula (2) we can compute the weight vector and priority of each early warning index level as listed in Table 5.

Table 5. The Priority Weights in the Network Sentiment Emergency Warning Index Levels

	Weight of top index	Weight of sub-index	Overall weight of sub-index
Index 1	[0.4366,0.8701]		
Sub-index 11		[0.576,0.9412]	[0.2515,0.8189]
Sub-index 12		[0.0692,0.1295]	[0.0302,0.1127]
Sub-index 13		[0.1258, 0.2263]	[0.0549, 0.1969]
Index 2	[0.0688, 0.1318]		
Sub-index 21		[0.5224,1.0448]	[0.0359, 0.1377]
Sub-index 22		[0.1847,0.3694]	[0.0127, 0.0487]
Index 3	[0.2183, 0.3801]		
Sub-index 31		[0.4151, 0.8434]	[0.0906, 0.3206]
Sub-index 32		[0.0571, 0.1014]	[0.0125, 0.0385]
Sub-index 33		[0.2376, 0.4642]	[0.0519, 0.1764]

From Table 5, we see that the weights w_{22} =[0.0127, 0.0487], w_{32} =[0.0125, 0.0385] are very small, so the two warning sub-indexes c_{22}, c_{32} can be omitted. Now we only select the six warning index $\{c_{11}, c_{12}, c_{13}, c_{21}, c_{31}, c_{33}\}$, which are viewed as the six criteria $\{r_1, r_2, \cdots, r_6\}$ of the network public sentiment emergency decision problem.

From linguistic term Table 1, we translate Table 4 regarding the selected six warning indexes into the following interval fuzzy decision matrix $D = (\tilde{r}_{ij})_{4\times6}$,

$$D = (\tilde{r}_{ij})_{4\times6} = \begin{pmatrix} [0.2,0.3] & [0.6,0.7] & [0.7,0.8] & [0.8,0.9] & [0.4,0.6] & [0.6,0.7] \\ [0.9,1.0] & [0.7,0.8] & [0.2,0.3] & [0.6,0.7] & [0.6,0.7] & [0.3,0.4] \\ [0.7,0.8] & [0.3,0.4] & [0.4,0.6] & [0.7,0.8] & [0.3,0.4] & [0.1,0.2] \\ [0.3,0.4] & [0.6,0.7] & [0.7,0.8] & [0.8,0.9] & [0.1,0.2] & [0.7,0.8] \end{pmatrix},$$

$\tilde{r}_{ij}$ is the interval membership degree of network sentiment emergency e_i with respect to j-th index considered.

From Table 5 we know that the weight vector of all the selected six warning sub-indexes is W =([0.2515, 0.8189], [0.0302, 0.1127], [0.0549, 0.1969], [0.0359, 0.1377], [0.0906, 0.3206], [0.0519,0.1764]).

And by formula (1) we calculate the interval weighted arithmetic aggregation value $\tilde{e}_i$ of each network public sentiment emergency e_i as below.

$$\tilde{e}_1 = \sum_{j=1}^{6} \tilde{w}_j \tilde{r}_{1j} = [0.2029, 0.9218]; \qquad \tilde{e}_2 = \sum_{j=1}^{6} w_j \tilde{r}_{2j} = [0.3499, 1.3595];$$

$$\tilde{e}_3 = \sum_{j=1}^{6} w_j \tilde{r}_{3j} = [0.2646, 1.092]; \qquad \tilde{e}_4 = \sum_{j=1}^{6} w_j \tilde{r}_{4j} = [0.2061, 0.8931].$$

Also, according to formula (3) we compute the interval preference degrees between any two fuzzy numbers as follows:

$P(\tilde{e}_1 \geq \tilde{e}_2) = 0.3309, \quad P(\tilde{e}_1 \geq \tilde{e}_3) = 0.425, \quad P(\tilde{e}_1 \geq \tilde{e}_4) = 0.5091,$

$P(\tilde{e}_2 \geq \tilde{e}_3) = 0.596, \quad P(\tilde{e}_2 \geq \tilde{e}_4) = 0.6798, \quad P(\tilde{e}_3 \geq \tilde{e}_4) = 0.585.$

And we then construct the following interval possibility matrix P, where $p_{ij} = P(\tilde{e}_i \geq \tilde{e}_j)$,

$$P = (p_{ij})_{4\times4} = \begin{pmatrix} 0.5000 & 0.3309 & 0.425 & 0.5091 \\ 0.6691 & 0.5000 & 0.596 & 0.6798 \\ 0.5750 & 0.4040 & 0.500 & 0.5850 \\ 0.4909 & 0.3202 & 0.415 & 0.5000 \end{pmatrix}.$$

By using formulae (4), (5) we can calculate the non-dominance degree of each network sentiment emergency $\tilde{e}_i$ as follows.

$NDD_1 = \min_{j\neq1}\{1 - p_{j1}^* \mid 1 \leq j \leq 4\} = 0.6618,$

$NDD_2 = \min_{j\neq2}\{1 - p_{j2}^* \mid 1 \leq j \leq 4\} = 1,$

$NDD_3 = \min_{j\neq3}\{1 - p_{j3}^* \mid 1 \leq j \leq 4\} = 0.808,$

$NDD_4 = \min_{j\neq4}\{1 - p_{j4}^* \mid 1 \leq j \leq 4\} = 0.6404.$

Since $NDD_2 = \max_j \{NDD_j\}$, $e^{ND} = \{e_2\}$, that is to say, $\boldsymbol{e_2}$ is the most severe emergency.

And due to that $NDD_2 > NDD_3 > NDD_1 > NDD_4$, we obtain that the severity ranking of all the alternate network public sentiment emergencies is as

$$e_4 \prec e_1 \prec e_3 \prec e_2.$$

Thus, the network sentiment emergency e_2 is the optimal decision alternative. That is to say, e_2 is the most severe network sentiment emergency in all the possible network sentiment emergencies, the network sentiment emergency management decision-maker must firstly deal with this network sentiment emergency, next to cope with the secondary severe emergency e_3, then e_1, and so e_4. The related network sentiment emergency management will raise the corresponding early warning and take urgent decision mechanism to coordinate all kinds of emergency facilities among different municipal zones and districts to avoid or decrease the risk loss of the unexpected network sentiment significant emergency before implementing some emergency response.

5. Conclusion
In this paper, we employ an interval fuzzy AHP method to assign the rational weights of selected early warning indexes for network public sentiment emergency. And then by using interval weighted aggregation operator of all the warning index value we can rank all the severity of network public sentiment emergencies and make emergency decision to select the most severe network public sentiment emergency, which can help the related network public sentiment emergency management department take the corresponding emergency strategy and mechanism in accord with the obtained severity ranking result of the network public sentiment emergency with interval linguistic values.

References
[1] Ashley WL, Morrison JL. Anticipatory management: Tools for better decision making. *The futurist.* 1997; 31: 47-50.
[2] Morrison JL, Wilson I. Analyzing environments and developing scenarios for uncertain times. In: Planning and management for a changing environment, San Francisco, 1997.
[3] Zeng RX, Xu XL. The early warning system, index and mechanism of network public sentiment emergency. *Journal of Informatics.* 2009; 11: 52-55.
[4] Zeng RX. The construction of early warning index of network public sentiment. *Informatics Theory and Practice.* 2010; 33: 77-80.
[5] Zhang WP. Study on the index selecting and weight evaluation for emergency early warning. *Journal of Chinese People's Public Security University.* 2008; 6: 80-89.
[6] Peng ZH. Discussion on population emergency and network public sentiment. *Journal of Shanghai Public Security College.* 2008; 1: 46-50.

[7]   Zhang YW, Qi YJ. The interaction mechanism between network public sentiment and abnormal emergency. *Journal of Informatics.* 2010; 9: 1-6.

[8]   Wu SZ, Li SH. The study of mechanism for network public sentiment early warning, Journal of Chinese People's Public Security University, 2008; 3: 38-42.

[9]   Zhang LL. The investigation on the model of emergency network public sentiment early warning. *Journal of Library and Information Service.* 2010; 11: 135-138.

[10] Lin C, Li BC, Wang J. The method of network public sentiment early warning based on fuzzy reasoning. *Journal of Information and Engineering University.* 2011; 12: 72-76.

[11] Zeng W, Luo C. Comprehensive decision model of interval-number. *Journal of Theory and Practice of System Engineering.* 1997; 17(11): 48-50.

[12] Zhang JJ, Wu DS. The method of grey related analysis to multiple attribute decision problems with interval numbers. *Mathematical and Computer Modelling.* 2005; 42: 991-998.

[13] Rodriguez RM, Martinez L, Herrera F. Hesitant fuzzy linguistic term sets for decision making, IEEE Transactions on Fuzzy Systems, 2012; 20(1): 109-119.

[14] Kahraman G, Cebeci U, Ulukan Z. Multi-criteria supplier selection using fuzzy AHP. *Logistics Information Management.* 2003; 16(6): 382-394.

[15] Burillo P, Bustince H. Entropy on intuitionistic fuzzy sets and on interval-valued fuzzy sets. *Fuzzy Sets and Systems.* 1996; 78: 305-316.

[16] Grzegorzewski P. Distances between intuitionistic fuzzy sets and/or interval-valued fuzzy sets based on Hausdorff metric. *Fuzzy Sets and Systems.* 2004; 148: 319-328.

[17] Patricia M, Victor H, Danniela R, Fevrier V, Oscar C. Genetic Optimization of Neural Networks for Person Recognition Based on the Iris. *TELKOMNIKA.* 2012; 10(2): 309-320.

[18] Nasution H, Jamaluddin H, Syeriff JM. Energy Analysis for Air Conditioning System Using Fuzzy Logic Controller. *TELKOMNIKA.* 2011; 9(1):139-150.