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Semantic graph construction for 3D geospatial data of multi-versions

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ABSTRACT

3D geospatial data holds rich information that causing significant tough workload in 3D geospatial semantic building. In order to avoid those difficulties in building high precise semantic, this paper focuses on creating a semantic graph for 3D geospatial data via the novel approach called semantic graph. Firstly, all data related to geo-spatial are organized through semantic conceptualization processing. Its result is divided into conceptual description and formal pattern involving all features belong to certain 3D object or scene. Then from perspective of spatial, thematic and temporal domains, multi-versions semantic relations are created depend on relational rules and semantic mapping mechanism. On the basic of semantic conceptualization processing, all conceptual and formal patterns are controlled as semantic integrated result. Since the result covers spatial, thematic and temporal semantic information of 3D geospatial field, approach proposed by this paper can generate 3D geospatial data semantic graph based on semantic conceptualization and accomplish the transform from 3D geospatial data to 3D geospatial semantic effectively.

1. Introduction

Holding appropriate ability to provide virtual geospatial scene and reality, 3D geospatial data has been exploited in multi-fields implements of geomatics [1–3]. However, in general the similar geospatial 3D original data in geomatics would be resulted in different information based on diverse backgrounds and fields. These different descriptions for similar 3D geospatial scene or interesting object lead to significant restrictions in 3D geospatial data applications. Therefore, semantic building for 3D geospatial data was proposed for eliminating the semantic heterogeneity problem. Current researches on 3D semantic modeling can be divided into three major categories. Most of methods are oriented to 3D object features, they employ object properties, shape features and other features to build 3D semantic. Larrivee et al. [4] proposed the method to rich semantic information of geo-spatial data through 3D object concept processing, Pitikakisd et al. [5] created the management framework for 3D shape knowledge, Marco et al. [6] built semantic annotation based on description on 3D shape features. The second type of semantic modeling approach focuses on segmentation of 3D virtual scenes or visual recognition based on 3D space simulation, it mainly create 3D granularity, 3D assembling and other segment results to build 3D semantic. Mendez et al. [7] successfully gave visual model for 3D underground equipment, Mortara et al. [8] built a semantic model driven study on visual constancy of 3D semantic. Papamanthou et al. [9] and Luis et al. [10] made semantic application based on 3D visual recognition, Rabiahak et al. [11] proposed natural language oriented to 3D visualization via semantic description. The final kind of method concentrate on the transformation from 3D features to 3D knowledge, they employ methodologies including semantic driven model or data mining tool to build domain database or information interface between machine learning and human being recognition. Zlatabivaas et al. [12] provided topological model for object staying in 3D space. Vrotsou et al. [13] created a 3D feature mining method from geographic spatio-temporal data. Groeger et al. [1] designed an interactive urban 3D semantic modeling methodology.

Those above achievements stand for current trend of semantic modeling for 3D data. However, at least three major limits have been arisen in several aspects. Firstly, integration of spatio-temporal representations and object or scene semantic can't be accomplished completely in most 3D semantic model, which makes dynamic variation can only be described in semantic without reasoning mechanism and semantic relations. Secondly, researches on concept processing of 3D geospatial data only focus on object or scene definition rather than creating formalized description for characters of object or scene. Thirdly, semantic modeling achievements are built according to single version instead of semantic gap solution and semantic organization for multi-versions. Therefore, this paper concentrates on building 3D geospatial semantic based on semantic graph, which was created by semantic conceptualization for certain 3D object. Whereafter, series of single semantic

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concept are organized by ontology and semantic mapping mechanism as semantic graph.

The following parts of this paper include: Section 2 gives significant aspects related to semantic conceptualization for 3D geospatial data. Section 3 proposes the methodology of multi-versions 3D semantic graph building via relational rules and semantic graph mapping. Section 4 provides demonstrative experiment based on diverse 3D models extracted from our image city infrastructure [15]. Section 5 makes summary about our approach and prospect on future development of 3D semantic and semantic building.

2. Semantic conceptualization for 3D geospatial data

Concept semantic [14,15] is regards to a semantic building procedure based on descriptive concept. In 3D geospatial space, it can be viewed as the transformation from 3D geospatial data to 3D semantic. The key of concept semantic lies in organizing general concept and giving knowledgeable connotation through knowledge-driven model, semantic interface tool, ontology formalization and other approaches. Whereas, semantic concept or semantic conceptualization [16,17] not only covers semantic knowledgeable building but also includes multi-versions background. Since geo-spatial space includes significant wide fields, 3D geospatial data would be applied in different domains and should be transferred into knowledge depend on diverse backgrounds. In this paper, our model of semantic conceptualization for 3D data is shown as follows,

$$3dSC \in \{def, sub, pac, teo, loc, \theta\} \tag{1}$$

In Eq. (1), $(3d)SC$ stands for semantic concept of 3D geospatial data, it contains six sub-structures:

def stands for definition of 3D geospatial data or concept semantic of 3D geospatial data. It is a *string* data structure and is designed for definitive description of 3D geospatial data like building, road, tunnel etc.

sub stands for applied field of 3D geospatial data. It is a *string* data structure and is designed to restrict 3D application background. For example, 3D geospatial data of concept semantic named building can be restricted into certain fields like cadaster, infrastructure, landscape etc.

teo stands for time of 3D geospatial data. It contains time quantum (teo_i) and time point (teo_p). Both of them belong to *int* data structure. Time quantum refers to available time range. For example, the property right of one 3D building object of China stays in 2006–2076. Time point refers to available time node and contains year (teo_p_y), month (teo_p_m) and day (teo_p_d). Both of them belong to *int* data structure.

loc stands for location element of 3D geospatial data and contains geospatial coordinate (loc_cs) scale (loc_s) and geospatial location (loc_l). Geospatial coordinate is the geographic coordinate system applied in creating 3D space, and it belongs to *string* data structure. Scale refers to visual scale of 3D scene and is *string* data structure. In addition, the size of scale determines 3D geospatial data expression form and variation of locationing elements. Geospatial location contains text location (loc_l_d) and coordinates position (loc_l_c). Text location belongs to *int* data structure and coordinates position is designed as *double* data structure. For example, one 3D geospatial object owns text location: NO.1, Luoyu Road, Wuhan, Hubei Province, China. And it also owns coordinate location: 120.56/201.30.

pac stands for module of 3D geospatial data. It contains module tag (pac_n) with *double* data structure and module geometric feature (pac_g) with *string* data structure. Especially, geometric feature can be created based on text description (e.g. angular, circle etc.) or code description (e.g. N21 etc.). θ stands for memo, which can be viewed as interface with other version semantic.

3. Multi-versions 3D semantic graph building

3.1. Relational rules

In general, multi-versions semantic organization calls for ontology support [18]. Semantic from multi data sources can be integrated by complete restriction and continuous description [19]. In addition, Ontology Web Language (OWL) is regard as appropriate tool to build ontology currently [20]. It includes five basic category: domain, range, class, individual and property and extensive forms like subclass, subdomain etc.

$$\begin{cases} \{domain\} : (property) : \{range\} \\ \{class\} : (property) : \{individual\} \end{cases} \tag{2}$$

Eq. (2) gives one of the fundamental forms of building ontology. In this paper, the property structure of 3D multi-versions geospatial data based on OWL concludes three major sub-categories: relation property, data property and basic property. Relation property gives all relations in 3D geospatial semantic and contains *part-of*, *coincide-of*, *connect-of*, *distinct-of*, *prior-to* and *posterior-to*. Data property creates the bridge between domain and range, it contains *has-number*, *has-volume* and *has-value*. Basic property is designed to control the connection between class and its individual, it contains *instance-of* and *class-of*.

In order to illustrate relation property clearly, α, β and ε are employed to represent for the descriptions of space feature, thematic feature and temporal feature.

$$\begin{cases} \alpha : \{Shanghai\} : (part\text{-}of) : \{China\} \\ \beta : \{Shanghai\} : (part\text{-}of) : \{China\} \\ \varepsilon : \{Sep, 2012\} : (part\text{-}of) : \{2012\} \end{cases} \tag{3}$$

In Eq. (3), *part-of* expresses the dependent relations in spatial, thematic and temporal separately. In spatial category (α), Shanghai is part of China. In thematic category (β), Shanghai is one of four province-level municipalities where under the direct control of the Chinese State Council. In temporal category (ε), September in 2012 is part of the whole 2012 year.

$$\begin{cases} \alpha : \{Changjiang\ River\} : (coincide\text{-}of) : \{Yangtze\ River\} \\ \beta : \{Beijing\} : (coincide\text{-}of) : \{Peking\} \\ \varepsilon : \{Labour\ Day\} : (coincide\text{-}of) : \{1st, May\ 2012\} \end{cases} \tag{4}$$

In Eq. (4), *coincide-of* expresses the similar relations in spatial, thematic and temporal separately. In spatial category (α), Changjiang is overlapped with Yangtze River. In thematic category (β), Beijing is equal to Peking, they are belong to two different names of the same city. In temporal category (ε), 1st May 2012 is the International Labor Day.

$$\begin{cases} \alpha : \{Nile\ River\} : (connect\text{-}of) : \{Mediterranean\} \\ \beta : \{tornado\} : (connect\text{-}of) : \{typhoon\} \\ \varepsilon : \{2011\} : (connect\text{-}of) : \{Rabit\ Year\} \end{cases} \tag{5}$$

In Eq. (5), *connect-of* expresses the cross relations in spatial, thematic and temporal separately. In spatial category (α), Nile River is adjacent with the Mediterranean. In thematic category (β), tornado is equal to typhoon in several certain aspects. In temporal category (ε), most of 2011but not the whole year are belong to the Rabbit Year of Chinese traditional culture.

$$\begin{cases} \alpha : \{California\} : (distinct\text{-}of) : \{Maryland\} \\ \beta : \{Washington\ D.C.\} : (distinct\text{-}of) : \{Washington\ State\} \\ \varepsilon : \{2012\} : (distinct\text{-}of) : \{2013\} \end{cases} \tag{6}$$

Table 1
Attribute of property.

Attribute	Property
union	coincide-of/has-number/has-volume/has-value
inUnion	coincide-of
reverse	coincide-of/connect-of/distinct-of
trans	part-of/coincide-of
reflex	coincide-of

In Eq. (6), *distinct-of* expresses the distinct relations in spatial, thematic and temporal separately. In spatial category (α), California stays in different area compared with Maryland. In thematic category (β), Washington D.C. is capital city of USA, different with Washington State. In temporal category (ε), 2012 year is different with 2013 year.

$$\begin{cases} \alpha : \{Russia\} : (prior\text{-}to) : \{France\} \\ \beta : \{Oympic\ Games\} : (prior\text{-}to) : \{Asia\ Games\} \\ \varepsilon : \{2006\} : (prior\text{-}to) : \{2008\} \end{cases} \tag{7}$$

In Eq. (7), *prior-to* expresses the precede relations in spatial, thematic and temporal separately. In spatial category (α), land area of Russia is larger than France's. In thematic category (β), the level of the Olympic Games is higher than the Asia Games. In temporal category (ε), 2006 is before 2008.

$$\begin{cases} \alpha : \{Germany\} : (posterior\text{-}of) : \{Canada\} \\ \beta : \{county\} : (posterior\text{-}of) : \{province\} \\ \varepsilon : \{2010\} : (posterior\text{-}of) : \{2009\} \end{cases} \tag{8}$$

In Eq. (8), *posterior-to* expresses the inferior relations in spatial, thematic and temporal separately. In spatial category (α), land are of Germany is smaller than Canada's. In thematic category (β), the level of province is higher than county. In temporal category (ε), 2010 is posterior to 2009.

Specifically, the difference between *part-of* and *connect-of* is given as follows.

Assuming object A is "*part-of*" object B, any sub-parts of object A are belong to object B. Whereas, assuming object A is "*connect-of*" object B, not all but some sub-parts of object A are belong to object B.

$$\begin{cases} \{A\}(part\text{-}of)\{B\} : \forall a \in A \Rightarrow a \in B \\ \{A\}(connect\text{-}of)\{B\} : \exists a \in A \Rightarrow a \in B \end{cases} \tag{9}$$

Furthermore, the difference between *part-of*, *prior-to* and *posterior-to* is given as follow. Assuming object A is "*part-of*" object B, any sub-parts of object A are belong to object B. Whereas, assuming object A is "*prior-to*" object B or is "*posterior-to*" object B, there are not any sub-parts of object A are belong to object B.

$$\begin{cases} \{A\}(part\text{-}of)\{B\} : \forall a \in A \Rightarrow a \in B \\ \{A\}(prior\text{-}to)\{B\} : \forall a \in A \Rightarrow a \notin B \\ \{A\}(posterior\text{-}to)\{B\} : \forall a \in A \Rightarrow a \notin B \end{cases} \tag{10}$$

In data property, *has-value* regards to descriptive information is the content between domain and range, *has-number* regards to numeric information is the content between domain and range, *has-volume* regards to 3D geometric information is the content between domain and range.

In basic property, *class-of* and *instance-of* are fundamental relation in formal pattern for class and individual. For example, Chicago is class of Wisconsin, and Singapore is instance of countries of the United Nation.

All attributes of element in property are shown in Table 1.

In Table 1, Union stands for uniqueness. For example, London is the only one capital of the Great British. InUnion stands for inverse uniqueness. For example, Paris is the only one capital of France. Inversely, France is the only one country that Paris appears as capital city. Reverse stands for reversibility, like the Changjiang River equals to the Yangtze River. Reversely, the Yangtze River equals to the Changjiang River. Trans stands for transitivity, like Italy belongs to Europe, and Turin belongs to Italy, therefore Turin belongs to Europe. Reflex stands for reflexivity, any 3D object who owns this attribute should belong to the only one substance. For example, the Earth can reflect itself because it belongs to the unique one substance.

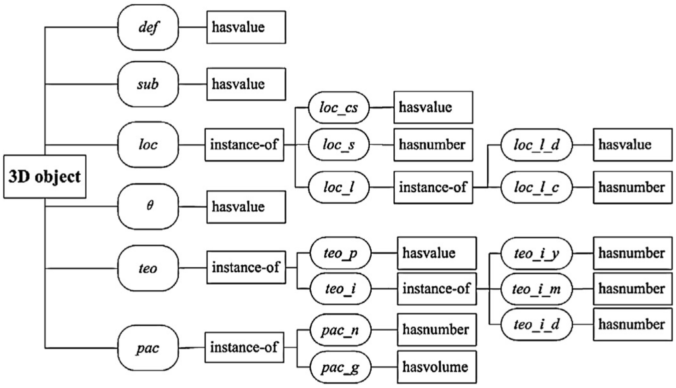

Fig. 1. Mapping formula of semantic conceptualization oriented to 3D geospatial object.

3.2. Semantic graph mapping of 3D geospatial data

Since semantic building based on 3D geometric space (e.g. 3D cadaster, 3D underground etc.) focuses on fuzzy handling for geometric graph, the semantic precision of fine 3D geospatial data can't be guaranteed fully. In this paper, semantic of multi-version 3D geospatial data is achieved by object semantic conceptualization rather than object oriented method. Semantic graph mapping mechanism of 3D geospatial data contains mapping formula and Semantic graph mapping.

Mapping formula includes two basic types: relation of domain and range, and relation of class and instance. The whole 3D semantic mapping formula is constructed based on six fundamental sub-structures involving relation property, data property and basic property (Fig. 1).

In Fig. 1, the formal pattern is built based on relation property. All the formal patterns are displayed by curved frame. The major structure of formal pattern contains the following aspects: definition of 3D geospatial data (def), applied field of 3D geospatial data (sub), time of 3D geospatial data (teo), location element of 3D geospatial data (loc) and module of 3D geospatial data (pac). In addition, the sub-structure of formal pattern includes: time quantum (teo_p), time point (teo_i), year (teo_i_y), month (teo_i_m) and day (teo_i_d), geospatial coordinate (loc_cs), scale (loc_s), geospatial location (loc_l), text location (loc_l_d), coordinates position module (loc_l_c), tag module (pac_n) and geometric feature (pac_g).

Conceptual description is given based on data property and basic property, which are displayed by rectangular frame. Basic property creates the hierarchical structure of conceptual descriptions, and data property creates the detailed information according to data structure of formal pattern.

Semantic graph mapping refers to the mechanism that making transformation from single semantic conceptualization to global semantic conceptualization into reality. It is designed to organize all mapping formulas of 3D object into a complete semantic network (Fig. 2).

In Fig. 2, black hexagonal pattern stands for diverse 3D objects, curved rectangle with twill stands for all details of formal

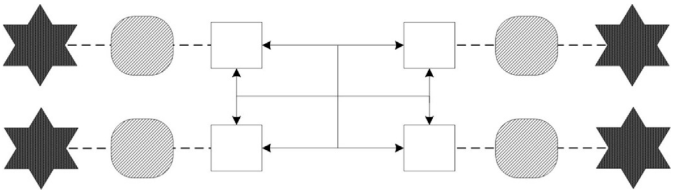

Fig. 2. Semantic concept driven multi-versions 3D geospatial data mapping model.

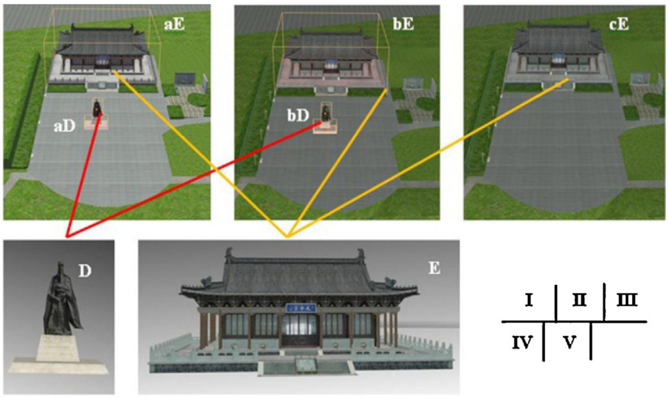

Fig. 3. Multi-versions 3D geospatial data sample.

patterns, and white rectangle stands for all details of conceptual descriptions. Depend on relational rules and semantic graph mapping, the complete semantic network including different 3D objects is constructed depend on conceptual description of formal pattern.

4. Experiment and discussion

In this section, our experiment is created based on 3D city model of Taizhou [15], Jiangsu Province, China. In Fig. 2, graph I gives 3D model built based on aerial remote sensing image of 2009. Graph II gives 3D model built based on aerial remote sensing image with 0.1 resolution shot by SWDC-4 measurement system. Graph III gives the same 3D model as graph III applied in another field.

4.1. Semantic conceptualization

a) Semantic conceptualization of object *E* lied in graph V of Fig. 3:

{def□sub□geo□teo∩pac}(class-of){E}	#Concept semantic, applied field, time, locationing element and module are semantic subclasses of object *E*
{def}(hasvalue){Wenhuitan Temple}	#Concept semantic is “Wenhuitan Temple”
{loc_cs}(hasvalue){Beijing_1980}	#Geographic coordinate is “Beijing 1980”
{loc_s}(hasnumber){11.0+2.0}	#Scale is “11.0+2.0”
{loc_l_d}(hasvalue){10 Dongnanyuan, Taizhou}	#Text geographic location is “10 Dongnanyuan, Taizhou”
{loc_l_c}(hasnumber){113.3□240.5}	#Coordinate geographic location is “113.3□240.5”

b) Semantic conceptualization of object *D* lied in graph IV of Fig. 3:

{def∩sub∩geo∩teo∩pac}(class-of){D}	#Concept semantic, applied field, time, locationing element and module are semantic subclasses of object *D*
{def}(hasvalue){Fangzhongyang Statue}	#Concept semantic is “Fangzhongyang Statue”
{loc_cs}(hasvalue){Beijing_1980}	#Geographic coordinate is “Beijing 1980”
{loc_s}(hasnumber){11.0+2.0}	#Scale is “11.0+2.0”
{loc_l_d}(hasvalue){10 Dongnanyuan, Taizhou}	#Text geographic location is “10 Dongnanyuan, Taizhou”
{loc_l_c}(hasnumber){113.3□240.5}	#Coordinate geographic location is “113.3□240.5”

c) Semantic conceptualization of object *aD* lied in graph I of Fig. 3:

{sub}(hasvalue){city management}	#Applied field is “city management”
{teo_i_y□teo_i_m□teo_i_d}(hasvalue){2008□05□10}	#Year, month and day are“2008□05□10”
{pac_n}(hasnumber){102}	#Module tag is “102”
{pac_g}{hasvolume}{matric5}	#Module geometric character is “matric5”

d) Semantic conceptualization of object *bD* lied in graph II of Fig. 3:

{sub}(hasvalue){relics management}	#Applied field is “relics management”
{teo_i_y□teo_i_m□teo_i_d}(hasvalue){2011□10□20}	#Year, month and day are“2011□10□20”
{pac_n}(hasnumber){128}	#Module tag is “128”
{pac_g}{hasvolume}{matric5}	#Module geometric character is “matric5”

e) Semantic conceptualization of object *aE* lied in graph I of Fig. 3:

{sub}(hasvalue){city management}	#Applied field is “city management”
{teo_i_y□teo_i_m□teo_i_d}(hasvalue){2008□05□10}	#Year, month and day are“2008□05□10”
{pac_n}(hasnumber){89}	#Module tag is “89”
{pac_g}{hasvolume}{matric8}	#Module geometric character is “matric8”

f) Semantic conceptualization of object *bE* lied in graph II of Fig. 3:

{sub}(hasvalue){relics management}	#Applied field is “relics management”
{teo_i_y□teo_i_m□teo_i_d}(hasvalue){2011□10□20}	#Year, month and day are“2011□10□20”
{pac_n}(hasnumber){98}	#Module tag is “98”
{pac_g}{hasvolume}{matric8}	#Module geometric character is “matric8”

g) Semantic conceptualization of object *cE* lied in graph III of Fig. 3:

{sub}(hasvalue){relics management}	#Applied field is “relics management”
{teo_i_y□teo_i_m□teo_i_d}(hasvalue){2011□10□20}	#Year, month and day are“2011□11□20”
{pac_n}(hasnumber){91}	#Module tag is “91”
{pac_g}{hasvolume}{matric8}	#Module geometric character is “matric8”

4.2. Semantic logic reasoning

a) *aE* and *bE*:

{aE}:{loc_l}(coincide-of){loc_l}:{bE}	#Geographic location of object *aE* is equal to *bE*’s
{aE}:{def}(coincide-of){def}:{bE}	#Concept semantic of object *aE* is equal to *bE*’s
{aE}:{pac_g}(coincide-of){pac_g}:{bE}	#Module geometric character of object *aE* is equal to *bE*’s

b) *bE* and *cE*:

{bE}:{loc_l}(coincide-of){loc_l}:{cE}	#Geographic location of object *bE* is equal to *cE*’s
{bE}:{def}(coincide-of){def}:{cE}	#Concept semantic of object *bE* is equal to *cE*’s
{bE}:{sub}(coincide-of){sub}:{cE}	#Applied field of object *bE* is equal to *cE*’s
{bE}:{teo}(coincide-of){teo}:{cE}	#Time of object bE is equal to cE’s
{bE}:{pac_g}(coincide-of){pac_g}:{cE}	#Module geometric character of object *bE* is equal to *cE*’s

c) *aE* and *aD*:

{aE}:{loc_cs}(coincide-of){loc_cs}:{aD}	#Geographic coordinate of object *aE* is equal to *aD*’s
{aE}:{loc_s}(coincide-of){loc_s}:{aD}	#Scale of object aE is equal to aD’s
{aE}:{sub}(coincide-of){sub}:{aD}	#Applied field of object *aE* is equal to *aD*’s
{aE}:{teo}(coincide-of){teo}:{aD}	#Time of object aE is equal to aD’s

d) *aD* and *bD*:

{aD}:{loc_l}(coincide-of){loc_l}:{bD}	#Geographic coordinate of object *aD* is equal to *bD*’s
{aD}:{def}(coincide-of){def}:{bD}	#Concept semantic of aD is equal to bD’s

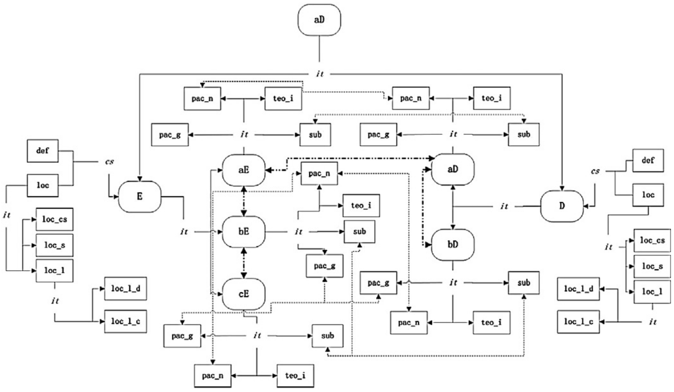

Fig. 4. Multi-versions 3D semantic graph construction based on semantic conceptualization.

{*aD*}*:*{*pac_g*}*(coincide-of)*{*pac_g*}*:*{*bD*}	#Module geometric character of object *aD* is equal to *bD*'s

e) *bE* and *bD*:

{*bE*}*:*{*loc_cs*}*(coincide-of)*{*loc_cs*}*:*{*bD*}	#Geographic coordinate of object *bE* is equal to *bD*'s
{bE}:{loc_s}(coincide-of){loc_s}:{bD}	#Scale of object bE is equal to bD's
{*bE*}*:*{*sub*}*(coincide-of)*{*sub*}*:*{*bD*}	#Applied field of object *bE* is equal to *bD*'s
{bE}:{teo}(coincide-of){teo}:{bD}	#Time of object bE is equal to bD's

According to the above five relational groups, relations can be achieved as follows:

{*aE*}*:*{*loc_l*}*(coincide-of)*{*loc_l*}*:*{*cE*}	#Geographic location of object *aE* is equal to *cE*'s
{*aE*}*:*{*def*}*(coincide-of)*{*def*}*:*{*cE*}	#Concept semantic of object *aE* is equal to *cE*'s
{*aE*}*:*{*pac_g*}*(coincide-of)*{*pac_g*}*:*{*cE*}	#Module geometric character of object *aE* is equal to *cE*'s
{*aE*}*:*{*loc_cs*}*(coincide-of)*{*loc_cs*}*:*{*bD*}	#Geographic coordinate of object aE is equal to *bD*'s
{aE}:{loc_s}(coincide-of){loc_s}:{bD}	#Scale of object aE is equal to bD's
{*aD*}*:*{*loc_cs*}*(coincide-of)*{*loc_cs*}*:*{*bE*}	#Geographic coordinate of object *aE* is equal to *bE*'s
{aD}:{loc_s}(coincide-of){loc_s}:{bE}	#Scale of object aE is equal to bE's
{*cE*}*:*{*loc _cs*}*(coincide-of)*{*loc_cs*}*:*{*bD*}	#Geographic coordinate of object *cE* is equal to *bD*'s
{cE}:{loc_s}(coincide-of){loc_s}:{bD}	#Scale of object cE is equal to bD's
{*cE*}*:*{*sub*}*(coincide-of)*{*sub*}*:*{*bD*}	#Applied field of object *cE* is equal to *bD*'s
{cE}:{teo}(coincide-of){teo}:{bD}	#Time of object cE is equal to bD's
{aE}(connect-of){aD}(connect-of){bE}(connect-of){bD}(connect-of){cD}	#Partly equal relation are shared among object aE, aD, bE, bD and cD

In Fig. 4, *it* signifies instance-of, *cs* signifies class-of, broken line signifies coincide-of, dotted broken line signifies connect-of. On basic of object *D* and *E*, five 3D objects named *aE*, *bE*, *cE*, *aD* and *bD* are employed to build separate semantic concept for each objects through six categories of semantic conceptualization. Then, semantic network is constructed by diverse objects staying in multi-versions via semantic relation.

5. Conclusion

Since 3D geospatial data holds multi versions while applying in diverse implement fields, methodologies for text based and 2D image based semantic building cannot be exploited directly into represent and semantic modeling of 3D geospatial data. In this paper a novel method called semantic conceptualization is proposed to build semantic graph oriented to 3D object. It creates a new semantic concept with six main aspects. Then relational rules and semantic graph mapping are employed in building multi-version 3D semantic. The result of demonstrative application shows that not only multi-versions 3D geospatial semantic can be organized well based on our semantic graph. The future study fields include appropriate approach to 3D geospatial semantic granularity, fuzzy set. Moreover, 3D geospatial semantic integration under certain restricted condition is worth paying attention, as well.

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