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A Model to Store and Reuse Geographic Application Patterns

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Abstract. User access to knowledge beyond the stored geographic information is a prominent and problematic issue. A major difficulty is the underlying problem of knowledge reuse : knowledge, potentially useful to users, is stored in information resources and users cannot extract it from the raw resources without assistance. In our work, we apply techniques from artificial intelligence (AI) and knowledge engineering to assist in addressing this issue of geographic knowledge reuse. The general approach consists in building a description of the stored geographic information sets in terms of information content and of mechanisms to manipulate this information. In the paper, we describe our proposed solution, an expert system, which practical objective is to store patterns of manipulation of geographic data, i.e. geographic tasks, in an extensible knowledge base. This system does not derive knowledge on demand but rather it stores and proposes geographical knowledge derivation recipes. It allows users to browse and customise these recipes. A prototype of this system, coded in java, is under implementation process.

1. Introduction

In the context of interoperable geographical data and software, a prominent issue is users' access to information stored in these components. In this paper, access refers to the users' understanding of knowledge implicitly held within available resources, and more specifically of knowledge relevant to their needs. It requires the interoperability of geographic data and software with another type of component : the end user.

Research to enhance users access to geographic information stems from such varied areas as : visualisation, geographic information systems (GIS) users interfaces and users guides, e.g. [Mitchell 99], metadata for geographic digital libraries and spatial data infrastructures, e.g. [Frew et al. 99], spatial data warehouses and electronic services marketplaces, e.g. [Abel et al. 99]. Those contributions globally address two distinct issues : the need to bridge the expertise gap between a user and the domain of geographic databases (GDB) and GIS, and the need for federating access to numerous, distributed, possibly heterogeneous GDBs.

2. Users access and knowledge reuse

2.1 Knowledge reuse, and the need for an intermediate description

In both the above mentioned issues, a difficulty impossible to circumvent is the underlying problem of knowledge reuse : knowledge potentially useful to users is stored in information resources which users cannot extract from the raw resources without assistance. Knowledge sharing and reuse is the essential aim of almost all knowledge engineering research. In this research we apply AI techniques to assist in addressing this difficulty. In the process of information resources becoming knowledge for a user, several steps are commonly identified [Schreiber et al. 99]. These correspond to different types of enrichment of the resources:

- a notification of the existence of the resources,
- a description of the meaning of the resources,
- a description of how to perform an action with the resources, i.e. how to use them in the user's context.

This enrichment may be performed by each user, by the resources provider, or with the support of assisting services. In the case of geographic information, users can not perform the enrichment themselves : most semantics are implicit in geographic databases, handling the data requires a specific expertise, and there is a gap between most users inner conception of geographic information and the models used to store this information –those models being imposed by information acquisition constraints-. However the resources cannot be dedicated to the needs of just a few users so it is difficult to provide elaborated information products.

In such situations, the general approach to assist in the enrichment process depicted above is to provide users with an intermediate understandable description of the resources, in terms of references, content and possible uses [Bucher 99].

2.2 Experience from AI to improve knowledge reuse

Lessons learned from AI are to integrate in this intermediate description two types of knowledge [Gomez and Benjamins 99]:

- What knowledge : a factual knowledge about an information domain, e.g. a domain ontology.
- How knowledge : a description of how to manipulate pieces of the What to produce new statements in the What, also called problem-solving knowledge.

“To integrate” means that both types of knowledge are often already available but need to be restructured into a single model. Building such unifying models is still a challenge. Software engineering techniques, like the Unified Modeling Language (UML), do not yet provide a model to integrate both problem-solving knowledge and domain ontology. Such models are rather proposed by knowledge engineering techniques. In this area, the notion of “task”, i.e. the description of a problem and of how to solve it, is a promising technique to make a connection between domain knowledge and problem-solving methods [Chandrasekaran 98].

A task-based model is used to describe resources by giving examples of tasks that can be achieved with the resources. It intuitively corresponds to the following approach : to teach the user methods to handle the resources, and to give the user an overview of possible use-goals, i.e. “what-for”, using the resources. Both types of help are needed by users of geographic digital resources.

Our approach is built upon the successful experience of the Atelier Logiciel project (cf figure 1) [Ficet 99]. This is an expert system which describes pieces of image processing codes to users who are not experts in image processing and who need to process images in their work, e.g. in medicine or optical

surveillance. The description proposed is structured following the Task-Method-Tool model. The user is asked to specify the goal of their task, in a "image-dedicated" vocabulary, and the expert system, proposes methods and corresponding tools (image-processing parameterized algorithms) to reach this specified goal, cf figure 1.

Figure 1. : Part of the task-method-tool description built in the Atelier Logiciel (after [Ficet 99]).

3. Our approach

3.1 A compilation of existing "enriching" descriptions of geographic information

Geographic databases are enriched, more or less explicitly, and in different forms. The data producer builds metadata depicting the database, e.g. the schema. The data provider can attach methods to objects in the data sets, e.g. methods attached to GObjects to use the terminology of the OGIS specifications [OpenGIS TC 99]. Researchers have formalised sets of necessary queries for GDBs [Egenhofer and Frank 87]. The GIS builders provide tools to handle the data. Available GIS operations, or services, have been formalised for interoperability purposes [OpenGIS TC 99] and by researchers wishing to enumerate and organise the functionalities of GIS [Maguire and Dangermond 91][Albrecht 96]. The GIS provider may describe, in a user guide, methods to use these tools [Mitchell 99]. Moreover, researchers dedicated to specific uses of geographic information, e.g. spatial analysis, mapping, environmental modelling, have formalised methods to manipulate GDB in these domains. There are also attempts at formalising geographic information as employed in human reasoning [Egenhofer and Mark 95].

3.2 A model to integrate these descriptions : CommonKADS

The different types of knowledge built in these approaches are not integrated in one formalism. Especially, the linking of *what* knowledge and *how* knowledge is always in terms of types found in the signature of a function. But there are no affordances "à la Gibson" between objects of the geographic domain and behaviors relying on them. Moreover, there are several "how-to-handle" but very few "what-for" descriptions of geographic data.

Applying lessons learned from AI, we chose a task-based model to integrate these different types of knowledge : the CommonKADS model [Schreiber et al. 99], because it is a reference. It is structured in three categories :

- the *domain* is the description of manipulated objects,
- the *inferences* are descriptions of elementary operations on these objects,
- the *tasks* are the descriptions of complex manipulations, i.e. applications : goals to achieve, methods (combination of operations to reach a goal), strategy to chose a method.

The *domain* models the geographic *What*. The *inferences* and the *tasks* model the geographic *How*, including the *what-for*.

4. First results and on-going work

4.1 A CommonKADS generic model of geographic application patterns

So far, the generic CommonKADS knowledge model has been specified into a core CommonKADS model of the exploitation of geographic information, that should act as an integrating framework as in figure 2 [Bucher 99].

An important characteristic of this model is to represent concepts necessary to word goals, e.g. a navigation, a city, a mountain. These concepts are part of the geographic domain knowledge even if they are not explicitly represented in the GDBs. They are rather commonsense geographical notions. We represent them in our model by “reasoning concepts”.

This geographic CommonKADS model is then represented in UML, i.e. into storable objects, cf figure 2.

Figure 2. : Simplified overview of our approach : the integration and restructuration of existing How and What descriptions of geographic information resources in a generic geographic CommonKADS knowledge model, translated in UML.

4.2 A prototype

On top of the static knowledge represented in figure 2 we build the following functionality: to translate a user’s needs into the specification of a stored geographic task, and to point the user to the building bricks of an application –data, processes, methods- that should perform this task.

A prototype of the system has been coded to store instances of the generic geographic CommonKADS model and test the functionality on them.

The Java language is used to build the static knowledge base and the dynamics of the system. The knowledge base comprises :

- metadata sets of the French National Mapping Agency, IGN, which follow the European standard XP-ENV12657,
- Tasks and Domain elements necessary for the basic generic tasks “locating an entity”, “addressing a spatial reference ”.

Another functionality not tackled in this prototype is the enrichment of the static knowledge base : the integration of descriptions of new data, new GIS tools, or new methods.

[here figure in file BucherFigure.bmp]

Figure 3. : Our prototype. The bottom frame displays application objectives. The upper frame guides the specification of an application objective by the user and the side frame shows the actions that should lead to the objective.

5. Conclusion

The system presented here relies on a specific task-based model describing :

- the GDBs,
- the tools to handle the data,
- the methods to handle the tools,
- the concepts needed to word application objectives.

It aims at supporting a new type of browsing of geographic information resources: neither the name of resources nor its content is searched, but instead the possible application objectives that can be achieved using such resources. Again, the system does not derive knowledge on demand but rather it stores and proposes customizable geographical knowledge derivation recipes.

Our approach does not build an exhaustive knowledge base but rather a theoretically sound framework, the generic model and the first instances, that should further integrate other instances describing existing data, processes, methods and application objectives.

The global functionality we eventually wish to build upon such a model are :

- to store patterns of manipulation of geographic information,
- to serve them back to end users.

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Fig 1

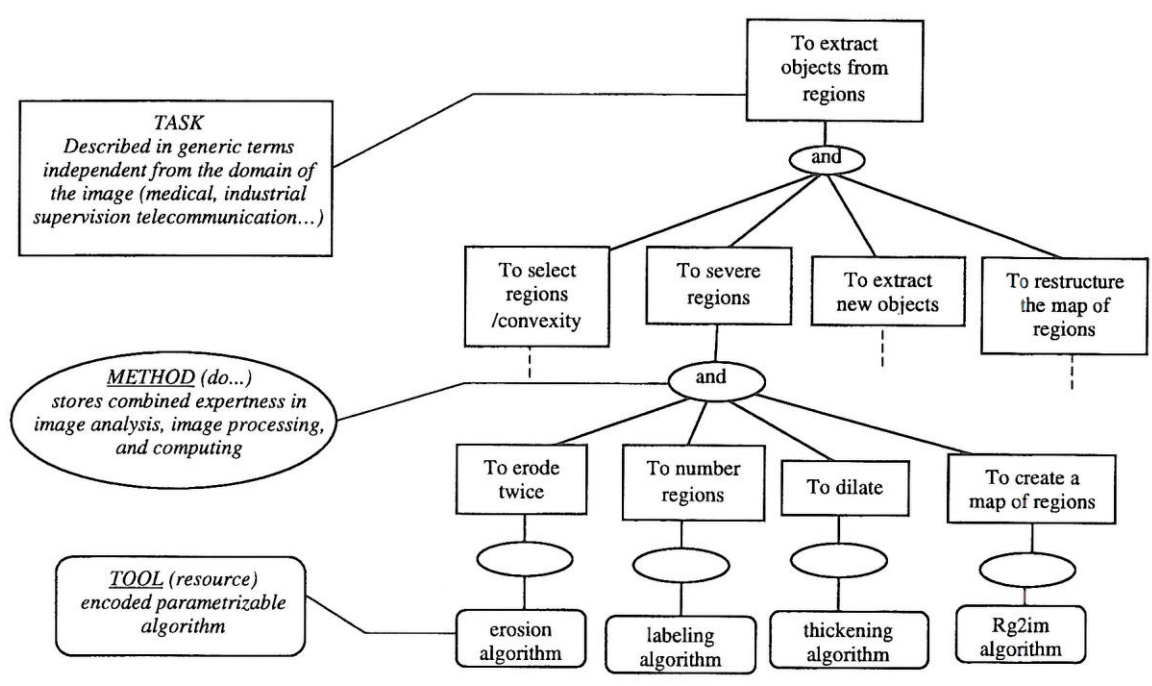
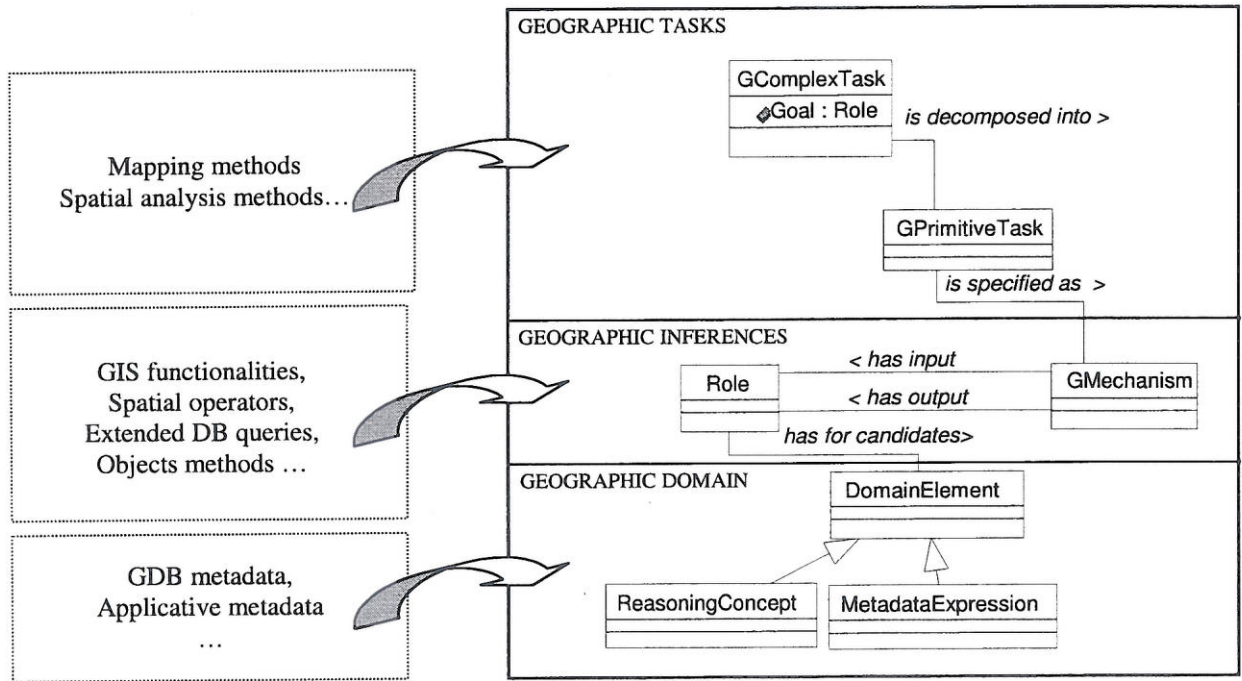


fig 2



fenêtre de SPECIFICATION de la tâche

Role important : localisation

Eléments pour la spécification

- localisation
 - de quoi
 - entité à localiser
 - où
 - reference spatiale
 - est définie dans
 - systeme de reference
 - valeur

Informations pour vous :

Une localisation renvoie à un objet géographique indirect.

Les relations à d'autres localisations sont définies dans la recherche de localisation.

fenêtre de PLANIFICATION

(ce plan, d'abord très général, est une spécification des rôles de la tâche)

(sources1 :) représentation

--(mecanisme de représentation)

(sortie1 :) représentation

spécifier la caractéristique choisie :

Quitter en sauvegardant cet état de spécification :

Voir le plan :

Voir si les ressources pour le plan sont disponibles, et leur "valeur" (prix, actualité, qualité,...) :

Voir les descriptions des objets utilisés dans la représentation :

VUE SUR LA BASE DE CONNAISSANCES DU SYSTEME :

Objectifs Connus

- Application Géographique
 - Localisation
 - Adressage

A propos de la tâche selectionnee :

L'objectif dans cette tâche est de répondre à la question : où est-ce?

Pour définir comment répondre à la question "je veux savoir où se trouve ça", il faut spécifier le vocabulaire de cette question, c'est-à-dire :

"ça" : l'entité à localiser

"où se trouve" : un système de référence, et une référence de "ça" dedans

"savoir où" : il s'agit de la représentation de cette "référence" en vue