Middle-East Journal of Scientific Research 23 (9): 2251-2255, 2015
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2015.23.09.22711

A Decision Making Mechanism During Disaster Event Monitoring and Control

[1]T.K. Das, [2]Arati Mohapatro and [3]Sunitha Abburu

[1]School of Information Technology & Engineering, VIT University, Vellore, India
[2]Department of Computer Science, Bangalore City College, Bangalore, India
[3]Department of Computer Applications, Adhiyamaan College of Engineering, Hosur, India

Abstract: In this paper, a novel approach is being presented for handling man made disaster resulting out of propagating sensitive information and rumor. Our approach is based on intuitionistic fuzzy sets, which well handle uncertainty aspects of the underlying data. Furthermore, the technique of the rough set with intuitionistic fuzzy value is being used for measuring the wider public sentiments and also prioritizing the decision making strategy. Generally, the public sentiments are linguistic and highly uncertain in nature. In order to cope this, rough set technique with intuitionistic fuzzy approximation space has been employed. This has been illustrated by the help of an empirical study. This study would be useful in managing the impending disaster proactively.

Key words: Intuitionistic Fuzzy Set · Rough Set · Public Sentiment · Sentiment Severity

INTRODUCTION

Public sentiment and opinion have always been a sought-after study for most of the types of analysis, whether Government organization or corporate or business establishments. Hence sentiment analysis and opinion mining has become very popular research issue. It is well known that uncontrolled negative sentiment any time triggers an event which leads to social unrest. It can go a long way in damaging the societal structure even leading to violence and hence economic and financial turmoil. In order to avoid the abrupt events to cause damage, there is a need of disaster control measure like calculating the risk factor and urgent decision making mechanism. However, it is very important to keep the eye and ear open so that public sentiment analysis and decision making could be done at the right time in an effective manner. Though sentiment analysis is a technique to evaluate the sentiment polarity of the public towards a product or a service, but this process only determines the sentiment orientation like positive, negative or neutral [1]. However, the intensity level of sentiments is very hard to determine [2].

So, in order to avoid or decrease the risk of emergency and to make urgent decision [3], there is immediate need to analyze and control the network public sentiment effectively. Some of the work has been carried out by Zeng and Xu [4], Zeng [5] and Zhang [6] in this area. Their work relates to methods of selecting sentiment indexes and determining their weights for network sentiment emergency. Peng [7], Zhang and Qi [8] discussed the close relationship between network public sentiment and emergency. Also few works [9, 10] have been proposed related to early warning decision methods for network emergency. Most of these early warning mechanisms and hence decision making can deal with situation under certain and precise conditions. But due to the lack of knowledge of the problem domain, disaster activities are involved with various uncertain factors. So, in this research a fuzzy risk factor is being considered for prioritizing and addressing the events.

Intuitionistic fuzzy set proposed by Atanasov [11] has been found useful in dealing with imperfectly defined facts and data and also for vague and imprecise knowledge. It is the generalization of ordinary fuzzy set of Zadeh [12] and has been applied extensively in decision making, pattern recognition and diagnosis problems.

The rest of the paper is organized as follows. In section II, concept of intuitionistic fuzzy set is presented. Also we have recalled definition of Rough set in this section. The strength of Rough set lies in approximating a target set by calculating its lower and

Corresponding Author: T.K. Das, School of Information Technology & Engineering, VIT University, Vellore, India.

upper approximation. Furthermore lower and upper approximation has been generalized in intuitionistic fuzzy approximation space. In section III, various types of disasters has been discussed. In section IV, an empirical study of disaster monitoring and decision making has been clearly explained by the help of a real-life example. The paper is concluded in section V.

Preliminaries: In this section we would like to bring back the definitions of basic rough set theory developed by Pawlak [13]. Let U be a finite nonempty set called the universe. Suppose $R \subseteq (U \times U)$ is an equivalence relation on U. The equivalence relation R partitions the set U into disjoint subsets. Elements of same equivalence class are said to be indistinguishable. Equivalence classes induced by R are called elementary concepts. Every union of elementary concepts is called a definable set. The empty set is considered to be a definable set, thus all the definable sets form a Boolean algebra and (U, R) is called an approximation space. Given a target set X, we can characterize X by a pair of lower and upper approximations. We associate two subsets $\underline{R}X$ and $\overline{R}X$ called the R-lower and R-upper approximations of X respectively and are given by

$$\underline{R}X = \cup\{Y \in U/R : Y \subseteq X\}$$
$$\overline{R}X = \cup\{Y \in U/R : Y \cap X \neq \phi\}$$

The R-boundary of X, $BN_R(X)$ is given by $BN_R(X) = \overline{R}X - \underline{R}X$. We say X is rough with respect to R if and only if $\overline{R}X \neq \underline{R}X$, equivalently $BN_R(X) \neq \phi$. X is said to be R- definable if and only if $\overline{R}X = \underline{R}X$ or $BN_R(X) = \phi$. So, a set is rough with respect to R if and only if it is not R-definable.

In fuzzy set theory it is taken into consideration that there exist a membership value for all the elements of the set and we do not consider non membership values of the elements of the set. However, it is not true in many real life problems due to the presence of hesitation. In fuzzy set theory, if $\mu(x)$ be the degree of membership of an element x, then the degree of non membership of x is calculated using mathematical formula $1-\mu(x)$ with the assumption that full part of the degree of membership is determinism and in-deterministic part is zero. This is not always applicable in real life and hence intuitionistic fuzzy set theory is better. At the same time, intuitionistic fuzzy set theory reduces to fuzzy set theory if in-deterministic part is zero. It indicates that intuitionistic fuzzy set model is a generalized model over fuzzy set model. Therefore, intuitionistic fuzzy rough set on two universal sets is a better model than fuzzy rough set on two universal sets. Now, we present the definitions, notations and results of intuitionistic fuzzy rough set on two universal sets as established and introduced by Acharjya and Tripathy [14]. We define the basic concepts leading to intuitionistic fuzzy rough set on two universal sets in which we denote μ for membership and ν for non membership functions that are associated with an intuitionistic fuzzy rough set on two universal sets.

Definition 1 [11]: Let U be a universe of discourse and x is a particular element of U. An intuitionistic fuzzy set X of U is defined as $\langle x, \mu_X(x), \nu_X(x) \rangle$, where the function $\mu_X(x): U \to [0,1]$ and $\nu_X(x): U \to [0,1]$ define the degree of membership and non membership respectively of the element $x \in U$. For every element $x \in U$, $0 \le \mu_X(x) + \nu_X(x) \le 1$. The amount $\pi(x) = 1 - (\mu_X(x) + \nu_X(x))$ is called the hesitation part, which may cater either membership value or non membership value or the both. For simplicity we will use (μ_X, ν_X) to denote the intuitionistic fuzzy set X. The family of all intuitionistic fuzzy subsets of U is denoted by $IF(U)$. The complement of an intuitionistic fuzzy set X is denoted by

$$X' = \{< x, \nu_X(x), \mu_X(x) > | \, x \in U\}$$

Definition 2 [11]: Let U and V be two non empty universal sets. An intuitionistic fuzzy relation R_{IF} from $U \to V$ is an intuitionistic fuzzy set of $(U \times V)$ characterized by the membership function $\mu_{R_{IF}}$ and non-membership function $\nu_{R_{IF}}$

where $R_{IF} = \{\langle (x,y), \mu_{R_{IF}}(x,y), \nu_{R_{IF}}(x,y) \rangle \mid x \in U, y \in V\}$ with $0 \le \mu_{R_{IF}}(x,y) + \nu_{R_{IF}}(x,y) \le 1$ for every $(x,y) \in U \times V$.

Definition 3 [14]: Let U and V be two non empty universal sets and R_{IF} is a intuitionistic fuzzy relation from U to V. If for $x \in U$ $\mu_{R_{IF}}(x,y) = 0$ and $\nu_{R_{IF}}(x,y) = 1$ for all $y \in V$, then x is said to be a solitary element with respect to R_{IF}. The set of all solitary elements with respect to the relation R_{IF} is called the solitary set S. That is,

$$S = \{x \mid x \in U, \; \mu_{R_{IF}}(x,y) = 0, \; \nu_{R_{IF}}(x,y) = 1 \;\; \forall \;\; y \in V\}$$

Definition 4 [15]: Let U and V be two non empty universal sets and R_{IF} is a intuitionistic fuzzy relation from U to V. Therefore, (U, V, R_{IF}) is called a intuitionistic fuzzy approximation space. For $Y \in IF(V)$, an intuitionistic fuzzy rough set is a pair $(\underline{R_{IF}}Y, \overline{R_{IF}}Y)$ of intuitionistic fuzzy set on U such that for every $x \in U$

$$\underline{R_{IF}}Y = \{\langle x, \mu_{\underline{R_{IF}}(Y)}(x), \nu_{\underline{R_{IF}}(Y)}(x)\rangle \mid x \in U\}$$
$$\overline{R_{IF}}Y = \{\langle x, \mu_{\overline{R_{IF}}(Y)}(x), \nu_{\overline{R_{IF}}(Y)}(x)\rangle \mid x \in U\}$$

where

$$\mu_{\underline{R_{IF}}(Y)}(x) = \wedge_{y \in V}[\nu_{R_{IF}}(x,y) \vee \mu_Y(y)]$$
$$\nu_{\underline{R_{IF}}(Y)}(x) = \vee_{y \in V}[\mu_{R_{IF}}(x,y) \wedge \nu_Y(y)]$$
$$\mu_{\overline{R_{IF}}(Y)}(x) = \vee_{y \in V}[\mu_{R_{IF}}(x,y) \wedge \mu_Y(y)] \text{ and}$$
$$\nu_{\overline{R_{IF}}(Y)}(x) = \wedge_{y \in V}[\nu_{R_{IF}}(x,y) \vee \nu_Y(y)]$$

The pair $(\underline{R_{IF}}Y, \overline{R_{IF}}Y)$ is called the intuitionistic fuzzy rough set of Y with respect to (U, V, R_{IF}), where $\underline{R_{IF}}$ and $\overline{R_{IF}}$ are referred as lower and upper intuitionistic fuzzy rough approximation operators on two universal sets.

Disaster Management: Most of the crucial decisions are taken when a crisis occurs. However, a decision can be taken proactively by monitoring disaster event as it provides basic information for many decisions in today's social life. Although some of the disaster cannot be avoided, but the disaster recovery strategies of countries make a country a safe haven for financial investment plans of investors or the level of the tourism activities or. A disaster can be defined as an unforeseen event that causes great damage, destruction and human suffering, evolved from a natural or man-made event that negatively affects life, property, livelihood or industry [16]. A disaster is the start of a crisis and often results in permanent changes to human societies, ecosystems and the environment.

Based on the experts' observations [16, 17], a disaster can be classified as i) natural disasters or ii) man-made disasters

The natural disasters can also be grouped mainly based on the root cause as

- Hydro-meteorological disasters (floods, storms, droughts)
- Geophysical disasters (earthquakes, tsunamis, volcanic eruptions)
- Biological disasters (epidemics and insect infestations)

Man-made disasters often caused by unintended incidents or willful events Man-made disasters have an element of human intent or negligence. However, some of those events can also occur as the result of a natural disaster. Man-made circumstances and disasters can be contrasted in a manner similar to the natural risks and events. The following classifications are the result of the basic man-made risk factors or disaster events:

Unintended Events:

- Industrial accidents (chemical spills, collapses of industrial Infrastructures)
- Transport or telecommunication accidents (by air, rail, road or water means of transport)
- Economic crises (growth collapse, hyperinflation and financial crisis)
- Willful events (violence, terrorism, civil strife, riots and war).

Empirical Study: In order to explain the criteria of decision making at the time of a crisis, this section discusses the methodology of calculating the severity of multiple events that constitutes the said crisis. Suppose a government department is going to announce a major policy for the tribal involved in unsocial activities in a particular region. In connection to this, a news is appeared in a local newspaper and this news has been spreading in the social media The government is closely monitoring this event and they are in the process of calculating risk factors out of the situation arising from the origin of the news. They are keen in quantifying the public sentiments by measuring the level of damage has been incurred in order to restore law and order situation.

The public sentiments are being expressed as in the form of events $E = \{e_1, e_2, e_3, e_4, e_5\}$. The various characteristics of news are being expressed as Y= {importance of topic (y_1), consideration level of news (y_2), popularity of news (y_3), covering of news (y_4)}. Linguistic terms in public sentiment and their associated intuitionistic fuzzy values are represented in Table 1.

Let events e_1, e_2, e_3, e_4, e_5 denotes VL, L, M,U and VU respectively. Taking the example for importance of topic (y_1), if 30% people select "VL" and 60% select "not VL"; for consideration level of news (y_2), if 80% select "VL" and 10% select "not VL"; for popularity of news (y_3), if 90% select "VL" and 10% select "not VL"; for covering of news (y_4), if 80% select "VL" and 10% select "not VL", then for event "VL", the vector can be obtained as (0.3,.6; 0.8,0.1; 0.9,0.1; 0.8, 0.1)

Similarly based on the values of events (e_1, e_2, e_3, e_4, e_5) for different parameters (y_1, y_2, y_3, y_4), the intuitionistic fuzzy relation is presented by the following matrix

Table 1: Linguistic Terms for predicting the public sentiment

Linguistic Terms	IFVs
Very strong/very high/very important/	
Very likely occur (VL)	<0.9,0.1>
Strong//High/Important/Likely occur(L)	<0.7, 0.2>
Medium occur(M)	<0.5, 0.4>
Weak/Low/Not important/Unlikely occur (U)	<0.3,0.6>
Very weak / Very Low/Rarely occur (VU)	<0.2,0.7>

$$R_{IF} = \begin{array}{c} \\ e_1 \\ e_2 \\ e_3 \\ e_4 \\ e_5 \end{array} \begin{array}{cccc} y_1 & y_2 & y_3 & y_4 \\ 0.3, 0.6 & 0.8,0.1 & 0.9,0.1 & 0.8,0.1 \\ 0.7,0.2 & 0.3,0.5 & 0.7,0.3 & 0.8,0.2 \\ 0.6,0.2 & 0.5,0.2 & 0.6,0.3 & 0.2,0.8 \\ 0.4,0.5 & 0.9,0.1 & 0.8,0.1 & 0.6,0.3 \\ 0.8,0.1 & 0.8,0.2 & 0.7,0.2 & 0.4,0.5 \end{array}$$

It is assumed that there are categories of customers, where right weights for each criterion in are

$$Y = (<0.3,0.6>, <0.5,0.4>, <0.9,0.1>, <0.7,0.2>)$$

Using upper approximation, we have

$$\mu_{\overline{R_{IF}}(Y)}(e_1) = \vee_{y\in V}[\mu_{R_{IF}}(e_1, y) \wedge \mu_{Y_1}(y)]$$
$$= [0.3 \wedge 0.3] \vee [0.8 \wedge 0.5] \vee [0.9 \wedge 0.9] \vee [0.8 \wedge 0.7]$$
$$= 0.3 \vee 0.5 \vee 0.9 \vee 0.7$$
$$= 0.9$$

$$\nu_{\overline{R_{IF}}(Y)}(e_1) = \wedge_{y\in V}[\nu_{R_{IF}}(e_1, y) \vee \nu_{Y_1}(y)]$$
$$= [0.6 \vee 0.6] \wedge [0.1 \vee 0.4] \wedge [0.1 \vee 0.1] \wedge [0.1 \vee 0.2]$$
$$= 0.6 \wedge 0.4 \wedge 0.1 \wedge 0.2$$
$$= 0.1$$

$$\mu_{\overline{R_{IF}}(Y)}(e_2) = \vee_{y\in V}[\mu_{R_{IF}}(e_2, y) \wedge \mu_{Y_1}(y)]$$
$$= [0.7 \wedge 0.3] \vee [0.3 \wedge 0.5] \vee [0.7 \wedge 0.9] \vee [0.8 \wedge 0.7]$$
$$= 0.3 \vee 0.3 \vee 0.7 \vee 0.7$$
$$= 0.7$$

$$\nu_{\overline{R_{IF}}(Y)}(e_2) = \wedge_{y\in V}[\nu_{R_{IF}}(e_2, y) \vee \nu_{Y_1}(y)]$$
$$= [0.2 \vee 0.6] \wedge [0.5 \vee 0.4] \wedge [0.3 \vee 0.1] \wedge [0.2 \vee 0.2]$$
$$= 0.6 \wedge 0.5 \wedge 0.3 \wedge 0.2$$
$$= 0.2$$

$$\mu_{\overline{R_{IF}}(Y)}(e_3) = \vee_{y\in V}[\mu_{R_{IF}}(e_3, y) \wedge \mu_{Y_1}(y)]$$
$$= [0.6 \wedge 0.3] \vee [0.5 \wedge 0.5] \vee [0.6 \wedge 0.9] \vee [0.2 \wedge 0.7]$$
$$= 0.3 \vee 0.5 \vee 0.6 \vee 0.2$$
$$= 0.6$$

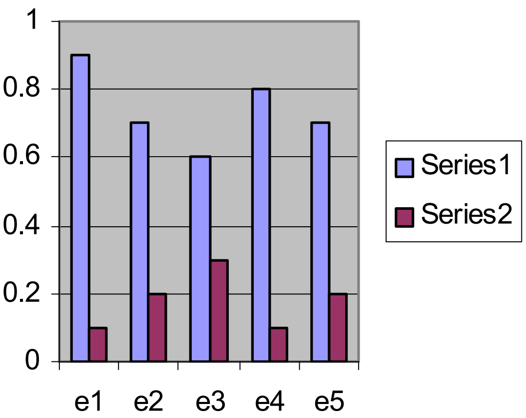

Fig. 1: Decision criteria of the events

$$\nu_{\overline{R_{IF}}(Y)}(e_3) = \wedge_{y\in V}[\nu_{R_{IF}}(e_3, y) \vee \nu_{Y_1}(y)]$$
$$= [0.2 \vee 0.6] \wedge [0.2 \vee 0.4] \wedge [0.3 \vee 0.1] \wedge [0.8 \vee 0.2]$$
$$= 0.6 \wedge 0.4 \wedge 0.3 \wedge 0.8$$
$$= 0.3$$

$$\mu_{\overline{R_{IF}}(Y)}(e_4) = \vee_{y\in V}[\mu_{R_{IF}}(e_4, y) \wedge \mu_{Y_1}(y)]$$
$$= [0.4 \wedge 0.3] \vee [0.9 \wedge 0.5] \vee [0.8 \wedge 0.9] \vee [0.6 \wedge 0.7]$$
$$= 0.3 \vee 0.5 \vee 0.8 \vee 0.6$$
$$= 0.8$$

$$\nu_{\overline{R_{IF}}(Y)}(e_4) = \wedge_{y\in V}[\nu_{R_{IF}}(e_4, y) \vee \nu_{Y_1}(y)]$$
$$= [0.5 \vee 0.6] \wedge [0.1 \vee 0.4] \wedge [0.1 \vee 0.1] \wedge [0.3 \vee 0.2]$$
$$= 0.6 \wedge 0.4 \wedge 0.1 \wedge 0.3$$
$$= 0.1$$

$$\mu_{\overline{R_{IF}}(Y)}(e_5) = \vee_{y\in V}[\mu_{R_{IF}}(e_5, y) \wedge \mu_{Y_1}(y)]$$
$$= [0.8 \wedge 0.3] \vee [0.8 \wedge 0.5] \vee [0.7 \wedge 0.9] \vee [0.4 \wedge 0.7]$$
$$= 0.3 \vee 0.5 \vee 0.7 \vee 0.4$$
$$= 0.7$$

$$\nu_{\overline{R_{IF}}(Y)}(e_5) = \wedge_{y\in V}[\nu_{R_{IF}}(e_5, y) \vee \nu_{Y_1}(y)]$$
$$= [0.1 \vee 0.6] \wedge [0.2 \vee 0.4] \wedge [0.2 \vee 0.1] \wedge [0.5 \vee 0.2]$$
$$= 0.6 \wedge 0.4 \wedge 0.2 \wedge 0.5$$
$$= 0.2$$

Hence the upper approximation for Y is given as

$< e_1, 0.9, 0.1 >, < e_2, 0.7, 0.2 >, < e_3, 0.6, 0.3 >, < e_4, 0.8, 0.1 >, < e_5, 0.7, 0.2 >$

From the above analysis, event category e_1 has membership function 0.9, while e_2 has 0.7, e_3 has 0.6, e_4 has 0.8 and e_5 has 0.7. According to principle of maximum membership, the event categorized under e_1 is of highest priority which is of Figure 1. shows membership and non-membership values 0.9. Hence the event e_1 must be addressed first of all the events e_1, e_2, e_3, e_4, e_5.

CONCLUSION

Disaster management and control activities area very complex to model due to their multi-faceted underlying structure. Usually multi-criteria decision making strategy quite fits for this purpose as the data are inherently uncertain. Rough set and fuzzy set are well known mathematical tools for handling uncertain, vague and imprecise data. Hence in this paper, we have employed a combined approach known as intuitionistic fuzzy rough set to compute the severity of public sentiments, which would be the basis of urgent decision making for controlling the imminent disaster. This approach can be extended by including the information contents of the individual events by the help of entropy measures.

REFERENCES

1. Pang, B. and L. Lee, 2008. Opinion mining and sentiment analysis, Foundations and Trends in Information Retrieval, 2(1-2): 1-135.
2. Das, T.K., D.P. Acharjya and M.R. Patra, 2014. Opinion Mining about a Product by Analyzing Public Tweets in Twitter, In the proceedings of the 2014 International Conference on Computer Communication and Informatics, pp: 1-4.
3. Zhang, Q., F. Liu and Y. Huang, 2013. A Warning and Urgent Decision-making Mechanism for Uncertain Network Public Sentiment Emergency, Journal of Computers, 8(10): 2640-2647.
4. Zeng, R.X. and X.L. Xu, 2009.The early warning system, index and mechanism of network public sentiment emergency, Journal of Informatics, 11: 135-138.
5. Zeng, R.X., 2010. The construction of early warning index of network public sentiment, Informatics Theory and Practice, 33: 135-138.
6. Zhang, W.P., 2008. Study on the index selecting and weight evaluation for emergency early warning, Journal of Chinese People's Public Security University, 6: 80-89.
7. Peng, Z.H., 2008. Discussion on population emergency and network public sentiment, Journal of Shanghai Public Security College, 11: 46-50.
8. Zhang, Y.W. and Y.J. Qi, 2010. The interaction mechanism between network public sentiment and abnormal emergency, Journal of Informatics, 9: 1-6.
9. De, S.K., 1999. Some aspects of fuzzy sets, rough sets and intuitionistic fuzzy sets. Ph.D. Thesis, Kharagpur: IIT.
10. Zhang, L.L., 2010. The investigation on the model of emergency network public sentiment early warning, Library and Information Service, 11: 135- 138.
11. Atanassov, K., 1986. Intuitionistic fuzzy sets, Fuzzy Sets and Systems, 20(1): 87-96.
12. Zadeh, L.A., 1965. A Fuzzy sets, Information and Control, 8(3): 338-353.
13. Pawlak, Z., 1982. Rough sets, International Journal of Computer Information Science, 11: 341-356.
14. Acharjya, D.P. and B.K. Tripathy, 2012. Intuitionistic fuzzy rough set on two universal sets and knowledge Representation, Mathematical Sciences International Research Journal, 1(2): 584-598.
15. Das, T.K., D.P. Acharjya and M.R. Patra, 2015. Multi-Criterion Decision Making using Intuitionistic Fuzzy Rough Set on Two Universal Sets, I.J. Intelligent Systems and Applications, 7(4): 26-33.
16. Takács, M., 2010. Multilevel Fuzzy Approach to the Risk and Disaster Management, Acta Polytechnica Hungarica, 7(4): 91-102.
17. Zeng, R.X., 2010. The construction of early warning index of network public sentiment, Informatics Theory and Practice, 33: 135-138.