GENERATING SPATIAL ONTOLOGIES BASED ON THE SPATIAL SEMANTICS

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ABSTRACT

Spatial ontologies (SO) are used to improve the geographical objects representation in spatial databases. We generate SO by means of the interaction between a spatial subject domain (SSD) and spatial taxonomy (ST). SSD is composed by a priori spatial knowledge, which is related to the "essential properties" (spatial data semantics) of the geographical objects. On the other hand, ST describes the classification among the spatial data, according to the primitives of spatial objects representation. Using such method, it is possible to improve the spatial data representation establishing the geo-information conceptualization that results useful for subsequent spatial data processing and interpretation. Thus, this method of spatial data semantic processing can be considered as a knowledge discovery in the spatial databases (SDB).

KEY WORDS

Spatial Semantics, Spatial Ontology, Spatial Taxonomy, Spatial Subject Domain, Geographic Information System

1. INTRODUCTION

Nowadays, the spatial databases are very useful and powerful tools to handle, display, and process the geographical information. These databases integrate Geographic Information Systems (GIS), which are composed to store and process spatial data. To solve some ambiguities in the spatial data processing and interpretation, the geo-information should have good quality from the input to the representation. The "adequate" representation of spatial data is crucial for improving the decision making in different environments [1].

In this paper, we generate spatial ontologies based on the spatial semantics, which can be used to represent geographical objects by means of spatial concepts ("not words"). Such spatial data conceptualization aim to compress the data and facilitate the knowledge discovery into SDB.

Up-to-date GIS do not extensively explore the spatial data semantics. To develop a spatial semantic theory is a great challenge in the new trends of Geocomputation field. Thus, the spatial analysis can use alternative methods to represent spatial data: this data representation jointly with the semantic rules - both based on data semantics - can be stored in a knowledge-base to generate new concepts that form the spatial ontologies. These concepts are defined by the properties and behavior of geographical objects and explored the by human experience. In general, we seek to correctly represent spatial objects for their subsequent processing [2].

Several works related to semantic interoperability have been published. In particular [3] presents an approach to semantic similarity assessment combining two different strategies: feature-matching process and semantic distance computation.

An approach proposed in [4] has been achieved to improve the spatial data handling. As described in this work, LOBSTER system combines the artificial intelligence techniques to provide a query language more flexible and powerful than standard SQL. This system has been developed in Prolog for object-oriented modeling, geomorphology, and query optimization.

In [5] and [6] an ontology-driven GIS as a system integrator has been proposed. In these works, a special model to conceptualize the geographical information and solve problems related to the integration and interoperability in GIS of different types at different levels of detail has been described.

In [7] the Naive Geography is introduced as a body of knowledge that captures the way people reason about geographic space and time. Probably, future generations of GIS will incorporate formal models of naive geography.
Other works relate to the semantic approach to the spatial data processing based on the concept of geographic entities. [8] enables the seamless integration of several types of information through the use of flexible spatial object classes. These classes are composed by the

combination of other classes that represent the richness of the geographic world.

Nowadays, the interoperability in GIS is approached by using the spatial semantics representation. This interoperability is based on the integration of spatial schemas, query languages and sets of semantic rules, which can provide knowledge of data and geographical representation interfaces [9].

A peculiarity of our proposal is the definition of spatial semantics, which is based on intrinsic properties of the geographical objects. These properties integrate a *knowledge-base*, which can be represented by concepts that form the *spatial ontologies*. In other words to generate spatial ontologies, we define a data *description* that is composed by semantic properties of the spatial data to compose the *spatial subject domain*. Moreover, the spatial data are classified by *spatial taxonomies*. The latter are interacted with the subject domain to generate ontologies. In particular an improvement of representation of the spatial databases can be achieved by using our approach.

This proposal consists of generating ontology levels, which can be defined by *top* or *down* ontologies according to the particularization of the concepts. For this purpose, we consider 2D partition of a map that is composed by a set of primitives of representation. Such maps are stored in spatial databases. However, the approach is focused on describing the semantics of a particular map in two dimensions, which is formed by geographical objects. The approach attempts to find out the spatial semantics throughout spatial ontologies. Using this approach, we seek to enrich the concepts by means of the "interaction" and to improve the spatial data representation.

The rest of the paper is organized as follows. In Section 2 we describe a spatial semantics definition, which is proposed to use in spatial databases. The spatial subject domain and the spatial taxonomy are described in Section 3. Section 4 presents the spatial ontology definition and the interaction approach to generate it. Section 5 contains some results for topographic case of study. Our conclusions are outlined in Section 6.

2. SPATIAL SEMANTICS DEFINITION

To define *spatial semantics*, we use the essential characteristics that involve the spatial data. Our definition is based on providing a set of rules. This set is composed by relationships, properties, functions and behaviors, which define the characteristics of the geographical objects [2].

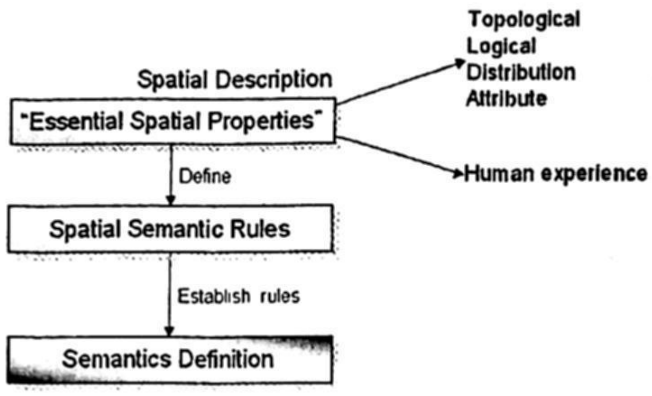

Figure 1. Spatial semantics definition

Figure 1 shows that the spatial semantics definition starts with a spatial description of the geographical objects. This description consists of topological, logical, attribute and spatial distribution properties, which define conceptually spatial semantic rules. To generate the description, it is important to take into account the human experience for establishing the constraints that compose the set of rules. Based on these considerations, we proposed the *spatial semantics definition* [2]. In which 2D spatial objects system is defined by a set of primitives of representation, which form a partition of a map.

A map is composed by tree basic primitives of representation, which are the following:

Point objects. The only geometric information given for a point object is the location, therefore it is represented by a node.

Line objects. The geometric information given for a line object is the location, shape and the length. This can be done by representing it as a polyline. The nodes contain the position information and shape information can be derived from the angles between the edges and their length. The edges can be linked to the line object through the polyline, we can express this link by saying that "the edge is part of the line object". Because of their definition, segments can take the role of edges in the description of the line object.

Polygons objects. The geometry of area objects is given by their boundaries. We assume that the definition of the area objects is such that they cover the total area of interest completely and that they do not overlap. In that case, they form a *geometric partition* of the area. This assumption implies that any part of an object boundary is always the boundary between two objects. If the geometry of these boundaries is described by polygons consisting of edges, then any edge will have an area object at its right hand side and an area object at its left hand side. The possibility of the distinction between "left" and "right" only exists if the edges are directed. Here two segments can take the role of edges. We can obtain the length of the perimeter and the area is the size measure.

Let P be the spatial partition as above and U_i the discourse domain (universe of geographical objects), which consists of a set of primitives of representation (lines, points or polygons). P is the set of partitions of the primitives of representation that can exist in that partition P and present in the same partition, such as shown in (1):

$$P = U_i \cap \{Rp_l \vee Rp_p \vee Rp_a\},\ i=1,\dots,n, \qquad (1)$$

where:
Rp_l is the primitive of representation "lines".
Rp_p is the primitive of representation "points".
Rp_a is the primitive of representation "polygons".
i represents the thematic number that involves the spatial partition.

In all cases, these sets are associated with the geographical objects, which are denoted by f_G.

We also denote:

O_T represents a set of operations related to the topological properties such as: meet, contain, cover, overlap, etc.

O_L represents a set of operations based on the logical constraints, for example: the behavior of the land is considered to build a road in a specific zone.

O_D represents a set of functions that correspond to spatial distribution properties.

O_A represents a set of the characteristics associated to the geographical objects such as: elevation, names, area, direction, etc.

The properties considered for this definition can be described as follows:

A. Topological properties (P_T). These compose the spatial object layers. They represent the topologic and geometric shapes and the spatial relationships, keeping the consistency as well as the congruency of the geographical structures. Therefore P_T properties can be defined:

$$P_T = \{\forall f_G \mid \exists p_t \in T, p_t \subset O_T\}, \qquad (2)$$

where:
T represents the set of topological properties and,
p_t indicates a particular topological property that can be considered.

B. Logical properties (P_L). They provide rules that define the behavior, relationships and combined properties of the spatial structures. These characteristics are focused on the description of the phenomena, and can be used to simulate and model the geographical phenomena behavior, based on the human experience. Therefore P_L properties can be defined as:

$$P_L = \{\forall f_G \mid \exists p_l \in L, p_l \subset O_L\}, \qquad (3)$$

where:
L represents the set of logical properties and,
p_l indicates a particular logical property that can be considered.

C. Spatial distribution properties (P_D). They are used to locate any geographical object in the space. These properties consider the spatial reference of the geographical systems. Therefore P_D properties can be defined as:

$$P_D = \{\forall f_G \mid \exists p_d \in D, p_d \subset O_D\}, \qquad (4)$$

where:
D represents the set of spatial distribution properties and,
p_d indicates a particular spatial distribution property that can be considered.

D. Attribute properties (P_A). They describe the characteristics about a phenomenon. It is necessary to consider *qualitative* and *quantitative* attributes, because these specific attributes support the knowledge of the similarities between the geographical objects. Therefore P_A properties can be defined as:

$$P_A = \{\forall f_G \mid \exists p_a \in A, p_a \subset O_A\}, \qquad (5)$$

where:
A represents the set of attribute properties and,
p_a indicates a particular attribute property that can be considered.

Therefore, the initial exploration to define a priori and intuitive spatial semantics (S_E) is the description of the content of all these properties and relations that are involved them, in any spatial partition P.

$$S_E = content\left(\bigcup_{i=1}^{n} U_i \cap \{P_T \wedge P_L \wedge P_D \wedge P_A\}\right)^{1} \qquad (6)$$

All the properties are considered in the object systems of a finite space of geographical objects. Therefore, the content of the set of spatial rules reflect the topological, logical, spatial distribution and attribute properties of the spatial data. In general, in this definition, we are looking for improving the spatial data representation for their subsequent processing [2].

However, considering the *content* of all these properties and relations, the spatial semantics is defined by the *interaction* (between the spatial taxonomy and the spatial

[1] The concept of "content" will be particularized in the following sections in dependence on application.

subject domain) *iterative process* with the possibility to feedback this process to generate the spatial ontologies again in the following interaction. Each new defined concept is put into spatial subject domain. Then the interaction process is repeated up to no new concepts found. The resulting spatial ontology represents the semantics of the spatial object system.

In this sense, the spatial semantics relates the content and the data representation of entities or frameworks of the real world. The main purpose of spatial semantics is to identify the characteristics of geographical objects, which belong to different spatial databases and adapt them to the resolution levels of the spatial information [10].

The idea to use spatial semantics for representing geographical objects is focused on generating a knowledge-base. This depository is based on the human experience and the "essential" properties of spatial data. The knowledge-base can be transformed into a *Spatial Expert System (SES)*, which stores a set of semantically defined rules [11]. Based on defined rules, a spatial taxonomy is generated. This spatial taxonomy is defined according to the primitives of representation of the spatial data. Spatial subject domain embedded into the knowledge-base interacts with the spatial taxonomy; that is *Spatial Semantic Analysis (SSA)*. Figure 2 shows the scheme of the Spatial Semantic Analysis.

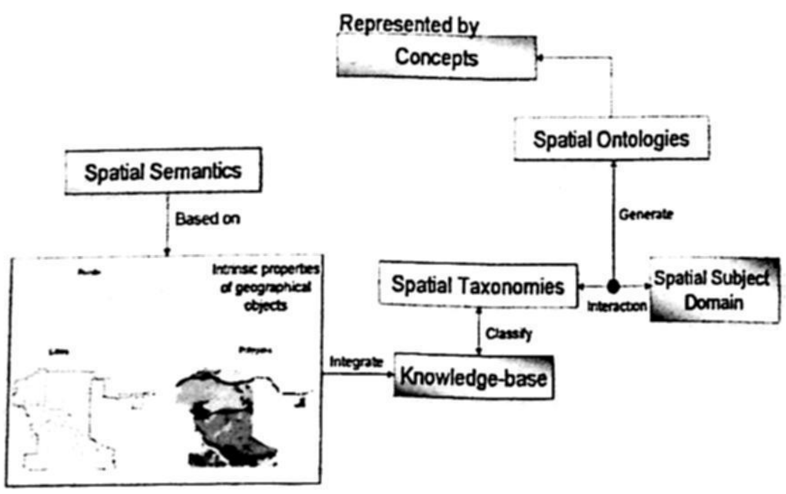

Figure 2. General scheme of the spatial semantic analysis

3. SPATIAL SUBJECT DOMAIN AND SPATIAL TAXONOMY

In our approach, the interaction between the subject domain and the taxonomy generates the "ontologies", according to the spatial semantic rules. These rules are composed by the "essential characteristics" of the geographical objects.

We define the rules to classify and represent the spatial entities. In this context, our approach leads to the "correct" representation of the spatial data. We have to look for the most adequate representation in each case of study.

3.1 SPATIAL SUBJECT DOMAIN

Spatial Subject Domain is defined as a set of "names" that describe the primitives of spatial representation. Thus, we can start with a priori knowledge of the geographical objects that appear, e.g. in the map legend. For instance, "blue" lines are united under the concept (name) "river" and "black" lines are united under the concept "fracture", etc. In reverse, the different concepts are united under the same description of the spatial representation that is *"line"*. The interaction between the subject domain and the taxonomy is used to locate concepts into the spatial subject domain that correspond to a case of study, and to process these concepts to generate spatial ontologies [2]. Figure 3 shows the definition of spatial subject domain and its interactions.

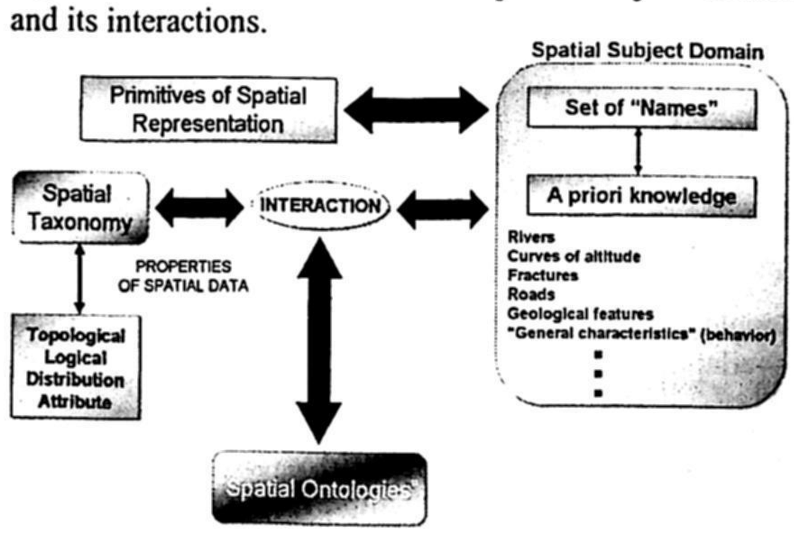

Figure 3. Interactions of Spatial Subject Domain

In our approach, it is important to count with a priori knowledge that is defined by the user depending on the case of study. However, the prompt is that this knowledge should be composed by the relationships, properties, functions and behaviors, which describe the characteristics of the geographical objects and these should be put into the spatial subject domain.

For this purpose, it is convenient to consider a particular case of study to define the knowledge, because the spatial subject domain interacts with the spatial taxonomy according to the spatial thematic.

To define the spatial subject domain, it is necessary to elaborate a description of the thematic to analyze, considering the main elements that compose this theme, such as the data model and the resolution levels of the spatial information. For instance, suppose that we have to generate "concepts" related to topographic data.

All the characteristics, which are considered in spatial description of the spatial subject domain, should represent relationships between themselves too. Spatial subject domain should recognize the different semantic levels of a priori knowledge that is stored in this domain. A framework of this description for the topographic data is presented in Figure 4.

```
<Spatial Data Description>
  <Layer_Name:Topo>
  <Thematic:Topography>
  <Type:Line>
  <Geographical_Properties>
     <Projection:UTM 14>
     <Datum:NAR_D>
     <Units:METERS>
     <Spheroid:GRS1980>
     <Scale:1:50000>
  <Geographical_Features>
     <Aqueduct relationship with the land >
       <Values domain:
           Underground
           Superficial>
     <Condition of Aqueducts >
       <Values domain:
           Construction
           Operation
           Not use>
   <Type of airports >
       <Values domain:
           International
           National
           Local>
   <Type of streets >
       <Values domain:
           First order
           Second order
           Third order
           Fourth order>
   <Population >
       <Values domain:
           State:
                  Low inhabitants
                  Medium inhabitants
                  Large inhabitants
           City:
                  Low inhabitants
                  Medium inhabitants
                  Large inhabitants
           County:
                  Low inhabitants
                  Medium inhabitants
                  Large inhabitants>
  <Type of roads >
     <Values domain:
           Pavement:
                  One rail
                  Two rails
                  Three rails
                  Four rails
                  More than four rails
           Unpavement
           Breach
           Path>
  <Hydrology >
     <Values domain:
           Intermittent
           Always presented>
  <Contour >
     <Values domain:
           Depression
           Altitude>
  ...
```

Figure 4. Partial description of spatial subject domain for topographic thematic

Using this description, it is possible to obtain "concepts" related to the topographic thematic, besides that, it is required that the spatial subject domain interacts with the spatial taxonomy to generate the spatial ontologies.

The description used to obtain the concepts is not general. Every case of study is different, because it presents characteristics that cannot be defined in a "general way". Thus, a priori knowledge is defined by every particular environment. In other words, it is not possible to develop a "general" spatial subject domain, not only for the complex structures that provides the shapes of the primitives of representation but also by the behavior, which is defined by the properties of every geographical object (line, point or polygon).

3.2 SPATIAL TAXONOMY

We define a *spatial taxonomy* as a classification method to describe every spatial entity (primitive of representation) [2]. The use of spatial taxonomies is served to classify and organize a priori knowledge in a hierarchical way. It can be communicated throughout spatial subject domain to make an interaction for generating the spatial ontologies. In this classification, the spatial entities can be generalized according to some spatial semantic rules.

We consider a subset of spatial data, which is generated by the spatial taxonomy for every spatial thematic layer that is stored into the spatial database.

Using this schema, we can define the spatial semantics of the geo-information. This method allows processing the geographical information according to the semantics of the geographical objects.

Figure 5 shows a general scheme of the spatial data conceptualization and representation as an interaction between the taxonomy and the subject domain.

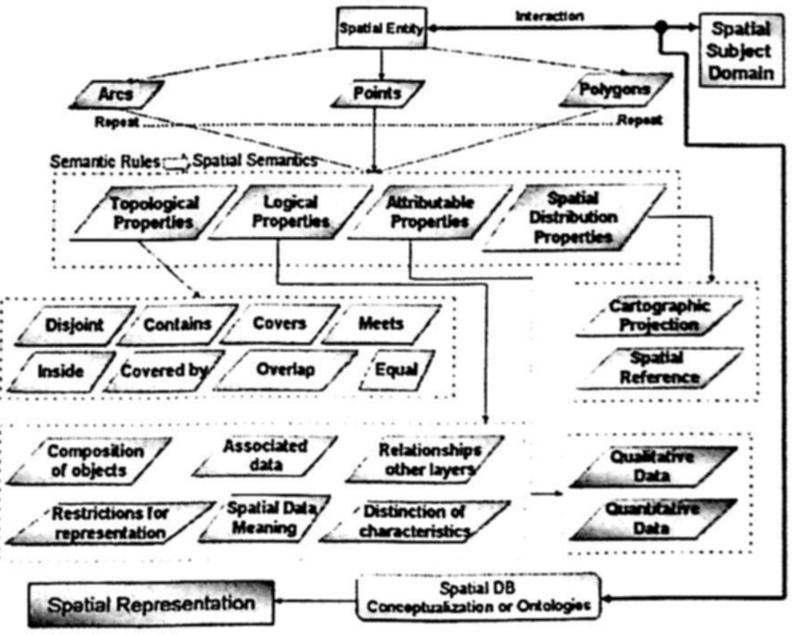

Figure 5. Spatial data representation based on spatial data conceptualization

In general, our approach uses the object properties and generates a set of spatial semantic rules. All generated rules are stored into a knowledge-base, which relates and classifies the geographical information according to the characteristics that correspond to each geographical object. The spatial data are classified in spatial digital layers, which are defined by basic primitives of representation of the spatial data such as arcs, points and polygons. Thus, a *spatial taxonomy* is generated. The taxonomic classification is based on the properties of the spatial data (Figure 5; the union of dotted rectangles).

To generate the spatial taxonomy, we establish spatial semantic rules. They are defined by the properties of the spatial data (Section 2). Therefore, to maintain these rules, we use a set of artificial intelligence techniques, which support the retrieval and acquired knowledge processes. The acquired knowledge represents other characteristics of the spatial data, which are used to partially automate the spatial representation. This representation sometimes calls for the human intervention to solve problems related to the ambiguity between the different contexts that the spatial data can take in a case of study.

4. SPATIAL ONTOLOGY GENERATION

Most widely accepted common conceptualization of the geographical data is based on the description of geographical objects and fields [8]. These objects are not necessarily related to a specific geographic phenomenon, because human-built features are typically modeled as objects. The spatial semantics definition (Section 2) is proposed and aimed to correctly represent spatial data in an alternative and universal way to generate spatial ontologies.

For this purpose, we consider a spatial ontology as an explicit and structured specification of conceptualization, that is, a description of the concepts and relationships that can exist between the geographical objects. In this context, the spatial ontologies represent definitions, functions, attributes, relationships, etc., of the geographical objects by means of "concepts" [2]. Besides that, ontologies can be considered as "languages", which use a specific vocabulary to describe entities, classes, properties and functions related to a certain view of the geographical world [10].

These concepts are considered as a knowledge, which can be put into the knowledge-based system. This knowledge-base can be used to share concepts, according to the spatial semantic rules that correspond to the spatial data by using an agent interaction language. [12].

In particular, our approach is designed to solve the ambiguities that can exist with single characteristics of the geographical objects, because the spatial ontology is defined by concepts (not by words) according to the geographical objects.

It is important to make a distinction between ontology and conceptualization [8]. According to Guarino, an ontology is a logical theory accounting for the intended meaning of a formal vocabulary (i.e., its ontological commitment to a particular conceptualization of the world), whereas a conceptualization is the formal structure of reality as perceived and organized by an agent, independently of the vocabulary used or the actual occurrence of a specific situation.

To mimic the ontologies in spatial data modeling, we consider three stages to model the spatial data representation. *Real world stage*, which is composed by the geographical objects and phenomena that will be modeled in the computer. *Logical stage* consists of formal definition of these objects considering their properties and behavior. *Representation stage* is a description of the geographical objects and phenomena based on the definition proposed in the logical stage. These stages are shown in Figure 6.

The schema shown in Figure 6 can be used to catch what human-mind perceives about the real world. The sense of the model has several concepts as rivers, contours, roads, soils, etc. The logical stage is composed by the formal description of geographical objects. Later, the representation stage represents the ontologies that can be generated from the formal description.

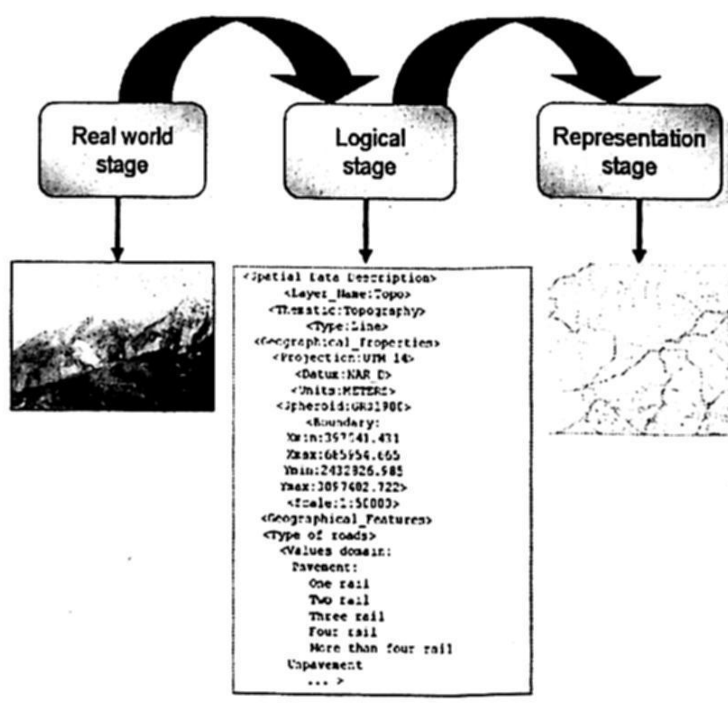

Figure 6. Stages to model the spatial data representation to generate ontologies

Therefore, we assume that spatial ontologies should be essential components of the logical stage for geographic data modeling [8].

Moreover, the geographical environment uses different levels of ontologies to guide processes for the extraction-representation (E-R) of more detailed geo-information and to allow the E-R of geographical objects in different stages of classification.

The spatial ontologies can be classified by levels according to their dependence on a specific task or point of view. These levels are generated for a specific spatial ontology (*top-ontology*) and it can be particularized to define a particular ontology (*down-ontology*). There are also different levels of information detail. Low-level ontologies correspond to very detailed information and high-level ontologies correspond to more general information.

In this situation, the generation of more detailed ontologies should be based on the high-level ontologies, such that each new ontology level incorporates the knowledge present in the higher level. These new ontologies are more detailed, because they refine general descriptions of the level from which they have been generated [10].

The levels of ontologies can be used to guide processes for the extraction of more general detailed information. The use of multiple ontologies allows the extraction of information in different stages of classification.

The use of explicit spatial ontologies contribute to better correct spatial representation, because every geographical object description is based on an implicit ontology, making it explicit avoids conflicts between the ontological concepts and the implementation.

On the other hand, spatial ontologies play an essential role in the conceptualization of spatial databases, allowing the establishments of correspondences and interrelations among the different domains of geographical objects and relations.

For instance, the concept "Limit" can be represented in different contexts in diverse spatial databases. "Limit" in some cases represents "coast boundary", separation between the "ground" and the "sea", "contour of value zero", "boundary" among two regions (states, countries, etc.), and so on (Figure 7).

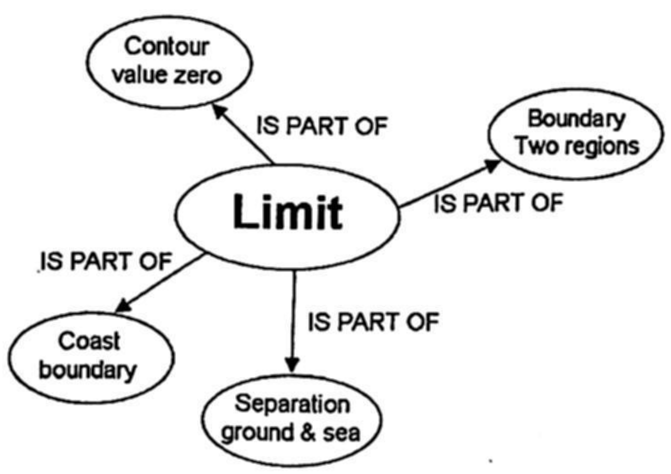

Figure 7. Semantic network related to the concept "Limit" interpreting the different concepts related to "limit" for subsequent spatial representation

For the concept "Limit", we can use a semantic network to interpret and organize the different context that it can take in the spatial ontology as presented in Figure 7.

Using this approach, we can generate specific spatial ontologies after defining the top-ontology to particularize the conceptualization in other specific ontologies (down-ontologies).

We propose a schema to generate the spatial ontologies. This schema consists of a set of spatial semantic rules that are stored in a knowledge-base. The rules are defined by the characteristics and behavior of the geographical objects. Spatial subject domain is used to work with a priori knowledge and interacted it with the spatial taxonomy to find out the concepts related to the spatial thematic aimed to generate the spatial ontologies. Figure 8 shows the schema to generate the spatial ontologies.

The use of ontologies in spatial databases enables knowledge sharing and information integration. The proposed approach provides dynamic and flexible information exchange and allows partial integration of spatial data when completeness is impossible.

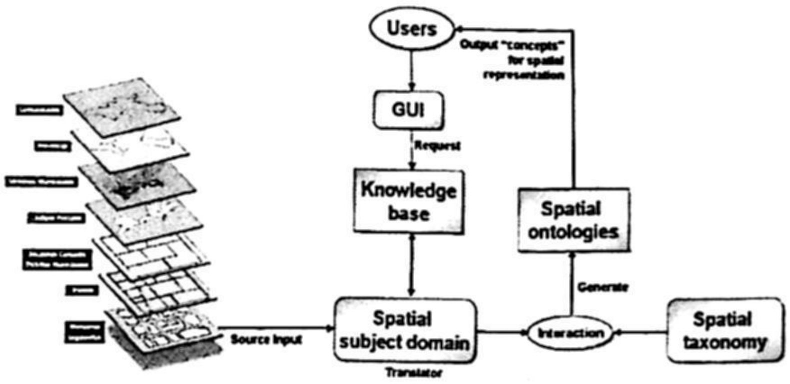

Figure 8. General schema to generate spatial ontologies

This can help to the next generation of spatial databases to solve semantic ambiguities in the available geo-information, because the context of the spatial data can change, according to the case of study or for the representation state by means of concepts of the geo-information.

5. PRELIMINARY RESULTS

The following results illustrate the interaction between spatial subject domain and spatial taxonomy, to obtain spatial ontologies by using the spatial semantics definition. Some tests have been made to prove our approach.

We design a spatial taxonomy related to topographic thematic, it is convenient to consider a particular case of study. Figure 9 shows the taxonomy of topographic data.

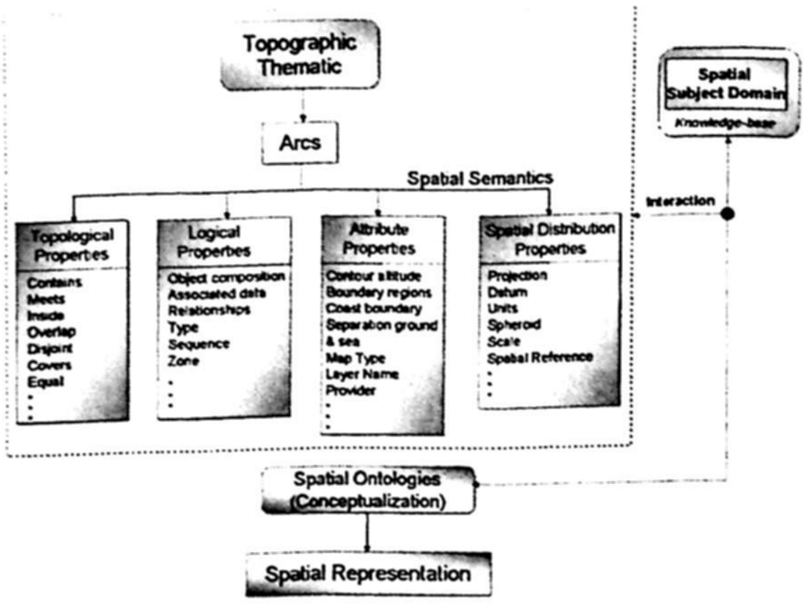

Figure 9. Spatial taxonomy for topographic thematic and its interaction

To generate the spatial ontology, it is required that the spatial subject domain interacts with the spatial taxonomy. As a result of this interaction, we can obtain "concepts" related to the topographic data in different semantic contexts. For instance, in Figure 10 the concept "Limit" of spatial ontology is generated. This spatial ontology presents several "sub-concepts" related to "Limit". The users make a query to the geographical data according to the criteria or interested concept that they need.

The query functionality is the following: the user makes a request by means of a GIS-application, which sends it to the administration query module to process the request for obtaining the spatial ontology. Inside of GIS-application, a priori knowledge that is stored in the spatial subject domain interacts with the spatial taxonomy, considering in this case, the "arcs" as primitive of representation. Figure 10 shows the mechanism to obtain the spatial ontology by means of GIS-application. The architecture of the GIS-application is described in [2, 13].

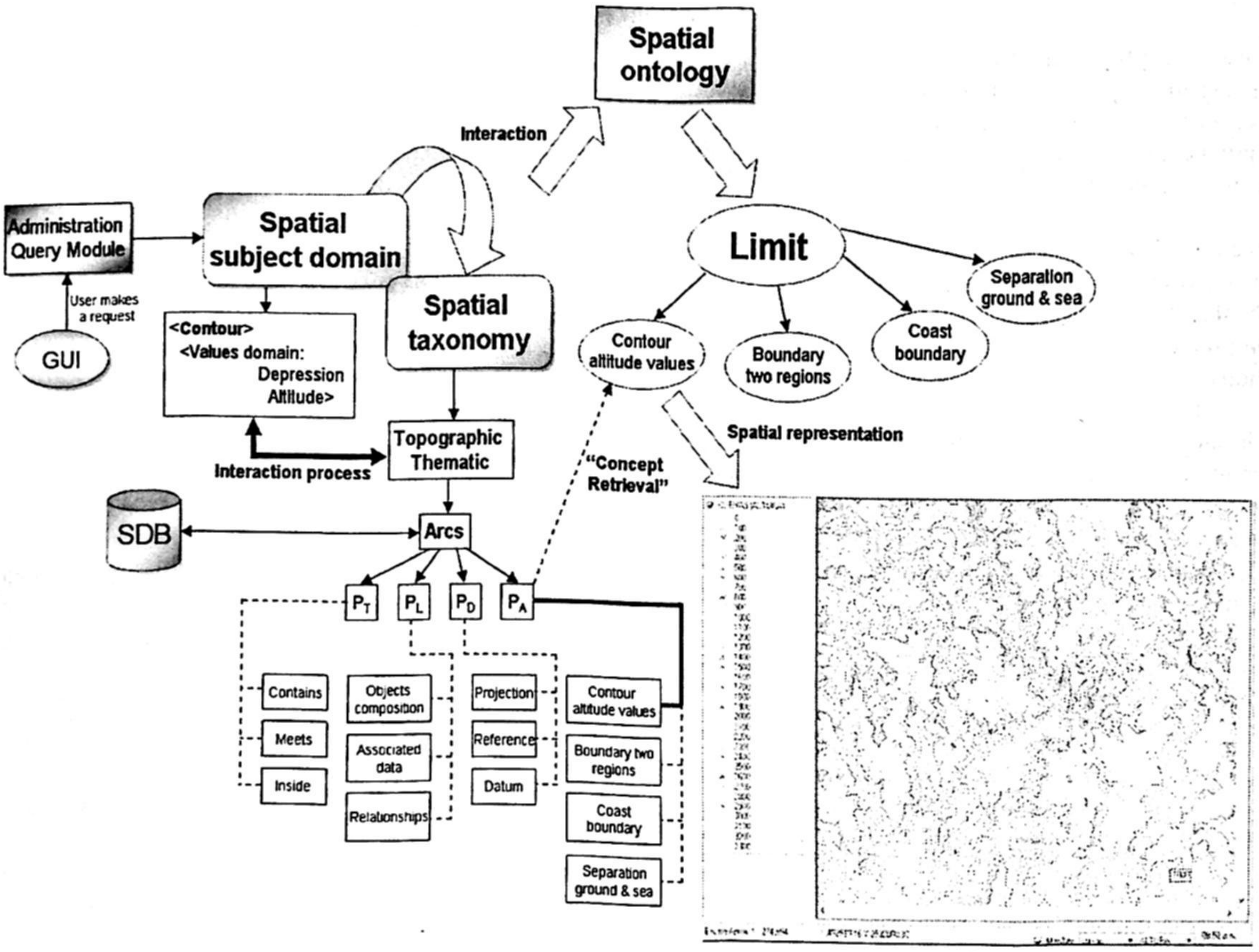

Figure 10. The concept "Limit" in spatial ontology that represents the *contours*

Figure 11 shows the query mechanism to describe the concept "Roads" into the spatial ontology. In this case, the ontology is composed by several "sub-concepts", which are ordered in a hierarchical way. In Figure 11, we see the different levels of the concepts, starting with a top-level (Roads) and finishing with down-levels (One rail, two rails, etc.). When the ontologies present more levels of concepts, it is possible to particularize these in sub-concepts, while the level is less (down-level), the concept is more particular.

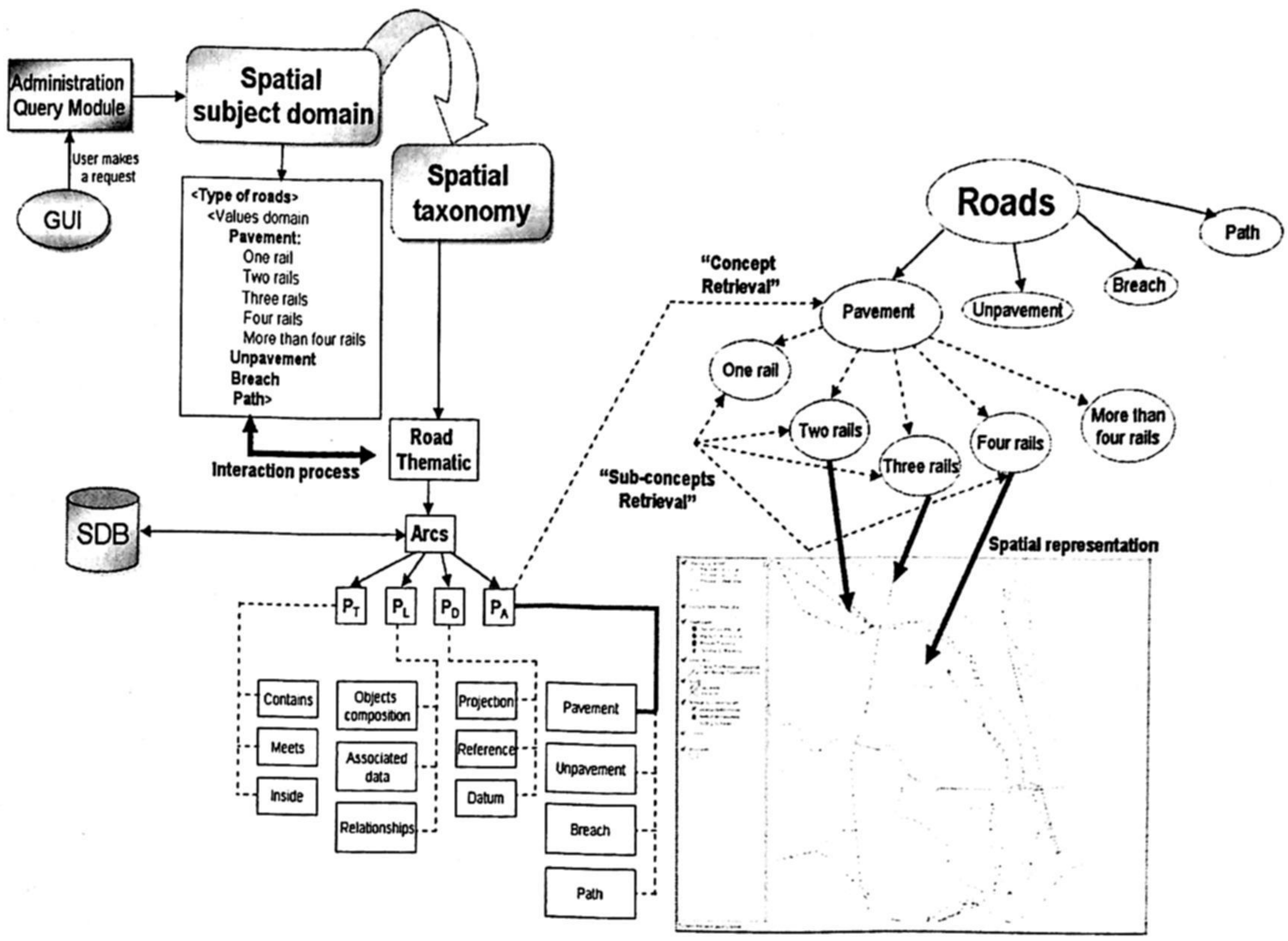

Figure 11. The concept "Roads" in spatial ontology that represents *pavement roads* with one, two, three and four rails

6. CONCLUSION

In the present work, the spatial semantics definition to represent geographical objects has been sketched. This definition is developed considering the intrinsic properties of spatial data, which are defined by the basic spatial representation primitives. The properties involved in this definition are: topological, logical, spatial distribution, and attribute.

By using our method, it is possible to classify geographical objects, generating a *spatial taxonomy*. The proposed definition of spatial subject domain is oriented towards an interaction with spatial taxonomy to conceptualize the spatial databases. Also, we presented a spatial data description that is based on a set of spatial semantic rules, obtained from the spatial object analysis. Using this set of rules, the request of the user evaluates and filters the geo-information according to the semantic criteria.

In essence, the spatial subject domain is defined as a set of "names" that describe the primitives of spatial representation. Thus, we can start with a priori knowledge of the geographical objects to examine the spatial data, which interact with the spatial taxonomy to generate spatial ontologies.

We attempt to show an alternative approach to represent spatial data considering their spatial semantic properties, besides that, it can act as a system to integrate geo-information at different levels of detail.

The proposed spatial ontologies represent real world entities using a hierarchical structure, which is composed by "concept" (not words). These concepts can be formed by definitions, functions, spatial properties, rules, relationships that constitute the *spatial semantic analysis*.

Moreover, the spatial ontologies catch the semantics of geo-data to provide additional information related to the concepts. These ontologies can be used to establish agreements about diverse views of the world and consequently carry out the "meaning" of the geo-information. In many situations this geo-information embedded in the spatial representation of geographical phenomena in the human-mind.

Use of ontologies in spatial databases enables knowledge sharing and information integration. The proposed approach provides dynamic and flexible information exchange and allows partial integration of spatial data when completeness is impossible.

This approach can aid to solve semantic ambiguities between the available geo-information, because the context of the spatial data can change, according to the case of study or for the representation state by means of concepts of the spatial data.

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