Map Samples to Help GI Users Specify their Needs

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Abstract

Accessing the user interfaces proposed by GISs, G-DBMS or geographic Web sites shows how complex they may prove for novice users of geographic information. Such users have needs in geographic information, but they do not have the means to express them and thus to adequately fulfil them. The objective of this paper is to outline an approach that may help users specify their needs with geographic information. This approach consists in converging on one available solution, the closest possible to the user needs, by using new means of communication between user and computer: map samples and natural language. Map samples are geographical data, extracted from the database and possibly processed by available GIS treatments. A few map samples are proposed to the user, who makes the relevant choices. The system tries to "understand" the interactions to help in the choosing. A search engine navigates through the available map samples in order to identify the most appropriate map samples and proposes them to help the user identify the need more precisely. Natural language allows the expression of user needs to be captured in a manner more consistent with a dialogue and provides more freedom or versatility for example, for general queries and quantitative evaluation. A virtual scenario shows the combination between these two languages.
Keywords: geographic information, user needs, map samples, natural language, user interface

1 Introduction

To access geographic information, we should use both geographic applications and data. These applications are available through user interfaces included in

Geographic Information Systems (GIS), Geographic Database Management Systems (G-DBMS) or other software. Moreover, GI is mainly accessible as maps on the Web and we can only visualise them. The Web is the visible part of Internet and the majority of users are novices in geographic information. Some advantages of Internet explain the increase in the number of geographic Web sites, but there are limitations as well. Geographic Web sites offer little functionality compared to standard desktop GISs. Most of the time no tools are available to help users specify their needs, although they would be most welcome especially when the user is not an expert (Hubert 2001).

Contributing to this issue, we focus on spatial query languages as a way to help formulate queries without using expert languages such as SQL. Some approaches have been proposed to improve the expression of queries by extending the current interfaces of GIS. They propose new kinds of interfaces that include texts, graphics, icons, and so on. (Egenhofer 94) proposes an extension of the SQL language with *Spatial SQL*. *PICQUERY* is a textual language inviting users to enter words in display tables corresponding to spatial operators (Joseph and Cardenas 88). Visual languages like *CIGALES* (Calcinelli and Mainguenaud 94) or *LVIS* (Bonhomme *et al.* 99) offer a graphic interface where users can draw their request by using icons and metaphors. *Sketch!* (Meyer 92), *Spatial-Query-by-Sketch* (Egenhofer 96) and *VISCO* (Haarslev and Wessel 97) are sketch languages where users draw their requests and the system interprets them by trying to identify the spatial operators involved. Hybrid languages combine a few means of communication, for example (Lee and Chin 95) with icons and graphics, *PEGASE* (Proulx *et al.* 95) with graphics and text and the *Geographical Anteserver* (Szmurlo *et al.* 98) with graphics and labels in natural language. Even though these spatial query languages offer more freedom to express requests, there are three major limitations: we can only make simple queries, the interfaces are not always intuitive, and user needs are not taken specifically into account.

Our work gives the priority to the expression and the understanding of users' needs. Our purpose is to identify and to understand these needs before running geographic applications that may be complex and time consuming. With regard to works on spatial query languages, we do not only want to replace SQL languages. Our aim is, on the one hand, to treat queries that modify representations, and on the other hand to treat queries that create information (i.e. information that will be computed from existing data by means of expert GIS functions such as generalisation). To improve the expression of needs in geographic information, a link should be established between novice users and the stored and computed information on remote machines. Needs could be, for example, "*show city monuments by localising them with a chosen symbol*" or "*create a map with only roads and some buildings along a river*". Actually, the challenge is to relate two means of thinking: human thinking and computer "thinking". Users should not have to adapt themselves to the machine, the machine should "understand" users. To conceive this link to help users, we propose to introduce new means of communication to help users: map samples and natural language. Through an interaction with the users, the system can be made to understand and to specify their requests. Our approach allows the running of geographic applications without prior knowledge in geographic information from the users.

This paper discusses the principles of our interface combining map samples and natural language: Section 2 explains why we have chosen map samples and natural language. Section 3 gives definitions about map samples. Section 4 presents a scenario on the specification of queries by combining map samples and natural language. Section 5 proposes a method to find map samples from a "map samples" database. Section 6 explains briefly the general architecture of our system and its different modules, more precisely the Web interface and the dialogue module, which have been fully implemented.

2 Why Use Map Samples and Natural Language?

The purpose of our work is to make a system to identify user's needs in an effort to apply the relevant geographic treatments on appropriate data. We introduce a mechanism between users and server of geographic applications designed to help users to specify and fulfil their needs in geographic information (see Fig. 1). Geographic data are currently manipulated through specific applications like GISs. For an expert in geographic information, using a GIS may be easy. For a novice, however, many non-intuitive, even random manipulations are necessary before finding some more or less satisfactory treatment. We think that an automated identification of the user's need is necessary to efficiently produce the desired result.

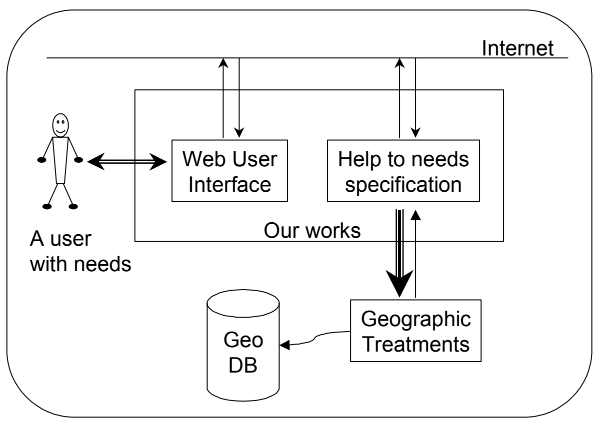

Fig. 1. General model

To obtain information on the user's needs, we propose a user interface to capture the needs. The interface's engine manages the events: input of user's needs and visualisation of the intermediate or final results. Hidden to the user is the "intelligent" engine, to receive the input data from the interface engine and to understand, validate and process the user's needs. As we focus on novice users, we must offer an intuitive means of communication. Our first choice is to use map samples. Map samples are like images. They are used to illustrate solutions as made possible by GIS treatments. The samples subdue the specificity of geographic information and of the precise treatments in favour of intuitive representation. Users indeed do not know the specific treatments and do not have expert background in geographic information. Moreover, users are in the habit of visualising and using maps, like paper maps.

We cannot only use map samples, however, since users cannot usually express their needs graphically (most of the communicability of a map indeed lies in its legend). Natural language is one an option for resolving this limitation.. It can be used to start the dialogue and to identify a global application concerning the need, for example "*I want to generalise buildings*". Further it can be used to validate a proposed map sample, for example "*I like that*" or "*I don't understand*". Finally, it allows the user to express refinements on a map sample, like "*This sample without roads*", "*More square*" or "*Less big*". The use of natural language is easy for users. They need no technical knowledge on interfaces and their mechanisms. Some freedom of expression is offered as well (Frank *et al.* 1991).

In combining these two means of communication, we obtain a harmonious dialogue with the users to help them specify their needs on geographic information: natural language corresponds to a facility for people, while map samples corresponds to a facility for machine. This article will focus on map samples.

3 What are Map Samples?

A map sample is a small extract or part of a geographic database. We distinguish two types of samples: basic samples and treated samples. Basic samples are a small subset of data from the GDB. Treated samples are results of geographic treatments on basic samples. Three views on map samples are presented and can be distinguished as follows: samples as a graphic object, samples as a discourse object and samples as a computer object. In fact, one sample corresponds to one graphic representation and one computer representation. The discourse representation is used to establish a relation between natural language and map samples.

3.1 Map Sample as Graphic Object

The graphic object representation of a map sample is a GIF, JPEG or TIFF image, which are easy formats to use in Web pages. This object can be easily integrated in Web pages and visualised by users. The main interests of using this representation are:

- Map sample is in the geographic information language with its cartographic representation;

- The user is in the habit of visualising maps without adaptation problems;
- The user has no specific knowledge in geographic information.

This last representation masks information on parameter's values or geographic treatments to the user.

3.2 Map Sample as Discourse Object

The graphic sample becomes a discourse object when the user can express reactions about the sample in natural language, when he can enter sentences, like "*I want that buildings are smaller*", "*I choose the third sample, but I want fewer details*", " *I don't like that*". In this case, it is necessary to establish the possibility of entering sentences, and the link between sentences and relevant samples. Some knowledge is necessary to translate words in context, like "*smaller*", "*less than details*", "*the third sample*": to associate a meaning to a word or a group of words in the sample's context, we use specific knowledge (see Section 5.3).

3.3 Map Sample as Computer Object

The computer object representation gives information on raw and treated samples. Replacing geographic applications by graphic and computer objects allows one to have some information on the creation of samples by GIS or other processes. The computer representation allows the handling of the graphic and discourse objects coherently. The user analyses the graphic properties of a map sample and criticises them in natural language. The system uses the computer representation of this sample to translate criticisms into expectations by using another knowledge defined in Section 5.3. The aim is to find another sample corresponding to the user's wishes by using the computer object representation of the current sample.

To understand the complementarity between map samples and natural language, a virtual scenario is given in the next Section. This scenario shows how the user may use our interface to interact with the system.

4 A virtual Scenario

Our user interface is organised into two major interaction areas (Fig. 2): (1) the dialogue box where the user interacts with the system in natural language and (2) the result area where the user interacts by mouse clicks.

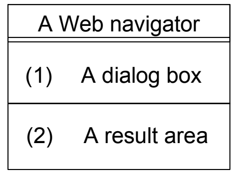

Fig. 2. The user interface

The following scenario, presents a simple query with few interactions between the user and the system, and provides an example of the interaction that is made by our interface between the user and the system. To start the dialogue, the user writes a request, in the form of a sentence: "*I want to generalise some buildings*" (Fig. 3).

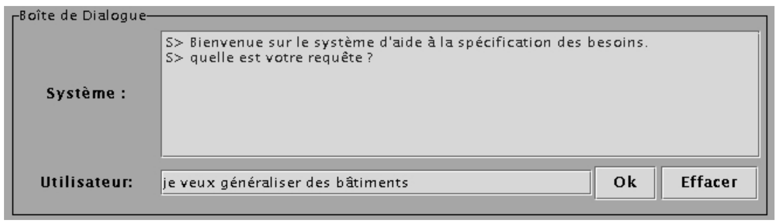

Fig. 3. The first query in the dialogue box

The system analyses this request by using a dictionary with subjective terms (e.g. "*I want to*", "*I like that*"), technique terms (e.g. "*generalise*", "*smooth*", "*zoom*"), and thematic terms (e.g. "*buildings*", "*house*", *roads*"). Then, the system proposes first result according to the buildings' nature (e.g. house, church, hospital, and school). The nature of the buildings is presented on a page by using checkboxes as graphic objects. The user can select an element or write a sentence in the dialogue box.

The system records the user's choice and displays another page with some images corresponding to map samples. It shows one or several basic samples and their treated samples. The user selects the building he wants (Fig. 4). For example, he chooses sample E2. In this case he is allowed to add a constraint by writing a sentence in the dialog box: "*I select this sample, but without the small square from the right wall*".

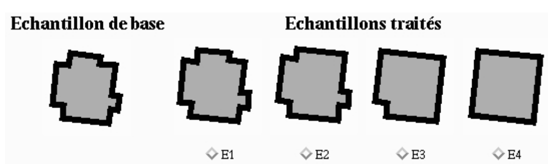

Fig. 4. A results Web page with map samples

The system records the user's choice and analyses the sentence. After the research of samples, it displays another page with one sample as close as possible to the user's request (Fig. 5).

Fig. 5. A map sample as result

The user sees the map sample and reacts by writing: "*OK, for this sample*". The system interprets the response as an order of validation of the results and can pursue the helping the user further specify his needs. The process is pursued by proposing additional map samples that correspond to the first selected sample. This is reasonable since the process should not be based on only one simple sample.

This virtual scenario shows that the system must be able to translate indications, from the users to find further map samples. We have defined some strategies to search one or several samples in a database of map samples.

5 Search Strategies on Map Samples

In the previous section, we have presented a simple virtual scenario, but the choice and the search of map samples are not trivial. To manage map samples, we connect our system with a "map samples" database. In this Section, we present this map samples database, and explain two different research strategies. Finally, we describe some knowledge to process these strategies.

5.1 The "Map Samples" Database

The map samples database has been created by geographic treatments on a GDB. These geographic treatments come from GISs, G-DBMS, and so on. This database stores computer objects of basic and treated map samples. An organisation of the database is necessary to improve the access to map samples. We distinguish some categories of samples according to their type (e.g. buildings, roads, urban blocks, map of city, and so on), their nature (e.g. house, school, church, administrative building, among other aspects). The database groups the basic and treated samples as well.

The current state of our map samples database contains only map samples resulting from cartographic generalisation processes. The computer properties are based on the use of constraints as defined in (Ruas 1999). The treated map samples are identified by different constraints such as "size", "width", "granularity", "squareness" and "concavity". These constraints have goal values and current values to identify the interest of the sample. In this way, and as a first prototype , samples are described by means of their properties and not by means of their GIS treatment. Our prototype database contains 63 basic map samples. Nicolas Regnauld from the University of Edinburgh has processed 32 different generalisation processes using these basic samples.

5.2 Search Strategies

Our two competitive strategies are based on the use of space criteria for map samples (Fig. 6). The axes represent the values of criteria. A criterion can be a parameter or a constraint. In the figure, we have 3 criteria: c1, c2 and c3. E1, E2, E3 and E4 are the treated map samples selected by a user at different steps. Each symbol on the figure corresponds to a map sample.

<u>Strategy 1: Search of coherent values of criteria</u>

Conditions: After several interactions, a set of map samples, or a selection of several samples has been selected by the user. **Actions**: According to the chosen samples, the set of relevant criteria is constituted, and a space of their possible values is defined. The search method then consists in building hypotheses in that space and in restricting them by proposing new samples. Fig. 6 shows a volume including the chosen samples E1, E2, E3 and E4. If the system finds 20 map samples in this volume, it proposes for example 4 samples to the user and so restricts the initial volume. The aim is to find the sample closest to the user's need in this volume.

<u>Strategy 2: Queries in natural language on map sample</u>

Conditions: A user has selected a map sample and written a sentence qualifying this sample (e.g. "*larger*", "*fewer details*", "*bigger*", "*smoother*" and so on.).

Actions: Expert linguistic and geographic knowledge is used to translate the previous terms into criteria. For example, "*fewer details*" corresponds to "*less granular*" which corresponds to a specific criterion in the search space, say c2 on Fig. 6. The system must find within the space one or several map samples whose value for criterion c2 is smaller than that of the selected sample.

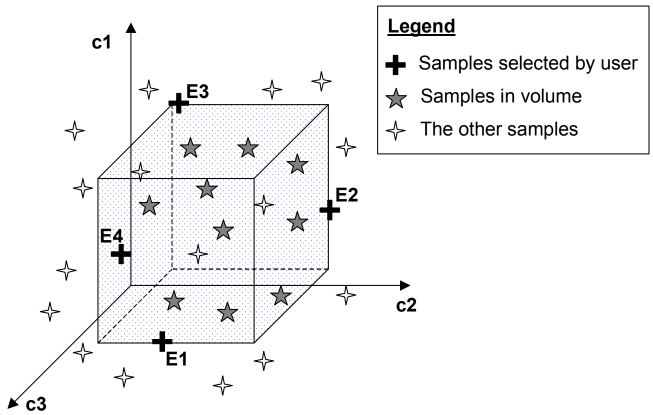

Fig. 6. A space of criteria for map samples

The aim is not to find the map sample which corresponds exactly to the request, but to converge on the must appropriate available solution. Some tools for proximity assessment should be included to answer terms such as "*close to*".

5.3 Necessary Knowledge

To run the research strategies, we need to use specific knowledge:

- Information on the map samples database: This information facilitates the research on available map samples, on possible parameters and on their possible values. For example, the "size" parameter of for building samples generally has values between 25 and 400 m2.
- Information on the generic terms of natural language: Allowing the use of terms in natural language implies their translation in parameter values for map samples. Generic terms include "*more*", "*less*", "*close to*", and so on. For example, the term "*more*" corresponds to an increase of one or several constraint values.
- Information between natural language and properties of map samples: This information is used to establish a mapping between a term in natural language and one or several parameters for map samples. Moreover, it depends on the context. For example, in the term "*bigger*", the system identifies the term "*big*" as corresponding to the size of a map sample. In fact, it must increase the "size" of the current map sample.
- Information on available treatments: Information on geographic treatments can make the searching easier. A geographic treatment can be associated with several constraints, where some variations are forbidden. For example, smoothing implies different values for some constraints. If the system "knows" the different parameters associated with a geographic treatment, it only searches map samples according to these parameters.

These strategies are integrated in a "map samples" manager. This manager is a module of the general architecture of our prototype presented in the next section.

6 General Architecture

Fig. 7 gives us an overview of our prototype. It is composed of 3 modules with different roles: the Web interface, the dialogue manager and the map samples manager.

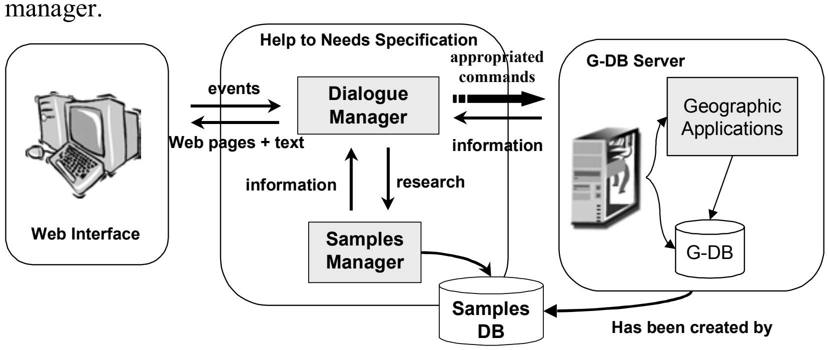

Fig. 7. General schema of our architecture

6.1 Web Interface

The Web user interface offers the user the means to interact with the system and to visualise results including graphics or texts. It is divided in 3 areas as shown on Fig. 8: (1) dialogue box, (2) result area and (3) "common ground" area.

The dialogue box (1) allows the input of text in natural language and displays the response from the system. This box is a Java applet and uses a RMI (Remote Method Invocation) connection with the dialogue manager. The result area (2) allows the display of intermediate and final results. The user can interact with the system by using graphic objects like checkboxes, radio boxes, buttons and so on. These pages are written in HTML and JavaScript languages. The connection with the dialogue manager is established with a JavaScript socket. The last area (3) is used to display the evolution of the "common ground". The "common ground" corresponds to knowledge resulting from an inter-understanding between the user and the system (Nicolle *et al.* 1999). In fact, the dialogue manager stores all interactions with the user by creating a reasoning tree. This tree is used to avoid the loops of reasoning and to describe the "common ground".

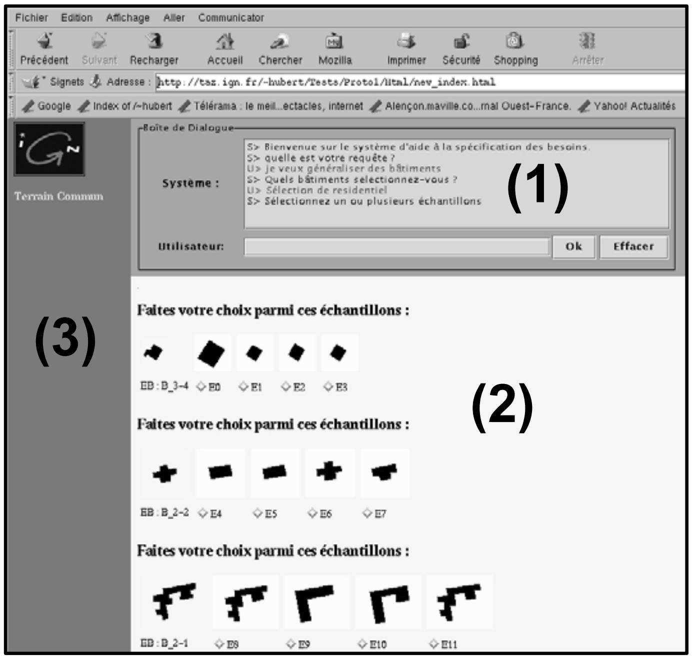

Fig. 8. The Web user interface

6.2 Dialogue Manager

The dialogue manager is the brain of our system. It establishes a link between the Web interface, and the map samples manager or the available GIS. This manager is divided into two modules: a Web server and a dialogue module.

The Web server intercepts events from the Web interface and sends them to the dialogue module. It has an "on-the-fly" generator of Web pages containing graphic objects, text, and images like map samples.

The dialogue module retrieves events and treats them by various actions. It analyses all inputs in natural language with a syntactic and semantic analyser. With these analyses, it can contact the map samples manager or a GIS software to run the relevant action with the relevant information such as constraints goal value. This module must be able to generate language acts, to report bugs or to manage a history of interactions. To conceive this module, we have integrated the Genedic prototype (Lemeunier 2000). Genedic manages a dialogue between human and machine in natural language and it includes functionalities such as the management of waits and the recognition of communication intentions.

6.3 Samples Manager

The map samples manager allows access to samples and analysis. Different kinds of knowledge corresponding to the different strategies (see Section 5) are integrated. Information from samples manager to dialogue manager must include the different locations of samples in the samples database and the results of the analyses

7 Conclusion

The primary role of our system is to translate user's needs in an effort to derive geographic information on the Web. Translating needs requires an expression of those needs. As a result, we propose the use of innovative means of communication: natural language and map samples. These choices allow the design of a Web interface to assist in the specification of needs for geographic information and to identify the necessary and appropriate data.

Current investigation is focussing on the design of a first prototype allowing the user-friendly generalisation of buildings, roads and urban blocks. Some adaptations are being added to the Genedic prototype to treat geographic information. The map samples manager is still to be designed. Further work includes adding the "common ground" facilities in the user interface. Additionally to validate both the interface and the dialogue on map samples, the application scope will be extended to address cartographic symbolisation and allow users to draw their own maps.

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