An Approach Based on Environment Attributes for Representation of Disaster Cases

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ABSTRACT

In this paper we overview the ongoing research into the application of case-based reasoning in emergency management, based on which we propose a new approach for representation of large-scale disaster cases. The approach takes the environmental factors into account, and the case is organized according to key scenes, rather than disaster types. Each scene consists of inherent attributes, which are concerned with the disaster type, and environment attributes, which usually facilitate the adjustment of the decision-making, and sometimes play crucial role. To describe the environment attributes, the fuzzy sets are employed to take use of the non-quantitative information. The nearness of the fuzzy sets is used to retrieve the similar case. Based on this approach, the case retrieval could even extract the case with different type but similar environment, supposing the inherent attribute is analogous.

Keywords

Case-based reasoning, emergency management, case representation, environmental contributes, fuzzy sets.

INTRODUCTION

Case based reasoning (CBR) is a methodology which exploits the specific knowledge collected on previously encountered and solved situations, in other words, to resolve the current problems with past experience. Since CBR was put out in the 80s, a large amount of theoretical and applicative works have been dedicated to CBR research. Actually, the application of CBR has been implemented in many fields, as industrial decision making, diagnosis, health care, environmental risk assessment, etc. The heterogeneity of the involved application domains demonstrates the flexibility of CBR, and its applicability in those fields where experiential knowledge can be collected and reused (Montani et al., 2010).

Recently with the increasing occurrence of disasters or instances, emergency management becomes topical and high on the political and research agendas in many countries (Coates et al., 2011). Due to the lack of adequate information, changing conditions and high urgency, the decision-making in emergency management is a quite tough task. While the methodology of models or rules cannot satisfy the requirement of emergency management, CBR seems to be an alternative choice.

We propose an approach to represent the large-scale disaster cases with serial key scenes. Each scene consists of inherent attributes, which are concerned with the disaster, and environment attributes, like time, geography, temperature, etc. Both of the inherent and environment attributes determine the emergency response with corresponding weights. The environmental attribute usually facilitates the adjustment of the decision-making, and sometimes even plays crucial role in supporting emergency management. To describe the environment attributes, the fuzzy sets are employed to take use of the non-quantitative information.

The organization of the paper is as follows. Part 2 reviews the current works on the application of CBR in emergency management. Part 3 describes the approach of representing cases in the form of scenes: first the importance of environment is discussed, and then we utilize the fuzzy sets to denote the environmental attributes, finally we respectively figure out the membership functions for each attribute. Part 4 illustrates the feasibility and practicability of the proposed approach with a test of simplified case representation and case retrieval. In section 5 we summarize the ideas and outline the possible improvement for practical application.

RELATED WORKS

Chakraborty established a fire emergency handling system that uses CBR to assist decision making in solving a fire problem (Chakraborty et al., 2010). The system represent the fire cases with pre-defined attributes like ire location, area under fire, and wind velocity, etc. when a fire accident occurs, the system acquires the current fire emergency condition though query filled up manually.

Sotoodeh used the ontological approach to represent the model of emergency operation center and interdependent infrastructure systems in an urban area. The focus in the domain disaster management is on interdependencies between main players in disaster response and on infrastructure systems (Sotoodeh et al., 2008).

Zhang proposed a universal mode to represent and store emergency cases based on three-tier structure to avoid the limitation of presenting research that representing one kind of emergency cases at a time only, the structure is based on the pre-defined disaster ontology for each type of disasters (Zhang et al., 2009).

Topically, the representation of disaster case is based on analysis of domain knowledge. The cases are all within one specific disaster, or separated according to the disaster types. Our approach is not to fragment the large-scale disaster case with disaster types, but with the key scenes, each of which is composed of inherent attributes and environmental attributes.

THE REPRESENTATION OF DISASTER CASE

The importance of environmental issues

For the instances occurred in the specific city or region, the background environment is relatively stable, to pay attention to the inherent characters is enough. However, for the large-scale disaster or catastrophe, the environmental factors play an important role in emergency management, sometimes might dominate the decision-making. Take the 2008 Sichuan earthquake in China for example, except for the damage directed caused by earthquake, the barrier lake and debris flow occurred simultaneously, besides, the next day after the earthquake, the rain over the disaster area brought a lot of problems. The emergency management should take into accounted all of the above factors, and the plan would be mended corresponding to the environment. The environmental factors affected the emergency response to the 2010 Yushu earthquake in China to greater extend, the high altitude and heavy snow after the earthquake caused a lot of trouble for life-saving and settlement of civilians. The low temperature and oxygen even threatened the health of life-savers, and decreased the efficiency of equipment. Under such circumstances, the experience in history earthquake cases seems to be helpless compared to the blizzards disasters with similar environment.

Fuzzy sets of environmental attributes

In our approach of case representation, the case are departed as scenes, and each scene is composed of inherent and environmental attributes and represented as follows,

$$Scene = \{IA, w; EA_i, w_i\} \tag{1}$$

Here the *IA* stands for the inherent attribute, with *w* as its weights, while EA_i stands for the environmental attributes. Obviously, the inherent attributes are essential for emergency management, and determine the main direction of decision-making. To discuss the inherent attribute needs the analysis of domain knowledge, which is a bottleneck for application of CBR, as the large-scale disaster usually involve amount of issues. But for one scene and focusing on the hazard bearing entity, the inherent attributes could be simplified to "one topic of the scene", as like "to save the engulfed lives", "to settle the civilians who lost home", or "to provide medical service to the injured". Once identified the main target of the scene, the influence of the circumstance should be taken into account.

The reason to employ the fuzzy sets to describe the attributes, rather than the numeric value lies that some of the attributes are quantitative, and some are qualitative. Furthermore, when the disaster bursts out, the information is usually hard to acquire, and some attribute value might be default, while the fuzzy sets could take advantage of the non-quantifiable or even subjective information. We chose 5 main aspects to describe environment, as temporal issue, geography, meteorology, traffic capability, and visibility. Take the visibility for example, the fuzzy sets are defined as *high*, *avg*, *low*, which denotes the visibility is good or not. The membership functions could be generated through statistics approach or empirical method. According to the warning signal of mist in China, the yellow signal means the visibility is limited in 500 meters and beyond 200 meters, and the red signal means the visibility is less than 50 meters. Here we use a triangle function to illustrate the membership function for the element *avg* of the visibility sets. The function is displayed as follows.

$$S_A(x) = \begin{Bmatrix} 0, x \le 50 \\ \dfrac{x-50}{150}, 50 \le x \le 200 \\ \dfrac{500-x}{300}, 200 \le x \le 500 \\ 0, 500 \le x \end{Bmatrix} \tag{2}$$

The following figure displays the fuzzy sets as *high, avg,* and *low* respectively.

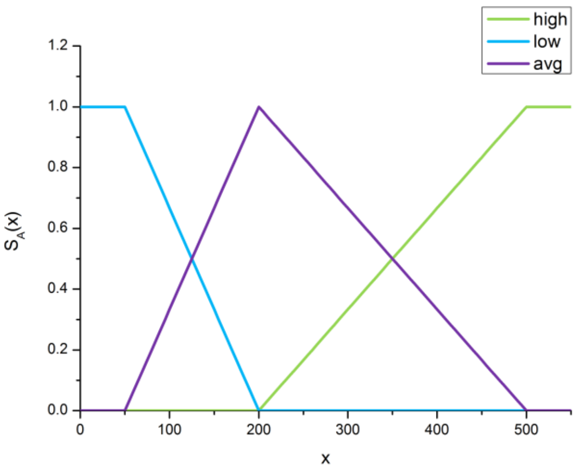

Figure 1. Membership Function

During the environmental attributes, the meteorology is more complicated. We defined several subsets like precipitation, temperature, wind, and lightning. All of the fuzzy sets have the elements as *high, avg, low*, or more accurate with more elements. The membership function could also be Gaussian function, normal distribution function, or Cauchy function. For simplification we chose the triangle function. The whole framework of the scene is displayed in the following.

$$IA_i = \left\{ \frac{S_A(x)}{low} + \frac{S_A(x)}{avg} + \frac{S_A(x)}{high}; w_i \right\} \tag{3}$$

Due to the different disaster or incidents, the weights of attributes would also change. The dispatch of weights between inherent and environmental attributes, and the within the environmental attributes is determined by the analysis of the onsite circumstances and expert suggestion. The algorithm could be principal component analysis, analytic hierarchy process, etc.

The retrieval step

Several typical scenes compose the integral case. When a new disaster occurs, the retrieval would be implemented to acquire not only the similar whole case, but also the similar scene, which might provide stronger support for specific decision-making. The retrieval step is to calculate the similarity of cases. As to the fuzzy sets, the similar measure is equivalent to the nearness between two sets, that is

$$d\left(E_A, E_B\right) = \left(\sum_{k=1}^{n} \left| w_A S_A\left(x_k\right) - w_B S_B\left(x_k\right) \right|^p \right)^{\frac{1}{p}} \tag{4}$$

Here the *d* means the nearness, or distance of two fuzzy sets, p is positive real number. When *p=2*, the nearness is the Euclid distance of the two sets. Then the whole distance of the two cases is the weighted sum of the nearness,

$$Dis = \sum_{i=1}^{m} d_i\left(E_A, E_B\right) \tag{5}$$

which is negative to the similarity of the two sets.

TEST OF THE APPROACH

To illustrate the practicability of the proposed approach, a test concerned the 2010 Yushu earthquake is implemented. One typical scene of is represented as follows. The inherent attribute of the scene is "to save the trapped people", and the brief environment is: altitude, 4500 km; temperature, -3~12 ℃; wind velocity, 7 km/s; traffic capability, a little low. The fuzzy sets would be:

$$Scene = \left\{ \begin{array}{c} \text{Life-save} \\ \text{Altitude}: \left\{ \frac{0.8}{high} + \frac{0.2}{avg} \right\}, 0.4 \\ \text{Temperature}: \left\{ \frac{0.3}{avg} + \frac{0.7}{low} \right\}, 0.2 \\ \text{Wind}: \left\{ \frac{0.4}{high} + \frac{0.6}{avg} \right\}, 0.2 \\ \text{Traffic}: \left\{ \frac{0.4}{avg} + \frac{0.6}{low} \right\}, 0.2 \end{array} \right\} \tag{6}$$

One typical "life-save" scene in the Sichuan earthquake is:

$$Scene = \left\{ \begin{array}{c} \text{Life-save} \\ \text{Altitude}: \left\{ \frac{0.2}{avg} + \frac{0.8}{low} \right\}, 0.2 \\ \text{Temperature}: \left\{ \frac{0.6}{high} + \frac{0.4}{avg} \right\}, 0.1 \\ \text{Precipitation}: \left\{ \frac{0.6}{high} + \frac{0.4}{avg} \right\}, 0.3 \\ \text{Traffic}: \left\{ \frac{0.3}{avg} + \frac{0.7}{low} \right\}, 0.4 \end{array} \right\} \tag{7}$$

Then the distance between the two scenes is 1.42 according to the above equations.

Compared with the 2007 Shannan blizzard disaster in Tibet, the environmental attributes are:

$$Scene = \left\{ \begin{array}{c} \text{Life-save} \\ \text{Altitude}: \left\{ \frac{0.9}{avg} + \frac{0.1}{low} \right\}, 0.2 \\ \text{Temperature}: \left\{ \frac{1}{low} \right\}, 0.2 \\ \text{Precipitation}: \left\{ \frac{0.8}{high} + \frac{0.2}{avg} \right\}, 0.2 \\ \text{Wind}: \left\{ \frac{0.3}{high} + \frac{0.7}{avg} \right\}, 0.2 \\ \text{Traffic}: \left\{ \frac{0.3}{avg} + \frac{0.7}{low} \right\}, 0.2 \end{array} \right\} \quad (8)$$

The distance is 0.6. The result shows that for life saving in Yushu earthquake, the blizzards disaster case with similar environment is more reliable. The practical result reinforced the conclusion, as the altitude illness haunting the rescue staffs, the usage of bulldozer, the arrangement of relief, etc.

THE CONCLUSION

In this paper we proposed a new approach for representation of disaster cases to apply CBR in emergency management. The approach takes the environmental factors into account, and the case is organized with scenes, rather than types. Based on this approach, the case retrieval could even extract the case with different type but similar environment, supposing the inherent attribute is analogous. The fuzzy sets allow the usage of defective information or subjective experience.

The further research would be focused on the relationship between inherent attributes and the environmental attributes, like effect of the wind or precipitation on poisonous gas leak, and the one within the environmental attributes, which is more significant in natural disasters. The practical method of dispatching attribute weights would also be one direction. Moreover, with deep analysis of disaster information we would excavate more specific "environmental attributes and corresponding solutions" patterns, based on which we would establish a CBR system with revising steps, which could support the decision-making in emergency management, especially on the influence of environmental factor.

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