A Quick Emergency Response Model for Micro-blog Public Opinion Crisis Based on Text Sentiment Intensity

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***Abstract*—On the basis of discussing the information spreading mechanism under Internet environment, we have studied on how to build a public opinion monitoring model according to the semantic content or text mining in recent years. A micro-blog public opinion corpus named *MPO* Corpus on the content of micro-blog information as a test data set has been constructed by our research team. In this paper, it proposes a quick emergency response model (QERM) for micro-blog public opinion crisis oriented to Mobile Internet services. Firstly, it describes the micro-blog cases and emergency response plan library using web ontology language (OWL), which makes the transitive logical reason capacity among micro-blog subjects, micro-blog cases and emergency plans. Secondly, it proposes an algorithm to calculate the sentiment intensity of micro-blogs from three levels on words, sentences and documents based on *HowNet* Knowledge-base respectively. Thirdly, we continue to study on how to update cases under the subjects and quick response processes for micro-blog case base. Finally, we design a test experiment which shows some merits of QERM in time, which basically meets the quick emergency response demand on the micro-blog public opinions crisis under Mobile Internet environment. Thus, it will provide more efficient support to the government and related monitoring departments involved with the public opinions crisis.**

***Index Terms*—public opinion crisis; sentiment intensity; Emergency response; Mobile Internet Services**

I. INTRODUCTION

Micro-blog is a kind of blogging variants arising under the mobile Internet environment in recent years. It gains more and more attention and recognition for its short format and real-time characteristics, and becomes an important platform for public opinion expression. Recently, it becomes one of typical applications of Mobile Internet. In Wikipedia, micro-blog is described as "a broadcast medium in the form of blogging allows users to exchange small elements of content such as short sentences, individual images, or video links [1]." The differences between micro-blog and traditional blog are that users of micro-blog could make use of web browsers, mobiles and other network terminals to read and publish text, images, audio and video links and other types of information anywhere at any time. Because the content of micro-blog is shorter (generally no more than 140 chars or Chinese words), the transmission speed among users is faster, and the expression is also more freely.

The "Social Blue Book", published in December 2009 by the Chinese Academy of Sciences, considered micro-blog as "the most lethal carriers of public opinion"; The "2010 third-quarter Assessment Analysis Report of China's Response capacity to Social public opinion", published in October 2010 by Shanghai Jiaotong University, claimed that micro-blog was becoming an important channel for enterprises and individuals to respond to public opinion.

In 2010, from the event of 'Yihuang self-immolation caused by demolition' in Jiangxi province, the protagonist Zhong Rujiu registered a micro-blog account and made a live publication about the incident's development. Many blogs written by Zhong were reproduced by many net friends to be a hot topic in micro-blog network. In the 'Guo Meimei event' , Guo showed off her luxurious life using micro-blog, and opened her ID as a business general manager of the China Red Cross, which caused a big uproar on the network and made the China Red Cross into a confidence crisis. And during the Japan earthquake in 2011, some rumors that because of the contaminated sea water by nuclear radiation, the production of sea salt was unhealthy spread over the net work, which caused a rush of salt.

From the cases above, it can be found that new challenges are brought to the government monitoring public opinion trends and discovering public opinion crisis. At present, research on micro-blog for public opinion in China has just started, and lacks of sophisticated systems and applications. Especially there are not enough experience and integrated emergency response framework on how to handle public opinions crisis quick. On the basis of the research work about micro-blog services model, the status of public opinions crisis in China and the micro-blog public opinions corpus constructed by our research team. In this paper it analysis and studies the quick response mode for micro-blog public opinion crisis to improve the response capacity to handle out the public opinion events.

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II. Related Work

Ontological knowledge representation is a kind of explicit description about the concept and the relationship between the concept in some domain, which could provide a syntax or semantic standard for communication between human and computers and improve system reliability and knowledge acquisition capacity [2]. Web Ontology Language (OWL) is a part of series W3C web-related and expanding standard, which takes with strong representation and reasoning ability. OWL provides three increasingly expressive sublanguages (OWL Lite, OWL DL and OWL Full) designed for use by specific communities of implementers and users. OWL Lite supports those users primarily needing a classification hierarchy and simple constraint features. OWL DL supports those users who want the maximum expressiveness without losing computational completeness and decidability of reasoning systems. And OWL Full is meant for users who want maximum expressiveness and the syntactic freedom of RDF with no computation guarantees.

HowNet built by Professor *Dong Zhendong* is a common sense knowledge base for Chinese words, which reveals and reflects the relationships among concepts abstracted from Chinese characters or attributes of concepts. The crux of the *HowNet* philosophy is all matters are in constant motion and ate ever changing in a given time and space in the corresponding change in their attributes [3]. *HowNet* extracts sememes from about 6000 characters with a bottom-up grouping approach, respectively, classified as event class, entity class, attribute or quantity class, attribute or quantity values class. Event Role is a semantic relation between concepts. Event role is the possible participants and roles playing in the event. *HowNet* also describes the entity class as event role in some events that it plays in. Relations among those concepts mainly include hypernym-hyponym, synonym, antonym, converse, part-whole, attribute-host, material-product, agent-event, patient-event, instrument-event, location-event, time-event, value-attribute, entity-value, event-role and concepts co-relation etc.

Emergency response is an extreme important stage during the process of dealing with emergencies [4] [9] [10] [12]. The result of response would directly influence the quantity of casualties and the degree of property loss and environment damaging [6] [7] [8] [18]. Wang believes that emergency response relies on successful execution of one or more contingency plans, often managed by a command and control center [5]. A common approach is using decision support system which integrates exports' knowledge and emergency response cases based on case reasoning[11][13][15][16[17].

Our research team has been studying on the micro-blog public opinion. It proposed an approach to calculate the sentiment intensity from three levels on words, sentences and documents respectively of the micro-blog texts, and constructed a public opinion corpus on the content of micro-blog information.

In this paper, it proposes a quick emergency response model consisting of a micro-blog case library, a response pan library and an emergency response handler engine. The rest of this paper is organized as follows. Section 3 describes the micro-blog cases and emergency response plans using OWL. Section 4 introduces an approach to the micro-blog sentiment intensity. Section 5 details the quick emergency response model. Section 6 analyzes experimental result and evaluates the performance. Finally, conclusion remarks are given in Section 7.

III. OWL-based Micro-blog Cases and Response Plans Description

In this paper, it makes use of ontology as the knowledge representation of micro-blogs and subjects. It describes the micro-blog cases and emergency plans based on OWL. To make the reasoning ability between subjects and individuals, the micro-blog ontology consists of Category class and Micro-blog class. A one-to-many relation connects the two classes discussed above, which means a micro-blog individual belongs to one subject; otherwise a subject may include many micro-blog individuals.

A. Subject Class Description

In order to clearly describe the login relationship between micro-blogs and micro-blog subjects, it makes use of the inheritance of OWL classes to define the hierarchy structure of subjects. The Subject Class definition includes two aspects: for one thing, according to the content of public opinion, the subjects are classified into political, economic, cultural, social and other as the first level classification. Furthermore, according to micro-blog text under each first-level classification, establishing different child subject categories by extracting keywords from micro-blog texts. A structure of subject class is shown in Fig.1.

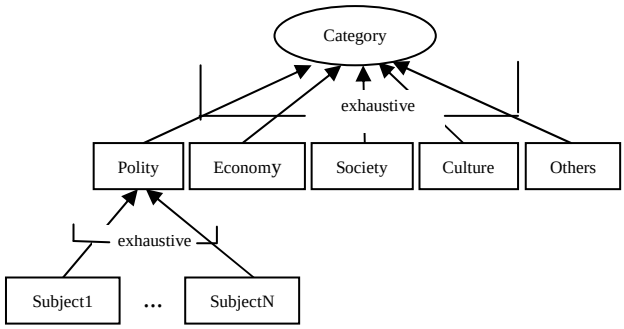


Figure 1 A Structure of Subject class

In Fig.1, the class *Category* is the top Class, and classes *Polity*, *Economy*, *Society*, *Culture* and *Others* are its subclasses, which represent different public opinion categories respectively. And each public opinion classification has many different subclasses except the *Other* class. In default, micro-blogs in the *Other* class are unclassified and the reasoned would select blogs in the *Other* class to classify into other different public opinion categories.

Each subject class has two data type attributes 'start_time' and 'keywords' inherited from its parent

class. And the reasoned will decide the blogs' categories by these two attributes. Currently, for the convenience of experiment test, the case library now only consists of 14 subject subclass, including 3 subjects 27 micro-blogs in the polity category, 5 subjects 51 blogs in the economy category, 6 subjects 72 blogs in the society category and 0 subjects in the culture category and others category. The cases distribution of micro-blog case base is shown in Table I.

TABLE II.
THE CASES DISTRIBUTION OF MICRO-BLOG CASE BASE

	Quantity of Subjects	Quantity of blogs
Polity	3	27
Economy	5	51
Society	6	72
Culture	0	0
Others	0	0
Total	14	150

Besides, there are three other attributes: 'ID' for a unique number in the library, 'opinion_grade' for representing the subject's opinion grade and 'panID' for connecting the response plan in the plan library. Part of program description of *Category* class is shown as follows.

```
<!—Description of Category class-->
<owl:Class rdf:ID"Category"/>
  <owl:Class rdf:ID="Polity">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Category"/>
    </rdfs:subClassOf>
  </owl:Class>
<!-Attribute description for  start_date -->
<owl:DatatypeProperty rdf:ID="start_date">
    <rdfs:domain rdf:resource="#Category"/>
    <rdfs:range
rdf:resource="http://www.w3.org/2001/XMLSchema#dat
eTime"/>
  </owl:DatatypeProperty>
```

B. Micro-blog Class Description

Description of Micro-blog content is a knowledge representation of micro-blog information. In this paper, it defines a Micro-blog class as a blueprint of micro-blog, and treats each real micro-blog text as an instance or individual of Micro-blog class. According to the guide of OWL, the concept of attribute is defined as a binary relation, which could be specified a number of ways to restrict like the domain and range. The Micro-blog class has many attributes include data type and object type to describe the general fact of blog instances and relationship between with Category class. Part of attributes of Micro-blog class is listed in Table II as follows.

TABLE I.
PART OF ATTRIBUTES OF MICRO-BLOG CLASS

Attribute Name	Attribute Type	Attribute Description
reference_from	object type	point at the referenced or reproduced blog
reference_at	data type	point at the referenced blog's url
belong_to	object type	point at to the subjected ID
blog_ID	data type	the unique index number
blog_author	data type	micro-blog author
blog_date	data type	published time
meta_information	data type	including provider, client type and so on
blog_keywords	data type	keywords of micro-blog
blog_content	data type	micro-blog's content

Class Micro-blog include 2 object type attributes '*reference_from*' and '*belong_to*' and 8 data type attributes: '*blog_ID*', 'author', 'date', '*meta_information*' and 'content'. The object type attributes reveal relations among instances of class Micro-blog and Category. '*reference_from*' is used to point at a referenced micro-blog, and '*belong_to*' to point at an individual of Category class which the micro-blog belongs to. The data type attribute '*meta_information*' includes the Micro-blog Provider like 'sina', publication client type like web or mobile and IP information. As described above, some definition program of class Micro-blog is shown as follows.

1) namespace definition:

```
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
syntax-ns#"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-
schema#"
   xmlns:owl="http://www.w3.org/2002/07/owl#"
   xmlns="http://www.owl-ontologies.com/.owl#"
  xml:base="http://www.owl-
ontologies.com/microblog.owl">
```

2) Class Micro-blog and attributes definition:

```
<!—Microblog class-->
<owl:Class rdf:ID="MicroBlog"/>
<!— object type attribute: reference_from -->
<owl:ObjectProperty rdf:ID="refence_from">
   <rdfs:domain rdf:resource="#MicroBlog"/>
   <rdfs:range rdf:resource="#MicroBlog"/>
 </owl:ObjectProperty>
<!—data type attribute: date -->
<owl:DatatypeProperty rdf:ID="date">
   <rdfs:domain rdf:resource="#MicroBlog"/>
```

<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#dateTime"/>
</owl:DatatypeProperty>

C. Response Plan Ontology Description

Response Plan is an important component of the emergency response system, which is a process template including formulating, executing one or more disposal options. After the analysis of more than 100 sets of emergency plan instances and some reference papers, this paper considers that a plan template consists of application scope, organizational structure, resource, workflow and other relative content.

As discussed above, it describes organization, resource, event and workflow as an entity class respectively. And in the definition of class plan includes attributes like '*planID*' for a unique number, '*planAim*' for the plan's aim and '*planPrinciple*' for the principle of formulating the plan. Some attributes are detailed in table III.

TABLE III.
ATTRIBUTES OF PLAN ONTOLOGY

	Name	Type	Description
Plan	planAim	date type	plan aim
	planPrinciple	date type	formulating principle
	organization	object type	organization structrue
	resource	object type	resource need
	event	object type	event
	workflow	object type	workflow
Organization	leader	date type	direct responser
	members	date type	members
Resource	tag	date type	resource name
	quantity	date type	quantity
	status	date type	status, like 'ready'
Event	eventType	date type	event type
	eventSummary	date type	event summary
	eventLevel	date type	event level
Wokflow	workFlowTag	date type	task name
	condition	date type	trigger conditions
	organization	object type	responser
	taskDescription	date type	task description
	status	date type	status
	nextTask	date type	next task

The response plan ontology consists of class *Plan*, class *Organization*, class *Resource*, class *Event* and class *Workflow*. And the organization in the plan means those who directly response for execution of the whole plan, and the one in the *Workflow* those who for one task execution. The event levels in the Event class are defined according to the Nation Accidents Classification Standards as particularly significant (I level), major (II level), large (III level) and general (IV level).

D. CBR-based Reasoning Process

The core principle of case-based reasoning is that when a new issue is encountered, firstly, the system will match the key feature of the issue in the case base to find out one or more most similar cases with the issue, and secondly reuse the solution of the cases. If the system is not satisfied with the candidate solution to the issue, the system would modify it to fit the issue, and finally store the modified case as a new case into the case base as a reference when encountering a new question next time.

The case-based reasoning in the paper is formalized for purposes as the common four-step (R4) process:

1) Retrieve. To the given target micro-blog subject, the system will retrieve similar-subject cases from the case base to process it.
2) Reuse. Each case has a *PlanID* to its response plan. Map the response plan from the previous similar-subject cases to the target micro-blog subject. This may involve adapting the solution as needed to fit the new situation.
3) Revise. Having mapped the previous response plan to the target micro-blog subject, analyze the plan with experts' validation and, if necessary, revise.
4) Retain. After the plan has been passed by validation, store the final result experience as a new case-plan in the library.

This paper below will introduces the quick emergency response model (QERM), plan reproduction based on the CBR mechanism and the reasoning process driven by the above QERM model separately in section 5.

IV. SENTIMENT INTENSITY COMPUTATION MODEL

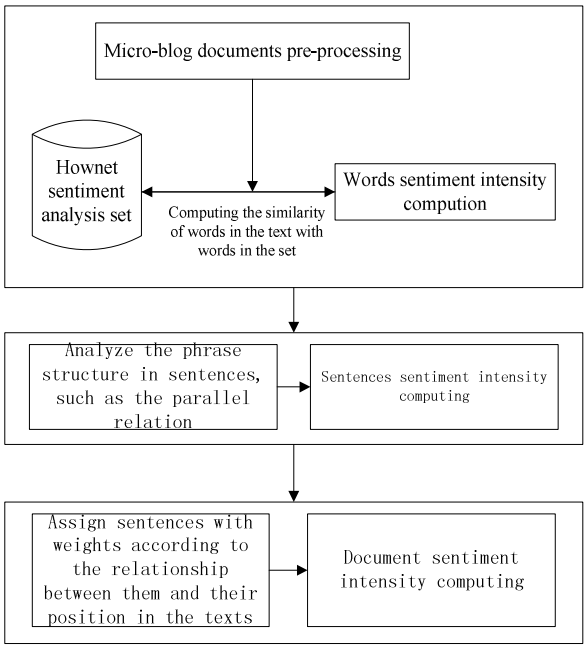


Figure2. A Frame for Sentiment Intensity Computing Model

The sentiment intensity computing model oriented micro-blog is the foundation of classification of documents based on the text emotional intensity, and is also the basis of public opinion research about micro-blog information

platform. The model proposed in the paper includes three levels with the emotional intensity calculation from words, sentences and documents. The model frame is show in Fig.2

In Fig.2, for the starts, the original documents will be pre-processed as words segmentation. Then the program will compute the similarity based the algorithm in reference [11] between the words in the documents and HowNet sentiment analysis set to set the words' emotional intensity. This is the words' level process. For the sentences level, the program will analyze the relationships between words consisting of phrases like modified relationships, parallel relationship.etc. The sentimental intensity of sentences is computed based on the relationships of words and words' intensity. Finally, with different positions of sentences, the program analyzes the position of sentences in the context and sets each sentence different weight to calculate the document's intensity. The detailed instructions will be shown as follows respectively.

A. Word Emotional Strength

Word emotional intensity computing is based on HowNet sentiment analysis set, which consists of Chinese and English emotion analysis words sets, including positive and negative evaluation words, positive and negative emotion words, degree-level words and words and claim words. Because the emotion difference between the evaluation words and emotional words are not very obvious in the research, the sentiment analysis words are merged into the positive words set and negative words set in the paper, such as:

Positive words: love and dote, love and esteem, caress, love.

Negative words: sad, pity, grieved, deep sorrow, dump.

Pre-process the words in the set and give all the positive emotional words the weight 1, all the negative emotional words the weight -1 for the emotion sets. The degree-level words in the set do not contain any emotional information, but modify emotions degree intensity. So the paper gives these words a positive real number weight between 1 and 10. Then compute the similarity based the algorithm in reference [11] between words in the documents and the processed HowNet sentiment analysis set. The proposed computing algorithm of words emotional intensity list as follows:

if speech of word is Degree Adverb then

Calculate the similarity between word and word' in the HowNet degree-level words set;

Note the biggest similarity 'sim' and weight 'weight'of word';

else if speech of word is one of nouns, verbs, adjectives then

Calculate the similarity between word and word' in the HowNet emotional words set;

Note the biggest similarity 'sim' and weight 'weight'of word';

else intensity(word) = 0;

*intensity(word) = weight * sim;*

B. Sentence Emotional Strength

Words are the basic unit of the sentences, but sometimes a single word does not accurately reflect the semantics of a sentence such as:

Sentence 1: Fuel consumption of Excelle is really high

Sentence 2: Etta's cost performance is very high

Sentence 1 and sentence 2 are emotional sentences, but the emotional word 'high' shows different polarities when modified different objects: 'high' indicates derogatory in the sentence 1 while compliment in the sentence 2. Therefore, we study the modified relationship between the adjacent words before calculating the sentences emotional intensity. Some researchers have found the phrases structures with certain emotional meaning are usually nouns, verbs, adjectives, adverbs phrases. The common Chinese phrase types such as prejudiced phrase are shown in Table IV.

TABLE IV.
ATTRIBUTES OF PLAN ONTOLOGY

	Grammar Structures	Examples
One center word	adjective+noun	A clever girl (Chinese: 聪明的女孩)
	noun+verb, noun+adjective	Wang likes (Chinese: 小王喜欢)
	verb+noun, verb+adjective	Like clean (Chinese: 爱干净)
	noun+'of'+noun	The affinity of idols (Chinese: 偶像的亲和力)
	degree-adv.+ adj./adv., adj./adv.+ degree-adverb	Very good (Chinese: 很好)
	Negative word +adj./ verb/adv.	Do not like (Chinese: 不喜欢)
Multiple center words	Adjective+adjective, noun+noun, verb+verb	Bright and smart (Chinese: 聪明伶俐)

To compute the emotional intensity, it obeys the following rules in the paper:

a) The emotional strength of the parallel structure phrases such as: "noun + noun", "adjective + adjective" is equal to the sum of the each word' strength.

b) The emotional strength of the modified structure phrases such as: "adjective + noun", "adjective + adverb" is equal to the product of multiplying like intensity(adverb) * intensity(adjective)

To facilitate the calculation of the emotional intensity of the sentence, two presumptions are made:

a) Each sentence is a single sentence, and complex sentences composed by the conjunction artificially are split into two sentences;

b) The similarity based on HowNet is increased by 10 times.

Under the analysis of semantic relations between words in the phrases and the context relations in the sentences, the sentence emotional intensity algorithm is designed and shown as follows:

```
Intensity = 0;
While (word1is not the last word){
    If there is modified relationship between word1and word2
        Combine word1 and word2 into word;
        Intensity (word) += intensity (word1) * intensity (word2);
        word1 = word;
    Else intensity += intensity (word1) + intensity (word2);
}
```

C. Document Emotional Strength

In a document, the relationships between sentences, such as the assumed, transition and progressive, affect the document emotion intensity. The topic sentence in the document occupies a central position having significant impact on document emotion intensity. In this paper, it calculates the intensity of document using a linear expression. It gives each sentence a different weight to reveal diffident positions in a micro-blog text. To the topic sentence or central sentence, it has a higher weight. The calculation is according to the following formula (α and β are the correlation coefficients):

$$intensity = \alpha * intensity(topic\ sentence) + \beta 1 * intensity(sentence1) + \ldots + \beta n * intensity(sentenceN) \quad (1)$$

In the formula discussed above, the position is more important in the document, the coefficient is larger. Usually, the coefficients about the topic sentences are set a float number among 0.5-1 and other sentences' coefficients are set among 0-0.5.

Sentiment Intensity Computation Model is part of the QERM. By the intensity, the QERM will identity the micro-blog's public opinion intensity and select seed cases in the case base. The next section will detail the QERM and introduce the information flow in the QERM.

V. QUICK EMERGENCY RESPONSE MODEL

Emergency response is an information sharing process. The QERM works on the R5 model of CBR, and is based on case base and response plan library. It is driven by topic tracking, and approached by owl reasoning. Topic tracking, case-based reasoning, the case and response plan base automatically updated compose the response engine. The workflow of QERM is shown in Fig.3.

A. Keywords-based Topic Tracking

The purpose of topic tracking based on micro-blog keywords is to make the instances in the subjects' categories more affluent and get a more accurate response. Its main idea is:

1) *Sort the cases by their sentiment intensity from the big to small in one subject. And select N micro-blog cases as seed cases;*
2) *Extract the key attributes of the seed cases;*
3) *Track the micro-blog with the url address value of attribute 'reference_at' until the address is null;*
4) *If the publication client is mobile, then get the base station position through the mobile IP stored in the 'meta_information' attribute; And continue tracking the similar micro-blog examples around the base station;*
5) *Handle the blog examples by semantic analysis and sentiment intensity computing.*
6) *Decide the examples category using reasoner*
7) *Update the public opinion intensity of the subject category*

The micro-blog sentiment intensity uses the method in reference. The public opinion intensity of one subject category is calculated by the linear addition of each blog's sentiment intensity.

B. Case Retrieval and Plan Reproduction

Case retrieval and reproduction is an important part of emergency response system based case-reasoning base. In this paper, it makes use of subject keywords and public opinion intensity to retrieve the case base.

1) *select the approximately equal intensity of subjects as the optional subjects;*
2) *computing the semantic similarity of the keywords between optional subject and new subject, and choose the biggest similarty as the final optional subject;*
3) *modify the response plan of the optional subject until the modified one is passed by expert;*
4) *store the passed response plan into the plan base and start the emergency response;*

C. The Reasoning Process for QERM

The quick emergency response model is based on case base and response plan base. The most important part is the engine which consists of topic tracking and case-retrieval and reproduction subsystems. The topic tracking subsystem track new micro-blog example using the blog case as seeds, and then updates the case base. And The subject class Category is defined as a three-dimensional vector :< keywords, intensity, planID>, with which the system will start emergency response. Detail steps are described as follows:

```
// extract the key attributes of the subject
  while the value of 'reference_at' is not null then
      tracking the micro-blog with the address at the value of 'reference_at'
  end
  if type is mobileType then
     get the base station position through the mobile IP stored in the 'meta_information' attribute;
  track the similar micro-blog examples around the base station;
  end
  ...
  // computing the semantic similarity of the keywords between optional subject and new subject
  if similarity > the threshold TH then
     decide the blog case as the final optional
  end
```

The proposed QERM uses the owl reasoning tool in the processes of topic tracking, case retrieval and plan reuse to implement the update of case base and plan base. It provides a quick response to the micro-blog public opinion, which can assist the government and experts to emergency incidents.

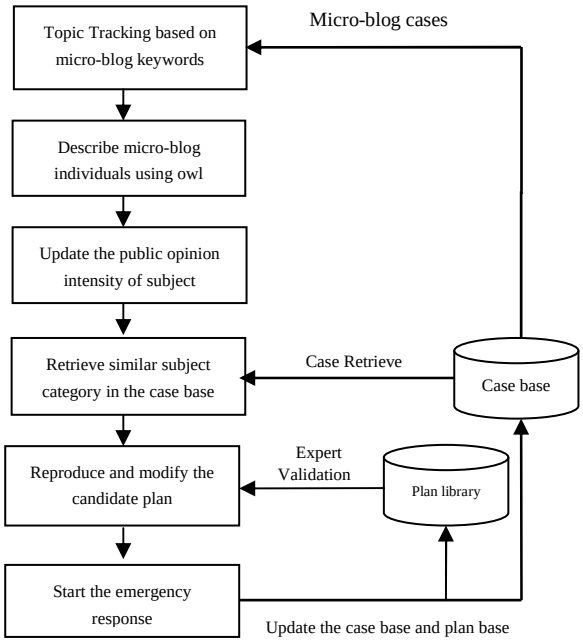


Figure 3. The workflow of QERM

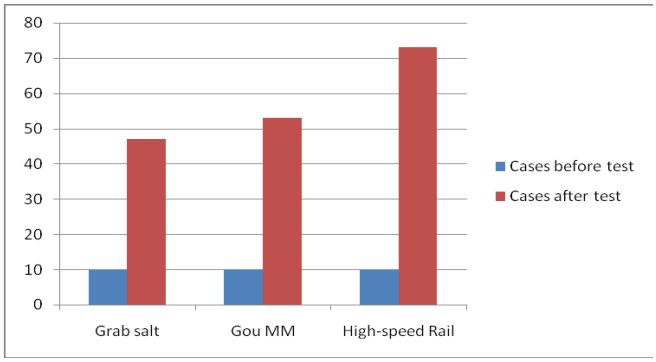
VI. Experiment and Results Analysis

To test the performance of the proposed model, this paper design a simulation experiment using the case base as the data set, and choosing subjects 'Guo MM event', 'grab salt incident', and '7.23 high-speed rail event' as the test subjects. The experiment takes the time in which the system gets a reliable plan as the test result. The results are shown in Fig.4.

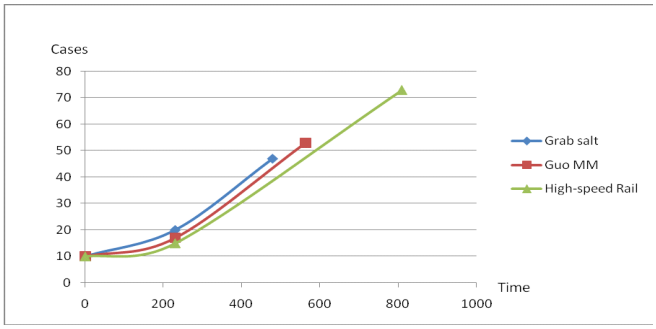
It can be seen from Fig.4a and Fig.4b that the proposed QERM has some merits in the response time (about 15 minutes). It could meet the quick response demand in the micro-blog public opinion emergency event. However, the proposal model has some disadvantages that the performance of topic tracking is not enough good. And this is also the future work we will work for.

VII. Conclusion

Recently, the Micro-blog as a new personal media network service is becoming an important channel for people to get and publish their information and ideas. With that the micro-blog public opinion events discussed in this paper, it continues to study the quick micro-blog emergency response model (QERM) by using OWL reasoning tools on the base of lab's research result. The public opinion intensity of micro-blog subjects is computed by the given sentimental intensity algorithm. The QERM is driven by topic tracking, and approached by OWL reasoning mechanism. On the other hand, its core engine is composed of CBR-based topic tracking, the case base and response plan library. The test experiment proves the superior of the quick emergency response model, which also provides a better technical support for government monitoring department to handle the emergency public opinion incident quickly and successfully. In the future research work, we will pay more attention to propagation chain and model to get better results for the public opinion monitor.



a



b

Figure 4. Results of Experiment

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