Research on Ontology Construction and Reasoning of The Theft Cases

Han Zhong[1], Jianqian Zhang[1], Ziyang Yuan[1]

[1]College of Information Technology and Network Security，People's Public Security University of China.

Beijing, 100038, P.R.China.

Abstract:

At present, the degree of automation in the investigation of theft cases is still relatively low. The summary and classification of the contents for the cases are mainly completed manually. In view of these problems, the idea of ontology is introduced into the field of the theft cases in this paper. On the basis of theft case knowledge, this paper puts forward the ontology model construction method. Through analyzing the factors needed for the construction of theft case domain ontology model, the ontology modeling software protégé is used to construct the theft case. The development of case detection intelligent systems provides theoretical basis and technical support. Finally, the inquiry and the reasoning of the design example of the theft cases are implemented, which verifies the feasibility and effectiveness of constructing ontology model.

Keywords:

the theft cases; ontology model; protégé; inquiry ; reasoning

1. Introduction

With the rapid development of intelligent internet and artificial intelligence, the construction of intelligent knowledge base has become an important channel for investigators to obtain information. Researchers have studied the detection of theft cases, trying to sum up the regular characteristics of the contents for the cases. In this context, the construction of ontology plays an important role in the management of theft cases and intelligent knowledge service. And it has become an important method of big data modeling as well, which can provide a general way of knowledge sharing. This study builds ontology to construct the data

set of theft cases so as to further improve the level of knowledge reuse in the process of investigating theft cases. In this paper, the ontology is introduced into the field of the theft case. Constructing the ontology model of the theft case realizes the preservation of the theft case knowledge and verifies the validity of the ontology model through the design examples for query and reasoning.

2. Background and Related Work

Originated from the field of philosophy, the concept of ontology is a systematic description of the objective things in the world [1]. The concept of ontology has been introduced into the computer field in the 1990s. It can describe knowledge at the semantic level and belongs to the general conceptual model of domain knowledge. At present, with the development of ontology technology and knowledge graph, many research institutions at home and abroad have carried out research about ontology construction in their respective fields [2]. Teng Chune et al. [3] put forward the ontology construction of intangible cultural heritage resources knowledge organization and analyzed the importance of ontology theory in the construction of intangible heritage organization. Xu Wei et al. [4] put ontological idea into the field of ship cabin layout design and the construction method of ontology model is proposed. For education, Yuan Man et al. [5] constructed a standardized ontology model supporting multilingual retrieval to solve the problem of cross-language semantic information retrieval in the field of education. In the field of language, Yuan Wei and others [6] designed a method to describe Russian news text and topic information based on ontology. In the field of water resources, Xie Zeyu et al. [7] constructed a facet ontology in the field of international freshwater disputes and realized the storage of facet ontology knowledge. In the field of petroleum, Gong Faming et al. [8] proposed a domain ontology construction process based on graphical database. The analysis of the ontology construction is mostly used in the ontology

construction of e-commerce domain [9], the field of knowledge representation [10], the research of knowledge reasoning construction [11] and other fields [12]. In the military field, it is common to study the ontology modeling of enemy tactical intention [13], the construction of combat operations ontology [14] and the description of complex video content with ontology framework [15]. In the security field, there are the ontology modeling from the early network forensic ontology construction [16] to the construction of terrorist organization ontology [17], the construction of crime domain ontology and knowledge reasoning [18] in recent years. Ontology is essentially a representation of knowledge and there is a demand for knowledge representation in any field. However, there is little research on the knowledge representation in the field of theft cases using ontology technology.

The specific form of knowledge set in ontology can be obtained by ontology reasoning because the ontology is the organization form of information. And the knowledge in the ontology can be used to realize the semantic reasoning and application. In order to optimize the ontology construction or expression and obtain the specific form of knowledge collection to serve the case investigation, ontology-based reasoning can extract the implicit semantic association in the ontology and use it to detect whether there is conflict or inconsistency in the ontology definition. Ontology-based reasoning can effectively sum up knowledge, accumulate knowledge and solve inaccurate research problems caused by lack of experience. At the same time, ontology technology can standardize the accuracy of knowledge formation rules within a certain scope. In recent years, ontology-based reasoning has been applied to many fields. For example, ontology-based reasoning has been studied [19] in criminal trial cases. Li formulated reasoning rules to realize the cognition and reasoning of the attributes for objects, using ontology modeling language to model the knowledge of objects [20]. In the field of innovative design, Zhang Xing and others used ontology to express scientific effect

knowledge and constructed a model of scientific effect ontology. And they realized the sharing and reuse of scientific effect knowledge through semantic reasoning [21]. In terms of combat, Li Xin et al. put forward a semantic reasoning method for the operational plan of the action mode framework, which provides a reference for constructing the model through ontology and using semantic reasoning for operational evaluation [22]. Concerning how to judge the incidence of emergencies in emergency scenarios, Li Shuoming et al. proposed an ontology-based emergency scene reasoning model, which provides a method for dealing with emergencies [23]. Therefore, ontology modeling or reasoning application of many fields provide reference to the process of case investigation. At present, there are few researches about the use of ontology technology in the field of theft investigation. And the semantic understanding of the content needs specific background knowledge. There is lack of unified and standardized semantic description in the field of case investigation. This paper constructs the knowledge model of theft case through the ontology construction technology and seeks to improve the knowledge sharing and reuse methods, helping researchers to improve the level of utilization for domain knowledge in this field. The theory of ontology modeling is applied to the field of case investigation and the domain ontology knowledge base is constructed by collecting key concepts in the field and describing the relationship between concepts. At the same time, there is an urgent need for intelligent methods to understand, store, index and retrieve clue data at the semantic level with the growth of clue resources in the process of case investigation. In order to facilitate the investigation by the police, the semantic layer description of shared clue content requires a unified definition. Therefore, the definition of clue semantics using ontology normalization has become an inevitable development trend in the field of clue analysis in the process of case investigation.

3. The Method of Ontology Construction for The Theft Cases

3.1 The Construction of Conceptual Hierarchical Relationship in Theft cases

It is necessary to determine the hierarchical relationship of the concepts in the ontology before constructing the ontology of theft cases. By analyzing the characteristics of many theft cases, the categories of theft cases are divided into the first class and the second class. The first class includes: the occurrence time of the case, the place, criminal instrument, criminal act, involved person, the loss, stolen goods, protective measures, etc. The time of the case includes daytime, evening, late night. And this is a secondary class. Among them, if the crime occurs in the daytime, the daytime can also be divided into working hours, spare time and rush hour. That is, the class level can be gradually expanded to the next level according to the hierarchical relationship. In this way, the hierarchical relationship of theft case is obtained. OWL Viz represents the hierarchical diagram of class relationship in protégé. The conceptual hierarchy system of theft case ontology is shown in Fig. 1.

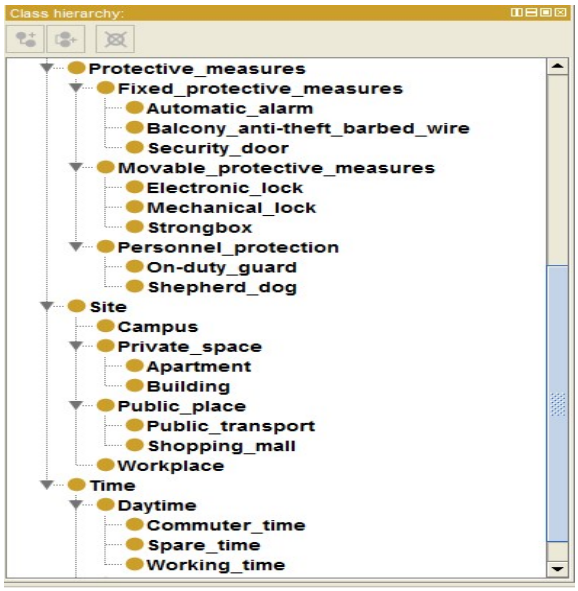

Fig. 1. Conceptual system of theft case ontology

3.2 The Definition of Classes, Properties, Relationships and Related Constraints

The class is a set of individuals, which can describe the actual concepts in the domain. And the concept can be the actual thing or the abstract concept. For example, Violent-physical-tool which is a violent physical tool among the crime tools is a collection of axe, gun and crowbar. These individuals can also be regarded as a separate class, that is, an individual can't belong to two categories at the same time. Equivalent classes, disjoint classes and subclassof are the three axioms of the class. For example, the equivalent classes of the violent-physical-tool in the criminal tool are set as criminal-tool and violent-stealing some involved-objects, which represents the relationship between classes and is mainly used for reasoning. At the same time, there is a parent-child relationship between classes. The superclass refers to the parent class and the subclass refers to the child class. Disjoint classes indicate that the class does not intersect with each other.

Properties include the object properties and data properties. The object properties mainly describe the relationship between classes. And its characteristics contain belong, electronic-stealing, violent-stealing, stealing-wisely and so on. At the same time, break-technically is a sub-attribute of electronic-stealing and break is a sub-attribute of violent-stealing, which describe the domains and ranges of object properties separately. The object property is a relational attribute that defines the relationship for the two classes. For example, the domains of the "belong" is a criminal tool and its ranges is a tool involved in the theft cases, describing the relationship between the criminal tools and the theft cases. Data properties mainly describe the relationship between instances and the data. They can assign values to a class. For example, the data properties in the theft case ontology contain the volume, weight, etc. of the theft tool. If a crowbar is the criminal tool, it can describe the size and weight of the crowbar with defining its data properties. The object properties in the theft means ontology are listed, as shown in Table 1.

Table 1. Object property of the theft means ontology

Object properties	Domains	Ranges
belong	Criminal-tool	Larceny-cases
electronic-stealing	Criminal	Involved-objects
violent-stealing	Criminal	Involved-objects
stealing-wisely	Criminal	Involved-objects

In the software of protégé, the OWL ontology is mainly composed of class, properties and individual. Equivalent classes are used to define classes that are equivalent to the current class, mainly for reasoning. Superclasses are the parent classes that define the parent class of current class and it is the restricted class. There are existential quantifier some, universal quantifier only, minimum cardinal quantifier min, maximum cardinal quantifier max and

accurate value of cardinal quantifier exactly. These are the conditions for restricting attributes to confine the object attributes. Constraints include quantifier constraints, cardinality constraints and existential value constraints. As shown in Table 2, these constraints will be used as a reasoning basis for inference engines.

Table 2. The main relationships in the theft case ontology

Main relationship	Examples	Description
Equivalent classes	Violent-physical-tool	Criminal-tool and Violent-stealing some involved-objects
Superclasses	Crowbar	Violent-stealing some lock
Disjoint classes	Insert-code-breaker	Memory-electronic-card-reader

3.3 The Definition of Individuals for The Theft Case Ontology

It is necessary to organize the knowledge of the theft case in the process of constructing the theft case ontology. And it is not only to establish a data structure of the theft case resource, but also to express the inner knowledge connection and facilitate the sharing of knowledge. At the same time, the theft case ontology is equivalent to a conceptual map, which could search relevant resources through the hierarchy and relationships between the classes. It determined which class the instance belongs to through filtering common theft case data and created an instance under this class and assigned its attributes. Based on the addition and construction of individuals, the added individuals and the property panel are shown in Fig. 2.

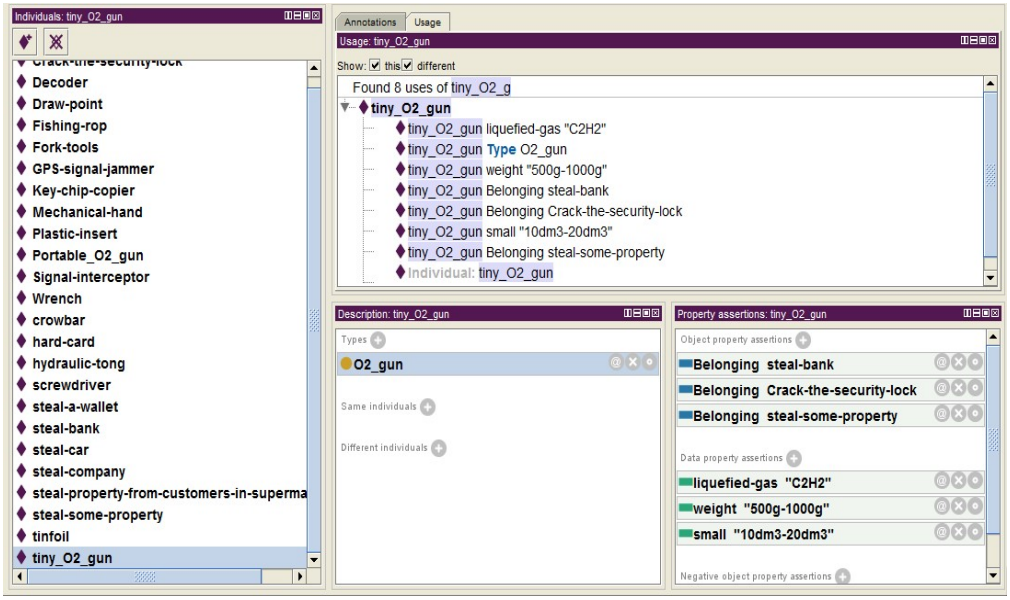

Fig. 2. Visualized result of individuals and properties

4. Semantic Reasoning and Verification Based on The Ontology

4.1 The Construction of Ontology Model

In order to verify the feasibility of the theft case ontology proposed above, the metadata standard and specification are used for semantic description and converted into the computer language. The ontology editing tool protégé 4.1 is used to construct the ontology of the theft case and the reasoning machine used in this paper is the HermiT 1.3.8. The visualization results of the theft case ontology model are shown in Fig. 3.

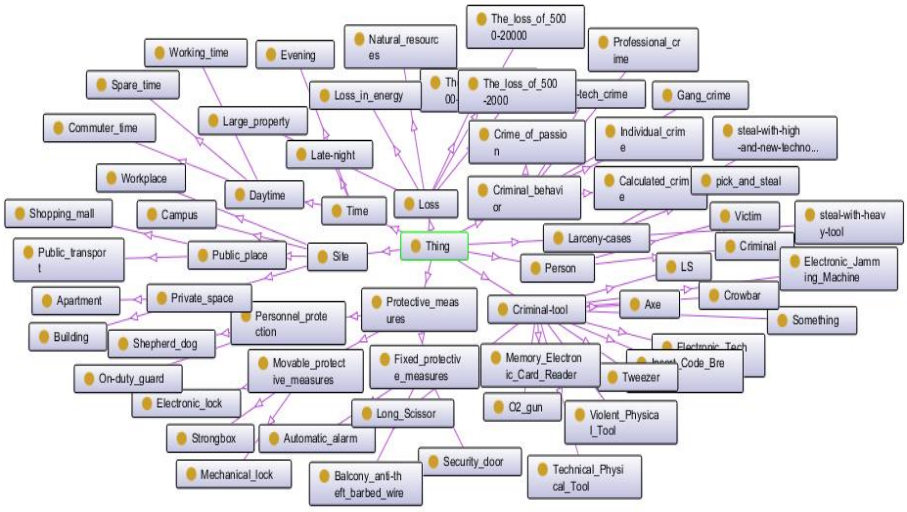

Fig. 3. Visualized result of the theft case ontology

The fragment of the theft case ontology is described in OWL(Ontology Web Language) as follows:

…

<owl:Class>

<owl:intersectionOf rdf:parseType="Collection">

<rdf:Description rdf:about="http://www.semanticweb.org/ontologies/2019/1/Ontology1550305505578.owl#Crime_Tool"/>

<owl:Restriction>

<owl:onProperty rdf:resource="http://www.semanticweb.org/ontologies/2019/1/Ontology1550305505578.owl#Steal_Technically"/>

<owl:someValuesFrom rdf:resource="http://www.semanticweb.org/ontologies/2019/1/Ontology1550305505578.owl#Something"/>

</owl:Restriction>

</owl:intersectionOf>

</owl:Class>

…

The main concepts of the theft case are as follows:

Time: working time, spare time, rush hour, evening, late night, etc.

Venue: public transport, shopping malls / hospitals / coffee shops / Internet cafes / KTV, places of work or production, campuses, private places, etc.

The person involved: the victim, the criminal.

Types of crime: individual crime, gang crime, high-tech crime, short-term passion crime, long-term premeditated crime, etc.

Criminal tools: electronic technology tools, violent physical tools, etc.

Loss: natural resources, large assets, etc.

Protective measures: protective personnel, fixed protective measures, movable protective measures, etc.

4.2 The Implementation of Class Query and Simple Reasoning

Taking a theft case as an example, we used the ontology knowledge base to query the case firstly. If you query the class object “Electronic_Technique_Tool” in the description of logic

plug-in DL query and run the inference engine, the query panel is shown in Fig. 4. You can get the query results of this class description, as shown in Table 3.

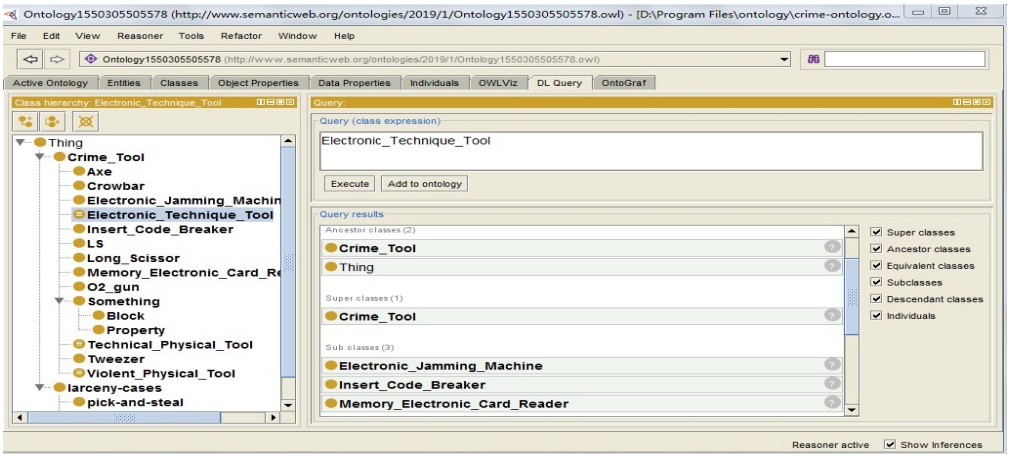

Fig. 4. Simple query based on DL query

Table 3. The result of DL query

Queried objects	The result of query
Super classes	Crime_Tool
Ancestor classes	Crime_Tool, Thing
Equivalent classes	Electronic_Technique_Tool
Sub classes	Electronic_Jamming_Machine,Insert_Code_Breaker,Memory_Electronic_Card_Reader
Descendant classes	Electronic_Jamming_Machine,Insert_Code_Breaker,Memory_Electronic_Card_Reader
Individuals	Key-chip-copier, Signal-interceptor, GPS-signal-jammer

In addition to the above query, you can also make reasoning. The electronic technology tools used by criminal tools is a class, which also defined electronic jammers, plug-in password lock decider, memory electronic card readers and so on. At first, only the electronic technology tools were involved in the initial cases. The memory electronic card reader was a

kind of electronic technology tool by the reasoning, which provided assistance for investigators to identify the theft cases of electronic technology. The plug-in password lock decider was originally considered as a criminal tool and turns into the electronic technology tool after reasoning. The ontology relationship graph before reasoning is shown in Fig. 5. And the visualization tree diagram after reasoning is implemented, as shown in Fig. 6.

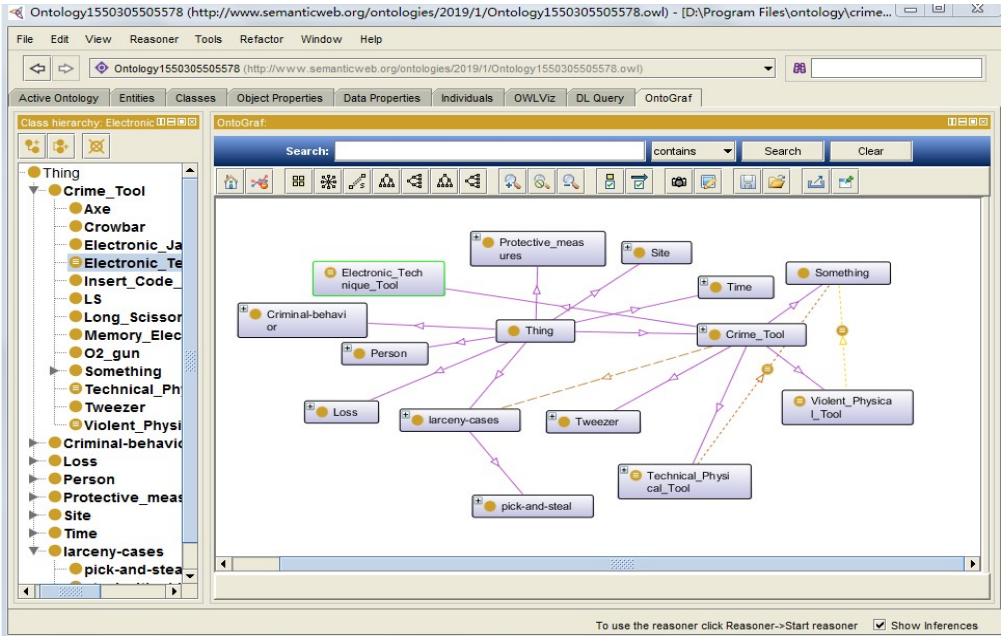

Fig. 5. The ontology model before reasoning

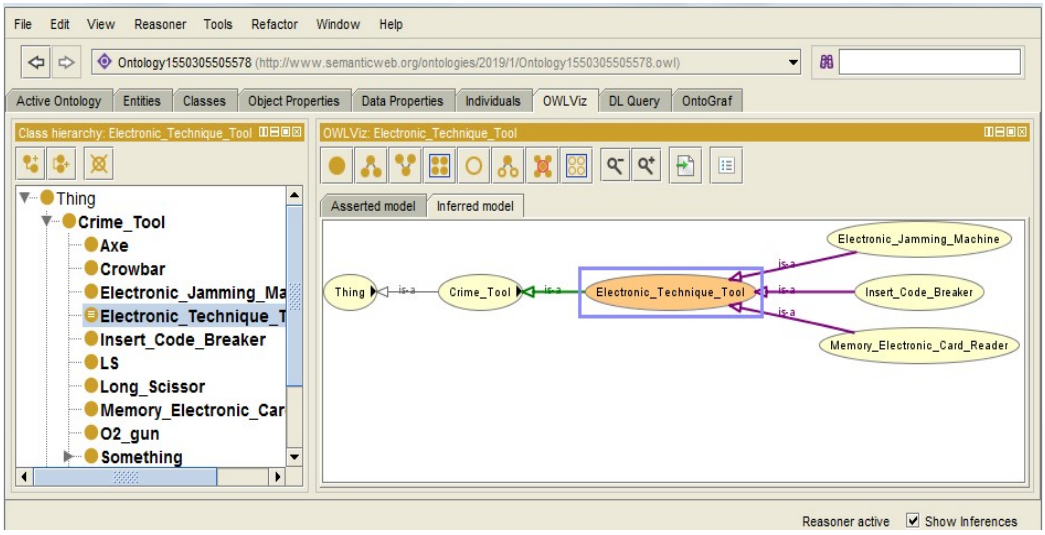

Fig. 6. The inferred model about electronic_technique_tool

5. Conclusion and Future Work

This paper sorts out and sums up the characteristics of theft cases and proposes the construction method of theft case ontology by establishing the class, attributes and relationships. Ultimately，the simple class query and reasoning are carried out through the established ontology model, which verifies the feasibility and effectiveness of the ontology model. It is necessary to update and develop the ontology constantly because of the long-standing incompleteness of domain knowledge. The future work will develop the deeper layer of the theft case ontology and realize the semi-automatic classification or early warning research about theft cases.

Acknowledgments

This work was supported by the JKF program of People's Public Security University of China (2019JKF334), and the National Key Research and Development Plan (2016YFC0801003).

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