

Construction of Fuzzy Ontology-Based Terrorism Event Extraction

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Abstract—Fuzzy ontology is based on the concept that each index object is related to every other object in the ontology, with a degree of membership assigned to that relationship based on fuzzy set theory. This paper proposes use cases based on the related process of the terrorism event extraction using fuzzy ontology, especially the terrorism fuzzy ontology construction methodology. The related use cases are represented using the Web Ontology Language (OWL) which is designed to support the representation ontology relation. Additionally, to make the proposed use cases more relevant to implementing the system, the paper presents linguistic variables which serve as a mean of approximate characterization of fuzzy phenomena concepts and also the appropriate characterization of the terrorism fuzzy relations in their properties.

Keywords—fuzzy ontology; ontology construction; OWL; event extraction; terrorism domain;

I. INTRODUCTION

Recent terrorism events in Southern Thailand have shown the degree of unrest, which has now extended to continuous violence. Therefore, there is a need for a decision tool to support policy decisions. In this situation, the research into developing a framework for event extraction using fuzzy ontology learning with a case study on the terrorism domain can be put into practice. It aims to develop an automatic event extraction system for the prediction of which terrorist group is most likely to be responsible for an event. This framework may be alternative decision tool that can support the decision-making for the Southern province policy. This paper is part of the research into developing a framework for the event extraction mentioned above.

Gruber defines ontology as in [1] an explicit specification of a conceptualization which is the objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold among them. The essential point of this definition is that ontology

specifies the concepts, relationships, and other distinctions that are relevant for modeling a domain. The specification takes the form of the definitions of representational vocabulary, such as classes and relations, which provide meanings for the vocabulary and formal constraints on its coherent use. There are many ontological applications that have been presented for the different tasks in information extraction in various domains as in [2, 3, 4, 5].

Fuzzy ontology is extended domain ontology as in [6] and is based on the concept that each index object is related to every other object in the ontology, with a degree of membership assigned to that relationship based on fuzzy set theory invented by Zadeh as in [7]. The fuzzy membership value μ is used for the relationship between the objects in question, where $0 < \mu < 1$, and μ corresponds to a fuzzy membership relation such as “low”, “medium”, or “high” for each object. However, current fuzzy ontology models play a key role in many software applications, but the models describing an uncertainty knowledge representation of ontology is difficult. To present the fuzzy knowledge formally, this paper proposes a solution of the incorporative fuzzy logic into ontology in specific domain as in [8, 9]. Previous research papers have been concerned into ontology construction as in [9], however only a few relate to how to build fuzzy ontology but no paper showing how fuzzy ontology can be applied to the terrorism domain. Therefore, this paper proposes the methodology for constructing terrorism fuzzy ontology for event extraction work using Web Ontology Language (OWL¹).

This paper is organized as follows: Section 2 presents some related definitions of terrorism in fuzzy ontology; Section 3 presents a fuzzy relation using the OWL format; Section 4 proposes the fuzzy ontology construction methodology; Section 5 presents the linguistic variable

¹ OWL is a W3C Candidate Recommendation, designed to support ontologies distributed on the Web, using RDF

analysis of terrorism concepts; and Section 6 concludes the paper.

II. THE RELATED DEFINITIONS OF TERRORISM FUZZY ONTOLOGY

The definition relating to fuzzy ontology based on fuzzy logic theory and reproducing as in [7, 10] for the terrorism domain is given below.

Definition 1: Fuzzy Set. A fuzzy set A on a domain U , is defined by a membership function μ from U to 0 and 1 such that each item in A has a membership value given by μ . This denotes $\varphi(S)$ as a fuzzy set generated from a traditional set of items S . Each item in S has a membership value between 0 and 1. S can also be called as a *crisp set*.

Definition 2: Fuzzy Relation. A fuzzy relation R is a set of triples $\{ \langle x, y, \mu_R(x, y) \rangle \mid x \in X, y \in Y \}$. The $\mu_R(x, y)$ is a membership function mapped from an universe of discourse $X \times Y$ to a real number region 0 and 1. For every $x \in X, y \in Y$, $\mu_R(x, y)$ denotes the membership degree of relation R between x and y .

Definition 3: Fuzzy Ontology. Fuzzy ontology for the terrorism domain is extended domain ontology, to represent notion as $\{S, O, R_U\}$. Here S is set that contain objects, $S = \{O_1, O_2, \dots, O_m\}$. O_k is objects of the concept in set S , and $R_U = R \cup \{C, D\}$ where R is a set of binary relations between S and O of the terrorism domain.

Definition 4: Fuzzy Representation. Each object O can be represented by a fuzzy set $\varphi(O)$ as $\varphi(O) = \{A_1(\mu_1), A_2(\mu_2), \dots, A_m(\mu_m)\}$ where $\{A_1, A_2, \dots, A_m\}$ is the set of attributes and μ_i is the membership of O with attribute A_i . $\varphi(O)$ is called the *fuzzy representation* of O .

III. HOW TO REPRESENT THE TERRORISM FUZZY RELATION USING OWL

The OWL language is a research based revision of the DAML² plus the OIL³ web ontology language. The data described by OWL ontology is interpreted as a set of individuals and a set of property assertions which relate these individuals to each other. The ontology consists of a set of axioms which place constraints on sets of individuals and the

² The DARPA Agent Markup Language that focuses on the creation of machine-readable representations for the Web
³ Ontology Interchange Language regards as an ontology infrastructure for the Semantic Web.

types of relationships permitted between them. This paper, the representation of terrorism fuzzy relations, is modified from [9]. The basic idea is to reify the relation, and is similar to the well-known W3C⁴ technique for presenting N -ary relations in OWL. The set of individuals and its fuzzy relations are built, which includes two-class properties such as class-A and class-B, and one data type property namely *has_fuzzy_degree*. Two classes imply two universes of discourse in fuzzy relation, and the *has_fuzzy_degree* data type property means the corresponding membership degree, for example, 0.79, is the membership degree of any connection between class-A and class-B. Whenever there is a need for an element of fuzzy relation, an instance of their concept and assignment specific values for each property are created.

IV. THE RELATED USE CASES BASED THE EVENT EXTRACTION USING FUZZY ONTOLOGY IN THE TERRORISM DOMAIN

Fuzzy ontology is extended domain ontology which concerns the fuzzy information processing. Fig. 1 describes the total processes of the construction of fuzzy ontology which make use of the specific domain as follows: 1) the input is unstructured data; 2) the definition of related concepts in the domain e.g. instances, objects, and their relationships; 3) the generation of domain ontology; 4) the domain ontology extended as fuzzy ontology; and 5) applying the fuzzy ontology in to the specific domain. This paper proposes the use of case based fuzzy ontology construction methodology for the terrorism domain and is described as follows. Fig. 2 presents the resultant use case that is applied to terrorism domain with the following details:

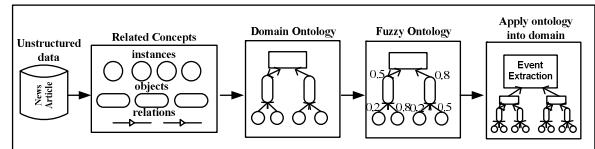


Figure 1. The total process of the construction of fuzzy ontology for event extraction in the terrorism domain.

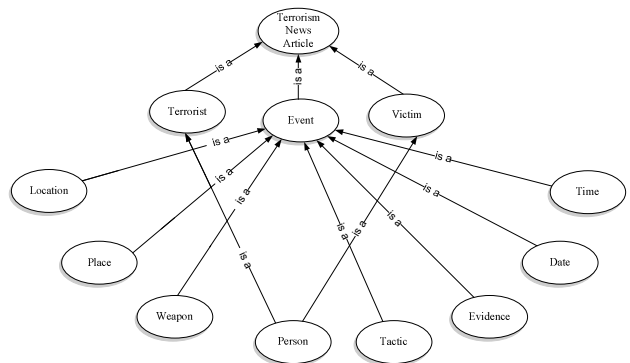


Figure 2. The hierarchy core concepts of terrorism fuzzy ontology

⁴ is the World Wide Web Consortium.

- 1) *Use Case*: The fuzzy ontology construction for event extraction in the terrorism domain.
- 2) *Reusing Consideration*: considering all the existing extended domain ontology.
- 3) *Objects Enumeration*: list all objects which might be related in the terrorism domain.
- 4) *Defined Classes*: classify objects into suitable concepts.
- 5) *Concept Hierarchy*: diagram concepts with restriction relations.
- 6) *Define Properties*: characterize appropriate properties for each concept.
- 7) *Pruning*: removes the unnecessary concepts and properties.
- 8) *Define Constraints*: make clear other right restriction relations among concepts.
- 9) *Create Instance*: produces essential individuals and build component parts of the terrorism fuzzy ontology from relative individuals.

This paper is part of constructing a terrorism fuzzy ontology for an event extraction process. The goal of this event extraction process is to extract relevance instances of a terrorism event, for example, victims, date, places, time, and tactics. The resultant instances from each news article are used to input into the prediction process of the terrorism groups which cause the terrorism events in Southern Thailand. Fig. 3 specifies the use of a case diagram of the prediction process in the form of N -ary relations using OWL.

V. LINGUISTIC VARIABLE ANALYSIS OF TERRORISM CONCEPTS

The analysis of linguistic variables is modified from [7] which is characterized by a quintuple $(\varphi, T(\varphi), U, G, M)$ in which φ is the name of the variable; $T(\varphi)$ is the *term-set* of φ , that is the set of names, X , of *linguistic values* of φ ; U is a universe of discourse; G is a syntactic rule for generating the names, X , of values of φ ; and M is a *semantic rule* for associating a *meaning*, $M(\varphi)$, with each name(linguistic value) in $T(\varphi)$. Generally, $M(\varphi)$ will be assumed to be a fuzzy subset of U .

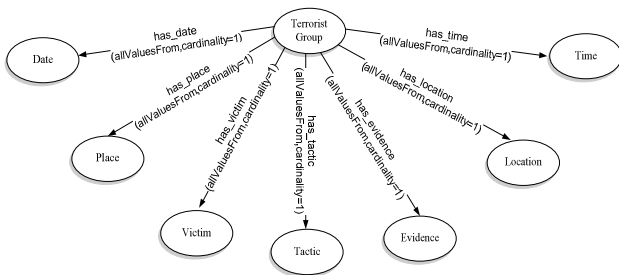


Figure 3. The use of case diagram of the process for prediction of the terrorism group in the form of N -ary relations using OWL hierarchy.

Considering a linguistic variable named *tactic*, the term-set of *tactic*, $T(\textit{tactic})$, may be represented in (1) as follows:

$$\textit{Tactic} = \textit{suicide attack} + \textit{assassination} + \textit{demolition} \quad (1)$$

where '+' denotes the union operation. The universe of discourse for *tactic* may be taken to be the interval of month $[1, 12]$, with the numerical variable μ which ranges over $U = [1, 12]$ constituting the *base variable* for *tactic*. Then, a value of *tactic*, for example, *demolition* may be viewed as a name of a *fuzzy subset* of U which is characterized by its *compatibility function* $c: U \rightarrow [0, 1]$, with $c: (U)$ representing the compatibility of a numerical *tactic* μ with the label *demolition*. For example, the compatibilities of the numerical *tactic* 2, 5, and 3 with *demolition* might be 0.2, 0.5, and 0.3, respectively. A typical linguistic value in (1) contains one or more primary terms whose meaning is both subjective and context-dependent and hence must be defined *a priori*. The syntactic rule represents a context-free grammar which generates the linguistic values in a term set, while the semantic rule is a procedure for computing the meaning of a linguistic value from the knowledge of the meaning of its components.

Fig. 4 reveals an example of a part of terrorism fuzzy ontology, *tactic* object, in the form of a concept diagram referring to OWL restrictions.

VI. CONCLUSION

The research has proposed the use of cases providing for the event extraction using fuzzy ontology in the terrorism domain. The related use cases are represented in the OWL form, which is designed to support the representation ontology distribution. All the proposed use cases are most useful for guiding the implementation of the system in the real world.

However, there is still an initial state of the proposed framework, so another point that helps to clarify the significance of a linguistic variable may be likened to ball-parks with fuzzy boundaries.

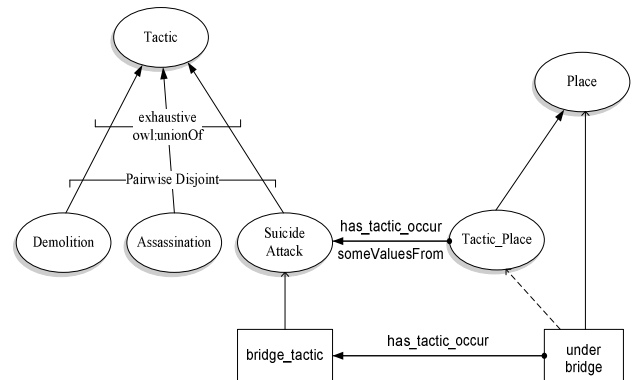


Figure 4. The tactic object and related objects diagram referring to OWL restrictions

Furthermore, the compatibility function which defines the meaning of a linguistic value may be regarded as the membership function of a fuzzy restriction on the values of the base variable. In further research, we would like to represent what the appropriate compatibility function for the calculus of fuzzy restrictions in the terrorism domain is.

REFERENCES

- [1] T. R. Gruber, "Toward Principles for the Design of Ontologies Used for Knowledge Sharing," in *International Journal Human-Computer Studies*, 1995, 43(5-6), pp.907-928.
- [2] D. W. Embley, D. M. Campbell, R. D. Smith, S. W. Liddle, "Ontology-based extraction and structuring of information from data-rich unstructured documents," in *Proceedings of ACM Conference on Information and Knowledge Management*, 1998, pp. 52-59.
- [3] H. S. Alani, S. Kim, D. E. Millanrd, M. J. Weal, W. Hall, P. H. Lewis, and N. R. Shadbolt, "Automatic ontology-based knowledge extraction from web document," in *IEEE Intell. Syst.*, 2003, vol. 18, no. 1, pp. 14-21.
- [4] R. Navigli, P. Velardi and A. Gangemi, "Ontology learning and its application to automated terminology translation," in *IEEE Intell, Syst.*, 2003, vol. 18, no. 1, pp. 22-31.
- [5] N. Guarino, C. Masolo, G. Vetere, "OntoSeek: content-based access to the web," in *IEEE Intelligent Systems*, 1999, pp.70-80.
- [6] D. Parry, "Evaluation of a Fuzzy Ontology-Based Medical Information System," in *Publication of International Journal of Healthcare Information System and Informatics Volume 1, Issue 1*. Idea Group Inc, 2006.
- [7] Eds. G. J. Klir and B. Yuan, "Fuzzy sets, fuzzy logic, and fuzzy system: Selected papers by Lotfi A. Zadeh," in *Advances in Fuzzy systems-Application and Theory*, 1996, Vol.6 pp.195-207.
- [8] H. Gu, H. Lv, J. Gao, J. Shi, "Towards a general fuzzy ontology and its construction," in *The proceedings of ISKE a part of series: Advances in intelligent system research*, October 2007.
- [9] H. Gu, X. Wang, Y. Ling, J. Shi, "Building a Fuzzy Ontology of Edutainment Using OWL," in *ICCS 2007, Part III, LNCS 4489*, Springer-Verlag Berlin Heidelberg, 2007, pp.591-594.
- [10] Q. Thanh Tho and S. Cheung Hui, "Automatic Fuzzy Ontology Generation for Semantic Web," in *IEEE transactions on knowledge and data engineering*, June 2006, Vol.18, No.6.