THE HYPOTHESIS OF VERB LOGIC AND ITS APPLICATION IN UNIVERSAL EMERGENCY RESPONSE INFORMATION SYSTEM DESIGN

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ABSTRACT:

It is always a challenge to build up a stable and high-level integrated system capable of different types of emergencies. The biggest obstacle is how to build a universal work flow mode for the different events. To solve the problem, our research adopts an unusual way based on the self-evident truth that full text description of phenomena is a whole map of it. Then the system analysis' subject can be altered from the real emergency response to the text description of it. Therefore semantic annotation which uses the semantic labels in propbank can be employed in the analysis process. The annotation subjects are the documents that each of them described a full emergency response process of different emergency type. After classification and statistic, three linguistic rules are found out. First, every sentence have a predicate verb which indicate an executable action and it belongs to a fixed set, second, each verb coexists with semantic role Arg0(actor), third, all the complement roles of predicate verbs converge into a fixed subset of semantic roles ,these conclusions are named together as Verb Logic. It is a high abstract semantic model, for it not only contains domains but also tell the relations among domains. Based on verb logic, universal work flow mode is constructed, and a universal emergency response system can be built up. The design of the system is also stated in this paper.

1 INTRODUCTION

Emergency system involved researches are booming since the 9.11 attack which is a reminder to the necessity of efficient integrated emergency response. Most of the researches of computer aided emergency response derived from the former expert decision systems, which focused on decision models extraction from domain ontology and knowledge. The others contribute to the technology of system construction in special event type. But these solutions are not integrated in a universal framework yet, because the work flows differ in different types of emergency, and the relations between these kinds of emergency response are not stable, if the business logic changed in any of the collaborated event response, the integration would be broken. So the basic challenge is the construction of a universal emergency response work flow mode.

But in the need to build a first emergency response system which must integrate with other emergency systems for national security department, we have to consider the compatibility in prior in the system design.

Originally, the first step of software design in OO programming era is extracting the object from concrete business process, for they can be redefined and saved in computer format. this procedure commonly only existed in the mind of designer who digest the business flow and then figure it out in ways that are more familiar to the programmer, like UML.

Until R.A. Meersman I in his research put forward an semantic way to speed this procedure up, in his work, a "global" common ontology (lexicon, thesaurus) is conjectured, and some desirable properties are proposed[1].

One following similar research by Meenakshi is about extracting domain ontology entities through semantic web. the foundation of the research is "The Semantic Web is a vision: the idea of having data on the Web defined and linked in such a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications." (Semantic Web Activity Statement), His research used an ontology database which can aid in entity extraction in web document, after a disambiguation process.

The researches mentioned above are both innovative, despite of their different methods and results they all use semantic annotation to extract domain model to facilitate other application automatically perceiving and integrating the meaningful entity.

In the other hand, either of them can not figure out the interoperation details between entities yet, because there are uncountable relations which couldn't be unambiguously identified. This fault makes the results not suitable for system design but class construction.

In our research, firstly we regard the construction of a universal emergency response system as the goal, second, based on the axiom that full text description of an phenomena is a whole map of it, as well as a full work flow of the same phenomena executed in computer, then the system analysis' subject can be altered to the text description which act as an agent of the real phenomena.

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This way may be indirect but could find some useful rules that can not be found out in ordinary ways, therefore analysis is directly taken on the linguistic descriptions of emergency response process in our research, and semantic annotation also adopted, which use the semantic labels in propbank.
The subjects are some documents that each of them described a full emergency response process. After the annotation, a statistic way is tried, finally three linguistic rules are found out namely Verb Logic.

In this paper, first the process of verb logic is addressed, second the system design based on it is described, and then the system's capability is discussed, finally three cases of different event type are used to demonstrate its capability.

2 VERB LOGIC

2.1 Semantic labels and Propbank

Representing the predicate-argument structure has been one of the focal points in recent efforts to develop semantic resources. This is generally achieved by specifying the semantic roles for the arguments anchored by the predicate, but the specific semantic role labels used differ from project to project. They range from very general role labels such as agent, theme, beneficiary adopted in the VerbNet(Kipper et al. 2000; Kipper et al. 2004; Kipper et al. 2006) and the semantic component of the Sinica Treebank (Chen et al. 2004), to labels that are meaningful to a specific situation, like the role labels used in the FrameNet (Bakeret al. 1998) and the Salsa Project for German (Burchardt et al. 2006), to predicate specific labels used in the English PropBank (Palmer et al. 2005) and the Nombank (Meyers et al. 2004). The difference between the various approaches can be characterized in terms of levels of abstraction. The Propbank style of annotation can be considered to be the least abstract, as it uses argument labels (Arg0, Arg1, etc.) that are meaningful only with regard to a specific predicate.

Table 1 semantic roles in Propbank

Core semantic role		Additional Semantic Role	
labels	meaning	labels	meaning
Arg0	Agent, Experiencer	ArgM -ADV	Adverbials
Arg1	Theme ,Topic, Patient	ArgM -BNE	Beneficiary
Arg2	Recipient, Extent, Predicate	ArgM -CND	Condition
Arg3	Asset, Theme2, Recipient	ArgM -DIR	Direction
Arg4	Beneficiary	ArgM -DGR	Degree
Arg5	Destination	ArgM -EXT	Extent
		ArgM -TMP	Temporal
		ArgM -TPC	Topic
		ArgM -PRP	Purpose or Reason
		ArgM -FRQ	Frequency
		ArgM -LOC	Locative
		ArgM -MNR	Manner

2.2 Statistic and analysis

There are many kinds of Linguistic documents described emergency response process such as Emergency Processing Conclusion, Counterplan or Exercise instruments, even journalistic reports can provide the detail of response.

In our study, we collect 16 different kinds' documents.

Table 2 The subject documents

index	Event type	Document type	Source organization	The number of sentence
1	Fire incident	Handling norms	Community property companies	52
2	Drug trafficking	Handling norms	Public security bureau	33
3	smuggling	counterplan	Border Corps	75
4	Public health crisis	Handling norms	Health Department	46
5	Bombings	counterplan	Public security Department	118
6	earthquake	counterplan	Seismological Bureau	81
7	Refugees	counterplan	Border Corps	87
8	Human smuggling	Processing Conclusion	Border Corps	48
9	smuggling	Processing Conclusion	Border Corps	103
10	Human smuggling	Exercise instruments	Border Corps	35
11	Drug trafficking	Exercise instruments	Coast guard	105
12	Robberies	Processing Conclusion	Public security bureau	74
13	power grids damaged	counterplan	Power company	36
14	First aid	Handling norms	medical emergency center	66
15	Fire incident	Processing Conclusion	Fire Squadron	64
16	Mass riots	Handling norms	Public security Department	79

As table 1 show, each of them has at least 30 sentences and fully covers an emergency response process whether finished or just in preparation.

Because samples are of a small quantity, manually semantic annotations could be done in acceptable time, and no existed program affords the unambiguous work, for the frequently phenomena that one sense is multiple referenced in forms as verb Nominalizations phrase in documents. Then we assign semantic role labels which are defined in propbank system to the constituents by ourselves.

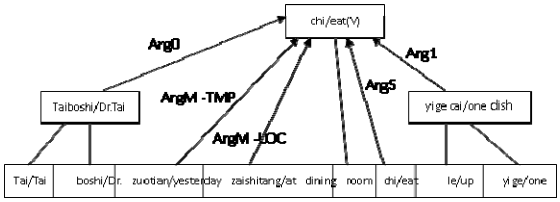

Figure. 1. Semantic annotation in propbank labels

Fig. 1 is illustrating the annotation of an isolated sentence. It is not difficult to judge the semantic roles in a single sentence, but in a written document some semantic roles are often omitted for the context implicitly provides their meaning. This phenomenon will introduce errors into the statistic work. So we take a pretreatment that regenerate the documents to make each sentence can describe a complete and unambiguous meaning independently by appending the implicit roles from context.

When the annotation work finished, we count each semantic role present times in all samples and get table 3.

Table 3 Appearance frequency of all semantic roles

Semantic role	Meaning	Appearance frequency	Possibility of appearance in a sentence(total of sentences: 1102)
V	Verb	1102	1
Arg0	Agent, Experiencer	1102	1
Arg1	Theme ,Topic, Patient	484	0.439201
Arg2	Recipient, Extent, Predicate	327	0.296733
Arg3	Asset, Theme2, Recipient	59	0.053539
Arg4	Beneficiary	4	0.003633
Arg5	Destination	75	0.068058
ArgM -ADV	Adverbials	0	0
ArgM -BNE	Beneficiary	0	0
ArgM -CND	Condition	0	0
ArgM -DIR	Direction	5	0.004537
ArgM -DGR	Degree	0	0
ArgM -EXT	Extent	2	0.001815
ArgM -FRQ	Frequency	0	0
ArgM -LOC	Locative	752	0.682396
ArgM -MNR	Manner	5	0.004537

ArgM -PRP	Purpose or Reason	0	0
ArgM -TMP	Temporal	5 7 8	0.524501
ArgM -TPC	Topic	0	0
ArgM -CAU	Cause	0	0
ArgM -NEG	Negation	0	0
ArgM -MOD	Modal	0	0

In this table, we confirm that these documents consist of predicate centered sentences, and each verb always coexists with an Arg0 role which denotes the doer of the action. But no discipline of other arguments can be told yet.

Little was raveled from detailed statistic which has been done in different ways until we classify the annotation by the sense of core verb. While the same meaning can be expressed in different forms, so to simplify the statistic we choose the most common expression of each independent meaning and name it as predicate verb (PV) and filter out the roles conveying dispensable meaning and of unremarkable present frequency like Arg4 ArgM–EXT, Next step is do the statistic of appearance frequency of the PV's complement roles, then we find one PV and its coherent semantic roles have a fixed relationship. The part of result is shown in table 4.

Table 4 Appearance frequency of some verb's coexisted roles

Predicate verb	Semantic role	Meaning	Coexist frequency	Predicate verb frequency	P(V|Arg*)
ganfu/go for	Arg0	Agent, Experiencer	1 2 3	1 2 3	1
	Arg5	Destination	1 2 3	1 2 3	1
	ArgM-LOC	Locative	1 2 3	1 2 3	1
	ArgM-TMP	Temporal	1 2 3	1 2 3	1
jiuhu/ cure	Arg0	Agent, Experiencer	7 5	7 5	1
	Arg2	Recipient, Extent, Predicate	7 5	7 5	1
	Arg3	Asset, Theme2, Recipient	7 5	7 5	1
	ArgM-LOC	Locative	7 5	7 5	1
sushan/evacu	Arg0	Agent, Experiencer	1 8	1 8	1
	Arg1	Theme ,Topic, Patient	1 8	1 8	1
	ArgM-LOC	Locative	1 8	1 8	1
	ArgM-TMP	Temporal	1 8	1 8	1
daibu/arrest	Arg0	Agent, Experiencer	3 7	3 7	1
	Arg1	Theme ,Topic, Patient	3 7	3 7	1
	ArgM-LOC	Locative	3 7	3 7	1
	ArgM-TMP	Temporal	3 7	3 7	1
fengshuo/ Bl	Arg0	Agent, Experiencer	5 3	5 3	1
	ArgM-LOC	Locative	5 3	5 3	1
	ArgM-TMP	Temporal	5 3	5 3	1

Given the result, the semantic roles which have the possibility to coexist with one particular predicate verb can be limited, and all of them must show up with the predicate verb while the other roles absent. Now we confirm the conclusion that each predicate verb must coherent with several fixed semantic roles to express a complete and independent meaning. Furthermore, we collect all presented semantic roles, and the result is interesting that the complement roles is not the rest roles exclude Verb, the complement roles converged into seven types: Arg-tmp Arg-loc Arg0 Arg1 Arg2 Arg3 Arg5. That means in description of emergency response process, fixed types of arguments must be addressed, in other words, these types is enough for linguistic description of a whole response process of any event type.

But why these roles are necessary to the documents? Why not the others? Some points are presented.

First, Arg0 is the actor and Arg1 is the objects or persons that received or affected by the action of the predicate verb. In rescue and response process, every action must executed by special persons or forces and the action must have specific effect to objects, otherwise the action is of no meaning.

Second, Arg2 is the influence or goal of the action of the predicate verb, it is a basic complements of lasting actions to work for ,and implicitly for emergency manager estimate effect to decide the action' going on or not.

Third, Arg3 is the equipments or methods that took by the actions. it is reasonable that response team could not accomplish mission with empty hand and they must make preparation for the different situations in the spot.

Fouth, Arg-TMP is the argument indicate temporal period or point in a sentence. Emergency response has the basic require for proceeding in an efficient time-ordered manner. So the time point when action take place or finished is remarkable important to the accuracy in the whole process.

Fifth, Arg5 is the Destination and Arg-LOC is about the location. Actually they are the most important complement to a response action, because both emergency and its response are spatial, which means any event has its limited effective area in the whole life cycle. Their spatial properties is the foundation of where the response actions implements. Furthermore they are the necessary elements of most decision-making models which can tell the suitable route that emergency troop takes to reach the spot or other target place.

2.3 Expression of VL

As a summary of statistics above, three useful points are stated.
First, the emergency response describe documents compose of sentences which has a core predicate verb without exceptions.
Second, with each verb the appearance of the semantic role Arg0 is a certainty.

Third, all the complement semantic roles in the documents converge into a fixed and countable set that has seven members of roles in propbank. Enumerated as: Arg-tmp Arg-loc Arg0 Arg1 Arg2 Arg3 Arg5.

We name these points together as verb logic in emergency response, VL for abbreviation. It is an semantic abstraction which is in a higher level than domain ontology, because the discipline has nothing to do with the specific type of events, neither fixed analytic model nor fixed reader or users, while in domain ontology, both the entities and their relations are concrete and can not extend to other domain that make the systems based on them hardly interoperate with each other.
So VL is the rules of all kinds of emergency response. And it can be the foundation of universal emergency response system design.

3 UNIVERSAL EMERGENCY RESPONSE SYSTEM DESIGN

First Any Concrete emergency itself is belong to a domain.

Since every concrete emergency has domain ontology as its metadata, classifying emergent events by their superior domain is a right-on taxonomy which is the foundation of the universal emergency response system to keep it providing the particularity while in capable of every kinds of emergency.

To build up these classes in practice, a tree structure, which has a root node named abstract emergency as the parent of any emergency, is helpful. And child nodes of the tree can be specific domain and other emergency type, but only the domain

node can have descendants. If a concrete emergency happened, there must be a sole domain node can contain it and all it's involved, that indicate the type of the emergency. And if an emergency is complex, also there is a high level domain node, which includes other detailed domains, can be the superior.

In addition, the events belonging to one same domain should be grouped by its quantitative property such as numbers of involved persons. Acreage of the spot etc. for the superior domain ontology is more of qualitative classification.

After the preparation listed above, the work flow of a concrete emergency response can be constructed as following.

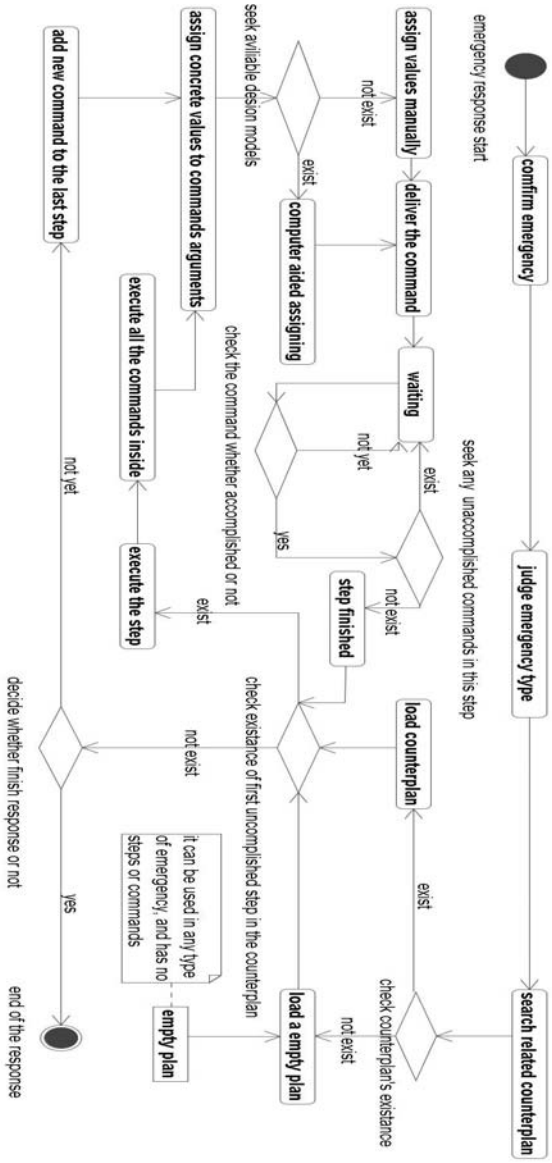

Figure. 2. Workflow in universal emergency response system

4 CONCLUSION

In front of the challenge of complexity of emergency, path divides. Most of emergency response system researches focus on the interoperation among different information systems which aiming at one type of emergency or one part of the response procedure. But we choose the construction of a universal emergency response system, and are enlightened by the semantic analysis which has make lots of achievements in build up domain ontology or semantic web; we research on the documents in which the response process wholly described, using methods of semantic annotation.

After statistic and analysis, we put forward three somatic rules as VL, which indicate the inner logic of all kinds of emergency responses. Then on the base of VL, the detailed design of universal emergency response system is made out, this design is capable of storing all the information fragments in emergency response process, even more it is capable of all types of emergency and related decision models.

Future issues

First, VL is extracted from limited samples; it could be of more persuasion if more documents of other kinds of emergency be analyzed.

Second, mapping the semantic roles into computer could be more accurate and quantitative, in the system, the semantic roles that the goal and the object of action using String to provide for compatibility. The assumption that deeper semantic analysis of the predicate verb's arguments could bring some new consequence to define the arguments more accurate and quantitative needs proof.

Third, software engineering technology could make the system development more convenience. In our programming some design patterns and aspect oriented programming are adopted to provide the flexibility. Some other efficient technical methods need to be found out.

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